THE UNIVERSITY OF HULL

# HIERARCHY THEORY AND EPIDEMIOLOGY: A NARRATIVE CRITIQUE

being a Thesis submitted for the Degree of

Doctor of Philosophy

in the University of Hull

by

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Date: January 31, 2007

## Abstract

Integrating approaches from systems thinking with the methods and tools from the discipline of epidemiology, at the level of the management of international health policy and emerging (and re-emerging) infectious disease (EID), the subject of this thesis, is a novel approach. The aim of integrating these approaches in this thesis was to provide additional insights into the management of EID, alongside the aims of enriching the practice of both systems and epidemiology.

This thesis proposed that applying a systemic approach using systems thinking (and specifically the systems approach that addresses problematical situations from a hierarchical perspective) in combination with existing epidemiological knowledge, could provide an enriched description for the modelling, planning, intervention, and response in an analysis of international guidance in public health policy-making. This research was undertaken using a multi-disciplinary multi-paradigm approach of combining the systematic review process with critical systems thinking to explore a functionalist and interpretive approach to hierarchical systems thinking.

There are several outcomes from this research: 1) The compilation of a comprehensive narrative of published work on hierarchy theory and those areas of epidemiology relevant to this study; 2) a process for critical systematic review; 3) a narrative review and critical systems thinking analysis of functionalist and interpretive hierarchical approaches in complex systems; and 4) a critical reflection on the usefulness of combining these hierarchical systems approaches with methods and data from other disciplines; in this case, epidemiology and the study of EID.

This research has shown that there are contributing risk factors in the emergence of infectious disease not addressed in current policy making procedures for EID. The implications of this are important in

reviewing current EID policies. Further work in this area is suggested to investigate whether the functionalist and interpretive hierarchical analysis is feasible in other complex systems, and in further investigating the philosophy, principles and practice of this multi-disciplinary approach.

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## List of Published Work and Prior Research

Part of Chapter 8 was included as the case study in a thesis for the Masters in Public Health received from The Nuffield Institute, University of Leeds in 1998.
Part of Chapter 9 was included in a thesis that reviewed the use of hierarchy theory in a waste management system in San Jose California.

| Publication | Drawn from chapter |
|---|---|
| Wilby, J. M. (1992) A critique of hierarchy theory Unpublished MSc thesis, San Jose State University, San Jose. | 9, 10 |
| Wilby, J. M. 1993, "Research on a General Theory of Hierarchy", Proceedings of the 37th Meeting of the International Society for the Systems Sciences, Hawkesbury, Australia, 248-253. | 3 |
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## Acknowledgements

This thesis would not have been accomplished without the support of my supervisors, colleagues, friends and family; especially to Fiona and Cameron.

I would like to acknowledge and thank Bob Flood, Mike Jackson and Steve Clarke for their input and encouragement throughout this process. Their work has influenced the content and the development of this thesis and it would not have been completed without their help.

I would like to acknowledge those I learnt from at San Jose State University in California. If not for my experiences and learning in that programme, I would not have begun this adventure with hierarchy theory.

Len Troncale has provided much support, mentoring and feedback throughout this thesis and has allowed me access to many materials about hierarchy and systems from his own library and databases. I thank him and his colleagues Lynn Rasmussen and Todd Bowers for their support.

Thank you also my friends and colleagues: especially Debora Hammond, Amanda Gregory, G A Swanson, David Ing, Gary Metcalf, Nestor Valero-Silva, Misha Hebel, Andrea deLaine, Mandy Brown and Martin Hall, for your much appreciated friendship, support and encouragement throughout this process.

# Chapter 1

# Structure of the Thesis

## 1.0 Introduction

Systems thinkers strive to appreciate complex situations employing systemic models and methodologies as insightfully as possible. Within systems thinking, the insights gained can be used to develop strategies for intervention in organisations and society. Integrating approaches from systems thinking with the methods and tools from the discipline of epidemiology, at the level of the management of international health policy and emerging (and re-emerging) infectious disease (EID) is a novel approach. The aim of such integration is to provide additional insights in to the management of EID, along with the aims of enriching the practice of systems and epidemiology.

Epidemiology has many similarities with systems thinking in its history and development as a field of study. As with many areas of inquiry, both systems thinking and epidemiology were originally exploratory, people-driven inquiries that were initially qualitative in approach. As in systems thinking, areas or strands of epidemiology have moved towards measurement. The use of measurement has been a core principle within 'hard' systems approaches such as operational research, systems dynamics and Miller's work in Living Systems Theory (1978). Epidemiology then moved (in the mid 20$^{th}$ century) towards modern, or molecular, epidemiology, which was strongly influenced, as was systems thinking, by measurement, validity, and repeatability using the scientific paradigm. Troncale (2000) writes:

> "There are many parallels between the history of medicine and systems science. Both began descriptively; both involve investigation of highly complex systems; both have the highest purpose of eventually leading to diagnosis of poorly functioning systems with the hope of prescription and prognosis. The words and intents of medicine can be usefully superimposed on systems science to good and instructive effect." (Troncale, 2000, p.236)

Epidemiology is "the study of the distribution and determinants of health-related states or events in specified populations, and the application of this study to control of health problems" (Last, 1995). Emerging infectious disease is "new, re-emerging or drug-resistant infections whose incidence in humans has increased within the past two decades or whose incidence threatens to increase in the near future" (CDC, 1997). EID is a major topic of research within the discipline of epidemiology and would include specific diseases such as tuberculosis, HIV, MRSA, hantaviruses, bubonic plague, and cholera (Last, 1995, p.55).

This chapter introduces the areas for research in this thesis (systems thinking, the hierarchical approach to systems thinking and epidemiology) that will be used in concert to investigate and address the problematical situation (Checkland, 1981) at the heart of this thesis: that of the lack of systemic thinking in the investigation and management of EID. A brief overview of the research question, aims and objectives is presented in this chapter, extracted from the sections on the development of the question, rationale, aims and objectives in chapter 3.

This thesis proposes to show that the study of emerging infectious disease is a complex research issue and requires the use of several disciplines for its adequate description and modelling. Individual disciplines have been employed, most notably those in the natural sciences, to address the management of emerging infectious disease. However, a systems approach, integrating several disciplines in this research, is not currently occurring in the practice of modern epidemiology.

This thesis proposes whether applying a systemic approach using systems thinking (and specifically the systems approach that addresses problematical situations from a hierarchical perspective) in combination with existing epidemiological knowledge, can provide an enriched description for the modelling, planning, intervention, and response in an analysis of international guidance in public health policy-making.

The changes at work in current research in epidemiology are turning back to the social, subjective influences for explanations and improved research and policy making in the form of eco-epidemiology (Krieger, 1994, 2001). These changes have mirrored the more inclusive, participatory developments in the recent history of systems thinking and reflect relevance for the pairing of these two fields in the search for a more comprehensive policy making for EID.

This thesis explores complex systems and there are many definitions of complexity and complex systems (Klir, 1985). Klir draws on definitions from dictionaries, which he believes are common sense but lacking in specific meaning for the study of complex systems, and instead adds the interpretation that complexity is a function of what we observe (Klir, 1985). Ashby (1973) defines complexity in a similar vein, stating that there is no one "pre-eminent meaning" but that complexity can be measured/defined by "the quantity of information required to describe the vital system" (Ashby, 1973, p.2). In other words, where more than one level of description is required to adequately describe a situation, that situation can be called complex (Allen, 1985).

This thesis proposes that the study of emerging infectious disease is a complex research issue because it will require the use of many levels of description to adequately represent the EID system and further, that it requires several disciplines for its adequate description and modelling.

This research will address the study of emerging infectious disease (EID) using a research approach that is both systemic and systematic. This approach will use approaches from systems thinking and a case study and data from international guidance in public health policy-making. The term 'systems thinking' is used throughout this thesis as encompassing systems theory, systems science, and systems methods (Jackson, 2000, 2003). In the research process, being systematic refers to processes that are repeatable and predictable, while being systemic involves describing, defining and interacting with the inter-relatedness and inter-dependency of parts and people within a system of interest.

Underpinning systems thinking are the goals of understanding and managing the variety inherent in complex systems. Hierarchy is one approach that addresses the description and explanation of such systems. Systems thinkers have worked on the possibility of such explanations for many years. Pattee wrote in 1973:

> "Is it possible to have a simple theory of very complex, evolving systems? Can we hope to find common, essential properties of hierarchical organizations that we can usefully apply to the design and management of our growing biological, social, and technological organizations? Such a theory will require a deep and general understanding of the nature of hierarchies, how they originate, how they evolve, how the levels interact, and how failure occurs." (Pattee, 1973, p.131)

Allen (2003) has defined hierarchy theory as "a dialect of general systems theory. It has emerged as part of a movement toward a general science of complexity. Rooted in the work of economist, Simon, chemist, Prigogine, and psychologist, Piaget, hierarchy focuses upon levels of organization and issues of scale ... [with] ... significant emphasis upon the observer in the system" (Allen, 2003). Stan Salthe (1985) says that "hierarchical analysis is always driven by a given problem or project" and this ties with the position of Ahl and Allen that hierarchy theory is not "seeking data within old frameworks that may have internal contradictions ... [but] ...considers how we can frame new questions" (Allen, 1996).

Whyte, an influential writer on hierarchical structures in the 1920s through late 1960s, wrote: "What is most obvious may be most worthy of analysis. Fertile vistas may open out when commonplace facts are examined from a fresh point of view" following from his thought that new compelling arguments had to lead from earlier ideas (Whyte, 1949, p.6).

This thesis follows this approach in first investigating the nature of hierarchies, as currently perceived, and how the use of hierarchy has evolved in systems thinking. The case study used in this research will explore from two different paradigms how hierarchies can be used to look at the interactions within and between systems, and the implications for failure arising from not having a necessary and sufficient understanding of such complex systems. One of the underpinning hypotheses of this thesis is that emerging infectious illnesses have been caused by interactions between several different causes, and that these causes cannot be addressed from within or with the use of only one discipline, such as epidemiology. Addressing these hypotheses will be done using a framework of research designed to be both systematic in enhancing the quality of the process and systemic in the scope of the research process, so as to fully explore the interactions and provide an on-going method for such exploration in future research.

Although it is most commonly held that systems thinking employs systemic practice, the process of being systematic can also be employed in a complementary fashion to increase the rigour and comprehensiveness of the research process. Combining a systematic and systemic process with the process of critical review is one of the aims of this thesis.

Integrating hierarchy theory with the discipline of epidemiology is a novel approach. Such integration can lead to additional insights for both disciplines and this is another aim underpinning the work in this thesis. The topic of this thesis has been chosen because it is a current public health concern and because it matches this researcher's personal interests in international health concerns, systems thinking (specifically, hierarchical systems) and ecological systems.

## 1.1 Summary of Aims, Objectives and the Research Question

This section briefly states the aims, objectives and research question for this thesis. The development of the research question, its rationale and the aims and objectives are discussed in depth in chapter three of this thesis.

The two research questions for this thesis are as follows:

- Would a more holistic systems approach to the study and control of emerging infectious disease, combining systems thinking, and the systems approach of hierarchy theory, with methods and data from epidemiology, provide an enriched description for the modelling, planning, intervention, and response to EID, and in particular, a case of international guidance in public health policy-making?

- Would this improve the understanding of the process of public health policy-making and intervention in EID for those involved in managing these issues?

The aims of this research are:

- To develop a narrative comprehensive review of epidemiology past and present and of hierarchical approaches in systems thinking from a functionalist and interpretive perspective;

- To use the functionalist and interpretive perspectives of hierarchy and the narrative reviews in concert to investigate EID within the discipline of epidemiology;

- To develop, apply and evaluate a critical review process in the design and the evaluation of this research using the methodologies of systematic review and critical systems thinking and practice (CST/P).

The objectives used in achieving these aims are:

- To present a process for critical systematic review for review of systems thinking, hierarchy theory and epidemiology in concert in this thesis;

- The compilation of a comprehensive literature review of published work on hierarchy theory and those areas of epidemiology relevant to this study;

- To review the hierarchy literature using a functionalist and interpretivist analytical approach, so as to construct a narrative comprehensive review of each of these perspectives for the purpose of comparing and contrasting the outcomes of this process in a practical exploration of EID.

- To critically review the functionalist and interpretive hierarchy approaches and their use in this thesis; and further

- To critically evaluate and reflect on the usefulness of combining functionalist and interpretive approaches with methods and data from epidemiology to answer the questions as to whether or not this combined approach is relevant and valid in: (1) the analysis of EID as a complex situation, and (2) the generalisability of this work to other areas in the management of complex systems; and

- To propose recommendations for the improvement of policy-making in EID, and suggest future research in hierarchy theory.

An overview of the thesis structure and process is shown in figure 1.1. This is followed by an extended introduction to systems thinking. Epidemiology and hierarchy are introduced later in this chapter, but are not dealt with in detail in chapter one since they will be the subject of extensive literature reviews in chapters 4, 5, and 6. Chapter 4 is the literature review for epidemiology, chapter 5 for functionalist hierarchy and chapter 6 for interpretive hierarchy.

As shown in figure 1.1, the thesis is centred on the use of a systematic review of the topic, coupled with the application of the gathered data on hierarchy and epidemiology to a complex system (the management of emerging infectious disease).

The intervention is followed by the introduction of critical systems thinking and practice (CST/P) to evaluate the outcomes of the intervention from the dual viewpoints of the functionalist hierarchy and the interpretive hierarchy in practice.

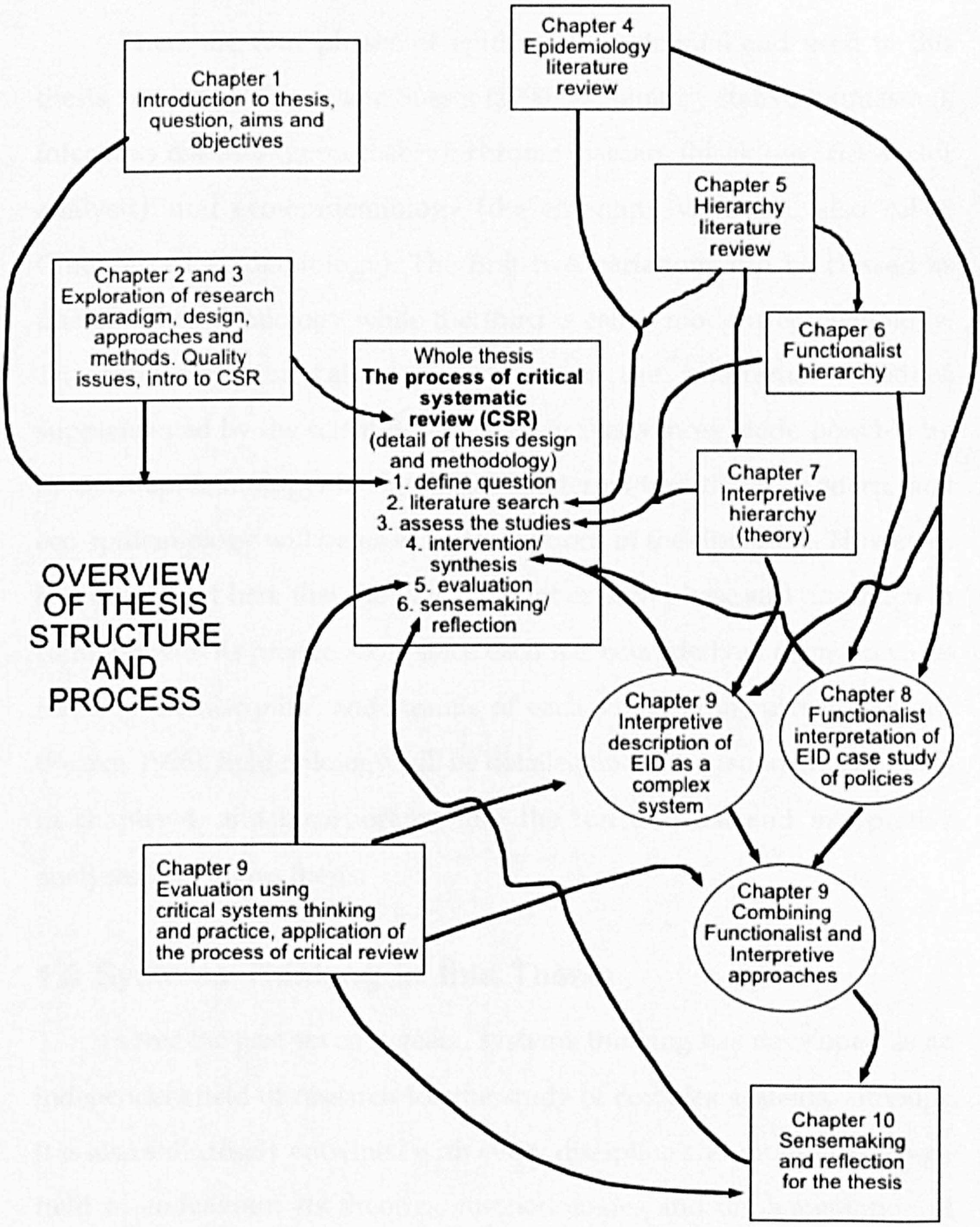


**Figure 1.1 The Structure and Process of this Thesis**

The thesis concludes with the final stage of the systematic review process of 'making sense' and 'putting the results into context' with a chapter of conclusions, recommendations and reflection.

## 1.2 Epidemiology in this Thesis

There are four phases of epidemiology defined and used in this thesis, named by Susser and Susser (1996) as: sanitary statistics (miasma); infectious diseases (germ theory); chronic diseases (black box/risk-factor analysis); and eco-epidemiology (the emerging variation, also called Chinese box epidemiology). The first two variations can be classed as traditional epidemiology while the third is called modern epidemiology. The final variation calls for a return to the traditional variations supplemented by the scientific and statistical advances made possible by modern epidemiology. In this thesis the terms traditional, modern, and eco-epidemiology will be used in descriptions of the discipline. However, it is also noted here that the development of each phase still has much in common with its predecessors since each has been derived from previous forms of the discipline, and strands of each still exist in current research (Pearce, 1996). Epidemiology will be detailed and critiqued in greater detail in chapter 4, and incorporated into the functionalist and interpretive analyses later in this thesis.

## 1.3 Systems Thinking in this Thesis

Over the past seventy years, systems thinking has developed as an independent field of research for the study of complex systems, although it is also still closely entwined with every discipline and multi-disciplinary field of endeavour. Its theories, methodologies and implementation of systemic processes of inquiry have been applied in such diverse topics as management (Jackson, 2000, 2003), economics (Simon, 1973), psychology, sociology (Bailey, 1994, 1999), ecology (Allen, 1985), botany (Allen and Starr, 1982) and biology (Miller, 1978).

Although "hierarchy" and "hierarchical analysis" has always been present as a core concept in systems thinking, this thesis proposes that this way of approaching and working with systems concepts does not specifically within hard, soft, or critical systems thinking. The output of the hierarchy literature analysis and methodology construction in chapters 5-8 are intended to give a wider appreciation of the concepts, rather than limiting them *a priori* to any one place in the development of systems thinking. Hierarchy is a core concept of systems thinking that is of a different logical type to that of a classification of systems and cannot therefore be placed within only one specific area in the history of systems thinking; it belongs as an underpinning to them all.

### 1.3.1 Defining a System

A system can be defined as "a set of objects together with relationships between the objects and between their attributes, related to each other and to their environment so as to form a whole" (Schoderbek et al, 1990, p29). Klir calls his definition of system a "common sense" definition:

> "S = (T, R)
>
> where S is the system, T is a set of certain things (thinghood), and R is a relation defined on T (systemhood)" (Klir, 2001, p9).

Klir explains that although the definition looks simple, the symbols T and R are rich in content. The process of systems thinking looks at the T and the R together, rather than separately, and is one distinguishing feature of the systems approach to the study of complexity.

Weiss defines a system as "a complex unit in space and time so constituted that its component subunits, by "systematic" cooperation, preserve its integral configuration of structure and behavior and tend to restore it after non-destructive disturbances" (Weiss, 1971, p.14).

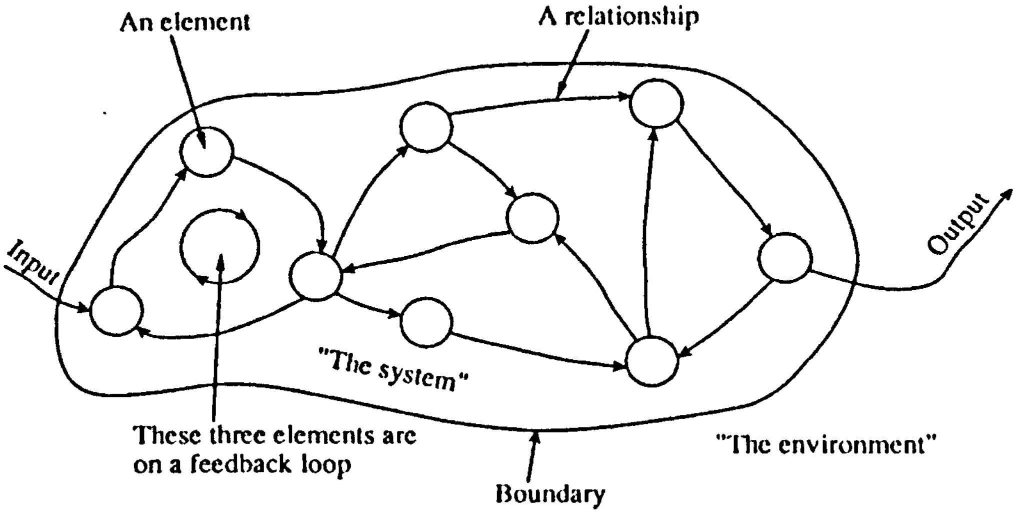


**Figure 1.2 A General Conception of "System" (from Schoderbek et al., 1990)**

Jackson and Gregory (2006) explain the content of figure 1.2 thus: "A system consists of a number of elements and the relationships between the elements. A richly interactive group of elements can be separated from those in which few and/or weak interactions occur. This can be achieved by drawing a boundary around the richly interactive group. The system identified by a boundary will have inputs and outputs, which may be physical or abstract. The system does the work of transforming inputs into outputs. The processes in the system are characterised by feedback ... A system so described is separated by its designated boundary from its environment. ... Systems are generally understood to occur in hierarchies, so that a system we are considering may also be considered as a sub-system of a wider system." In a verbal comment, Gregory (2006) believes the boundary line ought to be a dotted line rather than a solid line, to better illustrate the concept that the line is not absolute, and that the internal part of the system is in constant interaction with the environment on many levels. This is especially so in the case of hierarchy theory where the decisions as to where to draw the boundary are based on the subjective judgement of the observer of the 'system'. The perceptions and data influencing the observer are also fluid over time, in turn influencing the content and shape of the boundary drawn by the observer. Further discussion of a 'system' and its parts and behaviours as they relate to this thesis will be given in the chapter on hierarchy theory.

The study of "wholes" is the domain of systems thinking, and specifically the study of the relationships between the parts of the whole that together give rise to properties that cannot be discerned from the individual study of the parts. These properties are called emergent properties and the philosophy underpinning the study of the whole is called holism. An holistic approach is also to be found in the discipline of epidemiology known as traditional or eco-epidemiology (Savitz, 1997; Susser and Susser, 1996). In contrast "modern epidemiology" now focuses on biological information and experimental research which is reductionist rather than holistic in design (Pearce, 1996).

### 1.3.2 An History of Systems Thinking

Systems thinking began with the search for isomorphisms; laws, concepts, and models which could be transferred between disciplines (von Bertalanffy, 1968). The practical expression of this was the concept of holism "...looking at the world in terms of "wholes" that exhibit emergent properties, rather than believing, in a reductionist fashion, that understanding is best obtained by breaking wholes down into their fundamental elements." (Jackson, 1991a, p.9) This strand of thinking, attempting a unification of science, was the beginning of general systems theory (GST)., although as will be seen in chapter six, the roots of this movement are several hundred years old.

In this thesis the phrase "systems thinking" will be used to describe the discipline that contains systems approaches such as GST, hierarchy theory, and the various problem-solving systems methodologies that have developed from operations research, soft systems thinking, and critical systems thinking. Systems thinking is an approach to studying complex systems but, like epidemiology, that approach can be focused within disciplines or be interdisciplinary.

Checkland's definition of the systems paradigm clarifies the scope of the "whole" being studied in the systems approach:

> "the systems paradigm is concerned with wholes and their properties. It is holistic, but not in the usual (vulgar) sense of taking in the whole; systems concepts are concerned with wholes and their hierarchical arrangement rather than with *the* whole." (Checkland, 1981, pp13-14)

The goal of holistic study is not to look at "everything". Instead it is to make a decision about what is relevant to the study and what is not (Phillips, 1976). This is why the biases and interests of the person designing the study make a difference to the scope of a study (Ahl and Allen, 1996). Those biases and interests affect the choice of scale for a study, and hence what is likely to be included and excluded (i.e. what is in the system as opposed to what is relegated to the environment of the system.) Since the definition of system of interest hinges on the scale of data input into the investigation (whether it is molecular or at the level of the social sciences) this scale is a continuum between the terms of reductionism and holism. So these terms are not opposites. Both can offer differing scales of data for the same research.

Schoderbek et al. (1990) discuss that the systems approach should not be viewed as being either holistic or analytical; that both approaches must work together to not only see the whole but also recognise and know the parts and their relationships. They also caution that the researcher has to be careful in choosing the appropriate scale for the research so that essential interrelationships are not destroyed.

In the service of making something larger "qualitative researchers are constantly involved in synthesis. ... All of this activity revolves around what may be called a *holistic injunction*" (Noblit and Engel, 1992, p43). The goal however is not building lots of packets of information at the levels of fine or coarse data. The additional imperative of the holistic approach is to link those packets together and view the outcomes (possible emergent properties) by focusing on the links rather than the individual packets (parts) of a larger system.

Holism developed from organicism in the field of biology in the early 20th century when it was proposed that "the analytic approach as typified by the physico-chemical sciences proves inadequate when applied to certain cases..." (Phillips, 1976). This in turn is linked to the principles of internal relations proposed by Hegel, where "entities are *necessarily* altered by the relations into which they enter" (Phillips, 1976, p8). Phillips criticises holism using semantics: that it is not possible to say that all the entities can be seen to have defining characteristics for the whole (Phillips, 1976) and therefore there are some which may or may not alter the behaviour of the "whole" and thus may or may not contribute to the display of a higher emergent property. So in holistic study researchers may or may not have discerned the appropriate entities necessary to explain the behaviour of the whole system.

The counter to this is that the researcher can use various methods of triangulation (data, investigator, theoretical and methodological) (Noblit and Engel, 1992) to check the scope of the insights, and thus work to discover the non-productive relationships as well as the productive ones for defining and understanding the whole.

This is the direction a multi-disciplinary holistic approach must take: to sweep in as many viewpoints, theories, methodologies and researchers as possible to discover the pertinent internal relationships while also being reflective about what is being included and left out of the research.

This view might be contradicted by those systems thinkers who focus on structure of the system (its parts), rather than its process (the relationships between the parts) e.g. in the mathematical methodologies of systems thinking such as operations research or systems analysis. This thesis proposes that epidemiology and systems thinking are two different approaches which both operate on the holistic level, as defined earlier by Checkland. Traditional- and eco-epidemiology focus on researching groups rather than individuals, as does systems thinking, especially in its most-common orientation towards organisational problem solving (Hall, 1997). The systems approach differs in that it is currently working to address human interests and power issues as well as the technical aspects of a problem addressed so concisely by modern epidemiology (see critical systems thinking, Flood and Jackson, 1991a,b; and Flood and Romm, 1996). This thesis proposes that CST/P is an area that can be incorporated into epidemiology.

This early systems thinking, with its search for a unification of science, has been criticized as being: 1) ironic, in that it is actually inherently divisive in its call for one set of laws, concepts and models for all disciplines rather than many (Midgley, 1996); and 2) incapable of exploring the underpinning philosophy, principles, and practice of those laws, concepts and models so as to address basic ontological and epistemological differences between the strands of systems thinking and their associated disciplines (Flood, 1995a). These unresolved issues and conflicts have contributed to systems thinking following the general trend within all research towards greater specialisation, and it has itself become quite fragmented (Flood, 1995a; Midgley, 1996).

More recently, there has been a movement to reverse this fragmentation; to bring together, in some fashion, the diversity of systems ideas and methods. This is partially reflected in the development of critical systems thinking and practice that is discussed in section 1.2.5.

These concerns will be addressed in this thesis. It is also interesting that one of the criticisms levelled by researchers in systems thinking, that newer initiatives in the areas of complexity, chaos, and systems modelling do not (or do not adequately) reference past systems work, is also demonstrated to be the case in this thesis, where some systems thinkers have not adequately addressed the prior work of their predecessors (cf. chapters 6 and 7 of this thesis).

Klir (2001, p45) writes that Ludwig von Bertalanffy introduced the terms 'general systems' and 'general systems theory', at first orally in the 1930s, and then in writing (von Bertalanffy, 1968). These terms arose from a growing awareness of a need to describe more complex ideas.

> "The ideas of holism, the emergence of interdisciplinary areas in science, and the increasing recognition of the existence and utility of isomorphisms between disciplines of science created a growing awareness among some scholars that certain concepts, ideas, principles, and methods were applicable to systems in general, regardless of their disciplinary categorization" (Klir, 2001, p45).

Kenneth Boulding describes the same need thus:

> "In recent years increasing need has been for a body of systematic theoretical construction which will discuss the general relationships of the empirical world. This is the quest

of General Systems Theory. It does not seek, of course, to establish a single, self-contained "general theory of practically everything" which will replace all special theories of particular disciplines. Such a theory would be almost without content, for we always pay for generality by sacrificing content, and all we can say about practically everything is almost nothing." (Boulding, 1956, p197).

and

"General Systems Theory is a name which has come into use to describe a level of theoretical model-building which lies somewhere between the highly generalized constructions of pure mathematics and the specific theories of the specialized disciplines..." (Boulding, 1956, p197).

Boulding, Gerard, Rapoport, and von Bertalanffy went on to found the Society for General Systems Research in 1954 with the following aims:

- to investigate the isomorphism of concepts, laws, and models in various fields, and to help in useful transfers from one field to another

- to encourage development of adequate theoretical models in fields that lack them

- to minimise the duplication of theoretical effort, and

- to promote the unity of science.

The founders used the word isomorphisms as an adjective, describing an abstraction, "something similar between real systems resulting from a comparison" (Troncale, 1988, p17). However, some recent theorists use this as a noun, "to draw attention to the possibility that these similarities actually precede the origin of the system in many natural systems" (Troncale, 1988, p17). In this thesis, in terms of the social systems being observed, that view is modified by this observer to: *preceding the observation, and hence definition, of the system being observed.* GST has since developed into the field of research more commonly termed "systems thinking", and in its applied variant has evolved throughout the changes in the areas of hard, soft, and critical systems thinking.

As with the evolution in epidemiological methods, the individual stages are still in use, soft has not replaced hard systems thinking, nor has critical systems thinking eradicated hard or soft methodologies. Instead each evolution of either epidemiology or systems thinking might be seen to have its best use in differing situations in various combinations.

### 1.3.3 Hard Systems Thinking

In systems thinking, there have been a variety of approaches, beginning with the strand of "hard" systems thinking which is exemplified by systems analysis, systems engineering, and operations research. The complex problems tackled by these approaches were addressed through the use of methods that were rational, used the scientific method, and interdisciplinary teamwork. In the 1960s, people began to realise however that these hard methodologies had become only implementations of mathematical modelling (Jackson, 1991a) rather than approaches that could address the less tangible variables brought about by the involvement of people in the problem situations. It was no longer sufficient to believe that problems were manageable outside of the social context in which they were defined.

### 1.3.4 Bridging to Soft Systems Thinking

Bridging between hard and soft systems, and even considered as a critical systems thinking approach (Jackson, 2003), Viable Systems Modelling (Beer, 1979, 1981, 1985) pursues the same goals of the authors explored in this thesis: that of looking for the mechanisms and explanations why systems were viable in the same way that hierarchy theorists such as Simon and Pattee were exploring this goal from the perspective of biological systems. Beer uses the biological metaphor in the VSM in a parallel development to those who were exploring the same issues, in the same time period of the 1950s to 1970s in the literal fields of biology and ecology. The VSM is a cybernetic approach but one that incorporates social, organisational and management factors (Flood and Carson, 1993). The VSM and its principles will be drawn into the narrative on hierarchy later in this thesis.

### 1.3.5 Soft Systems Thinking

C. West Churchman (1971, 1979, 1982), Ackoff (1974, 1978) and Peter Checkland (1981) began the next shift in systems thinking: that of "soft" systems thinking. They wrote that earlier systems work had failed to get to grips with issues that require "whole pictures" of external reality, i.e. systems in the world, and the inclusion and addressing of the interests of a variety of stakeholders in a system. Soft methodologies include soft systems methodology (SSM) (Checkland, 1981) and interactive planning (IP) (Ackoff, 1974; 1978; 1981).

Checkland's SSM developed through the 1980s and into the 1990s as parts of the critiques of the methodology were addressed. The shifts in knowledge about human activity systems and the more participatory and collaborative approach also apparent in many other fields within social systems research have also been incorporated into SSM. Issues for SSM are still raised by the field within systems thinking called "critical" systems thinking (CST) which draws on the work of soft systems thinking but specifically addresses emancipatory concerns and issues of coercion. There is still a tension between SSM and the ideological critiques of its methodology (see Romm, 1994) and Flood (1999) wrote: "the main criticism of Checkland's work is that it neglects certain difficulties in achieving open and meaningful debate. ... The idea of social transformation seems to be missing in Checkland's concern for feasible changes, given the history, dominant attitudes, and power structures of a problem situation." (p. 60).

### 1.3.6 Critical Systems Thinking

Later developments in systems thinking have focused on developing individual methodologies in greater detail; in working on frameworks for linking hard and soft methods, and in the development of another area of systems thinking called "critical" systems thinking (CST) which draws on the work of soft systems thinking but adds emancipatory concerns and issues of coercion to its methodologies.

CST explores the strengths and weaknesses of different methodologies (derived from systems laws, concepts, and models), using a framework to determine the methodology(ies) most suitable and appropriate in addressing specific complex issues or situations.

Unlike GST, CST not only explores the underpinning philosophy, principles, and practice of systems approaches, but it also acknowledges a diversity of approaches and seeks to use those approaches within a complementarist framework rather than from an isolationist or imperialist[1] position. It is the acknowledgment of this diversity, and the use of a complementarist path in finding the most suitable and appropriate systems approach for an intervention, that separates CST from previous work on unifying theories in the systems sciences.

When first introduced to systems thinking, CST had three commitments: critical awareness, emancipation, and complementarism. More recently, these commitments have been addressed and described as critical reflection (rather than critical awareness), pluralism (rather than

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1 "Isolationism therefore means sticking to one method or methodology only, because the analyst wants to know no other approach. More sophisticated isolationists engage in a kind of imperialism, adhering to one well worked out approach that is linked to one theory or philosophy. Methods or methodologies emerging from other positions are interpreted and employed according to the favored theory or philosophy. This denatures, distorts, and reduces the capability of the approaches so dealt with. It divides systems science into opposing factions who argue for the primacy of their own approach. It ultimately contradicts the original holistic or unifying vision of systems science" (Flood and Carson, 1993, p. 127).

complementarism), and improvement (rather than emancipation)" (Flood and Romm, 1996).

CST has relevance to this thesis in terms of providing an underpinning philosophy for evaluation and critical reflection and in realising the limitations of the individual researcher in any study. The observer (researcher) should always be engaged in a constant and iterative self-reflection as an ongoing part of any analysis. This would also involve the "sweeping-in" of alternate perspectives (Churchman, 1982).

The task of self-reflection is necessary and vital, and requires an on-going self-examination and self-reflection of the biases, filters and paradigms brought to the study by the individual researcher, and by the physical and intellectual communities of which the researcher is a part recognising that the output of this thesis is only one of many explanations from the data gathered.

CST therefore underpins the generic model for critical review that will be applied in this thesis to evaluate the development and combination of two very diverse approaches: epidemiology and hierarchy theory.

## 1.4 Hierarchy Theory in this Thesis

Hierarchy theory has raised much interest in the field of systems thinking, and it has been applied in many areas of research, particularly ecology (Ahl and Allen, 1996; Allen and Starr, 1982), biology (Miller, 1978), and management (Jackson, 2000, 2003; Mingers and Gill, 1997).

Hierarchical concepts have been applied in many of the disciplines dealing with issues common to systems science and epidemiology. Research into outbreaks of EID and the development of responses to such outbreaks requires the use of a wide range of data and the use of many disciplines such as, but not limited to, biology, biochemistry, chemistry, ecology, epidemiology, psychology, politics, economics, statistics, and mathematics. Some of the research issues of interest to this thesis include: the importance of the observer in defining the scale (or level) of the observation (resolution) and the level of data gathering; the many parts and (inter)-relationships involved in a situation; and the issues of communication, constraints and control among the parts of the system.

Hierarchy theory has also suffered from fragmentation in its theory, philosophy, and practice and, at present, it lacks an internal coherence and a methodology for implementing hierarchical concepts has not yet been clearly defined.

It is proposed in this thesis that hierarchy theory may be able to demonstrate theoretical and methodological coherence and relevance for addressing complexity, and facilitating organisational and societal improvement. It is further proposed that this relevance can be applied in concert with other disciplines (in this case, epidemiology) so as to more fully address an issue more commonly only found within the remit of epidemiology.

Hence, it seems appropriate to explore the development and application of hierarchy theory in a critical fashion that is operationalised by the use of critical systems thinking. The resulting critique will help us to determine whether it is possible to bring together the different strands of hierarchy theory into a coherent and relevant discussion, and whether it is possible to use hierarchy theory in concert with other approaches in complex interventions.

The aim of integrating these three fields of research, systems thinking, hierarchy theory and epidemiology leads to the research question stated in the next chapter.

## 1.5 Chapter Outlines

Chapter one introduces the thesis, the fields of research covered in this research project and presents a short overview of the history and development of systems thinking, hierarchy theory and epidemiology. Chapter one also contains a map of the thesis as a visual representation of the structure and process of the thesis in addition to the following narrative summary.

Chapter two details the research philosophy, research design and research approaches using several research frameworks to explore and categorise the underpinnings of this research.

Chapter three introduces the process of critical systematic review presents the first three stages of that process with the development of the research question, aims, objectives and rationale for this research project.

Chapter four continues this process with a literature review for epidemiology and the policy making that has been done for the prevention and control of emerging infectious disease at the international level. Several cases of current epidemiological policy making at the national and international levels will be surveyed for the later analysis in chapter 8.

Chapter five is a traditional literature review of hierarchy theory, with the aim of illustrating the need for a more detailed form of the theory and a means for its implementation in an intervention.

Chapter six describes the literature in the functionalist form of hierarchy theory, the frameworks hierarchical systems approach, and lists the work of those systems authors who have developed hierarchical frameworks and descriptions for the exploration of complex systems.

Chapter seven describes the literature in the interpretive form of hierarchy theory, the descriptive and subjective form of the hierarchical systems approach that is also known as 'hierarchy theory' by some authors in this area of research. This chapter lists the work of those systems authors who have developed a descriptive, interpretative approach for the exploration of complex systems.

Chapter eight will present the case study consisting of three EID international health policies to be explored through the use of an exemplar functionalist framework chosen from the group of functionalist hierarchical frameworks presented in chapter 6.

Chapter nine has three sections. The first section presents an interpretive, narrative discussion of hierarchical analysis (hierarchy theory). . The second section presents a combination of the results of the usefulness of both functionalist and interpretive approaches to analysing

EID using the interpretive approach developed from chapter 7. And the third section follows with a critical review of hierarchy using principles from critical systems thinking and critical systematic review

Chapter ten states findings, contributions to knowledge surfaced by this research, reflection on the process of this research, proposed recommendations for the improvement of policy making in the prevention and control of EID, and suggested further research in hierarchy theory. This evaluation will also argue for an expanded epidemiology that merges the breadth of traditional epidemiology with the clinical support of modern epidemiology.

## 1.6 Summary of this Chapter

This chapter has introduced the research topic for this thesis and the structure of the project. It has proposed that the scope of one health-related situation (EID) could be more adequately addressed using a systems approach (hierarchy theory) in combination with epidemiological methods. It has also presented an overview of systems thinking, hierarchy and epidemiology that will be used in concert to address the research question. This thesis proposes that by combining epidemiological methods and the insights from the hierarchical systems approach, a more comprehensive assessment of a problem situation is possible. The field of systems thinking also benefits from the exploration of a theory of a hierarchical systems approach to problem solving.

The next chapter introduces and addresses issues concerning the research design and process for this thesis. The chapter first looks at different frameworks used in the literature to think about the research paradigm underpinning this thesis. It then explores issues of reliability, validity and generalisability in the thesis, and how these can be addressed through the development of a process called critical systematic review (CSR).

# Chapter 2

# Design and Methodology

## 2.0 Introduction

This chapter introduces and addresses the research design and methodologies for this thesis. The chapter first looks at different frameworks used in the literature to think about the research paradigm underpinning this thesis. It then explores issues of reliability, validity and generalisability in the thesis, and how these can be addressed through the development of a process called critical systematic review (CSR).

The process of determining reliability, validity and generalisability is a process to which both the researcher and the readers of the research should submit themselves in the interests of surfacing hidden assumptions which can be then acknowledged and addressed in the course of the thesis and its testing and evaluation.

This thesis was conceived from interests based in several different fields of research, emerging from studying in those fields over twenty years. Beginning with positivistic science (biochemistry), moving to political science and public planning in the social sciences, then to systems thinking and back to the health sciences. All of these influences are present in this research a priori and it is therefore not possible to state that this research was framed without the influence of these past experiences, nor that the stated research paradigm, approach and methods are free of these influences.

The first section explores different frameworks of research paradigms with the aim of exploring the researcher's stated influences and determining the paradigm that underpins this research. The section on paradigms is followed by a discussion of the need for validating this research, with definitions of what constitutes validity, reliability and generalisabilty in research. This need for evaluation of the research is then covered in the final section of this chapter. A process is proposed for a new methodology, developed from an existing, well-documented research design (the systematic review), that incorporates systematic review with critical review (drawn from the work in critical systems thinking and practice (CST/P)).

The outline of this new approach is presented in the final section of this chapter along with a summary of the work covered in this chapter, and will then be implemented in chapter 3.

## 2.1 Exploring The Research Paradigm and Approach

Knox (2004) agrees the need to examine the relationship between the philosophy of the research and the methods chosen and that while methodological pluralism is possible, philosophical pluralism is not. Therefore he proposes "some form of research hierarchy of needs could be a useful starting or discussion point between students, researchers and supervisors, i.e. what is expected in terms of understanding, analysis, synthesis and criticality at various levels of the research process ..." Knox presents this hierarchy of needs in a diagram, shown in figure 2.1.

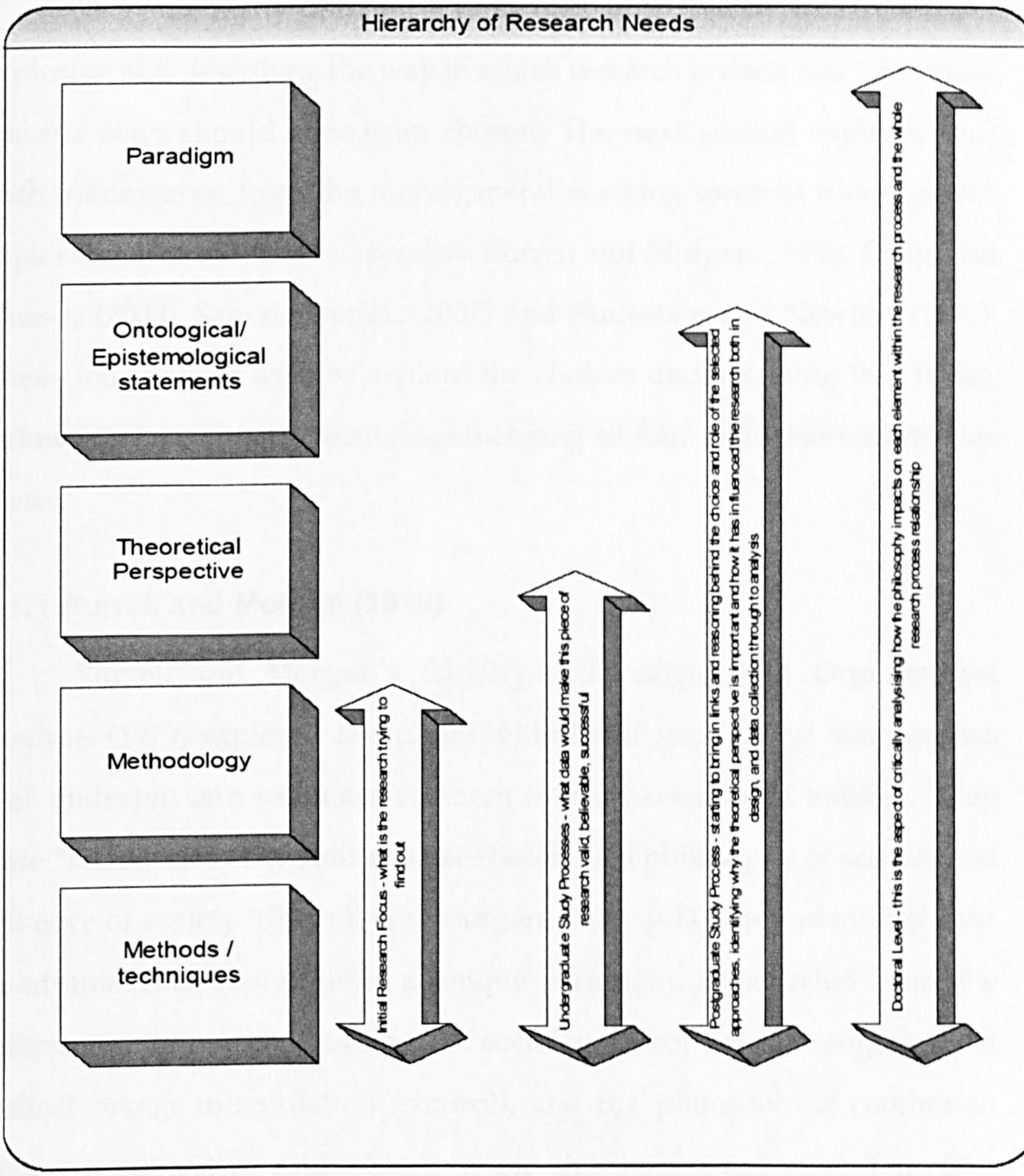



**Figure 2.1 Hierarchy of Needs (Knox, 2004, p129)**

At the doctoral level there should be a "critical analysis of these philosophies in line with the research being undertaken" (Knox, 2004). This is the aim of this section of the thesis and this also underpins the design of the different methods for gathering, analysing and interpreting used in this thesis.

There are many different frameworks proposed by researchers for exploring and describing the way in which research is done and why those specific ways should have been chosen. The next section explores four such frameworks, from the more general working towards more specific explorations of the research process: Burrell and Morgan (1979), Collis and Hussey (2003), Saunders et al. (2007) and Rudestam and Newton (1992). These four will be used to explore the choices underpinning this thesis, followed by a summary section synthesising all four with reference to this thesis.

### 2.1.1 Burrell and Morgan (1979)

Burrell and Morgan's *Sociological Paradigms and Organisational Analysis* (1979) explored the philosophical and sociological assumptions that underpin and influence research into organisational entities. They state "all theories of organization are based on a philosophy of science and a theory of society' (Burrell and Morgan, 1979, p.1). They identified four quadrants, each representing a unique paradigm, constructed from the intersection of two continuums: the sociological continuum ranging from radical change to regulation (control), and the philosophical continuum between subjective and objective on the horizontal axis. The four quadrants emerging from this construction are shown in Figure 2.2.

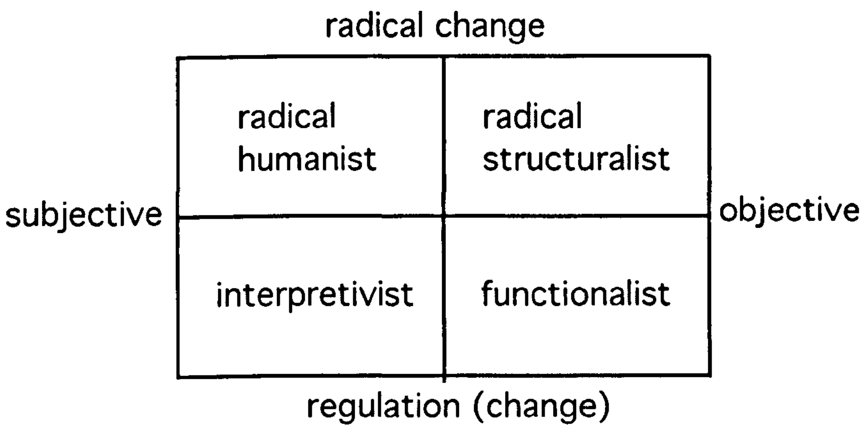



**Figure 2.2 Four Paradigms for the Analysis of Social Theory (from Burrell and Morgan, 1979, p.22)**

Burrell and Morgan defined a paradigm as "a term which is intended to emphasise the commonality of perspective which brings the work of a group of theorists together in such a way that they can be usefully regarding as approaching social theory within the bounds of the same problematic" (p. 23) The authors acknowledge this does not imply complete unity of thought and this is important in the current thesis in that here the notion of a continuum is preferred rather than definitive boundaries between each of the boxed paradigms shown in figure 2.2. The four paradigms defined are listed in the following sections.

Radical structuralist – this paradigm is grounded in objectivity and the sociology of radical change where structural conflicts with society are seen as inherent, causing continual change through social, political and cultural crises. "Whereas the radical humanists forge their perspective by focusing upon 'consciousness' as the basis for a radical critique of society, the radical structuralists concentrate upon structural relationships within a realist world. They emphasise the fact that radical change is built into the very nature and structure of contemporary society, and they seek to provide explanation of the basic interrelationships within the context of total social formations". (Burrell and Morgan, 1979, p.34)

Functionalist - grounded in objectivity and the sociology of regulation. This is the paradigm that has dominated organisational and sociological research. B and M state that this paradigm is "characterised by a concern for providing explanations of the status quo, social order, consensus, social integration, solidarity, need satisfaction and actuality. It approaches these general sociological concerns from a standpoint which tends to be realist, positivist, determinist and nomothetic" (p.26). Although this paradigm has great resonance with the beginnings of general system theory, in its attempts to find models and methods applicable to both natural sciences and social sciences, and its attempts to also use natural systems concepts in the social sciences, this is not the paradigm used in the methodology of this thesis. The functionalist paradigm is also applicable to the discipline of epidemiology but again, the design of the research and the objectives of this project are closer to the following fourth B and M paradigm, that of interpretivism.

Radical humanist – The radical humanist paradigm is located within a subjective philosophical commitment, but as with the radical structuralist, is interested in developing a sociology of radical change. "Its approach to social science has much in common with that of the interpretivist paradigm [see below ... However, its frame of reference is committed to a view of society which emphasises the importance of overthrowing or transcending the limitations of existing social arrangements." (Burrell and Morgan, 1979, p.32) The work of Habermas falls within this paradigm, and this paradigm is therefore central in the development of critical systems thinking and practice which is used and incorporated into the critical review process used in this thesis.

Interpretivist – Burrell and Morgan (1979) state that the interpretivist paradigm "adopts an approach consonant with ... the sociology of regulation, though its subjective approach to the analysis of the social world makes its links with this sociology often implicit rather than explicit. The interpretivist paradigm is informed by a concern to understand the world as it is, to understand the fundamental nature of the social world at the level of subjective experience. It seeks explanation within the realm of individual consciousness and subjectivity, within the frame of reference of the participant as opposed to the observer of action" (p.28). In hierarchy theory the observer of the system is a participant in the system in that it is the observer who determines the system of interest, draws the boundary of the system of interest and who does this acknowledging the subjective experiential nature of this process.

The interpretivist paradigm underpins this approach to hierarchy theory in this thesis, and works in combination with the radical humanist approach. However, Burrell and Morgan draw set boundaries between the two approaches and hold that they are incommensurable with each other. If the two dimensions of the 2 x 2 grid are held to be continuums however, there may be elements of each paradigm to inform the other and this will be explored further later in this thesis.

### 2.1.2 Collis and Hussey (2003)

Collis and Hussey (2003) propose a four-criteria framework for categorising a piece of research:

- Purpose: why you are conducting it and these are further categorised by the research being exploratory, descriptive, analytical or predictive

- Process of the research: the way in which the research will be implemented and this can be either quantitative or qualitative in approach

- Logic of the research: whether the research is moving from the general to the specific or the specific to the general, i.e. inductive or deductive

- Outcome of the research: solving a particular problem or making a contribution to knowledge, applied or basic research. (Collis and Hussey (2003).

As a way of following the framework proposed by Collis and Hussey (2003), the definition of purpose, the research proposed in this thesis, is a combination of exploratory and descriptive research, with some analytical processes. Collis and Hussey (2003) state that exploratory research "is conducted when there are very few or no earlier studies to which we can refer for information about the problem" and "where the aim of the research is to look for patterns, ideas or hypotheses" (p.10) To generate new models and explanations in systems, hierarchy and epidemiology and to propose further research areas is one of the objectives of this thesis. Combined with this, descriptive research adds depth to the gathering of information in this thesis for the detail used in building the model of hierarchy theory and in the rigour proposed by the use of the critical systematic review process. Analytical approaches are also planned in both the combining of the views on hierarchical principles and practice from authors and their questionnaire inputs, and in the evaluation of generated hierarchy frameworks and their application to the issues in epidemiological policy-making.

The process of the research can be either quantitative or qualitative according to Collis and Hussey (2003) depending on many variables such as the philosophical underpinning of the proposed research, methods available, and resource issues. In this thesis there is a combination of quantitative and qualitative methods and this may be seen as one of the strengths of interdisciplinary research. Issues arising from using both approaches will be addressed in the evaluation of this thesis.

The logic of the research proposed in this thesis is that of an inductive process. It is not the aim of this research to use existing theory and testable hypotheses but rather to build models and frameworks generated from analysis of literature and other data sources.

With regard to the outcomes of the research, it appears that in this Collis and Hussey category there is also a mix of both applied and basic research. This thesis is basic research, working in an inductive fashion to generate new knowledge in the fields of systems, hierarchy and epidemiology. However, there is also an applied element where the thesis analyses specific health policy statements and hierarchical frameworks are utilised in this process.

In summary, for the categories proposed by Collis and Hussey, the categories do not offer a clear distinction in the description of the research proposed in this thesis. Apart from the clearer distinction that the logic of this research is inductive rather than deductive, the remaining three categories require a mix of terms to adequately describe the research process proposed in this thesis.

### 2.1.3 Saunders, Lewis and Thornhill (4th ed, 2007)

Saunders et al. (2007) is the fourth edition of a book on research methods in business and management. It presents a framework for making research philosophy, research approaches and research methods explicit: The Research Onion. The metaphor of the onion is used to help researchers at all levels to consider the need to start on the outer layer of the 'onion' and with care and reflection, peel away each layer of the onion in the process of research design, from the general research philosophy, all the way into the particular research method to be employed in a research project. Figure 2.3 shows the diagram for the research onion.

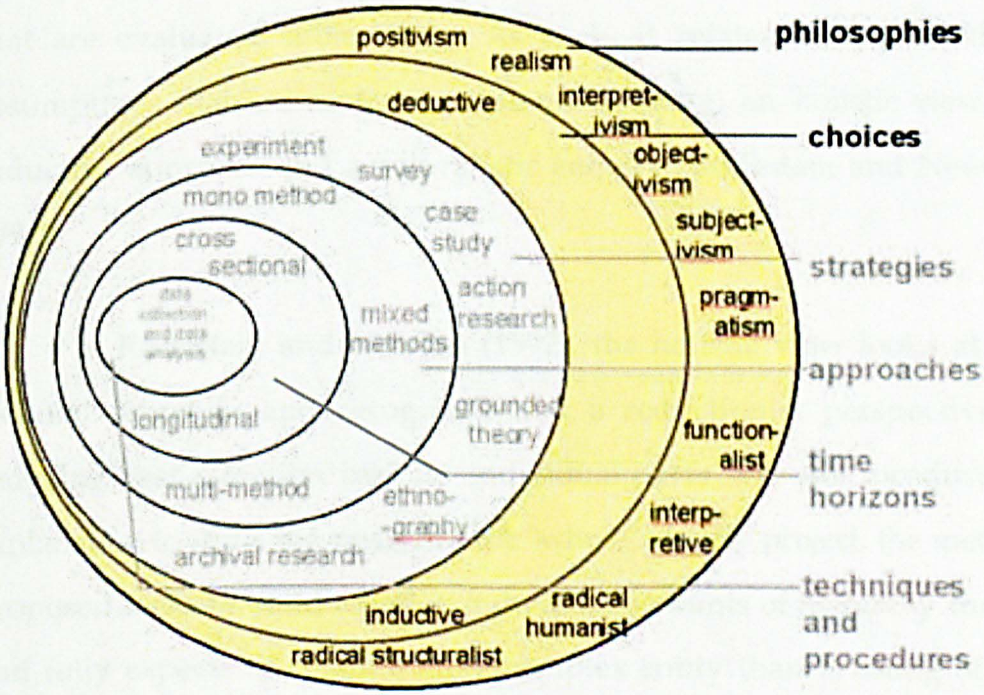



**Figure 2.3 The Research Onion (Saunders et al. 2007, p. 102)**

As with the previous framework, there are categories from which choices concerning the research design and implementation are made. These categories, philosophies, choices, strategies, approaches, time horizons and techniques and procedures, the layers of the 'onion', are closer to the research hierarchy suggested by Knox (2004) earlier and the onion shows the full range of research needs that Know believes should be addressed in a doctoral thesis. The categories in the research onion are more intuitive than those from Collis and Hussey although even in this framework, a mixing of paradigms and approaches can be questioned if a range of approaches is required within a research project.

### 2.1.4 Rudestam and Newton (1992)

Research may be quantitative or qualitative in content or a mix of these in certain situations. The focus in this project is qualitative in nature in that it pertains to information that investigates themes or categories that are evaluated subjectively. As such, it relates closely to three assumptions that are central in systems thinking: an holistic view, an inductive approach and a naturalistic enquiry (Rudestam and Newton, 1992).

In Rudestam and Newton (1992), the holistic view looks at the "whole" situation and recognises that a reductionist perspective of reducing that situation into its individual parts will not produce an explanation to equal the variety of the "whole". In this project, the method proposed seeks to build together individual accounts of hierarchy theory and fully expects to obtain a more-complex entity than a listing of the individual accounts of the theory would produce.

The inductive approach covers the move from investigating the individual to the discovery of the general patterns in a situation. In this project, the individual accounts of hierarchy gathered by the ID-ID questionnaires will be used to see whether there is a general pattern in the principles and practices of hierarchy theory. The contrast in deductive approaches would be to disintegrate the various accounts of hierarchy and hence miss these general patterns.

Naturalistic enquiry expects to observe situations or theories "in the wild". No pre-set conditions or controls are imposed on the study. In this project, the information to be gathered is not predetermined by this researcher; hierarchy theory's authors give their own accounts of the theory.

The task of self-reflection is necessary and vital, and requires an on-going self-examination and self-reflection of the biases, filters and paradigms brought to the study by the individual researcher, and by the physical and intellectual communities of which the researcher is a part recognising that the output of this thesis is only one of many explanations from the data gathered.

### 2.1.5 Summary of the Exploration through Research Frameworks

This section summarises and makes direct statements concerning the nature of the proposed research.

Using the Saunders et al. (2007) framework to explore the approach used in this thesis leads to a determination that this research is interpretive, subjective and inductive in its philosophical paradigm, research approach and logic. Using the framework of Burrell and Morgan (1979), this research lies within the interpretivist paradigm and the process of 'naturalistic' research as defined by Rudestam and Newton (1992). However, using Collis and Hussey (2003) it is more difficult to select a particular purpose and process. This will be discussed in more depth in the analysis and evaluation sections of this thesis, along with the difficulties of incommensurability in using an evaluation process derived from positivist science but underpinned by radical humanism (the critical review of methodologies in systems thinking and social theory) combined with investigating two disciplines (hierarchy theory and epidemiology) that are also incommensurable themselves in their philosophical stance.

In the work of Korpel (2005) specific ontological and epistemological statements can be made regarding a research study. Scott and Usher (1999) state that this process of exploring and making explicit underpinning beliefs is "what researchers 'silently think' about research" (p.10). Drawing on the framework from Korpel's work on business performance and eLearning, the following ontological and epistemological statements pertinent to this research can be made.

Ontological statements include:

- The system being studied in this thesis is complex as defined by the observer(s) of that system

- The observer(s) of the system have their own biases, influences, values and philosophical perspectives and these influence how the system is described, defined and interpreted and the choice of scale (detail) and therefore level of complexity the observation will be looked at

- Different observers of the complex situation will define the system in their own way, and this will be different from any other observer of the system

Epistemological statements pertinent to the realisation of validity in this research include:

- Data is gathered using a previous, rigorous, validated process of systematic review that has been modified to apply to research in systems thinking with the addition of critical systems thinking and practice

- Questionnaires will be incorporated from researchers working in hierarchy theory

- Texts and studies in systems thinking, hierarchy theory and epidemiology that have been peer reviewed will be used

- A process of critical reflection and 'sweeping in" of alternate opinions (Churchman, 1982) will be applied with the data gathered and the outcome of the analysis and evaluation.

Revealing further layers of the Saunders et al. (2007) 'onion', the research strategies proposed are case studies, ethnographies and archival (secondary) research. Some of these are described in chapter three, while the case studies are presented in chapter eight with the analysis of the three chosen international health policy statements on the management of emerging infectious diseases.

As stated above, the research approach will be inductive in approach and will be a mix of qualitative and quantitative research strategies as discussed in the section on Rudestam and Newton (1992).

Hence, the research approach will employ mixed methods and also be longitudinal in time scale (Saunders et al., 2007) in that the process of generating data will be done using several sampling points over a two-decade time period (the literature searches as well as the use of secondary questionnaire data from the ID-ID study) as reported in chapter three. The specific techniques and procedures for gathering and analysing the data are shown in chapter three within the presentation of the critical systematic review process.

## 2.2 Ethics

The research in this thesis has been conducted with reference and compliance with the Hull University Business School ethics procedures. These regulations and procedures can be found at http://www.hull.ac.uk/hubs/05/informationfor/media/Ethical%20Procedures%20for%20Research%20and%20Teaching.pdf

This research does not contain any research practices that would place any person in a position of personal risk, whether physical or psychological. None of the data gathered is confidential, or will cause personal harm to the authors of the material. The thesis cites all sources with due credit for the source of all material.

## 2.3 The Reliability and Validity of the Research Process

Validity and reliability of the research is addressed by employing several strategies for data collection (triangulation) and by designing a research process that is itself rigorous and formed and adapted from a previously validated model (systematic review), operationalised through the creation of the CSR process introduced later in this chapter and chapter three.

Applying rigorous scientific methods is the usual yardstick for measuring such success or failure of research questions. The application of deductive scientific process in social systems, and specifically in problem solving methodologies, is not feasible in that social systems do not stand still, cannot be held stable for the length of experimentation, and any received results are difficult to generalise even in very similar problem situations. It is still imperative to consider how to assess and validate research in the social sciences, and in particular for this thesis, a qualitative approach to the research issue.

To address these drawbacks in investigating social systems using systems sciences, one means of introducing rigour in systems science and its methodologies and models is to incorporate a process of critical systematic review and critique of the research process in order to provide a process of assessing reliability, validity and generalisability. While critique is necessary in any discipline for any evolving model or theory, it is especially appropriate in systems where feedback and the iterative processes involved in model development are core principles. Before moving through the proposed process of critical systematic review, a discussion of reliability, validity and generalisability is first presented.

## 2.4 Addressing Validity

Within the qualitative approach there are different methods of tackling validity. Empirical (technical) approaches are still used in qualitative research but there are also practical and emancipatory approaches that move away from the positivistic underpinnings of the empirical approaches. Some of the different methods for data gathering and analysis in these latter two areas of research are the phenomenological, hermeneutic, naturalistic, experiential and dialectical approaches.

In this project the method for gathering and analyzing the data includes the hermeneutic approach, "the interpretation of texts or transcribed meanings" (Polkinghorne, 1983).

"...in interpreting history and thought [the hermeneutic approach] denies both that there is a single objective true interpretation transcending all viewpoints and that we are forever confined within our own viewpoint. Interpretation is rather something to be arrived at by a gradual interplay between the subject-matter and the interpreter's initial position" (Lacey, 1986, p91).

In combination with hermeneutics, a dialectical approach will also be evident which is "literally, a method of conversation and debate" (Lacey, 1986). To these must be added an as-yet-undeveloped discussion of emancipatory (power) threats to validity not sufficiently addressed through the simple interplay and discussion process and arising from underlying power structures within these conversations (Wilby, 1994b).

The project will benefit from such conversations and the resulting consensus theory will be a result of the interplay between the individual participants creating a "whole" different and greater than its individual parts. This consensus will come from data taken from questionnaires with authors in hierarchy theory (Troncale, 1985) and the hermeneutic approach (which will be discussed in more depth later in this thesis) of interpreting their original writings (done in chapters 6 and 7) and the questionnaires (Troncale, 1985). Working alongside these approaches is the need to explore the emancipatory interest, which is linked to evaluative validity, and which is not yet defined in this project (Wilby, 1994b).

### 2.4.1 Types of Validity

Different authors describe types of validity using their own individual terms. Maxwell's scheme lists descriptive, interpretative, theoretical, generalisability and evaluative validity (Maxwell, 1992). More general schemes list reliability (internal, external, and construct) as the types of validity. Relating to these latter schemes for qualitative research Guba and Lincoln assign the terms 'audibility' for reliability, 'credibility' for internal, and 'fittingness' for external validity (Guba and Lincoln, 1981). Maxwell's theoretical validity covers the general terms of construct validity and internal (or causal) validity; reliability is discussed under descriptive validity; and generalisability covers external validity.

### 2.4.2 Preliminary Discussion of Validity Concerns

*Descriptive Validity*

With regard to descriptive validity, the questionnaires are reported without editing and are an actual representation of the information provided by the authors. The questionnaires are there as the required backup if concerns about agreement on content of the accounts should arise.

### *Interpretative Validity*

Interpretative validity is a more subjective enterprise involving the interpretation of those questionnaires and literature review for the meaning assigned to the data by the authors themselves. This is a detailed process and it is at this point that a discussion of the influences bearing on the researcher and the situation is required practice, and should include a discussion of the process of critical self-reflection and iterative critique utilised by the researcher.

One of the methods of gathering data about hierarchical approaches that is used in this thesis was the extraction of data from a set of questionnaires formulated and administered by Troncale (1985) at California State University, Pomona, CA. Through the iterative dialectical process of the questionnaires, the individual perspectives of the authors could be verified by those authors, and any disagreements with the interpretation of their meaning was addressed. In this way, even in processes of data gathering, there is still the implementation of critical self-reflection.

### *Theoretical Validity*

Theoretical validity is split into two areas and goes beyond the experiential into the explanatory and abstract areas of construct validity and internal validity. These relate to the validity of the concepts and categories applied to this project (the building blocks) and the nature of the relationships between those building blocks (Maxwell, 1982). The work still to be done here involves determining the appropriateness of the models for the development of the general theory.

It should also be noted that the validity does not reside in the methodology under review itself (in this case the functionalist and interpretive hierarchical approaches), or in whether there is a 'good enough' general hierarchy theory. It does however depend on the internal validity regarding the relationships constructed between the account and the general theory.

One method of ensuring theoretical validity is through the use of descriptive exemplars (the best and accepted-as-best examples in the field) as a valid method of proceeding (Mishler, 1990). By choosing core authors already known as having defined the concepts and principles of hierarchy theory, this requirement is addressed. Further, the use of the exemplar will be incorporated into the design of chapter 8 of this thesis, where the exemplar of the functionalist approach is decided to be the *Skeleton of Science* (Boulding, 1956). This exemplar is then used in chapter 8 for the implementation of a functionalist approach to hierarchical analysis.

#### *Generalisability Validity*

The discussion regarding the generalisability of this project and the proposed general hierarchy theory will happen in chapter seven. It is at this point that the utility of the general theory will be determined as to its usefulness in research and practice in systems thinking and intervention in complex systems.

*Evaluative Validity*

Evaluative validity is central in the discussion of whether or not this proposed general theory has a legitimate place within the requirements of critical systems thinking regarding its ethical and value perspectives and in the planned discussion of emancipatory interests. This evaluation will take place in chapters 9 and 10 of this thesis.

## 2.5 Critical Systematic Review

The method proposed for assessing the aims and objectives of determining reliability, validity and generalisability are woven into a process here called critical systematic review (CSR), introduced in this chapter and applied throughout the thesis from the proposal of the research question through to the analysis and presentation of the results of this research.

Systematic reviews are a recent development in the field of medical research, employing a more rigorous, and usually quantitative, approach to the meta-analysis of primary data (Chalmers and Altman, 1995; Egger et al., 2001). This process of review can be found in many areas of social sciences research including education, psychology, criminology, and sociology. In any area, a systematic review addresses the need for additional rigorous investigation where a collection of primary data and studies may offer different conclusions from the same type of intervention, thereby causing uncertainty in decision-making and possible allegations of biased analysis, interpretation and reporting of results.

"Systematic reviews identify, appraise and synthesise research evidence from individual studies and are therefore valuable sources of information. Systematic reviews differ from other types of review in that they follow a strict protocol to ensure that as much of the relevant research base as possible has been considered and that the original studies have been appraised and synthesized in a valid way. These methods minimize the risk of bias and are transparent, thus enabling replication". (CRD website, 2005)

Systematic reviews are beneficial for the following reasons (Mulrow, 1995):

- Large quantities of information can be reduced to manageable size for decision-making

- The information generated can help to define further research questions

- The process of review is efficient and can reduce the need for large new primary studies

- Reviews can offer a greater generalisability with the increase in data received from many rather than one similar study

- Reviews can address the consistency of relationships among studies with the same intervention

- Reviews can highlight inconsistencies in the data and between studies for further discussion

- Reviews offer a larger sample size and therefore additional sample power

- Following from an increase in sample size, the review can offer greater precision in estimates of effect

- Systematic reviews offer greater accuracy with the specific aim of reducing random and systematic errors.

As drawn from a publication overview of the process of systematic reviews (Davies and Crombie, 2001), systematic review involves several stages:

1. Defining the research question - this addresses four criteria of the participant (methodology) for the study; the intervention; the outcomes to be measured; and the intervention design (Davies and Crombie, 2001).

2. Searching the literature – one of the hallmarks of a systematic review is in how it differs from a traditional literature review. A systematic review, like a traditional literature review, also employs a search of the literature but it is always planned a priori to be an extensive, exhaustive, and strategically determined search pattern. The search strategy is documented, reviewed by peers, and involves not only published, database literature, but also unpublished 'grey' literature such as unpublished reports, contact with other researchers, incomplete studies and studies that may have been published in languages other than English (Davies and Crombie, 2001).

3. Assessing the studies – in a systematic review data are evaluated against inclusion and exclusion criteria to determine whether data should be included or excluded from the review. These criteria are again determined a priori in the protocol designed for that piece of research. Included studies are also assessed using validated quality criteria regarding study intervention and outcomes. All of these procedures are checked by at least one other reviewer and are sometimes entirely duplicated by the second reviewer depending on the resource constraints within the project (Davies and Crombie, 2001).

4. Combining the results – in a systematic review the included data are analysed in a form of meta-analysis that may be quantitative (statistical meta-analysis) or qualitative (narrative synthesis). This part of a systematic review most closely matches that of a traditional meta-analysis project (Davies and Crombie, 2001).

5. Placing the findings in context – the results of the review have to be discussed and evaluated as to the relevance of the results and whether the results are sensible in light of the possible impacts of heterogeneity, chance and bias introduced in the research process by the choices made by the reviewers (Davies and Crombie, 2001).

However, systematic reviews have some drawbacks in the way they are performed in that there may be errors introduced into the process by less skilled reviewers, inappropriate judgements as to the way of selecting and analysing collected studies may be made, and the results of a review may differ in outcomes from other reliable evidence. (Davies and Crombie, 2001).

In addition to this critique however, from a critical systems perspective by Jackson et al. (2004), the practical considerations of intervention also involve the issues of:

1) understanding the problem context by the researcher(s) and others and the role the researcher and the contributors to an investigation have in defining and interpreting situations;

2) the need to employ differing methodologies in one investigation and the skills of the researchers and contributors in doing so; and

3) the reflection needed when an the investigation either succeeds or fails and how that affects the current research and future research.

All of these issues are not addressed in an explicit fashion by the process of systematic review. A systematic review is assumed to be less biased due to the rigor in which it is performed. In that process it is not seen to require reflective practice beyond the placing of the findings managed in the discussion section of the review. Bias may be minimized by the quality of the review process and the manipulation and elimination of bias through additional statistical analysis. For these reasons, these issues require additional attention for the development of a more critically systematic review process.

In the diagram below, literature review and meta-analysis are part of the process of systematic review. They can however also stand alone in many other forms of research so therefore only overlap the systematic review process. The drawbacks of the systematic review, also listed earlier, focus on the systematic review standing alone without reference to the research context and the environment and influences surrounding the research. To address such drawbacks, critical systems thinking and practice (CST and CSP) is one way of adding evaluation and reflection to the theoretical rigor of systematic review.

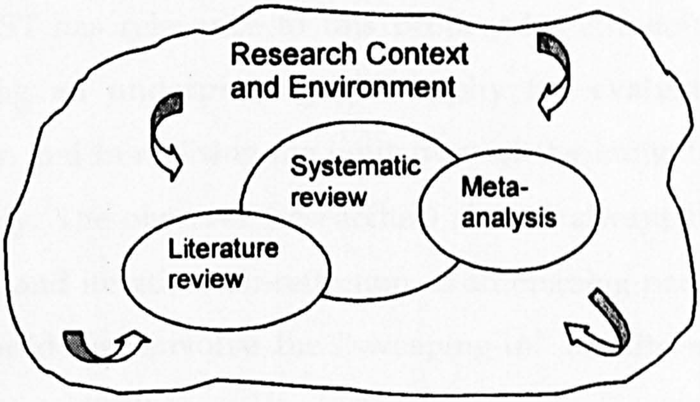



**Figure 2.4 The Systematic Review Process**

## 2.6 The Framework For Critical Systems Review

One means of providing that evaluation is through a combination of systematic review with the methodology of critical systems thinking (CST) (Flood and Jackson, 1991a) and critical systems practice (Jackson, 2003). CST/P is an evaluation and questioning of the technical (hard systems), practical (soft systems), and empowerment interests in the method or model of interest. This use, of a critique of one model from within the standpoint of another methodology, is an important implementation of CST/P.

When first introduced into systems thinking, CST had three commitments: critical awareness, emancipation, and complementarism. In another iteration, these commitments have been addressed and described as critical reflection (rather than critical awareness); pluralism (rather than complementarism); and improvement (rather than emancipation)" (Flood 1995a,b,c). In CST/P currently, the work focuses on critical awareness, pluralism and improvement (Jackson, 2003) and on providing a more flexible method of critical practice.

CST has relevance to this proposed methodology in terms of providing an underpinning philosophy for evaluation and critical reflection and in realising the limitations of the individual researcher in any study. The observer (researcher) should always be engaged in a constant and iterative self-reflection as an ongoing part of any analysis. This would also involve the "sweeping-in" of alternate perspectives (Churchman, 1982).

The need to explore "the relationship between a methodology, the types of problems it was designed to address, and its value its use added to the decision making process" (Jackson et al., 2004) is the basis for the development of CST/P. It is also the reason for utilizing CST/P to enrich the practice of systematic review and counter the drawbacks inherent in the process of systematic review that were enumerated earlier in this chapter.

## 2.7 Summary

This chapter has explored several frameworks for describing the research process, helping to explore and make explicit the research philosophy, principles and method underpinning this thesis. The introduction of the CSR process, used to increase the rigour, and hence, the reliability, validity and generalisability of this research is the content of chapter 3, showing the implementation of this process for this thesis.

# Chapter 3

# Implementing Critical Systematic Review

## 3.0 Introduction

In this chapter the first steps of the CSR methodology of stating the research question, and the rationale, aims and objectives of this research project will be implemented and discussed. The second section of this chapter presents an overview of all of the steps of the CSR with an explanation of the methods used to search for and gather data, along with the results of the data gathered by these methods. These methods include a sorting of the data that will be used in extracting the core data about hierarchical approaches used in the field of systems thinking that are summarised in a set of three models (Model 1, 2 and 3).

The remaining sections list the remaining parts of the CSR process that will be used in later chapters of this thesis: chapter 6 and 7 for presentation of the data on hierarchy; chapter 8 and 9 for the implementation of this data with the issues proposed by emerging infectious disease; chapter 9 for the evaluation of this implementation using the critical review mode; and chapter 10 for the placing in context and summary of the work in this thesis.

As stated in chapter two, the need to present a reasoned validation for the quality and reliability of a research project must be addressed in that research and it is to meet this need that the process of critical systematic review, incorporating the tenets of critical systems thinking, has been developed and will be implemented throughout the work in this thesis. The five stages of implementing a systematic review were presented in detail in section 2.5: 1) defining the research question; performing data searches and literature review; 3) assessing the studies for inclusion/exclusion and quality; combining the results; and placing the findings in context. 1) 3.1 Defining the Research Question

The research question must ask a clear, concise question that can be addressed and researched within the constraints of the resources available for this study. The research question gives this research project its underpinning structure, boundary and focus. It cannot be too narrow or too broad, and the results of the research, at the doctoral level, must provide a contribution to knowledge.

"The importance [of defining the research question] cannot be overemphasised. One of the key criteria of your research success will be whether you have a set of clear conclusions drawn from the data you have collected. The extent to which you can do that will be determined largely by the clarity with which you have posed your initial research questions." (Saunders et al., 2003, p.23).

"The critical issue in any systematic review is to ask the right question. In this context, the right question is usually one that:

- Is meaningful and important to practitioners as well as researchers. ...
- Will lead either to changes in current ... practice or to increased confidence in the value of current practice. For example,

researchers and practitioners ...(might both like to know the benefits and drawbacks such changes might hold] ... and,

- Identify discrepancies between commonly held beliefs and reality.

Nonetheless, there are systematic reviews that ask questions that are primarily of interest to researchers. Such reviews ask questions that identify and/or scope future research activities. For example, a systematic review in a PhD thesis should identify the existing basis for the research student's work and make it clear where the proposed research fits into the current body of knowledge." (Kitchenham, 2004, p.5)

In a systematic review, as defined earlier in chapter 2, this process involves the inclusion of four criteria relevant to the development of the research question: the participant (methodology) for the study; the intervention; the outcomes to be measured; and the intervention design (Davies and Crombie, 2001). These criteria will be adapted to construct the research questions in this thesis.

Questioning the process of knowledge-gathering and examining rigorously the perceptions of theorists and those who carry the theory into practice is done through a process of validating the inputs and outcomes of the research. Validation attempts to provide others with work that is transparent in terms of the theory, methods and analysis utilised in an intervention or theoretical thesis, that gives an account of the influences bearing on the researcher and the situation, and a discussion of the process of critical self-reflection and iterative critique entered into by the researcher and his or her audience.

This thesis will also add to the discipline of epidemiology through its combining with the insights possible from a useable hierarchy theory. Epidemiology has many similarities with systems thinking in its history and development as a field of study. As in systems thinking, areas or strands of epidemiology tended initially towards measurement. This coincided with the general influences of that period in history (early 20th century). This was followed (in the mid 20th century) by the development of modern or molecular epidemiology, which is strongly influenced, as was systems thinking, by measurement, validity, and repeatability of the scientific paradigm. In parallel with developments in systems thinking, eco-epidemiology is now emerging as a means of looking for expanations of social, subjective influences in the management of healthcare and disease (Waltner-Toews, 1999; Krieger, 1994, 2001).

In developing the research question for this research, the aims of the research and the rationale underpinning the choice of research question is presented first, followed by the research question itself, and then by the objectives that will be utilised in achieving the aims of the research.

### 3.1.1 Aims of the research

The following section presents the detail for the aims for this thesis, previously stated in chapter 1. The first aim is to focus on twinning the perspectives of epidemiology and hierarchy theory for the purpose of improvement in public health policy-making and, specifically, the study and control of emerging infectious disease (EID).

A second aim is to develop hierarchy theory and use hierarchical frameworks from this body of work to aid in the explanation for complex natural phenomena. It may also be possible to transfer such powers of explanation into the realm of social systems. It is to this end that the present study is undertaken using an analysis of international guidance in public health policy-making.

The final aim is to maintain a critical and self-reflective position throughout the process of this research, so as to evaluate and validate the presentation of the conclusions for the inclusion of hierarchy theory in concert with epidemiology. This will be further explained in the objectives section of this chapter detailing the process of critical systematic review used in this thesis.

This critical position will address:

- the process of critiquing the research methodology underpinning this thesis,

- the process of critiquing the person doing the research methodology in this thesis, and

- the process of critiquing the defining of the boundaries of the research methodology in this thesis.

The process of critique is very important to fulfil the need to evaluate the strengths and weaknesses of the approaches used in this thesis. Critical thinking "...involves calling into question the assumptions underlying our customary, habitual ways of thinking and acting and then being ready to think and act differently on the basis of this critical questioning" (Brookfield, 1987, p1). In systems thinking, it is important that the practitioner should examine and reflect on the preconceptions, biases, filters and choice of scale chosen for the study and/or the intervention. This concept will guide the process of critical appraisal, evaluation and reflection in this work.

In this way the process of critique and reflection is truly a part of the process -- it is the underpinning of the thesis; and no longer simply a framework for the objective critique of hierarchy theory. The thesis is a recursive process for the development of hierarchy theory and of the process of critical review in turn.

In the process of this thesis the anticipated output will determine whether or not hierarchy theory is a useful and valid systems approach for: (1) the analysis of complexity in situations, (2) the planning of interventions in those situations, and (3) the design of future systems for those situations.

This thesis will also gather a significant database of hierarchical principles and practice for synthesis into a body of knowledge. The primary outcomes, and significance of this project, will be: 1) the construction of a hierarchy methodology and the framework for a means of incorporating that methodology with epidemiological processes; and, 2) a possible generic approach to combining such disciplines in future research.

### 3.1.2 Rationale for the Research

A suitable topic for a research review is one that is already well-known in the area of interest, usually already having several publications on the topic and still able to hold the interest of researchers due to its depth and the need to fully explore the topic (Cooper, 1984) Hierarchy theory is one such topic of interest within systems and the study of EID is another such topic in the field of public health.

Hierarchy theory is found in such diverse fields of study as ecology, business, philosophy, mathematics and physics and much knowledge has been accumulated from these individual efforts. Despite this, there is no single definition of the principles and practices of hierarchy theory and there has also been little work done on defining the linkages and possible utilities of applying hierarchy theory in concert with other methodologies (Troncale, 1978a).

The aim of this research project is to provide an overview of hierarchy principles and evaluate its utility for use in combination with other disciplines. Within this project however, the combination will be with the public health study approach called epidemiology.

### 3.1.3 The Research Question

This thesis has already proposed that the study of emerging infectious disease is a complex research issue, requiring the use of several disciplines for its adequate description and modelling, and that this is not occurring in the practice of modern epidemiology. This thesis therefore asks the following two research questions:

- Would a more holistic systems approach to the study and control of emerging infectious disease, combining systems thinking, and the systems approach of hierarchy theory, with methods and data from epidemiology, provide an enriched description for the modelling, planning, intervention, and response to EID, and in particular, a case of international guidance in public health policy-making?

- Would this improve the understanding of the process of public health policy-making and intervention in EID for those involved in managing these issues?

Underpinning these research questions is the rationale that the public health issue of EID outbreaks and their control is a complex system that cuts across many boundaries and disciplines. Hierarchy theory and systems thinking focus on analysing such complex systems. Hence, hierarchy theory, in combination with epidemiological methods, could be an effective tool for better understanding the complexity of the public health issue of EID.

### 3.1.4 The Research Objectives

Research is "a critical and exhaustive investigation or experimentation having as its aim the revision of accepted conclusions, in the light of newly discovered facts." (Dubin, 1978, p17). This thesis proposes that current policy statements for the control of emerging infectious disease could be more comprehensive. A qualitative focus is used, along with the subjective critique that such a focus must face. As such, it relates closely to three assumptions that are central in systems thinking: an holistic view, an inductive approach, and naturalistic enquiry (Rudestam and Newton, 1992).

The holistic view looks at the "whole" situation and recognises that a reductionist perspective of reducing that situation into its individual parts will not produce an explanation to equal the variety of the "whole". This project seeks to view both the parts and the interrelationships in emerging infectious disease to show that a holistic multi-disciplinary systems approach should be used in researching and policy making for emerging infectious disease.

The process in this thesis will follow both an inductive and deductive approach in different parts of the research methodologies.

A deductive approach disintegrates the parts of the system, studying separate groups of factors in isolation. While it is possible that emergent information would be missed e.g. studying hydrogen and oxygen separately and missing the interaction that produces the emergent property of $H_2O$ (Phillips, 1976), these more detailed methods of data gathering, of being systematic, are of use in generating the data to be used later in the thesis and can work in concert with an inductive mode of operation.

The inductive approach covers the move from investigating the individual to the discovery of the general patterns in a situation and works well for analysing both systems and epidemiological data. The objectives of this thesis used to fulfil the earlier stated aims of this work are as follows:

- To present a process for critical systematic review for review of systems thinking, hierarchy theory and epidemiology in concert in this thesis;

- The compilation of a comprehensive literature review of published work on hierarchy theory and those areas of epidemiology relevant to this study;

- To review the hierarchy literature using a functionalist and interpretivist analytical approach, so as to construct a narrative comprehensive review of each of these perspectives for the purpose of comparing and contrasting the outcomes of this process in a practical exploration of EID.

- To critically review the functionalist and interpretive hierarchy approaches and their use in this thesis; and further

- To critically evaluate and reflect on the usefulness of combining functionalist and interpretive approaches with methods and data from epidemiology to answer the questions as to whether or not this combined approach is relevant and valid in: (1) the analysis of EID as a complex situation, and (2) the generalisability of this work to other areas in the management of complex systems; and

- To propose recommendations for the improvement of policy-making in EID, and suggest future research in hierarchy theory.

## 3.2 Literature Searching

### 3.2.1 Database searching

Following the guidance of extensive literature searches as proposed by a systematic review process, the following searches were undertaken for this thesis. The literature search for hierarchy was carried out on several occasions at the Universities of Hull and York (using BIDS and the library catalogue.) The results of these searches are reported in Appendix 1 of this thesis along with an explanation of the process of doing the searches.

The BIDS system used at the time of the search dates listed was a product of the Institute for Scientific Information Inc, USA. It has since been replaced by searching on the ISI Web of Science database. BIDS searched three multi-disciplinary Citation Indices (Science Citation Index (SCI), Social Science Citation Index (SSCI), and Arts and Humanities Citation Index (A&HCI)) and the Index to Scientific and Technical Proceedings (ISTP). The first three indices contained details of articles from over 7000 national and international journals, and the latter index contained details of papers presented at over 4000 conferences yearly.

A second type of search is designed to show the number of abstracts obtained from CD-ROM searches and the keywords or author names used in the searching. These searches were also done using the computer-search reference materials through the Brynmor Jones library at the University of Hull. The abstracts found will be cross-checked against the listings obtained in the BIDS search for any overlap.

The results from searches in hierarchy will be incorporated into the literature review of hierarchical approaches in chapters 5, 6 and 7, and used in the construction and analysis of hierarchy theory in practice in chapters 8 and 9. The results from the epidemiology searches, made in 1998, will be covered in the review of the epidemiology literature, discussed in detail in chapter 4.

### 3.2.2 The ID-ID Questionnaires

Data has also been entered from the existing questionnaire results gathered in the ID-ID study managed by Professor L. R. Troncale at California State University, Pomona, USA. The data from that research was gathered from two iterations of the ID-ID questionnaire replied to by 30 hierarchy researchers. The ID-ID questioned those authors regarding their understanding of the principles of the theory and their definition of those principles. The second iteration of the questionnaire asked additional questions based on the information and comments gathered in the first, using only those authors who had replied to the first questionnaire. The ID-ID questionnaire is shown in Appendix 2. This interview data was obtained to triangulate the published data on hierarchy extracted from books and journals. Individual answers from these questionnaires are incorporated and discussed throughout the remainder of this thesis in the literature reviews and the implementation chapters.

### 3.2.3 Visits to Other Research Centres

A visit to the Centers for Disease Control (CDC) in Atlanta was made to gather information on emerging viruses and to research the focus of the CDC in addressing those issues. The web sites of various organisations were also accessed for policy statements and information on emerging infectious disease. These documents are enclosed as appendices to this thesis.

### 3.2.4 Notes about the Gathered Material

The work of major authors in hierarchy theory will also be discussed in chapters 5, 6 and 7, and some of these sources may overlap with information gathered in the computer-generated searches. Books will be included in this part of the review along with some overlapping articles from the previous stage of the literature review. Major authors in hierarchy have been defined as those with either published books or a series of articles on the theory over a several-year time span.

Following the literature review, an exploratory lateral search will also be made of the bibliographies that are part of the literature already listed, as a final check for any additional material relevant to this study.

The work of each major hierarchy author will be investigated using the third model described in this chapter. This will be combined with an analysis of each author's work as to the material's philosophy, principles, practice and process. This analysis will follow the process of 1) **categorisation** of the information generated through the literature review, 2) **comparison** of that information between possible different forms of hierarchy, 3) **evaluation** of that comparison, and 4) **critical appraisal** of the performance of the first three steps of the analysis. The results of this investigation will contribute to the application of hierarchy, which will then be applied to a case study of current policymaking concerning the control and prevention of emerging infectious disease.

## 3.3 Assessing the Studies

### 3.3.1 Description of the Models

In a systematic review data are evaluated against inclusion and exclusion criteria to determine whether data should be included or excluded from the review. These criteria are again determined a priori in the protocol designed for that piece of research. Included studies are also assessed using validated quality criteria regarding study intervention and outcomes. In a systematic review, these procedures are checked by at least one other reviewer and are sometimes entirely duplicated by the second reviewer depending on the resource constraints within the project (Davies and Crombie, 2001). In this thesis, authors in hierarchy theory have reviewed this material to assess the completeness of the search from their positions as experts in this domain.

### 3.3.2 Inclusion and Exclusion Criteria

Inclusion and exclusion criteria to be applied to the found literature have been built into Model 2 and are described as follows:

- Does the material cover hierarchy as generally known within the field of systems thinking? If yes, the material will go on to the next step; if no, the material will be excluded and summarised only as a tally.

- Does the material present hierarchy theory or an application of the theory? The sorting results will be as in the previous criteria.

Theoretical discussions will be kept in a separate database, and will be sorted into core, level one, or level two authors. Core authors are those who have written extensively or had their work referenced extensively by other researchers. The principles from these authors will be taken for the work of chapters 5 and 6.

Levels one and two authors will be summarised for possible future work; level one in more detail than level two. Levels one and two authors may be further analysed in future work.

Applications of hierarchy theory will be kept in another database from which examples of the theory will be drawn as needed in the analysis and evaluation.

The three models in this chapter act as filters of information. They are constructed, in this case, by one researcher and cannot be thought of as neutral. There is bias in the choice of information used in the construction of the models, and in the choice of inclusion and exclusion criteria. These biases will be addressed by having the models, along with the rest of the analysis, subjected to external peer review.

The models begin with a database of gathered materials, the contents of which have been previously published in conference proceedings (Wilby, 1993) and recently updated through additional searches. In implementing a longitudinal design for this research, and also following common practice in systematic reviews, database searches for additional literature and other materials have been undertaken on an on-going basis throughout the research process. Update of each of these searches is given later in this section.

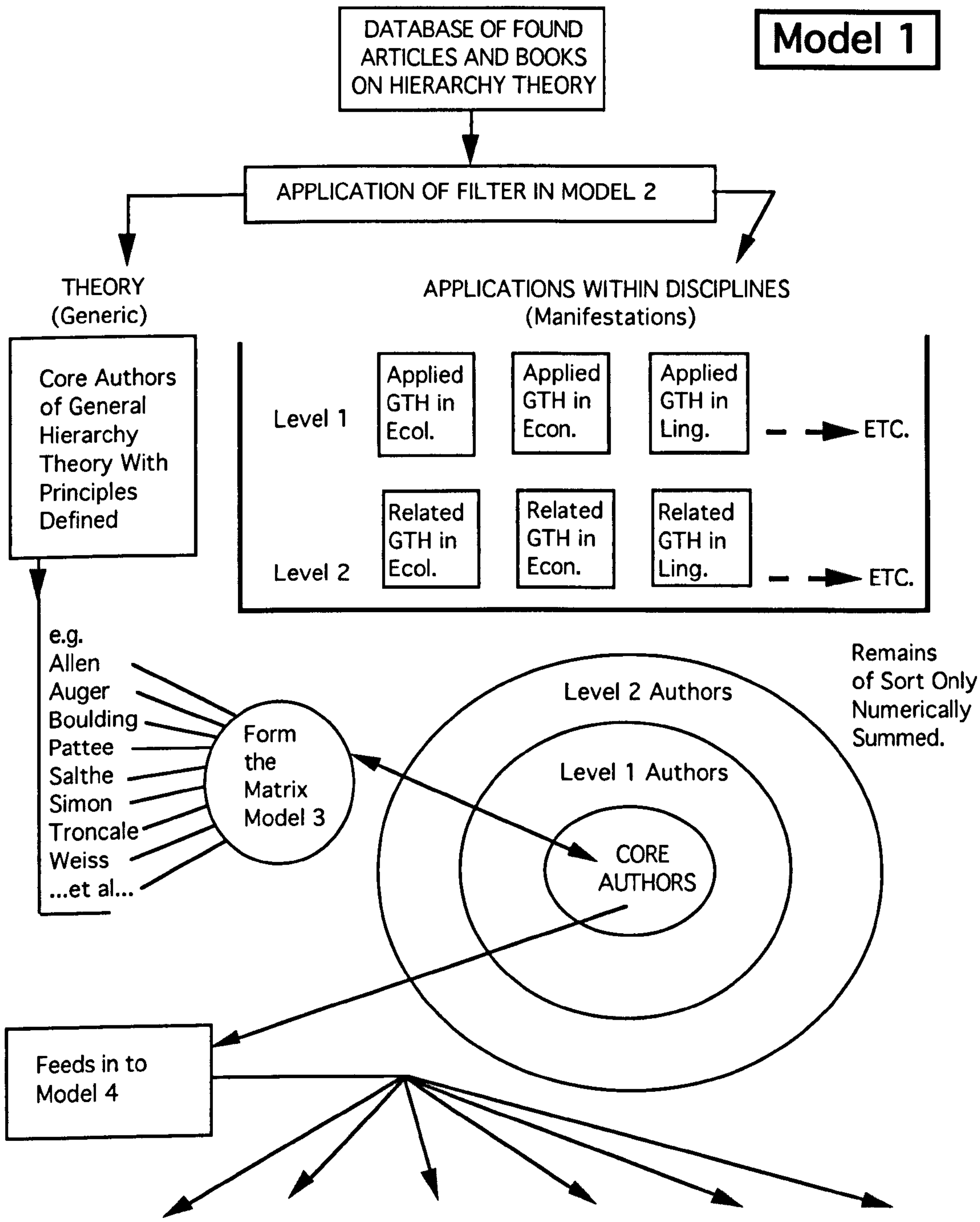
The first model is an overview of the whole sorting process (Model 1, figure 3.1). The database will be processed through the selection criteria model (Model 2, figure 3.2). The selection achieved from Model 2 will provide a core list of theoretical authors within hierarchy theory, and some of these authors may already be listed in the overview model. Further, in Model 2, it is possible that an author could be sorted into both theory and application and their work stored and drawn on accordingly in the thesis. The other 'sorting bins' from Model 2 will produce level 1 and 2 authors who employ hierarchy literature and principles in some manner. Level 1 authors are central researchers of hierarchy theory and Level 2 make only peripheral mention to the theory. The remaining bin will be a numerical note of the remainder of the database that does not truly relate to hierarchy theory.

The core authors will be the basis for the core principles matrix (Model 3, figure 3.3) that aims to build a matrix of the philosophy, principles, and practice of hierarchy theory. A part of the future analysis of the work of each of the core authors (chapters 5 and 6) will be the study of the relationships between the authors' accounts and this researcher's accounts of the authors' work. These relationships are one of the outcomes that will be critiqued and validated in the evaluation chapter.

The first relationship concerns the individual author's version of hierarchy theory that is obtained from selecting and listing the hierarchy literature. The second relationship covers the interpretation of each individual account combined with the data taken from the ID-ID questionnaire (Troncale, 1985). This data will be laid out in the core principles matrix (Model 3) in chapter 6. The third relationship consists of a summary of all of the individual accounts into a proposed theory for hierarchy (chapter 7).

The fourth relationship concerns the validation of the core principles matrix information about the proposed general theory through external peer review of this researcher's analysis (an on-going process throughout the writing of this thesis). The final, fifth, level of validation concerns the critique of the general theory in light of the comments and discussion of external comments on this work and critical reflection on the part of this researcher (chapters 9 and 10).

The next four pages contain the three models created to classify the literature, followed by a description of the models and a preliminary discussion of their validity concerns and any threats to validity arising from the creation and use of these models.




CORE AUTHORS are intensively detailed and feed into the MATRIX and questionnaire process, LEVEL 1 Authors are given detailed summaries (analysed for essence of work and where work has been done). LEVEL 2 Authors are given scant summaries (listed and counted, for breadth of research), and all of the remaining articles are counted and reported only in statistical format.

**Figure 3.1 Model 1 - Overview of Process**

Model 2

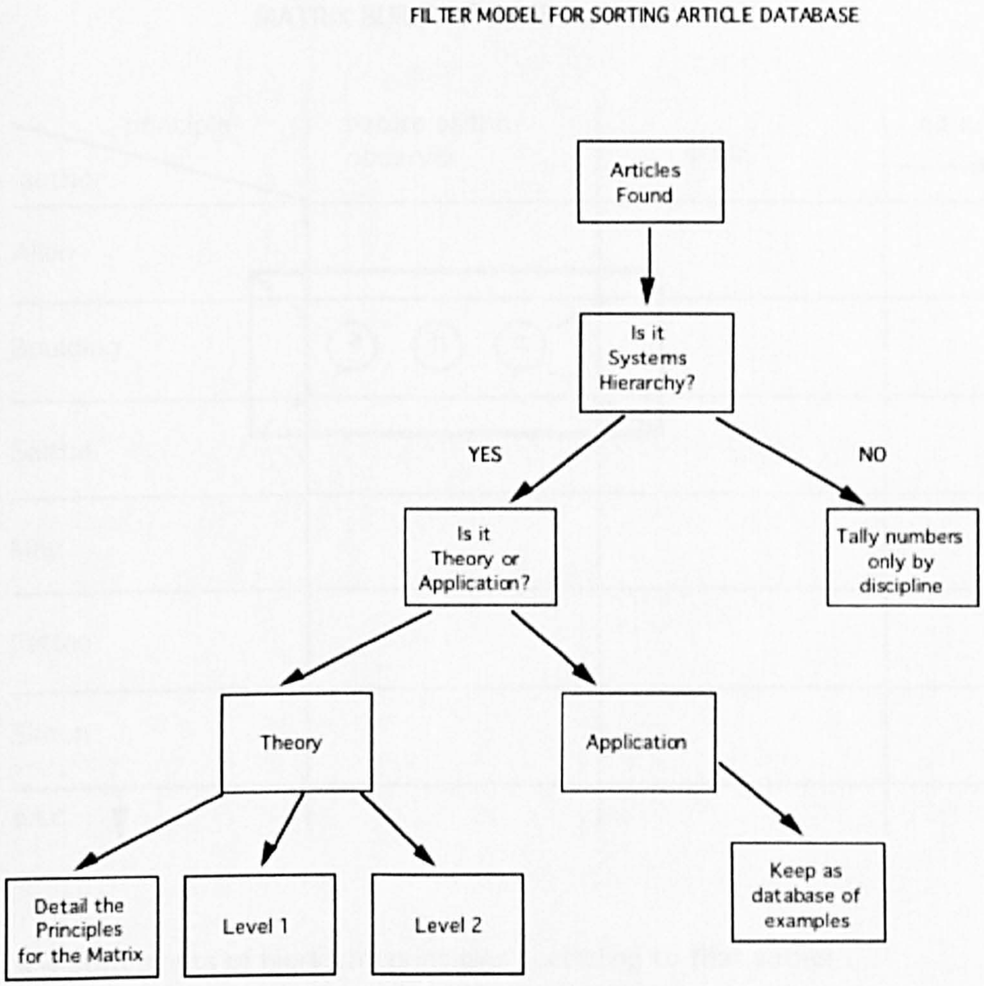
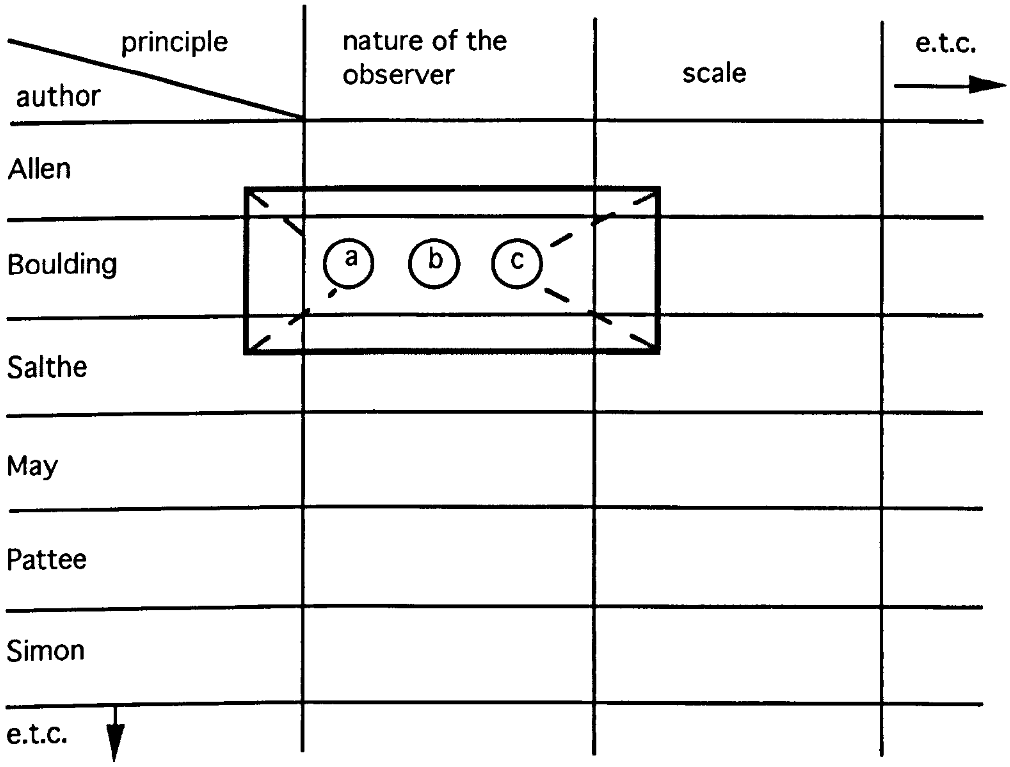



**Figure 3.2 Model 2 - The Selection Process**

**Model 3**

MATRIX BUILT OF CORE AUTHORS




a = statements of hierarchy principles according to that author
b = the author's conjectures/hypotheses (testable)
c = possible linkage propositions (action-oriented
outward into other areas of systems science.)

Each box in the above matrix contains a, b, and c for every author and that author's position on the principles of hierarchy theory.

a + b + c sum to a position on that principle by that author that can also point to linkages to other principles and theories in systems theory and practice.

**Figure 3.3 Model 3 - The Core Principles Matrix**

### 3.2.3 Additional Sources

As mentioned earlier in this chapter, data has also been received from the existing questionnaire results gathered in the ID-ID study managed by Dr. L. R. Troncale of California State University, Pomona, USA. The data from that research came from two iterations of the ID-ID questionnaire gathered from 30 hierarchy researchers. The ID-ID questioned authors regarding their understanding of the principles of the theory and their definition of those principles. The second iteration of the questionnaire asked additional questions based on the information and comments gathered in the first, using only those authors who had replied to the first questionnaire. The questionnaire is shown in Appendix 2.

The work of major authors was the next source for data. Books have been included in this part of the review along with some overlapping articles from the previous stage of the literature review. Major authors in hierarchy have been defined as those with either published books or a series of articles on the theory over a several-year time-span.

An exploratory search was also made of the bibliographies that are part of the literature already listed, as a final check for any additional literature relevant to this study. The results of the literature reviews have been given in a previous section of this chapter.

## 3.4 Combining the Results

In a systematic review the included data are analysed in a form of meta-analysis that may be quantitative (statistical meta-analysis) or qualitative (narrative synthesis) (Davies and Crombie, 2001). This part of a systematic review most closely matches that of a traditional meta-analysis project and is conducted as a narrative (qualitative) synthesis of the data.

### 3.4.1 Data Extraction Categories

There are two levels of data extraction to be performed. The first level will apply to the questions in the list of inclusion and exclusion criterion from section 3.3.2. This will provide the initial sort into three groupings:

- The tally of non-systems hierarchy. It would be interesting to sub-group the tally of this data into disciplines, but this would be beyond the scope of the present project.
- The grouping of application examples, and
- The grouping of theoretical material, subdivided into:
    - Core authors
    - Level one authors, in some detail
    - Level-two authors, briefly summarised.

The main data extraction will begin with the core authors of the theory group. The data extracted will cover:

- Name and contact details for author
- Where the information is found

- Field of research (e.g., biology, ecology, philosophy, management, etc)

- The principles of hierarchy covered by their theory, which will be entered into model 3 (e.g., role of the observer, parts, wholes, constraint, containment, scale, resolution, boundaries, etc.)

- The philosophy underpinning that author's approach to hierarchy (e.g. functionalist, interpretivist (Burrell and Morgan, 1979))

- Examples of practice of their theory if any, and

- Comments regarding the use of hierarchy by that author.

The data extracted will be presented and summarised using the framework shown in model 3. This data will then be used to construct the hierarchy theory to be applied to the case study in this thesis.

Again, bias may be introduced in the choice of data extracted and this will also be addressed by having these results checked by external peer review and further validated through the process of examination of this thesis.

### 3.4.2 The Hierarchy Narratives

Chapters 6 and 7 will develop a narrative of the principles of hierarchy using input derived from the literature reviewed for this project and the ID-ID questionnaire data.

## 3.5 Placing the Findings in Context

The results of the review have to be discussed and evaluated as to the relevance of the results and whether the results are sensible in light of the possible impacts of heterogeneity, chance and bias introduced in the research process by the choices made by the reviewers (Davies and Crombie, 2001).

### 3.5.1 Analysis and Evaluation

The hierarchy theory developed in this thesis will be applied to case studies. The case studies will be drawn from policy documents of international-level public health organisation concerned with the issues of EID. Hierarchy in practice and the process of the thesis in general will be evaluated and critiqued using the frameworks and practices developed by critical systems thinking and other systemic evaluation methods. The thesis will conclude with recommendations and conclusions about the project.

### 3.5.2 Validation

The process of gathering knowledge must be examined on an on-going basis so as to strive for a more complete understanding of the complexity that systems thinking seeks to explain and manage. The validation in this thesis attempts to provide others with work that is transparent in terms of the theory, methods and analysis utilised in an intervention or theoretical thesis, that gives an account of the influences bearing on the researcher and the situation, and a discussion of the process of critical self-reflection and iterative critique entered into by the researcher and his or her audience.

## 3.6 Summary

This chapter has covered the design of the research methodology used in this thesis and specifically presented the processes implemented in the collection, analysis, and synthesis of the data generated by this project. This chapter has also presented the models whose outputs were used to sort the database searches. This produced a list of authors whose work will be described and analysed in the following chapters with the objective of building a narrative description of the core principles and practice for hierarchical analyses from both the functionalist and the interpretive stance. The aim of this thesis is not only to review the application of hierarchy to an analysis of international guidance in public health policy-making, but also to deepen the existing narrative about hierarchy theory and epidemiology. To further this aim, of also contributing to knowledge through a richer form of literature review for each of these fields, the next chapter discusses the discipline of epidemiology and why it is relevant for this thesis. In chapter 5, there is a similar review of the historical development of 'hierarchy' in the literature. The thesis is thereby balanced in three main divisions: that of introduction and methods (1-3); traditional, followed by in-depth narrative reviews (4-7); and exploration of the narrative in an analysis of international guidance in public health policy-making and the implications and recommendations from that exploration (8-10).

# Chapter 4

## Epidemiology Literature Review

"A new epidemic, caused by an emerging virus, is potentially more threatening because it does not lie within the remit of human control." (Ryan, 1996, p127)

"When is a virus new?
When it matters."
Joshua Lederberg
(Miller, 1989, p510)

## 4.0 Introduction

In chapter one, epidemiology was introduced along with the concept that its epistemological development closely mirrors that of systems thinking. In the same way as the history of systems thinking, epidemiology also began with exploration of both natural and social phenomena and made no division between either, the theory and practice of such explorations, or any subdivision into specialisations in those explorations, i.e. it began with a holistic approach in both domains. This changed for both systems and epidemiology into a focus on the domain of the natural sciences, using positivist approaches at the time of the Scientific Revolution of the 1600s. Recently both have moved towards the incorporation of human, social issues in the 1970s, and each are now beginning to address influences that require a return to a more comprehensive, reflective, holistic approach.

Chapter one stated that there are four phases of epidemiology defined and used in this thesis, named by Susser and Susser (1996) as: sanitary statistics (miasma); infectious diseases (germ theory); chronic diseases (black box/risk-factor analysis); and eco-epidemiology (the emerging variation, also called Chinese box epidemiology). The first two variations are combined in this thesis into what is termed 'traditional' epidemiology. The third phase in the development of this field is called 'modern' epidemiology. The final stage of its development calls for a return to the traditional variations supplemented by the scientific and statistical advances made possible by modern epidemiology.

The first two phases mentioned above, traditional and modern, will be summarised for historical context in this chapter. Some of the methods for surfacing the influences at work in the EID system will be drawn from traditional and modern epidemiological methods, but the use of ideas and concepts from eco-epidemiology will be drawn in and reflected upon in the evaluation of the thesis and its contribution to both approaches in systems thinking and epidemiology. However, this chapter will show that although the discipline of epidemiology has many tools and methods at its disposal, it is lacking in its ability to competently address the full range of influences at work in international health issues such as EID.

Loomis and Wing (1990) state that the basic challenge for today's epidemiologists is that we have to look for patterns that reflect the interplay between social and biological influences. They also believe that this requires a change in the dominant paradigm (modern epidemiology). Expanding epidemiology into this area of interplay, into the interrelationships between all of the issues, is a valid and appropriate direction, and one that is necessary in order to understand the complexity of natural and social systems (McMichael, 1995; Susser and Susser, 1996). As stated in the previous chapter, hierarchy theory focuses on analysing the relationships and inter-relationships of complex systems. Hence it appears feasible to combine hierarchy with epidemiological methods to create a more comprehensive approach in dealing with the complexity of EID.

Before turning back to the creation of this new approach however, this chapter will first review three areas of epidemiology to give a fuller understanding of this subject. The three areas covered are: 1) the history of the discipline of epidemiology; 2), the scope of emerging infectious disease (EID); and 3) policy documents at the international level in the prevention and control of EID. These policies are given in summary form here but will be presented in more detail in later chapters that discuss the case study implementation and analyses.

## 4.1 The Development of Epidemiology

Epidemiology is rooted in and "evolved from the Scientific Revolution of the 1600s, which suggested an ordering of nature explicable in mathematical relationships" (Lillienfeld et al, 1994). The basis that still underpins epidemiology, even in the face of debate about the discipline's history, boundaries and purposes, is the philosophy of pragmatism, which Savitz proposes is "the attempt to extend knowledge in ways that will be beneficial to public health" (Savitz, 1997, p1). It should be noted that the discipline of epidemiology is applicable to a much wider field of research topics than that covered in this thesis, and it consists of many different historical and methodological strands. This thesis focuses on only one area of research in epidemiology: that of the investigation and control of emerging and re-emerging infectious diseases. As mentioned in chapter 1, there are four strands of epidemiology defined and used in this thesis and these can be further merged into the three strands of traditional, modern and eco-epidemiology.

### 4.1.1 Traditional Epidemiology

Beginning in the 1800s in England, concerted efforts were made by people such as Louis, Farr, Guy, and Snow (Lillienfeld et al, 1994) to investigate the causes of disease. These men were predominantly interested in public health, rather than statistics or science. They gathered data about disease for analysis and used that information in tracking and preventing diseases such as cholera, smallpox and workplace illnesses. They had little in the way of statistical methods but they began by studying populations at risk rather than focusing on individual illness (Lillienfeld et al, 1994).

> "Epidemiology suggests etymologically a science of something falling upon the people, and statistics suggests the study of states; as originally used the word statistics had no necessary connection with arithmetic. ... It differs from the study of disease by a clinician primarily in respect of the unit of investigation. A physician is concerned with, say, typhoid fever from the point of view of the individual patient, ... . An epidemiologist is concerned with a prevalence of typhoid fever; he wishes to determine the probable course of that prevalence, whether there are likely to be more cases, where

the maximum will be reached, what should be done to reduce the prevalence" (Greenwood, 1935, p15).

Hence, traditional epidemiology had its focus in the study of the population as the unit of investigation, rather than the individual, and while statistics is an important part of the discipline, it is only a tool in the investigation of the causes of the diseases being studied. The statistics themselves are not the definition of this discipline.

This era comprises the phase of epidemiology known as traditional epidemiology. During the 1800s to mid 1900s epidemiology moved from the debate as to whether disease was caused by miasma or by contagion and whether social conditions such as poverty or workplace conditions affected health (Krieger, 1994), the germ theory of epidemiology.

Traditional epidemiology focused on research in the social context when social change was a strong priority in industrialised countries just before and at the turn of the 20th century. It investigated illness in populations rather than in the laboratory. From the systems perspective the difference can be described in terms of choice of scale by the observer/investigator/researcher. Traditional epidemiology intervenes at the population, community and organisational levels while modern epidemiology is positivist and intervenes at the individual or molecular level of natural systems (Pearce, 1996).

This strand of epidemiology has been criticised as moving away from the rigorous methods of science (Vandenbroucke, 1994). It is thus weakened in its efforts to prove its conclusions and influence change in public health policy and action at the population and societal levels.

This debate is similar to the criticisms levelled at systems thinking, as discussed later in this chapter regarding Boulding's work. In other words, if the methods and results of a study cannot be quantified, then there is not proof and the study or the model employed in the research is not "good science" (Vandenbroucke, 1994).

Other writers believe it is not the defence of science that is the core issue in this debate. Rather it may be that at the time when modern epidemiology developed it was not politically wise to be researching social causes of illness (Krieger, 1994) and that fear continues today in the risk of losing funding for research that is socio-economic in focus rather than individually- or family-oriented (i.e. the influence of conservatism and Thatcherism on the goals of research) (Pearce, 1996).

It is more likely a combination of changing social and political structures and ideologies on the one hand and increased skills and methods in the laboratory and statistics of the discipline on the other hand that have facilitated the development of the current paradigm of modern epidemiology, and the subset called molecular epidemiology (McMichael, 1994; Loomis and Wing, 1990).

The development of the microscope led to the proof that organisms caused disease (germ theory) rather than a mysterious miasma. A miasma was described as "an invisible, noxious cloud created by putrid vapours and particles emanating from dead human and animal bodies, rotting waste and vegetation and the stagnant water of swamps" (Robins, 1995, p10). These advances have resulted in a modern system of public health laboratories, research facilities, surveillance systems on a global scale, and international co-operative systems for the monitoring of public health. Table 4.1 from Pearce (1996) summarises the differences he perceives between traditional and modern epidemiology.

**Table 4.1 Epidemiological Paradigms (from Pearce, 1996, p679)**

| | Traditional Epidemiology | Modern Epidemiology |
|---|---|---|
| Motivation | Public health | Science |
| Level of Study | Population | Individual/organ/tissue /cell/molecule |
| Context of study | Historical/cultural | Context free |
| Paradigms | Demography/social science | Clinical test |
| Epistemological approach | Realist | Positivist |
| Epistemological strategy | Top down (structural) | Bottom up (reductionist) |
| Level of intervention | Population (upstream) | Individual (downstream) |

### 4.1.2 Modern Epidemiology

The process for modern epidemiological investigation is outlined and summarised in the following flowchart (figure 4.1) from Mera (1997) that is also based in the positivist perspective focusing on observation, experimentation, and analysis. Outcomes are evaluated statistically with the confidence intervals and/or p-value attached for validation.

Last's (1995) Dictionary of Epidemiology gives a definition for modern epidemiology but also encompasses some of the spirit of traditional epidemiology.

> "The study of the distribution and determinants of health-related states or events in specified populations, and the application of this study to control of health problems. "Study" includes surveillance, observation, hypothesis testing, analytic research, and experiments. "Distribution" refers to analyses by time, place, and classes of persons affected. "Determinants" are all the physical, biological, social, cultural, and behavioral factors that influence health. "Health related states and events" include diseases, causes of death, behavior such as the use of tobacco, reactions to preventative regimens, and provision and use of health services. "Specified populations" are those with identifiable characteristics such as precisely defined numbers. "Application to control..." makes explicit the aim of epidemiology—to promote, protect, and restore health" (Last, 1995, pp55-56).

The statistics of modern epidemiology have developed into highly sophisticated methods for analyses, many of which methods require computers for implementation, e.g. in regression analyses which can process multiple variables.

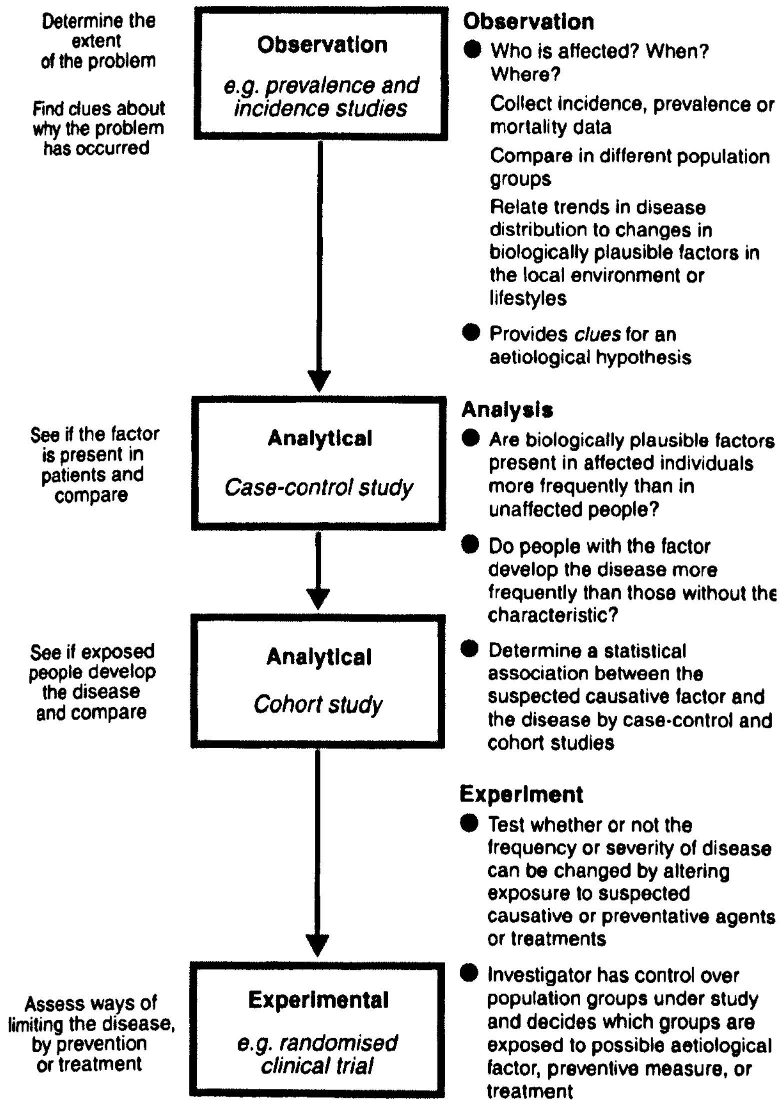



**Figure 1.3** The epidemiological approach. The logical sequence of epidemiology is to find out how common a disease is, or how many people die from it, and to relate this to other events going on at the same time. This gives clues as to what might be important in causing changes in incidence, prevalence or mortality. These factors can be further investigated by case-control and cohort studies. It may then be appropriate to conduct experimental studies, perhaps designed to limit exposure to causative agents and therefore prevent the disease, or to test new drugs. In practice this sequence is not necessarily followed. It is not necessary to know how many people are affected by a disease, or its cause, before a new drug is tested. At some point, however, a drug company would want to know the potential market for its product. Although there are many effective drugs that work empirically without knowing how the disease is caused, knowledge of aetiology helps in the rational design of new drugs.

**Figure 4.1 The Process of Modern Epidemiology (from Mera, 1997, p7)**

However, Castle et al. (1995) have stated that significance tests in statistics are not concrete. They are open to interpretation and should only be viewed as an aid in decision-making. Statistical inference is an imaginary world because statistics has to deal with the issue of never being able to deal with a real, complete population since it is only a sample drawn from that real population that is dealt with and that sample can never bear all the same characteristics of the whole population. Knowing which statistics to use and when is the essential element (Castle, et al., 1995). This is where a more reflective process of critical review in the performance of these analyses would aid in the critique that modern epidemiology cannot claim the rigour of scientific exploration.

From a later, but similar structured text (Webber, 1996), figure 4.2 shows the boundaries of these inquiries, with social influences clearly outside the system in the surrounding environment; not a part of the model. This model of host, agent, environment and means of transmission was developed during the transition debate between traditional to modern epidemiology.

Modern epidemiology continues to develop its methods (case-control, cohort, ecological and RCT studies, and now meta-analyses of groups of these study designs) within which statistics are used calculate the degree of confidence surrounding those calculations. As with every discipline, epidemiology focuses on the causes and effects within its limits of knowledge. This can be seen in the early textbooks in epidemiology that discussed emerging infectious diseases at length, but mainly from the perspective of infectious agent (microbe) versus host coupled with the means of transmission and the environment (Creighton, 1891; Greenwood, 1935; Wu, 1936; Hirst, 1953).

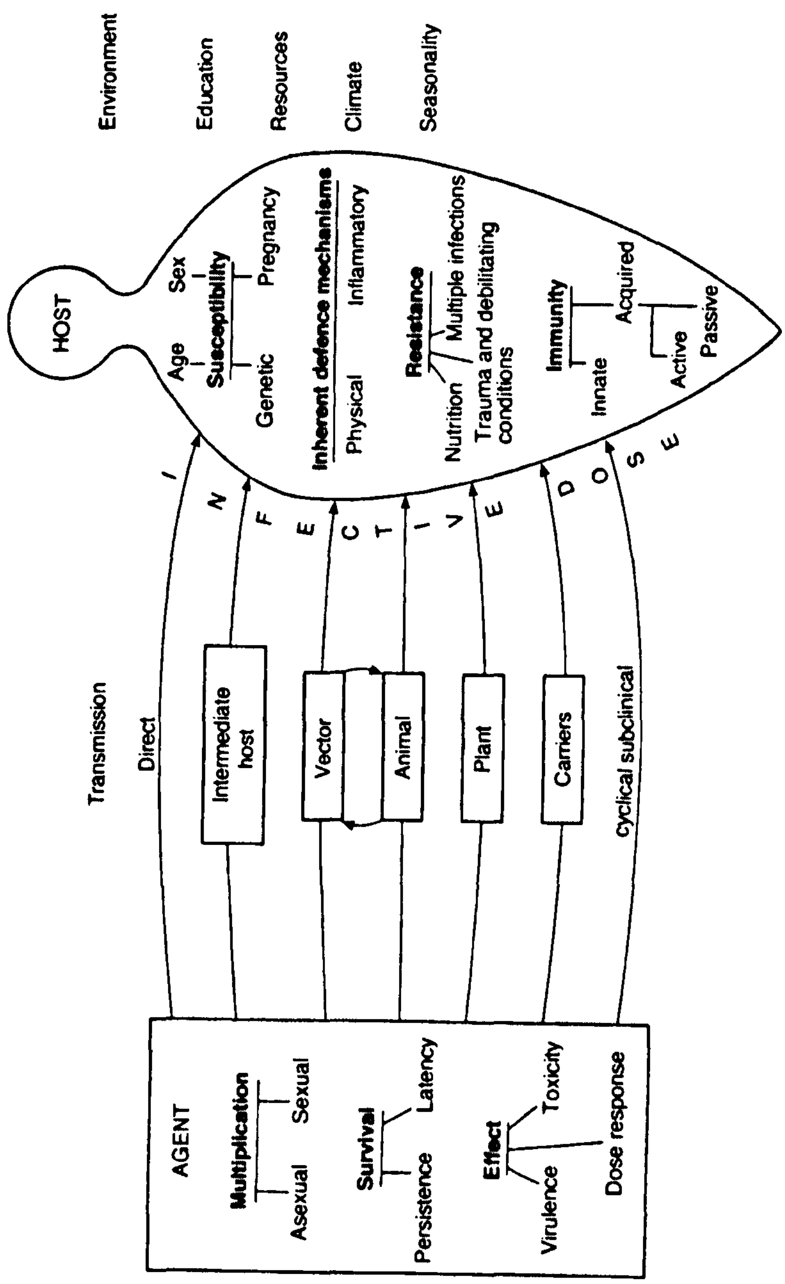



**Figure 4.2 Agent, Transmission, Host, and Environment (Webber, 1996, p4)**

The earliest textbooks from the discipline of epidemiology are meticulously detailed and corroborated with statistical data gathered from all around the world, from Europe, India, Africa and Asia. The example focused on in these textbooks is the bubonic plague (*Yersinia pestis*). More recent reference and textbooks have been published in the intervening decades between the turn of the 20th century and the 1970s. These books focus primarily in the same manner as earlier texts on the mechanisms for communication of disease and do not concern themselves with societal or evolutionary issues.

### 4.1.3 Multi-disciplinary (Eco-)Epidemiology

However, over the past thirty years, and especially over the past five years, there has been a number of texts which address and question the changing patterns of global health and their consequences for health and the environment (Zeigler, 1972; McNeill, 1976; Morse, 1993; Kennedy, 1993; Garrett, 1994; Preston, 1994; Cannon, 1995; Karlen, 1996; Ryan, 1996; Chesworth, 1996; Wills, 1997; Diamond, 1997; Sapolsky, 1997; Tomes, 1998).

While these books address social and evolutionary, technological and political influences on the study of emerging infectious disease, they still choose to focus on only one or a few of the possible causes for the changes being perceived. For instance, Tomes (1998) believes that technological and sanitary improvements have reduced the incidence of disease, while McNeill (1976), Karlen (1996), Ryan (1996) and Wills (1997) believe that there are symbiotic and evolutionary changes at work in the co-existence of humans and microbes. Writers such as Garrett (1994), Chesworth (1996), Diamond (1997) and Sapolsky (1997) hold that societal influences and their environmental effects are driving the increase in emerging infectious diseases.

Each author has their own hypothesis and perspective on the causes of the increase in emerging infectious disease but each author chooses to focus on only one part of the possible influences while downplaying other issues. What is required is a combination of the issues raised by all of these authors (including the expansion of the literature search for additional issues) to be used in a more holistic approach to the study of emerging infectious disease.

In all of the theoretical textbooks listed in this section on epidemiology, Last's dictionary is the only one with an expanded definition of the goals of epidemiology which recognises that "the definition [of epidemiology] has broadened from concern with communicable disease epidemics to take in all phenomena related to health in a population" (Last, 1995, p56). Kriegler and Zierler (1995) describe such information as a focus on study methodology rather than on addressing and debating epidemiologic theory and that we have to look for patterns which reflect an interplay between social and biological influences. They believe that this is the basic challenge for today's epidemiologists, and that a change in the dominant paradigm (modern epidemiology) is required (Loomis and Wing, 1990).

Expanding epidemiology into this area of interplay, into the interrelationships between all of the issues, is a valid and appropriate direction, and one that is necessary in order to understand the complexity of natural and social systems (McMichael, 1995; Susser and Susser, 1996). Several names are given for a similar desire: a reintegration with public health rather than the discipline of science (Pearce, 1996); "recognising the historical context of public health phenomena and the sciences which address them", and "reconstructing the connections between disease agents and their contexts" (Wing, 1994, 74, 84) thereby moving from a reductionist to a holistic approach; the use of models and metaphors and specifically an eco-social metaphor using two spiders in the web of causation model, one biological and the other social; and eco-epidemiology (Chinese rather than black boxes) which aims to use molecular, societal and individual levels of organisation in epidemiological studies (Susser and Susser, 1996).

Epidemiology theory has to act on different levels in order to model our experiences and these models cannot always be based in the languages and models of mathematics or natural science. In an article comparing molecular biology with germ theory, Loomis and Wing state that epidemiologists must now combine molecular epidemiology with information about the role of the environment "without isolating either one from the whole system of which they are essential parts" (Loomis and Wing, 1990, p1).

The main thrust of all of these developments is that biological and social levels of organisation must be combined and the interrelationships between the levels studied together in the same research. This closely matches the holistic and hierarchical principles proposed in systems thinking.

One of the main objectives of this thesis will to be to gather these different perspectives together in the form of a list of possible causes (recognising that many other forms of that list could be made depending on the researcher doing the compiling) and filter that list from the perspective of a framework in systems thinking.

The next section describes the specific area of interest on which the implementation of the methodology of this thesis will be performed; that of emerging infectious disease (EID).

## 4.2 Emerging Infectious Diseases

Emerging or re-emerging infectious diseases, e.g. MRSA, hantaviruses, tuberculosis, bubonic plague, HIV, and cholera are complex problems where the issues and information generated by research into these outbreaks requires the use of a wide range of data and the use of many disciplines such as, but not limited to, biology, biochemistry, chemistry, ecology, epidemiology, psychology, politics, economics, statistics, and mathematics. Emerging infectious disease is "new, re-emerging or drug-resistant infections whose incidence in humans has increased within the past two decades or whose incidence threatens to increase in the near future" (CDC, 1997).

The different strands of epidemiology used in this thesis were explained in the introduction to this chapter. In this thesis the terms traditional, modern and eco-epidemiology will be used in descriptions of the discipline. However, it is also noted here that the development of each phase still has much in common with the preceding phase since each has been derived from previous forms of the discipline and strands of each still exist in current research (Pearce, 1996).

The study of emerging infectious diseases is an important and topical issue for research since a significant increase in emergence has been noted by public health agencies. The graph in Figure 4.3 shows that emerging infectious disease was the leading cause of death in the world in 1993. The figures shown are through the year 1993. While the leading cause of death may change over time, and be different for specific countries, it remains high on every variation of this list, and can therefore be judged to be a serious health issue for health researchers and practitioners (Berkelman and Hughes, 1993). In addition, the CDC state that these figures are an under-estimate because non-infectious disease can be influenced by infectious causes (CDC, 1997) and can also contribute actively to death in other cases (Nuland, 1997).

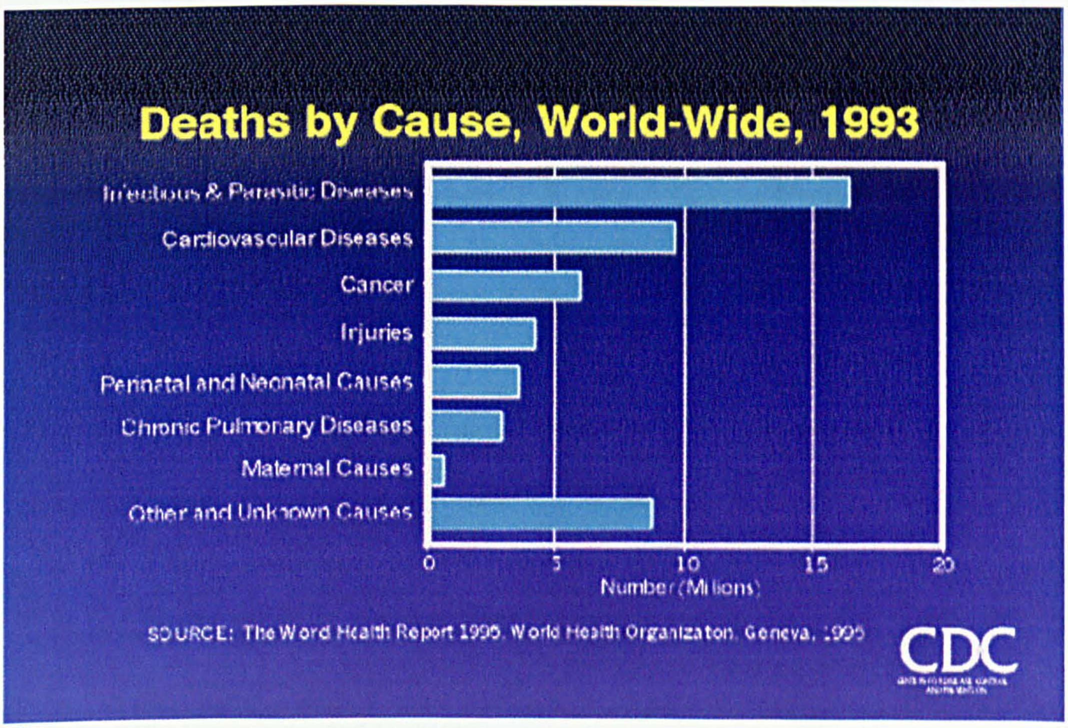



**Figure 4.3 Deaths by Cause, World-Wide, 1993**

Developing countries have made progress in reducing this cause of death to a more minor role, although gains may be short-term with the rise in cases of tuberculosis, HIV/AIDS, herpes, food poisonings, and nosocomial infections.

**TABLE 2.1.** Some Examples of "Emerging" Viruses

| Virus | Signs/Symptoms | Distribution | Natural host |
|---|---|---|---|
| *Family: Orthomyxoviridae* (RNA, 8 segments) | | | |
| **Influenza** | Respiratory | Worldwide (often from China) | Fowl (and pigs) |
| *Family: Bunyaviridae* (RNA, 3 segments) | | | |
| **Hantaan, Seoul, etc.** | Hemorrhagic fever with renal syndrome | Asia, Europe, U.S. | Rodent (e.g., *Apodemus*) |
| Rift Valley Fever* | Fever, ± hemorrhage | Africa | Mosquito; ungulates |
| Oropouche* | Fever | Brazil, Trinidad, Panama | Midge |
| *Family: Togaviridae* (Alphavirus genus) (RNA) | | | |
| O'nyong-nyong* | Arthritis, rash | Africa | Mosquito |
| Sindbis* | Arthritis, rash Australia | Africa, Europe, Asia, | Mosquito; birds |
| *Family: Flaviviridae* (RNA) | | | |
| Yellow Fever* | Fever, jaundice | Africa, S. America | Mosquito; monkey |
| **Dengue*** | Fever, ± hemorrhage | Asia, Africa, S. America, Caribbean | Mosquito; human/monkey |
| Rocio* | Encephalitis | Brazil | Mosquito; birds |
| Kyasanur Forest* | Encephalitis | India | Tick; rodent |
| *Family: Arenaviridae* (RNA, 2 segments) | | | |
| Junin (Argentine HF)† | Fever, hemorrhage | S. America | *Calomys musculinus* |
| Machupo (Bolivian HF) | Fever, hemorrhage | S. America | *Calomys callosus* |
| Lassa fever | Fever, hemorrhage | W. Africa | *Mastomys natalensis* |
| *Family: Filoviridae* (RNA) | | | |
| Marburg, Ebola | Fever, hemorrhage | Africa | Unknown |
| *Family: Retroviridae* (RNA + reverse transcriptase) | | | |
| **HIV§** | AIDS | Worldwide | Human virus (? originally from primate) |
| HTLV‡ | Often asymptomatic; adult T-cell leukemia, neurological diseases (e.g., tropical spastic paraparesis) | Worldwide, with endemic foci | Human virus (? originally primate virus) |
| *Family: Poxviridae* (DNA) | | | |
| Monkeypox | Smallpox-like | Africa (rainforest) | Rodent (squirrel) |

[From S. S. Morse and A. Schluederberg (1990). Emerging viruses: The evolution of viruses and viral diseases. J. Infect. Dis. 162:1-7. ©1990 by The University of Chicago Press.]
*Transmitted by arthropod vector
† HF: Hemorrhagic fever
§ HIV: Human immunodeficiency virus
‡ HTLV: Human T cell leukemia/lymphoma virus (human T-lymphotropic virus) I, II (types I and II)
**Bold:** Viruses with greatest apparent potential for emergence in near future

**Figure 4.4 Examples of "Emerging Viruses" (from Morse, 1993, p13)**

Figure 4.4 is a table from Morse (1993, p13) showing the emerging and re-emerging diseases currently of concern. To this list can be added more recent examples such as the SARS outbreak and the on-going threat of influenza with the 'Bird Flu'. One of the underpinning hypotheses of this thesis is that these emerging infectious illnesses, as shown in the table below, have been caused by interactions between several different causes, and that these causes cannot be addressed from within or with the use of only one discipline, such as epidemiology.

The CDC believes that addressing emerging infectious disease should be the major preoccupation of public health agencies charged with the oversight of these diseases and to this end they have developed a plan for addressing emerging infectious disease based on the basic epidemiologic principles of research and surveillance. These CDC aims will be incorporated and discussed further in the implementation chapters when the case study on policy is introduced. The next section begins the critical review of the discipline of epidemiology and its study of this issue.

## 4.3 International Policy Documents

For this thesis, three policy statements will be analysed using hierarchy theory and insights from the methods and practice of epidemiology. A very short summary of these documents is given in this chapter with the full text enclosed in Appendix 5 of this thesis.

### 4.3.1 The Centers for Disease Control (CDC), Atlanta, GA, USA

The CDC is a unit of the federal government of the United States of America. It was founded in 1946 for the control of disease. In the intervening fifty years the CDC has become, among many of its functions, a resource centre at the international level, sending its researchers around the world when requested to investigate outbreaks of disease (CDC, 1996).

The CDC has developed a plan for addressing emerging infectious disease threats in the USA that was published by the CDC on April 15, 1994, in the CDC's Morbidity and Mortality Weekly Report. This report has not yet been updated. The four goals of the plan for addressing infectious disease threats are shown in the next table.

**Table 4.2 CDC Policy Statements and Analysis**

| POLICY GOAL |
|---|
| Detect, promptly investigate, and monitor emerging pathogens, the diseases they cause, and the factors influencing their emergence. The ability to detect what is new or emerging depends on the capacity to identify and track the routine as well as the unusual. This goal focuses on improving our country's early warning network and developing more effective international surveillance networks. |
| Integrate laboratory science and epidemiology to optimise public health practice. Advances in diagnostic technologies can be brought into common public health practice. This requires close ties between personnel involved in disease prevention. For example, public health microbiologists have to collaborate with epidemiologists to support efforts to determine the sources of infection, develop interventions to prevent spread and recurrence, implement the interventions successfully, and measure their effectiveness. |
| Enhance communication and public health information about emerging diseases and ensure prompt implementation of prevention strategies. Building awareness of emerging infectious diseases requires forming teams of diverse partners from the public and private sectors. More creative methods of communicating public health messages are needed to reach a variety of target audiences. These audiences include such groups as state public health policy makers, physicians in training and in practice, and behavioral scientists and health communicators who are implementing community-based prevention programs. |
| Strengthen local, state, and federal public health infrastructures to support surveillance and implement prevention and control programs. State and local health department staff, as well as hospital and university personnel, need training in the diagnosis, surveillance, and control of infectious diseases. Sufficient numbers of skilled personnel and well- |

| |
|---|
| equipped physical facilities are essential to maintain control of old disease threats and support prevention of new ones. Public health laboratories represent an area of critical need and crumbling infrastructure. If such laboratories are unable to provide key information in detecting an epidemic, monitoring resistant and epidemic strains of organisms, and defining the course of the epidemic, then all prevention efforts suffer. |

These guidelines are available from the CDC in full text at the website address: http://www.cdc.gov/ncidod/publications/eid_plan/home.htm (last accessed June 12, 1998).

### 4.3.2 The World Health Organisation (WHO), Geneva, Switzerland

The World Health Organisation has a similar document within the remit of the WHO directive *WHA34.36—Global Strategy for health for all by the year 2000* (WHO, 1981) which are the International Health Regulations adopted by the 22nd World Health Assembly (WHA) in 1969 and amended by the 26 WHA in 1973 and the 34th WHA in 1981. The text represents the regulations in force as of 1 January 1982, and most recently updated in 1995. The goals are even more clearly focused on clinical epidemiology and bio-medical research than the CDC regulations.

**Table 4.3 WHO Policy Statements and Analysis**

| POLICY GOAL |
|---|
| The purpose of the International Health Regulations is to ensure the maximum security against the international spread of diseases with a minimum interference with world traffic. Following the increasing emphasis on epidemiological surveillance for communicable disease recognition and control, the new Regulations are intended to strengthen the use of epidemiological principles as applied internationally, to detect, reduce or eliminate the sources from which infection spreads, to improve sanitation in and around ports and airports, to prevent the dissemination of vectors and, in general, to encourage epidemiological activities on the national level so that there is little risk of outside infection establishing itself. |

### 4.3.3 Program Objectives for Pan American Health Organisation (PAHO)

The Pan American Health Organization is headquartered in the United States with field offices throughout South America. Its goals are "to strengthen national capabilities to implement effective preventative, therapeutic and control programs which are technically feasible, economically viable, and socially acceptable" (PAHO, 1998). Its policy statements can be located at the web address http://www.paho.org/english/hct01.htm (June 12, 1998).

**Table 4.4 PAHO Policy Statements and Analysis**

| POLICY GOAL |
|---|
| To strengthen national and local capabilities to detect and analyze changes in the frequency and distribution of common, new emerging and re-emerging infectious diseases and to implement proper prevention and control activities; |
| To support member countries in the process of elimination of leprosy, onchocerciasis, non-venereal treponematosis, and Chagas' disease vectorial transmission; |
| To collaborate with the Regional efforts to control blood transfusion transmitted infectious agents; |
| To develop, in cooperation with national counterparts, cost-effective measures to prevent and control childhood diseases, particularly diarrheal diseases and acute respiratory infections; |
| To implement the Global Malaria Control Strategy based on administrative and programatic integration of especialized services into the local level; |
| To foster the development of applied research in support of prevention and control activities. |

## 4.4 Summary

Three areas of literature were covered in this chapter: emerging infectious diseases, the discipline of epidemiology, and policy documents at the international level in the prevention and control of EID. The development of the discipline of epidemiology, and its changes in focus over the years, have been covered. From this discussion, it can be seen that there is a drive to expand 'modern' epidemiology into the area of dealing more closely with the interrelationships between all of the issues, and that taking a more comprehensive approach is valid and appropriate. It is a necessary change in focus in order to more fully understand the complexity of natural and social systems, and move the discipline of epidemiology from a purely reductionist approach to a more holistic approach.

The next chapter is a review of the historical development of 'hierarchy' in the literature, covering both the original and the changing use of the term over time as it has been influenced by changes in human society and beliefs. The chapter moves from the general use of the term 'hierarchy' to a more specific use of a hierarchy as a core principle of systems, and into an exploration of its use in the systems approach called 'hierarchy theory'.

# Chapter 5

## Hierarchy Literature Review

### 5.0 Introduction

The previous chapter described the field of epidemiology and discussed the similarities and differences to systems thinking. The previous chapter also listed issues and critiques current in that area of study. In the same way, this chapter follows the same format for the development of hierarchy theory within systems thinking.

If it is indeed the case that the discipline of epidemiology is lacking in its ability to competently address the full range of influences inherent in international health issues such as EID, can hierarchy theory, in its current form, add anything to this topic of research?

This chapter investigates the retrieved data on hierarchy theory, specifically looking for applications of the theory in the available literature. Where those applications are found, the data will be critically appraised in search of the theory, practice, utility and methods used so as to demonstrate whether a developed methodology currently exists that can be used to complement the practice of epidemiology in addressing international health issues.

The structure of this chapter will follow the outline of: 1) ascertaining where hierarchy originated in the literature; 2) how hierarchy has been linked with systems thinking in the literature; and 3) discussing how some authors have developed hierarchy in systems thinking in light of the stated aim of this research, i.e. whether they have, or have not, developed a useful theory and methodology for hierarchy in systems thinking and/or in other disciplines. An overview of this last section will be followed in chapters six and seven by presenting the work of each systems theorist and practitioner who has worked with hierarchy, but sorted using a filter as to whether their work is from a functionalist (chapter six) or interpretive standpoint (chapter seven).

The field of systems thinking covers a very wide area of philosophy, principles and practice and some researchers have attempted to draw maps to show this wide territory. These maps are the work of individuals and some include areas of systems thinking that others do not. The perception of what, or whose work, should be classed as systems thinking is a fluctuating definition and is dependent on the individual viewpoint, grown from the training and experiences of that particular map-maker. In this way, these maps demonstrate the interpretive and subjective process that also underpins this thesis. The construction of a theory and method for the use of hierarchy is this researcher's definition and would be different from the work of another researcher and this is also demonstrated by the differing accounts of hierarchy enclosed within this chapter. Some of the core principles are the same, but the ontological and epistemological perspectives of each author may define them from a different perspective. Different perspectives would place hierarchy theory with different originators of the work and in differing disciplinary areas. The following five maps are examples of the territory of systems thinking.

The first map is the most general in concept, showing areas of application for systems theory mixed with some methodological terms used within systems thinking. The source of this map is a European practitioner/consultant in organisational development, Prof. Dr. Hans Georg Graf (2006) from (SGZZ) St. Gallen Zentrum for Zukunftsforschung, whose website for further detail is at: http://sgzz.ch/?Systems_Thinking_Practice (last accessed January 15, 2007).

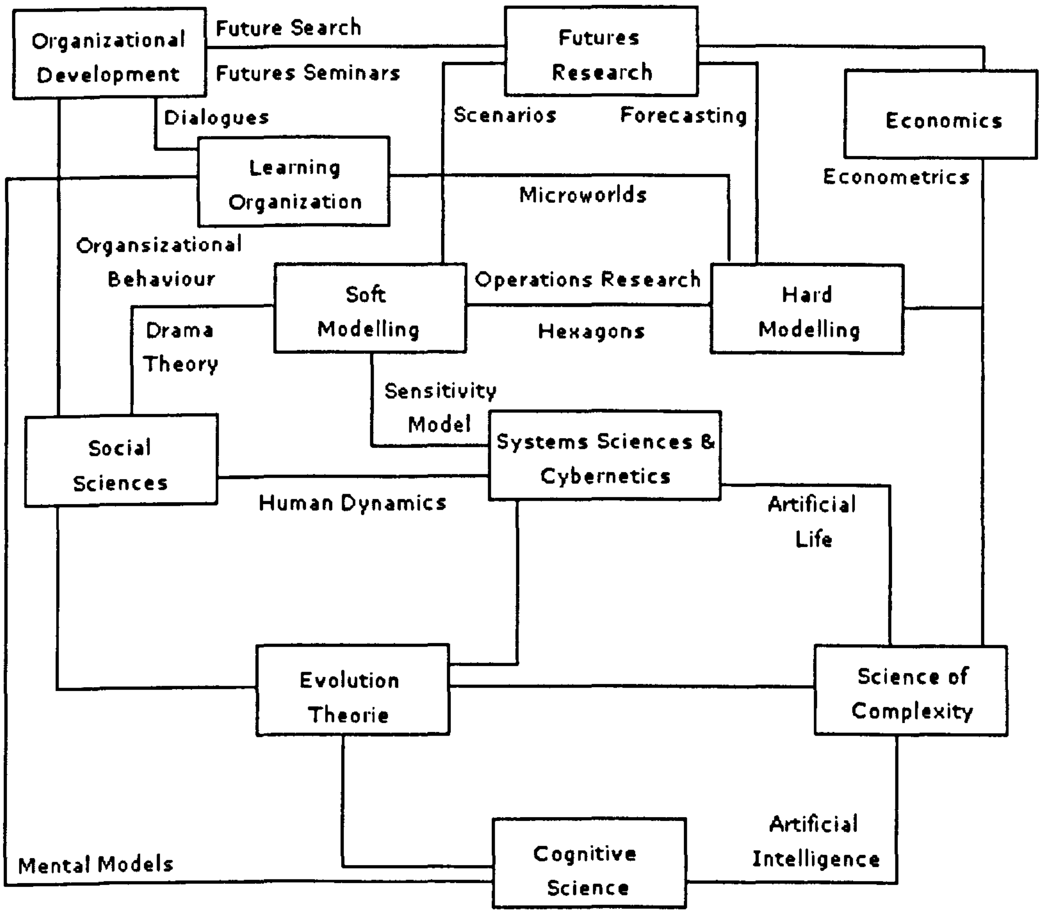



**Figure 5.1 Graf's Map of Systems Thinking Practice**

In the second map, proposed by Checkland (1981) hierarchy theory is described within the area of theoretical developments (3.1) of systems ideas (2.1) within the systems movement as a whole (1). In this scheme, hierarchy theory is not seen as a problem solving development within systems thinking.

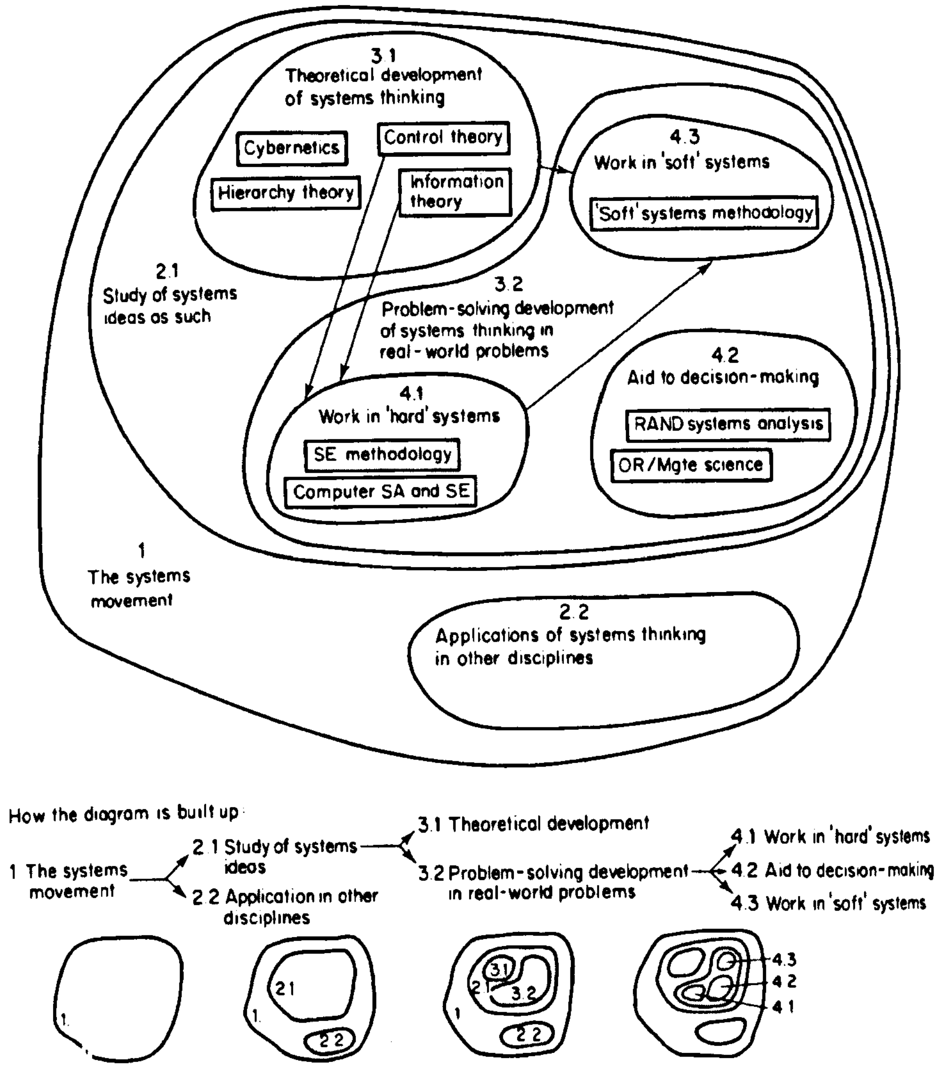



**Figure 5.2 Inter-relationships of Systems Diagram (Checkland, 1981, p.96)**

The third map "Some Streams of Systemic Thought" is the work of Dr Eric Schwartz (1996). Dr Jeffrey Yi expanded this work at the International Institute for General Systems Research (2000-1). This map is the most comprehensive example in its mapping of both philosophy and methodologies in systems thinking.

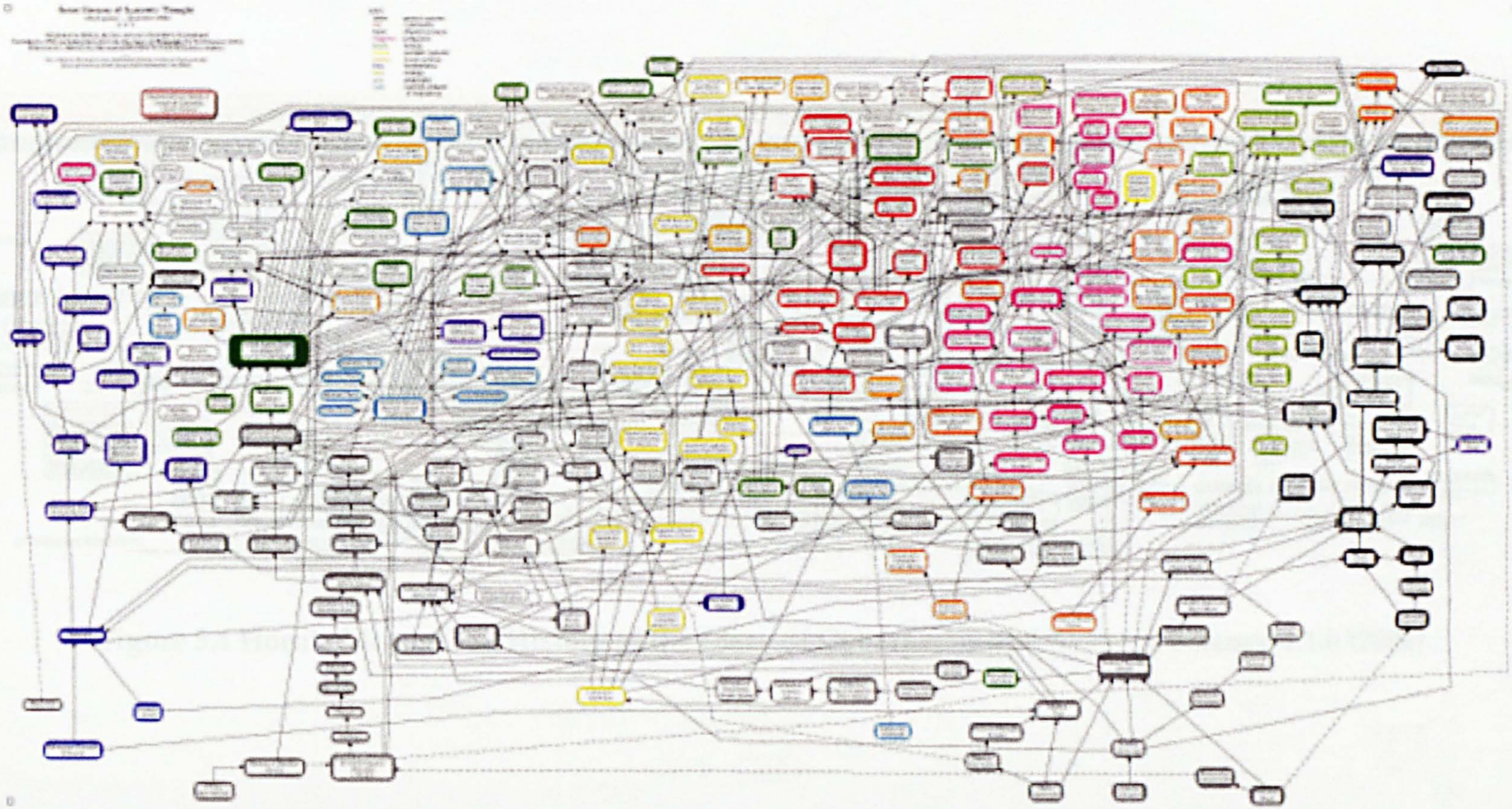


**Figure 5.3 Schwarz's and Yi's Map of Some Streams of Systemic Thought (1996/2000-1)**

The fourth map is an overview of the history of the ideas of cybernetics and systems science presented by Dr Robert Horn (2006) at the 50th meeting of the International Society for the Systems Sciences (July 2006).

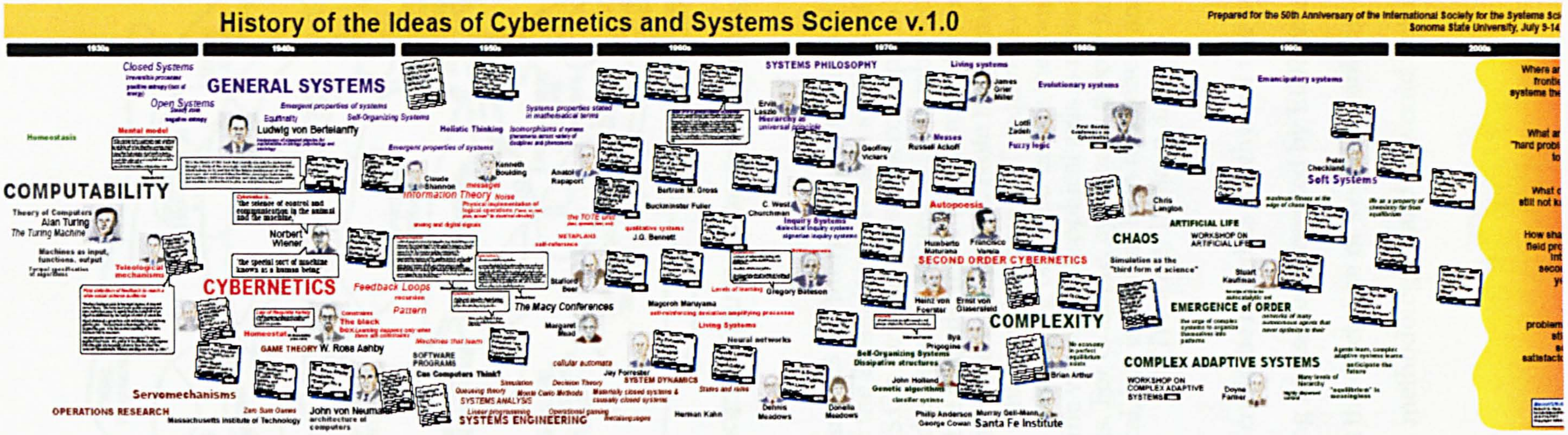



**Figure 5.4 Horn's Map of The History of the Ideas of Cybernetics and Systems Science v.1.0 (2006)**

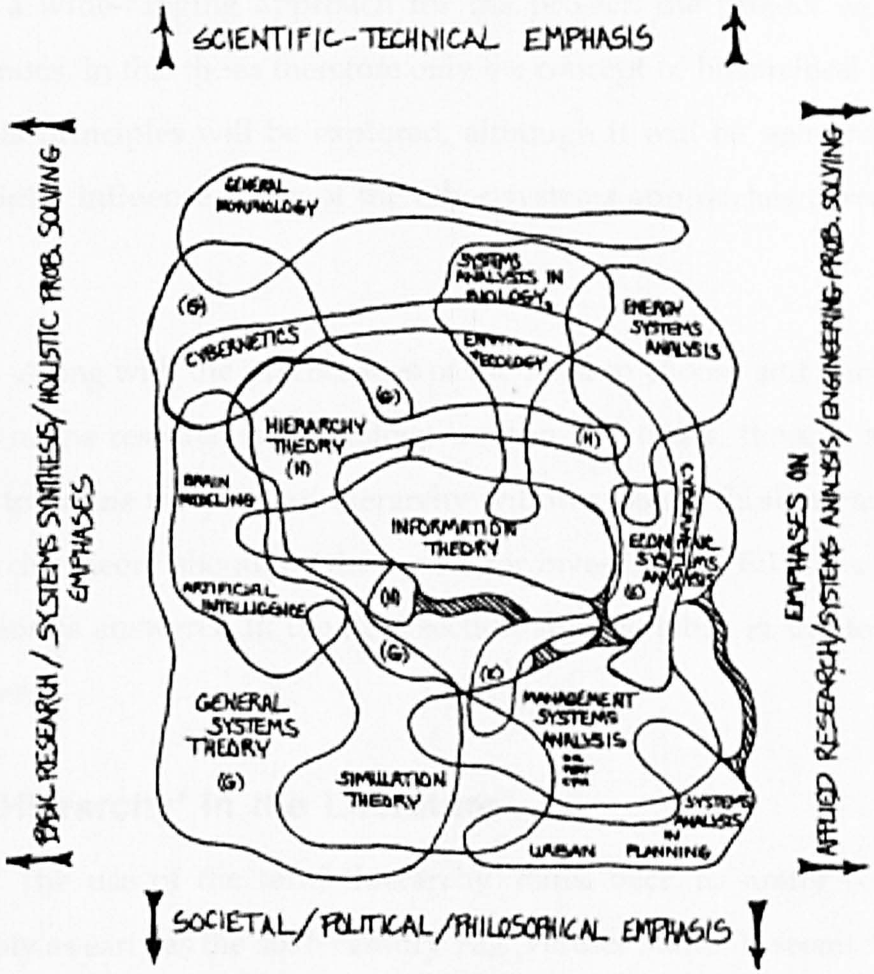



**Figure 5.5 A "Morphological" Picture ...**
of some of the 23 fields involved in systems of holistic studies which contribute P.S.C.s [principal systems concept] to this model. Size of the field's boundaries is not related to its numbers of practitioners. Overlapping of the boundaries of two or more fields indicates their mutual use of some systems concepts. Note that some fields are totally isolated from each other, while a true GST requires synthesis of abstract ideas across all. The positioning of a field on the theoretical vs applied axis, or on the scientific vs the philosophical axis is meant to portray its particular emphasis. For example, cybernetic theory favors the scientific over the philosophical, but is used in both theoretical and applied contexts. (Troncale, 1978a, p.32)

The question could be raised as to why not use systems thinking as a whole in addressing the issues presented by EID? From the maps shown above, it is clear that the discipline of systems thinking is a very wide mix of philosophies and methodologies and it would not be feasible to take such a wide-ranging approach for the project: the project would be enormous. In this thesis therefore only the concept of hierarchical analysis and its principles will be explored, although it will be seen that these principles influence many of the other systems approaches currently in use.

Along with the practicalities of the need to choose and narrow the focus of the research methodology used in this thesis, there is also the need to define the place of hierarchy within systems thinking and why hierarchy theory should be the means for investigating EID. The former question is answered in the next section and the latter in the following chapter.

## 5.1 'Hierarchy' in the Literature

The use of the term 'hierarchy' dates back to many centuries, possibly as early as the sixth century AD. Verdier states: It seems to have been coined by Pseudo-Dionysis the Areopagite... It is made up of *hieros* "sacred" and *archia* "rule". The first clear meaning arises from this etymology, since hierarchy at that time is "the governance of things sacred" (Verdier, 2006, p. 13).

The use of the word in the literature reflects the changes in its meaning over time. Figure 5.6 shows the results of a search by Lane (2006) on the incidence of the term 'hierarchy' using two databases, one French and one American. The graph shows that although the term was in use long before the 1960s, when most recent publications about hierarchical analysis began, its occurrence as a word in the literature did not rapidly increase until just before that date.

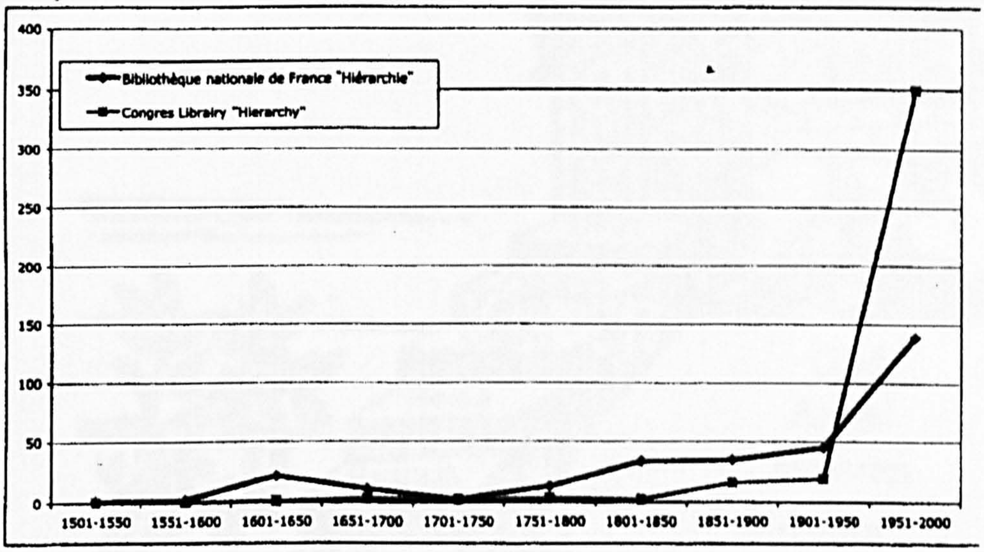



**Figure 5.6 Frequency of the Word 'Hierarchy' in Book Titles (from Lane, 2006, p.34)**

Verdier has written an interesting chapter in an edited book "Hierarchy in Natural and Social Sciences" (Pumain, 2006a,b,c) describing the development of the usage of this word and the change in meaning for hierarchy as a term as political, cultural, religious, social and philosophical changes have happened from that time until the present. The governance aspects of the term are described in a statement by Pumain as: "Hierarchy is a type of systemic organisation into levels that are ordered with reference to criteria of a normative character, and fully or partially subordinated by relationships of power, influence, or control" (Pumain, 2006a, p1). One of the oldest hierarchical frameworks is that known as the Great Chain of Being, shown in figure 5.7.

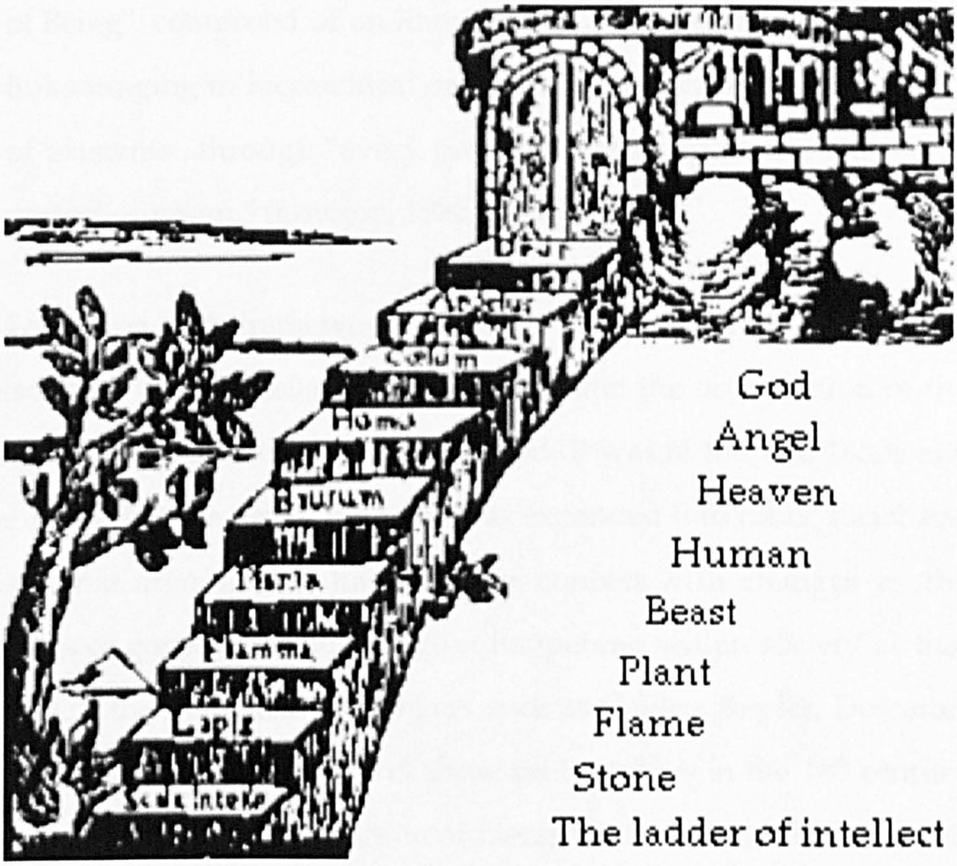



**Figure 5.7 The "Great Chain of Being" (from Kazlev, 2004, http://www.kheper.net/topics/greatchainofbeing/introduction.html)**

Lovejoy's "Great Chain of Being" (1936) underpins the use of hierarchy in the 17th and 18th centuries. It is rooted in the philosophies of both Plato and Aristotle (Ladder of Nature) (Kazlev, 2004) and posits that at the top of the ladder is God, and below Him, the angels, and so on down the ladder to the rock of the planet as the lowest level. Lovejoy described the "Great Chain of Being" in his book of the same name as:

> A "conception of the plan and structure of the world which, through the Middle Ages and down to the late eighteenth century...most educated men were to accept without question - the conception of the universe as a "Great Chain

> of Being", composed of an immense, or...infinite, number of links ranging in hierarchical order from the meagerest kind of existents...through "every possible" grade up to the ens perfectissumum." (Lovejoy, 1936, p.xx.)

Following such frameworks, until the 1700s hierarchy remained a term associated with ecclesiastical governance and the organisation of the Church and its relationships with the sacred. It was in the late 1600s and into the 1700s that the use of the term was expanded into other social and organisational arenas. This happened in concert with changes in the perceptions of governance and religion happening within society at that time through the influences of thinkers such as Galileo, Kepler, Descartes and Newton. It is with the work of these philosophers in the 18$^{th}$ century that hierarchy moves to a distinction of hierarchies within both the sacred and Church, and in societies as well. "Thus according to the Encyclopedie, [produced by Diderot and d'Alembert in 1751] it is St Denis who distinguishes the different hierarchies, it is Christian society that makes up the hierarchy, and it is the citizens that build the hierarchy" (Verdier, 2006, p17). Verdier describes this a move from "The Hierarchy" to "Hierarchies" and this is line with the increasing independence of society from the dominance of the ecclesiastical. "While the 16$^{th}$ and 17$^{th}$ centuries saw the shift of the concept of hierarchy from the sacred to the profane, the 18$^{th}$ century, because it undermined the concept of a unified hierarchy, widened its application, hitherto restricted to certain domains" (Verdier, 2006, p18).

Verdier states that this widening of application was happening not only in the natural sciences but also in social systems and the organisations and governing of human activity systems, such as the organisations of towns and cities (Verdier, 2006).

Verdier notes that it is in the writing of Alexis de Toqueville in 1835 that administrative hierarchies are discussed along with two other meanings of the Ancien Regime and its aristocracy and a natural social hierarchy. "In the eyes of Tocqueville, hierarchy is a natural form of society, and absence of hierarchy only appears possible under a rule of tyranny aiming at the ignorance of the people.", and "Finally, what this man [Tocqueville] ... seems to abhor are the superimposed categories with their stereotyped boundaries." (Verdier, 2006, p.26).

It was not until the mid 1800s, with the work of Auguste Comte that the idea of hierarchy as a system came into view, and with this the ideas of a "general manner of apprehending the organisation of formal (disciplinary) areas of knowledge into the encompassing system of knowledge" (Verdier, 2006, p27). This is an early conception of the work made explicit in the writing of Kenneth Boulding (*Skeleton of Science*, 1956) and general system theory (1940s) that will be explored in later chapters of this thesis. However, in the *Skeleton of Science*, Comte's work is not discussed.

## 5.2 Where did Hierarchy and Systems Thinking Originate?

Comte held that there was a hierarchy of disciplines, that hierarchy was "the fundamental condition imposed by the general theory of classifications" (Comte, 1937) and that there was "a genuine continuum among these same sciences. In his view, each science is at least in part at once sovereign and subordinate" (Verdier, 2006, p28). Verdier suggests that there may indeed be a 'comtian' model "for the hierarchical organisation of knowledge" ... "placing the "positive sciences" one after the other in the construction of the ultimate science, i.e. sociology – or the study of man – re-uses the ancient model of the "chain of beings", from the most simple to the most complex, while at the same time attributing the same value of necessity to each component." (ibid, 2006, p29).

Following Comte, the work of Durkheim and Freud are explored by Verdier, moving from Durkheim's work on the interrelationships among parts of the social system and Freud's work moving from analysing the social to analysing the collective (Verdier, 2006).

Verdier summarises the historical use of hierarchy in four key variations of the concept:

- "The importance of stressing the wide range or scope of the concept

- The contrast between continuity and discontinuity [discontinuity being central to hierarchy theory and the definitions of parts within a system]

- The status given to the concept [e.g. it can carry a value definition as in its negative meaning as being tyrannical and authoritarian], and

- The place given to hierarchy in reasoned thought ... the two extremes set the proponents if a hierarchy that is to be discovered [e.g. Allen, Salthe, Eldridge: an interpretive approach] against the proponents of an elaboration of a hierarchy by researchers in a given area" [e.g. Miller, Boulding: a functionalist approach] (Verdier, 2006, p.33).

It is this last variation of 'hierarchy' that is important in the classification and understanding of the use of hierarchy theory in this thesis.

Troncale, in a personal correspondence (2007), has written on the origin of discoveries in hierarchy, and the confusion that can arise through its difference in use in natural and social contexts:

> "Many times a natural process is first discovered while studying natural systems. But other times, what turns out to be an important process in all systems is first discovered in human systems. This is the case with hierarchy. The result has been that even the word itself is burdened by human peculiarities. Human hierarchies have been traditionally characterized as authority or competition-based, top-down systems. but that is often <u>not</u> the case with natural hierarchies. The natural systems basis for hierarchy is clustering and inhomogeneity rather than control. Control can and does proceed bottom-up as well as later top-down. In fact, the emergence H. levels are typically a bottom-up controlled process, while subspecialization H. levels are typically top-down. While all natural systems must follow the requirements of minimization and maximization, human

systems can be organized and operate for long periods of time (relative to us) breaking H. rules of operation and optimization" (Troncale, 2007, personal correspondence).

In the last variation mentioned on the previous page, the latter 'elaboration' variation of hierarchy notes that there is 'an hierarchic order to the world' (von Bertalanffy, 1968) that can be presented in a form of a static framework displaying that progression of order: a functionalist approach.

According to Whyte (1969a) four very early thinkers, Newton (1705), Lambert (1761), Fournier d'Albe (1907) and Charlier (1908) used these static frameworks to explore a hierarchical structure for the physical universe.

Miller's *Living Systems Theory* (1978) and Boulding's *Skeleton of Science* (1956) can be viewed as part of this variation of hierarchy: a pursuit of an explanation using a static structure. But it is the other extreme of this fourth variation of 'hierarchy' that underpins the implementation of hierarchy theory: an interpretive approach where the exploration of a system of interest is an interpretive process rather than a static framework, although it is still useful to use the frameworks (some of which, like Miller's work, are also processes for exploring and understanding living systems).

Such frameworks can aid description and exploration of a system of interest, as will be seen in the implementation chapters of this thesis. The use of this drive of looking for order has its roots in the fact that the universe as a whole is a homogeneous [similar] system. "Classical close-packing generates uniformity, while hierarchical arrangement yields heterogeneity [difference]" (Whyte, 1969a, p9). This was realised by Newton in his investigations and will be discussed in chapter 6.

Sections 5.1 and 5.2 explored the use of the term 'hierarchy' from a historical viewpoint, exploring its development from a term used only within the structure and control mechanism of the Church to a term used widely, with many variations, in both natural and social sciences. The next section moves to exploring the development of hierarchy within the field of systems thinking, specifically, as the area of systems thinking known as 'hierarchy theory'.

## 5.3 Hierarchy in Systems Thinking

Ludwig von Bertalanffy began his work in general system theory in the mid-1920s. Forty years later, in the mid 1960s he wrote about the new 'notion and fashionable catchword, 'systems' (1968) using an introduction to that book that would not be out of place in any current text on systems thinking, another forty years on.

> "If someone were to analyze current notions and fashionable catchwords, he would find "systems" high on the list. The concept has pervaded all fields of science and penetrated into popular thinking, jargon and mass media. Systems thinking plays a dominant role in a wide range of fields from industrial enterprise and armaments to esoteric topics of pure science. Innumerable publications, conferences, symposia and courses are devoted to it.

Professions and jobs have appeared in recent years which, unknown a short while ago, go under names such as systems design, systems analysis, systems engineering and others" (von Bertalanffy, 1968).

The subject, and the possibility for the development of von Bertalanffy's work, has its roots in the 1800s with Comte, as discussed in the previous sections of this chapter, and the development of the research about knowledge as a secular investigation, separated from the sacred dominance of such knowledge about the world. That first split, between the sacred and the profane, led to the first thoughts of different levels, of 'hierarchies'. Acknowledging the work of others, notably Kohler (1924, 1927) and Lotka (1925), von Bertalanffy researched a general system theory (GST). These works also proposed a hierarchical ordering of knowledge about the system of interest, from a functionalist perspective, adapted from Boulding (1956) and this is presented in chapters 6 and 7.

According to Simon (in Pattee, 1973) without hierarchy, complex systems would not be able to organise and maintain complex structures and processes. An example of how hierarchy facilitates the emergence of complex systems lies in the story of the two watchmakers, told in detail in chapter six in the section about Herbert Simon's work on hierarchy.

This is reflected in a basic three-level diagram of hierarchical structure as drawn by Pavé (2006) in figure 5.8. This diagram is also just about every other introduction to systems thinking and descriptions of hierarchical structure. Pavé shows organisational levels in this diagram, assembling units in networks in the same way as the successful watchmaker.

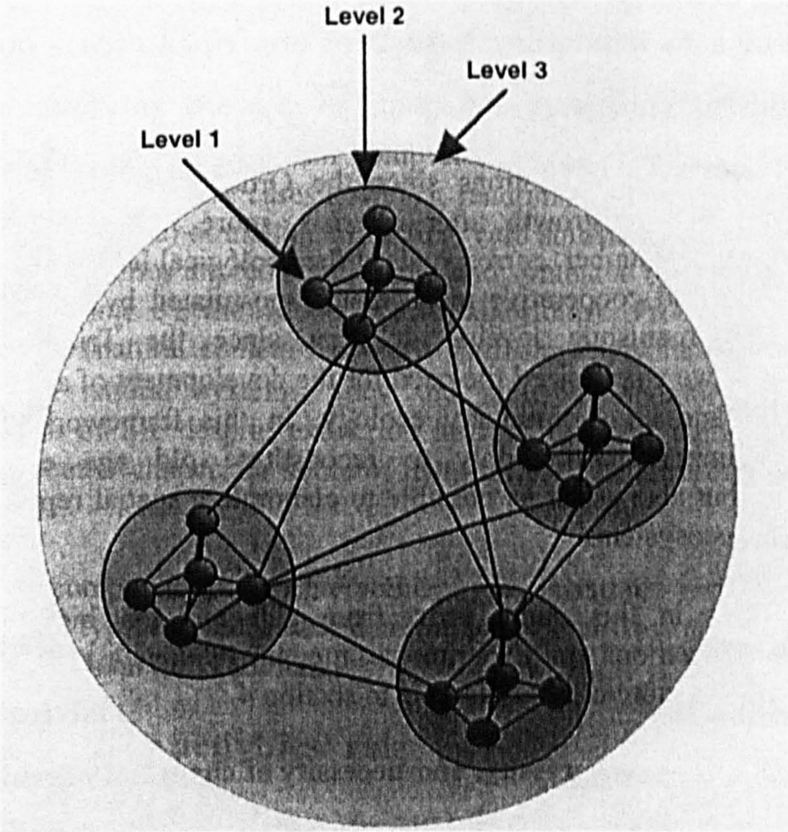



**Figure 5.8 Pavé's Diagramme of Organisational Levels (Pavé, 2006, p.53)**

## 5.4 Hierarchy Theory

In map two in this chapter, hierarchy theory is linked to the work of Howard Pattee as the originator of this work (Schwartz, 1996 and Yi (2000-1). However, the work of other authors, for example Simon (1962), Mesarovic (1970) and Weiss (1971) also investigated hierarchies using the phrase 'hierarchy theory' in their work. These authors moved from the use of hierarchical descriptions of complex systems, as they perceived them, to a more interdependent stance on the involvement of researchers (the observer) with the 'discovery' of hierarchies in the perceived world.

O'Neill et al. (1986) state however, that they believe that credit for the introduction of hierarchy theory as a term should belong to the work of Overton (with C. White) in their development of a functionalist approach involving the use of computer modelling to describe the behaviour of ecological systems (O'Neill et al. 1986; Overton, 1972, 1974, 1975).

However, the first use of hierarchy theory appears to be proposed by Simon in his 1962 article "The Architecture of Complexity". In the concluding remarks of that article Simon summarises his work on some of the core concepts of a descriptive form of hierarchical analysis and states:

> **"My thesis has been that one path to the construction of a nontrivial theory of complex systems is by way of a theory of hierarchy"** (Simon, 1962, p.117). (Emphasis mine).

Pattee also commented on the form such a theory would have to take, reasoning that it could not be a static, closed theory like those found in some of the natural sciences (the functionalist approach): "Hierarchy theory must be more like theories of language or programming that give us useful rules or methods for the most effective design and control of open-ended systems that can continually grow and evolve new levels" (Pattee, 1973, p.132).

Following Simon's work, there are several authors who further explored the concepts of boundaries, observation of systems, calculations of scalar jumps between levels and the implications of such breaks between levels for information and energy flows. These concepts will be discussed in detail throughout chapters 6, 7, 8 and 9.

Hierarchy theory is one of several possible systems approaches that have been used successfully in the study of complexity. It has been used in the observing of complex situations, and it has been applied successfully in many other systems and non-systems studies. (The searches in this research project discovered that 1400 papers per year since 1985 have been published using some form of hierarchical analysis). It should also be noted that the theory is systemic in itself, dealing with the issues central to systems science, e.g. the importance of the observer, and the flows of matter, energy, and information throughout the system.

Hierarchy theory is a study of systems which can be viewed as "entities ...built up of smaller entities which are themselves wholes ... and so on. In a hierarchy, emergent properties denote the levels" (Checkland, 1981, p314). A basic concept underpinning hierarchy is that the legitimate members of a set at one level all belong to the level just below. This was developed through the work of Bertrand Russell In *Principia Mathematica* (1903) that dealt with the elimination of paradoxical statements in mathematics. He called this "the theory of types", which made a distinction among statements in a form of a hierarchical arrangement:

- statements,
- statements about statements,
- statements about statements about statements,
- and so on....

Each of these levels was a different "type" (of statement). Every statement had to belong to one type or another, so that it was not allowed for a statement to be of more than one type. Logical types are used in many disciplines, e.g. computer programming and diagramming structures. Logical types are at the heart of several of the hierarchical explorations of those authors covered in chapters 6 and 7.

The concepts of parts and wholes are basic in the study of systems. A whole system can be broken down into various parts or subsystems and those subsystems can be broken down into even smaller subsystems. These different sets of subsystems can also be called the levels within the system. Hierarchy theory looks at these levels in a system and investigates how they relate to one another and how their inter-related behaviours come together to form the emergent behaviour of the whole system. Systems are hierarchical when they need more than one level to explain their complex behaviour (Allen and Starr, 1982).

Each of the levels in a system can be viewed as being at a different scale from the level above or below. When we look at an organisation as a system, we choose a scale to use to study the system. Perhaps the level of interest is the purchasing division within a company. Perhaps it is at a lower level; looking at the work of only one individual within the purchasing department. Or perhaps it is at a higher level; looking at how the purchasing function operates within the company as a whole. No matter what scale is chosen, the goal is to understand how the levels fit together, and whether the behaviour of the individual levels can perhaps help explain the behaviour of the whole.

The observer is the critical determination and influence on system description, design and intervention (Ahl and Allen, 1996; Allen and Starr, 1982). However, since it is the observer who thus describes the parts of the studied system and their interrelationships, that same individual is therefore imposing a bias on the observations that must be acknowledged and investigated. Defining a complex system requires an examination of the interrelationships between the phenomena being defined and the people doing the defining. This produces representations (models) that address several levels of organisation of which Boulding's *Skeleton of Science* (1956) is an example.

While much knowledge has been accumulated from the application of hierarchy theory in such diverse fields of study as ecology, biology, linguistics, business, philosophy, mathematics and physics, there are three main critiques that can be levelled at the current state of knowledge regarding hierarchy theory in systems thinking. First, there is no unified definition of the principles and practices of the theory. Second, there has also been no work done on defining the linkages and possible utilities of applying hierarchy theory in concert with other practical methodologies. Third, there is also the lack of a specific methodology for the application of hierarchy theory to demonstrate its practical utility. It is one of the goals of this thesis to address these deficiencies.

## 5.5 Authors Writing on Hierarchical Frameworks and Hierarchy Theory

Many authors have written about hierarchical systems. Some of these people have organised hierarchies from physical to chemical, to biological or man-made in order to explain how smaller units can build to form extremely complex systems. Further reading should include a discussion of hierarchy by Checkland (1981), or Boulding's hierarchy of nine increasingly complex levels from basic inert frameworks through organisms to transcendental systems (Boulding, 1956) or James Miller's hierarchy in Living Systems Theory (Miller, 1978).

Studies of hierarchy include the work of authors such as Boulding (1956, 1961), Pattee (1969, 1973), Bunge (1963, 1969), Miller (1978, 1992), Simon (1973), Weiss et al. (1968, 1969, 1971), Allen and Starr (1982), Ahl and Allen (1996), Troncale (1978a,b, 1988) and Salthe (1985, 1993).

All of these scholars have developed hierarchical analyses of complex systems with similar philosophies, principles, and methodologies, with differences reflected principally by the disciplinary and philosophical backgrounds of each author: i.e. Boulding is an economist; Simon is a management theorist; Miller, Troncale, and Weiss are biologists; and Allen, Starr, and Salthe are ecologists.

Each author describes the same issues of hierarchy, but brings their own unique interpretation to the descriptions: Boulding describes his hierarchy in nine levels; Bunge describes his in five categories; Simon describes his in four intertwined hierarchies; Miller uses eight levels; while Pattee, Salthe, Allen and Starr, and Ahl and Allen do not propose such progressions, but instead work on involvement with the system of interest, its discovery and interpretation using a descriptive investigation that they call 'hierarchy theory'. Weiss discusses the nature of science and the limitations in the way it goes about studying the universe. He talks about units and their properties, discussing the distinction between parts and wholes (Weiss et al, 1971). Salthe makes similar distinctions, discussing "the basic triad": that of the entity, the parts of the entity, and the environment beyond the entity (Salthe, 1985).

## 5.6 Critically Appraising Core Hierarchy Authors

Each author's work will be examined in light of the following questions, and how the writer's have interacted with each other. The questions will aim to critique each body of literature on hierarchy theory in terms of the theory, practice, utility and methods to be found in each piece of work.

The questions to be asked of each author's work are:

- Is the variation of hierarchy that of a framework (an elaboration of a hierarchy by researchers): the functionalist approach; or a hierarchy that is to be discovered by the researcher and others: an interpretive approach?

  This section will first divide those authors to be reviewed according the classification by this first question and then within the two sections of functionalism and interpretivism, address each of the two following questions. The interpretive authors are those to be explored in developing the methodology to be used in analysing the case studies from EID in this thesis. However, the frameworks (the functionalist perspectives of hierarchy, which cannot be called versions of a hierarchy 'theory') will be incorporated into the analysis for a richer picture of the issue being researched in this thesis.

- In addressing the philosophy and principles of an author's interpretation of hierarchy theory: What has the writer contributed to hierarchy as a framework or as a discovery methodology, and has it been examined or critiqued by anyone, including its author?

- In addressing the process and methodology of an author's interpretation of hierarchy theory: Has it ever been developed into a methodology and put into practice, and has that model or practical implementation been examined or critiqued by anyone, including its author?

In *Systems Approaches to Management* (2000), M. C. Jackson explores systems approaches using four research paradigms: the functionalist systems approach; the interpretative systems approach; the emancipatory systems approach; and the postmodern systems approach. In the history of the development of systems thinking, the first corresponds to hard systems, the second to soft systems, and the third and fourth to the current work in critical systems thinking and practice (CST/P). The next two chapters of this thesis explore work done on hierarchies in systems thinking using Jackson's first two frameworks, the functionalist and the interpretive.

The following two chapters do not list all of the literature written about hierarchy, whether functionalist or interpretive: it limits the discussion to the core works of writers in this field. Additional data generated through interviews and questionnaires focused on the theory and application of hierarchy theory will be incorporated into chapter eight.

# Chapter 6

## The Functionalists: Hierarchical Frameworks

This chapter includes the authors working in hierarchy from a functionalist approach. The authors are discussed in order of their contributions to the study of hierarchy. The authors included in this chapter are: Newton, Comte, Gerard, Whyte, von Bertalanffy, Boulding, D. Wilson, Weiss, Pattee, Miller, Aulin, Troncale, Salthe and Eldredge. There are other authors who have worked on hierarchical analyses from a functionalist perspective but these have been filtered (Model 1 from chapter 3) as being derivative from the core authors of Model 1 who are the ones included in this chapter. It is their work that will be used in combination with the work of core interpretive authors of chapter 7 in developing the matrix of principles presented at the end of chapter 7 and implemented and reviewed in chapter 9.

### 6.0 Introduction

We build models and frameworks in order to gain understanding of our "unordered experiences" (Dubin, 1976; Allen and Starr, 1982). One of the frameworks used in this chapter is Boulding's representation for understanding the increasing complexity he saw in each of the levels of organisation, which he then associated with particular disciplines.

Other systems frameworks have been proposed for such analysis such as Jordan's (1968) Systems Taxonomy (in Checkland, 1981) which groups organising principles for systems in terms of rate of change, purpose and connectivity. Jordan then matched those to the polar opposites of being either structural or functional. These organising principles produced eight combinations of increasingly complex system definitions, e.g. structural/purposive/ mechanical, and structural/ purposive/organismic, to name just the first two sets. These are not related however to specific disciplines and they do not offer any measurement tools for defining a scale for complexity.

Another framework for addressing the placement of disciplines was the "system of system methodologies" (SOSM) (Jackson and Keys, 1984), which addressed the increasing levels of complexity in the subject matter of disciplines or methodologies. The SOSM does not address the measurement of that complexity or issues of holism, hierarchy and emergence.

Burrell and Morgan's framework of sociological paradigms underpinning the disciplines (1979) also omits the hierarchical or emergent connections between the subject matter of the disciplines. Checkland himself (1981) proposed a systems typology of natural systems, designed physical systems, designed abstract systems, and human activity systems. The omission again is in dealing with the interrelations between, and the measurement of, these groupings.

Jackson (2000) proposes a set of constitutive rules for a generic functionalist systems methodology, and it is proposed that the work of the authors in this chapter meets the conditions of the constitutive rules shown in table 6.1.

**Table 6.1 Constitutive Rules for a Generic Functionalist Systems Methodology (Jackson, 2000, p.203)**

1 A functionalist systems methodology is a structured way of thinking, with an attachment to the functionalist theoretical rationale that is focused on improving real-world problem situations.

2 A functionalist methodology uses systems ideas as the basis for its intervention strategy and will frequently employ methods, models, tools and techniques, which also draw upon systems ideas.

3 The claim to have used a systems methodology according to the functionalist rationale must be justified according to the following guidelines:

a. an assumption is made that the real-world is systemic;

b. analysis of the problem situation is conducted in systems terms;

c. models aiming to capture the nature of the situation is constructed enabling us to gain knowledge of the real-world;

d. models are used to learn how best to improve the real-world and for the purposed of design;

e. quantitative analysis is presumed to be useful since systems obey mathematical laws;

f. the process of intervention is systematic and is aimed at discovering the best way to achieve a goal;

g. the intervention is conducted on the basis of expert knowledge;

h. solutions are tested primarily in terms of their efficiency (do the means use minimum resources?) and efficacy (do the means work?)

4. Since a functionalist systems methodology can be used in different ways in different situations, and interpreted differently by different users, each user should exhibit conscious thought about how to adapt to the particular circumstances.

5. Each use of a functionalist systems methodology should yield research findings as well as changing the real-world problem situation. These research findings may relate to the theoretical rationale underlying the methodology, to the methodology itself and how to use it, to the methods, models, tools and techniques employed, to the real-world problem situation investigated, or to all of these.

## 6.1 Sir Isaac Newton (1700s)

Working in the late 1600s and early 1700s, the exploration of the physical universe by Newton led to his experiment in the ordering of solid particles. "In his mind's eye Newton arranged solid particles cohering in a stable pattern under mutual attraction and repulsions so that held the space was left void. Then he arranged these pattern similarly on a larger scale, again so as to leave the void at this second level also one half, and so on, until at the fifth level on 1/32 of the total space was filled with matter while 31/32 was void..." (Whyte, 1969a, p9).

According to Whyte (1969a) this work led to the model for other heterogeneous systems such as the periodic table, the hierarchy of electronic states in different atoms, the magic numbers of the atomic nuclei, and Pauling's speculative model of the atomic nucleus" (Whyte, 1969a, p10) [at least it was speculative at the time Whyte was writing in 1969].

Newton's model of hierarchical ordering of the physical universe has since been quantified and diagram by A. Wilson (1969) based on Allen's work (1963) (figure 6.1). This is expanded in figure 6.2 to show the expanded cosmic levels to include atomic scales as well. Several researchers have used this diagram to illustrate the hierarchical concepts of levels, gaps, scale and resolution, as will also be seen in the work of Troncale (1982a) later in this chapter.

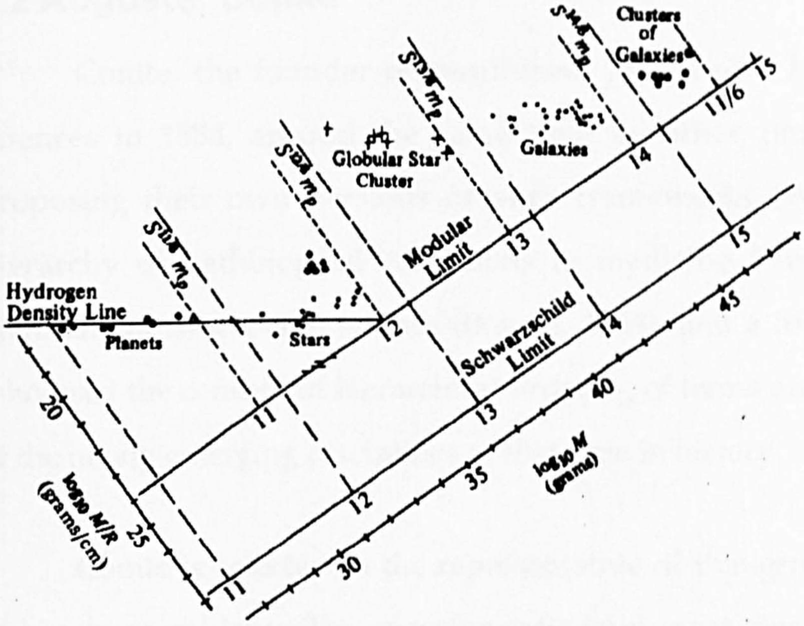



**Figure 6.1 Mass Bounds of Cosmic Bodies (Wilson, 1969a, p125)**

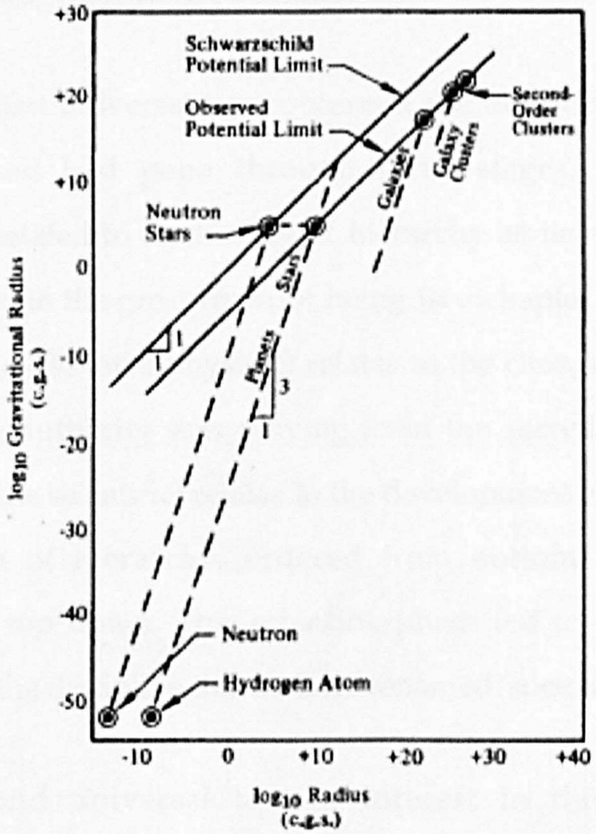



**Figure 6.2 Mass and Size Relations between Atomic and Cosmic Bodies (Wilson, 1969a, p123)**

## 6.2 Auguste Comte

Comte, the founder of positivism, proposed a hierarchy of the sciences in 1854, around the same time as other philosophers were proposing their own versions of such frameworks (Whyte, 1969a): a hierarchy of pathological conditions in medicine (Virchow, 1858), a hierarchy of concepts in science (Bowen, 1864), and a long list of others who used the concept of hierarchical-ordering of terms and concepts in all of the newly emerging disciplines of that time in history.

Comte is selected as the representative of this group because one of his universal laws (the encyclopaedic law) most closely matches the work of von Bertalanffy in the development of general system theory (1968) and Boulding's *Skeleton of Science* (1956).

Comte's first universal law concerned the development of society that he proposed had gone through three stages. The first stage (theological) is related to the history of hierarchy as being rooted in the framework noted in the great chain of being (see chapter 5 of this thesis). The second stage (the metaphysical) relates to the changes of that period in history when authority was moving from the sacred to the profane. The final stage (the scientific) relates to the development of the current use and conception of hierarchy, ordered from bottom up rather than governed from top down. This scientific phase led to his founding of 'social physics', the discipline that he later renamed 'sociology'.

The second universal law of interest to this thesis is the encyclopaedic law, which when combined with the first universal law, produced his systematic and hierarchical classification for all science, the discipline that he called sociology. Comte believed that this new discipline would be the field of endeavour that would unite all of the disciplines into one whole body of knowledge. This was the same aim for von Bertalanffy in his proposal for a general system theory in 1968, which has also not yet come to fruition. Boulding's *Skeleton of Science* (1956) also follows this same pattern of positivist research.

## 6.3 Ralph Waldo Gerard (1940, 1942, 1956, 1957, 1969)

Ralph Gerard was a neurobiologist who was interested in "systematically fitting the biological and social sciences into a single scheme with the view of developing methodologies applicable to both" (Hammond, 2003, p.146). He was a mentor and co-collaborator, along with Rapoport, of Miller from the early 1950s onwards, and work done with Miller, Rapoport and others at the Centre for Advanced Studies in the Behavioral Sciences formed the base for Miller's major work on *Living Systems* published in 1978 (Hammond, 2003)

His work focussed on the concept of entitation: the identification of entity and levels. He developed a framework similar to that of Boulding but displayed in a different form as a field displaying along the x-axis the levels of 'orgs' (his name for levels, similar to that of 'holon' (Koestler, 1967), and along the y-axis, their properties (being, becoming and behaving). The intersections of these axes reveal a discipline that is used to study that org holding that property. My interpretation of this arrangement is shown in figure 6.3.

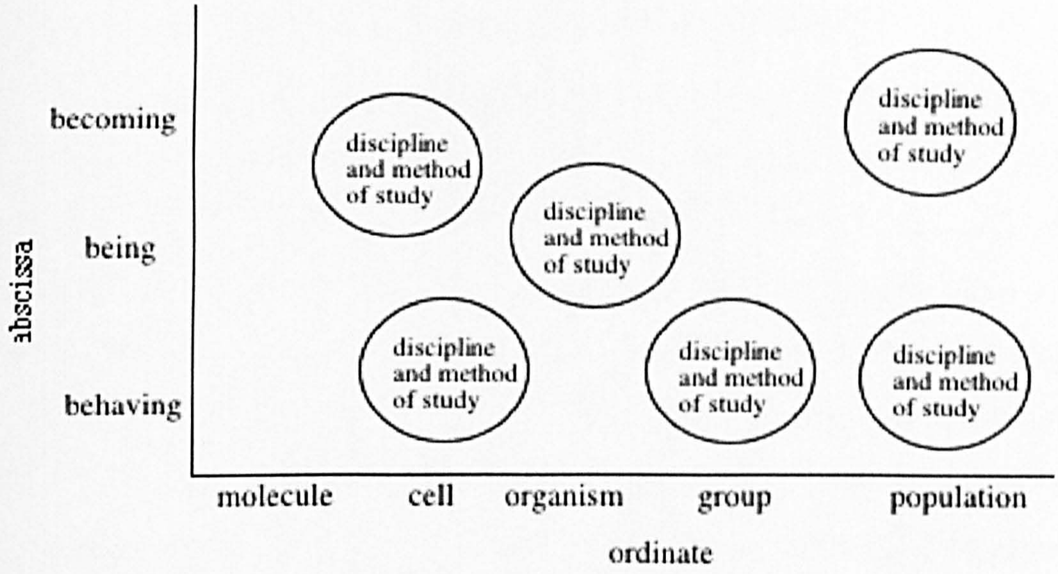



**Figure 6.3 Diagramme of Gerard's Fields of Disciplines (Wilby, 2007, from data in Gerard, 1957)**

Gerard listed the disciplines in a hierarchy, as did Boulding in 1956. Gerard's described his hierarchy thus: "The hierarchy has two main branchings: (i) above the molecule level, into more organized entities with or without the collective properties that describe the living; and (ii) above the organism level, into entities based on human or non-human components. Biology is thus superordinate to physics and chemistry and, at its lower levels, coordinate to the earth sciences; it is subordinate to and, at its higher levels, coordinate to the social sciences" (Gerard, 1957, p.433).

Hammond summarised Gerard's being, behaving and becoming, to the categories of: "structure (including static relationships among constituent parts, such as channels of communication and lines of authority; function (including the way systems at each level react to inputs from the environment; and evolutionary change" (Hammond, 2003).

## 6.4 Lancelot Law Whyte (1949, 1965, 1969a,b)

L. L. Whyte teamed with Albert G. Wilson and Donna Wilson in producing the proceedings for one of the central meetings in hierarchy that was held in November 1968 in Huntingdon Beach, California. The conference was funded through the sponsorship of the Douglas Advanced Research Laboratories and the University of California, Irvine, California. The theme of the conference was *Hierarchical Structure in Nature and Artifact* and it brought together several of the authors covered in chapters 6 and 7 of this thesis. It also produced the book *Hierarchical Structures* (1969). Arthur Koestler, mentioned earlier in chapter 5 and later again in chapter 7, held his own symposium on the same topic in the same year at Alpsbach in Austria. The work of the participants at both of these meetings is included in this thesis where appropriate.

L. L. Whyte was interested in what he called the "unitary principle": how particles form themselves into patterns, in increasingly ordered and complex structures. He was one of many thinkers at that time who were interested in the explanation of the origin of life from the physical and biological perspective. He is reported to have worked with Einstein for one year in Germany, and he founded Power Jets, Ltd. In the mid 1930s, which financed and then developed Frank Whittle's invention: the jet engine (Craig, 2002).

Whyte's works on hierarchical structures, published in 1949 and 1969, will be detailed in this section. However, first there is the discussion as to why he has been placed in this section with the functionalist approaches.

In his introduction to the proceedings he alludes to the philosophical stance that the effects of the observer (or researcher) must be carefully removed: "In this symposium we try to give both aspects their due [ideas and facts]: the ideal of logical clarity and the stubborn kernal of fact from which subjective prejudices have been removed, as far as possible. Our exchanges should assist that difficult task" (Whyte, 1969a, p5).

Whyte suggests "that the time has arrived for the gradual development of a comprehensive physical theory of the structural hierarchies of nature, perhaps a geometrical physics of clusters, nested structures, and nuclei of atoms and crystals, etc., including the processes which produce these. And of the biophysical hierarchies too, followed later by the social" (Whyte, 1969a, p11). This is the precursor of thought in the development of the frameworks that follow in this chapter.

## 6.5 Ludvig von Bertalanffy (1952, 1955, 1968)

Ludvig von Bertalanffy wrote on levels in the early 1950s (1952, 1955, and 1968) beginning with his book entitled: *Problems of Life* (1952). In *Problems of Life* von Bertalanffy proposed a hierarchy of statistics; that all laws of nature are of a statistical nature" and that "science as a whole appears as a hierarchy of statistics; that "they are statements about the average behaviour of collectives" (von Bertalanffy, 1952, p.172). The hierarchy he presented in this work was as follows:

- A "statistics of microphysics: that is, of those phenomenon where a great number of elementary physical units is concerned;"

- A second level ... "by the laws of macrophysics, that is of those phenomena where a great number of elementary physical units is concerned."

- A third level "represented by the biological realm. ... we can state overall laws for the biological system as a whole, foregoing determination of the individual physico-chemical processes comprised", and

- A fourth level, "represented by "the laws that apply to supra-individual units of life. e.g. the growth of populations, or for the incidence of death within a human population." (von Bertalanffy, 1952, p.172-3).

This hierarchy represents an increase in the degrees of freedom within the system i.e., different possibilities are left open to the individual events (ibid, p175).

His other work on a hierarchical functional representation is included in this section as an interpretation of Boulding's work from 1956. His other more notable work on general systems theory began in the 1940s as seen in the section on Auguste Comte earlier in this chapter.

von Bertalanffy thought that a "general theory of hierarchic order ... will be a mainstay of general systems theory" (von Bertalanffy, 1968, p.28) and presented an interpretation of the levels of Boulding's *Skeleton* in his book on *General System Theory* (1968). von Bertalanffy's interpretation of the *Skeleton* drew from the levels stated by Boulding and the description and examples as well, but added a column and note exploring the limits of current knowledge and development within disciplines of theories and models to adequately address the content of each of Boulding's levels in the *Skeleton*. It is for this reason, a similar outcome to one shown later in this thesis, that von Bertalanffy is included in this section. While he has not created his own framework of hierarchic order, he is included here for his own interpretation of the *Skeleton*.

**Table 6.2** ***Skeleton of Science*** **(von Bertalanffy, 1968, pp.28-9)**
An informal survey of main levels in the hierarchy of systems. Partly in pursuance of Boulding (1956).

| LEVEL | DESCRIPTION AND EXAMPLE | THEORY AND MODELS |
|---|---|---|
| Static structures | Atoms, molecules, crystals, biological structures from the electron-microscope to the macroscopic level | e.g. structural formulas of chemistry; crystallography; anatomical descriptions |
| Clockworks | Clocks, conventional machines in general, solar systems | Conventional physics each as laws of mechanics (Newtonian and Einsteinian) and others |
| Control mechanisms | Thermostat, servo-mechanisms, homeostatic mechanism in organisms | Cybernetics; feedback and information theory |
| Open systems | Flame, cells and organisms in general | (a) Expansion of physical theory to systems maintaining themselves in flow of matter (metabolism).<br>(b) Information storage in genetic code (DNA)<br>Connection of (a) and (b) presently unclear |
| Lower organisms | "Plant-like" organisms: Increasing differentiation of system (so-called "division of labor" in the organism); distinction of reproduction and functional individual ("germ track and soma") | Theory and models almost lacking |

| | | |
|---|---|---|
| Animals | Increasing importance of traffic in information (evolution of receptors, nervous systems); learning; beginnings of consciousness | Beginnings in automata theory (S-R relations), feedback (regulatory phenomena), autonomous behaviour (relaxation oscillations), etc |
| Man | Symbolism; past and future, self and world, self-awareness, etc., as consequences; communication by language, etc. | Incipient theory of symbolism |
| Socio-cultural systems | Populations of organisms (humans included); symbol-determined communities (cultures) in man only | Statistical and dynamic laws in population dynamics, sociology, economics, possibly history. Beginnings of a theory of cultural systems. |
| Symbolic systems | Language, logic, mathematics, sciences, arts, morals, etc. | Algorithms of symbols (e.g. mathematics, grammar); "rules of the game" such as in visual arts, music, etc. |

"N.B.—This survey is impressionistic and intuitive with no claim for logical rigor. Higher levels as a rule presuppose lower ones (e.g. life phenomena those at the physico-chemical level, socio-cultural phenomena the level of human activity, etc.); but the relation of levels requires clarification in each case (cf. Problems such as open system and genetic code as apparent prerequisites of "life"; relation of "conceptual" to "real" systems, etc.). In this sense, the survey suggests both the limits of reductionism and the gaps in actual knowledge." (von Bertalanffy, 1968)

## 6.6 Kenneth Boulding (1956)

Kenneth Boulding was a co-founder of the Society for General Systems Research in (SGSR) 1954. In 1956 Kenneth Boulding wrote *The Skeleton of Science* and in that paper he proposed a practical framework for studying and integrating the knowledge between different disciplines. He began his training in economics, but from the pull towards the thinking and work of the generalist was evident from a very early age.

This section discusses the hierarchy of system complexity that Boulding proposed in his article *General Systems Thinking - The Skeleton of Science*, originally published in Management Science, 2 (1956), pp. 197-208, and also to explore the development of the thought behind the writing of that article. The paper will also address the implications the Skeleton has for systems theory and practice and specifically advances, or lack thereof, in general systems research. The *Management Science* article came from earlier work done on the *The Image*, written during Boulding's residency at the Stanford University Center for Advanced Study in the Behavioral Sciences in 1954-1955.

Boulding designed his framework to reflect that different disciplines are bodies of knowledge that focus on the investigation of a particular unit. He further proposed that each discipline had its own measurement, experimentation, and evaluation techniques. Therefore simply transferring individual models and languages of description from one level of unit-analysis to another would lead to an inadequate representation: that lower-level (e.g. biological) techniques would not adequately describe higher-level (e.g. societal), more complex, units of investigation (Boulding, 1956). The underlying theme in Boulding's research and writing was the search for governing principles, rules and system structures. He admitted to "a secret and insidious passion for generality and for system" (Kerman, 1974). He desired to find some system of measurement applicable to the general field of social systems.

> "Metaphor is his natural mode; it seems to come as easily as breathing. But perhaps one of the wildest stretches of imagination occurs in his description of the gravimeter. If,

he suggests, the physical world were as difficult to predict as social systems are, with the gravitational constant changing as rapidly as do such vital quantities as the price level or the range of the deadly missile, 'we would literally never know how to get out of bed. On Monday we fly through the window and Tuesday we would crack our head on the floor . . . we would have to have a gravimeter by the bedside to tell us before we even got up whether to make a desperate leap or a gentle movement . . . We desperately need a social systems equivalent of the gravimeter by the bedside.'" (Kerman, 1974)

Boulding's proposal for a social-systems gravimeter was the "Skeleton of Science", consisting of nine levels of organization showing an ever-increasing complexity. In *The Skeleton of Science* Boulding describes two possible aims of GST:

> "it aims to point out similarities in the theoretical constructions of different disciplines, where these exist, and to develop theoretical models having applicability to at least two different fields of study. At a higher level of ambition, but with perhaps a lower degree of confidence it hopes to develop something like a "spectrum" of theories—a system of systems which may perform the function of a "gestalt" in theoretical construction. Such "gestalts" in special fields have been of great value in directing research which they reveal" (Boulding, 1956, p197).

So in high ambition/low confidence Boulding proceeds to propose two ways of attacking the construction of a "system of systems": either as a series of relationships or as a hierarchy (based on empirical theories/models) of empirical units also seen as an hierarchical progression of increasing complexity of information.

Below the surface of this structure therefore, there are at least four different frameworks to be found with the skeleton. The first three frameworks address Boulding's thoughts of an hierarchical description of systems, while the fourth framework addresses the series of interrelationships that are perceived by the observer of the system.

- the first is that the structure simply explains the ever-increasing complexity of phenomenon

- the second, and the one seen most clearly in the Skeleton, is that the structure develops ever more complex levels of systems

- the third is that of a structure of progressively more complex models for describing what is happening at those system levels, and

- the fourth is that of the increasing complexity of the image of the world held at each level of the Skeleton and how that image is observer-dependent (or level-dependent) in its interpretation of its incoming messages and in perceiving the interrelationships between the parts of a level, or systems levels.

### The Nine Levels of Boulding's Skeleton of Science

The frameworks presented here are from Mingers (1997). These tables explain the characteristics of each level of the framework. In the first table the disciplines are shown as Boulding presented them, ascribing specific disciplines to each level of the framework depending on the unit of their investigation were the disciplines in 1956 and newer disciplines could be added at every level in 1998, e.g. ecology at either level 7 or 8, and neurobiology at level 7.

| Level | Description | Characteristic | Example | Discipline |
|---|---|---|---|---|
| 1 | Structures and frameworks | Static, spatial pattern | Bridge, mountain, crystal, atom | Descriptive elements of all disciplines |
| 2 | Clockworks | Predetermined motion | Clocks, machines, solar system | Physics, astronomy, engineering |
| 3 | Control mechanisms | Closed-loop control | Thermostat, homeostasis | Cybernetics |
| 4 | Open systems | Structurally self-maintaining | Flames, cells | Theory of metabolism |
| 5 | Genetic–societal systems | Society of cells, functional parts | Plants | Botany |
| 6 | Animals | Nervous system, self-awareness | Birds and beasts | Zoology |
| 7 | Humans | Self-consciousness, knowledge, language | Human beings | Biology, psychology |
| 8 | Socio-cultural systems | Roles, communication, values | Families, boy scouts, clubs | History, sociology, anthropology |
| 9 | Transcendental systems | Inescapable unknowables | God? | Philosophy, religion |

**Figure 6.4 Boulding's *Skeleton of Science* (from Mingers, 1997, p306)**

Figure 6.5 on the next page is taken from Mingers (1997). Mingers used and modified the Boulding Skeleton of Science (1956) and offers the additional specification of types of relations for each of the levels and updates the characteristics in light of new developments in description since 1956. Mingers (1997) first changes the descriptions of Boulding's nine levels to more closely describe the organisation of the system in terms of its different types of internal and external relationships. This adds clarity, but the work proceeds then to change and relate the levels of the *Skeleton* to increasing levels of complexity using terms from autopoiesis. This was done to escape the need for defining a scale of complexity, but it changes the *Skeleton* from addressing disciplines into a more general taxonomy and it mixes types by equating physical systems with biological (or living) systems, whereas it is not possible to describe a corporation as an actual living system except as an analogy (Checkland, 1981) or metaphor.

| Level | Description | Characteristic | Type of relations | Example |
|---|---|---|---|---|
| 1 | Structures and frameworks | Static, spatial patterns | *Topology* (where) | Bridge, mountain, table, crystal |
| 2 | Single mechanistic systems | Dynamic, pre-determined changes, processes | *Order* (when) | Solar system, clock, tune, computer |
| 3 | Control mechanisms, cybernetic systems | Error-controlled feedback, information | *Specification* (what) | Thermostat, body temperature system, auto-catalytic system |
| 4 | Living systems | Continuous self-production | *Autopoietic* relations | Cell, amoeba, single-celled bacteria |
| 5 | Multicellular system | Functional differentiation | *Structural coupling* between cells (Second-order autopoiesis) | Plants, fungi, moulds, algi |
| 6 | Organisms with nervous systems | Interaction with relations | *Symbolic, abstract* relations | Most animals (except, e.g., sponges) |
| 7 | Observing systems | Language, self-consciousness | *Recursive, self-referential relations* | Humans |
| 8 | Social systems | Rules, meanings, norms, power | *Structural coupling* between organisms (third-order autopoiesis) | Families, organizations |
| 9 | Transcendental systems | | | |

**Figure 6.5 Minger's Adaptation of Boulding's *Skeleton of Science* (from Mingers, 1997, p307)**

The descriptions of each of the levels are as follows, with text extracted and summarised from the *Skeleton of Science* (Boulding, 1956).

The first level is that of the static structure, e.g. the jigsaw puzzle, the picture or the statue, or even the atom and molecule. The world of static structures is the world of things, trees, houses, land, roads, oceans, and planets (Boulding, 1956).

The second level is the level of the clockwork. This is the level of the predetermined dynamic structure repeating its movements because of some simple law of connectedness among its parts. This is the world of mechanics (Boulding, 1956).

The third level is the thermostat or homeostatic control mechanism. These mechanisms consist of a sensor, a control, and an effector. Homeostasis, which was first coined by the physiologist Cannon, describes the control systems operating in all biological systems (Boulding, 1956).

The concept of the image, (which will be explained in greater detail following this section), begins at this third level where even the thermostat must have an image of the outside world so that it can control the difference between the normal, or goal, behaviour and any deviation from that goal (Boulding, 1956).

The fourth level of the skeleton is the cell, which is the simplest unit of life. This level differs from the previous level in that it is an open system unlike the closed-system control mechanism, i.e., it maintains its structure in the midst of a throughput of chemical material. The cell also has knowledge of its environment, like the thermostat above, but it has the additional capability of being able to interpret the information it receives into the form of a knowledge structure (Boulding, 1956).

The fifth level is the botanical level. A plant is a society of cells, with an intricate structure and division of labour. The behaviour of plants can only be explained on the assumption that they build the messages received from the environment into some kind of a simple image. Plants know when to do certain things in relation to their environment, e.g. seeding, flowering, and following the seasons (Boulding, 1956).

The sixth level is that of the first animal structures, not only cell societies with division of labour, growth, and the simplest images of time, but also cell societies with something like awareness and mobility, sleep and waking times, and perhaps even the simplest of self images (Boulding, 1956).

> "Corresponding to this increased capacity for absorbing information, there is an increased complexity of the image and a greatly increased capacity for learning. Plants mutate, but animals actually learn." (Boulding, 1961)

The seventh level is that of the human level. Boulding states that man's capacity for gathering sensory information is not that much different from the animals at lower levels. What is different however, "is man's capacity for organizing that information into large and complex images. (Boulding, 1956)

The human level of organization has the capacity for language, for recording, for an image of time (past, present and future); not possessed by prior levels of organization. "The human also has self-awareness; man knows that he knows." (Boulding, 1956)

The eighth level is that of the social organization, a level that along with the ninth, and final, level, were not explicitly discussed or developed in The Image, but were included in the later article in Management Science. The level of social organization consists of the "role", "which is that part of the person which is concerned with the organization or situation in question, and it is tempting to define social organizations, or almost any social system, as a set of roles tied together with channels of communication." (Boulding, 1956)

The ninth and final level is the level of the transcendental system, the level of the unknowable, the absolute, and the level of questions without answers. At this level, Boulding has very little description or explanation of the structure of a transcendental system (Boulding, 1956).

Boulding is not the only systems thinker to develop such a hierarchy, but he was one of the first to do so in the 1950's. While other systems theorists, notably James Miller, also developed a hierarchical approach to living systems and extensively developed that in further writings, Boulding never returned to the *Skeleton* in his later writings.

Boulding designed his skeleton to reflect that different disciplines are bodies of knowledge that focus on the investigation of a particular unit. He further proposed that each discipline had its own measurement, experimentation, and evaluation techniques. Therefore simply transferring individual models and languages of description from one level of unit-analysis to another would lead to an inadequate representation: that lower-level (e.g. biological) techniques would not adequately describe higher-level (e.g. societal), more complex, units of investigation (Boulding, 1956).

Checkland writes (where italics denote the additional unit required at the next higher level of the framework):

> "To specify a structure, length and perhaps mass are needed; clock-works require lengths, masses, and *time*; a thermostat specification requires lengths, masses, times, and a measure of *information*. But thereafter, not surprisingly, this essentially reductionist approach breaks down, and the problem remains that we have no adequate account of systemic complexity (Checkland, 1981, p106).

While not provable objectively or quantitatively, Boulding does conceptually address both hierarchy and the increasing complexity of the subject matter of the disciplines, and recognises that with each new level, more complex models and languages of description are required.

Although Boulding cannot prove the boundaries between the disciplines and the units of investigation in his framework he at least does not ignore that this is a requirement. Instead he concludes that above level 4 of his framework there is no adequate measurement of the increase in complexity. This produces a valid warning that "we should never accept as final 'a level of theoretical analysis which is below the level of the empirical world which we are investigating'" (Checkland, 1981, p104). For instance, in management science:

> "During and after the second World War...the development of cybernetics put emphasis on 'level 3' feedback control systems. Most recently there has been a considerable attempt to bring in behavioral science in order to treat management problems at levels 7 and 8. Thus the historical development of management science can be seen as an attempt to treat its problems as being those of ever more complex systems. This can be a useful perspective. It serves as a reminder, for example, that a typical management science model constructed in terms of multiple interacting feedback loops, even if complicated, is only a level 3 model and hence can cover only certain aspects of a management problem at level 8. Management scientists have been known to claim more." (Checkland, 1981, p106)

It is acknowledged that this is a specific critique from the perspective of Checkland concerning the nature of cybernetic systems as they were developed in the 1940s and 1950s, and that the work of Beer, for example, adds depth with the addition of Beer's work in control mechanisms within social systems and a full theoretical framework explaining in detail issues of control, communication and adaptation in organisations (1979, 1981, 1985).

The fourth framework seen within Boulding's Skeleton, that of the increasing complexity of the image of the world held by each level of his structure and how that image is observer-dependent (or level-dependent) in its interpretation of its incoming messages, comes from the work Boulding was doing with his writing in *The Image* (1961).

To briefly explain Boulding's idea about image: the image determines the behaviour of the entity and is built up as a result of all the past experiences of the holder of the image. Messages are received by the entity's image through its value filters and they can either be ignored, added to the image, or radically restructure the image depending on the values placed on the incoming messages by the entity. Values are very important in determining the impact of any message on the image.

> "The message which comes through the senses is itself mediated through a value system. We do not perceive our sense data raw; they are mediated through a highly learned process of interpretation and acceptance. What this means is that for any individual organism or organization, there are no such things as 'facts'. There are only messages filtered through a changeable value system. Part of our image of the world is the belief that this image is shared by other people like ourselves who also are part of our image of the world. e.g. If a group of people are in a room together, their behavior clearly shows that they all think they are in the same room." (Boulding, 1961, p.14)

This is the problem of the observer in the system and deals directly with Checkland's concern that there is no definition of the scales for defining systems complexity. If the messages received are interpreted by each of Boulding's entities through individually-determined value filters then no two entities above the mechanistic second or third levels could hope to agree exactly on the incoming data, its interpretation, the size of gaps between levels, or even the drawing of the boundaries of those levels. There could be no agreed-on, absolute, mathematical yardstick for developing models or descriptions at Boulding's upper levels of the Skeleton.

So it is interesting that while we can look at Boulding's attempt to define a systems structure and feel that it may be intuitively correct, it is also not surprising that because we are at a high level of complexity in that structure, and at that level we have a very complex and individual image of our incoming world, we cannot hope to reach a consensus concerning an absolute definition for the structure of these higher levels and the models and methods for exploring those higher levels.

However, while not provable objectively or quantitatively, Boulding does conceptually address both hierarchy and the increasing complexity of the subject matter of the disciplines, and recognises that with each new level, more complex models and languages of description are required. So, although Boulding cannot prove the boundaries between the disciplines and the units of investigation in his framework he at least does not ignore that this is a requirement. Instead he concludes that above level 4 of his framework there is no adequate measurement of the increase in complexity. Systems theory can be criticised for its inability to develop credible models and languages of description for those levels that involve living systems (level 4 and above). This is a valid critique and many practical consequences such as professional reputation and funding considerations depend on the validity of the research content as judged by those within the dominant paradigm. There is the danger that if non-scientific models were proposed for interventions at the higher levels of the Skeleton, then the results of those interventions would find credibility in the scientific community a difficult achievement.

Boulding's Skeleton does feel intuitively correct. The problem of increasing complexity in image, message filtering and observer-dependency at the higher levels of the Skeleton will continue to frustrate the search for a working, valuable, social-science gravimeter. It may also explain the lack of specific follow-up work on the Skeleton by Boulding and other writers in the field of general systems theory.

This thesis cannot provide the missing boundary definitions and measurements for the complexity at the higher levels of the framework, but it can carry Boulding's warning into the implementation and evaluation in later chapters in this thesis.

## 6.7 Donna Wilson (1969)

Donna Wilson was one of the organisers with Albert G. Wilson and L. L. Whyte for the conference that produced *Hierarchical Structures* (1969). Wilson's contribution was a survey of the existing literature in hierarchical structures and the reporting of a typology of hierarchical structures from the work of Bunge (1960) that is summarised in figure 6.6.

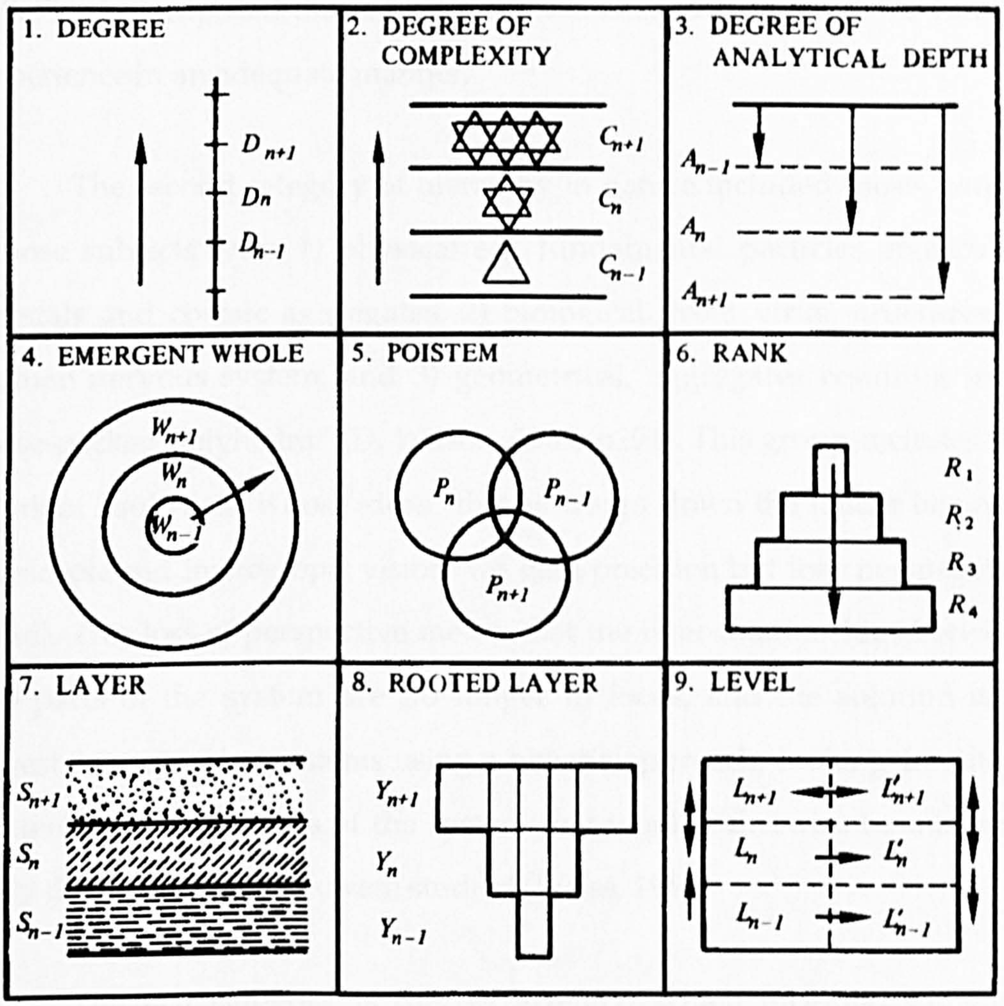



**Figure 6.6 Uses of the Term Level (From Levels: A Semantic Preliminary, Bunge 1960)**

Wilson's analysis of hierarchy was sorted into three categories: hierarchy as a concept; hierarchy in nature; and hierarchy in artefact (computer systems and modelling).

In the first category of hierarchy as a concept, Wilson places Simon, Weaver, Koestler, Gerard, Whyte (who traced the concept historically in his 1969 book) stating that the term 'hierarchy' has been important in biological research since only about 1910, Bunge (see figure 6.6), Grene

(1967) who proposed that a hierarchy was needed to account for human experience in an adequate manner,

The second category of hierarchy in nature included those "works whose subjects were 1) physical e.g. fundamental particles, molecules, crystals and cosmic aggregates, 2) biological, from virus structures to human nervous system, and 3) geometrical, aggregates resulting from close-packed polyhedra" (D. Wilson, 1969, p291). This group includes the work of Paul Weiss whose ideas "that as we go down the ladder between telescopic and microscopic vision, we gain precision but lose perspective" (ibid). This loss of perspective means that the inter-relationships between the parts of the system are no longer in focus, and the solution is to investigate complex systems using a holistic approach, looking for those patterns and behaviours of the system that would otherwise be missed if only the individual parts were studied (Weiss, 1969),

The last category is that of artefact, which included software; hardware; organizations of data (files, management schemes); cognition (dealing with knowing and pattern recognition); and epistemology (classifying knowledge and disciplines) (D. Wilson, 1969, p.291).

Wilson's philosophical approach to studying hierarchy is not stated in her writing, but since there is also no discussion of an interpretive or descriptive process to discovering hierarchy acknowledged in her text, then Wilson has been placed within this chapter with the functionalist paradigm.

## 6.8 Paul Weiss (1969, 1971)

Paul Weiss contributed to the hierarchy conference held in Austria in 1968 (publication, 1969), and published his book *Hierarchically Organized Systems in Theory and Practice* (1971) incorporating that previous presentation. Weiss discussed the nature of science and the limitations in the way it goes about studying the universe. He researched units and their properties, discussing the distinction between parts and wholes (Weiss, 1971).

His functionalist philosophical position in this chapter is based on his statement that: "My prime object here is to document that certain basic controversies about the nature of organisms and living processes, which have long failed to melt away in the heat of argument (e.g. reductionism versus holism), readily vanish in the light of realistic studies of the actual phenomena, described in language uncontaminated by preconceptions, In this light (!) the principle of hierarchic order in living nature reveals itself as a demonstrable descriptive fact, regardless of the philosophical connotations that it may carry" (Weiss, 1969, p.4).

He believed that taking living organisms apart and putting them back together again did not yield a necessary and sufficient explanation of the behaviour of even the most-simple living system (Weiss, 1971, p7). Why parts function within the whole, despite their individual constructions, was one of the foci of his work. He discussed the implications of the statement about the whole being greater than the sum of its parts as being not a mathematical implication but rather that "more": "does not refer to any measurable quantity in the observed systems themselves; it refers solely to the necessity for the observer to supplement the sum of statements that can be made about the separate parts by any such additional statements as will be needed to describe the collective behavior of the parts, when in an organized group. In carrying out this upgrading process, he is in effect doing no more than restoring information content that has been lost on the way down in the progressive analysis of the unitary universe into abstracted elements" (Weiss, 1971, p.11) [i.e. in the process of reductionism].

Weiss developed a model to demonstrate his thesis that hierarchy was a biological necessity for the maintenance of life in living systems. His model progressed from the living cell, through organelles (subsystems) and up in the opposite direction to suprasystems. He also included a discussion of the brain as a system. His model is illustrated in figure 6.7.

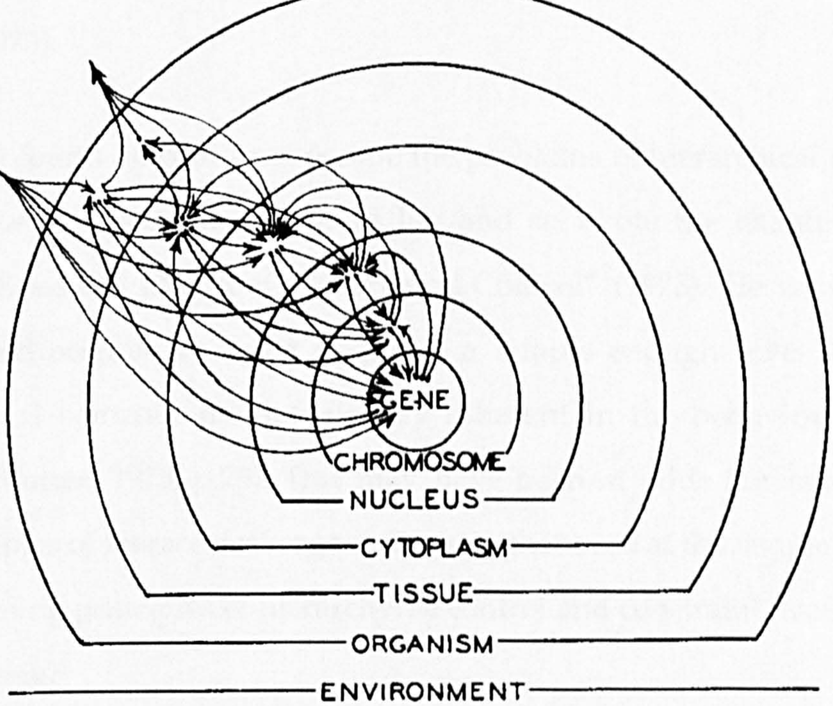



**Figure 6.7 Interactive Relations among the Hierarchically Ordered Subsystems of an Organism (Weiss, 1968)**

The use of his terminology and framework is similar to the one developed by Miller in his work on *Living Systems,* in section 6.9. It is similar also to the work of Herbert Gutman, another participant in the Huntington Beach conference who wrote on structure and function in living systems (Gutman, 1961, 1964, 1969).

## 6.9 Howard Pattee (1973)

In his chapter in his edited book *Hierarchy Theory,* (1973) Howard Pattee explored the physical basis for the origin of life through the discipline of physics, which he acknowledges was not the usual approach since hierarchical structures were more commonly explored through biology and ecology at that time (Pattee, 1973). Pattee states that the purpose of his book is "to clarify relationships between parts and wholes of hierarchical systems from the perspectives of basic physics and biology" (Pattee 1973).

He found he could not escape the problems of hierarchical control in his research into the origins of life and so wrote the chapter "The Physical Basis and Origin of Hierarchical Control" (1973). He wrote: "to understand origins we must begin at a simple enough level so that hierarchical controls are not already inherent in the behavior of the system" (Pattee, 1973, p.75). This may have been at odds however with the principles of hierarchical organisation, in that even at the simple levels, the governing principles of hierarchy, of control and constraint, would still be operating.

One of the themes in his book describes the necessity of using several levels of description to extract significant data from a system since "what is true at a lower level does not usually give a clear picture of the upper level" (Pattee, 1973). This point is also taken up in the work of Allen and Starr (1982) seen in this chapter of this thesis. Allen and Starr explain that the behaviours and structures of higher levels cannot be predicted by the behaviours of the lower levels due to differences in scale and filters.

He was also interested in the functional simplicity of complex systems and the "apparent paradox that hierarchical controls both limit freedom and give more freedom at the same time. The constraints on the genetic code on ordinary chemistry make possible the diversity of living forms. At the next level, the additional constraints of genetic repressors make possible the integrated development of functional organs and multicellular individuals" (Pattee, 1973, p.73). This pattern continues with social, legal and political levels. So, he equated the search for the physical basis for the origin of life with the same control constraints that allow free living matter to evolve along innumerable pathways" (p.75).

He found three criteria in these investigations: number, force and time scales:

- Levels -- "the atom, the molecule, the crystal, and the solid can be distinguished as levels by the criterion of number; that is, each level is made up of a large collection of the units of the lower level." (p.76)

- Forces – "a physical hierarchy of forces underlying these levels, the strongest forces being responsible for the smallest of lowest level structures. The strongest force holds together the nuclei of the atoms, and the weakest force, gravity, holds together the largest bodies of matter." (p.76)

- Time scales – "a hierarchy of dynamical time scales, which may be associated with the levels of forces, the shortest time with the strongest force and smallest structures, and the longest time with the weakest force and largest structures." (p.76)

These interactions of levels, forces and timescales lend themselves to mathematical equations for the level of the hierarchy under investigation and relate to the term of "near-decomposability" coined by Simon (Pattee, 1973). Pattee was also vexed with the structure-function problem, understanding that there were serious disagreements on the interrelationships between these two states. He also defined in this article, control and constraint in hierarchy that are core principles, explicit in the description of a hierarchy (interpretive) although not explored but more of a given in hierarchy frameworks (functionalist).

The problem with control was "find[ing] how to add constraints without giving up all the degrees of freedom in an entity. What we need for a useful control system is a set of constraints that holds between certain degrees of freedom, but that does not lead to completely rigid bodies" (Pattee, 1973, p.83). These control systems have two conditions: "First, an effective control event cannot be simply a passive, spatial constraint, but must actively change the rate of one particular event, reaction, or trajectory relative to the unconstrained rates. ... Second, the operation of the constraint must be repeatable without leading to the freezing up of the system." (Pattee, 1973, p.83-4).

Constraint he defines as "a forcible limitation of freedom". (p.85). After debate he states that "a hierarchical constraint is established by a particular kind of new rule that represents not merely a structure but a classification of microscopic degrees of freedom of the lower level it controls" (p.89). Finally, he states that: "we cannot understand the nature of biological hierarchies simply by a finer look at molecular structure, nor by application of non-equilibrium statistical thermodynamics. While each of these physical disciplines is useful for describing a particular level of biological organization, hierarchical control operates between levels and is therefore a problem of the nature of the interface between levels" (p.105).

Pattee's approach to the classification of hierarchy and the understanding of the interfaces between levels rests on three things: 1) there must be a classification of detail, a detailed description of the microscopic dynamics of the elements; 2) an optimum constraint that is evaluated by the effectiveness of the function of the entity; and 3) statistical closure reflecting the "indefinite capability" of biological organisations "to evolve new functions and new hierarchical levels of control while maintaining a relatively fixed set of elementary parts at each level." (p.107)

Pattee does not believe that such a physical theory for the explanation of the origins of life currently exists but for the reason that he proposes this explanation should be statistical, mathematical and based in physical science, his work has been placed in the functionalist category of this thesis.

## 6.10 James Miller (1978)

James Miller's framework was developed over many years of working within a combination of fields in the natural and social sciences, leading not only to this work in living systems theory but also to the origination of the discipline of behavioural science. His work is an attempt to explain living systems in both the natural and social spheres. The primary text of this work is *Living Systems* (1978) which was supplemented by an overview of his work in *More than the Sum of the Parts* in 1992 and several other articles that added the twentieth subsystem (the timer) to the framework, and those where he and Jessie Miller (his wife) have discussed further implications and applications of this framework. Miller's framework has been used widely in systems applications, most notably in the work of Simms (1971, 1983, 1999, and 2006 (in press)), Tracy (1989, 1994), Bailey (1990, 1994, 19992001a,b; 2005) and Swanson (1989, 1997).

Miller stated that "LST demonstrates that living systems exist at eight levels of increasing complexity: cells, organs, organisms, groups, organizations, communities, societies, and supranational systems" (Miller and Miller, 1992). The community was a later addition to the framework first presented by Miller in 1978. This framework is shown in figure 6.8.

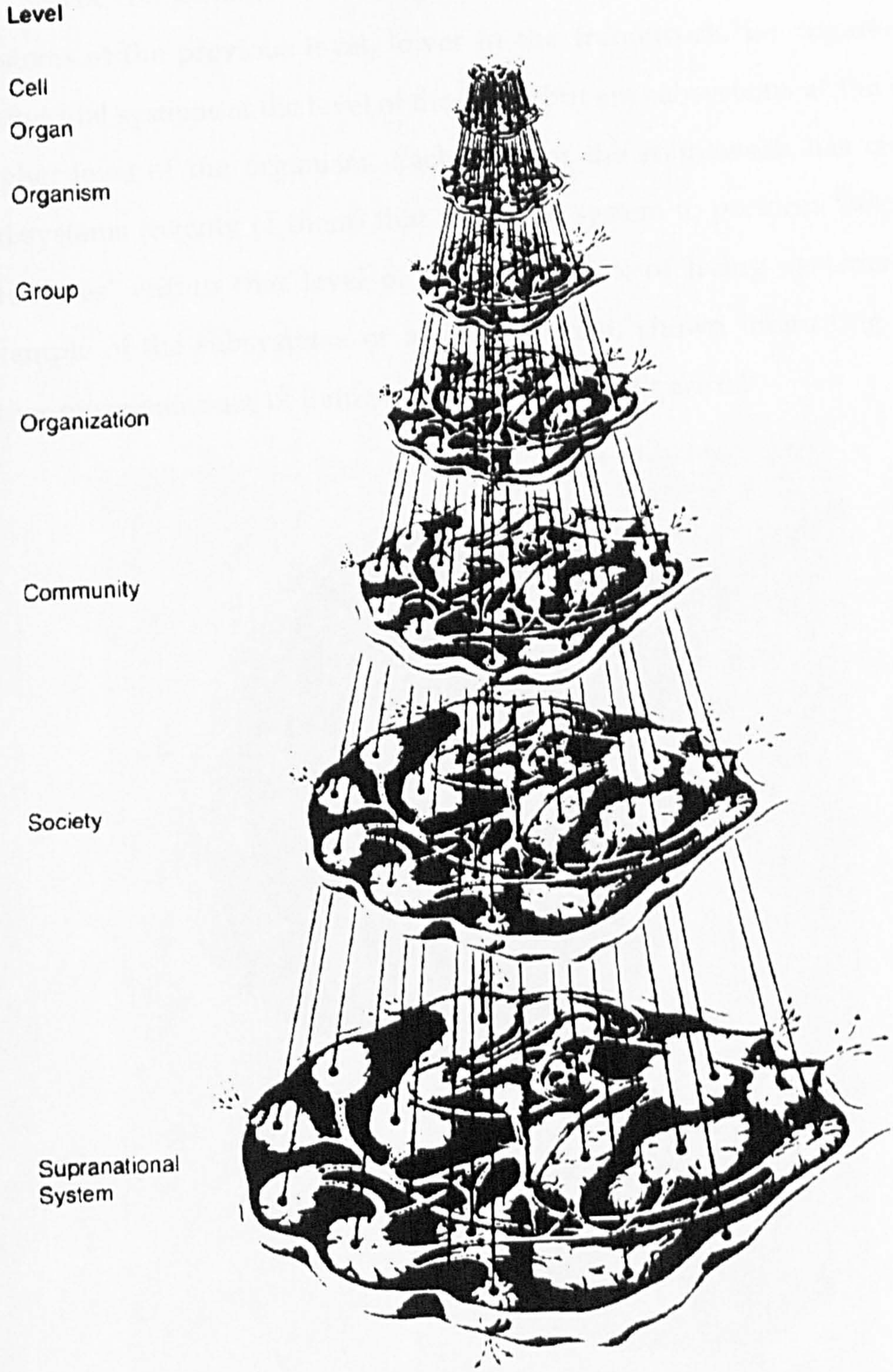



**Figure 6.8 Miller's LST 'Fray-Out" (Miller, 1978, p.4)**

The components of each higher level in the system are themselves systems at the previous level, lower in the framework, i.e. organs are individual systems at the level of the organ but are subsystems at the next higher level of the organism. Each level of the framework has critical subsystems (twenty of them) that allow the system to perform 'essential processes' within that level of the framework of living systems. An example of the subsystems of a living system, shown interacting with other representations of living systems, is seen in figure 6.9.

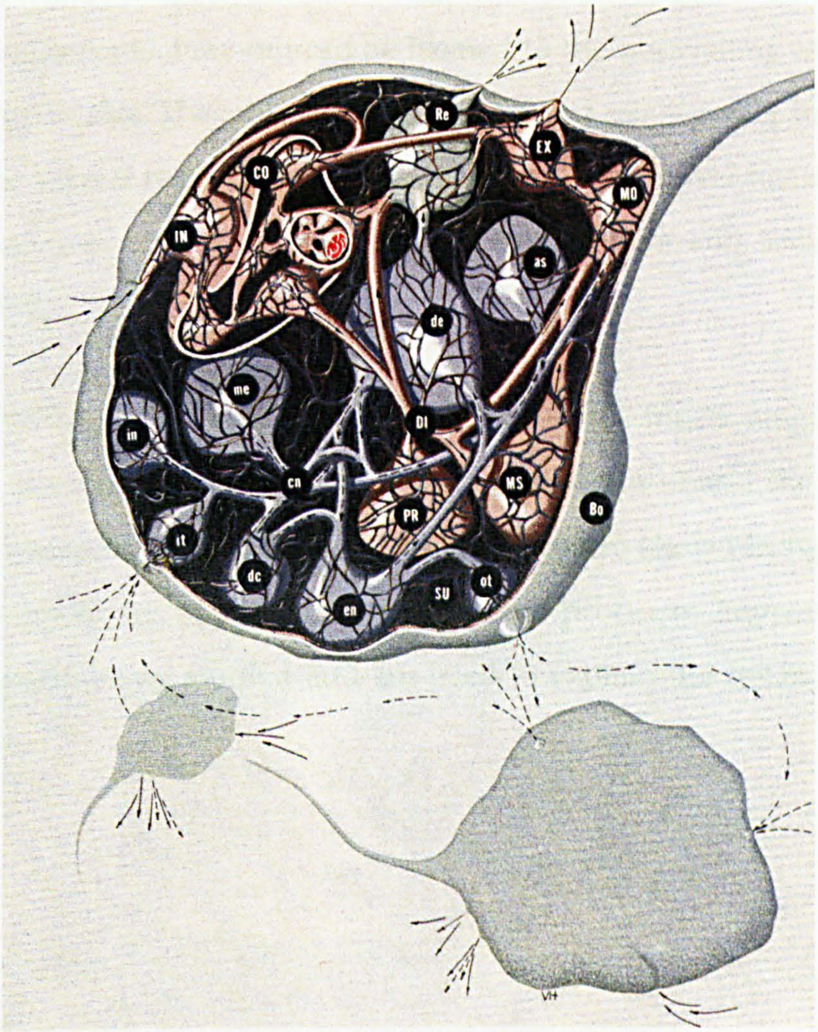



**Figure 6.9 A Generalized Living System Interacting and Inter-communicating with two others in its Environment (Miller, 1978, p.3)**

The eight levels of increasing complexity are the result of the evolving of living systems into ever more increasingly complex entities. This evolving happens,

> "by a process of fray-out in which the larger, higher-level systems developed increasingly more complex components in each subsystem than those below them in the hierarchy of living systems. The cell membrane, for example, carries out many processes that, at higher levels, require many components. Fray-out can be likened to the unravelling of a ship's cable. The cable is a single unit but it can separate into the several ropes that compose it. These can unravel further into finer strands, strings, and threads" (Miller and Miller, 1992).

The twenty critical subsystems that allow the functioning of living systems at each of the levels are shown in figure 6.10 and the symbols used by researchers using living systems theory are shown in figure 6.11. These symbols are used in representing the processes happening in a living system being studied and are used to explain the detail of those processes.

## The 20 Critical Subsystems of a Living System

SUBSYSTEMS WHICH PROCESS BOTH MATTER-ENERGY AND INFORMATION

1. *Reproducer*, the subsystem which carries out the instructions in the genetic information or charter of a system and mobilizes matter, energy, and information to produce one or more similar systems.

2. *Boundary*, the subsystem at the perimeter of a system that holds together the components which make up the system, protects them from environmental stresses, and excludes or permits entry to various sorts of matter-energy and information.

| SUBSYSTEMS WHICH PROCESS MATTER-ENERGY | SUBSYSTEMS WHICH PROCESS INFORMATION |
|---|---|
| 3. *Ingestor*, the subsystem which brings matter-energy across the system boundary from the environment. | 11. *Input transducer*, the sensory subsystem which brings markers bearing information into the system, changing them to other matter-energy forms suitable for transmission within it. |
| | 12. *Internal transducer*, the sensory subsystem which receives, from subsystems or components within the system, markers bearing information about significant alterations in those subsystems or components, changing them to other matter-energy forms of a sort which can be transmitted within it. |
| 4. *Distributor*, the subsystem which carries inputs from outside the system or outputs from its subsystems around the system to each component. | 13. *Channel and net*, the subsystem composed of a single route in physical space, or multiple interconnected routes, over which markers bearing information are transmitted to all parts of the system. |
| | 14. *Timer*, the subsystem which transmits to the decider information about time-related states of the environment or of components of the system. This information signals the decider of the system or deciders of subsystems to start, stop, alter the rate, or advance or delay the phase of one or more of the system's processes, thus coordinating them in time. |
| 5. *Converter*, the subsystem which changes certain inputs to the system into forms more useful for the special processes of that particular system. | 15. *Decoder*, the subsystem which alters the code of information input to it through the input transducer or internal transducer into a "private" code that can be used internally by the system. |
| 6. *Producer*, the subsystem which forms stable associations that endure for significant periods among matter-energy inputs to the system or outputs from its converter, the materials synthesized being for growth, damage repair, or replacement of components of the system, or for providing energy for moving or constituting the system's outputs of products or information markers to its suprasystem. | 16. *Associator*, the subsystem which carries out the first stage of the learning process, forming enduring associations among items of information in the system. |
| 7. *Matter-energy storage*, the subsystem which places matter or energy at some location in the system, retains it over time, and retrieves it. | 17. *Memory*, the subsystem which carries out the second stage of the learning process, storing information in the system for different periods of time, and then retrieving it. |
| | 18. *Decider*, the executive subsystem which receives information inputs from all other subsystems and transmits to them information outputs for guidance, coordination, and control of the system. |
| | 19. *Encoder*, the subsystem which alters the code of information input to it from other information processing subsystems, from a "private" code used internally by the system into a "public" code which can be interpreted by other systems in its environment. |
| 8. *Extruder*, the subsystem which transmits matter-energy out of the system in the forms of products or wastes. <br> 9. *Motor*, the subsystem which moves the system or parts of it in relation to part or all of its environment or moves components of its environment in relation to each other. | 20. *Output transducer*, the subsystem which puts out markers bearing information from the system, changing markers within the system into other matter-energy forms which can be transmitted over channels in the system's environment. |
| 10. *Supporter*, the subsystem which maintains the proper spatial relationships among components of the system, so that they can interact without weighting each other down or crowding each other. | |

**Figure 6.10 The Twenty Critical Subsystems (Miller and Miller, 1992, p.4)**

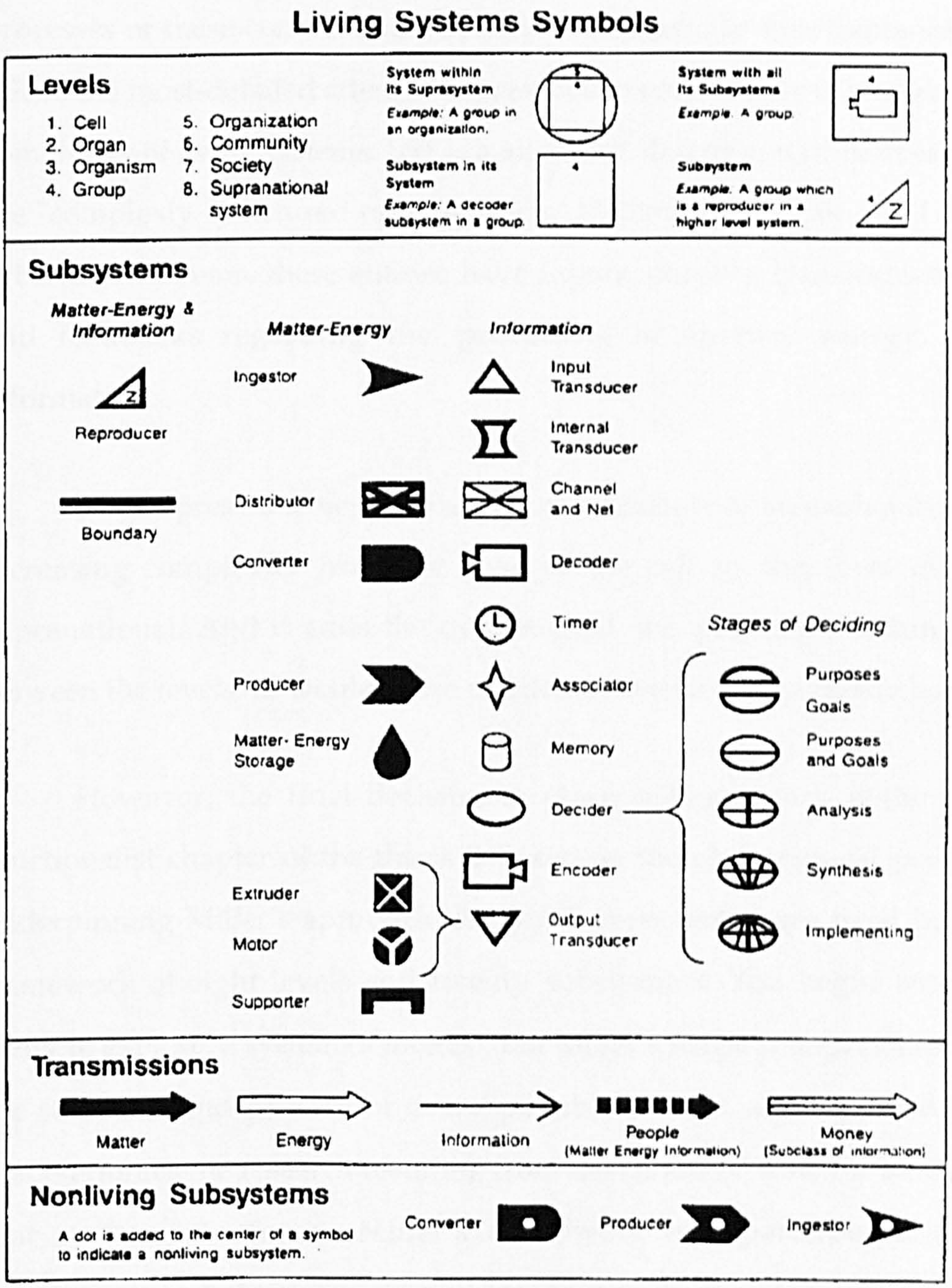



**Figure 6.11 Living Systems Symbols (Miller and Miller, 1992, p.5)**

Miller's "Living Systems Theory" (1978, 1992) is more than a simple framework of the hierarchical description of living systems. The description of these eight levels and the detail of the subsystems and processes of these components requires 1100 pages for their explanation. LST is the most-detailed attempt to present a general theory to explain the complexity of living systems. LST is a biological description of entities that are "complexly structured open systems" (Miller, 1992). As in all such cybernetic systems, these entities have inputs, outputs, transformations, and feedbacks regarding the processing of matter, energy, and information.

It does present a hierarchical-ordered structure as an explanation of increasing complexity from the level of the cell to the level of the supranational. And it adds the dynamics of the processes within and between the levels, as would those of interpretive hierarchy researchers.

However, the final decision to place Miller's work within this functionalist chapter of the thesis is based on the philosophical position underpinning Miller's approach that levels represented are fixed by his framework of eight levels and twenty subsystems. You begin with an entity to explore, a system of interest, but Miller's single interpretation for the structure and process of every possible level is already fixed and predetermines the research resulting from the choice of scale for studying that system of interest. Miller's framework is superimposed as a description of what you are researching. In a sense, the observer is there, but is unable to act independently in describing the system. His or her choice of describing the system should lead to the discovery of the levels and parts of the system, highly dependant on the choices and underpinning philosophy of that observer. It is the observer who does the drawing and explanation of what is seen and this is different from fitting the systems into Miller's set of eight levels and twenty subsystems.

In presenting this explanation of living systems, Miller was an observer himself at the beginning of his research. He did make an interpretation of a 'living system' as an interpretive would do, as shown in the next chapter. However, Miller's work then becomes the fixed structure and processes that are used by following researchers applying this framework and that is why his work remains in this section on functionalist hierarchical systems approaches.

## 6.11 Arvid Aulin (1982, 1989)

Two of the books Arvid Aulin wrote were: *Cybernetic Laws of Social Progress* in 1982, and *The Foundations of Mathematical Systems Dynamics* in 1989. Aulin's work investigated the development of mathematical theorems and models for explanation of complex systems and he was particularly interested in using these methods for the understanding of the acts of individuals and social systems.

One of his proposals is called The Law of Requisite Hierarchy and this states: "...the lack of regulatory ability can be compensated to a certain extent by greater hierarchy in organization" (Aulin, 1982, p115).

The more complex a system, the more regulation by increasing numbers of levels of organisation are needed to manage this complex system. This underpins the statements of Allen for example, when he says that if more than one level of description is needed to adequately describe a system it can be classed as a complex, rather than a simple, system. Following from this, and reversing the concept, it is the aim of many practitioners in management in particular, to reduce or eliminate hierarchy in organisations and social systems. Addressing this, Felix Geyer wrote:

> "However, the need for hierarchy decreases if this regulatory ability itself improves - which is indeed the case in advanced industrial societies, with their well-developed productive forces and correspondingly advanced distribution apparatus (the market mechanism). Since human societies are not simply self-regulating systems, but self-steering systems aiming at an enlargement of their domain of self-steering, there is a possibility nowadays, at least in sufficiently advanced industrial societies, for a coexistence of societal governability with ever less control, centralized planning and concentration of power" (Geyer, 1994, p10).

In eliminating or reducing levels within the system is to be possible, then the balance between the need for requisite hierarchy with the management of the system's requisite variety has to be addressed. This is possible but requires additional organisation, the input of additional matter, energy, or information to a system to reverse entropy, as illustrated by Geyer. The management term 'working smarter' comes to mind in summarising Aulin's concepts.

### 6.12 Lenard Raphael Troncale (1972, 1978a,b, 1981, 1982a,b, 1984, 1987, 1988, 1990, 1993)

Len Troncale has researched in general systems for over thirty years while working at California State Polytechnic University in Pomona (CSUP), California where he founded and maintains the work of the Institute for Advanced Systems Studies. One of his major products at CSUP has been a programme of integrated studies in systems, which satisfies the general education credits requirement of the undergraduate bachelor's degree at CSUP. His statement about this programme of general education is:

> "Across a decade of work sponsored by the U.S. National Science Foundation, the Integrated Science General Education (ISGE) project has sought to define the key features of 80 systems processes like hierarchical structure and function. The purpose of finding these key features is to enable those not working in systems science, new to systems science, or students of science in general to "see" hierarchical form and pattern in newly encountered cases in the natural world and society. Currently, the list of key features for hierarchy includes (1) "inhomogeneity", (2) "sequence of levels", (3) "gaps" between the levels, (4) "clustering", (5) "subunit-unit" /or/ "subsystem-system" relations", (6) "emergence", (7) "self-similarity", (8) "potential fields", (9) "subsumption", and (10) "directional parameter trends across levels." Distributions of entities that have all of these characteristics may be tentatively described

as hierarchical. The ISGE project includes text, graphic logo's and multimedia descriptions of each ID Feature" (Troncale, 2007, personal interview).

Part of his research has also involved the study of hierarchy theory from the point of view of developing the core principles of hierarchy not only as they relate to hierarchy itself, but also as those principles are discovered and applied in other areas of systems: i.e. whether they are isomorphic properties where linkage propositions can be constructed between hierarchy and other systems concepts. "The primary product of our work is the formulation of a detailed System of Systems Processes ... Please see the attached Chart of Linkage Propositions suggesting many other systems processes that influence hierarchical structure and function or that are influenced by them" (Troncale, 2007, personal communication). Troncale has developed a long list of such linkage propositions, and these are shown in figure 6.12.

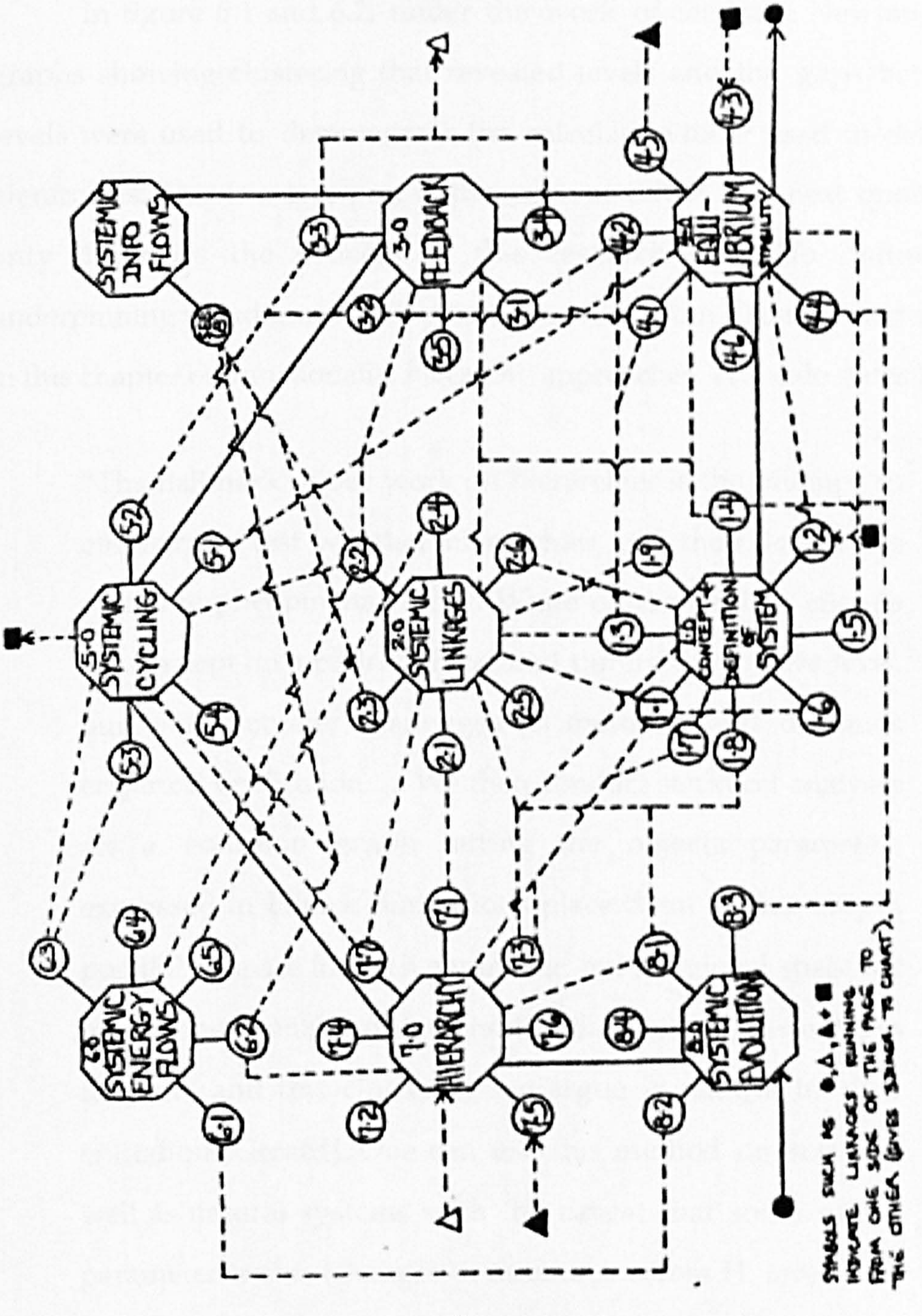



**Figure 6.12 Troncale's Map of Linkage Propositions (1978a)**
The basal diagram of linkages. A preliminary graphic display of some of the linkage propositions and the connections they make between principal systems concepts. Each line represents a linkage proposition. The numbers in the circles correspond to the numbered systems concepts in table 1 (not included here). A continuous line means a linkage between a systems concept and is packet name or between packet names. A dotted line means linkage between systems concepts. A [upside down 'v'] means "not connected at nexus." This figure in its full form is the 'template" or "master model".

In figure 6.1 and 6.2, under the work of Sir Isaac Newton, two graphs showing clustering that revealed levels and the gaps between levels were used to demonstrate the calculation tools used in defining hierarchies. This is a core part of the work at CSUP. The next quote not only describes the process of this research but also defines its underpinning paradigm, which places the work from Troncale and CSUP in this chapter on functionalist hierarchy approaches. Troncale states that:

> "The hallmark of our work on hierarchies is the attempt to empirically test whether hierarchies and their levels are objective phenomena or not. While others tend to engage the concept on a philosophical and purely descriptive level, our work actually challenges its existence and demands empirical verification. ... We then conduct statistical analyses on a common graph letting the objects parameters expressed in Planck dimensions place them in not only a possibility space for each parameter, but the global space for multidimensional parameters. Do the objects cluster? Yes they do, and this clustering we argue is natural to their entitation [Gerard]. One can use this method on social as well as natural systems with the caveat that some of the parameter trends (changes in measures across H. levels) are not as useful as others because they are more difficult to measure in social systems, and social scientists do not regard these measures as important so the literature on some may be non-existent" (Troncale, 2007, personal communication).

Troncale's work in defining the gaps between levels is shown in Figure 6.13 below.

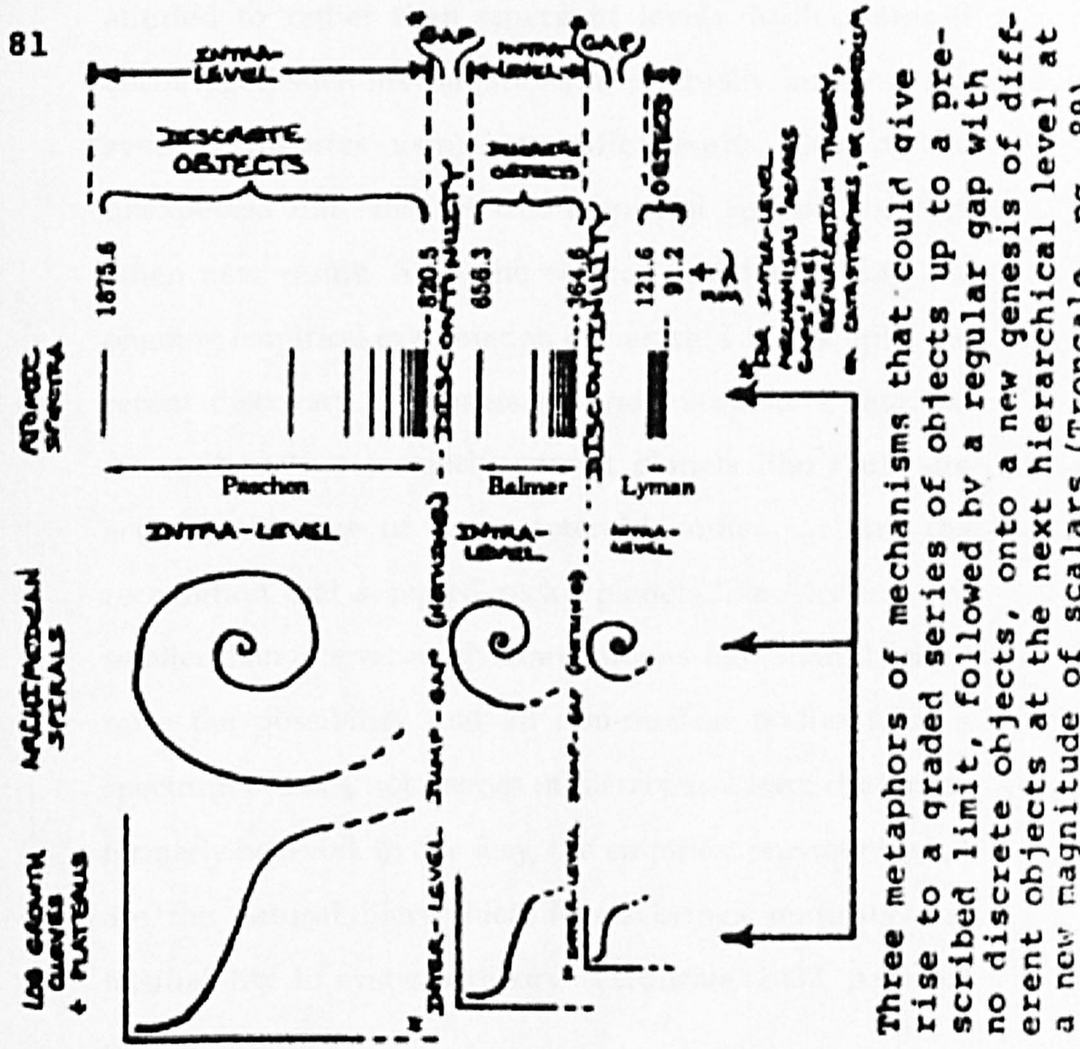



**Figure 6.13 Juxtaposition of possible inter-level mechanisms producing gaps, and intra-level mechanisms producing horizontal proliferation of entities within clusters. (Troncale, 1982a).**

A final communication discusses the relation of Troncale's work with that of Miller's work in *Living Systems*. Troncale has found new levels that expand, but do not necessarily negate Miller's previous work.

"In a detailed comparison of Miller's classical hierarchical levels for living systems, Troncale finds that some may not be levels at all or may be the sub-specialization levels earlier alluded to rather than emergent levels. Miller himself encouraged such investigations to gradually improve our systems theories using scientific results. One of the unexpected outcomes of this empirical approach occurs when new results from the sciences are folded into the ongoing empirical examination of nature. For example, the recent discovery of planets around many stars, and the recognition that formerly named planets like Pluto are actually the size of large asteroid bodies, ... and the recognition that accepted rocky planets like Mercury are smaller than interesting dynamic moons like Titan (Jupiter) raise the possibility that all non-nuclear bodies form a spectrum of sizes, not a series of hierarchical level clusters as formerly believed. In this way, the empirical pursuit of what are the natural hierarchical levels brings maturity and falsifiability to systems theory" (Troncale, 2007, personal communication).

## 6.13 Salthe (1985, 1993)

Salthe makes the distinction of "the basic triad"--that of the entity, the parts of the entity, and the environment beyond the entity (Salthe, 1985). This triad is evident in both of the types of hierarchy that he has defined: the scalar hierarchy and the specification hierarchy. The scalar is that of the frameworks, functionalist hierarchy described in chapter 6. It could be argued that the specification is that of the descriptive, interpretive hierarchy reviewed in this chapter 7.

> "The scalar hierarchy represents subsystems (or components) nested within supersystems (or wholes). In order not to lose the complexity, models of this kind need to explicitly represent at least three levels simultaneously. The lower level proposes possible dynamics at the focal level, while the higher level regulates or interprets them, as via boundary conditions.
>
> The specification hierarchy too has a synchronic interpretation, as when we overlay a physical description of an organism on a chemical description. Each of these represents a different integrative level. Higher levels here transitively integrate dynamics and phenomena at lower levels, as when biology selects or harnesses a few chemical pathways, or a few physical processes, from the many possible to interact at the biological level. Any two levels are sufficient to explore integration. The polarity of rank here is imposed by the observer, whose level is the highest in the hierarchy, which traditionally is presented as a hierarchy of discourses, ... The specification hierarchy is the core of the philosophy of nature as received from the Nineteenth Century." (The SEE Project (Semotics, Evolution, Energy), University of Toronto,

http://www.library.utoronto.ca/see/pages/Terminology.html
and http://www.library.utoronto.ca/see/pages/hierarchydef.html

(both pages last accessed December 18, 2006)

However, Allen writes that the Salthe (1985) book: "has a strong structural bias, in contrast to the process oriented approach of Allen and the other ecologists in this bibliography. Salthe introduces the notion of the Triadic, where there is a focus on 1) the system as both a whole above the levels below and 2) a part belonging to another level above, 3) not forgetting the level of the structure itself in between. While much biological hierarchy theory takes an anti-realist point view, or is at least reality-agnostic, wherein the ultimate reality of hierarchical arrangement is left moot, Salthe's version of hierarchy theory is concerned with the ultimate reality of structure. The anti-realist view of structure is that it is imposed by the observer, and may or may not correspond to any ultimate reality. If structure does correspond to ultimate, external reality, we could never know that to be so. Salthe's logic is consistent but always takes a structural and ontological position" (Allen, 2003, online)

Salthe is a biologist who also works in philosophical issues and the field of semiotics dealing with complexity and evolution, and he has worked closely with Eldridge in these areas. On balance his concepts are those of the functionalist researcher and are therefore included in this chapter.

## 6.14 Niles Eldredge (1984, 1985)

Eldridge is an evolutionary biologist and paleontologist, co-founding the theory of punctuated equilibria with Stephen Jay Gould in 1972. His interest in hierarchy is from the perspective of understanding and providing a single evolutionary process (Eldredge, 1985). He has worked with Salthe and also with Vrba in exploring the use of hierarchy theory to explain the structures and processes of his work in evolutionary biology.

His work with Salthe involved the development of an evolutionary theory that accounts for "the several ontologically-based hierarchies in the biotic realm" (Eldredge and Salthe, 1984, p184). Eldredge and Salthe developed a hierarchical schema (figure 6.14) for what they termed the "twin process hierarchies of evolution." Their work in hierarchies focussed on using these twin process hierarchies to explain the origin of life in a way not managed by Darwin's evolutionary theory.

| *Genealogical hierarchy* | *Ecological hierarchy* |
|---|---|
| **Codons** | **Enzymes** |
| **Genes** | **Cells** |
| **Organisms** | **Organisms** |
| **Demes** | **Populations** |
| **Species** | **Local ecosystems** |
| **Monophyletic taxa** | **Biotic regions** |
| **(Special case: all life)** | **Entire biosphere** |

**(Eldredge and Salthe 1984)**

**Figure 6.14 The Genealogical and Ecological Hierarchies (from Eldredge and Salthe, 1984, p.187)**

The work of Eldredge, linked closely with the work of Salthe, and his hierarchical concepts and insights are also those of the functionalist researcher and are also therefore included in this chapter.

## 6.15 Summary

This chapter has explored the hierarchical approaches of those authors considered to be core to the development of hierarchical systems from a functionalist standpoint. The frameworks and insights discovered in this chapter will be incorporated with the principles and method for a theory of hierarchy that will be developed in chapter 9. Future work on the contributions of each of these authors and many examples of their work in hierarchical explorations of complex issues is a topic for future research.

# Chapter 7

## The Interpretivists: Those Who Discover Hierarchy

This chapter explores the work of Bunge, Simon, Koestler, Platt, Mesarovic et al., Holling (with Gunderson), and Allen et al. All of these authors worked on hierarchy from an interpretive stance -- their differences depending principally on their different disciplinary backgrounds. In exploring the interpretive approach to hierarchies, it is first noted that there are some important difficulties to be addressed in the aim of developing a theory for hierarchy. There is currently:

- a lack of a single set of definitions of principles for all variants of the theory,

- a lack of a specific methodology for the application of hierarchy theory, and

- a lack of a capable mathematical structure for all of hierarchy's middle-number systems.

The work of each author will be explored in this chapter and this is followed by a synthesis of the core principles that could be used in a theory and methodology for the exploration of hierarchy. This chapter is structured the same way as chapter six, beginning with Jackson's constitutive rules for a generic interpretive systems methodology.

**Table 7.1 Constitutive Rules for a Generic Interpretive Systems Methodology (Jackson, 2000, p.282)**

1 An interpretive systems methodology is a structured way of thinking with an attachment to the interpretive theoretical rationale that is focused on improving real-world problem situations.

2 An interpretive methodology uses systems ideas as the basis for its intervention strategy and will frequently employ methods, models, tools and techniques which also draw upon systems ideas.

3 The claim to have used a systems methodology according to interpretive rationale must be justified according to the following guidelines:

a. there is no assumption that the real-world is systemic;

b. analysis of the problem situation is designed to be creative and may not be conducted in systems terms;

c. models are constructed which represent some possible 'human activity systems";

d. models are used to interrogate perceptions of the real-world and to structure debate about changes which are feasible and desirable;

e. quantitative analysis is unlikely to be useful except to clarify the implications of world views;

f. the process of intervention is systemic, is never-ending, and is aimed at alleviating unease about the problem situation and generating individual and organizational learning;

g. the intervention is best conducted on the basis of stakeholder participation;

h. changes that might alleviate the feelings of unease or contribute to learning are evaluated primarily in terms of their effectiveness, elegance and ethicality.

4. Since an interpretive systems methodology can be used in different ways in different situations, and interpreted differently by different users, each user should exhibit conscious thought about how to adapt to the particular circumstances.

5. Each use of an interpretive systems methodology should yield research findings as well as changing the real-world problem situation. These research findings may relate to the theoretical rationale underlying the methodology, to the methodology itself and how to use it, to the methods, models, tools and techniques employed, to the real-world problem situation investigated, or to all of these.

Writing about the problems inherent in describing systems from a functionalist, mathematical approach, Pattee proposes that the problem with a functionalist approach is that the description of the system leads to a total decomposition of the observed system to where the interactions are no longer visible (Pattee, 1973). Hence, a description of hierarchy theory that allows only partial decomposability is required as proposed by Simon (1962). Pattee writes:

> "...dynamical systems theory emphasizes holistic, single-level descriptions, avoidance of instabilities, optimization under fixed constraints and artificial isolation of adjacent levels. In contrast to systems theory, hierarchy theory must be formulated to describe at least two levels at a time, it must optimize constraints for a given function, and it must allow interactions between alternative levels. Since there is no way to extend the dynamical language to encompass these requirements, perhaps hierarchy theory will require a dualistic or parallel type of theory not unlike the wave-particle duality of quantum physics, where neither description alone is adequate, but where simultaneous use of both appears inconsistent. The essential rules of such a theory would specify under what conditions or for what type of question each description is to be applied" (Pattee, 1973, p. 150-1).

This is the aim of this chapter: first, to gather the information on work done in hierarchical systems analysis from an interpretive stance; second, to propose an interpretive approach for the use of a theory of hierarchy that may also incorporate the insights gained from the use of the functionalist hierarchical approaches implemented in chapter 8; and third, to explore the uses of both functionalist and interpretive approaches using the process of critical review in chapter 10 of this thesis. The authors working in hierarchy from an interpretive approach are now listed in the remainder of this section. The authors are discussed in order of their contributions to the hierarchical study of complex systems.

## 7.1 Mario Bunge (1959a,b; 1960, 1963, 1967, 1969)

Mario Bunge was a philosopher who wrote on hierarchical systems (1959a,b; 1960, 1963, 1967, 1969). He believed these were a human invention, and his specific focus was the topic of levels within hierarchies. He was interested in hierarchies (multilevel structures of the world) that he defined as integrative levels, or levels of organisation (Bunge, 1969). " ... a hierarchy or hierarchical structure is a set equipped with a relation of domination or its converse, subordination" that he then continues to define using logic and set theory (Bunge, 1969, p.17-18). Bunge proposed a set of ontological, epistemological and methodological hypotheses for levels that are summarised in table 7.2.

**Table 7.2 Hypotheses for Levels (Bunge, 1969, pp22-26)**

| **Metaphysics (Ontology) of Levels** | |
|---|---|
| O1 | Reality (= the world) is a level structure such that every existent belongs to at least one level of that structure. |
| O2 | In the course of every emergence process (self-assembly or evolution) some properties, hence also some laws, are gained while others are lost. |
| O3 | The newer levels depend on the older ones both for their emergence and for their continued existence. |
| O4 | Every level has, within bounds, some autonomy and stability. |

| | |
|---|---|
| O5 | Every event is primarily determined in accordance with the set of specific flaws that characterize its own level(s) and the contiguous levels. |
| **Epistemology of Levels** | |
| E1 | The real level structure is knowable and scientific knowledge is a level structure that matches the former. |
| E2 | Every newly formed science has its peculiar objects and special methods. And, although every science retains some of the ideas typical of the parent science(s), it does not preserve them all and it introduces new concepts absent from the latter. |
| E3 | The understanding of any level is greatly deepened by research into the adjacent levels, particularly by the underlying ones. |
| E4 | Every level of science has, within bounds, some autonomy and stability. |
| E5 | Every system and every event can be accounted for (described, explained or predicted, as the case may be) primarily in terms of its own levels and the adjoining levels, without necessarily involving the whole level structure. |
| **Methodology of Levels** | |
| M1 | Start by limiting your inquiry to one level. Should this level prove insufficient, scratch its surface in search for further levels. |
| M2 | Face emergence and try to explain it: begin by attempting to explain novelty away but, should this move fail, take it seriously. |
| M3 | Explain the emergence of every level in terms of some of the older levels without skipping any intermediate level. |
| M4 | Begin by investigating your class of facts on their own level(s): introduce further levels only as required. |
| M5 | Start by finding or applying the intralevel laws. Should this strategy fail, resort to hypothesizing or applying interlevel laws (cf. Bunge 1967). |

Bunge believes that this framework for addressing hierarchical levels is "consistent with integrated pluralism, an ontology that proclaims both the diversity and the unity of the world" (Bunge, 1969, p22). Bunge has been placed in this section on interpretative approaches because, although he does not specifically state his own ontology, he does not deny or clarify that there is an independent observer doing this methodological investigation as specified in table 7.2; in fact, it appears from the exhortations of the proposed methodology there is an unwritten assumption that each investigator would arrive at different interpretations of the level(s) under study, otherwise the methodological process he proposes would be redundant.

## 7.2 Herbert A. Simon (1962, 1973)

Herbert Simon wrote two core articles on hierarchy. The first, "The Architecture of Complexity" was published in 1962 and the second "The Organization of Complex Systems" as a chapter in Pattee's book *Hierarchy Theory* in 1973. Rather than pursuing the "development of "general systems theory" that, abstracting from properties peculiar to physical, biological, or social systems, would be applicable to all of them" (Simon, 1962, p.467) he thought it might not be in vain to instead "search for common properties among diverse kinds of complex systems" (ibid. p.467).

This is a slight misinterpretation of the goal of general system theory however, since von Bertalanffy, in 1968, was not writing of a unity of all science, but that he was interested in a new realm of science (GST) that had as its goal only "the formulation and derivation of those principles which hold for systems themselves" (von Bertalanffy, 1952, p.189). So Simon is more closely aligned with von Bertalanffy.

Moving back to the core of his writing however, Simon wrote in 1973 that most of the complex systems found in nature can be described in four intertwined hierarchic sequences. His first hierarchy contains sets of component molecules, atoms, nuclei, electrons, and elementary particles. The second hierarchy contains living organisms, tissues, organs, cells, macromolecules, and organic compounds--and intertwines at its highest level with the molecules of the first hierarchy. The third hierarchy is genes, chromosomes, and DNA; while the fourth hierarchy contains human societies, organizations, small groups, individuals, thinking processes, and "elementary information processes--where the junctions with the tissues and organs of neurobiology largely remain to be discovered" (Simon, 1973).

In investigating these inter-twined hierarchies, Simon addresses hierarchical complexity from four perspectives:

- "the frequency with which complexity takes the form of hierarchy"

- "the relation between the structure of a complex system and the time required for it to emerge through evolutionary processes (i.e. hierarchical systems do this quicker)"

- "the dynamic properties of hierarchically organized systems ... how they can be decomposed into subsystems in order to analyze their behavior"; and

- "the relation between complex systems and their description" (ibid. p. 468)

Simon illustrates these using the tale of the two watchmakers. In the watchmaker story, life is seen as a hierarchically-organised series of parts. It builds itself together into a complex structure in the same way as the successful watchmaker builds his watch--continuously from ever-increasingly complex subassemblies.

> "There once were two watchmakers, named Hora and Tempus, who manufactured very fine watches. Both of them were highly regarded, and the phones in their workshops rang frequently – new customers were constantly calling them. However, Hora prospered, while Tempus becomes poorer and poorer and finally lost his shop. What was the reason?
>
> The watches the men made consisted of about 1,000 parts each. Tempus had so constructed his that if he had one partly assembled and had to put it down – to answer the phone, say – it immediately fell to pieces and had to be reassembled from the elements. The better the customers likes his watches, the more they phoned him and the more difficult it became for him to find enough uninterrupted time to finish a watch.
>
> The watches that Hora made were no less complex than those of Tempus. But he had designed them so that he could put together subassemblies of about ten elements each. Ten of these subassemblies, again, could be put together into a larger subassembly; and a system of ten of the latter subassemblies constituted the whole watch. Hence, when Hora had to put down a partly assembled watch in order to

answer the phone, he lost only a small part of his work, and he assembled his watches in only a fraction of the man-hours it took Tempus" (Simon, 1962, p.470).

Simon goes on to calculate the difference in outcomes between the two watchmakers. He concluded:

1. "Hora must make 111 times as many complete assemblies per watch as Tempus; but

2. Tempus will lose on the average 20 times as much work for each interrupted assembly as Hora (100 parts, on the average, as against 5); and

3. Tempus will complete an assembly only 44 times per million attempts..., while Hora will complete nine out of ten.... Hence 'Tempus will have to make 20,000 as many attempts per completed assembly as Hora." (Simon, 1962, p.470).

Simon states: "hierarchies will evolve much more rapidly from elemental constituents than will non-hierarchic systems containing the same number of elements. Hence, almost all the very large systems will have hierarchic organisation. And this is what we do, in fact, observe in nature" (Simon, 1973).

Simon proposed many of the concepts that are used by those working in both functionalist and interpretive version of hierarchical analysis. The example of the watchmaker was given to illustrate the process by which parts of a system can achieve an ordering of those parts through their inter-relationships that provides stability, and the rate at which that evolution towards a stable integrity of those parts is possible. Another of his concepts was "span" of hierarchy, and a third was "near decomposability" of a system. Near-decomposability is a term that describes how an observer can investigate and determine the boundaries of a system and its subsystems. This work has led to the development of other components of hierarchy theory (in Allen's work for example) having to do with how information is passed between levels and visualising what Allen calls 'jumps' between the levels of a system.

Simon used the term 'span' to describe the number of subsystems a system is broken down into at that level of the system. Hence, one level of the system can be described as a flat wide hierarchical span, but the next higher or lower may not be so described.

In discussing near-decomposability, a core concept in the observation and description of complex systems, Simon develops this work from joint research with Ando (Simon and Ando, 1961) and writes:

> "In hierarchic systems, we can distinguish between the interactions among subsystems, on the one hand, and the interactions within subsystems – that is, among the parts of those subsystems – on the other. The interactions at the different levels may be, and often will be, of different orders of magnitude. In a formal organization there will generally be more interaction between two employees who are members of the same department than between two employees from different departments. In organic

> substances, intermolecular forces will generally be weaker than molecular forces, and molecular forces weaker than nuclear forces" (Simon, 1962, p. 473-4).

Joining the illustration of the watchmakers to the concept of near-decomposability leads to the description of a system in terms of its equilibration (Simon, 1962); the process by which a system reaches and why it maintains its stability. Near-decomposability also offers insight in the exploration of communication between and amongst levels of the hierarchy. If there is a lower frequency of interaction between the levels, then that can be observed and used in the delineation and describing of levels within the whole system. This is covered further in the work of Allen et al. (1982) and in the implementation of the interpretive approach to hierarchy in chapter 9. Simon concludes his 1962 article with:

> "Empirically, a large proportion of the complex systems we observe in nature exhibit hierarchic structure. On theoretical grounds we could expect complex systems to be hierarchies in a world in which complexity had to evolve from simplicity. In their dynamics, hierarchies have a property, near decomposability, that greatly simplifies their behavior. Near decomposability also simplifies the description of a complex system and makes it easier to understand how the information needed for the development or reproduction of the system can be stored in reasonable compass" (Simon, 1962, p. 481-2).

Simon is placed, for one reason, in this chapter with interpretive hierarchy because of his work in determining that a process description of hierarchical systems was needed as well as a structural definition. "The correlation between state description and process description is basic to the functioning of any adaptive organism, to its capacity for acting purposefully upon its environment" (Simon, 1962, p.481). In addition, although Simon states that he sees four sets of hierarchies inter-twined in his perception of complex systems, because of his work in defining many of the concepts used in the interpretive descriptive hierarchy explored in this chapter, Simon's work has been included here with the interpretive approaches to hierarchical analysis of complex systems.

## 7.3 Arthur Koestler (1967, 1969)

Arthur Koestler held a fellowship at the Center for Advanced Study in the Behavioral Sciences (CASBS), at Stanford University between 1964 and 1965 and developed his book *The Ghost in the Machine* (1967) during that period. He consulted with Whyte and Weiss and was the organiser for the Alpsbach symposium on hierarchy and reductionism. His work also influenced that of Tim Allen, whose hierarchy theory is central to the development of hierarchy in this chapter.

Koestler was interested in parts and wholes within the wider remit of his field of interest: that of human and social behaviour. It is Koestler who coined the phrase of the Janus-faced "holon" that is referred to by many authors of hierarchy texts. The word 'holon' was proposed as a simpler term than that of "sub-wholes (or sub-assemblies, sub-structures, sub-skills, sub-systems) ... nodes on the hierarchic tree" (Koestler, 1967, p48). Koestler wrote:

> "A 'part', as we generally use the word, means something fragmentary and incomplete, which by itself would have no legitimate existence. On the other hand, a 'whole' is considered as something complete in itself, which needs no further explanation. But *'wholes' and 'parts' in this absolute sense just do not exist anywhere*, either in the domain of living organisms or of social organisations. What we find are intermediary structures on a series of levels in an ascending order of complexity: sub-wholes which display, according to the way you look at them, some of the characteristics commonly attributed to wholes and some of the characteristics commonly attributed to parts. ... The members of a hierarchy, like the Roman god Janus, all have two faces looking in opposite directions: the face turned towards the subordinate levels is that of a self-contained whole; the face turned upwards towards the apex, that of a dependent part. One is the face of the master, the other the face of the servant. This *'Janus effect'* is a fundamental characteristic of sub-wholes in all types of hierarchies" (Koestler, 1967, p48),

Koestler is included in this chapter with interpretive approaches to hierarchy because of his recognition that it is the observer who determines the parts from the whole, and indeed the whole of the study to begin with, and that this determination is not a fixed framework as proposed by those authors in chapter six.

His work also included discussion of the nature of these holons, and their constraints and methods of communication that he termed "fixed rules and flexible strategies" (ibid, p.55). Within the hierarchy he saw that there was both 'cohesion' within the holon, and 'separation' between the holons, in the same way that Simon (1962, 1973) described in greater detail the concepts of near-decomposability. "The hierarchy concept of 'levels of organisation' in itself implies a rejection of the reductionist view that all phenomenon of life (consciousness included) can be reduced to and explained by physico-chemical laws" (ibid, p54). He likewise incorporated Simon's concept of span of hierarchies and added the term 'depth": "The number of levels which a hierarchy comprises is called its 'depth', and the number of holons on any given level its 'span'" (ibid, p58).

Koestler concluded his *Ghost in the Machine* with an appendix of general properties of open hierarchical systems, a summary of the ten sections of that appendix is included here as a summary of his work on hierarchy:

- five properties for the Janus effect;
- two properties for dissectibility (linking to Simon's work);
- nine properties covering rules and strategies;
- eight properties of integration and self-assertion, balancing the aims of the individual holon with the goals and needs of the whole system;

- eleven properties on triggers and scanners, where output hierarchies "generally operate on the trigger-release principle, where a relatively simple, implicit or coded signal releases complex, pre-set mechanisms" and "input hierarchies ... are equipped with 'filter'-type devices ... which strip the input of noise, abstract and digest its relevant contents, according to that hierarchy's criteria of relevance. 'Filters' operate on every echelon through which the flow of information must pass on its ascent from periphery to centre..." (ibid. p344);

- ten properties on arborisation and reticulation, where "hierarchies can be regarded as 'vertically' arborising structures whose branches interlock with those of other hierarchies at a multiplicity of levels and form 'horizontal' networks: arborisation and reticulation are complementary principles in the architecture of organisms and societies (ibid. p.345);

- three properties of regulation channels where "the higher echelons in a hierarchy are not normally in direct communication with lowly ones, and vice-versa; signals are transmitted through 'regulation channels', one step at a time, up or down" (ibid, p346); [this is not further defined, but appears to mirror the channels of communication proposed by Allen and Starr (1982) and Ahl and Allen (1996)].

- seven properties of mechanisation and freedom (linking to the work of Pattee (1973) and Simon (1962, 1973) again, on degrees of freedom and near decomposability);

- eight properties of equilibrium and disorder ("the term 'equilibrium' in a hierarchic system does not refer to relations between parts on the same level, but to the relation between part and whole" (ibid. p347)); and

- two properties on regeneration, linking to concepts of catastrophe (and to later work on catastrophic re-organisation of the system (Allen and Starr, 1982).

## 7.4 John Platt (1969, 1970)

Platt's research on hierarchical structures was focussed on boundaries and parts of complex systems. He contributed to the Whyte et al. (1969a) conference in 1969 with the following theorems about boundaries (table 7.3).

**Table 7.3 Platt's Theorems for Boundaries**

| **Theorems on Undifferentiated Boundaries** | |
|---|---|
| I. | Boundary definition: A sub-system in a nearly-decomposable system in n dimensions will have boundary surfaces of n-1 dimensions between a high-interaction region and a low-interaction region. The surface may be taken as passing through a family of points where some parameter such as "interaction-density" has a maximum gradient. |
| II. | Co-incidence of boundary-surfaces of different properties: this theorem seems to have been first pointed out by Campbell (1958, 1965). The boundary-surface for one property (such as heat-flow) will end to coincide with the boundary surfaces for many other properties (such as blood-flow, sensory endings, physical density, and so on) because the surfaces are mutually-reinforcing. ... This is what makes a collection of properties a "thing" rather than a smear of overlapping images. |
| III. | Parallel and perpendicular law: all gradients and flows in the region very near to a boundary will tend to be either parallel or perpendicular to the boundary. This is because flows of any kind will be down minimum or maximum lines ... of some property; and the perpendicular line of "normal" to a surface form the only |

| | |
|---|---|
| | unique set of minima or maxima of any property-gradients. In the case of a biological organism, the flows along the normal to the surface would include heat flow, perspiration, ... osmosis, and sensory inputs. Flows tangential to the surface would include blood flow in capillaries, surface stretching, ... muscular contraction ...the strong-coupling interactions within the system are parallel to the boundary, while the weaker-coupling interactions between the system and larger super-system flow in and out perpendicular to the boundary. |
| **Theorems on Differentiation of Boundaries** | |
| IV. | Gates: the n-1-dimensional boundary surface may likewise have lower-dimensional boundaries in or on it. A mouth is the most obvious example. |
| V. | Transducers at gates: the functional specificity of gates is not only to pass materials, energy, and information between the organism and the environment, but also to transform these entities back and forth between the external and the internal 'language' of the organism. |
| **Order-of-Magnitude Relations for Gates and Networks** | |
| VI. | "Surface-Volume" Relations of Networks: The "surface". Or "number of input gates, into a volume-filling network system, in general has a lower dimensionality that the number of nodes in the network itself. ... To put it another way, the number of interconnections in the network needed to make sense of the external world is probably necessarily greater than the number of sensory cells that are interconnected. |
| VII. | Relation of number of motor outputs to number of sensory inputs: for a variable living system, there is also probably a necessary relation between the number of sensory inputs and the number of motor outputs, so that the latter is comparable to the former, but may be smaller by something like an order of magnitude. |

Platt acknowledged that these theorems could be seen to already be implied if you assumed a hierarchical architecture for a system, but that they could be of use in studying and making clear questions for studying different levels of a complex system. These theorems will be incorporated into the interpretive analyses of the EID complex system in chapter 9.

## 7.5 Mesarovic et al. (1969, 1970)

M. D. Mesarovic, D. Macko, and Y. Takahara wrote *Theory of Hierarchical, Multilevel, Systems* in 1970, following a shorter work in the Whyte and Wilsons' conference proceedings on hierarchical structures in 1969. Their work aimed to construct a mathematical theory from a functionalist stance. "Our research in multilevel systems was motivated towards making systems theory relevant in a more direct way to the theory of organizations" (Mesarovic et al., 1970, p.16). Their generic model of a multilevel, hierarchical structure is shown in figure 7.1.

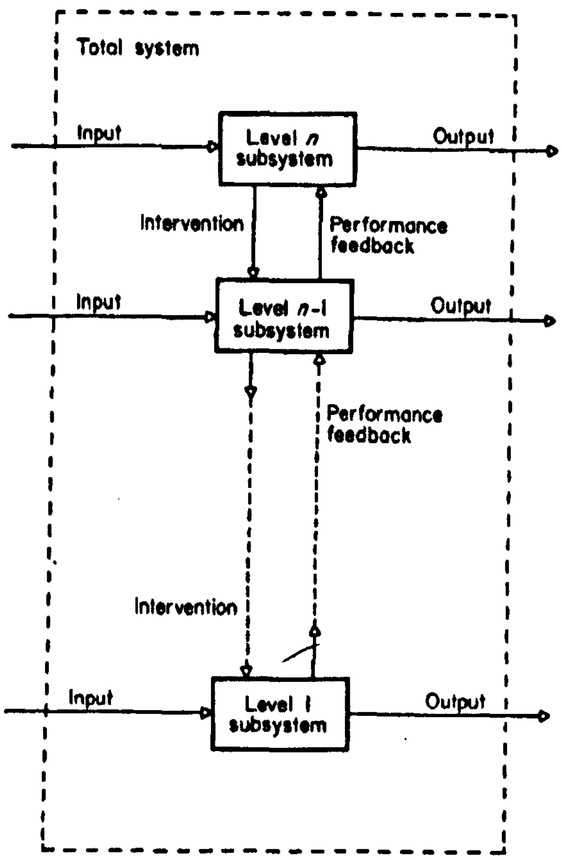



**Figure 7.1 Vertical Integration between Levels of a Hierarchy**

Their work is included in the interpretative approach because of their explicit recognition that it is the observer who defines the strata and describes the functioning of the hierarchical system (see table 7.4 for further detail).

In the article "Foundations for a scientific theory of hierarchical systems", Mesarovic and Macko wrote that their objective was "i) to define more precisely three basic, yet distinct, concepts of a hierarchy: strata layers and organizational levels and ii) to point out a specific problem, namely, that of coordination as a characteristic problem of hierarchical systems" (Mesarovic and Macko, 1969, p.29).

Strata are levels of description or abstraction and they can be found in both natural and man-made systems. Miller's work is an example of work on defining strata in natural and man-made organisations. Computer or industrial methods are also examples of man-made strata. The characteristics of strata are given in table 7.4 and illustrated in figure 7.2.

**Table 7.4 Stratified Systems (from Mesarovic and Macko, 1969, pp32-34)**

| | |
|---|---|
| 1. | Selection of strata in which a given system is described depends on the observer, his knowledge and interest in the operation of the system, although for many systems there are some strata [that] appear as natural or inherent. In general, stratification is a matter of interpretation of the systems operation. |
| 2. | Contexts are not in general mutually related, and the principles or laws used to characterize the system on any stratum cannot in general be derived from the principles used on other strata. |
| 3. | There exists an asymmetrical interdependence between functioning of a system on different strata. For a proper functioning of the system on a given stratum all the strata below have to function correctly. Therefore the requirements for proper functioning of the system on any stratum appear as conditions or constraints n the operation on the lower strata. |
| 4. | Each stratum has its own set of terms, concepts and principles and what is considered as a system and its objects are different on each stratum. Furthermore, there is a hierarchy of objects and |

| | |
|---|---|
| | languages in which they are described. As a rule, the description on any stratum is less detailed than on the lower strata: an object on a given stratum becomes a relation on a lower stratum and an element becomes a set. [This is shown in figure 7.2] |
| 5. | Starting from any given stratum, understanding of a system increases by crosses strata: moving down the hierarchy one obtains a more detailed explanation while moving up the hierarchy one obtains a deeper understanding of its significance. |

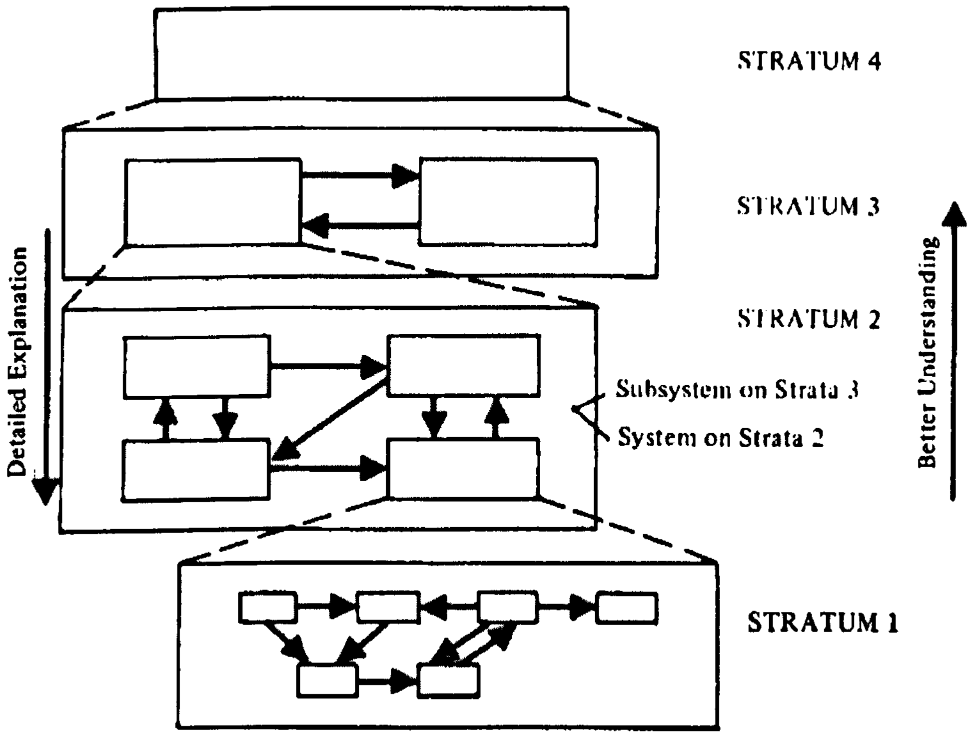



**Figure 7.2 Diagramme of a Multi-Strata System**

Their second aim of investigating organisation levels, or levels of decision complexity (a further example of hierarchy following the definitions of Allen and Starr (1982)), is addressed in this section, drawing from both the 1969 and 1970 texts. Mesarovic et al. wrote that their proposed mathematical theory for multilevel systems addressed all three areas of organization theory: classical (structural), behavioural (motivational), and systems oriented. "We argue that the position of multilevel systems theory ...

- emphasizes the hierarchical structure in the sense of the organizational charts of the classical theory; it views the hierarchical arrangement of decision-making units as one of the primary characteristics of the organization.

- views the participant as a decision-making (or goal-seeking) system in the sense of modern behavioural or, more specifically, motivational approaches. Levels of satisfaction and discrepancies between the actual and operational goals are explicitly recognized concepts.

- Recognizes, explicitly, that an organization invariably consists of an interconnection of decision-making subsystems" (Mesarovic, et al, 1970, p.19).

Later in the 1970s, Beer (1979, 1981, 1985) presented work addressing these concepts, within the field of organisational cybernetics, in more depth and adding to the development of the concepts of concepts of boundaries, goals and subgoals, span of control), specialization / decentralization and its coordination.

The work of Mesarovic et al. was also known to Miller and referenced in his development of living systems theory in 1978. The functionalist aims of addressing hierarchical structure in a mathematical approach is also at the core of Miller's work, which was presented in the previous chapter.

Their final aim for research, that of investigating coordination, integration and the crossing of levels, was the substance of the 1970 book and presented a mathematical theory of coordination for hierarchical systems. Their theory addressed the concepts of representation of the participant, issues of supervision and subordinate, coordination (as a tool for achieving integration), the hierarchy itself (with its concepts of boundaries, goals and subgoals, span of control), specialization / decentralization and its coordination. They state it:

- "provides a unified basis for different approaches through a framework in which the various approaches can be compared, contrasted, and used to complement each other.

- offers mathematical precision in defining both concepts and issues.

- provides a starting point for mathematical and computer simulation studies of various issues and problems both in analysis and design of organizations" (Mesarovic et al., 1970, p.20).

Mesarovic et al. contribute to the understanding of the principles of levels and coordination within hierarchical structures that will be carried forward into the summary of hierarchy principles at the end of this chapter.

## 7.6 C. S. Holling (1973, 2002 (with L. Gunderson))

C. S. Holling began in the 1970s to develop concepts of resilience in ecological systems and his work is now a core resource within the field of sustainability and complexity research. Holling's contribution, seen in an overview diagram of the concept of "panarchy" in figure 7.3 is developed from work parallel to that of interpretive hierarchy theorists and is a deepening of the understanding of how systems evolve and change, but also remember and adapt to previous experience. It is a more dynamic representation of the process ongoing in a hierarchical reorganisation that is talked about by Ahl and Allen (1996) for example.

In figure 7.3, there is the concept of higher-level systems, moving at a slower speed with respect to change, perturbations and reorganising events. This is represented by the larger figure of eight in the diagram shown in figure 7.3. The function of the larger cycle is to remember and pass that memory back to the lower levels, which move on a much faster time-frame, reacting quickly to change and possibilities of re-organisation. The lower, fast-moving levels are described as having the function of 'revolt', i.e. the possibility and the potential to change and adapt, and that occurrence is remembered and added to the overall system memory by the upper levels for ongoing adaptation and change (Holling, 1973).

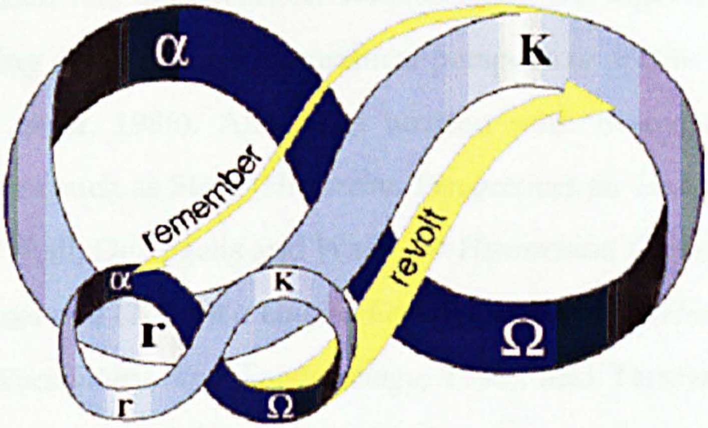



**Figure 7.3 Revolt and Remember (drawn from http://www.resalliance.org/593.php, last accessed July 12, 2007)**

The work of Holling is included in this section on interpretive hierarchy approaches since the focus of this work is an interpretation of moving, dynamic systems rather than those of a static framework.

## 7.7 Timothy F. H. Allen (1982, 1985, 1992, 1996, 2003)

Timothy Allen has written extensively on hierarchy theory, complexity and ecological systems. It is proposed in this thesis that Allen, and his co-authors, are currently the core authors in this field in proposing the most complete understanding of a 'theory' for hierarchical analysis. O'Neill et al. (1986) state that they believe that credit for the introduction of hierarchy theory as a term should belong to the work of Overton (with C. White) in their development of a functionalist approach involving the use of computer modelling to describe the behaviour of ecological systems (O'Neill et al. 1986; Overton, 1972, 1974, 1975).

Allen has also worked with O'Neill, DeAngelis, and Waide on developing an integrated hierarchical perspective on the field of ecology (O'Neill et al. 1986). Allen has written with many other hierarchy researchers such as Starr (*Hierarchy: Perspectives for Ecological Complexity*, 1982), O'Neill, DeAngelis and Wade (*A Hierarchical Concept of Ecosystems*, 1986), Hoekstra (*Toward a Unified Ecology*, 1992), Ahl (*Hierarchy Theory: A Vision, Vocabulary, and Epistemology*, 1996), and Tainter and Hoekstra (*Supply-side Sustainability*, 2003). Allen's colleague, Spencer Apollonio has also published research work based on the hierarchy theory proposed by Allen (*Hierarchical Perspectives on Marine Complexities*, 2002). In an interview with Barbara Wolff (2003), Allen says:

> “"My focus is on complexity per se, and so the particular things my students and I study are eclectic," he says. In addition to sustainability, some of the systems to which Allen has turned his attention include forest fire; ants, beavers and the thermodynamics of biological work; complexity in Wisconsin dairy farming; origins of the genetic code; and more. ... He has concluded from these and other topics that outside-of-box thinking should be standard procedure in science.
>
> "The technology that science uses to tell the story may tyrannize us by explaining how things work, blunting our curiosity about how things might otherwise work," he says. "We should continue to find out how things work, but we also need to put more effort into expansive theory"” (Wolff, 2003).

Allen and Starr's emphasis is a unified theory for botany and ecology (1982). In his first publication with Starr (1982), Allen introduced hierarchy theory from the perspective of the discipline of ecology but he readily acknowledges that this perspective is valid in other disciplines and complex systems (Allen, 1985). The need for hierarchical analysis is based on one of the premises of the book: that complex systems are what is known as middle-number systems, and that we do not currently have theories and methodologies available to address these forms of complex systems (Allen and Starr, 1982). Allen and Starr wrote that Weinberg (1975) first postulated the existence of middle-number systems when he determined that complex social situations could not be analyzed appropriately using calculus (for small-number systems) or statistics (for large-number systems) (Allen and Starr, 1982).

Middle-number systems (organized complexity) are those systems that defy the application of statistical averaging or the use of equations. They are examples of: "a system with too many parts for parts to be given individual account (as in small-number systems), but too few parts for parts to be substituted for by aggregates or averages (as in large-number systems)", (Allen and Starr, 1982).

Small-number systems (organized simplicity) are those systems with a small number of significant factors and a large number of insignificant factors, e.g. systems of planetary behaviour. These systems can be measured through the use of equations.

Large-number systems (disorganized complexity) are those systems with a large number of variables that exhibit random behaviour, e.g. gas laws. These systems can be measured by using methods of statistical averaging.

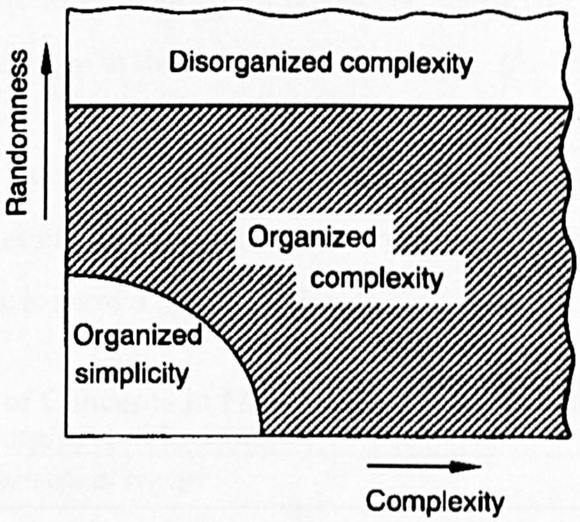



**Figure 7.4 Weaver's Three Classes of Systems and Associated Problems that Require Distinct Mathematical Tools (Klir, 2001, p.32)**

This concept of small-, middle-, and large-number systems is similar, however, to the "Line of Complexity" proposed by Weaver (1948), shown in an adaptation of these ideas in figure 7.4 by Klir (2001, p.32). Weaver's line matches small-number systems with organized simplicity, middle-number systems with organized complexity, and large-number systems with disorganized complexity. Clemson (1984) adds a fourth category of "relativistic organized complexity" to Weaver's classification so as to encompass the phenomenon of observing "observing systems." All of these concepts are recognition of the gap between simplicity and chaos—and of the need for a mathematical explanation for the structure of these middle-number, organized-complexity systems.

The 1982 book is divided into the first section on the principles and underpinning research for hierarchy theory, followed by a section on evolution from a hierarchical perspective, and finally a section on scale and complex systems, again from the perspective of ecology. This book also offers an extended glossary of terms for hierarchy theory, the only such glossary available in the field (Allen, 1982, pp. 261-280).

A shorter summary of hierarchy concepts and principles, written by Allen for a webpage on hierarchy for the International Society for the Systems Sciences, is shown in table 7.5.

**Table 7.5 A List of Concepts in Hierarchy (from Allen, 2004, http://www.isss.org/hierarchy.htm)**

| |
|---|
| *Hierarchy: in mathematical terms:* |
| ... is a partially ordered set. In less austere terms, a hierarchy is a collection of parts with ordered asymmetric relationships inside a whole. That is to say, upper levels are above lower levels, and the relationship upwards is asymmetric with the relationships downwards. |
| **Hierarchical levels:** |
| Levels are populated by entities whose properties characterize the level in question. A given entity may belong to any number of levels, depending on the criteria used to link levels above and below. For example, an individual human being may be a member of the level i) human, ii) primate, iii) organism or iv) host of a parasite, depending on the relationship of the level in question to those above and below. |
| **Level of organization:** |
| This type of level fits into its hierarchy by virtue of set of definitions that lock the level in question to those above and below. For example, a biological population level is an aggregate of entities from the organism level of organization, but it is only so by definition. There is no particular scale involved in the population level of organization, in that some organisms are larger than some populations, as in the case of skin parasites. |
| **Level of observation:** |
| This type of level fits into its hierarchy by virtue of relative scaling considerations. For example, the host of a skin parasite represents the context for the population of parasites; it is a landscape, even though the host may be seen as belonging to a level of organization, organism, that is lower than the collection of parasites, a population. |
| **The criterion for observation:** |
| When a system is observed, there are two separate considerations. One is |

the spatiotemporal scale at which the observations are made. The other is the criterion for observation, which defines the system in the foreground away from all the rest in the background. The criterion for observation uses the types of parts and their relationships to each other, to characterize the system in the foreground. If criteria for observation are linked together in an asymmetric fashion, then the criteria lead to levels of organization. Otherwise, criteria for observation merely generate isolated classes.

**The ordering of levels:**

There are several criteria whereby other levels reside above lower levels. These criteria often run in parallel, but sometimes only one or a few of them apply. Upper levels are above lower levels by virtue of: 1) being the context of, 2) offering constraint to, 3) behaving more slowly at a lower frequency than, 4) being populated by entities with greater integrity and higher bond strength than, and 5), containing and being made of - lower levels.

**Nested and non-nested hierarchies:**

Nested hierarchies involve levels that consist of, and contain, lower levels. Non-nested hierarchies are more general in that the requirement of containment of lower levels is relaxed. For example, an army consists of a collection of soldiers and is made up of them. Thus an army is a nested hierarchy. On the other hand, the general at the top of a military command does not consist of his soldiers and so the military command is a non-nested hierarchy with regard to the soldiers in the army. Pecking orders and food chains are also non-nested hierarchies.

**Duality in hierarchies:**

The dualism in hierarchies appears to come from a set of complementarities that line up with: observer-observed, process-structure, rate-dependent versus rate-independent, and part-whole. Arthur Koestler in his "Ghost in The Machine" referred to the notion of holon, which means an entity in a hierarchy that is at once a whole and at the same time a part. Thus a holon at once operates as a quasi-autonomous whole that integrates its parts, while working to integrate itself into an upper level purpose or role. The lower level answers the question "How?" and the upper level answers the question, "So what?"

**Constraint versus possibilities:**

When one looks at a system there are two separate reasons behind what one sees. First, it is not possible to see something if the parts of the system cannot do what is required of them to achieve the arrangement in the whole. These are the limits of physical possibility. The limits of possibility come from lower levels in the hierarchy. The second entirely separate reason for what one sees is to do with what is allowed by the upper level constraints. An example here would be that mammals have five digits. There is no physical reason for mammals having five digits on their hands and feet, because it comes not from physical limits, but from the constraints of having a mammal heritage. Any number of the digits is

| |
|---|
| possible within the physical limits, but in mammals only five digits are allowed by the biological constraints. Constraints come from above, while the limits as to what is possible come from below. The concept of hierarchy becomes confused unless one makes the distinction between limits from below and limits from above. The distinction between mechanisms below and purposes above turn on the issue of constraint versus possibility. Forget the distinction, and biology becomes pointlessly confused, impossibly complicated chemistry, while chemistry becomes unwieldy physics. |
| **Complexity and self-simplification:** |
| Howard Pattee has identified that as a system becomes more elaborately hierarchical its behavior becomes simple. The reason is that, with the emergence of intermediate levels, the lowest level entities become constrained to be far from equilibrium. As a result, the lowest level entities lose degrees of freedom and are held against the upper level constraint to give constant behavior. Deep hierarchical structure indicates elaborate organization, and deep hierarchies are often considered as complex systems by virtue of hierarchical depth. |
| **Complexity versus complicatedness:** |
| A hierarchical structure with a large number of lowest level entities, but with simple organization, offers a low flat hierarchy that is complicated rather than complex. The behavior of structurally complicated systems is behaviorally elaborate and so complicated, whereas the behavior of deep hierarchically complex systems is termed complex, rather than complicated (Allen et al., 2003). |
| **General notes on hierarchy theory:** |
| Hierarchy theory is as much as anything a theory of observation. It has been significantly operationalized in ecology, but has been applied relatively infrequently outside that science. There is a negative reaction to hierarchy theory in the social sciences, by virtue of implications of rigid autocratic systems or authority. When applied in a more general fashion, even liberal and non-authoritarian systems can be described effectively in hierarchical terms. There is a politically correct set of labels that avoid the word hierarchy, but they unnecessarily introduce jargon into a field that has enough special vocabulary as it is. |

In 1993, Allen wrote with O'Neill, DeAngelis and Waide on the development of hierarchy theory and proposed that a theory for hierarchy had to pass the following tests (O'Neill et al., 1986, p.74):

- "The theory must be internally consistent"; (they demonstrated this using the work of many of the authors covered in this thesis in chapters 5, 6 and 7);

- "The theory must not be adopted simply because of success in other fields"; (they discussed the limitations of the use in previous disciplines);

- "The theory must agree with known properties of ecosystems"; (they developed the exploration further in the fourth part of the book, exploring hierarchies of structure and process for new insights); and

- The theory must be capable of producing new and testable hypotheses" (O'Neill et al., 1986, p.74).

This book (1986) continued the development of the idea central to the work of many authors already covered in this and the previous chapter: "that organization results from differences in process rates" (O'Neill et al., 1986, p.75) and that these differences are what reveal the boundaries of the levels within the system of interest as developed by Simon (Simon, 1962) in his concept of near-decomposability. O'Neill et al. state: "medium-number systems ... operate over a wide spectrum of rates. Behaviors can be grouped into classes with similar rates, and if the classes are sufficiently distinct, then the system can be considered as hierarchical and dealt with as a small-number system" (O'Neill et al., 1986, p.75-6) [i.e. using mathematical equations to explain their behaviour and structure]. The differences between the rates are illustrated and determined by identifying steep gradient rates between those levels (O'Neill et al., 1986, p86).

Vertical and horizontal structures were also explored in this 1986 text: noting that behaviour at higher levels of the system operates at slow rates, while lower levels operate at much higher rates, and this is related to the response time of that level of organisation to an outside stimulus. O'Neill et al. show this in figure 7.5.

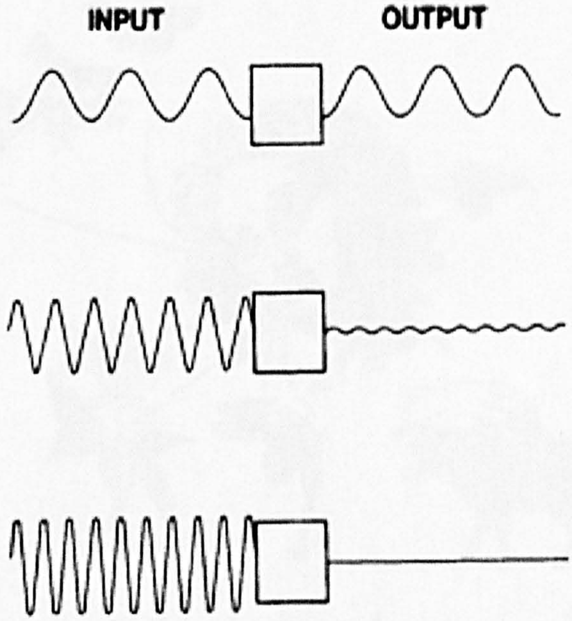



**Figure 7.5. Attenuation of an input signal by a linear "black box".** Low-frequency signals (top) pass unmodified while higher frequency signals (middle and bottom) have their amplitudes decreased. The figure illustrates how a [upper] level in a hierarchy can be isolated from high-frequency (i.e. rapid) dynamics at lower levels in the hierarchy. (O'Neill et al., 1986, p.77).

The attenuation demonstrated in figure 7.5 underpins the concept of filters and the process of filtering information between levels of a hierarchy; and is also related to the functions of control, constraint and containment. This can again be referred to the in-depth analysis of these concepts in the work of organisational cybernetics and the work of Beer (1979, 1981, 1985). The role of the observer in defining the choice of scale, and the hierarchical structure and processes will be discussed further in chapter 9.

Allen and Hoekstra use the following figure 7.6 to illustrate the importance of the observer in hierarchy theory.

**Figure 7.6 Ecology is a matter of primary human experience (Allen and Hoekstra, 1992, p.14)**

With Hoekstra in 1992, Allen focuses on ecological systems from the perspective of the need for addressing scale and a particular point of view in defining the system of interest, central to which is the observer in the system (Allen and Hoekstra, 1992, p.13). Following on from this, a primer in hierarchy theory (1986) was developed into the book by Ahl and Allen (1996). While also being a text on the practical use of hierarchy theory using many case examples, this book specifically addresses the role of the observer in not only defining the system but in framing the route for the start of the observation; i.e. defining the research question.

The final book in this section was again with Hoekstra and also Tainter, applying hierarchy theory in practice with supply-side sustainability for ecological and social systems (Allen et al., 2003). The hierarchy theory principles and applications from these books will be core to the application of hierarchy theory to EID in chapter 9.

## 7.8 Summary

This chapter has explored the hierarchical approaches of those authors considered to be core to the development of hierarchical systems from an interpretive standpoint. The insights discovered in this chapter will be incorporated with the principles and method for a theory of hierarchy that will be developed in chapter 9.

# Chapter 8

## The Functionalist Application

In this chapter, one of the functionalist frameworks from chapter 6 will be used to address the issue of the management of emerging infectious disease (EID). The framework chosen is that of the Skeleton of Science (Boulding, 1956) which is the most-developed framework, and therefore considered to be an exemplar of the available work in this area. The American Heritage Dictionary defines an exemplar as: 1) "one that is worthy of imitation; a model, 2) one that is typical or representative; and example, and 3) an ideal that serves as a pattern; an archetype" (2000). The Boulding framework is the most detailed model and explication found in the literature of the use of specific disciplines at specific scales of inquiry in an investigation. It is worthy of imitation as that best example, and it is an archetype of many other models of a similar form, and it is the most developed of the group.

This chapter also investigates whether this approach generates any limitations in the current methods employed by the discipline of epidemiology in addressing policy making for EID.

### 8.0 Introduction

The *Skeleton of Science* is used in this chapter to explore and surface additional knowledge about international health policy making for EID. Boulding's skeleton will be used to pull out the scope of disciplines to be found in three statements of current international epidemiological policy-making. The results of that comparison will be used in a later chapter to argue for an expanded epidemiology that incorporates a systemic approach that merges the breadth of traditional epidemiology and the clinical support of modern epidemiology.

The choice of Boulding's work for this project was based on the following requirements that:

1) the chosen framework had to incorporate the principles of holism, hierarchy and emergence;

2) the framework had to demonstrate increasing complexity in the organisation of the units in the framework; and

3) the framework had to be able to relate the increasing complexity of the units of investigation with an increasing complexity of disciplines within the same framework.

We build models in order to gain understanding of our "unordered experiences" (Dubin, 1978; Allen and Starr, 1982). The model used in this paper is Boulding's representation of the increasing complexity that he saw in each of the levels of organisation, and he associated each of those levels with particular disciplines.

Boulding designed his skeleton to reflect that different disciplines are bodies of knowledge that focus on the investigation of a particular unit. He further proposed that each discipline had its own measurement, experimentation, and evaluation techniques. Therefore simply transferring individual models and languages of description from one level of unit-analysis to another would lead to an inadequate representation: that lower-level (e.g. biological) techniques would not adequately describe higher-level (e.g. societal), more complex, units of investigation (Boulding, 1956).

At each level of Boulding's skeleton, value filters, that are determined individually, exist for each different level. It follows from this that no two entities above the mechanistic second or third levels could hope to agree exactly on the incoming data, its interpretation, the size of gaps between levels, or even the drawing of the boundaries of those levels. This leads to the problem that there can be no agreed-on, absolute, mathematical yardstick for developing models or descriptions at Boulding's upper levels of the *Skeleton*.

Boulding addresses both hierarchy and the increasing complexity of the subject matter of the disciplines, and recognises that with each new level, more complex models and languages of description are required. He, at least, does not ignore that this is a requirement. Instead he concludes that above level 4 of his skeleton there is no adequate measurement of the increase in complexity. This produces the valid warning that "we should never accept as final 'a level of theoretical analysis which is below the level of the empirical world which we are investigating'" (Checkland, 1981, p104).

| Level | Description | Characteristic | Example | Discipline |
|---|---|---|---|---|
| 1 | Structures and frameworks | Static, spatial pattern | Bridge, mountain, crystal, atom | Descriptive elements of all disciplines |
| 2 | Clockworks | Predetermined motion | Clocks, machines, solar system | Physics, astronomy, engineering |
| 3 | Control mechanisms | Closed-loop control | Thermostat, homeostasis | Cybernetics |
| 4 | Open systems | Structurally self-maintaining | Flames, cells | Theory of metabolism |
| 5 | Genetic–societal systems | Society of cells, functional parts | Plants | Botany |
| 6 | Animals | Nervous system, self-awareness | Birds and beasts | Zoology |
| 7 | Humans | Self-consciousness, knowledge, language | Human beings | Biology, psychology |
| 8 | Socio-cultural systems | Roles, communication, values | Families, boy scouts, clubs | History, sociology, anthropology |
| 9 | Transcendental systems | Inescapable unknowables | God? | Philosophy, religion |

**Figure 8.1 Boulding's *Skeleton of Science* (from Mingers, 1997, p306)**

In reviewing figure 8.1, the methods employed by modern (clinical and molecular) epidemiology can be seen to address levels 1, 2, 3 and 4 with typology, order and specification relating to the epidemiological considerations of place, time, and person respectively. In the same way that a systems approach attempts to address each of the levels of the skeleton, traditional and eco-epidemiology have investigated at the level of the relationships described from level 4 and above.

There has been concern that if epidemiology moves beyond the scope of the natural sciences then it will lose credibility in the scientific community Vandenbroucke (1994). Therefore this concern would also be extended to a move where epidemiology extended its research and interventions into these higher levels of the skeleton. This is a valid critique and many practical consequences such as professional reputation and funding considerations depend on the validity of the research content as judged by those within the dominant paradigm. The next section presents the material gathered from the literature review of epidemiology of possible contributing factors to the complex system of EID.

## 8.1 Possible Contributing Risk Factors in Emerging Infectious Disease

Focusing on emerging infectious disease from the systematic and systemic perspective held in this thesis requires finding source information from every discipline that might be able to add to the list of possible contributing factors. The following section lists the sources for each of the contributing risk factors that are current in the literature that deals with emerging infectious disease. These are then used in this chapter's matrix, which is the summary of these factors using the epidemiological categories of host, agent, transmission and environment. They are taken from the literature on emerging infectious disease and are judged important in this thesis because each can be found in several source materials, which, using the principles of drawing in triangulated data, attempts to add reliability to the data gathering process.

Contributing risk factors have also been named "traffic lights" by Morse (1993, p23) because surveillance of these issues points to occurrences of possible "viral traffic".

Figure 8.2 shows the leading global microbial threats in the 1990s. This slide is part of a series to raise awareness as to the increase in such threats and to inform groups about the priorities of the CDC in addressing these threats (CDC, 1997).

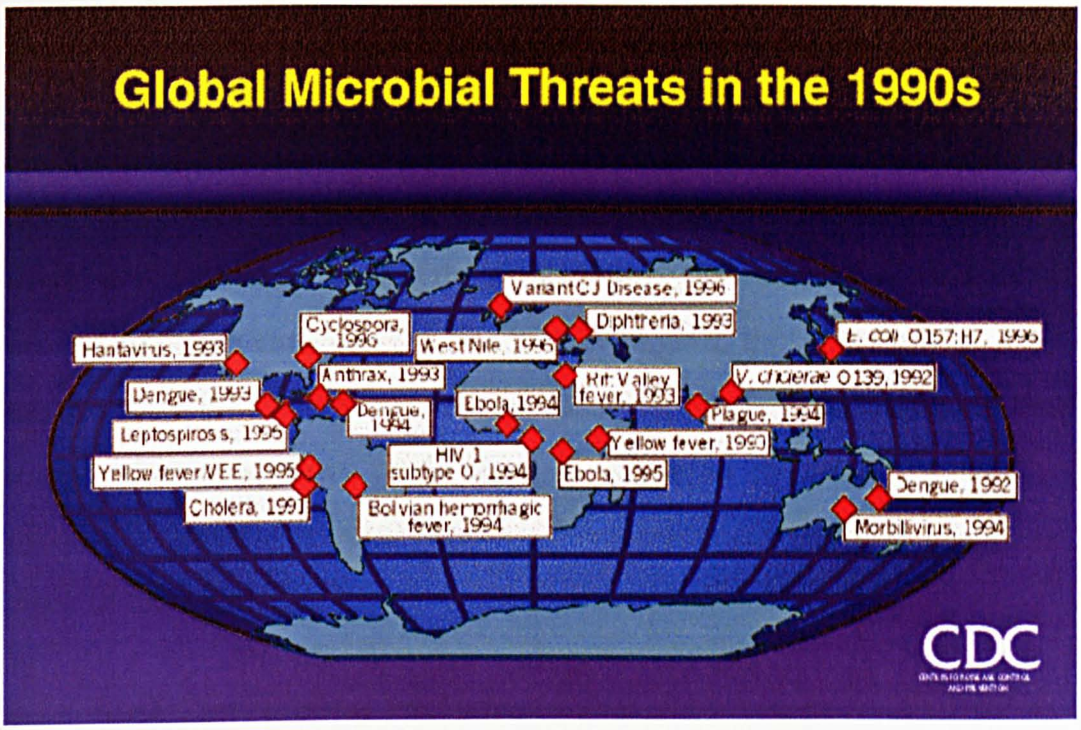



**Figure 8.2 Global Microbial Threats (from CDC, 1997, slide presentation)**

Figure 8.2 illustrates that the issue of emerging infectious disease is a worldwide concern that is impossible to separate into responsibilities for individual nations or disciplines to address. Its study requires a multi-national and multi-disciplinary approach. However, it was hard (in two different ways) to sort the contributing risk factors of these global-based emerging infectious diseases. First, deciding which issue was the result of host, agent, transmission or environmental factors was difficult because many of the issues could be addressed in several categories. For example, a change in the biology or habitat of either host and/or agent, could be placed in either of the four categories of host, agent, transmission or environment. For this list, the decision was made that the primary relationship between the factor and the category was extracted.

Second, it was also difficult to assign specific disciplines to the individual issues. After only two or three decisions into the list, it seemed as though every discipline was applicable in every contributing factor depending on what part of the factor was being studied. Additional reading led to questioning their placement and caused factors to be moved between categories in the matrix. Again, those disciplines most central to the issue were selected and it is acknowledged and accepted that many other disciplines could have been added for each factor. This process of choice of relevant factors is one possible direction for additional work in this topic.

### 8.1.1 Host Contributing Factors

"Biological, social, and behavioral characteristics of this group that are relevant to health..." (Last, 1995, p79).

*Higher concentrations in population*: this results in overcrowding and a lack of nutrition, sanitation, and clean water, and contributes to weakened immune systems and physical conditions which facilitate the spread of disease agents and their vectors (Morse, 1993; Karlen, 1995).

*Movement of populations*: this may occur because of political unrest, war, famine or general economic pressures where people are displaced in large numbers to other areas where overcrowding, lack of facilities and nutrition tie together to spread disease (Garrett, 1994, CDC 1997).

*Susceptibility to infection*: this is affected by factors such as poverty and poor nutrition and health services, lack of immunisations, or a reduced immunity e.g. with HIV/AIDS (Tomes, 1998; Morse, 1993; Gellert, 1993).

*Speed of global transport of people, recreational travel, and business travel*: the speed of air travel allows hosts and agents to reach all corners of the planet in days rather than years (Miller, 1989). These three factors are inter-linked in that extended travel possibilities can expose people to infectious diseases where they have no natural immunity and where they can acquire and take home new diseases into their own communities (Lederberg, 1988; Berkelman and Hughes, 1993; AAWH, 1997).

*Changes in human behaviour*: changes in nutrition, sexual attitudes and behaviour, drug addictions, and changing lifestyles from a local to more global focus lead to greater exposures to infectious disease for hosts (AAWH, 1997).

*Herd immunity*: this is a factor where people moving in and out of communities can reduce or increase that community's herd immunity i.e. their communal resistance to an infectious disease (Last, 1995; AAWH, 1997). This factor can also be linked to population increases, changes in behaviour, and travel of populations outside local communities (Berkelman and Hughes, 1993).

### 8.1.2 Agent Contributing Factors

"A factor, such as a microorganism, chemical substance, or form of radiation, whose presence, excessive presence, or (in deficiency diseases) relative absence is essential for the occurrence of a disease." (Last, 1995, p5).

*Changes in symbiosis in species, mutation of agent (new disease)*: this factor happens as a natural progression of host/agent interactions (Miller, 1989; Ryan, 1996). This factor has implications for the surveillance goals of health agencies (Ampel, 1991). The genetic makeup of infectious microbes changes quickly, e.g. influenza, and HIV, "against which humans have limited resistance" (AAWH, 1997) and surveillance methods have to match that variety.

*Antibiotic/drug resistance*: antibiotic and other drug resistances have developed towards several infectious agents (e.g. *staphylococcus aureus* (MRSA), tuberculosis, shigella dysyntery, and venereal diseases.) This is linked to the previous factor regarding the interaction and adaptation process between host, agent and vectors (AAWH, 1997; CDC, 1996)

*Sanitation changes*: Tomes (1998) has written that technological invention and social education programmes concerning sanitation and cleanliness have led to the improvements in public health, particularly in the United States. Others have countered that these improvements were coincidental to the natural decline in certain infectious diseases (McNeill, 1976). On the other hand, failures in these systems can increase the risk for a re-emergence of diseases (Tomes, 1998; Morse, 1993).

### 8.1.3 Transmission Contributing Factors

"Any mechanism by which an infectious agent is spread from a source or reservoir to another person." (Last, 1995, p167). These mechanisms can be direct or indirect.

*Changes in biology of biological carriers, and population increase in those carriers:* these factors are also related to environmental conditions. Changes to animal populations may be caused by weather changes that increase or decrease the food supplies of animal or insect vectors (e.g. the Sin Nombre outbreak in Four Corners, Arizona was linked to an increase in field mice, which in turn was linked to an abundance of their favourite food: pinon nuts and insects (like grasshoppers) (Ryan, 1996)).

*Transplants and hospital-source infections (nosocomial infections):* these are often overlapping in that the hospital or medical environment facilitates the transmission of infectious agents (Miller, 1989). Morse calls this a similar process to that of trade route transmission in that transplants and hospitals are "trade routes" for these infections (Morse, 1993; AAWH, 1997). This factor is also linked to antibiotic and drug resistance.

*Changes in dwelling construction*: changes to the physical built environment can break a chain of transmission. Shutting up entrances that agents can use either directly or indirectly through the use of their vectors (e.g. rats, insects, water supplies) can break the transmission route.

*Concentrations of livestock and changes in patterns of farming*: these factors are linked to environmental factors and are also influenced by the economic pressure for more intensive food production methods and use of the land (Miller, 1989; Berkelman and Hughes, 1993). Examples of these changes are the use of antibiotics in cattle generally, and the combination of pig and duck farming in China. Ducks are believed to be a major reservoir for influenza virus, but pigs are the "mixing vessels" for reassortment of the influenza virus, which is then transmitted to humans (Morse, 1993).

### 8.1.4 Environment Contributing Factors

"All that which is external to the individual human host. Can be divided into physical, biological, social, cultural, etc., any or all of which can influence health status of populations." (Last, 1995, p53).

*Trade route vectors*: trade routes can play a major role in the transmission of disease. These facilitated the spread of plague in the 1300s (Greenwood, 1935; Wu, 1936; Garrett, 1994) and the Kinshasa highway played a similar role in the spread of HIV (Garrett, 1994). The slave trade is also thought to have brought mosquitoes on ships from Africa to the northern hemisphere (Morse, 1993).

*War*: this factor is an erosion of political, social and economic infrastructures (Karlen, 1995) that would otherwise have the flexibility to monitor and address outbreaks of disease. This is also a way of introducing disease in new populations e.g. smallpox from Europe to the populations of the north and south Americas in the 16th and 17th centuries by settlers and invading armies (Ampel, 1991; Garrett, 1994; McNeill, 1996).

*Famine*: changes in agriculture and weather patterns are linked to successes and failures in food production. This can also be linked to political upheavals. Famine also increases susceptibility to disease (Morse, 1993; AAWH, 1997).

*Policy conflicts*: these conflicts also encompass the hypothesis of this thesis where the methods and approaches for studying, planning and controlling emerging infectious disease are in conflict. These also incorporate the behavioural sciences, and sociological, economic and political issues.

*Encroachment into wilderness/ increasing possibility of infection*: in cases of population expansion and the needs of increased land for agriculture, the pressures for these changes are greatest in the areas of the world where emerging disease is a high risk i.e. tropical areas (Lederberg, 1988; Miller, 1989; AAWH, 1997). Another viewpoint attributed to Karl Johnson is that "humans have already slashed and hacked their way into most of the world's unique ecosystems", the proposal being that we are not likely to find many more undiscovered microbes (Karlen, 1995, p228).

*Global warming*: changes in global temperature will cause changes in habitats, agricultural patterns, weather patterns, and oceanic currents (Lovelock, 1979; Miller, 1989; Karlen, 1995; Ryan, 1996). These changes in turn are linked to issues of adequate nutrition, the numbers of carriers, and the movement of people towards more supportable habitats.

*Oceanic currents/movements*: Karlen holds that water flushed "from the ballast tanks of ships from Asia" (Karlen, 1995, p216) caused the outbreak of cholera in Peru in 1991. However, a more recent article states that an epidemiological investigation of the two Asian ships that arrived at that time were not carrying cholera and that oceanic currents (facilitated by El Nino) from Asia carried the disease in association with zooplankton (Mouriño-Pérez, 1998). This view is not established elsewhere but adds to the requirements that investigations of such incidents should be multi-disciplinary.

*Germ warfare*: the current economic and political instability in the former USSR is of concern in that the controls for safeguarding the biological and chemical agents in that country may be in jeopardy (PROMED, 1998). This threat of germ warfare either by accident or plan is also an issue for multiple disciplines (Lederberg, 1998).

*Dam building*: in addition to removing the habitat for species in the flooded areas, dam building also provides additional bodies of standing water for the breeding of insects such as mosquitoes (Miller, 1989; Morse, 1993).

*Insufficient (limits of) knowledge*: this factor is acknowledged in my construction of the list of contributing risk factors and in my choice of the Boulding framework used to identify the disciplines. Insufficient knowledge about the risk factors can hinder at best, and cause to fail at worst, an investigation of emerging infectious disease. This has to be mitigated, and a multi-disciplinary approach is advocated.

The matrix (table 8.1) examines all of these contributing risk factors and determines which bodies of knowledge (disciplines) should be applied to the investigation of each of the risk factors.

The matrix is sorted into four groupings of contributing factors according to whether they can be attributed to the epidemiological categories of host, agent, (mode of) transmission, or environment, and the rationale for the choice of each factor has been detailed in the previous section. This mapping will show the levels of investigation that should be incorporated into the study of those cases of infectious disease.

Boulding's *Skeleton of Science (1956)* arranges some of the contributing factors for emerging infectious disease to develop a different perspective of the complexity of the research issues involved and the scope of the disciplines necessary for their adequate study. My perspective differs from those of other researchers and could and should be debated to generate alternative perspectives on this issue.

**Table 8.1 Matrix for Matching Contributing Risk Factors to Disciplines**

| ISSUES | BOULDING LEVEL AND DISCIPLINES ASSOCIATED AT THOSE LEVELS |
|---|---|
| **HOST FACTORS** | |
| higher concentrations in population | 7 population biology; 8 sociology, economics. |
| movement of populations | 3 feedback, cybernetic systems; 8 sociology, politics. |
| susceptibility to infection | 4 molecular/biochemistry; 8 sociology, psychology |
| speed of global transport of people | 2 clockworks; 8 sociology |
| changes in human behaviour | 8 sociology, politics, psychology; 9 religion, philosophy |
| herd immunity | 3 feedback mechanisms; 8 sociology, psychology |
| recreational travel | 8 sociology, economics |
| business travel | 8 sociology, economics |
| **AGENT FACTORS** | |
| changes in symbiosis in species | 4 molecular/biochemistry; 6 zoology; 7 ecology; 8 anthropology |
| antibiotic/drug resistance | 3 feedback mechanisms; 4 molecular/biochemistry |
| mutation of agent | 4 genetics, biochemistry |

| | |
|---|---|
| sanitation changes | 1 frameworks/structures; 2 clockworks; 7 biology, ecology; 8 sociology, politics |
| **TRANSMISSION FACTORS** | |
| changes in biology of animal carriers | 4 genetics, biochemistry; 6 zoology; 7 ecology |
| population increase in animal carriers | 3 feedback, cybernetic systems; 7 ecology, biology |
| transplants | 4 genetics, biochemistry; 7 biology |
| hospital-source infections (nosocomial) | 1 frameworks/structures; 8 sociology, economics, politics |
| changes in dwelling construction | 1 frameworks/structures; 2 clockworks; 8 sociology, economics, politics |
| concentrations of livestock | 6 zoology; 8 economics, sociology |
| changes in patterns of agriculture | 5 botany; 8 sociology, economics, politics |
| **ENVIRONMENT FACTORS** | |
| terrorism | 7 ecology; 8 sociology, economics, politics |
| trade route vectors | 7 ecology; 8 sociology, economics, politics |
| war | 1 frameworks/structures; 8 sociology, economics, politics |
| famine | 7 ecology; 8 sociology, economics, politics |
| insufficient (limits of) knowledge | all levels involved |
| policy conflicts | 8 politics, sociology; 9 religion |
| encroachment into wilderness/ increasing possibility of infection | 2 clockworks; 7 ecology; 8 sociology, economics, politics |
| global warming | Feedbacks between all levels. Focus on 2 clockworks; 3 feedback, cybernetic systems; 4 information systems; 7 ecology |
| oceanic currents/movements | 1 frameworks/structures; 2 clockworks; 3 feedback, cybernetic systems; 7 ecology |
| germ warfare | 4 molecular/biochemistry; 7 ecology; 8 politics |
| dam building | 1 frameworks/structures; 2 clockworks; 7 ecology; 8 politics, economics |

### 8.1.5 Discussion

In this analysis it is a given that it will include a level one description of framework in at least two ways: the first is that there is a framework present in terms of it being not only the epistemological structure that has been chosen for use in this thesis but also, in a more abstract form, it is an acknowledgement that there is a perceived structure and pattern observed in this research. This may be further classified as being a subjective interpretation and open to differing perspectives of that same observation.

The matrix shows that every level of Boulding's framework can be invoked for several of the very complex risk factors in the matrix, e.g. the factor concerning the lack of understanding of causes in many of the biological and social factors. Many levels are identified for each factor in the matrix and even without links between the factors, this reveals that even single factors require a multi-disciplinary approach in their study design. Further, the complexity greatly increases when several factors are linked together.

From this analysis there is also the warning that focusing on the individual issues at a lower level and remaining at that level may cause us to overlook consideration of possible emergent properties that may have future consequences. This point argues that the investigation into emerging infectious diseases should be designed to gather data using the languages and models from as many disciplines as possible so as to interpret those data as meaningfully as possible, and with a higher degree of confidence.

### 8.1.6 Summary

While the language of epidemiology can be used within different levels of the hierarchy of disciplines, that language alone is not sufficient at the more complex levels to explain completely the nature of the interactions and the emergent properties from those interactions (Checkland, 1981). At the levels of social and behavioural investigations, languages must be developed for those disciplines which can explain with confidence the interactions and emergent properties in that research.

Finally, the use of hierarchy and the Boulding framework in this chapter also highlight the imperative to work across disciplines, and to use a multi-disciplinary approach to investigate emerging infectious diseases. It is not adequate or sufficient to apply one discipline to address this research topic.

The underpinning goal of this thesis was to investigate a research topic of importance for public health. Epstein states that: "Public health workers must participate, then, in the debate about how society can reconstitute itself and how new global systems of support can be formulated" (Epstein, 1992, p265). The practical outcome of such research is addressed in this section concerning the improvement of public health and reduction of risks to public health. This is done by exploring whether multi-disciplinary epidemiology can influence research and policy making, in the pursuit of maximum effectiveness in addressing the risks of emerging infectious diseases.

In all of the groups or levels of issues described in chapter 3, there are authors who maintain that one or only a few of these factors are the dominating principle that explains the whole complexity of emerging infectious diseases. For example, as described previously, Tomes (1998) believes that it was technological improvements that have reduced the incidence of disease, while McNeill (1976), Karlen (1996), Ryan (1996) and Wills (1997) believe that there are symbiotic and evolutionary changes at work in the co-existence of humans and microbes, and Garrett (1994), Chesworth (1996), Diamond (1997) and Sapolsky (1997) hold that societal influences and their environmental effects are driving the probable increase in emerging infectious diseases.

These authors are well aware of the complexity of this subject. However, none of the books surveyed for this thesis have taken a multi-disciplinary approach to the study of emerging infectious diseases. If such a thorough research was available, then the conclusions would perhaps fall differently, into looking for the explanation and means for understanding and control in the interrelationships between the parts. Such research could also offer alternative explanations for the behaviour that the higher level exhibits and how that controls the behaviour of the lower levels.

In chapter 4 it was stated that emerging infectious diseases are a leading cause of death in the world, and that research in this area is a high priority. In the next section, three cases of policy statements by the Centers for Disease Control, the World Health Organisation, and the Pan American Health Organisation are presented and analysed to determine which disciplines are represented in their statements.

Specific statements were also sought from the publications of the British Public Health Laboratory Service but the information gathered is not in the same format as the three listed above and instead this organisation (PHLS) focuses on statements for the prevention of specific instances of infectious disease. Statements made at the organisational level would not be comparable with statements regarding specific programme levels.

The numbers in parenthesis in each of the tables represent the disciplines of the levels in Boulding's framework as used in the previous chapter. If the disciplines discerned in the policy statements in the following cases do not match the range of disciplines generated in the matrix at the beginning of this chapter, it is proposed in this thesis that the content of the cases in international health policy presented here are not fully representative of the range of disciplines available in the generation of new knowledge and practical applications arising from that research. If this is shown to be the case in the following cases, then recommendations for changes in those policies based on the benefits of applying systemic and systematic multi-disciplinary approach to the issue will be made later in this thesis.

Finally, in analysing these statements two things are acknowledged: first, that it is the outcome, the language in the statements that is being interpreted and not the process of the policy making itself which is outside the scope of this project; and second, that this researcher has a bias in reading the format of the statements: that this researcher is expecting a positivist approach to be revealed in the content and this is what was found in the tables which follow. A second pass was made through the table with this realisation and this resulted in listing additional disciplines, but this process cannot rest with one perspective, as the subject for future research, it has to be re-done and debated using many other perspectives.

## 8.2 Three Cases of Policy / Priority Statements for the Control of Emerging Infectious Disease

### 8.2.1 The Centers for Disease Control (CDC), Atlanta, GA, USA

The CDC is a unit of the federal government of the United States of America. It was founded in 1946 for the control of disease. In the intervening fifty years the CDC has become, among many of its functions, a resource centre at the international level, sending its researchers around the world when requested to investigate outbreaks of disease (CDC, 1996).

The CDC has developed a plan for addressing emerging infectious disease threats in the USA that was published by the CDC on April 15, 1994, in the CDC's Morbidity and Mortality Weekly Report. The four goals of the plan for addressing infectious disease threats are shown in the next table.

**Table 8.2 CDC Policy Statements and Analysis**

| POLICY GOAL | DISCIPLINES DISCERNED IN THE POLICY (Boulding's levels in parentheses) |
|---|---|
| Detect, promptly investigate, and monitor emerging pathogens, the diseases they cause, and the factors influencing their emergence. The ability to detect what is new or emerging depends on the capacity to identify and track the routine as well as the unusual. This goal | **Probable:**<br>Information systems (4)<br>feedback modelling (3)<br>analysis of statistics/patterns (looking for the differences) (1, 2)<br>operations research (1, 2) |

| | |
|---|---|
| focuses on improving our country's early warning network and developing more effective international surveillance networks. | mathematical modelling (1, 2)<br>**Possible:**<br>behavioural sciences (7, 8) for investigating "the factors influencing their emergence", although not detailed.<br><br>Emphasis on clinical epidemiology. |
| Integrate laboratory science and epidemiology to optimise public health practice. Advances in diagnostic technologies can be brought into common public health practice. This requires close ties between personnel involved in disease prevention. For example, public health microbiologists have to collaborate with epidemiologists to support efforts to determine the sources of infection, develop interventions to prevent spread and recurrence, implement the interventions successfully, and measure their effectiveness. | **Probable:**<br>biochemistry (4)<br>chemistry (1, 2)<br>biology (7)<br>mathematics (1, 2)<br>engineering (1, 2)<br>microbiology (4)<br>**Possible:**<br>education (7, 8)<br>communications (4)<br><br>Emphasis on laboratory science being filtered into educational programmes. |
| Enhance communication and public health information about emerging diseases and ensure prompt implementation of prevention strategies. Building awareness of emerging infectious diseases requires forming teams of diverse partners from the public and private sectors. More creative methods of communicating public health messages are needed to reach a variety of target audiences. These audiences include such groups as state public health policy makers, physicians in training and in practice, and behavioral scientists and health communicators who are implementing community-based prevention programs. | **Possible:**<br>collaboration/communications (4, 8)<br>education (7, 8)<br>behavioural sciences (8), politics (8)<br><br>Emphasis on disease, breaking strands in the web of causation, and maintaining support among diverse groups. |

| | |
|---|---|
| Strengthen local, state, and federal public health infrastructures to support surveillance and implement prevention and control programs. State and local health department staff, as well as hospital and university personnel, need training in the diagnosis, surveillance, and control of infectious diseases. Sufficient numbers of skilled personnel and well-equipped physical facilities are essential to maintain control of old disease threats and support prevention of new ones. Public health laboratories represent an area of critical need and crumbling infrastructure. If such laboratories are unable to provide key information in detecting an epidemic, monitoring resistant and epidemic strains of organisms, and defining the course of the epidemic, then all prevention efforts suffer. | **Probable:**<br>Physical science (2)<br>biochemistry (3, 4)<br>mathematics (1, 2)<br>microbiology (4)<br><br>Emphasis on medical skill building and maintaining and improving scientific resources. |

These guidelines were available from the CDC in full text at their website address (last accessed January 15, 2007):

http://www.cdc.gov/ncidod/publications/eid_plan/home.htm

The online copy of this report has now been withdrawn but can be requested in hardcopy from the CDC. This report has been updated in 2002, and now includes six priority areas rather than the four policy goals of the previous report. The report is entitled: Protecting the Nation's Health in an Era of Globalization: CDC's Global Infectious Disease Strategy and the full report is published online and can be requested from (last accessed January 15, 2007):

http://www.cdc.gov/globalidplan/request.htm

Using the same pattern of analysis, the 2002 update is presented in Table 8.3, using summary statements from the report (pp8-9). The full text of these statements (pp 28-58 of the report) and discussion by CDC is enclosed in Appendix 5 of this thesis.

**Table 8.3 CDC Priority Areas Statements and Analysis – Updated 2002**

| PRIORITY STATEMENTS<br>(taken from pp8-9 of the report) | DISCIPLINES DISCERNED IN THE PRIORITY STATEMENTS<br>(Boulding's levels in parentheses) |
|---|---|
| International outbreak assistance: the recognition that international outbreak assistance is an integral function of CDC. Supporting this function will require augmenting, updating, and strengthening CDC's diagnostic facilities, as well as its capacity for epidemiologic investigation overseas. In the future, CDC must also be prepared, as a matter of routine, to offer follow-up assistance after each acute emergency response. Such follow-up will assist host-country ministries of health to maintain control of new pathogens when an outbreak is over. | **Probable:**<br>Information systems (4)<br>feedback modelling (3)<br>analysis of statistics/patterns (looking for the differences) (1, 2)<br>operations research (1, 2)<br>mathematical modelling (1, 2)<br><br>**Possible:**<br>behavioural sciences (7, 8) for investigating "the factors influencing their emergence", although not detailed.<br>Emphasis on clinical epidemiology. |
| A global approach to disease surveillance: In the years ahead, regional surveillance networks should expand, interact, and evolve into a global "network of networks" that provides early warning of emerging health threats and increased capacity to monitor the effectiveness of public health control measures. CDC will help stimulate this process by providing technical assistance, evaluating regional progress, and working with many partners to strengthen the networks' telecommunications capacities and encourage the use of common software tools and harmonized standards for disease reporting. | **Possible:**<br>collaboration/communications (4, 8)<br>education (7, 8)<br>behavioural sciences (8), politics (8)<br><br>Emphasis on disease, breaking strands in the web of causation, and maintaining support among diverse groups. |

| | |
|---|---|
| Applied research on diseases of global importance: A research program on diseases that are of global importance, including some that are uncommon in the United States, is a valuable resource, both for humanitarian reasons and because of the dangers represented by some imported diseases. CDC's laboratorians, epidemiologists, and behavioral scientists will maintain an active research program to develop tools to detect, diagnose, predict, and eliminate diseases of global or regional importance. When a new disease threat is reported anywhere in the world, CDC's laboratorians and field investigators will be available to help answer questions about disease transmission, treatment, control, and prevention. | **Probable:**<br>Physical science (2)<br>biochemistry (3, 4)<br>mathematics (1, 2)<br>microbiology (4)<br><br>Emphasis on medical skill building and maintaining and improving scientific resources. |
| Application on proven public health tools: There is often a long delay between the development of a new public health tool and its widespread use. CDC will intensify efforts to couple applied research with research on ways to promote the use of newly developed tools for disease control ("implementation research"). CDC will help identify the most effective tools and actively encourage their international use, applying expertise and resources in laboratory research, public health policy, program management, and health communications to overcome scientific, financial, and cultural barriers. | **Probable:**<br>biochemistry (4)<br>chemistry (1, 2)<br>biology (7)<br>mathematics (1, 2)<br>engineering (1, 2)<br><br>education (7, 8)<br>communications (4)<br><br>Emphasis on laboratory science being filtered into educational programmes. |
| Global initiatives for disease control: CDC will make sustained contributions<br>to global initiatives to reduce the prevalence of HIV/AIDS in young people by 25% and reduce deaths from tuberculosis and malaria by 50% by 2010. CDC will also work with the Global Alliance for Vaccines and Immunization to reduce infant | **Probable:**<br>collaboration/communications (4, 8)<br>education (7, 8)<br>behavioural sciences (8), politics (8)<br>Emphasis on disease, breaking strands in the web of causation, and maintaining support among diverse groups. |

| | |
|---|---|
| mortality through enhanced delivery and use of new and under-utilized vaccines against respiratory illnesses and other childhood diseases. CDC and its partners will also consult on future international priorities for disease control, elimination, and eradication efforts—as well on monitoring for antimicrobial resistance and planning for pandemic influenza—and help evaluate progress through the collection and analysis of disease surveillance data. | |
| Public health training and capacity building: CDC will encourage and support the establishment of International Emerging Infections Programs (IEIPs) in developing countries—centers of excellence that integrate disease surveillance, applied research, prevention, and control activities. The IEIP sites will partner with Field Epidemiology Training Programs (FETPS) and other institutions to strengthen national public health capacity and provide hands-on training in public health. Over time, they may help to strengthen capacity in neighboring countries as well as within the host country. | **Probable:**<br>biochemistry (4)<br>chemistry (1, 2)<br>biology (7)<br>mathematics (1, 2)<br>engineering (1, 2)<br><br>**Possible:**<br>education (7, 8)<br>communications (4)<br><br>Emphasis on laboratory science being filtered into educational programmes. |

### 8.2.2 The World Health Organisation (WHO), Geneva, Switzerland

The World Health Organisation has a similar document within the remit of the WHO directive *WHA34.36—Global Strategy for health for all by the year 2000* (WHO, 1981) which are the International Health Regulations adopted by the 22nd World Health Assembly (WHA) in 1969 and amended by the 26 WHA in 1973 and the 34th WHA in 1981. The text represents the regulations in force as of 1 January 1982, and most recently updated in 1995. The goals are even more clearly focused on clinical epidemiology and bio-medical research than the CDC regulations.

**Table 8.4 WHO Policy Statements and Analysis**

| POLICY GOAL | DISCIPLINES DISCERNED IN THE POLICY (Boulding's levels in parentheses) |
|---|---|
| The purpose of the International Health Regulations is to ensure the maximum security against the international spread of diseases with a minimum interference with world traffic. Following the increasing emphasis on epidemiological surveillance for communicable disease recognition and control, the new Regulations are intended to strengthen the use of epidemiological principles as applied internationally, to detect, reduce or eliminate the sources from which infection spreads, to improve sanitation in and around ports and airports, to prevent the dissemination of vectors and, in general, to encourage epidemiological activities on the national level so that there is little risk of outside infection establishing itself. | **Probable:**<br>Information systems (4)<br>feedback modelling (3)<br>analysis of statistics (1, 2)<br>operations research (1, 2)<br>mathematical modelling (1, 2)<br><br>**Possible:**<br>behavioural sciences (7, 8) for investigating "the factors influencing their emergence", although not detailed.<br><br>Emphasis on clinical epidemiology and emphasis on disease, breaking strands in the web of causation. |

### 8.2.3 Program Objectives for Pan American Health Organisation (PAHO)

The Pan American Health Organization is headquartered in the United States with field offices throughout South America. Its goals are "to strengthen national capabilities to implement effective preventative, therapeutic and control programs which are technically feasible, economically viable, and socially acceptable" (PAHO, 1998). Its policy statements can be located at the web address http://www.paho.org/english/hct01.htm (accessed June 12, 1998).

**Table 8.5 PAHO Policy Statements and Analysis**

| POLICY GOAL | DISCIPLINES DISCERNED IN THE POLICY (Boulding's levels in parentheses) |
|---|---|
| To strengthen national and local capabilities to detect and analyze changes in the frequency and distribution of common, new emerging/re-emerging infectious diseases and implement proper prevention and control activities | **Probable:**<br>Information systems (4)<br>feedback modelling (3)<br>analysis of statistics/patterns (1, 2)<br>operations research (1, 2)<br>mathematical modelling (1, 2)<br><br>Emphasis on clinical epidemiology. |
| To support member countries in the process of elimination of leprosy, onchocerciasis, non-venereal treponematosis, and Chagas' disease vectorial transmission; | **Probable**<br>Information systems (4)<br>medical specialities (7)<br>analysis of statistics/patterns (1, 2)<br>operations research (1, 2)<br>mathematical modelling (1, 2)<br>Emphasis on bio-medical skills. |
| To collaborate with the Regional efforts to control blood transfusion transmitted infectious agents; | **Probable**<br>Information systems (4)<br>analysis of statistics/patterns (1, 2)<br>operations research (1, 2)<br>mathematical modelling (1, 2)<br>Emphasis on clinical epidemiology. |
| To develop, in cooperation with national counterparts, cost-effective measures to prevent and control childhood diseases, particularly diarrheal diseases and acute respiratory infections; | **Probable**<br>Information systems (4)<br>medical specialities (7)<br>mathematical modelling (1, 2)<br>economics (7)<br><br>Emphasis on bio-medical skills. |
| To implement the Global Malaria Control Strategy based on administrative and programmatic integration of specialized services into the local level; | **Probable**<br>Information systems (4)<br>medical specialities (7)<br>mathematical modelling (1, 2)<br><br>Emphasis on bio-medical skills. |
| To foster the development of applied research in support of prevention and control activities. | **Probable**<br>biomedical research (1, 2, 3, 4) |

| | |
|---|---|
| | **Possible**<br>sociological and behavioural sciences research (7, 8)<br>Emphasis possibly on a more comprehensive epidemiology. |

## 8.3 Discussion of the Statements of the Policies

The disciplines drawn from these statements are focused on achieving prediction and thereby control in the study of emerging infectious disease. The language of the statements is designed to instil confidence in scientific procedure to identify, isolate, and eradicate the threat of emerging infectious disease. The information gained in this process is communicated to the social community from the scientific community. There is no intuition of community feedback processes in either the goal setting, directions for the research interests or programme aims, or in the communication of the research outcomes. Specifically, the disciplines identified in these statements are listed in the table below. In the first column of the table are the disciplines that a multi-disciplinary approach should incorporate in the study of emerging infectious disease contributing risk factors. The second column lists the disciplines found in the organisational statements. A comparison between the policies and the disciplines available in this research shows which disciplines are being overlooked. A discussion follows as to how these statements could be expanded to encompass a multi-disciplinary systems approach for epidemiological inquiry.

**Table 8.6 Comparison of Disciplines Found in Matrix and Policy Statements**

| DISCIPLINES ADVOCATED BY BOULDING'S FRAMEWORK (Boulding's levels in parentheses) | DISCIPLINES DISCERNED IN THE POLICY (Boulding's levels in parentheses) |
|---|---|
| **CDC Statement:** | |
| (1) frameworks/structures | analysis of statistics/patterns (1, 2) |
| (2) clockworks | chemistry (1, 2), mathematical modelling, operations research (1, 2) engineering (1, 2) Physical science (2) |
| (3) feedback/cybernetic systems | feedback modelling (3) |
| (4) molecular/biochemistry, genetics, information systems | Information systems, biochemistry (4) communications (4) microbiology (4) collaboration/communications (4, 8) |
| (5) botany | |
| (6) zoology | |
| (7) ecology, population biology | biology (7) |
| (8) sociology, behavioural science, psychology, economics, anthropology, political science | behavioural sciences (7, 8) education (7, 8) politics (8) |
| (9) religion, philosophy | |
| **WHO Statement:** | |
| (1) frameworks/structures | analysis of statistics (1, 2) |
| (2) clockworks | operations research (1, 2) mathematical modelling (1, 2) |
| (3) feedback/cybernetic systems | feedback modelling (3) |
| (4) molecular/biochemistry, genetics, information systems | Information systems (4) |
| (5) botany | |
| (6) zoology | |
| (7) ecology, population biology | |
| (8) sociology, behavioural science, psychology, economics, anthropology, political science | |
| (9) religion, philosophy | |

| PAHO Statement: | |
|---|---|
| (1) frameworks/structures | analysis of statistics/patterns (1, 2) |
| (2) clockworks | biomedical research (1, 2, 3, 4), operations research (1, 2), mathematical modelling (1, 2) |
| (3) feedback/cybernetic systems | feedback modelling (3) |
| (4) molecular/biochemistry, genetics, information systems | Information systems (4) |
| (5) botany | |
| (6) zoology | |
| (7) ecology, population biology | medical specialities (7) economics (7) |
| (8) sociology, behavioural science, psychology, economics, anthropology, political science | sociological and behavioural sciences research (7, 8) |
| (9) religion, philosophy | |

Comparison between the two columns reveals gaps where some of the levels are not represented in the statements, and the range of the disciplines found in the organisational statements do not match the spread listed in the Boulding framework. The implications here are that additional disciplines must be enlisted in the study of the contributing risk factors for emerging infectious disease. The emphasis read from the organisations' statements is that of a scientific, positivist approach to the topic. In this case "knowledge is hard, real, and capable of being transmitted in a tangible form" (Flood and Carson, 1993, 247). This is seen in the statements where the direction of the intervention is stated without reflection or processes given for a circular discussion of the chosen directives.

In this chapter, Boulding's *Skeleton of Science* was used an exemplar of a functionalist hierarchical framework to explore and surface additional knowledge about international health policy making for EID. This approach generated limitations in the current methods employed by the discipline of epidemiology in addressing policy making for EID. These limitations will now be addressed and discussed in chapters 9 and 10.

The next chapter will use the information from the same three policy statements and the contributing factors shown in the matrix in table 8.1, as input to an analysis of this complex system of EID using an interpretive approach to hierarchical analysis that will be compared with the outcomes of the analysis undertaken in this chapter from the functionalist perspective.

# Chapter 9

# An Interpretive Approach and Critique of Hierarchy

## 9.0 Introduction

This chapter consists of three sections. The first section, the information from the matrix in table 8.1 can be used as input to an analysis of this complex system of EID following an interpretive approach to hierarchy theory. This application draws on the data from the traditional literature review of chapter 5, and the narrative review of interpretive hierarchy theory from chapter 7.

The second section will present a combination and comparison of the results of the functionalist hierarchical analysis of chapter 8 with the interpretive analysis presented in this chapter in section 9.1.

The final section of this chapter is the evaluation of the outcomes from the comparison of the two approaches (functionalist and interpretivist) hierarchical systems approach, using a combination of critical systems thinking and critical systematic review, adhering to the underpinning structure and process of this thesis.

## 9.1 The Interpretive Approach to Hierarchy

The term "hierarchy theory" is used in this dissertation, not in the defined sense of a validated theory but as a collection of principles in an approach that has been developed for the study of complex systems, i.e. systems that could not be adequately described by statistics and calculus (these have been previously described as middle-number systems).

Hierarchy theory can reveal the structure and behaviours of a system, incorporating the understanding that the benefits or limitations of that process are governed by the capabilities of the observer.

An interpretive hierarchical investigation begins with the observation of a phenomenon by an observer of that phenomenon. The role of the observer of the phenomenon is dealt with differently by researchers in hierarchy theory, leading to some of the many difficulties regarding the use of common definitions within this theoretical approach. Some researchers believe that the observer, the observer's biases, and the observer's very presence change the definition and behaviour of the system. The observer is therefore central to defining the system's structure and behaviour (Allen and Starr, 1982; Ahl and Allen, 1996). Others hold an objective viewpoint, removing the observer from primary importance and concentrating instead on objectivity (e.g. Miller, 1978). Still, the structure, behaviour, and interrelationships between a system's parts are the units common to all versions.

The ontological question is concerned with whether hierarchies exist external to the observer, or whether they are a reality held entirely within the consciousness of the observer. All of the authors discussed in the interpretive approach would hold the latter viewpoint. it is both the ontology and the epistemology of hierarchy theory that separates the authors , as was seen in the split between authors into chapters 6 and 7.

Some authors of hierarchy theory have addressed or stated their positions regarding ontological questions, but epistemological issues are not argued in depth by many of the hierarchy theorists. One exception is

Laszlo (1972), who devotes an entire chapter in his *Introduction to Systems Philosophy* to hierarchy in developing a "Framework for a Philosophy of Nature." He states that "the indicated position of a philosophy of natural hierarchy is *integrated pluralism*: an ontology that proclaims both the diversity and the unity of the world" (Laszlo, 1972). Authors who do address ontological questions in hierarchies are Boulding (1956), Grene (1967), Bunge (1963, 1969), and Laszlo (1972).

Other hierarchy theorists are less detailed on this subject. Allen, Starr, and Salthe choose not to debate ontology. Allen and Starr say that "we do not address questions of ontological reality for given levels, but prefer to take an epistemological stance in a utilitarian philosophy" (Allen and Starr, 1982). Salthe says, "science almost never asks ontological questions" and also that "ontology is the attractor of my statements, even if they ostensibly denote only epistemological matters" (Salthe, 1985).

Finally, whether hierarchy theory is objective or subjective in its approach depends again on which theorist's work is being examined. Since Salthe, Allen, and Starr emphasize so intensely the importance of the observer in the definition and description of the hierarchy, they lean to the subjective, synthetic method. The work of Miller, however, blends an objective analytic method, a reductionist epistemology, and a holistic ontology (Reckmeyer, 1982, 1990).

In all cases, the practice of the theory is governed critically by the capabilities and biases of the observer/practitioner of the intervention, since it is the observer who provides a unique definition of the system. Another important detail is that the implementation of a hierarchical approach, whether functionalist or interpretive has to overcome the existing linguistic biases and prior misuse of the concepts of the theory not only by the natural, but especially, by the social sciences.

Testing the theory/methodology presented in this chapter should involve the developed approach being able to address firstly, what is observed; second, to alter what is observed based on the information found in the latter explanation; and, third, to design a complex situation based on the knowledge inherent or predicted by the theory.

### 9.1.1 Principles of Hierarchy Theory

In this section, the aim is to explore the input from the data sources accessed in searching for the historical and current uses of interpretive hierarchy to present a narrative synthesis that encompasses:

1. the literature searches described in the methodology chapter;

2. the ID-ID questionnaire data; and

3. the material listed in the narrative reviews.

It is understood in this thesis that research is "a critical and exhaustive investigation or experimentation having as its aim the revision of accepted conclusions, in the light of newly discovered facts" (Dubin, 1978, p17). The research undertaken in this thesis on hierarchy theory goes back to "square one" by creating a new narrative review of hierarchy theory from two different ideological positions in the light of information gathered from other researchers in the field and in their writings about the use of hierarchy theory. The 're-searching' done may or may not alter or confirm previous perceptions of hierarchy theory; but the revision work itself will have worth nonetheless in having provided an overview of hierarchical approaches not currently available in the literature, and this is a core output from this thesis.

The way that hierarchy theory addresses the observation of the experienced world is that it seeks to use the explanatory principles such as control, constraint, and containment, levels, boundaries, channels of communication, surfaces, filters, scale, and the importance of the observer in the definition of the system, to order the complexity we perceive.

This may be done for several reasons or aims: firstly, to explain what is observed; second, to alter what is observed based on the information found in the latter explanation; and, third, to design a complex situation based on the knowledge inherent or predicted by the theory.

How well each of these are achieved is the test of the usefulness of the theory and this is specifically addressed in this chapter with use of the critical review mode, which is designed to critique proposed theories and methodological approaches. Theory in this case is taken to include the operationalisation of the built theory that includes the model and methodology inherent in the design of the theory.

Hierarchy theory has not been explored in depth in mainstream systems thinking, hence addressing this problem is important in terms of the issues of coherence and relevance. These concepts will be discussed in greater detail in the evaluation of the implementation later in this chapter.

Relevance issues for the proposed hierarchy theory are based on concerns about the decisions by this researcher about the inclusion or exclusion of data in building the theory.

The remainder of this section will detail the principles of hierarchy theory, drawn from the literature reviewed in this thesis; and concluding the process with a candidate theory/methodology, which will go forward for application in the case study section of this chapter on EID.

The following principles will be detailed in this section:

- Complexity
- Self-reflection
- Importance of the observer
- Boundaries
- Near-decomposability
- Surfaces and filters
- Channels of communication
- Control, constraint and containment
- Emergence

## Complexity

In the study of complexity, hierarchy theory is only one of many approaches. However, it is an approach that is specifically designed to model complex situations through a self-reflective process of observation and description.

**Definition:** Defining complexity could take the space of an entire thesis by itself. However, a few definitions of the term are appropriate. The word 'complexity' derives from the Latin word *complexus*, which signifies "entwined", "twisted together". Corning, who has written extensively on the topic from the perspective of evolutionary systems (Corning, 1997, 1998), takes this definition forward. Peter Corning describes it in this way:

> "What in fact does the word "complexity" connote. One of the leaders in the complexity field, Seth Lloyd of MIT, took the trouble to compile a list of some three-dozen different ways in which the term is used in scientific discourse. However, this exercise produced no blinding insight. When asked to define complexity, Lloyd told Johnson: "I can't define it for you, but I know it when I see it."
>
> Rather than trying to define what complexity is, perhaps it would be more useful to identify the properties that are commonly associated with the term. I would suggest that complexity often (not always) implies the following attributes: (1) a complex phenomenon consists of many parts (or items, or units, or individuals); (2) there are many

> relationships/interactions among the parts; and (3) the parts produce combined effects (synergies) that are not easily predicted and may often be novel, unexpected, even surprising.
>
> At the risk of inviting the wrath of the researchers in this field, I would argue that complexity per se is one of the less interesting properties of complex phenomena. The differences, and the unique combined properties (synergies) that arise in each case, are vastly more important than the commonalities (Corning, 1998, p.199).

**Discussion:** the entwining of many parts, twisted together with inter- and intra-relationships are at the core of a complex system. Adding depth to this definition, Allen has defined complexity thus: "Complexity arises when a system requires several levels of organization for its adequate description (Allen, 1985). This is of course, core to then implementing an approach that addresses many levels of description: the hierarchical approach. So working with complexity needs not only the parts and their intertwining and relationships, but also requires an observer to surface those parts and relationships, and if the observer can do so (that the observer needs more than one level of description to define what he or she sees) then what they are seeing is defined as a complex system.

So, it is the role and function of the observer to make the definition and determination of complexity as defined by the describer of the system: and it is the realization by the observer that a situation is that of complexity. Complexity is not an already existing, physical part of the system, independent of observation. The determination of that is observer-driven; the researcher determines through their description, faulted or otherwise, of what the parts, levels, sub-systems and inter- and intra-relationships are within the system of interest.

Related to the subjective position, another definition of complexity is that of a detainment in thought or progression (Salthe, 1993). In this sense then, complexity is a curtain drawn over the possible understanding or explanation of a phenomenon that can only be drawn back, and the phenomenon revealed, to the extent of the ability and perceptive power of the observers of that phenomenon. Removing the "detainment" is necessary for the efficient and effective management of complex situations; however, the methods used by observers in this "revealing process" must be tried and proven (Salthe, 1993).

**Practice:** the use of complexity in the practice of hierarchical analysis means that as one of the first steps of the process, an observer must not only define the system, but also surface and reflect on the choices inherent in that defining; the reasons for those choices; and the reasons for the exclusion of other choices. These ideas are explored again in the definition of the boundaries within a system.

### Importance of the Observer

The importance of the observer is the central principle in the versions of hierarchy theory that emphasize an interpretive perspective. Since it is the observer who reveals the levels in the studied system, that same individual will also impose their bias and perspectives on the observations.

**Definition:** Gershenson and Heylighen defined the role of the observer as that person who, "even in mathematical and physical models of self-organizing systems, ... ascribes properties, aspects, states, and probabilities; and therefore entropy or order to the system." Gershenson and Heylighen (2003) also write that "W. Ross Ashby (1962) noted decades ago the importance of the role of the observer in relation to self-organizing systems: "A substantial part of the theory of organization will be concerned with *properties that are not intrinsic to the thing but are relational between observer and thing*" (Ashby, 1962, p. 258)".

Ahl and Allen define observation "as the interface between perception and cognition" and that "observation is structured experience" (Ahl and Allen, 1996, p.51). Much as the conception of Koestler, Ahl and Allen see the observer as a form of holon: facing in two directions, on the one front constructing "internal cognitive models", and on the other, "interpreting experience", facing inwards and facing outward at the same time (ibid., p.53). For a systems hierarchy website Allen wrote: "when a system is observed, there are two separate considerations. One is the spatio-temporal scale at which the observations are made. The other is the criterion for observation, which defines the system in the foreground away from all the rest in the background. The criterion for observation uses the types of parts and their relationships to each other to characterize the system in the foreground. If criteria for observation are linked together in an asymmetric fashion, then the criteria lead to levels of organization. Otherwise, criteria for observation merely generate isolated classes" (Allen, 2003, online definition).

**Discussion:** The definition of complexity relies heavily on the individual philosophical and practical beliefs of the person doing the explaining and the influences inherent in the interactions between individuals and the phenomena being observed (Romm, 1994). Ahl and Allen (1996) diagram this point as shown in figure 9.1.

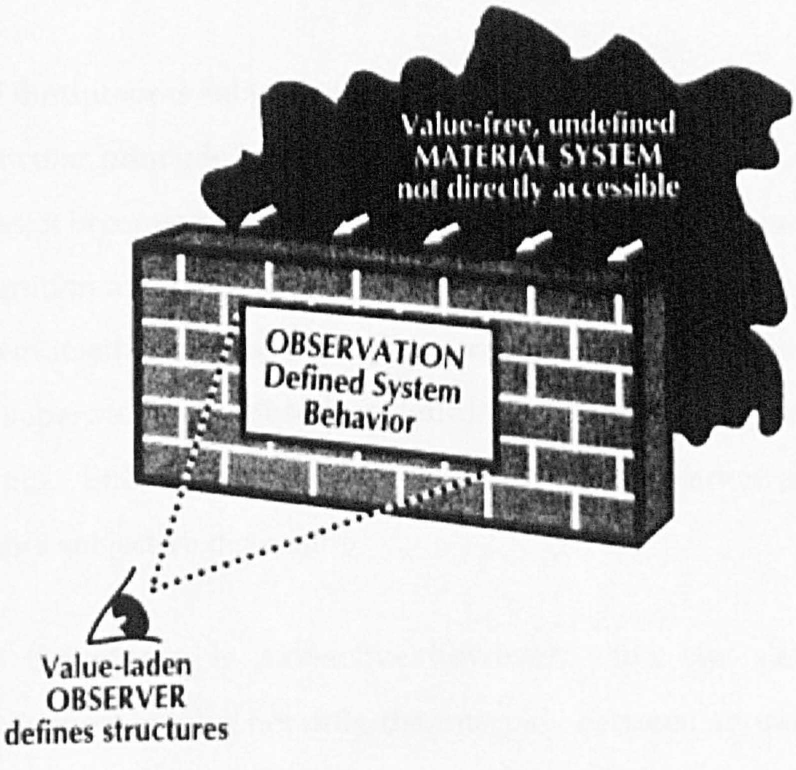



**Figure 9.1 Addressing Observer Bias (Ahl and Allen, 1996, p.36)**

Although not unique to hierarchy theory, its most important insight is the recognition that there is an observer in the system. The observer's nature, biases, and filters need to be more fully explored in any methodology. Further, the observer must be aware of the effect of his or her presence as it alters the environment and interactions of the system being observed.

Where the beliefs are of an objective stance, (the researcher believes that the phenomenon exists separate from interpretation and is free from any influence that observation might exert on the observed situation) then the model of the observed situation is often defined in a mathematical format. Complexity in such studies is a measure, the minimum amount of information needed to specify a system's structure.

If the author is subjective in defining the role of the observer, then this particular principle is interwoven within the definition of all other principles; it becomes the central principle. Without the observer, there is no recognition and definition of the levels within the system or even of the system itself. If the perception of complexity is that of an objective reality separate from observer-definition, then the observer loses importance. Still, even the action of ignoring the observer can also be viewed as a subjective distinction.

If the stance is subjective however, then the definition of complexity must involve not only the interplay between an observer and the object observed, but also the interplay between the researcher and the rest of society. This becomes more of an inter-subjective stance, and the definition is now limited not only by the capacity and abilities of the individual observer but also by the social meanings, perspectives and biases of the phenomena's social context.

**Practice:** the role of the observer in the practice of hierarchical analysis means that this underpins the first steps of the process: linked with identifying the complex system, an observer must not only define the system, but also surface and reflect on the choices inherent in that defining; the reasons for those choices; and the reasons for the exclusion of other choices.

### Self-reflection

This process is also closely linked with the role of the observer, and underpins the process of hierarchical analysis from the interpretive standpoint. The task of self-reflection is necessary and vital, and requires an on-going self-examination and self-reflection of the biases, filters and paradigms brought to the study both by the individual researcher, and their physical and intellectual communities.

**Definition:** In hierarchy theory, self-reflection involves more than self-examination and introspection; it is a more active and structured activity, and can be made more so with the addition of the three questions listed below in the next paragraph on the discussion of self-reflection.

**Discussion:** When considering the issues of reflection, this action by the observer is particularly important in light of decisions made by that observer about the hierarchical structure and process surfaced through his or her interaction and viewing of the system. In this practice, there are three questions that may be raised by practitioners. The first two: "What" should I reflect on? and "Why" is reflection necessary?, are based on the twin standpoints of the effectiveness of the intervention, and the moral responsibility of the facilitator. The third question: "How" can I as an individual reflect on my actions and their implications? (Brown and Wilby, 1996).

On an individual level, the observer should always be engaged in a constant and iterative self-reflection as an ongoing part of any analysis. This also involves the "sweeping-in" of alternate perspectives (Churchman, 1982).

**Practice:** In the practice of defining the complex system and doing the hierarchical analysis, the observer and other participants in the system should use the questions above to structure a reflective process concerning the definition of the defined system. As before, an observer must not only define the system, but also reflect on the choices inherent in that defining; the reasons for those choices; and the reasons for the exclusion of other choices.

### Scale and Resolution

**Definition:** "Scale may be temporal, spatial or both. A large-scale study covers either a long time period or a broad spatial expanse. A small scale study is narrowly focussed in space or time. ... and scale is defined by grain and extent" (Ahl and Allen, 1996, p60). Grain and extent will be covered in a later section. The level of resolution in a study follows from the choice of scale at which the observed phenomenon is investigated.

**Discussion:** The observer determines the choice of scale, and by that choice defines the hierarchical structure revealed, processes within the system, and the interrelationships seen within the system's structure. It further determines the type and quantity of data, because the choice of scale for a study is determined by the choice of unit of measurement. Ahl and Allen give the example of studying an elephant. The elephant remains an elephant no matter what choice of scale and resolution you choose to study him at. But the result of the choice determines the data and the understanding of the phenomenon (the elephant) that is possible as an outcome from the study. If you use a microscope to study the elephant, the data and understanding of the phenomena 'elephant' will be quite different from using from a far perspective at the whole animal. The elephant has not changed, but what the observer receives from the study is different at each scale of observation (Ahl and Allen, 1996, pp 54-55).

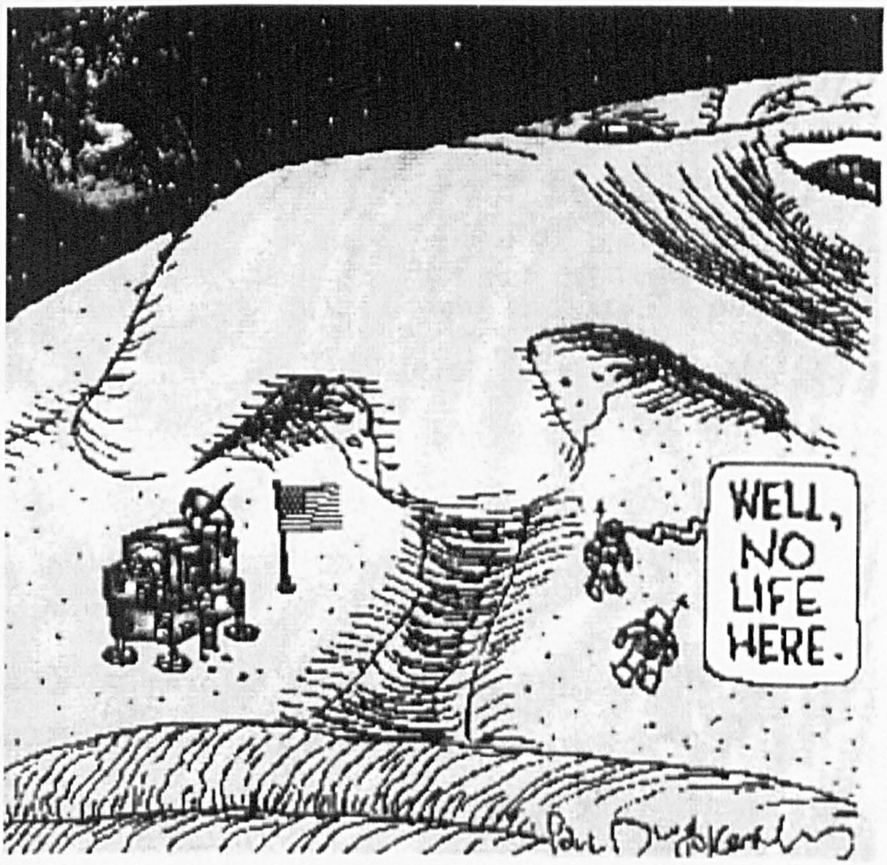



**Figure 9.2 Hierarchy Joke (The Man in the Moon)**
**(from Kolasa website, McMaster University)**

The joke in figure 9.2 is another example of the concept of choice of scale and resolution in the study of a system of interest. The astronauts have landed on what they believe is the surface of a planet. But they are working at the level of small-scale criteria, the surface of the planet, ridges and valleys rising and falling around them. Moving up the scale chosen....if the choice of scale was at the planetary level, perhaps seen from their spacecraft a few thousand miles away from the planet, they would realise the smaller scale parts at that higher level of investigation were revealing the pattern of nose, eyes and mouth, and the 'whole' of the living entity. At the smaller scale, those parts make no sense. The meaning, the emergence, comes from choosing a larger scale for investigation and seeing that there is a pattern: revealing the inter-relationships between the parts of the system.

When working at a lower level, using a small-scale investigation, the living entity is part of what is called the 'undifferentiated context' of the study. The entity as a whole is not seen, cannot be seen, by those working at the scale of the parts of the entity. Only by moving up the scale, and using larger units of measurement, can you change the perception (Ahl and Allen, 1996).

Any change in the resolution used to examine the system alters the definition and the information gained from the study. It also effects a bias on further description of the system in that alternate perspectives (and hence, possibly radically different system descriptions) can be obtained by altering the scale and resolution of the study. The level of resolution in an hierarchical observation is the finest distinction perceived by the observer. Changes in either direction of resolution could increase the information gathered to an unacceptable level for data-management and data-interpretation purposes.

**Practice:** As proposed by Ahl and Allen (1996), this part of the implementation will involve the choice of units of measurement for the system, which will result in what will be perceived in the study of the complex system.

### Measurement, Grain and Extent

Linked to the role of the observer and also to the scale of the observation, are the underpinning mechanics of measurement, grain and extent. The measurement used in an observation determines the scale of the system of interest.

**Definition:** There are technical terms in hierarchy theory to describe the upper and lower levels of an observation accessible by an observer of that phenomenon. "The threshold between the smallest things captured and those that slip through the net of observation unrecorded is the grain of an observation. Grain is analogous to the holes in the fishing net [example below]. ... Now consider the other end of the sampling protocol. Here the threshold is between the largest entities that the net can capture and those that simply are too big. This upper threshold is called the extent of an observation protocol. Extent is the span of the sample and is analogous to the size of the net, the area fished, and the entire period of the fishing expedition. ... The data set is analogous to the yield of the fishing expedition. Grain and extent limits are important because they fix the scale of experience" (Ahl and Allen, 1996, p. 58-9).

**Discussion:** The example used by Ahl and Allen (figure 9.3) to demonstrate the concept of measurement, grain and extent shows that the size of the holes in the net are what determine what is captured in the output of the data collection of observing a phenomenon. The upper and lower limits of the data collection are determined by the choice of measurement (the holes in the net) and "It will take a different strategy if one wants to capture entities that are either too large or too small for a fishing-net sampling method" (Ahl and Allen, 1996, p. 57).

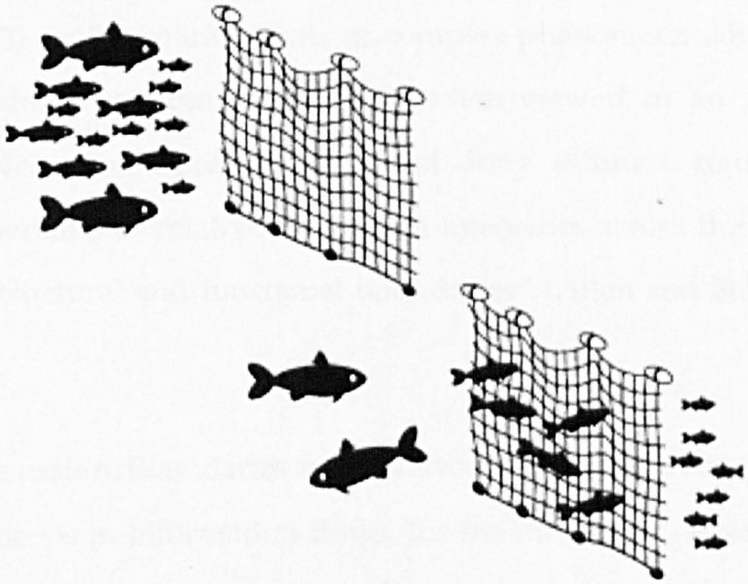


**Figure 9.3 The Example of the Fishing Net (Ahl and Allen, 1996, p. 56)**

**Practice:** As with the practical aspect of scale and resolution, this part of the implementation will involve the choice of units of measurement for the system, which will result in what will be perceived in the study of the complex system.

## Boundary Definition and Near Decomposability

**Definition:** Allen (2003) defines boundary definition as: Boundary: "A distinction made by an observer. Artificial boundaries are drawn arbitrarily and haphazardly. Natural boundaries are still arbitrary but tend to be robust under transformation. That is, natural boundaries coincide for many distinct criteria (Allen and Starr, 1982, p. 262).

He defines the concept of near-decomposability, a concept that underpins the discovery of a boundary and first written about by Simon (1962, 1973) as: "A characteristic of complex phenomena which may be seen to exhibit apparent disjunction when viewed in an appropriate fashion. Near decomposition does not deny ultimate continuity, but rather it pertains to relative interaction intensities across the continuous space of structural and functional boundaries" (Allen and Starr, 1982, p. 273).

**Discussion:** Boundaries are perceived by the observer to be where there are drops in information flows, for the most part caused by either mental or physical restrictions of the participants/situation e.g. filters, biases, distance, methods of communicating. In this model, the separate steps and levels of the model pass information between them so these explain the boundaries and gaps between the steps. So there may be lines/channels of communication (moving between steps or modes outside of the linear flow) but the steps are defined by these information boundaries. Within these bounded areas are where bonding is stronger, in comparison to the areas between and outside the bounded areas where there is lower bond strength. In this way, the bounded area maintains its cohesion and function.

The setting of boundaries within hierarchy are observer defined and must reflect on the considerations of complexity, interconnectedness, differences between boundary and surface, and differences in the perceptions of each individual observer/describer of that system. In entification, the researcher determines "the erection and implementation of criteria for the identification of discrete things. The giving of names to concrete or abstract objects is an aspect of entification (Allen and Starr, 1982, p. 267). This process is the link between observing the system and determining the boundaries: the process of discovering the structure and process of the complex system is done through the process of entitation.

Albert Wilson writes:

> "The manner of decomposition of a complex organism or structure into sub-components is arbitrary, With a scalpel in the dissecting room or with the knife of pure intellect, the decomposer has freedom to isolate many alternative sub-groupings. However, unless his knife follows the "natural interfaces," severing a minimum of connections in isolating the sub-components, his decomposition may prove to be confusing, uninteresting, and messy, ... What we call the "natural interfaces" are identifiable either by the occurrence of a steep decrement in the number or strength of linkages crossing them, as developed by Simon (1962) in the concept of near decomposability, or through the existence of some form of closure" (Wilson, 1969, p54).

Boundaries between levels are quite distinct in their operational definitions. The observer reveals the system's interactions and so reveals the boundaries between the levels of the structure. Through this process of observing the system and defining its complexity, the observer sees where the interactions are filtered--where the interactions have less strength. It is at those points of weaker strength that surfaces between levels within a system are found (Allen and Starr, 1982).

**Practice:** The observer begins the process of perceiving and defining the system and determining the boundaries: the practical step for this process of discovering the structure and process of the complex system is done through the process of entitation, distinguishing where the interactions are strong and weak, and where the boundaries should be drawn for the system of interest.

## Surfaces and Filters

**Definition:** Allen and Starr define a filter as: A device in theory or practice that takes a signal string which is undefined in terms of scale and converts it by a process of integration into a scaled message. Low-frequency characteristics of a signal may be deemphasized by a filter that places greater significance upon high-frequency behaviour. Alternatively, high-frequency aspects of the signal may be smoothed and averaged such that they become a less important part of the defined message than they were of the signal. The patterns of integration which are used in a filter may be very exotic and can even be influenced by aspects of the signal as it is encountered" (Allen and Starr, 1982, p.268).

As defined above, "filters can be any device in theory or practice" with the purpose of facilitating an interpretation of the incoming signal so that the incoming matter, energy or information can be processed by the internal system in producing output (Ahl and Allen, 1996). Filters can take the form of biological and chemical physical structures, or, depending on the entity under consideration (e.g. a social system, filters can take the form of conceptual filters such as values (Ahl and Allen, 1996).

For a surface, this is defined as being the place where filters are to be found, and may be either input or output filters (Allen and Starr, 1982). "Surfaces can be conceived as filters slowing the flow of material, energy, or information. Sometimes the delay is so long that the surface completely attenuates the flow altogether" (Ahl and Allen, 1996, p. 139).

**Discussion:** The levels of the system are defined through the observation of the points where the flow of communications and interactions within the system are seen to decrease and is controlled through the action of filters.

Activity is seen to decrease at surfaces because of the action of filters in restricting the flow of information between levels. While there are strong behavioural and informational connections within levels, bonds between levels are weakened by the actions of surfaces that filter the flow of information (Ahl and Allen, 1996). This area of reduced strength marks the jump in levels and becomes the definition of the level of bond strength at the next higher level, and so on up the hierarchy. The strength of the bonding at any level reveals their position in the hierarchy. Boundaries between levels (either up or down the hierarchy) restrict the flow of information using filtering mechanisms. A detailed investigation of these mechanisms is critical before any attempts at systems intervention are made. If there is no understanding of these filters or biases at work within the system, then miscommunication will result.

Changes in the observer's *Weltanschauung* (Checkland, 1981) or paradigm (Kuhn, 1970) are changes in the filters used by the observer, they will also change and redefine the structure of the system and its processes and interrelationships.

The organisational form that these levels reveal is based on the ordering of the time frames involved in the regulation of their activities and in the constraints of their gathering, management and use of information, material, and energy (Allen and Starr, 1982). Behaviour that is a variable at a higher level is a constant and the context for lower levels. Behaviour of the faster-operating lower levels is filtered out through the action of surfaces and filters which, together with determinable time-lags, dampen the effects of lower-level activities.

**Practice:** Once the boundaries and levels in a complex system have been determined by the observer, the observer must then investigate in detail the flow of matter, energy and information across the surfaces of those boundaries in and out of the system. An understanding of the filtering processes is vital to the full understanding of a system leading to the proposal of changes to that system that can be effective.

### Control, Constraint and Containment

**Definitions:** "The control exerted by one holon over another lower in a hierarchy. The constraining holon behaves more slowly than the constrained holon. The constraining holon influences more than it is influenced in the act of constraint" (Allen and Starr, 1982). Upper levels contain lower levels in a nested hierarchy. Upper levels provide the context for the lower levels and they constrain the lower levels. This is what gives the hierarchical ordering of a complex system its robustness to disturbances from the environment (Ahl and Allen, 1996, p. 107).

**Discussion:** Pattee (1969, 1973) and Simon (1962, 1973) developed the concepts of constraint and control, and the related concept of containment. The interconnections within complex systems that are managed and described by the principles of scaling, resolution, filters, surfaces, gaps and communication channels, facilitate the constraint, control, and containment of the system's lower levels by the higher levels.

Hierarchy theory also states that there are behavioural interconnections within systems, which by their nature allow the higher levels of the system to constrain, control, and contain their lower levels (Allen and Starr, 1982). The positioning of the levels of the hierarchy in any system is determined by the time constants of each level. The scale of observation chosen by the researcher determines these time constants. This principle will be illustrated in the case study on EID.

While the mismatching of filters increases miscommunication and conflict within the system, the responsiveness and flexibility of the system itself can also be a disturbance. If control is vested too high in the hierarchy, there is danger that the bonding will be too weak between the higher and lower levels and the information loss through the filtering of information up the hierarchy will be too great. This can lead to system collapse.

A new solution to the disturbances facing the existing system can create a "collapse to a higher level of organization" (Allen and Starr, 1982). There is a collapse of the previous system, but a higher level of organization is created because the reconstructed system incorporates the additional variety caused by the disturbance and gains stability from having dealt with those changes. Ashby (1962) and Beer (1979, 1981 and 1985) have both worked in depth in this field using organisational cybernetics and principles from requisite variety. Change is not something that a system must avoid at all costs; it can be very beneficial in that previously external disturbances are now neutralized through their incorporation into the reorganized system (Mannermaa, 1988).

**Practice:** This part of the implementation will involve interpretation of the data set with respect to implications for the inter-relationships between those parts of the observed phenomena that are defined within social, political and cultural settings.

## Emergence

**Definition:** Emergence relates to properties of the system "which are, in and of themselves, not derivable from the behaviour of the parts a priori" (Allen and Starr, 1982, p.267). "In a trivial sense, emergent properties are properties of an entity that one did not expect" (Ahl and Allen, 1996, p.146).

**Discussion:** Pattee wrote: "we normally adopt hierarchical explanations when dealing with complex systems. We look to higher levels for significance and to lower levels for mechanisms" (Pattee, 1978). The concept of emergence comes from this process: it is not possible to find explanations for the behaviour of a complex system by pulling the system apart and investigating the content of the sub-units. Behaviour is not only explained by the interactions of the parts working together, it is seen at the higher level rather than the lower levels. Emergence is an important concept in systems design since actions may be met by unanticipated results either because ineffective methods are applied to the situation or there was an initial inadequate understanding of the system.

**Practice:** Emergence will be a part of the reflection process of the implementation, behaviour that is discovered as an outcome of the observation. It is not a predictable outcome, but one that follows the process of observing a phenomenon.

### 9.1.2 The Practice of Hierarchy Theory

Hierarchy theory can be useful in revealing a system in concert with other methodologies since it does not claim to stand alone in some isolationist or imperialistic manner. Through relying on human observation and interpretation, it has been, for those of the interpretive perspective, a more abstract approach to systems definition. To the empiricist, such a model would be unacceptable; but to those systems practitioners who are able to address multiple perspectives in practice, such a different and more abstract approach could be a welcome addition to other approaches. Mingers and Gill (1997) propose to the use and practice of multi-methodology and the combination of multiple paradigms in their edited book of the same name. In this thesis, the aim of combining the functionalist and interpretive paradigms can be considered to be a use of multi-paradigms. The combination of the process of systematic reviewing with the process of critical systems thinking can be classed as a use of multi-methodology. Mingers and Gill (1997) propose three arguments for the use of "strong pluralism", where "most if not all intervention situations would be dealt with more effectively with a blend of methodologies from different paradigms" (ibid, p.9):

1. "real-world problem situations are inevitably highly complex and multi-dimensional. Different paradigms each focus attention on different aspects of the situation and so multimethodology is necessary to deal effectively with the full richness of the real world" (p.9).

2. "an intervention is not usually a single discrete event but is a process that typically proceeds through a number of phases. Those phases pose different tasks and problems for the agent. However, methodologies tend to be more useful in relation to some phases than others, [as with using rich pictures from SSM is to this design of an interpretive hierarchical approach], so the prospect of combining them has immediate appeal" (p.9).

3. "further consideration of the philosophical and theoretical aspects of multimethodology is timely since many people are already combining methodologies in practice" (p.9).

Mingers and Gill (1997) detail and individually name the different combinations of methodology and paradigm mixes in figure 9.4.

Figure 9.4 Different Possibilities for Combining Methodologies (from Mingers and Gill, 1997, p.7)

| | One/more methodologies | One/more paradigms | Same/ different intervention | Whole/ part methodology | Imperialist or mixed | Example | Name | Literature (*Theoretical* Case Study) |
|---|---|---|---|---|---|---|---|---|
| A | One | One | – | – | – | SSM only | Methodological isolationism | Checkland and Scholes (1990) |
| B | More | ditto | Different | Whole | – | SSM \| Strat. choice | Paradigmatic isolationism | |
| C | ditto | ditto | Same | Whole | – | Simulation + queueing theory | Methodology combination | Ormerod (1995, 1996a) |
| D | ditto | ditto | Same | Part | Imperialist | Cognitive mapping in SSM | Methodology enhancement | Mingers and Taylor (1992) |
| E | ditto | ditto | Same | Part | Mixed | Cog. map. + root definition | Single paradigm multimethodology | Ormerod (1994, 1996b), Holt (1993), Taket (1993), *Bennett* (1985, 1990) |
| F | ditto | More | Different | Whole | – | Simulation \| SSM | Methodology selection | *Jackson and Keys* (1984), *Jackson* (1987, 1989, 1990) |
| G | ditto | ditto | Same | Whole | – | VSM + interactive planning | Whole methodology management | *Flood and Jackson* (1991)*, *Flood* (1995)*, *Ulrich* (1991) |
| H | ditto | ditto | Same | Part | Imperialist | JSD in SSM | Methodology enhancement | Savage and Mingers (1996) |
| I | ditto | ditto | Same | Part | Mixed | Cognitive map + systems dynamics | Multi-paradigm multimethodology | Eden (1994), Lehaney and Paul et al (1994), Hocking and Lee (1994), *Midgley* (1989a, 1989b, 1990, 1992), *Flood* (1995)*, *Mingers and Brocklesby* (1996) |

In the Example column + means combined in the same intervention, | means used in separate interventions.
* These textbooks have both theory and case studies.

In the table shown in figure 9.4 the name that Mingers and Gill assign to the research design used in this thesis is that of "multi-paradigm multimethodology" shown on line "I" of the table.

In developing an interpretive use of hierarchy theory, it appears that there must be:

- an attempt to define the topic of study and to gather the data to describe the parts of the system observed by the researcher. This is accompanied and underpinned by a reflective stance by the researcher in questioning the choice of scale for the study and how the data is assigned to each level of the surfaced system;

- an attempt to creatively, either narratively or visually, some sort of description from the complex issue to be addressed by hierarchy;

- an attempt to match the principles of hierarchy theory to the structures and processes discovered in that complex issue; and

- an attempt to compare and contrast the interpretive narrative of hierarchy to possibly integrate existing functionalist descriptions of hierarchy, such as that developed from Boulding's *Skeleton of Science*, with the interpretive hierarchy discovered in this chapter, and chapter 7.

Ahl and Allen have proposed a process for the use of hierarchy theory (1996) that will be used in this chapter. Ahl and Allen describe their process thus:

"Hierarchy theory is a theory of observation whose function is to clarify those arguments in science where collecting more data will not help. Five junctures were delimited at which an observer's decisions are crucial to structuring the process of scientific observation:

1. posing a question
2. defining entities or units
3. choosing measurements
4. noticing phenomena, and
5. evaluating models.

These five decisions are the contribution of the observer. The contribution of the observed is system behaviour" (Ahl and Allen, 1996, p. 50). These five decisions, defining the role of the observer in this investigation can be further elaborated to draw out the detail of these decisions in the practice of thinking in an interpretative stance about hierarchy.

First, the observer must address the core principle of exploring and debating perspectives of the observer and associated biases and other influences on the perception process as stated above in decision one by Ahl and Allen (1996). This could be done through a narrative reflection by the observer in concert with feedback from additional stakeholders' opinions (i.e. the sweeping in of additional viewpoints as proposed by Churchman, 1982).

As part of defining and posing the research question (decision 2 of Ahl and Allen, 1996), further exploration could be done with a narrative or visual description of the problematical situation, the complex system. From this diagram, the parts and the inter-relationships of the problematical situation could then be seen. The observer must then decide on the choice of level of analysis / scale / resolution for the study as seen in decision three of Ahl and Allen (1996).

This will lead to an analysis of the interactions, strengths, weak links and strong links in grouping the levels in the system of interest.

Following this determination, it will be the observer's role to draw the boundaries of the system and determine the levels within that system based on the strength of the system inter-relationships.

Once the boundaries and levels are clear, this will also reveal the surfaces of the boundaries and parts and levels in the system.

The channels of communication that work between the levels of the defined system can be sought and described.

A discussion of the possible filters and filtering process for this system can then be undertaken for explanation of the processing of matter, energy and information in this system and the effectiveness of that information within the system.

Linked to this discussion is the definition of the control, constraints and containment structures and processes that are a part of this problematical situation and how they have arisen and how they could be managed.

It is possible then to reflect on the nature of the structure revealed in terms of the span and depth of the system and the emergence, or emergent properties, of this system, for example, by exploring combinations of the groupings from the analysis and comparing with research and information about those groupings in the real world to see if the groupings done in the analysis have any resonance.

Once the structure and processes have been determined and listed, it is possible to explore that description of the system for insights into the problematical situation and for noticing phenomenon as stated in decision four of Ahl and Allen (1996).

Drawing around and closing the full circle brings the observer back to the process of critical reflection on this process and self-reflection by that observer as to the definitions made, the system revealed through those defining actions, and the outcomes from this analysis. This is the decision five of evaluation as stated by Ahl and Allen (1996).

This process for the interpretative implementation of hierarchy theory will now be discussed in the next section, which looks at the problematical situation of emerging infectious disease and addressing the increasing levels of variety in its management.

### 9.1.3 The Case Study – Hierarchy Theory In Action

EID is a complex middle-number system. It can be defined as complex because it requires many levels for its adequate description (Allen, 1985). It is also the type of situation where biases and values do play an important role in describing the system.

In an analysis of the interactions, strengths, weak links and strong links of the phenomenon and problematical situation of EID, the scale of the observation produces data at the level of the risk factors (host, agent, environment and method of transmission) that were described in table 8.1 in chapter 8. This determination of scale and data definition groups the levels in the system of interest. This has revealed the following diagram (figure 9.5) of the system from the interpretive viewpoint. The eye in the diagram is taken from a larger diagram in Ahl and Allen, 1996, p.36, and the three-level model of the system from Allen and Hoekstra, 1992, p.53).

The levels shown in this representation are simplified for this diagram and several additional layers are seen in the analysis of the host factors and their relationship with levels of finer detail (grain) and levels with greater extent (the policy making levels of government agencies for instance). A full description of this intervention and analysis will be the subject of future research.

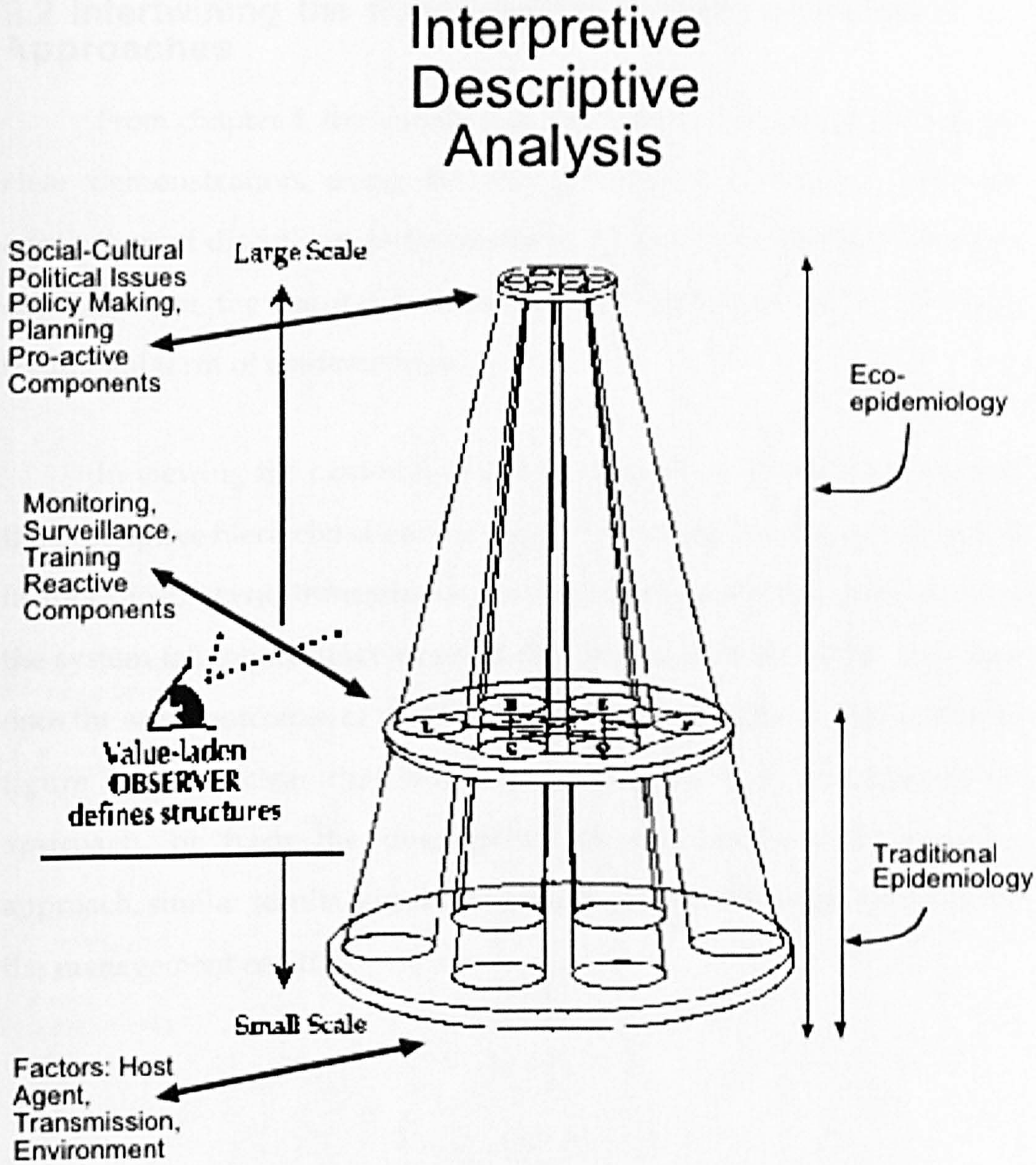



**Figure 9.5 Interpretive Hierarchy**

This section has explored the interpretation of the factors from the matrix of table 8.1 from the stance of the observer of the system. The next section addresses the possibilities for using the functionalist and the interpretive approaches together, in concert, in the review of this complex system of EID.

## 9.2 Intertwining the Functionalist and the Interpretive Approaches

From chapter 8, the outcome of the functionalist approach was the clear demonstration, using Boulding's *Skeleton of Science*, that the application of disciplines to the problem of EID was confined to those disciplines of the natural sciences, those employed in the medical, traditional form of epidemiology.

In viewing the exploration of an interpretive version of hierarchy, the descriptive hierarchy shown in figure 9.6 reveals that the groupings of factors (host, agent, transmission, environment) and other influences in the system fall into distinct levels of the interpretive hierarchy that map onto the same outcomes of the functionalist analysis. This is also drawn in figure 9.6. It is clear that whether approached from the framework approach, or from the descriptive, observer-defined interpretive approach, similar results and recommendations for action can be made for the management of EID.

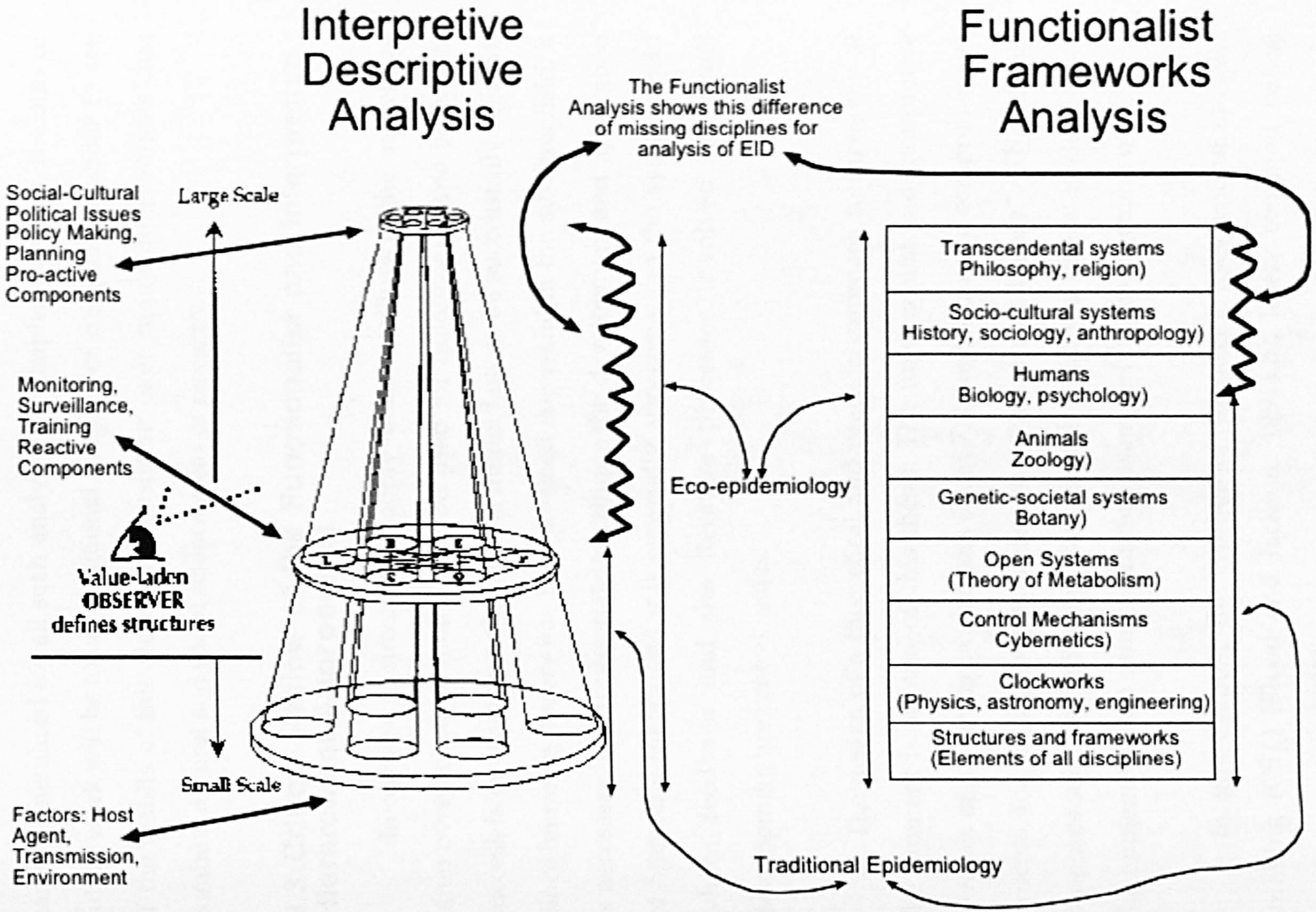



**Figure 9.6 The Combined Output from the Functionalist and Interpretive Approaches to Hierarchical Analysis**

One of the suggestions in chapter 10 is for further work to validate the results of this intervention and to explore whether this is a result that can be generalised for all such analyses of complex systems. The aim of future work will be to use additional analyses of complex situations to see if the results of this study are consistent over many interventions that combine natural and social science areas of research.

## 9.3 Critical Review of the Functionalist and Interpretive Hierarchical Approaches

In our zeal to successfully apply models, failures of the model are often overlooked. A model may be used for quite some time before its success is questioned or before the model fails to be successfully applied. Since hierarchy theory has been deemed successful in the systems field, it is necessary and appropriate to critique the development and application of hierarchy theory and it is especially appropriate in the systems field where feedback and the iterative processes involved in model development are central issues.

The design of a theoretical and practical approach to hierarchy at the moment is an aim of this thesis. The functionalist and interpretive reviews of hierarchy in chapters 6 and 7 do not include a comprehensive process for an implementation of a "hierarchy theory". This thesis proposes such an implementation and also offers a critical evaluation of the implementation using a practical example (the management of EID).

In this chapter, the critique of hierarchy uses critical systems thinking (CST) (Flood and Jackson, 1991a,b), lately renamed critical systems practice (CSP) in answer to critiques (Jackson, 2003) of previous implementations of its practice. One such previous implementation was Total Systems Intervention (TSI).

When first presented in *Creative Problem Solving* (Flood and Jackson, 1991a) Total Systems Intervention (TSI) was a framework that evolved from one of many possible operationalisations of critical systems thinking and practice (CST/P). In *Creative Problem Solving* (1991a), TSI employed metaphors, creative thinking, and the knowledge gained from the processes of reflection and critique to create its comprehensive approach.

TSI is not included in the process of this thesis, however a short overview due to its historical place in the development of this thesis is given in the following section. TSI was one framework that could have been developed from the principles of CST/P. Other authors such as Mingers and Gill (1997) and Nichols et al. (2001) have also addressed implementations of multi-methodological and multi-paradigm intervention and research. Following this short section on TSI, the implementation of the interpretive descriptive hierarchy theory approach will be addressed with reference to the work of these authors.

### 9.3.1 Total Systems Intervention

Total Systems Intervention (TSI) begins with the perception of the "mess." In problem-solving situations the majority of problem-solving methodologies simply present an implementation strategy for analyzing and dealing with this perceived "mess." TSI adds the dimension of creativity (thinking creatively about surfacing the issues inherent in the "mess") and choice (choosing the best methodology(s) for tackling the "mess") in a recursive structure and process that more fully addresses the complexity of the problem-solving situation or "mess" as referred to by Ackoff (1978). This cycle is shown in figure 9.7 that is taken from and explained in greater detail in *Solving Problem Solving* (Flood, 1995c).

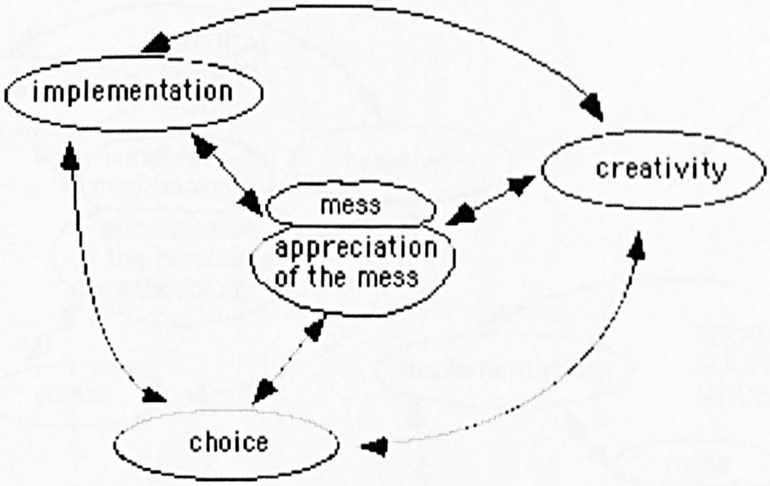



**Figure 9.7 The 3-Phase Process of TSI**

However, while the problem solving mode, as shown in figure 9.8, deals with solving the "mess", the central concern of the prior process of critical review is the critique of a problem solving approach, and the central concern of the subsequent critical reflection mode is the review of the implementation of the approach that was implemented in the problem solving mode. TSI was then expanded to include three modes: the process of critical review; the problem solving mode; and the critical reflection mode; which all involve the same recursive structure. These interconnections are shown in figure 9.8, which also shows how the entire process of TSI's three modes of operation can be viewed as being nested recursively within TSI's creativity, choice, and implementation cycle at a meta-methodological level. The critical review mode was explored further (Wilby, 1995a,b,c; 1996a,b,c; 1997) but that research is not applied in this thesis.

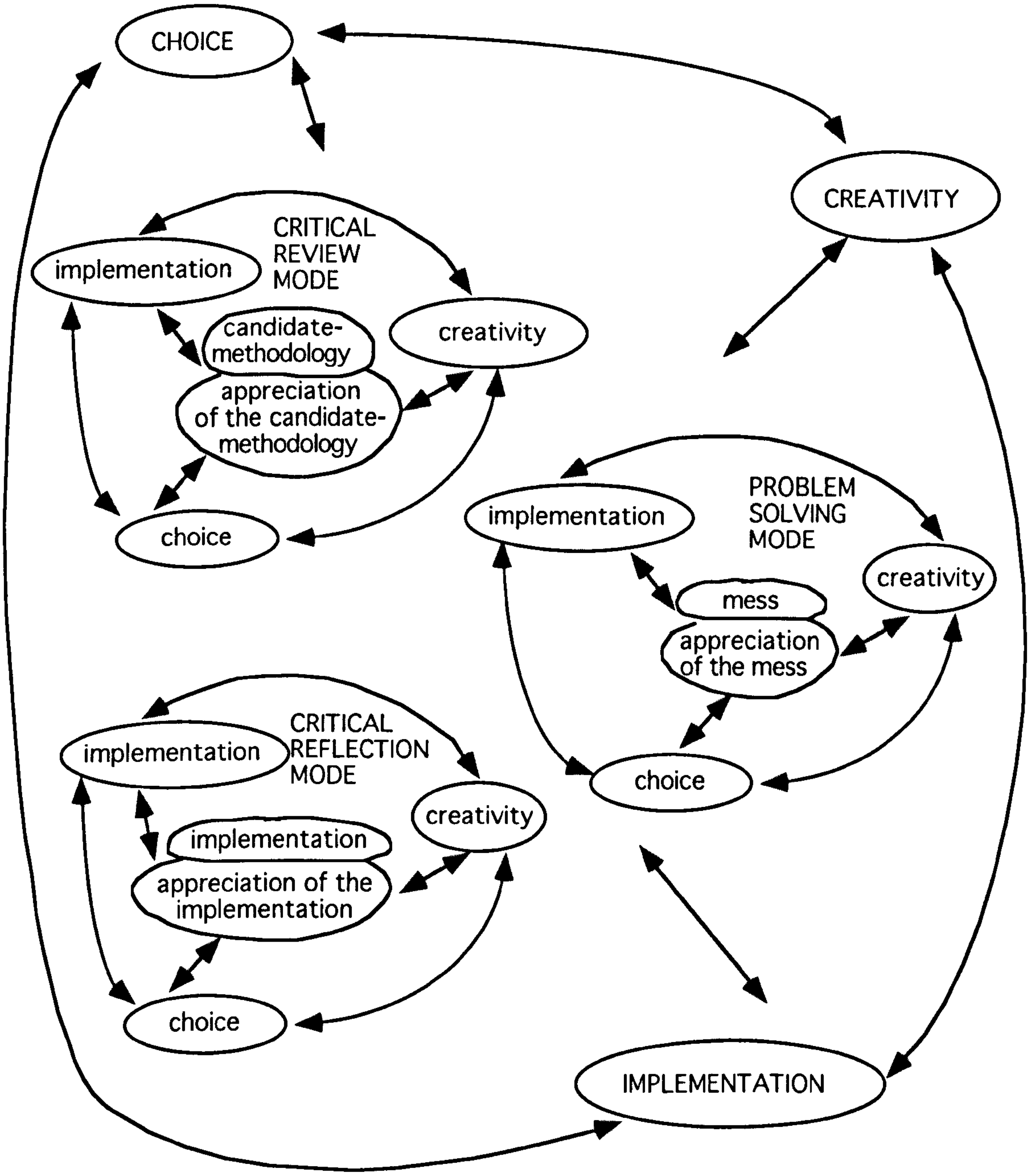



**Figure 9.8 Overview of the 3 Modes and 3 Phases in TSI**

In addressing critiques of the use of TSI, and its underpinning by CST, Jackson renamed CST as: critical systems practice (CSP) (2003). However, with respect to the development of critical systems thinking and its history, in this thesis critical systems will be referred to as critical systems thinking and practice (CST/P). This chapter now returns to the detail and use of the process of critical review for hierarchy theory.

### 9.3.2 Critical Systems Thinking and Practice (CST/P)

When first introduced to systems thinking, CST/P had three commitments: critical awareness, emancipation, and complementarism. More recently, these commitments have been addressed and described as critical reflection (rather than critical awareness), pluralism (rather than complementarism), and improvement (rather than emancipation)" (Flood and Romm, 1996).

The process of critical review investigates and explores hierarchy theory in this thesis but it can be applied to any methodological approach, whether in systems or another discipline. CST/P has relevance to this thesis in terms of providing an underpinning philosophy for evaluation and critical reflection and in addressing the limitations of the individual researcher in the study. The observer (researcher) should always be engaged in a constant and iterative self-reflection as an ongoing part of any analysis. This would also involve the "sweeping-in" of alternate perspectives (Churchman, 1982).

The task of self-reflection is necessary and vital, and requires an on-going self-examination and self-reflection of the biases, filters and paradigms brought to the study by the individual researcher, and by the physical and intellectual communities of which the researcher is a part recognising that the output of this thesis is only one of many explanations from the data gathered.

For further reading on the early development of CST/P, and earlier iterations of TSI, the reader is directed to Flood (1990), Flood and Jackson (1991a,b), Flood and Ulrich (1990), Jackson (1985a,b, 1990; 1991a,b), Jackson and Keys (1984), Oliga (1988), and Ulrich (1983). For further reading on more recent developments in CST/P the reader is directed to Jackson (2000, 2003), Payne (1992), Gregory (1992; 1996), Midgley (1992a,b; 1995, 2000), (Flood, 1993) and Flood and Romm (1995a,b).

### 9.3.3 Critique of the Hierarchical Approaches

As mentioned earlier, there are several important issues to address with hierarchy theory. One is the lack of a single set of principles for all variants of the theory; another is the lack of a capable mathematical structure for all of hierarchy's middle-number systems; and a third is the lack of a specific methodology for the application of hierarchy theory to demonstrate its practical utility.

In hierarchy theory the capability, biases, and values of the observer in describing a system determines whether or not such concerns will be met since the *Weltanschauung* of the observer greatly influences the definition of the system.

Flood's and Jackson's critique of the VSM discusses and answers questions regarding social processes, power structures, organizational culture, individual desires and needs, and a possible lack of foresight in achieving the goals of the system of interest (Flood and Jackson, 1991a).

In Jackson (2000), critiques of VSM are presented that summarise the lack of individual input into the design of the system, and the worry that this lack leads to possibilities of misuse of power by those designing and managing the system, to the detriment of the individuals within the system. Such critiques could also be laid in front of hierarchical analysis, especially from the viewpoint of the functionalist approach to hierarchical analysis, but in the interpretive approach, the observer is aware, and in the interpretive variety of hierarchy theory, is also reflective on the influences he or she has in the determination of the system, its scale of investigation, and what is inside and outside the boundary of the system of interest.

In one comment, Jackson states: "despite the terminology of Systems 1 though 5 [of the VSM], he [Beer] insists that the VSM should not be seen as hierarchical – all five functions are dependent upon each other" (Jackson, 2000, p.177). This however is a misinterpretation of the concept of hierarchy. Systems 1 through 5 being dependent on one another, and the emergence arising from the interactions among the levels of the VSM lead to an interpretation of increasing levels of complexity. Since it is this increasing level of complexity that is the definition of hierarchy rather than a description of increasing power and authority, it can thereby termed to be hierarchical in this sense.

The technical interests are not well served by hierarchy theory in that there is no formal methodology or set of measurements for the practical application of the theory in complex systems. Evaluation of data from a 1986 questionnaire about hierarchy theory found that the theory lacks a set of principles that can be agreed to by all authors in the field (Troncale, 1985).

In addressing this lack of an organized theory or mathematical measurement to apply in complex situations, some mathematical modelling and equations have been developed in the natural sciences applications of hierarchy (Allen et al., 1982, 1985; Mesarovic, 1970; Overton, 1972, 1974, 1975). At the present time, however, the use of hierarchy theory provides an intuitive, illustrative description of a system that is more closely linked to the thinking of soft-systems practitioners.

Checkland has stated that Boulding's *Skeleton of Science* (1956) appears to be convincing, but there has been no additional work on the topic of defining a concrete scale for "system complexity" or the size of the gaps between levels of hierarchies (Checkland, 1981). Given the subjective nature of the observer and the difficulties in reaching agreement on the definition of key concepts in hierarchy theory, concrete information is hard to obtain. However, some systems thinkers have proposed the use of fuzzy set mathematics to meet this need, e.g. Klir, 1985; or multivariate analysis (Allen and Starr, 1982); or a mathematical exploration of hierarchical structures and process, e.g. Mesarovic et al. (1970).

In addition to these general methodological and practical critiques of hierarchy theory, there are also philosophical and ideological critiques that can be presented for the hierarchical approaches to the study of complex systems.

In its implementation, CST/P provokes and provides a critique that focuses on the three specific interests originating from the work of Habermas (1972, 1976, 1984a,b). This use, of a critique of one model from within the standpoint of another, is an important implementation of CST/P. Jackson (1985a) has integrated these ideas into CST/P and they can be rephrased in question form (Schecter, 1991):

- The technical interest: to what extent, and how, does the theory (or can the theory) serve the technical interest of prediction and control, i.e., the hard-systems approach?

- The practical interest: to what extent, and how, can the theory serve the practical interest of understanding, shared meaning, language, ways of observing, worldviews, and roles in achieving consensus, i.e., the soft-systems approach?

- The empowerment interest: to what extent, and how, can the theory serve the emancipatory interest, i.e., people's interest in being free from unjust power relations. This is the added dimension of the critical systems approach.

There are technical, practical and emancipatory knowledge-constitutive interests (Habermas, 1972, 1976, 1984a,b) inherent in problem solving situations. A candidate methodology such as hierarchy has to be evaluated as to what extent, and how, it addresses these technical, practical, and emancipatory knowledge-constitutive interests.

Technical interests are those of prediction and control (the underpinnings of hard-systems approaches); practical interests are those of understanding, shared meaning, language, ways of observing, worldviews, and roles in achieving consensus (the underpinnings of soft-systems approaches); and emancipatory interests are those which address people's interest in being free from unjust power relations (the underpinnings of critical systems approaches) (Flood and Jackson, 1991a). These interests are similar to three other types of explanation that work together to provide an understanding of the underpinnings of critical review. Table 9.1 shows how these four concepts relate to each other.

**Table 9.1 Validity Statements and Systems Methodologies**

| Habermas (1972) | Flood and Jackson (1991a) | Flood (1993) | Flood (1995c) |
|---|---|---|---|
| Technical interests | Hard systems methodologies | Design methodologies | "How?" methodologies |
| Practical interests | Soft systems methodologies | Debating methodologies | "What?" methodologies |
| Emancipatory interests | Critical systems methodologies | Disemprisoning methodologies | "Why?" methodologies |

In table 9.1, each of the horizontal rows deal with the development of a line of thought ranging from the more complex to the simplified; from terms that are understandable and are of benefit to theoreticians, towards terms that are understandable and of benefit to practitioners and individual problem solvers. The first column lists the three knowledge-constitutive interests (technical, practical, and emancipatory) from the work of Habermas (1972). Flood and Jackson (1991a) translate these in the second column by into terms understood in the field of systems thinking. The third column (Flood, 1993) details the same concepts in terms of explaining what these concepts (and the systems methodologies they embody) mean in practice for addressing issues of freedom in systems design and implementation. Finally, the terms in the fourth column are concepts to which individual participants and managers of problem solving situations will, more possibly, relate to and understand.

Jackson (1985; 1991a) describes another framework that details the relationships between systems methodologies and the participants in problem solving situations and the reader is directed to these references for that framework's diagram and explanation since it is structurally different from the table described in this chapter.

The metaphor of complex systems from Flood and Jackson's "system of system methodologies" (Flood and Jackson, 1991a) applies to the hierarchical approach: hierarchy theory is designed to model complex situations. It does therefore belong in the group of systems approaches described as "complex" in the "system of system methodologies" (Jackson and Keys, 1984, Jackson, 1990). But the further definition of whether the method is unitary, pluralist, or coercive is less clear.

Hierarchy theory should not be called a unitary approach because many of the systems it could be applied to have many stated purposes or goals, as found in complex social systems, or are not assigned purpose or goals, as in natural complex systems. The revealing of information gathered from the hierarchical analysis can further emancipatory interests. But what to do with the information obtained? Can the system be reworked using additional methodologies to enhance the well being of all participants? It could as easily be reworked in an opposite fashion. In addition, it is not just emancipatory interests that must be served; the ideals of enlightenment must also be met. A working definition of enlightenment and emancipation in terms of each of the participants must be agreed on before any redesign of the system is attempted.

The evolution of systems depends on change. So, with regard to the idea that hierarchy theory is used to preserve existing systems, hierarchy is actually more interested in structural and process changes. A "collapse to a higher level of organization" after a collapse of the previous system has occurred incorporates the additional variety caused by the disturbance and gains stability from having dealt with those changes. Change is not something that a system must avoid at all costs; in fact, it can be very beneficial in that previously external disturbances are now neutralized through their incorporation into the reorganized system (Mannermaa, 1988). In this way hierarchy theory can be viewed as an approach to use in systems where radical change is desired or expected to occur since it has the capability to recognize instabilities, disturbances, and reorganizations of the system. It can also explain such reorganizations in terms of the new constraints and controls at work in the system.

One of the language difficulties hierarchy theory encounters is the definition of the word "hierarchy" itself. "Hierarchy" has many different meanings in management, politics, science, and systems thinking. "In discussions of the theory of complex systems, the term 'hierarchy' has taken on a somewhat generalised meaning, divorced from its original denotation in human organisations of a vertical authority structure" (Simon, 1973). Those working with hierarchy theory have tried to find a less-antagonistic terminology for the theory, although several have tried (e.g. heterarchy – Troncale; or Panarchy by Gunderson and Holling, 2002), but the terms have not been adopted into general usage in the field.

Hierarchy theory can in future research be developed to address emancipatory interests building on its initial stance of its commitment to the recognition of observer importance and observer paradigms. Hierarchy theory was not designed as a coercive approach in the study of natural complex systems, although its descriptive elements have achieved such notoriety in the analysis of complex social systems. Its use in any situation depends on the values held by the individual practitioner.

Since it is the observer (and that person's biases and viewpoints) who defines the system, it could be said that if an authoritarian bias were present and not countered, the hierarchy revealed would mirror an authoritarian philosophy. In the same way, if an emancipatory philosophy were at work, then the hierarchy would mirror that philosophy.

If the information gathered by the observer is given to the system participants that alone may provide empowerment to those participants. Stringent examination of personal intentions and biases in any redesign is very important, and enlisting the support of other systems practitioners could further this process. Following Churchman's ideal, this would involve continually observing oneself and one's actions and "carrying on a conversation" with oneself and one's colleagues (Churchman, 1982).

## 9.4 Summary

The aim of this chapter was to show that combining a functionalist and interpretive approach to hierarchy could be useful in the analysis of complex systems such as EID. The combined model, shown in figure 9.6, reveals an interesting outcome: that the lack of appropriate disciplines applied to the study and management of EID is apparent from both the functionalist perspective (chapter 8) and the interpretive perspective (chapter 9). Additional testing and practice is needed before generalisation to other problem solving situations can be inferred, since the application of these explorations needs to be made in different cases within different fields of research to further validate and to be able to generalise for this approach to complex systems. This will be the subject of further discussion in the next chapter and a topic for future research.

The work of this thesis will now be summarised in chapter 10, along with a reflection on the content and process of the thesis, some recommendations for the discipline of epidemiology, and thoughts for future research.

# Chapter 10

## Findings, Reflection, Summary and Further Work

### 10.0 Introduction

This chapter summarises the work of this thesis, and offers reflection on its content and process, some recommendations for the discipline of epidemiology, and thoughts for future research in systems, hierarchy and epidemiology.

In this chapter on reflections, there are three questions that underpin the discussion. The first two: "What" should I reflect on? and "Why" is reflection necessary?, are based on the twin standpoints of the effectiveness of the intervention, and the moral responsibility of the facilitator. These questions are addressed by the content of this chapter, i.e. the contributions to knowledge, the findings with regard to each of the contributing disciplines, the recommendations to be made, and any other issues that should be addressed in further research.

The third question: "How" can I as an individual reflect on my actions and their implications? (Brown and Wilby, 1996) is addressed by the working through each of the sections with the objective of being self-reflective alongside the practical reporting of the outcomes of this thesis.

### 10.1 Meeting the Aims and Objectives of the Thesis

In this section, the research questions, and the aims and objectives of this thesis are restated with the intention in the following section, 10.2, of answering each of these points with regard to how they have been addressed in the thesis. Further, section 10.2 will also detail the outcomes of contributions to knowledge that have been achieved through this work.

The two research questions for this thesis were stated as follows:

- Would a more holistic systems approach to the study and control of emerging infectious disease, combining systems thinking, and the systems approach of hierarchy theory, with methods and data from epidemiology, provide an enriched description for the modelling, planning, intervention, and response to EID, and in particular, a case of international guidance in public health policy-making?

- Would this improve the understanding of the process of public health policy-making and intervention in EID for those involved in managing these issues?

The aims of this research were:

- To develop a narrative comprehensive review of epidemiology past and present and of hierarchical approaches in systems thinking from a functionalist and interpretive perspective;

- To use the functionalist and interpretive perspectives of hierarchy and the narrative reviews in concert to investigate EID within the discipline of epidemiology;

- To develop, apply and evaluate a critical review process in the design and the evaluation of this research using the methodologies of systematic review and critical systems thinking and practice (CST/P).

The objectives used in achieving these aims were:

- To present a process for critical systematic review for review of systems thinking, hierarchy theory and epidemiology in concert in this thesis;

- The compilation of a comprehensive literature review of published work on hierarchy theory and those areas of epidemiology relevant to this study;

- To review the hierarchy literature using a functionalist and interpretivist analytical approach, so as to construct a narrative comprehensive review of each of these perspectives for the purpose of comparing and contrasting the outcomes of this process in a practical exploration of EID.

- To critically review the functionalist and interpretive hierarchy approaches and their use in this thesis; and further

- To critically evaluate and reflect on the usefulness of combining functionalist and interpretive approaches with methods and data from epidemiology to answer the questions as to whether or not this combined approach is relevant and valid in: (1) the analysis of EID as a complex situation, and (2) the generalisability of this work to other areas in the management of complex systems; and

- To propose recommendations for the improvement of policy-making in EID, and suggest future research in hierarchy theory.

## 10.2 Contributions to Knowledge in this Thesis

### 10.2.1 Systems Thinking

The thesis has produced a research project that meets the imperative of the founders of systems thinking of using systems to address complex systems (Boulding, 1956; von Bertalanffy, 1952). The research has not only employed existing systems methodologies but has also proposed new methods and process for the implementation of hierarchy theory. In addition to these processes, the implementation process itself has addressed the possibilities of working with multiple methods in multiple paradigms (Mingers and Gill, 1997; Nicholls et al., 2001). Hence, the results of this research can inform the practice of systems thinking.

### 10.2.2 Hierarchy

This research provides a unique review of the literature about hierarchical systems approaches from the stance of exploring each individual core author who has written extensively on hierarchy or who, at least, developed the explanation for a core concept in hierarchy. This is a novel outcome, not previously available in the literature.

This research has analysed hierarchical systems approaches from the dual perspectives of the functionalist and interpretive research paradigms, implementing a research design based on Mingers' and Gill's work in multi-methodology. This is also a novel outcome, not previously available in the literature.

This research used two paradigms, functionalist and interpretive, first as individual comprehensive narrative reviews and then in concert to produce a richer understanding of the problematical situation of EID. This form of implementation has not been done previously, and has offered additional insights into the scope of the field of research for hierarchy.

Specifically, this research provides an implementation of hierarchy in concert with other systems approaches and with data in the discipline of epidemiology, which reveals that the inferences and implications of the analysis of the EID complex system are similar from the outcomes of both paradigms: functionalist and interpretive. In both functionalist and interpretative interpretations of hierarchy, as shown in figure 9.6, there are areas of investigation and tools and disciplines that could be employed in those areas of investigation that are not currently being used. The addition of these tools and disciplines could provide a richer description of, for example, the management of EID, and this has been a goal of this research. This point is echoed and drawn forward by developments within the study of epidemiology, such as those by Kreiger (2001), Waltner-Toews (1999) and Parkes et al. (2005).

In designing this research project, the issues were to show the importance of this topic for research and also to investigate any benefits from employing a multi-disciplinary systems framework to this area of research. The first aim, whether the topic is important, has been addressed several times in this thesis. The second was answered by using Boulding's framework. Evaluation of that framework has been discussed by Checkland (1981) who says it must answer two questions: is it useful, does it resolve any problems?; and is it convincing? The first reply is that it does reveal the need to use different disciplines to address different levels of an investigation. Replying on the second, it is convincing in that people recognise when an emergent property becomes visible – when a new level of organisation can be explored; it is a concept understood in many disciplines. This similar isomorphy of emergence can be seen in the design and presentation of the process of meta-analysis and systematic review in epidemiology.

This work also found that individual disciplines used to study groups of issues such as those listed in the matrix of table 8.1 should not be used to work across levels without the realisation that the language of one level's discipline will not be sufficient for the description of the phenomena (the emergent property(ies)) arising at the next level of organisation (Boulding, 1956; Mingers, 1997, Checkland, 1981).

On the other hand, by focusing on the individual issues at a lower level and remaining at that level we may overlook consideration of possible emergent properties that may have future consequences. This point argues for the investigation into emerging infectious diseases to be designed to gather data from the language of as many disciplines as possible so as to increase the possibilities of discovering instances of emergence when they arise in practice.

Hierarchy theory has the potential for use in concert with other systems approaches if practical concerns about implementation can be addressed in future work. It is an approach that could offer that function or process when used in conjunction with other systems practice, and it has potential for enhancing self-reflection in systems analysis thereby serving emancipatory interests.

Hierarchy theory can address practical and emancipatory interests through its commitment to the recognition of observer importance and observer paradigms. deBivort and Barry and Mary Clemson have discussed the evolutionary challenge to cybernetics (Clemson, 1984; Clemson and deBivort, 1990) and the need to take better control of the evolution of the systems we manage so as to properly guide our own evolution. Such an interest coincides with the goal of the emancipatory interests of CST/P and the goal of hierarchical systems in recognising and addressing appropriately the observer's influence in systems practice.

### 10.2.3 Epidemiology

This thesis has demonstrated that the study of emerging infectious disease is a complex system and that by using a hierarchical systems approach in the exploration of that system, there is found to be a clear need to expand the practice of traditional epidemiology from the medical, natural sciences model to the more holistic approach of eco-epidemiology as proposed in the work of Kreiger (1994, 1995, 2001), Waltner-Toews (1999) and Parkes et al. (2005).

The research topic of emerging infectious diseases is recognised as important for research by these global and national agencies. However, this thesis found that the focus of the proposed regulation and direction for research does not include the additional issues that need to be addressed from the perspective of the social disciplines in addition to the biological and mathematical disciplines.

Specifically, this thesis has shown that there are contributing risk factors in the emergence of infectious disease not addressed in current policy making procedures for EID. This is shown in the following diagram, figure 10.1, which represents the lack of inclusion of certain contributing risk factors in current EID policies at the international level. The details of these risk factors have been described in detail in chapter 8 and summarised in the matrix in table 8.1, and which have been the content of the functionalist and interpretive analyses of hierarchy approaches in chapters 8 and 9.

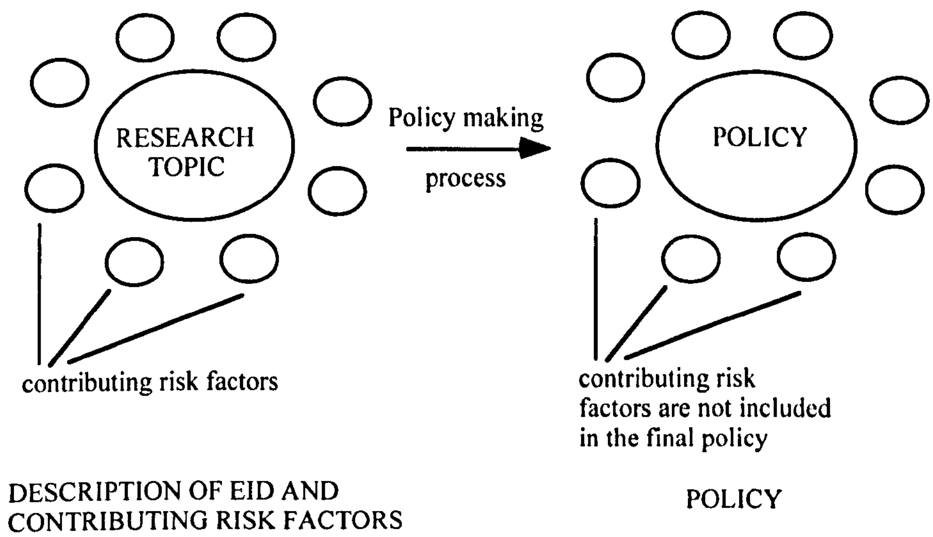



**Figure 10.1 Policy Making with Modern Epidemiology**

This thesis proposed that these are important risk factors and should be addressed in policy making and that a systems approach developed from various exemplars from both functionalist and interpretive hierarchical approaches can show that these factors are not addressed in current policy documents. The thesis also demonstrated that the disciplines associated with each of those factors are also not represented in current policy documents (chapter 8) and that recommendations can be made, based on a more multi-disciplinary epidemiology, which would include a wider range of risk factors (and their associated disciplines) to produce more meaningful policy statements for addressing emerging infectious disease. This change in focus is illustrated in figure 10.2.

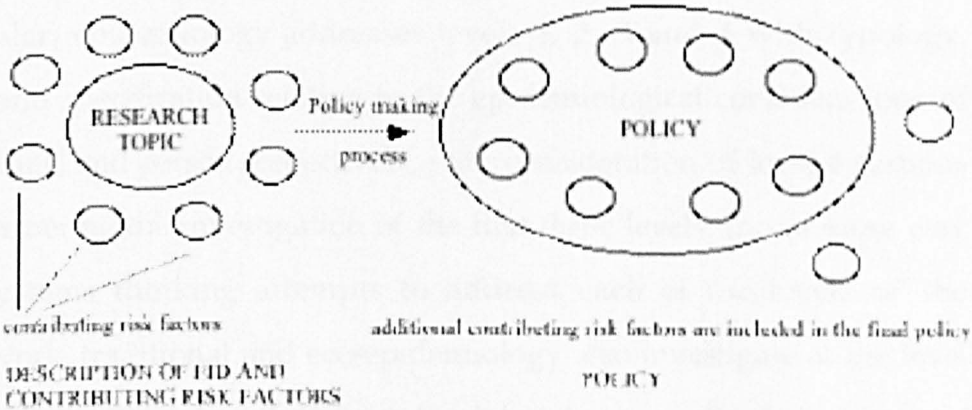



**Figure 10.2 Policy Making with Multi-disciplinary Epidemiology**

"Meaningful" is defined here as having made a perceived difference in the usefulness of the recommendations to the field of public health. Figure 10.2 also recognizes that although a multi-disciplinary approach can address many factors previously excluded, whether by lack of subject knowledge or through conflict of interests, there will always be some factors which remain outside the scope of the research topic and the policy making process either through error or by design. Although holism is an ideal, having all the information possible in studying emerging infectious disease, is in practice probable that less than "the whole" will be accomplished.

The result of this approach informs the practice of epidemiology (in that more variety is incorporated into the policy and decision making processes). The study of complex research issues, such as emerging infectious diseases, may thus be enriched through the use of different disciplines in the goal of adequately describing, modelling and intervening in such issues.

From Boulding's work it is inferred that modern (clinical and molecular) epidemiology addresses levels 1, 2, 3 and 4 with typology, order and specification relating to the epidemiological considerations of place, time, and person respectively, with consideration of level 4 systems also furthering the investigation of the first three levels. In the same way that systems thinking attempts to address each of the levels of the framework, traditional and eco-epidemiology also investigate at the level of the relationships described from level 4 and above. Epidemiology and systems thinking must be able to operate not only on the molecular level but also on a global scale (in both space and time) in order to address all of the contributing factors in emerging infectious disease.

### 10.2.4 General Research Contributions

This thesis provides a contribution to knowledge through the application of systematic review to the field of systems thinking and hierarchy, doing this in a similar way as has been done in the field of epidemiology. The end-result of the process of critical systematic review is not a simple summation of the individual steps, although much would be missed if any step were omitted – but the end-result gives a picture of the results of the implementation that is more than a step by step analysis of its contents. The on-going critique and reflection by the researcher, those taking part in the research process, and those evaluating the research all contribute to a deeper understanding of the investigation of this topic of research and as guidance for adding such depth to other researchers.

The thesis contributes to knowledge by:

- combining the systematic review process with the process of critical systems thinking and practice and the imperative of surfacing, and addressing, the underpinning ontological and epistemological perspectives of a research design and process. This has been achieved through the use of systematic review of the data, CST/P and the work of Mingers and Gill (1997), and Nicholls et al. (2001) in their work on multi-methodologies.

- presenting a comprehensive and novel narrative review of functionalism and interpretivism in hierarchy theory, and including a traditional literature review that has drawn together the historical development of hierarchy in a depth and breadth that is not currently available in the literature.

- and finally, implementing the content of those reviews in concert with a specific case of a complex system taken from the discipline of epidemiology (EID); an implementation noted as lacking by writers in epidemiology (Krieger, 1994, 2001; and

Waltner-Toews, 1991) and now available in the literature as an outcome of this thesis.

## 10.3 Reflections on the Thesis Process

### 10.3.1 Design of the Thesis

In designing this research, the first direction was to build a model of feedback loops using systems dynamics modelling, and running that model in a computer simulation. In hindsight this would have been addressing this research topic at the wrong level of analysis. Boulding's framework may not contain the detail or the direction for making an adequate model or discipline for explaining levels of organisation above level 4 or 5, but it can reveal that such models are necessary and that current models applied at those levels are not sufficient. This points the way for further research in more depth in this area.

Further, in making decisions about the sorting of factors in the matrix and in determining which disciplines could be read from the organisational statements, personal bias and expectations are admitted. This is consistent with the nature of qualitative research, and the mitigation is to have others review these choices and make alternate choices and recommendations that have been done. This has been accomplished through the review of supervisors, colleagues giving input to the data collection for this thesis, colleagues reviewing parts of the thesis for reliability, and in the examination process itself.

### 10.3.2 Design of the Hierarchy Approach

One of the shortcomings of the approach is the lack of a methodology that would be used for designing new systems or planning interventions in existing systems. However, in this regard, many of the systems explored to date using hierarchies for illustration are systems, which could not be designed meaningfully in advance, e.g. ecological or biological systems.

In reflecting on how this work in hierarchy theory has produced these changes, it appears that the research of this thesis has built on the existing principles in hierarchy theory. Because of the process of critical review that it has undergone in this thesis, hierarchy itself is informed and improved.

Hierarchy theory also raises several interesting points more relevant to the interests of soft-systems thinkers. The first is the importance of the observer in the system. Recognition of the importance of the observer, and of the observer's influence on the very structure of the system by his or her presence is an added benefit to many of the soft-systems approaches in addition to this way in which those approaches already address such issues. The interconnections between levels of the system being studied, and the knowledge gained from the study of the different types of matter, energy and information transfers across the surfaces and between the levels in the hierarchy is a second interesting point. The differences and matching of these *windows* at each level explain the filtering of information and its movement up and down the hierarchy.

Every participant in any process has a unique viewpoint or paradigm that must be considered and evaluated in systems analysis. To realise such an objective, the community of systems practitioners should always be engaged in observing, monitoring, and providing feedback to each other regarding individual research and implementation processes. In this way, the effects of the observer can be somewhat mitigated or at least openly and positively critiqued by other practitioners.

In choosing one scale for observation and decomposing the structure for analysis, a process used in studies of complex situations as much as in the traditionally reductionist fields, one critique is that such a process alters the system when all of the parts are reassembled. The structure is indeed different, not because there are changes or mistakes made in the reassembly, but because the observer's presence in any form within the system will alter the system. An equally important reply in terms of the emancipatory or critical interest would be to question the effects of such changes.

There are fewer consequences if the observer's effects are noted and the changes to the system are realized. These effects do matter if conflict is produced by the resulting changes in the system and those changes are so unmanageable that they threaten system viability. The methods of self-reflection and critique in research must always be used and "sweeping-in" critique and new ideas into one's work can mitigate probable biases.

### 10.3.3 Ethics and Decisions

Questioning our personal ethics and being aware of the effects of our actions as they emerge from our own personal paradigms allows us to move beyond any inability to act. We do not have to believe, like the relativists, that the search for absolute values is a hopeless enterprise; systems practitioners can simply get on with their work. Stafford Beer writes:

> "Only the most mature and sophisticated among us will know how to cut the knot of this confusion of moral imperatives, ethical double-binds, mathematical labyrinths, and practical glitches. I propose to you the devastatingly insightful conclusion. "Bring the old devil lots of dumplings, p.d.q." I have to tell you that this advice really works, whereas arguments about morality, about ethics, about mathematics, and about on-the-ground snags really do not work" (Beer, 1989).

Hierarchy theory is at present a method of describing and illustrating complex situations. It does not claim to take an isolationist or imperialistic position. To those systems practitioners who are able to address multiple perspectives in practice, such a different and more abstract approach could be a useful addition.

Finally, in reflecting on the content of this thesis and whether there is justification for the methods and process chosen: the answer is that "yes", the justification for this thesis is tenuous, but in this thesis I chose to address an issue that is not grounded in hard data. I chose instead:

- to accept the holistic injunction (Noblit and Engel, 1992) and focus at a multi-disciplinary level of investigation.

- to implement a multi-disciplinary approach in this thesis by moving outside of the defined area of modern epidemiology and by combining a systems framework to illustrate the need for several disciplines in the research of emerging infectious disease.

- to believe that there is an increase in complexity in these factors and in the disciplines which are used to study them and that by using these multi-disciplinary approaches the research can provide meaningful results for public health.

Decisions (choices) must be made between the differing outputs from the information generated in the critical review process must also be made about the use and interpretation of the resulting information about the candidate methodology. The result of this work is dependent on the need to be critically reflective about the underlying biases, values, aims, and philosophy both of the method, and of the researcher(s) involved in the critique process. One researcher's use of the critical review process will produce a critical review that is different from the critical review of any other researcher. The output from one researcher's critique will produce *an* understanding of the candidate methodology being critiqued, not *the* understanding of the candidate methodology being critiqued. These realizations are present and unavoidable in any research and intervention and no less so in the process of critical review.

The critical review process presented in this thesis also attempts to answer questions concerning the roles, limitations, and responsibilities of individual participants and expert practitioners in the process of critical review. It is probable that the people involved in the process of critique will not be the same people involved in the implementation of the methodology. Such a situation may lead to critique concerning the use of "experts" in the practice of critical review. However, the expert-led use is not so much a function of expertise being required for the review, as it is a function of the time available to individual participants involved in the managing of complex situations to accomplish such a review. It should also be noted that even though different people may be involved in the implementation, the critique will be improved on and added to at all times by every one of the people involved by their use of the critical feedback mechanisms embedded in the process of critical review.

## 10.4 Recommendations for Future EID Policy Making

This section addresses the question as to what recommendations a holistic, multi-disciplinary approach to epidemiology (such as eco-epidemiology) would make and how would this alter the four basic directions of surveillance; health education and promotion; interagency co-operation; and applied research in epidemiology and laboratory science? The perspectives of eco-epidemiology (Susser and Susser, 1996) are reflected in these recommendations as are the general statements made in *The Leeds Declaration* (Long, 1993).

Troncale (2000) writes: "It is important that systems science do what medicine did. In the face of daunting complexity, focus on the parts of the system that are malfunctioning and meticulously tease out how the normal system works from its dysfunctional state. Only then do you have a "handle" on, or a way through the maze of complexity of the normal system. This points out the need for a serious and detailed classification of systems pathologies. In a complex system, it is much easier to study what goes bad to tease out otherwise obscure interrelationships. Then following the medical model we could attempt to move systems science from its current fumbling descriptive phase to a prescriptive phase. The parallel even works in systems education. In medical schools the operative procedure is "watch one, do one." That is what we need for systems science. Unfortunately, our current status is more like the earlier medical practice of bleeding sick patients to rid them of imaginary bad blood. Thus, a dictum I have often cited at systems meetings; we need a Systems Hippocratic Oath: "DO NO HARM." (p.236)

Holling's work, noted in chapter 7, along with Gunderson and others (2002), is a dynamic representation of not only ecological systems but also organisational systems such as the global health system including the issues of EID. This work has the explanatory potential for implementation of changes to the way the current system is addressed and monitored, in that more dynamic and pro-active interventions could be planned for the investigation and management of EID. The recommendations that follow in the next section will be reviewed in future work in light of the insights received from Holling's research.

### 10.4.1 Surveillance Recommendations

In a similar way, Last defines surveillance of disease as " [t]he continuing scrutiny of all aspects of occurrence and spread of a disease that are pertinent to effective control" (Last, 1995, 163). "In other words, 'information for action'" (Berkelman et al., 1996, 735). According to Berkelman et al. the purpose of surveillance is to monitor and describe trends, both short- and long-term. The data from surveillance comes from notifications and the use of databases. The data analysis looks at time, place, and person statistics, looking at either case counts (acute disease) or rates (chronic disease). Finally, the data dissemination role of surveillance allows for the targeting of health care (from Table 20.1, Berkelman et al., 1996, 736).

Combining the "information for action" goal and the multi-disciplinary direction of this thesis one recommendation is that the talents of international and national surveillance agencies should be combined in a single network that can operate for all contributing agencies and disseminate that information without political or ideological interference. A similar recommendation has been made by a study at the Institute of Medicine (Lederberg et al, 1992), however those recommendations are towards standardising reporting of data within the United States and only suggest "taking the lead" in (rather than the design of) an international structure and process for surveillance. While this is a very broad recommendation, the core of this is to promote the ideas presented in this thesis as to the need to integrate knowledge about EID in a systematic and systemic practice.

Another recommendation is linked to the research direction. This recommendation is that the qualitative and quantitative data gathering be incorporated into the same databases. This will require advances in models and methodologies that are capable of mixing and interpreting such data.

Finally, Krieger (1994) and Susser and Susser (1996) suggest that an ecological approach to surveillance is necessary. This thesis proposes that Krieger's model of a spider web be expanded from a two-dimensional structure to a three-dimensional sphere of interconnections with not just two spiders in that web (the biological and social (Krieger, 1994, 2001)) but multiple spiders who can also communicate with each other.

### 10.4.2 Health Promotion/Education Recommendations

One area in which systems thinking, specifically critical systems thinking (Flood and Jackson, 1991a,b; Flood and Romm, 1996) can inform public health is in addressing the balance between the individual and social concerns inherent in health promotion. In health promotion, there needs to be a balance and awareness that social and political issues, not just bio-medical issues, are at work in the lives of individuals. The individual's rights and personal freedom and choice are often in conflict with political and social policies, e.g. balancing the rights to privacy of HIV/AIDS patients with those of the surveillance and monitoring goals of health agencies. Society has certain needs regarding the control of its individuals, especially in the economical and political settings but these are not always in favour of the health of the individual. Resolving these conflicts is an area of expertise to be found in critical systems thinking (Flood and Romm, 1996) and this expertise should be investigated for the design and implementation of health promotion programmes.

A second recommendation in this area is to refocus the educational content in the teaching of public health and epidemiology. This would have as its goal raising the awareness of future epidemiologists to the various forms of epidemiology so that they can assess the importance of working with different levels of complex issues and with multiple disciplines in the same research project.

### 10.4.3 Interagency Co-operation Recommendations

Education of international and national governmental bodies about the importance of multi-disciplinary research should be promoted. The success of such education would have two benefits: getting the political approval for an international network; and raising the financial support for such a network. This is also linked to research goals, which must work to provide the justification for incorporating "soft" data into such networks so that approvals are possible.

### 10.4.4 Applied Research Recommendations

It is prudent to expand the range of disciplines used in the investigation of emerging infectious diseases in order to possibly recognise emergent properties that come from intervening on levels that are beyond a singular discipline's capacity for understanding. Such mitigation for example would have forestalled the atmospheric ozone depletion that resulted from the lack of understanding about the emergent property that arises from the relationship between meteorological influences and the reactive properties of CFC molecules (Lovelock, 1979). One discipline alone cannot address the full complexity of such research issues.

## 10.5 Summary

The development of methodologies that can describe, measure, and effectively intervene in complex middle-number systems is a challenge for systems practitioners. Hierarchy theory is not as developed in its practical applications as Checkland's SSM or Beer's VSM, but it does require the practitioner to be aware of observer bias and influence in the system studied.

This thesis has revealed interactions and behaviours within the complex systems generally and within the complex system (EID) of interest in this research. These insights are unique to this thesis and may not have been made apparent using other approaches to this work. As these behaviours and interactions become apparent it may be possible to use this information to identify more effective, efficient, and appropriate levels for systems intervention.

In summary, outcomes of this thesis include: the realisation that a systems view of global-problem solving; an understanding of the limits of our knowledge; and an understanding that many disciplines are necessary to adequately describe all levels of a complex issue, can inform emerging infectious diseases research. These realisations should also be carried into widening the research aims of the global and national health agencies involved in such research so that purely biological or mathematical models are complemented with research into the political and social issues involved with emerging infectious disease.

Hierarchy theory reveals that, as population increases and resources decrease, people track ever closer to the carrying capacity of the systems they have created (Allen and Starr, 1982). This decrease in the flexibility of the world's major and minor systems reduces choices and reveals stress points that require attention before catastrophe occurs. The closer we track to the limits of flexibility, the closer we also become to the possibility of ever-smaller errors causing system disturbances, reorganisations, and ever-greater emergent consequences.

Joshua Lederburg is pessimistic. "...Pitted against microbial genes, we have mainly our wits." (CDC, 1997). Lederberg is correct, we do have our wits, but we also have the knowledge and common sense required to harness those wits to apply the information generated from our research—whether from epidemiology or systems methodologies—to address these issues. The discovery that the possible causes of an emerging infectious disease requires several levels of organisation to adequately describe its behaviour and interrelationships, and hence several different disciplines for the investigation, is important to public health. This information can inform the design of future public health research into emerging infectious diseases so that more informed, although never perfect, methods of health policy, education and promotion can be developed.

"While the human race battles itself, fighting over ever more crowded turf and scarcer resources, the advantage moves to the microbes' court. They are our predators and they will be victorious if we, *Homo sapiens*, do not learn how to live in a rational global village that affords the microbes few opportunities. ... It's either that or we brace ourselves for the coming plague." (Garrett, 1994, p620).

The interrelationships between humans and pathogens will always be a biological-level struggle, but there are multi-disciplinary strategies available to us in this struggle and epidemiology and systems thinking can and should be employed as a supplement to us using our wits.

## 10.6 Future Work

Future research will explore the following principles with reference to the system studied (EID), and will cover: defining/deciding the boundaries; defining the surfaces; defining the channels of communication; defining the filters; defining the control; defining the constraint, containment and control in the system; defining the span and depth, grain and extent; defining the emergence, and emergent properties of the system; and defining the reflection / self reflection of the observer (this researcher) in defining and interpreting the hierarchical system of EID management. Further, work in this area will concentrate on investigating different frameworks fin determining or a less tenuous basis for the hypothesis that multiple disciplines are necessary in studying emerging infectious disease; how to gather more information about contributing risk factors; building models that demonstrate the effects of links between contributing risk factors; and investigating further the philosophy, principles and practice of multi-disciplinary epidemiology.

As humankind evolves and individual and species survival on the planet continues to increase in importance, then our moral and altruistic nature must also evolve. Hierarchy theory should be used to investigate the higher levels of present systems to see if there are possible structures that would permit Boulding's transcendental level to evolve (Boulding, 1956) and also allow greater feelings of individual participation and empowerment. These goals might occur as a reorganisation of the present system of constraints and controls or it might be a completely new hierarchical structure. Such a higher level would not necessarily mean that a larger entity would be created. The goal of guiding the system towards enlightenment and emancipation could involve a structure that uses the level of the individual as the constraining and controlling mechanism. In light of ever-increasing changes to the biological, ecological and social systems not only in global health, but also in many other systems, such a search for these changes have become an imperative.

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# Appendix 1: The Search Results

The first searches that are reported were carried out in 1993. The second set were carried out using an internet interface in 2002 and collected a different set of data, seen in table A1.3. The literature search for epidemiology was carried out in 1998 using HELMIS and the library catalogue at the Nuffield Institute IRC, and by using the British Library catalogues at Wetherby, W. Yorkshire.

The 1993 search for articles on hierarchy was conducted using the Bath Information and Data Services (BIDS) system through on-line search facilities at the University of Hull, UK. Hierarchy, hierarchical structure, emergence, scale, complexity, or a combination of these keywords, were used in the search. The latter three keywords were used with the first two keywords to narrow the search.

However, to address this possible issue, earlier uses of hierarchy will be searched for using information from the introductions to later works and references used in those writings. Those finds will also be searched for the same type of information until the first uses of hierarchy are determined.

## Initial Searches

The computer-generated listing of articles and associated materials that mention and/or discuss hierarchy theory has generated an extensive database. A summary of the search results is listed in tables A1.1 and A1.2. The first table shows a statistical summary of the listings and their sources.

The search revealed several thousand articles that mention hierarchy, hierarchical structure, emergence, scale, complexity or a combination of these keywords. The latter three keywords were used with the former two keywords to narrow the search.

**Table A1.1 BIDS Searches 1981 to 1993**

| | BIDS Science Index H+E only | BIDS Soc. Sci. Index H+E+S+C | BIDS Arts Index H+E+S+C | BIDS Proceedgs H+E+S+C | BIDS Proceedgs H + E only |
|---|---|---|---|---|---|
| 1993 | 108 | 206 | 45 | 331 | 38 |
| 1992 | 986 | 1935 | 393 | 2487 | 298 |
| 1991 | 945 | 1638 | 384 | 2297 | 273 |
| 1990 | 556 | 967 | 270 | 2216 | 249 |
| 1989 | 518 | 927 | 301 | 1847 | 176 |
| 1988 | 509 | 889 | 266 | 2043 | 217 |
| 1987 | 522 | 859 | 241 | 2018 | 205 |
| 1986 | 510 | 953 | 247 | 1837 | 176 |
| 1985 | 445 | 852 | 267 | 1666 | 233 |
| 1984 | 430 | 820 | 226 | 1305 | 133 |
| 1983 | 468 | 893 | 221 | 1366 | 145 |
| 1982 | 337 | 896 | 233 | 1327 | 134 |
| 1981 | 342 | 812 | 217 | | |
| TOTALS | 6676 | 12647 | 3311 | 20740 | 2277 |

Where H = hierarchy, E = emergence, S = scale, C = complexity

One note for further investigation is the jump in the Social Sciences Index from 1990 to the present years is the doubling of the number of articles mentioning hierarchy. While a change in indexing, or an increase in the sources for the index, are possibilities the actual cause is not known.

Table A1.2 shows the number of abstracts obtained from CD-ROM searches and the keywords or author names used in the searching. These searches were also done using the computer-search reference material at the University of Hull. The abstracts found will be cross-checked against the listings obtained in the BIDS search for any overlap.

**Table A1.2 CD-ROM Searches (various dates as noted in table)**

| CDROM Abstract Disks | Terms Searched | Count |
|---|---|---|
| MLA 1981-1992 | Hierarchy | 27 |
| PSCLit Jan 1987-Sept 92 | Hierarchy and Structure | 380 |
| Bio and Agri. 7/83-6/92 | hierarchy, emergence, scale, troncale, allen, salthe | 0 |
| App. Sci + Tech 10/83-7/92 | hierarchy, emergence, scale, structure | 0 |
| Philosopher's Index 1940-9/92 | hierarchy | 716 |
| | emergence | 570 |
| | scale | 248 |
| ABI Inform | | |
| Jan 89-Sep 92 | hierarchy | 1549 |
| Jan 87-Dec 89 | hierarchy | 1117 |
| Hilites 1986-1991 | hierarchy | 588 |
| App. Soc. Sci. Index 1986/1992 | hierarchy | 100 |
| TOTALS | | 5295 |

## 2002 searches

Since previous searches became dated during the process of the thesis research process, a second set of searches was carried out using two internet interfaces in 2002. These searches collected a different set of data that are reported in table A1.3.

**Table A1.3 BIDS and ISI Searches (various dates as noted in table)**

| Internet Source | Terms Searched | Count |
|---|---|---|
| Web of Science Science Citations (1981-2002) | Hierarch* | 30,876 |
| | Hierarch* & complex* | 16 |
| | Hierarch* and level* | 516 |
| Web of Science Social Science Citations (1981-2002) | Hierarch* | 10,446 |
| | Hierarch* and level* | 178 |
| Web of Science Arts and Humanaties (1981-2002) | Hierarch* and level* | 6 |
| Web of Science Citations Search (1981-2002) | Boulding | 14 |
| | Hierarchy theory | 84 |
| | Skeleton of science | 0 |
| BIDS Intl Bibliography of the Social Sciences (1951 to 2002) | Hierarch* | 2143 |

# Appendix 2: The ID-ID Questionnaire

NAME:
FIELD(S):
ADDRESS:
PHONE:

**PART I: YOUR WORK**

Q.1
THERE IS A NEED TO CLARIFY DEFINITIONS. ARE WE TALKING ABOUT ONE THING OR MANY? CAN WE ABSTRACT THE CONCEPT OF HIERARCHY ENOUGH TO RENDER IT ONE PHENOMENON CAPABLE OF COMPARISON? MORE PRECISELY, WHAT DO YOU MEAN BY THE TERM? GIVE SEVERAL CRITERIA OR CHARACTERISTICS THAT HELP YOU TO RECOGNIZE HIERARCHY IN YOUR DISCIPLINE.

Q.2
SPECIFY THE HIERARCHIES YOU HAVE FOUND, DEMONSTRATED, OR ARE STUDYING IN YOUR DISCIPLINE.

Q.3
WHAT ORDER OF MAGNITUDE OF MEASUREMENT OR QUALITIES DESCRIBE THE LIMITS OF THE HIERARCHIES YOU STUDY? (For example, human levels of biological organization with masses from 2 x 10(-22) Kg to 4 Kg, or one might use size ranges, or energies, or several of these).

Q.4
WHAT DO YOU BELIEVE TO BE YOUR MOST SIGNIFICANT RESULTS TO DATE?

Q.5
TRY TO DESCRIBE THE METHOD OR TECHNIQUES THAT YOU USE TO STUDY YOUR PROPOSED HIERARCHIES IN TERMS THAT WOULD BE UNDERSTOOD BY A DISCIPLINE QUITE DISTANT FROM YOUR OWN?

Q.6
SPECULATE ON WHAT PORTIONS OF YOUR METHODS MIGHT BE APPLICABLE TO THE DISCIPLINES BORDERING ON YOUR OWN? QUITE DISTANT FROM YOUR OWN?

Q.7
NAME THE BEST APPLICATIONS TO DATE OF YOUR OR ALLIED WORK ON HIERARCHIES? (state none, if none, and what you think are the reasons).

Q.8
DESCRIBE ANY NEGATIVE RESULTS YOU HAVE OBTAINED THAT SHOW HIERARCHICAL STRUCTURE IS NOT PRESENT, OR IS LESS OPTIMAL THAN ALTERNATIVE STRUCTURES. (Are you aware of any work outside of your own that has produced negative results -- what other type of negative results can you imagine?)

**PART II: COMPARISONS AND INTEGRATION**

Q.9
WHAT DO YOU FEEL ARE THE MOST SIGNIFICANT (KEY, CRITICAL) QUESTIONS THAT THIS GROUP COULD INVESTIGATE ON HIERARCHY THEORY REMEMBERING THAT OUR PURPOSE IS CROSS-DISCIPLINARY AS WELL AS DISCIPLINARY RESEARCH?

Q.10
WHAT CONNECTIONS, CORRESPONDENCE PRINCIPLES, OR LINKAGES, WOULD YOU LIKE TO PROPOSE EXIST BETWEEN THE HIERARCHIES YOU STUDY AND OTHER HIERARCHIES (specify which hierarchies if possible)? I.E. WHAT PATTERNS/PROCESSES IN YOUR HIERARCHY EXIST IN OTHERS?

Q.11
DESCRIBE THE LIMITS OF A PARTICULAR FEATURE OF HIERARCHIES, OR THE LIMITS OF APPLICATION OF AN IDEA RELATIVE TO THE RANGE OF SCALES OF SIZE (OR OTHER PARAMETERS) FOUND ACROSS DISCIPLINARY HIERARCHIES TO WHICH THE IDEA STILL APPLIES?

Q.12
WHAT OBSTACLES TO SUCCESSFUL COMPARISONS ACROSS HIERARCHIES DO YOU FEEL ARISE FROM THE METHODS WE USE IN OUR INDIVIDUAL DISCIPLINES TO STUDY OUR LOCAL HIERARCHIES? DO YOU SEE ANY WAY TO OVERCOME THESE OBSTACLES?

**PART III: OUR PROCESS**

Q.13
NAME THREE KEY REFERENCES THAT EVERYONE STUDYING HIERARCHIES SHOULD READ. (This will serve as our common ground, if read).

Q.14
A. CONSIDERING YOUR DISCIPLINARY, AND OUR TRANSDISCIPLINARY
RESEARCH PROJECTS ON HIERARCHY, WHICH JOURNALS DO YOU FEEL...

Should we read (for their occasional articles on hierarchies):

Should we monitor (for occasional pertinent data or ideas):

Should we publish in (creating a critical mass of articles):

B. WHO IS NOT PART OF OUR GROUP BUT SHOULD BE?

DID FILLING OUT THIS FIRST CYCLE HELP YOU...

1. CLARIFY YOUR OWN IDEAS ABOUT HIERARCHY RESEARCH?
   Y N
2. HELP YOU VISUALIZE A BIT MORE HOW COMPARISONS MIGHT BE DEMONSTRATED ACROSS DISCIPLINARY BOUNDARIES?
   Y N

SUGGEST NEW QUESTIONS FOR THE NEXT CYCLE OF IDID. (What wasn't asked that you wanted asked; what questions would promote deep analysis of our individual work for promoting comparative work?)

## Appendix 3: Hierarchy Glossary
### (edited from Allen and Starr, 1982)

Adaptation: (a) The process whereby a biological system responds to its environment so as to accommodate to the constraints of the environment and to take greater advantage of the environmental circumstances. (b) A characteristic which has adaptive significance.

Adaptive significance: The meaning and helpfulness for the possessor of a given character. Adaptive significance is recognized by observers.

Altruistic: Defines behavior which is against the interests of the individual in favor of the interests of the group.

Amplitude: The maximum departure of an oscillatory motion from its time-average value.

Artificial surfaces: Boundaries imposed arbitrarily, even capriciously, and according to only a few criteria. Not robust under transformation, readily disappearing when viewed in an alternative fashion. They occur at relatively shallow regions on inter-action density gradients.

Autocorrelation: A statistical measure of the strength of association which exists between pairs of values of a time series as a function of the time interval which seperates them.

Biome: A high level in the ecological classification of associations between organisms; biomes are generally characterized by the physiognomy of the vegetation, e.g. deserts of deciduous forests.

Bond strength: The cohesiveness of entity as measured by the energy required to separate its parts.

Boundary: A distinction made by an observer. Artificial boundaries are drawn arbitrarily and haphazardly. Natural boundaries are still arbitrary but tend to be robust under transformation. That is, natural boundaries coincide for many distinct criteria.

Boundary conditions: A set of supplementary constraints that the solutions of differential equations must satisfy at all times.

Buffer compartment: A part of a system which acts as a reservoir for incoming energy, matter or information such that the input enters the rest of the system with smoothed and averaged characteristics. E.g. a bathtub with a constant or slowly carying outflow which represents the average of a highly variable input to the tub from a tap which is intermittently turned off and on.

Carrying capacity: (K) Refers to the largest number of a given type of consumer (maximum state of a consumer compartment) that may be maintained by a given resource.

Catastrophe theory: A theoretical construct used for the description of certain types of disjunct behavior. It derives from a topological consideration of folded surfaces describing the interactions between variables. Catastrophe theory is rather specific in its appropriate application, although it serves a more general usefulness as a mathematical metaphor.

Cluster Analysis: A series of techniques of data reduction where either species, samples or environmental factors are grouped together in classes according to some criterion of similarity. Most methods allow a graphic representation which shows the successive divisions that lead to, or aggregations that lead from, the final set of classes.

Collapse: A catastrophic change in a system which becomes, initially at least, overexcited such that some of the parts overstep the constraints of system rules. Characteristic of overconnected systems.

Communication: A transfer of meaning from one entity to another through a double scaling operation, once at signal transmission and once at signal reception. The double scaling may change the meaning between the transmitter and the receiver.

Competitive exclusion principle: The principle states that species with identical envionmental requirements cannot coexist indefinitely. The principle is of limited utility in that the definition "identical environmental requirements" may lead to a circular argument.

Complementarity: The principle that indicates that unified models will be necessarily contradictory. Deriving from the observed-observer duality, the principle demands a rate-independent description and a rate-dependent description. The rate independent description is associated with observer-independdt aspects of the phenomenon. Better definitions and explanations in one complement are gained by confounding or compromising the other complement. Neither complement is sufficient, but both complements are necessary for a full account of phenomena.

Complex character: A character whose phenotypic expression is the result of the interaction of several genes identified as seperate. E.g. the paricular form of the pattern on a butterfly.

Connectance: A measure of system connectedness based upon the mean number of nonzero interaction terms per compartment of the system under consideration.

Connected component: A component of a system which is involved in at elast one of the main lines of communication in a system.

Connectedness: A general term for the cohesiveness of a system. Systems with strong interaction terms are relatively highly connected, as are systems with a large number of the parts interconnected (as measured by connectivity and connectance)

Connectivity: A measure of the degree of connectedness of a system (Gardner and Ashby 1970). It is usually expressed as a percentage: the percentage of nonzero interaction terms as a percentage of all possible interaction terms, reasonable or otherwise, between the components of a system.

Conspecific cuing: Actions of individuals which are stimulated by the actions of their fellows. This tends to lead to aggregation of individuals; flocking in the extreme case.

Constraint: The control exerted by one holon over another lower in a hierarchy. The constraining holon behaves more slowly than the constrained holon. The constraining holon influences more than it is influenced in the act of constraint.

Continuum: Generally refers to a continous gradient, but specifically when as conceptual view of patterns of variability in vegetation wherein there is compositional continuity along environmental gradients. The environmental gradient may not be geographically continuous and may demand piecing together geographically disjunct representatives of intermediate envionmental conditions. Also seen as causal of the presumed vegetation continuum is the gradual and continuous process of species invasion and population demise.

Creon: The input filter of a holon in the terminology of Patten and Auble (1980)

Degeneration: Occurs when a system has insufficient free energy to maintain the integrity of its rule system. The system undergoes uncontrolled change, which results in a fundamental change in system structure. Characteristic of under connected systems.

Deterministic: Caused by explicit antecedent events.

Dialectical materialism: Hegel (1770-1831) maintained that every proposition (thesis) brings into a discourse its natural opposite (antithesis). These lead to a unified whole (synthesis), which reacts upon the original thesis. This view (the dialectic) was adapted by Marx in his materialist philosophy. The necessity of contraction is central to the doctrine.

Disconnected component: A component which is only part of a system incidentally or is included only because it is defined so. There may be weak interactions between a disconnected component and other components of the system, but these are incidental to what is recognized as the normal functioning of the system and are not involved in the main lines of communication in system functioning.

Diversity: A central concern of ecology for the richness of variety of species found in various ecological locales. Some measures of diversity only count the number of species, but others take into account the degree to which different species enjoy equivalent representation.

Domain of attraction: A region in a state space description of a system in which system behavior is localized indefinitely unless there is a change in system structure or a large exogenous disturbance

Dynamical: Pertaining to the pattern of change of a phenomenon with time.

Emergent properties (a) Properties which emerge as a coarser-grained level of resolution is used by the observer. (b) Properties which are unexpected by the observer because of his incomplete data set, with regard to the phenomenon at hand. (c) Properties which are, in and of themselves, not derivable from the behavior of the parts a priori.

Endogenous: Deriving from within the entity or system.

Endogenous cycle time: The time taken for a system to complete a cycle of charcteristic bahavior, e.g. a single heartbeat or the generation time in an organism.

Entification: The erection and implementation of criteria for the identification of discrete things. The giving of names to concrete or abstract objects is an aspect of entification.

Epistemology: The study of or theory associatied with the nature and limits of knowledge. Concerned only with that which is knowable. Science which does not go beyond the consequences of direct obvservation (Compare ontology)

Equilibrium: A state of a system when all forces for change are balanced. Stable equilibrium points are those where endogenous forces for system functioning lead to a return to the equilibrium point after displacement by forces exogenous to the system. Displacement from an unstable equilibrium point leads only to further displacement.

Exogenous: Deriving from outside the entity or system

Feedback loop: A Chain of causal relationships which closes upon itself. Positive feedback loops are unstable; negative feedback loops are self-correcting.

Filter: A device in theory or practice that takes a signal string which is undefined in terms of scale and converts it by a process of integration into a scaled message. Low frequency characteristics of a signal may be deemphasized by a filter which places greater significance upon high-frequency behavior. Alternatively, high-frequency aspects of the signal may be smoothed and averaged such that they become a less important part of the defined message than they were of the signal. The patterns of integration which are used in a filter may be very exotic and can even be influenced by aspects of the signal as it is encountered.

Fitness: (a) In the dynamical mode of description it refers only to differential re-productive success with no reference to adaptive significance. (b) In the linguistic mode of description fitness is measured by the possession of adaptive characters.

Frequency domain: A mode of discussion where events are not seen as occuring at points in time, but rather according to the frequency of their recurrence. (Compare time domain)

Functional isolation: Separation of an entity from its environment by virtue of its relatively more rapid intrinsic reaction rates. Entities may be functionally isolated while being spatially interdigitated with that which comprises its environment.

General systems theory: A body of theory, first developed by Ludwig von Bertalanffy, concerned with open as opposed to closed, systems. It is associated with, but is more deeply philosophically involved than, cybernetics.

Genon: The output filter of a holon in the terminology of Patten and Auble (1980)

Grain: The size, in time and/or space, of significant entities which are used to define the scale of a holon or an observation.

Heraclitean flux: Heraclitus (6th-5th century B.C) proposed that the only constant is change. Structure is apparent, not ontologically real; change is present even in the most apparently static forms. All is fluid.

Holism: A descriptive and investigative strategy which seeks to find the smallest number of explanatory principles by paying careful attention to the emergent properties of the whole as opposed to the behaviors of the isolated parts chosen by the observer in a reductionist strategy. Both holism and reductionism seek to explain emergent behavior by invoking a lower level of organization.

Holon: The representation of an entity as a two-way window through which the environment influences the parts, through which the parts communicate as a unit to the rest of the universe. Holons have characteristic rates for their behavior, and this places particular holons at certain levels in a hiearachy of holons. What a holon shall contain is determined by the observer.

Integration: A process of smoothing or averaging in which various parts of the signal sting to be integrated may be a given different weights in an averaging or smoothing operation

Integrative tendencies: The characteristics related to the manner in which holons are parts of larger wholes. These characteristics reflect the acceptance by the holon of the constraints placed upon it by more inclusive holons. These aspects of the holon may involve self-sacrifice for the whole of which it is part.

Interaction density gradients: At each point in space there is a certain rate of exchange of information or matter associated with a particular form of signal. At successive points in space there may be a change in the quantity of passing signal. Monotonic change in the amount of signal passing successive points constitutes an interaction density gradient. At surfaces, interaction density gradients are particularly steep.

Irreducible: An aspect of a phenomenon which may not be explained in a more dissected account.

Junction compartment: When two holons on different stems of a hierarchy exchange information, the information must first pass up the hierarchy to a point where the two stems meet. This point is a holon in its own right with lower frequency characteristic behavior than the holons thus connected.

Laws: A set of requirements upon which a system is dependent for its functioning but which are universal, inexorable, structure-independent, and associated with rate-dependent aspects of control.

Level: A section of a hierarchy which is defined by a scale. Many different entities may be observed scaled to a certain level distributed horizontally across a hierarchy. Or, the scale of an observation.

Level of resolution: The grain size of an observation as limited by the finest distinction which can be made given the observation filter. In a broader sense, level of resolution includes consideration of the scope of the investigation which determines the most coarse-grained aspects of the phenomenon that may be recognized.

Low-pass-frequency-filter: A filter which specifically allows the passage of low-frequency patterns in a signal. Note here that we do not mean the inverse, that is, a filter which specifically stops the passage of low frequency aspects of a signal.

Message: A scaled and integrated signal which has significance or meaning for either the transmitter in transmitted messages or the receiver in received messages.

Microlayer: Restricted to our discussion of surfaces. In the vicinity of a surface, it is a layer which possesses particular frequency characteristics determined by its position relative to two homogeneous spaces, one on each side, each side with its own frequency characteristic. A microlayer occurs at a particular point on a scale gradient.

Middle-number system: A system with too many parts for parts to be given individual account, but too few parts for parts to be substituted for by aggregates or averages.

Model: An intellectual construct for organizing experiences. We generally do not extend our use of the word to include models as approximations of ontological reality. We prefer to acknowledge that we do not know what is the relationship of models to ontological reality

Monotonic: A relationship is monotonic when it continuously increases or continuously decreases. At no point does a trend of increase change even momentarily to one of decrease in a monotonic relationship. With respect to its initial conformation, a stretched surface is nonlinear while a wrinkled or folded surface is nonmonotonic.

Natural boundary: See natural surface

Natural frequency: The inverse of the extent in time and space for the completion of a cycle of characteristic endogenously driven behavior of either a holon or a pattern of observation

Natural level: A level identifying entities which are robust under transformation.

Natural surfaces: Discontinuities across natural surfaces may be detected by any of a large number of co-incident criteria for large changes in interaction density.

Near-decomposable: A characteristic of complex phenomena which may be seen to exhibit apparent disjunction when viewed in an appropriate fashion. Near decomposition does not deny ultimate continuity, but rather it pertains to relative interaction intensities across the continuous space of strcutural and functional boundaries.

Nested: A restricted type of hierarchy which has the requirement that upper levels contain lower levels.

Noise: Any aspect of a signal string which is not considered significant. That part of a signal which is not considered to be associated with meaning for the purposes at hand.

Non-nested: A general type of hierarchy which only excludes hierarchies where upper levels contain lower levels.

Observation window: Observation window is determined for a given observation principally by the extent in time and/or space of integration used by the observer as he observes. Since the integration of the signal caught in the window may not be a simple integration, the differential significance given to different parts of the signal within the window also gives some of the character of the observation window in question.

Observer-independent: Referring to the ontologically "real" external world.

Overconnected: A system which has so many connections between its part that it is unstable and is wont to undergo uncontrolled change is described as over-connected. (See collapse)

Paradigm: The intellectual frame implicit in the acceptance and use of a given vocabulary; the frame determines the questions seen to be appropriate in the scientific investigation of a given phenomenon. The paradigm indicates the particular scientific procedure to be followed and encourages a particular interpretation of the results.

Reducible: A phenomenon or property which may be explained and given account in a more finally dissected description.

Reductionism: A descriptive and investigative strategy which gives account of phenomena in terms of a series of isolated parts, coupled together by direct causal linkages. Ambiguity in relationship between parts is met with further subdivision until the ambiguity disappears. (Compare holism)

Region of stability: See domain of attraction

Relaxation time: The time taken for a system to return to its normal (equilibrium) patterns of behavior after a disturbance. Approximately the inverse of the responsiveness of the system.

Resilience: In systems discussion of stability, resilience refers to the ability of a system to maintain its structure and general patterns of behavior when displaced from its equilibrium condition. More resilient systems are those which can return to an equilibrium condition despite large displacement.

Rules: A set of constraints which are local, arbitrary, structure-dependent, and associated with rate-independent aspects of control.

Scalar : Reference here is to Loucks (1962), where environmental gradients for moisture, temperature, and nutrients were synthetically derived using different measures to characterize a given site depending upon the environmental conditions which prevail there. For example, dry sites were characterized and placed upon the moisture scalar according to different criteria than were used to place wet sites.

Scale (noun): The natural frequency of either an observation or a holon.

Scale (verb): Take signal and integrate it so as to produce a message.

Scale gradient: (See also interaction density gradients) The continuum of structures which are seen by an observer who continuously changes the size of his observation window. A disjunction in a scale gradient occurs when very little if any of the substance in the system under investigation is held in configurations with endogenous cycling times which are simply in tune with the observation window in question.

Scope: (See also level of resolution) The breadth of the universe in which an observation of a set of observations is made, or the breadth of a universe of discourse.

Self-assertive tendencies: Characteristics of holons related to their existence as quasi-autonomous wholes. These tendencies are related to the holon's capacity to maintain its integrity. These aspects of holons pertain to the constraint that the holon asserts over its parts.

Signal: A string of strings of energy or matter in transit between a transmitter and a receiver; its meaning is undefined.

Simulation: A model usually implemented through a computer which mimics the behavior found in a phenomenon.

Sister Holon: Two communicating holons which occur at the same level in a hierarchy and do not therefore exert constraint over each other.

Social hierarchy: A pattern of social relationships in animals where some individuals take precedence, with respect to some resource, over other individuals who are lower in the social hierarchy.

Span: The number of entities at the next natural lower level in a hierarchy which report directly to the entity whose span is to be identified.

Stability: There are several definitions involved. (a) Sensu lato, the general display of persistence in both structure and patterns of behavior. Here, resilience is one aspect of stability. (b) Sensu stricto, specifically excludes resilience as part of the definition and refers only to the rapidity with which the equilibrium is re-established when displacement from the equilibrium occurs. Generally systems stable in this sense resist the influence of outside disturbance rather than accommodating the influence once it has had its effect. (c) Structural stability, the capacity of a system to display generally the same emergent behavior despite changes in the inter-relationships between its parts. In the case of an equation, structural stability would be represented by the persistence of general patterns of behavior despite changes in equation parameters.

Stable equilibrium point: See equilibrium.

Stable limit cycle: A persistent pattern of endogenously driven cyclical behavior of a system.

State-determined model: A model whose future states may be ascertained solely from information regarding past states.

State space: A mode of description of system behavior where, at each point in time, the system is described by the position of a point inside a space the dimensions of which are axes relating to the various system attributes expressed as states (as opposed to derivatives)

Structural isolation: A special case of functional isolation involving physical surfaces. Interactions occur rapidly within the systems on either side of the structural boundary, but occur much more slowly across the boundary which connects the two systems.

Structural stability: The capacity of a system to maintain the same essential patterns of behavior despite some modification in the structural interrelationships between system parts. (e.g. a change in the form of system equations). (See also stability)

System: Any interacting, interdependent, or associated group of entities.

Taxon: A level of organization within a taxonomic system. Examples of various taxa are species, genera and families.

Taxonomy: The biological study of the classification of organisms into natural groups.

Thermodynamic: Relating to processes by which various forms of energy, eg heat, work, chemical and electromagnetic energy, are transformed into one another.

Time domain: The mode of discussion where events are seen as occurring at particular points in the passage of time.

Uncertainty principle: In general, any statement which asserts that the act of observation has an effect on the phenomenon being observed. Specifically, the Heisenberg uncertainty principle established the minimum disturbance in the position (momentum) of a quantum-mechanical system introduced by the act of measuring its momentum (position) with a specified accuracy.

Unconnected component: See disconnected component.

Underconnected: this describes a system which is very susceptible to intrusion since there are insufficient connections between the parts for the system to maintain integrity. (See also degeneration)

Unnatural boundary: Artificial surface

Unstable equilibrium point: See equilibrium.

Variable: Any of the characteristics or attributes of a phenomenon which appear to change with time, e.g. biomass, light, $CO2$ concentration, population density.

Virus: A biological structure which consists principally of genetic information for its own replication. A virus lacks the machinery for its own self replication and so must take advantage of the machinery for production found in more complete living forms from bacteria to complex multicellular organisms.

Weighting function: A function which applies differential significance to various parts of a signal string. The parts are determined by their position relative to time zero.

Window: See observation window.

# Appendix 4: A Summary of the Principles of Hierarchy Theory

**Allen, (2003, ISSS website)**

Hierarchies occur in social systems, biological structures, and in the biological taxonomies. Since scholars and laypersons use hierarchy and hierarchical concepts commonly, it would seem reasonable to have a theory of hierarchies. Hierarchy theory uses a relatively small set of principles to keep track of the complex structure and a behavior of systems with multiple levels. A set of definitions and principles follows immediately:

- Hierarchy: in mathematical terms, it is a partially ordered set. In less austere terms, a hierarchy is a collection of parts with ordered asymmetric relationships inside a whole. That is to say, upper levels are above lower levels, and the relationship upwards is asymmetric with the relationships downwards.

- Hierarchical levels: levels are populated by entities whose properties characterize the level in question. A given entity may belong to any number of levels, depending on the criteria used to link levels above and below. For example, an individual human being may be a member of the level i) human, ii) primate, iii) organism or iv) host of a parasite, depending on the relationship of the level in question to those above and below.

- Level of organization: this type of level fits into its hierarchy by virtue of set of definitions that lock the level in question to those above and below. For example, a biological population level is an aggregate of entities from the organism level of organization, but it is only so by definition. There is no particular scale involved in the population level of organization, in that some organisms are larger than some populations, as in the case of skin parasites.

- Level of observation: this type of level fits into its hierarchy by virtue of relative scaling considerations. For example, the host of a skin parasite represents the context for the population of parasites; it is a landscape, even though the host may be seen as belonging to a level of organization, organism, that is lower than the collection of parasites, a population.

- The criterion for observation: when a system is observed, there are two separate considerations. One is the spatiotemporal scale at which the observations are made. The other is the criterion for observation, which defines the system in the foreground away from all the rest in the background. The criterion for observation uses the types of parts and their relationships to each other to characterize the system in the foreground. If criteria for observation are linked together in an asymmetric fashion, then the criteria lead to levels of organization. Otherwise, criteria for observation merely generate isolated classes.

- The ordering of levels: there are several criteria whereby other levels reside above lower levels. These criteria often run in parallel, but sometimes only one or a few of them apply. Upper levels are above lower levels by virtue of: 1) being the context of, 2) offering constraint to, 3) behaving more slowly at a lower frequency than, 4) being populated by entities with greater integrity and higher bond strength than, and 5), containing and being made of - lower levels.

- Nested and non-nested hierarchies: nested hierarchies involve levels which consist of, and contain, lower levels. Non-nested hierarchies are more general in that the requirement of containment of lower levels is relaxed. For example, an army consists of a collection of soldiers and is made up of them. Thus an army is a nested hierarchy. On the other hand, the general at the top of a military command does not consist of his soldiers and so the military command is a non-nested hierarchy with regard to the soldiers in the army. Pecking orders and a food chains are also non-nested hierarchies.

- Duality in hierarchies: the dualism in hierarchies appears to come from a set of complementarities that line up with: observer-observed, process-structure, rate-dependent versus rate-independent, and part-whole. Arthur Koestler in his "Ghost in The Machine" referred to the notion of holon, which means an entity in a hierarchy that is at once a whole and at the same time a part. Thus a holon at once operates as a quasi-autonomous whole that integrates its parts, while working to integrate itself into an upper level purpose or role. The lower level answers the question "How?" and the upper level answers the question, "So what?"

- Constraint versus possibilities: when one looks at a system there are two separate reasons behind what one sees. First, it is not possible to see something if the parts of the system cannot do what is required of them to achieve the arrangement in the whole. These are the limits of physical possibility. The limits of possibility come from lower levels in the hierarchy. The second entirely separate reason for what one sees is to do with what is allowed by the upper level constraints. An example here would be that mammals have five digits. There is no physical reason for mammals having five digits on their hands and feet, because it comes not from physical limits, but from the constraints of having a mammal heritage. Any number of the digits is possible within the physical limits, but in mammals only five digits are allowed by the biological constraints. Constraints come from above, while the limits as to what is possible come from below. The concept of hierarchy becomes confused unless one makes the distinction between limits from below and limits from above. The distinction between mechanisms below and purposes above turn on the issue of constraint versus possibility. Forget the distinction, and biology becomes pointlessly confused, impossibly complicated chemistry, while chemistry becomes unwieldy physics.

- Complexity and self-simplification: Howard Pattee has identified that as a system becomes more elaborately hierarchical its behavior becomes simple. The reason is that, with the emergence of intermediate levels, the lowest level entities become constrained to be far from equilibrium. As a result, the lowest level entities lose degrees of freedom and are held against the upper level constraint to give constant behavior. Deep hierarchical structure indicates elaborate organization, and deep hierarchies are often considered as complex systems by virtue of hierarchical depth.

- Complexity versus complicatedness: a hierarchical structure with a large number of lowest level entities, but with simple organization, offers a low flat hierarchy that is complicated rather than complex. The behavior of structurally complicated systems is behaviorally elaborate and so complicated, whereas the behavior of deep hierarchically complex systems is simple.

- Hierarchy theory is as much as anything a theory of observation. It has been significantly operationalized in ecology, but has been applied relatively infrequently outside that science. There is a negative reaction to hierarchy theory in the social sciences, by virtue of implications of rigid autocratic systems or authority. When applied in a more general fashion, even liberal and non-authoritarian systems can be described effectively in hierarchical terms. There is a politically correct set of labels that avoid the word hierarchy, but they unnecessarily introduce jargon into a field that has enough special vocabulary as it is.

## Appendix 5: WHO International Health Regulations 1996 and 2005, and CDC's Global Infectious Disease Strategy, 2002.

# INTERNATIONAL HEALTH REGULATIONS (1969)

adopted by the Twenty-second World Health Assembly in 1969 and
amended by the Twenty-sixth World Health Assembly in 1973
and the Thirty-fourth World Health Assembly in 1981

THIRD ANNOTATED EDITION

## WORLD HEALTH ORGANIZATION
## GENEVA
## 1983

Third annotated edition 1983
Updated and reprinted 1992, 1995

ISBN 92 4 158007 0







PRINTED IN ENGLAND

82/5447 — 91/9116 — 12500

95/10506 Clays - 3000

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## FOREWORD

The International Health Regulations adopted by the Twenty-second World Health Assembly on 25 July 1969[1] represent a revised and consolidated version of the previous International Sanitary Regulations.

The purpose of the International Health Regulations is to ensure the maximum security against the international spread of diseases with a minimum interference with world traffic. Following the increasing emphasis on epidemiological surveillance for communicable disease recognition and control, the new Regulations are intended to strengthen the use of epidemiological principles as applied internationally, to detect, reduce or eliminate the sources from which infection spreads, to improve sanitation in and around ports and airports, to prevent the dissemination of vectors and, in general, to encourage epidemiological activities on the national level so that there is little risk of outside infection establishing itself.

The Twenty-sixth World Health Assembly in 1973[2] amended the Regulations, particularly as regards the provisions for cholera. The Thirty-fourth World Health Assembly in 1981[3] amended the Regulations in order to exclude smallpox, in view of its global eradication.

This volume contains the text of the International Health Regulations in force as of 1 January 1982, together with interpretations and recommendations made by the Twenty-second and subsequent World Health Assemblies, as well as those made by the Committee on International Surveillance of Communicable Diseases (formerly the Committee on International Quarantine), in accordance with its duty "to submit recommendations on practice, methods and procedure relating to international surveillance of communicable diseases",[4] and approved by the World Health Assembly.[5]

This volume also contains the text of reservations made to the Regulations and other information annexes.

Important current notifications received by the Organization under the Regulations are made available on the automatic telex reply services[6] and published in its Weekly Epidemiological Record together with all other notifications and information concerning the application of the Regulations.



## Discontinuation of vaccination against smallpox

On 8 May 1980, the Thirty-third World Health Assembly accepted the finding of the Global Commission for the Certification of Smallpox Eradication that smallpox had been eradicated throughout the world. It also endorsed the Commission's recommendations with respect to post-eradication policy and urged Member States to give immediate effect to the recommendations that international certificates of vaccination against smallpox should no longer be required of any traveller and that smallpox vaccination should be discontinued in every country except for investigators at special risk (resolution WHA33.4).

All countries throughout the world then rapidly ceased requiring international certificates of vaccination against smallpox from travellers. But some embassies and consulates, as well as travel agencies, apparently unaware that such certificates can no longer be required of travellers, went on as in the past giving the same, now erroneous, information to travellers. In March 1982 WHO was therefore requested, by the Committee on Orthopoxvirus Infections, set up to advise it on the implementation of the policy for the post-eradication era, to make more widely known the fact that international certificates of vaccination against smallpox are no longer required.

With regard to the discontinuation of routine vaccination, almost all the Member States of WHO had officially discontinued compulsory vaccination by 1982.

At the above-mentioned meeting the Committee, referring to the fact that the complications of smallpox vaccination can be extremely serious and sometimes fatal, also emphasized that there is now no justification for vaccinating anyone except investigators whose work in orthopoxvirus research places them at special risk and persons involved in smallpox vaccine production. The Committee at the same time placed on record the view that unnecessary vaccination may be regarded as medical malpractice.

# INTERNATIONAL HEALTH REGULATIONS (1969)

## PART I - DEFINITIONS

*Article 1*

For the purposes of these Regulations—

"*Aedes aegypti index*"[7] means the ratio, expressed as a percentage, between the number of houses in a limited well-defined area on the premises of which actual breeding-places of *Aedes aegypti* are found, and the total number of houses examined in that area;

"*aerosol dispenser*" means a dispenser holding a pressurized formulation which produces an insecticidal aerosol when the valve is opened;

"*aircraft*" means an aircraft making an international voyage;

"*airport*" means any airport designated by the Member State in whose territory it is situated as an airport of entry and departure for international air traffic, where the formalities incident to customs, immigration, public health,[8] animal and plant quarantine and similar procedures are carried out;

"*arrival*" of a ship, an aircraft, a train, or a road vehicle means—

(a) in the case of a seagoing vessel, arrival at a port;

(b) in the case of an aircraft, arrival at an airport;

(c) in the case of an inland navigation vessel, arrival either at a port or at a frontier post, as geographical conditions and treaties or arrangements among the States concerned, under Article 85 or under the laws and regulations in force in the territory of entry, may determine;

(d) in the case of a train or road vehicle, arrival at a frontier post;



"*baggage*" means the personal effects of a traveller or of a member of the crew;

"*container (freight container)*"[9] means an article of transport equipment—

(a) of a permanent character and accordingly strong enough to be suitable for repeated use;

(b) specially designed to facilitate the carriage of goods, by one or more modes of transport, without intermediate reloading;

(c) fitted with devices permitting its ready handling, particularly its transfer from one mode of transport to another;

(d) so designed as to be easy to fill and empty.

The term "*container (freight container)*" does not include vehicles or conventional packing;

"*crew*" means the personnel of a ship, an aircraft, a train, a road vehicle or other means of transport who are employed for duties on board;

"*day*" means an interval of twenty-four hours;

"*direct transit area*"[10] means a special area established in connexion with an airport, approved by the health authority concerned and under its direct supervision, for accommodating direct transit traffic and, in particular, for accommodating, in segregation, passengers and crews breaking their air voyage without leaving the airport;

"*Director-General*" means the Director-General of the Organization;

"*diseases subject to the Regulations*" (quarantinable diseases) means cholera, including cholera due to the *eltor* vibrio, plague, and yellow fever;

"*disinsecting*" means the operation in which measures are taken to kill the insect vectors of human disease present in ships, aircraft, trains, road vehicles, other means of transport, and containers;

"*epidemic*" means an extension of a disease subject to the Regulations by a multiplication of cases in an area;

"*free pratique*" means permission for a ship to enter a port, disembark and commence operation, or for an aircraft, after landing, to disembark and commence operation;

"*health administration*" means the governmental authority responsible over the whole of a territory to which these Regulations apply for the implementation of the health measures provided herein;

"*health authority*" means the authority immediately responsible in its jurisdiction for the appropriate health measures permitted or prescribed by these Regulations;

"*imported case*" means an infected person arriving on an international voyage;

"*infected area*"[11] is defined on epidemiological principles by the health administration reporting the disease in its country and need not correspond to administrative boundaries. It is that part of its territory which, because of population characteristics, density and mobility and/or vector and animal reservoir potential, could support transmission of the reported disease;

"*infected person*" means a person who is suffering from a disease subject to the Regulations or who is subsequently shown to have been incubating such a disease;

"*in flight*" means the time elapsing between the closing of the doors of the aircraft before take-off and their opening on arrival;

"*in quarantine*" means that state or condition during which measures are applied by a health authority to a ship, an aircraft, a train, road vehicle, other means of transport or container, to prevent the spread of disease, reservoirs of disease or vectors of disease from the object of quarantine;

"*international voyage*" means—
*(a)* in the case of a ship or an aircraft, a voyage between ports or airports in the territories of more than one State, or a voyage between ports or airports in the territory or territories of the same State if the ship or aircraft has relations with the territory of any other State on its voyage but only as regards those relations;
(b) in the case of a person, a voyage involving entry into the territory of a State other than the territory of the State in which that person commences his voyage;

"*isolation*", when applied to a person or group of persons, means the separation of that person or group of persons from other persons, except the health staff on duty, in such a manner as to prevent the spread of infection;

"*medical examination*"[12] includes visit to and inspection of a ship, an aircraft, a train, road vehicle, other means of transport, and container, and the preliminary examination of persons, including scrutiny of vaccination certificates, but does not include the periodical inspection of a ship to ascertain the need for deratting;

"*Organization*"means the World Health Organization;

"*port*" means a seaport or an inland port;

"*ship*" means a seagoing or an inland navigation vessel making an international voyage;

"*suspect*" means a person who is considered by the health authority as having been exposed to infection by a disease subject to the Regulations and is considered capable of spreading that disease;

"*transferred case*" means an infected person whose infection originated in another area under the jurisdiction of the same health administration;

"*valid certificate*", when applied to vaccination, means a certificate conforming with the rules and the model laid down in Appendix 2.



# PART II - NOTIFICATIONS AND EPIDEMIOLOGICAL INFORMATION

## *Article 2*

For the application of these Regulations, each State recognizes the right of the Organization to communicate directly with the health administration of its territory or territories. Any notification or information sent by the Organization to the health administration shall be considered as having been sent to the State, and any notification or information sent by the health administration to the Organization shall be considered as having been sent by the State.

## *Article 3*[13]

1. Each health administration shall notify the Organization by telegram or telex within twenty-four hours of its being informed that the first case of a disease subject to the Regulations, that is neither an imported case nor a transferred case, has occurred in its territory, and, within the subsequent twenty-four hours, notify the infected area.

2. In addition each health administration will notify the Organization by telegram or telex within twenty-four hours of its being informed:
(a) that one or more cases of a disease subject to the Regulations has been imported or transferred into a non-infected area—the notification to include all information available on the origin of infection;
(b) that a ship or aircraft has arrived with one or more cases of a disease subject to the Regulations on board—the notification to include the name of the ship or the flight number of the aircraft, its previous and subsequent ports of call, and the health measures, if any, taken with respect to the ship or aircraft.

3. The existence of the disease so notified on the establishment of a reasonably certain clinical diagnosis shall be confirmed as soon as possible by laboratory methods, as far as resources permit, and the result shall be sent immediately to the Organization by telegram or telex.

*Reservations*—Egypt, India, Pakistan
(for text, see Annex II, page 53).

## *Article 4*[14]

1. Each health administration shall notify the Organization immediately of evidence of the presence of the virus of yellow fever, including the virus found in mosquitos or in vertebrates other than man, or the plague bacillus, in any part of its territory, and shall report the extent of the area involved.
2. Health administrations, when making a notification of rodent plague, shall distinguish wild rodent plague from domestic rodent plague and, in the case of the former, describe the epidemiological circumstances and the area involved.

*Reservations*—Egypt, India, Pakistan
(for text, see Annex 11, page 53).

### *Article 5*

Any notification required under paragraph 1 of Article 3 shall be promptly supplemented by information as to the source and type of the disease, the number of cases and deaths, the conditions affecting the spread of the disease, and the prophylactic measures taken.

### *Article 6*

1. During an epidemic the notifications and information required under Article 3 and Article 5 shall be followed by subsequent communications sent at regular intervals to the Organization.
2. These communications shall be as frequent and as detailed as possible. The number of cases and deaths shall be communicated at least once a week. The precautions taken to prevent the spread of the disease, in particular the measures which are being applied to prevent the spread of the disease to other territories by ships, aircraft, trains, road vehicles, other means of transport, and containers leaving the infected area, shall be stated. In the case of plague, the measures taken against rodents shall be specified. In the case of the diseases subject to the Regulations which are transmitted by insect vectors, the measures taken against such vectors shall also be specified.

### *Article 7*[15]

1. The health administration for a territory in which an infected area has been defined and notified shall notify the Organization when that area is free from infection.

2. An infected area may be considered as free from infection when all measures of prophylaxis have been taken and maintained to prevent the recurrence of the disease or its spread to other areas, and when:
(a) in the case of plague or cholera, a period of time equal to at least twice the incubation period of the disease, as hereinafter provided, has elapsed since the last case identified has died, recovered or been isolated, and there is no epidemiological evidence of spread of that disease to any contiguous area;
(b) (i) in the case of yellow fever not transmitted by *Aedes aegypti*, three months have elapsed without evidence of activity of the yellow-fever virus;
(ii) in the case of yellow fever transmitted by *Aedes aegypti*, three months have elapsed since the occurrence of the last human case, or one month since that occurrence if the *Aedes aegypti* index has been continuously maintained below one per cent;
(c) (i) in the case of plague in domestic rodents, one month has elapsed since the last infected animal was found or trapped;
(ii) in the case of plague in wild rodents, three months have elapsed without evidence of the disease in sufficient proximity to ports and airports to be a



threat to international traffic.

*Reservations*—India, Pakistan (for text, see Annex II, pages 53 and 54).

### *Article 8*[16]

1. Each health administration shall notify the Organization of:
(a) the measures which it has decided to apply to arrivals from an infected area and the withdrawal of any such measures, indicating the date of application or withdrawal;
(b) any change in its requirements as to vaccination for any international voyage

2. Any such notification shall be sent by telegram or telex, and whenever possible in advance of any such change or of the application or withdrawal of any such measure.

3. Each health administration shall send to the Organization once a year, at a date to be fixed by the Organization, a recapitulation of its requirements as to vaccination for any international voyage.

4. Each health administration shall take steps to inform prospective travellers, through the co-operation of, as appropriate, travel agencies, shipping firms, aircraft operators or by other means, of its requirements and of any modifications thereto.

### *Article 9*

In addition to the notifications and information required under Articles 3 to 8 inclusive, each health administration shall send to the Organization weekly:
(a) a report by telegram or telex of the number of cases of the diseases subject to the Regulations and deaths therefrom during the previous week in each of its towns and cities adjacent to a port or an airport, including any imported or transferred cases;
(b) a report by airmail of the absence of such cases during the periods referred to in subparagraphs (a), (b) and (c) of paragraph 2 of Article 7.

### *Article 10*

Any notification and information required under Articles 3 to 9 inclusive shall also be sent by the health administration, on request, to any diplomatic mission or consulate established in the territory for which it is responsible.

### *Article 11*[17]

1. The Organization shall send to all health administrations, as soon as possible and by the means appropriate to the circumstances, all epidemiological and other information which it has received under Articles 3 to 8 inclusive and paragraph (a) of Article 9 as well as information as to the absence of any returns required by Article 9. Communications of an urgent nature shall be sent by telegram, telex or telephone.

2. Any additional epidemiological data and other information available to the Organization through its surveillance programme shall be made available, when appropriate, to all health administrations.

3. The Organization may, with the consent of the government concerned, investigate an outbreak of a disease subject to the Regulations which constitutes a serious threat to neighbouring countries or to international health. Such investigation shall be directed to assist governments to organize appropriate control measures and may include on-the-spot studies by a team.

### *Article 12*

Any telegram or telex sent, or telephone call made, for the purposes of Articles 3 to 8 inclusive and Article 11 shall be given the priority appropriate to the circumstances; in any case of exceptional urgency, where there is risk of the spread of a disease subject to the Regulations, the priority shall be the highest available under international telecommunication agreements.

### *Article 13*[18]

1. Each State shall forward annually to the Organization, in accordance with Article 62 of the Constitution of the Organization, information concerning the occurrence of any case of a disease subject to the Regulations due to or carried by international traffic, as well as on the action taken under these Regulations or bearing upon their application.

2. The Organization shall, on the basis of the information required by paragraph 1 of this Article, of the notifications and reports required by these Regulations, and of any other official information, prepare an annual report on the functioning of these Regulations and on their effect on international traffic.

3. The Organization shall review the epidemiological trends of the diseases subject to the Regulations, and shall publish such data, not less than once a year, illustrated with maps showing infected and free areas of the world, and any other relevant information obtained from the surveillance programme of the Organization.



## PART III - HEALTH ORGANIZATION

### *Article 14*[19]

1. Each health administration shall ensure that ports and airports in its territory shall have at their disposal an organization and equipment adequate for the application of the measures provided for in these Regulations.

2. Every port and airport shall be provided with pure drinking-water and wholesome food supplied from sources approved by the health administration for public use and consumption on the premises or on board ships or aircraft. The drinking-water and food shall be stored and handled in such a manner as to ensure their protection against contamination. The health authority shall conduct periodic inspections of equipment, installations and premises, and shall collect samples of water and food for laboratory examinations to verify the observance of this Article. For this purpose and for other sanitary measures, the principles and recommendations set forth in the guides on these subjects published by the Organization shall be applied as far as practicable in fulfilling the requirements of these Regulations.

3. Every port and airport shall also be provided with an effective system for the removal and safe disposal of excrement, refuse, waste water, condemned food, and other matter dangerous to health.

### *Article 15*

There shall be available to as many of the ports and airports in a territory as practicable an organized medical and health service with adequate staff, equipment and premises, and in particular facilities for the prompt isolation and care of infected persons, for disinfection, disinsecting and deratting, for bacteriological investigation, for the collection and examination of rodents for plague infection, for collection of water and food samples and their dispatch to a laboratory for examination, and for other appropriate measures provided for by these Regulations.

### *Article 16*

The health authority for each port and airport shall:

(a) take all practicable measures to keep port and airport installations free of rodents;

(b) make every effort to extend rat-proofing to the port and airport installations.

### *Article 17*

1. Each health administration shall ensure that a sufficient number of ports in its territory shall have at their disposal adequate personnel competent to inspect ships for the issue of the Deratting Exemption Certificates referred to in Article 53, and the

health administration shall approve such ports for that purpose.

2. The health administration shall designate a number of these approved ports, depending upon the volume and incidence of its international traffic, as having at their disposal the equipment and personnel necessary to derat ships for the issue of the Deratting Certificates referred to in Article 53.

3. Each health administration which so designates ports shall ensure that Deratting Certificates and Deratting Exemption Certificates are issued in accordance with the requirements of the Regulations.

### *Article 18*

1. Depending upon the volume of its international traffic, each health administration shall designate as sanitary airports a number of the airports in its territory, provided they meet the conditions laid down in paragraph 2 of this Article, and the provisions of Article 14.

2. Every sanitary airport shall have at its disposal:
   *(a)* an organized medical service and adequate staff, equipment and premises;
   *(b)* facilities for the transport, isolation, and care of infected persons or suspects;
   (c) facilities for efficient disinfection and disinsecting, for the control of vectors and rodents, and for any other appropriate measure provided for by these Regulations;
   *(d)* a bacteriological laboratory, or facilities for dispatching suspected material to such a laboratory;
   *(e)* facilities within the airport or available to it for vaccination against yellow fever.

### *Article 19*

1. Every port and the area within the perimeter of every airport shall be kept free from *Aedes aegypti* in its immature and adult stages and the mosquito vectors of malaria and other diseases of epidemiological significance in international traffic. For this purpose active anti-mosquito measures shall be maintained within a protective area extending for a distance of at least 400 metres around the perimeter.

2. Within a direct transit area provided at any airport situated in or adjacent to an area where the vectors referred to in paragraph 1 of this Article exist, any building used as accommodation for persons or animals shall be kept mosquito-proof.

3. For the purposes of this Article, the perimeter of an airport means a line enclosing the area containing the airport buildings and any land or water used or intended to be used for the parking of aircraft.

4. Each health administration shall furnish data to the Organization once a year on the extent to which its ports and airports are kept free from vectors of epidemiological significance in international traffic.



### *Article 20*[20]

1. Each health administration shall send to the Organization a list of the ports in its territory approved under Article 17 for the issue of:
   (i) Deratting Exemption Certificates only and
   (ii) Deratting Certificates and Deratting Exemption Certificates.

2. The health administration shall notify the Organization of any change which may occur from time to time in the list required by paragraph 1 of this Article.

3. The Organization shall send promptly to all health administrations the information received in accordance with this Article.

### *Article 21*

1. The Organization shall, at the request of the health administration concerned, arrange to certify, after any appropriate investigation, that a sanitary airport in its territory fulfils the conditions required by the Regulations.

2. The Organization shall, at the request of the health administration concerned, and after appropriate investigation, certify that a direct transit area at an airport in a yellow-fever infected area in its territory fulfils the conditions required by the Regulations.

3. These certifications shall be subject to periodic review by the Organization, in co-operation with the health administration concerned, to ensure that the required conditions are fulfilled.

### *Article 22*

1. Wherever the volume of international traffic is sufficiently important and whenever epidemiological conditions so require, facilities for the application of the measures provided for in these Regulations shall be made available at frontier posts on railway lines, on roads and, where sanitary control over inland navigation is carried out at the frontier, on inland waterways.

2. Each health administration shall notify the Organization when and where such facilities are provided.

3. The Organization shall send promptly to all health administrations the information received in accordance with this Article.

# PART IV - HEALTH MEASURES AND PROCEDURE

## Chapter I—General Provisions

*Article 23*

The health measures permitted by these Regulations are the maximum measures applicable to international traffic, which a State may require for the protection of its territory against the diseases subject to the Regulations.

*Article 24*[21][21]

Health measures shall be initiated forthwith, completed without delay, and applied without discrimination.

*Article 25*

1. Disinfection, disinsecting, deratting, and other sanitary operations shall be carried out so as:

(a) not to cause undue discomfort to any person, or injury to his health;

(b) not to produce any deleterious effect on the structure of a ship, an aircraft, or a vehicle, or on its operating equipment;

(c) to avoid all risk of fire.

2. In carrying out such operations on cargo, goods, baggage, containers and other articles, every precaution shall be taken to avoid any damage.

3. Where there are procedures or methods recommended by the Organization they should be employed.

*Article 26*[22][22]

1. A health authority shall, when so requested, issue free of charge to the carrier a certificate specifying the measures applied to a ship, aircraft, train, road vehicle, other means of transport, or container, the parts thereof treated, the methods employed, and the reasons why the measures have been applied. In the case of an aircraft this information shall, on request, be entered instead in the Health Part of the Aircraft General Declaration.

2. Similarly, a health authority shall, when so requested, issue free of charge:

(a) to any traveller a certificate specifying the date of his arrival or departure and the measures applied to him and his baggage;



(b) to the consignor, the consignee, and the carrier, or their respective agents, a certificate specifying the measures applied to any goods.

*Article 27*[23],[24]3

1. A person under surveillance shall not be isolated and shall be permitted to move about freely. The health authority may require him to report to it, if necessary, at specified intervals during the period of surveillance. Except as limited by the provisions of Article 64, the health authority may also subject such a person to medical investigation and make any inquiries which are necessary for ascertaining his state of health.

2. When a person under surveillance departs for another place, within or without the same territory, he shall inform the health authority, which shall immediately notify the health authority for the place to which the person is proceeding. On arrival the person shall report to that health authority which may apply the measure provided for in paragraph I of this Article.

*Article 28*

Except in case of an emergency constituting a grave danger to public health, a ship or an aircraft, which is not infected or suspected of being infected with a disease subject to the Regulations, shall not on account of any other epidemic disease be refused free pratique by the health authority for a port or an airport; in particular it shall not be prevented from discharging or loading cargo or stores, or taking on fuel or water.

*Article 29*

A health authority may take all practicable measures to control the discharge from any ship of sewage and refuse which might contaminate the waters of a port, river or canal.

## Chapter II—Health Measures on Departure

*Article 30*[25][24]

1. The health authority for a port or an airport or for the area in which a frontier post is situated shall take all practicable measures:
   (a) to prevent the departure of any infected person or suspect;
   (b) to prevent the introduction on board a ship, an aircraft, a train, a road vehicle, other means of transport, or container, of possible agents of infection or vectors of a disease subject to the Regulations.

2. The health authority in an infected area may require a valid vaccination certificate from departing travellers.

3. The health authority referred to in paragraph 1 of this Article may, when it considers it necessary, medically examine any person before his departure on an international voyage. The time and place of this examination shall be arranged to take into account any other formalities, so as to facilitate his departure and to avoid delay.

4. Notwithstanding the provisions of subparagraph (a) of paragraph 1 of this Article, a person on an international voyage who on arrival is placed under surveillance may be allowed to continue his voyage. The health authority shall, in accordance with Article 27, notify by the most expeditious means the health authority for the place to which he is proceeding.



## Chapter III—Health Measures Applicable between Ports or Airports of Departure and Arrival

*Article 31*

No matter capable of causing any epidemic disease shall be thrown or allowed to fall from an aircraft when it is in flight.

*Article 32*

1. No health measure shall be applied by a State to any ship which passes through waters within its jurisdiction without calling at a port or on the coast.

2. If for any reason such a call is made, the laws and regulations in force in the territory may be applied without exceeding, however, the provisions of these Regulations.

*Article 33*

1. No health measure, other than medical examination, shall be applied to a healthy ship, as specified in Part V, which passes through a maritime canal or waterway in the territory of a State on its way to a port in the territory of another State, unless such ship comes from an infected area or has on board any person coming from an infected area, within the incubation period of the disease with which the area is infected.

2. The only measure which may be applied to such a ship coming from such an area or having such a person on board is the stationing on board, if necessary, of a sanitary guard to prevent all unauthorized contact between the ship and the shore, and to supervise the application of Article 29.

3. A health authority shall permit any such ship to take on, under its control, fuel, water and stores.

4. An infected or suspected ship which passes through a maritime canal or waterway may be treated as if it were calling at a port in the same territory.

*Article 34*[26][27]*5*

Notwithstanding any provision to the contrary in these Regulations except Article 69, no health measure, other than medical examination, shall be applied to:
   (a) passengers and crew on board a healthy ship from which they do not disembark;
   (b) passengers and crew from a healthy aircraft who are in transit through a territory and who remain in a direct transit area of an airport of that territory, or, if the airport is not yet provided with such an area, who submit to the measures for segregation prescribed by the health authority in order to prevent the spread of disease; if such persons are

obliged to leave the airport at which they disembark solely in order to continue their voyage from another airport in the vicinity of the first airport, no such measure shall be applied to them if the transfer is made under the control of the health authority or authorities.



## Chapter IV—Health Measures on Arrival

### *Article 35*[28][2][29][6]

Whenever practicable States shall authorize granting of free pratique by radio to a ship or an aircraft when on the basis of information received from it prior to its arrival, the health authority for the intended port or airport of arrival is of the opinion that its arrival will not result in the introduction or spread of a disease subject to the Regulations.

### *Article 36*[30][27]

1. The health authority for a port, an airport, or a frontier station may subject to medical examination on arrival any ship, aircraft, train, road vehicle, other means of transport, or container, as well as any person arriving on an international voyage.

2. The further health measures which may be applied to the ship, aircraft, train, road vehicle, other means of transport, and container shall be determined by the conditions which existed on board during the voyage or which exist at the time of the medical examination, without prejudice, however, to the measures which are permitted by these Regulations to be applied to the ship, aircraft, train, road vehicle, other means of transport, and container if it arrives from an infected area.

3. Where a health administration has special problems which could constitute a grave danger to public health, it may require a person on an international voyage to give on arrival a destination address in writing.

### *Article 37*

The application of the measures provided for in Part V which depend on arrival from an infected area as notified by the health administration concerned shall be limited to the ship, aircraft, train, road vehicle, or other means of transport, person, container or article as the case may be, arriving from such an area, provided that the health authority for the infected area is taking all measures necessary for checking the spread of the disease and is applying the measures provided for in paragraph 1 of Article 30.

### *Article 38*[31][28]

On arrival of a ship, an aircraft, a train, a road vehicle, or other means of transport, an infected person on board may be removed and isolated by the health authority. Such removal by the health authority shall be compulsory if it is required by the person in charge of the means of transport.

### *Article 39*

1. Apart from the provisions of Part V, a health authority may place under

surveillance any suspect on an international voyage arriving by whatever means from an infected area. Such surveillance may be continued until the end of the appropriate period of incubation specified in Part V.

2. Except where specifically provided for in these Regulations, isolation shall not be substituted for surveillance unless the health authority considers the risk of transmission of the infection by the suspect to be exceptionally serious.

### *Article 40*

Any health measure, other than medical examination, which has been applied at a previous port or airport shall not be repeated at a subsequent port or airport, unless:

(a) after the departure of a ship or an aircraft from the port or airport where the measures were applied, an incident of epidemiological significance calling for a further application of any such measure has occurred either in that port or airport or on board the ship or aircraft;

(b) the health authority for the subsequent port or airport has ascertained on the basis of definite evidence that the individual measure so applied was not substantially effective.

### *Article 41*

Subject to Article 73, a ship or an aircraft shall not be prevented for health reasons from calling at any port or airport. If the port or airport is not equipped for applying the health measures which are permitted by these Regulations and which in the opinion of the health authority for the port or airport are required, such ship or aircraft may be ordered to proceed at its own risk to the nearest suitable port or airport convenient to the ship or aircraft.

### *Article 42*

An aircraft shall not be considered as having come from an infected area if it has landed only in such an area at any sanitary airport which is not itself an infected area.

*Reservations*—India, Pakistan (for text, see Annex II, pages 53 and 54).

### *Article 43*

Any person on board a healthy aircraft which has landed in an infected area, and the passengers and crew of which have complied with the conditions laid down in Article 34, shall not be considered as having come from such an area.

*Reservations*—India, Pakistan (for text, see Annex II, pages 53 and 54).

### *Article 44*

1. Except as provided in paragraph 2 of this Article, any ship or aircraft, which is



unwilling to submit to the measures required by the health authority for the port or airport in accordance with these Regulations, shall be allowed to depart forthwith, but it shall not during its voyage call at any other port or airport in the same territory. Such a ship or an aircraft shall nevertheless be permitted, while in quarantine, to take on fuel, water and stores. If, on medical examination, such a ship is found to be healthy, it shall not lose the benefit of Article 33.

2. A ship or an aircraft arriving at a port or an airport situated in an area where the vector of yellow fever is present shall not, in the following circumstances, be allowed to depart and shall be subject to the measures required by the health authority in accordance with these Regulations:

(a) if the aircraft is infected with yellow fever;

(b) if the ship is infected with yellow fever, and *Aedes aegypti* have been found on board, and the medical examination shows that any infected person has not been isolated in good time.

### *Article 45*

1. If, for reasons beyond the control of the pilot in command, an aircraft lands elsewhere than at an airport, or at an airport other than the airport at which the aircraft was due to land, the pilot in command or other person in charge shall make every effort to communicate without delay with the nearest health authority or any other public authority.

2. As soon as the health authority has been informed of the landing it may take such action as is appropriate, but in no case shall it exceed the measures permitted by these Regulations.

3. Subject to paragraph 5 of this Article, and except for the purpose of communicating with any such health or public authority or with the permission of any such authority, no person on board the aircraft shall leave its vicinity and no cargo shall be removed from that vicinity.

4. When any measure required by the health authority has been completed, the aircraft may, so far as health measures are concerned, proceed either to the airport at which it was due to land, or, if for technical reasons it cannot do so, to a conveniently situated airport.

5. The pilot in command or other person in charge may take such emergency measures as may be necessary for the health and safety of passengers and crew.



## Chapter V—Measures concerning the International Transport of Cargo, Goods, Baggage, and Mail

### *Article 46*[32][29]

1. Cargo and goods shall be submitted to the health measures provided for in these Regulations only when coming from infected areas and when the health authority has reason to believe that the cargo and goods may have become contaminated by the agent of a disease subject to the Regulations or may serve as a vehicle for the spread of any such disease.

2. Goods, other than live animals, in transit without transhipment shall not be subject to health measures or detained at any port, airport, or frontier.

3. The issue of a certificate of disinfection of merchandise which is the subject of trade between two countries may be governed by bilateral agreements between the exporting and the importing countries.

### *Article 47*

Except in the case of an infected person or suspect, baggage may be disinfected or disinsected only in the case of a person carrying infectious material or insect vectors of a disease subject to the Regulations.

### *Article 48*

1. Mail, newspapers, books, and other printed matter shall not be subject to any health measure.

2. Postal parcels may be subject to health measures only if they contain:
   (a) any of the foods referred to in Article 63 which the health authority has reason to believe comes from a cholera-infected area;
   (b) linen, wearing apparel, or bedding, which has been used or soiled and to which the provisions of Part V are applicable;
   (c) infectious material; or
   (d) living insects and other animals capable of being a vector of human disease if introduced or established.

### *Article 49*

A health administration shall ensure as far as practicable that containers used in international traffic by rail, road, sea or air shall, in packing, be kept free of infectious material, vectors or rodents.

# PART V - SPECIAL PROVISIONS RELATING TO EACH OF THE DISEASES SUBJECT TO THE REGULATIONS

## Chapter I—Plague

### *Article 50*

For the purposes of these Regulations the incubation period of plague is six days.

### *Article 51*

Vaccination against plague shall not be required as a condition of admission of any person to a territory.

### *Article 52*

1. Each State shall employ all means in its power to diminish the danger from the spread of plague by rodents and their ectoparasites. Its health administration shall keep itself constantly informed by systematic collection and regular examination of rodents and their ectoparasites of the conditions in any area, especially any port or airport, infected or suspected of being infected by rodent plague.

2. During the stay of a ship or an aircraft in a port or an airport infected by plague, special care shall be taken to prevent the introduction of rodents on board.

### *Article 53*[33][30]

1. Every ship shall be either:
   (a) permanently kept in such a condition that it is free of rodents and the plague vector; or
   *(b)* periodically deratted.

2. A Deratting Certificate or a Deratting Exemption Certificate shall be issued only by the health authority for a port approved for that purpose under Article 17. Every such certificate shall be valid for six months, but this period may be extended by one month for a ship proceeding to such a port if the deratting or inspection, as the case may be, would be facilitated by the operations due to take place there.

3. Deratting Certificates and Deratting Exemption Certificates shall conform with the model specified in Appendix 1.



4. If a valid certificate is not produced, the health authority for a port approved under Article 17, after inquiry and inspection, may proceed in the following manner:
   (a) If the port has been designated under paragraph 2 of Article 17, the health authority may derat the ship or cause the deratting to be done under its direction and control. It shall decide in each case the technique which should be employed to secure the extermination of rodents on the ship. Deratting shall be carried out so as to avoid as far as possible damage to the ship and to any cargo and shall not take longer than is absolutely necessary. Wherever possible deratting shall be done when the holds are empty. In the case of a ship in ballast, it shall be done before loading. When deratting has been satisfactorily completed, the health authority shall issue a Deratting Certificate.
   (b) At any port approved under Article 17, the health authority may issue a Deratting Exemption Certificate if it is satisfied that the ship is free of rodents. Such a certificate shall be issued only if the inspection of the ship has been carried out when the holds are empty or when they contain only ballast or other material, unattractive to rodents, of such a nature or so disposed as to make a thorough inspection of the holds possible. A Deratting Exemption Certificate may be issued for an oil tanker with full holds.

5. If the conditions under which a deratting is carried out are such that, in the opinion of the health authority for the port where the operation was performed, a satisfactory result cannot be obtained, the health authority shall make a note to that effect on the existing Deratting Certificate.

### *Article 54*

In exceptional circumstances of an epidemiological nature, when the presence of rodents is suspected on board, an aircraft may be disinsected and deratted

### *Article 55*

Before departure on an international voyage from an area where there is an epidemic of pulmonary plague, every suspect shall be placed in isolation by the health authority for a period of six days reckoned from the date of the last exposure to infection.

### *Article 56*

1. A ship or an aircraft on arrival shall be regarded as infected if:
   (a) It has a case of human plague on board;
   *(b)* a plague-infected rodent is found on board.
   A ship shall also be regarded as infected if a case of human plague has occurred on board more than six days after embarkation.

2. A ship on arrival shall be regarded as suspected if:
   (a) it has no case of human plague on board, but such a case has occurred on board within the first six days after embarkation;
   *(b)* there is evidence of an abnormal mortality among rodents on

board of which the cause is not yet known;
(c) it has a person on board who has been exposed to pulmonary plague and has not met the requirements of Article 55.

3. Even when coming from an infected area or having on board a person coming from an infected area, a ship or an aircraft on arrival shall be regarded as healthy if, on medical examination, the health authority is satisfied that the conditions specified in paragraphs I and 2 of this Article do not exist.

### *Article 57*

1. On arrival of an infected or suspected ship or an infected aircraft, the following measures may be applied by the health authority:
(a) disinsecting of any suspect and surveillance for a period of not more than six days reckoned from the date of arrival;
*(b)* disinsecting and, if necessary, disinfection of:
(i) any baggage of any infected person or suspect; and
(ii) any other article such as used bedding or linen, and any part of the ship or aircraft, which is considered to be contaminated.

2. On arrival of a ship, an aircraft, a train, road vehicle or other means of transport having on board a person suffering from pulmonary plague, or if there has been a case of pulmonary plague on board a ship within the period of six days before its arrival, the health authority may, in addition to the measures required by paragraph I of this Article, place the passengers and crew of the ship, aircraft, train, road vehicle or other means of transport in isolation for a period of six days, reckoned from the date of the last exposure to infection.

3. If there is rodent plague on board a ship, or in its containers, it shall be disinsected and deratted, if necessary in quarantine, in the manner provided for in Article 53 subject to the following provisions:
(a) the deratting shall be carried out as soon as the holds have been emptied;
*(b)* one or more preliminary derattings of a ship with the cargo in *situ*, or during its unloading, may be carried out to prevent the escape of infected rodents;



(c) if the complete destruction of rodents cannot be secured because only part of the cargo is due to be unloaded, a ship shall not be prevented from unloading that part, but the health authority may apply any measures, including placing the ship in quarantine, which it considers necessary to prevent the escape of infected rodents.

4. If a rodent infected with plague is found on board an aircraft, the aircraft shall be disinsected and deratted, if necessary in quarantine.

### *Article 58*

A ship shall cease to be regarded as infected or suspected, or an aircraft shall cease to be regarded as infected, when the measures required by the health authority in accordance with Articles 38 and 57 have been effectively carried out, or when the health authority is satisfied that the abnormal mortality among rodents is not due to plague. The ship or aircraft shall thereupon be given free pratique.

### *Article 59*

On arrival, a healthy ship or aircraft shall be given free pratique, but, if it has come from an infected area, the health authority may:
(a) place under surveillance any suspect who disembarks, for a period of not more than six days, reckoned from the date on which the ship or aircraft left the infected area,
(b) require the destruction of rodents on board a ship and disinsecting in exceptional cases and for well-founded reasons which shall be communicated in writing to the master.

### *Article 60*

If, on arrival of a train or a road vehicle, a case of human plague is discovered, the measures provided for in Article 38 and in paragraphs I and 2 of Article 57 may be applied by the health authority, disinsecting and, if necessary, disinfection being applied to any part of the train or road vehicle which is considered to be contaminated.

## Chapter II—Cholera[34][31]

*Article 61*

For the purposes of these Regulations the incubation period of cholera is five days.

*Article 62*

1. If on arrival of a ship, aircraft, train, road vehicle or other means of transport a case of cholera is discovered, or a case has occurred on board, the health authority (a) may apply surveillance or isolation of suspects among passengers or crew for a period not to exceed five days reckoned from the date of disembarkation; (b) shall be responsible for the supervision of the removal and safe disposal of any water, food (excluding cargo), human dejecta, waste water including bilge water, waste matter, and any other matter which is considered to be contaminated, and shall be responsible for the disinfection of water tanks and food handling equipment.

2. Upon accomplishment of (b) the ship, aircraft, train, road vehicle or other means of transport shall be given free pratique.

*Article 63[35][32]*

Foodstuffs carried as cargo on board ships, aircraft, trains, road vehicles or other means of transport in which a case of cholera has occurred during the journey, may not be subjected to bacteriological examination except by the health authorities of the country of final destination.

*Article 64*

1. No person shall be required to submit to rectal swabbing.

2. A person on an international voyage, who has come from an infected area within the incubation period of cholera and who has symptoms indicative of cholera, may be required to submit to stool examination.



## Chapter III—Yellow Fever

*Article 65*

For the purposes of these Regulations the incubation period of yellow fever is six days

*Article 66*

1. Vaccination against yellow fever may be required of any person leaving an infected area on an international voyage.

2. If such a person is in possession of a certificate of vaccination against yellow fever which is not yet valid, he may nevertheless be permitted to depart, but the provisions of Article 68 may be applied to him on arrival.

3. A person in possession of a valid certificate of vaccination against yellow fever shall not be treated as a suspect, even if he has come from an infected area.

4. The yellow-fever vaccine used must be approved by the Organization, and the vaccinating centre must have been designated by the health administration for the territory in which it is situated. The Organization shall be assured that the vaccines used for this purpose continue to be of suitable quality.

*Article 67[36][33]*

1. Every person employed at a port or an airport situated in an infected area, and every member of the crew of a ship or an aircraft using any such port or airport, shall be in possession of a valid certificate of vaccination against yellow fever.

2. Every aircraft leaving an airport situated in an infected area shall be disinsected in accordance with Article 25, using methods recommended by the Organization, and details of the disinsecting shall be included in the Health Part of the Aircraft General Declaration, unless this part of the Aircraft General Declaration is waived by the health authority of the airport of arrival. States concerned shall accept disinsecting of aircraft by the approved vapour disinsecting system carried out in flight.

3. Every ship leaving a port in an area where *Aedes aegypti* still exists and bound for an area where *Aedes aegypti* has been eradicated shall be kept free of *Aedes aegypti* in its immature and adult stages.

4. An aircraft leaving an airport where *Aedes aegypti* exists and bound for an area where *Aedes aegypti* has been eradicated shall be disinsected in accordance with Article 25, using methods recommended by the Organization.

*Article 68*

A health authority in an area where the vector of yellow fever is present may require a person on an international voyage, who has come from an infected area and is unable to produce a valid certificate of vaccination against yellow fever, to be isolated until his certificate becomes valid, or until a period of not more than six days reckoned from the date of last possible exposure to infection has elapsed, whichever occurs first.

### *Article 69*

1. A person coming from an infected area who is unable to produce a valid certificate of vaccination against yellow fever and who is due to proceed on an international voyage to an airport in an area where the vector of yellow fever is present and at which the means for securing segregation provided for in Article 34 do not yet exist, may, by arrangement between the health administrations for the territories in which the airports concerned are situated, be prevented from proceeding from an airport at which such means are available, during the period provided for in Article 68.

2. The health administrations concerned shall inform the Organization of any such arrangement, and of its termination. The Organization shall immediately send this information to all health administrations.

### *Article 70*[37] 34

1. On arrival, a ship shall be regarded as infected if it has a case of yellow fever on board, or if a case has occurred on board during the voyage. It shall be regarded as suspected if it has left an infected area less than six days before arrival, or, if arriving within thirty days of leaving such an area, the health authority finds *Aedes aegypti* or other vectors of yellow fever on board. Any other ship shall be regarded as healthy.

2. On arrival, an aircraft shall be regarded as infected if it has a case of yellow fever on board. It shall be regarded as suspected if the health authority is not satisfied with a disinsecting carried out in accordance with paragraph 2 of Article 67 and it finds live mosquitos on board the aircraft. Any other aircraft shall be regarded as healthy.

### *Article 71*

1. On arrival of an infected or suspected ship or aircraft, the following measures may be applied by the health authority:

(a) in an area where the vector of yellow fever is present, the measures provided for in Article 68 to any passenger or member of the crew who disembarks and is not in possession of a valid certificate of vaccination against yellow fever;

(b) inspection of the ship or aircraft and destruction of any *Aedes aegypti* or other vectors of yellow fever on board; in an area where the vector of yellow fever is present, the ship may, until such measures have been carried out, be required to keep at least 400 metres from land.



2. The ship or aircraft shall cease to be regarded as infected or suspected when the measures required by the health authority in accordance with Article 38 and with paragraph 1 of this Article have been effectively carried out, and it shall thereupon be given free pratique.

### *Article 72*

On arrival of a healthy ship or aircraft coming from an infected area, the measures provided for in subparagraph (b) of paragraph 1 of Article 71 may be applied. The ship or aircraft shall thereupon be given free pratique.

### *Article 73*

A State shall not prohibit the landing of an aircraft at any sanitary airport in its territory if the measures provided for in paragraph 2 of Article 67 are applied, but, in an area where the vector of yellow fever is present, aircraft coming from an infected area may land only at airports specified by the State for that purpose.

### *Article 74*

On arrival of a train, a road vehicle, or other means of transport in an area where the vector of yellow fever is present, the following measures may be applied by the health authority:

(a) isolation, as provided for in Article 68, of any person coming from an infected area, who is unable to produce a valid certificate of vaccination against yellow fever;

(b) disinsecting of the train, road vehicle or other means of transport if it has come from an infected area.

### *Article 75*

In an area where the vector of yellow fever is present the isolation provided for in Article 38 and in this Chapter shall be in mosquito-proof accommodation.

# PART VI - HEALTH DOCUMENTS

## *Article 76*

Bills of health, with or without consular visa, or any certificate, however designated, concerning health conditions of a port or an airport, shall not be required from any ship or aircraft.

## *Article 77*

1. The master of a seagoing vessel making an international voyage, before arrival at its first port of call in a territory, shall ascertain the state of health on board, and, except when a health administration does not require it, he shall, on arrival, complete and deliver to the health authority for that port a Maritime Declaration of Health which shall be countersigned by the ship's surgeon if one is carried.

2. The master, and the ship's surgeon if one is carried, shall supply any information required by the health authority as to health conditions on board during the voyage.

3. A Maritime Declaration of Health shall conform with the model specified in Appendix 3.

4. A health administration may decide:
(a) either to dispense with the submission of the Maritime Declaration of Health by all arriving ships; or
(b) to require it only if the ship arrives from certain stated areas, or if there is positive information to report.

In either case, the health administration shall inform shipping operators.

## *Article 78*

1. The pilot in command of an aircraft, on landing at the first airport in a territory, or his authorized agent, shall complete and deliver to the health authority for that airport the Health Part of the Aircraft General Declaration which shall conform with the model specified in Appendix 4, except when a health administration does not require it.

2. The pilot in command of an aircraft, or his authorized agent, shall supply any information required by the health authority as to health conditions on board during the voyage.

3. A health administration may decide:
(a) either to dispense with the submission of the Health Part of the Aircraft General Declaration by all arriving aircraft; or



(b) to require it only if the aircraft arrives from certain stated areas, or if there is positive information to report.

In either case, the health administration shall inform aircraft operators.

## *Article 79*[38] 35

1. The certificates specified in Appendices 1 and 2 shall be printed in English and in French. An official language of the territory of issue may be added.

2. The certificates referred to in paragraph 1 of this Article shall be completed in English or in French. Completion in another language in addition is not excluded.

3. International certificates of vaccination must be signed in his own hand by a medical practitioner or other person authorized by the national health administration; his official stamp is not an accepted substitute for his signature.

4. International certificates of vaccination are individual certificates and shall in no circumstances be used collectively. Separate certificates shall be issued for children.

5. No departure shall be made from the model of the certificate specified in Appendix 2, and no photograph shall be included.

6. A parent or guardian shall sign the international certificate of vaccination when the child is unable to write. The signature of an illiterate shall be indicated in the usual manner by his mark and the indication by another that this is the mark of the person concerned.

7. If a vaccinator is of the opinion that vaccination is contraindicated on medical grounds he shall provide the person with reasons, written in English or French, underlying that opinion, which health authorities should take into account.

## *Article 80*

A vaccination document issued by the Armed Forces to an active member of those Forces shall be accepted in lieu of an international certificate in the form shown in Appendix 2 if:
(a) it embodies medical information substantially the same as that required by such form; and
(b) it contains a statement in English or in French recording the nature and date of the vaccination and to the effect that it is issued in accordance with this Article.

## *Article 81*[39] 36

No health document, other than those provided for in these Regulations, shall be required in international traffic..

*Reservations*—India, Pakistan (for text, see Annex II, pages 53 and 54).

# PART VII - CHARGES

*Article 82*[40][3][41] *7*

1. No charge shall be made by a health authority for:

   (a) any medical examination provided for in these Regulations, or any supplementary examination, bacteriological or otherwise, which may be required to ascertain the state of health of the person examined;

   (b) any vaccination of a person on arrival and any certificate thereof.

2. Where charges are made for applying the measures provided for in these Regulations, other than the measures referred to in paragraph 1 of this Article, there shall be in each territory only one tariff for such charges and every charge shall:

   (a) conform with this tariff;

   (b) be moderate and not exceed the actual cost of the service rendered;

   (c) be levied without distinction as to the nationality, domicile, or residence of the person concerned, or as to the nationality, flag, registry or ownership of the ship, aircraft, train, road vehicle, other means of transport, and containers. In particular, there shall be no distinction made between national and foreign persons, ships, aircraft, trains, road vehicles, other means of transport, and containers.

3. The levying of a charge for the transmission of a message relating to provisions of these Regulations by radio may not exceed the normal charge for radio messages.

4. The tariff, and any amendment thereto, shall be published at least ten days in advance of any levy thereunder and notified immediately to the Organization.



# PART VIII - VARIOUS PROVISIONS

*Article 83*[42][3][43] *8*

1. Every aircraft leaving an airport situated in an area where transmission of malaria or other mosquito-borne disease is occurring, or where insecticide- resistant mosquito vectors of disease are present, or where a vector species is present that has been eradicated in the area where the airport of destination of the aircraft is situated, shall be disinsected in accordance with Article 25 using the methods recommended by the Organization. States concerned shall accept disinsecting of aircraft by the approved vapour disinsecting system carried out in flight. Every ship leaving a port in the situation referred to above shall be kept free from the immature and adult stages of the mosquito concerned.

2. On arrival at an airport in an area where malaria or other mosquito-borne disease could develop from imported vectors, or where a vector species has been eradicated that is present in the area in which the airport of origin is located, the aircraft mentioned in paragraph 1 of this Article may be disinsected in accordance with Article 25 if the health authority is not provided with satisfactory evidence that disinsecting has been carried out in accordance with paragraph 1 of this Article. Every ship arriving in a port in the situation referred to above should be treated and freed, under the control of the health authority, from the immature and adult stages of the mosquito concerned.

3. As far as practicable, and where appropriate, a train, road vehicle, other means of transport, container, or boat used for international coastal traffic or for international traffic on inland waterways, shall be kept free of insect vectors of human disease.

*Article 84*[44][39]

1. Migrants, nomads, seasonal workers or persons taking part in periodic mass congregations, and any ship, in particular small boats for international coastal traffic, aircraft, train, road vehicle or other means of transport carrying them, may be subjected to additional health measures conforming with the laws and regulations of each State concerned, and with any agreement concluded between any such States.

2. Each State shall notify the Organization of the provisions of any such laws and regulations or agreement.

3. The standards of hygiene on ships and aircraft carrying persons taking part in periodic mass congregations shall not be inferior to those recommended by the Organization.

*Article 85*

1. Special treaties or arrangements may be concluded between two or more

States having certain interests in common owing to their health, geographical, social or economic conditions, in order to facilitate the application of these Regulations, and in particular with regard to:

(a) the direct and rapid exchange of epidemiological information between neighbouring territories;
*(b)* the health measures to be applied to international coastal traffic and to international traffic on inland waterways, including lakes;
(c) the health measures to be applied in contiguous territories at their common frontier;
(d) the combination of two or more territories into one territory for the purposes of any of the health measures to be applied in accordance with these Regulations;
*(e)* arrangements for carrying infected persons by means of transport specially adapted for the purpose.

2. The treaties or arrangements referred to in paragraph 1 of this Article shall not be in conflict with the provisions of these Regulations.

3. States shall inform the Organization of any such treaty or arrangement which they may conclude. The Organization shall send immediately to all health administrations information concerning any such treaty or arrangement.



# PART IX - FINAL PROVISIONS

*Article 86*

1. These Regulations, subject to the provisions of Article 88 and the exceptions hereinafter provided, replace, as between the States bound by these Regulations and as between these States and the Organization, the provisions of the following existing International Sanitary Conventions, Regulations and similar agreements:

(a) International Sanitary Convention, signed in Paris, 3 December 1903;
*(b)* Pan American Sanitary Convention, signed in Washington, 14 October 1905;
(c) International Sanitary Convention, signed in Paris, 17 January 1912; (d) International Sanitary Convention, signed in Paris, 21 June 1926;
(e) International Sanitary Convention for Aerial Navigation, signed at The Hague, 12 April 1933;
(f) International Agreement for dispensing with Bills of Health, signed in Paris, 22 December 1934;
(g) International Agreement for dispensing with Consular Visas on Bills of Health, signed in Paris, 22 December 1934;
(h) Convention modifying the International Sanitary Convention of 21 June 1926, signed in Paris, 31 October 1938;
(i) International Sanitary Convention, 1944, modifying the International Sanitary Convention of 21 June 1926, opened for signature in Washington, 15 December 1944;
(j) International Sanitary Convention for Aerial Navigation, 1944, modifying the International Sanitary Convention of 12 April 1933, opened for signature in Washington, 15 December 1944;
(k) Protocol of 23 April 1946 to prolong the International Sanitary Convention, 1944, signed in Washington;
(l) Protocol of 23 April 1946 to prolong the International Sanitary Convention for Aerial Navigation, 1944, signed in Washington;
(m) International Sanitary Regulations, 1951, and the Additional Regulations of 1955, 1956, 1960, 1963 and 1965.

2. The Pan American Sanitary Code, signed at Habana, 14 November 1924, remains in force with the exception of Articles 2, 9, 10, 11, 16 to 53 inclusive, 61, and 62, to which the relevant part of paragraph 1 of this Article shall apply.

*Article 87*

1. The period provided in execution of Article 22 of the Constitution of the Organization for rejection or reservation shall be nine months from the date of the notification by the Director-General of the adoption of these Regulations by the World Health Assembly.

2. Such period may, by notification to the Director-General, be extended to eighteen months with respect to overseas or other outlying territories for whose international relations the State may be responsible.

3. Any rejection or reservation received by the Director-General after the expiry of the periods referred to in paragraph 1 or 2 of this Article shall have no effect.

### *Article 88*

1. If any State makes a reservation to these Regulations, such reservation shall not be valid unless it is accepted by the World Health Assembly, and these Regulations shall not enter into force with respect to that State until such reservation has been accepted by the Assembly or, if the Assembly objects to it on the ground that it substantially detracts from the character and purpose of these Regulations, until it has been withdrawn.

2. A rejection in part of the Regulations shall be considered as a reservation.

3. The World Health Assembly may, as a condition of its acceptance of a reservation, request the State making such reservation to undertake that it will continue to fulfil any obligation or obligations corresponding to the subject matter of such reservation, which such State has previously accepted under the existing conventions, regulations and similar agreements listed in Article 86.

4. If a State makes a reservation which in the opinion of the World Health Assembly detracts to an insubstantial extent from an obligation or obligations previously accepted by that State under the existing conventions, regulations and similar agreements listed in Article 86, the Assembly may accept such reservation without requiring as a condition of its acceptance an undertaking of the kind referred to in paragraph 3 of this Article.

5. If the World Health Assembly objects to a reservation, and that reservation is not then withdrawn, these Regulations shall not enter into force with respect to the State which has made such a reservation. Any existing conventions, regulations and similar agreements listed in Article 86 to which such State is already a party consequently remain in force as far as such State is concerned.

### *Article 89*

A rejection, or the whole or part of any reservation, may at any time be withdrawn by notifying the Director-General.



### *Article 90*

1. These Regulations shall come into force on the first day of January 1971.

2. Any State which becomes a Member of the Organization after that date and which is not already a party hereto may notify its rejection of, or any reservation to, these Regulations within a period of three months from the date on which that State becomes a Member of the Organization. Unless rejected, these Regulations shall come into force with respect to that State, subject to the provisions of Article 88 upon expiry of that period.

### *Article 91*

1. Any State not a Member of the Organization, which is a party to any conventions, regulations and similar agreements listed in Article 86 or to which the Director-General has notified the adoption of these Regulations by the World Health Assembly, may become a party hereto by notifying its acceptance to the Director-General and, subject to the provisions of Article 88, such acceptance shall become effective upon the date of coming-into-force of these Regulations, or, if such acceptance is notified after that date, three months after the date of receipt by the Director-General of the notification of acceptance.

2. For the purpose of the application of these Regulations Articles 23, 33, 62, 63 and 64 of the Constitution of the Organization shall apply to any non-Member State which becomes a party to these Regulations.

3. Any non-Member State which has become a party to these Regulations may at any time withdraw from participation in these Regulations, by means of a notification addressed to the Director-General which shall take effect six months after he has received it. The State which has withdrawn shall, as from that date, resume application of the provisions of any conventions, regulations and similar agreements listed in Article 86 to which it was previously a party.

### *Article 92*

The Director-General shall notify all Members and Associate Members, and also other parties to any conventions, regulations and similar agreements listed in Article 86 of the adoption by the World Health Assembly of these Regulations. The Director-General shall also notify these States as well as any other State, which has become a party to these Regulations, of any additional Regulations amending or supplementing these Regulations, of any notification received by him under Articles 87, 89, 90 and 91 respectively, as well as of any decision taken by the World Health Assembly under Article 88.

### *Article 93*

1. Any question or dispute concerning the interpretation or application of these Regulations or of any Regulations supplementary to these Regulations may be

referred by any State concerned to the Director-General who shall attempt to settle the question or dispute. If such question or dispute is not thus settled, the Director-General on his own initiative, or at the request of any State concerned, shall refer the question or dispute to the appropriate committee or other organ of the Organization for consideration.

2. Any State concerned shall be entitled to be represented before such committee or other organ.

3. Any such dispute which has not been thus settled may, by written application, be referred by any State concerned to the International Court of Justice for decision.

### *Article 94*

1. The English and French texts of these Regulations shall be equally authentic.

2. The original texts of these Regulations shall be deposited in the archives of the Organization. Certified true copies shall be sent by the Director-General to all Members and Associate Members, and also to other parties to one of the conventions, regulations and similar agreements listed in Article 86. Upon the entry-into-force of these Regulations, certified true copies shall be delivered by the Director-General to the Secretary-General of the United Nations for registration in accordance with Article 102 of the Charter of the United Nations.



## Appendix 1 [45*] Appendice 1

**DERATTING CERTIFICATE ([a]) — CERTIFICAT DE DERATISATION ([a])**
**DERATTING EXEMPTION CERTIFICATE ([a]) — CERTIFICAT D'EXEMPTION DE LA DERATISATION ([a])**

*issued in accordance with Article 53 of the International Health Regulations* — délivré conformément à l'article 53 du Règlement sanitaire international (1969)
*(Not to be taken away by Port Authorities )* — (Ce certificat ne doit pas être retiré par les autorités portuaires.)

**Appendix 2**[46][40] Appendice 2

## INTERNATIONAL CERTIFICATE OF VACCINATION OR REVACCINATION AGAINST YELLOW FEVER
## CERTIFICAT INTERNATIONAL DE VACCINATION OU DE REVACCINATION CONTRE LA FIEVRE JAUNE

This is to certify that ---------------------------- date of birth ---------------------------- sex ----
Je soussigné(e) certifie que né(e) le sexe

whose signature follows ----------------------------------------------------------------
dont la signature suit

has on the date indicated been vaccinated or revaccinated against yellow fever.
a été vacciné(e) ou revaccinée) contre la fièvre jaune à la date indiquée.

This certificate is valid only if the vaccine used has been approved by the World Health Organization and ff the vaccinating centre has been designated by the health administration for the territory in which that centre is situated.

The validity of this certificate shall extend for a period of ten years, beginning ten days after the date of vaccination or, in the event of a revaccination within such period of ten years, from the date of that revaccination.

This certificate must be signed in his own hand by a medical practitioner or other person authorized by the national health administration; his official stamp is not an accepted substitute for his signature.

Any amendment of this certificate, or erasure, or failure to complete any part of it, may render it invalid.

Ce certificat n 'est valable que si le vaccin employé a été approuvé par l'Organisation mondiale de la Santé et si le centre de vaccination a été habilité par l'administration sanitaire du territoire dans lequel ce centre est situé.

La validité de ce certificat couvre une période de dix ans commençant dix jours après la date de la vaccination ou, dans le cas d'une revaccination au cours de cette période de dix ans, le jour de cette revaccination.

Ce certificat doit être signé de sa propre main par un médecin ou une autre personne habilitée par l'administration sanitaire nationale, un cachet officiel ne pouvant être considéré comme tenant lieu de signature.

Toute correction ou rature sur le certificat ou l'omission d'une quelconque des mentions qu'il comporte peut affecter sa validité.



## Appendix 3

## MARITIME DECLARATION OF HEALTH

(To be rendered by the masters of ships arriving from ports outside the territory)

Port of ---------------------------------------- Date ----------------------------------
Name of ship ---------------------------------- From -------------------- To --------
Nationality ---------------------------------- Master's name ---------------------------
Net Registered Tonnage ----------------------------------------------------------------

Deratting or Deratting Exemption — Certificate -------------------- Dated -------------------- Issued at ----------------------------------------

Number Of passengers — Cabin ---------------------- Number of crew ---------------------- Deck ----------------------------------------

List of ports of call from commencement of voyage with dates of departure:

----------------------------------------------------------------

----------------------------------------------------------------

| | Health Questions | Answer Yes or No |
|---|---|---|
| 1. | Has there been on board during the voyage[47][41] any case or suspected case of plague, cholera or yellow fever? Give particulars in Schedule. | |
| 2. | Has plague occurred or been suspected among the rats or mice on board during the voyage,[48][42] or has there been an abnormal mortality among them? | ............ |
| 3. | Has any person died on board during the voyage[49][43] otherwise than as a result of accident? Give particulars in Schedule. | ............ |
| 4. | Is there on board or has there been during the voyage [50][44] any case of disease which you suspect to be of an infectious nature? Give particulars in Schedule. | ............ |
| 5. | Is there any sick person on board now? Give particulars in Schedule | ............ |

Note: In the absence of a surgeon, the Master should regard the following symptoms as ground for suspecting the existence of disease of an infectious nature: fever accompanied by prostration or persisting for several days, or attended with glandular swelling; or any acute skin rash or eruption with or without fever; severe diarrhoea with symptoms of collapse; jaundice accompanied by fever.

6. Are you aware of any other condition on board which may lead to infection or the spread of disease? ..............

I hereby declare that the particulars and answers to the questions given in this Declaration of Health (including the Schedule) are true and correct to the best of my knowledge and belief.

Signed

Master

Countersigned ----------------------------------------------

Date ------------------------------------------------- Ship's Surgeon

## Appendix 3 *(continued)*

## SCHEDULE TO THE DECLARATION

Particulars of every case of illness or death occurring on board

| Name | Class or rating | Age | Sex | Nationality | Port of embarkation | Date of embarkation | Nature of illness | Date of its onset | Results of illness [51]* | Disposal of case [52]** |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |



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|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |

* State whether recovered, still ill, died.

** State whether still on board, landed at (give name of port), buried at sea.

## Appendix 4

## HEALTH PART OF THE AIRCRAFT GENERAL DECLARATION

*Declaration of Health*

Persons on board with illnesses other than airsickness or the effects of accidents (including persons with symptoms or signs of illness such as rash, fever, chills, diarrhoea) as well as those cases of illness disembarked during the flight -----

---

Any other condition on board which may lead to the spread of disease ---

---

Details of each disinsecting or sanitary treatment (place, date, time, method) during the flight. If no disinsecting has been carried out during the flight, give details of most recent disinsecting---

---

---

Signature, if required: ---

Crew member concerned



## ANNEXES

## Annex I

### POSITION OF MEMBER STATES, ASSOCIATE MEMBERS AND OTHER STATES BOUND BY THE INTERNATIONAL HEALTH REGULATIONS (1969)

**(on 1 January 1995)**

**Unless otherwise indicated, the States listed are bound without reservations**

I International Health Regulations (1969)
II Additional Regulations, 1973
III Additional Regulations, 1981
R Bound with reservations
\- Not bound



| | I | II | III |
|---|---|---|---|
| Afghanistan | | | |
| Albania | | | |
| Algeria | | | |
| Angola | | | |
| Antigua and Barbuda | | | |
| Argentina | | | |
| Armenia | | | |
| Australia | | | |
| Austria | | | |
| Azerbaijan | | | |
| Bahamas | | | |
| Bahrain | | | |
| Bangladesh | | | |
| Barbados | | | |
| Belarus | | | |
| Belgium | | | |
| Belize | | | |
| Benin | | | |
| Bhutan | | | |
| Bolivia | | | |
| Bosnia and Herzegovina | | | |
| Botswana | | | |
| Brazil | | | |
| Brunei Darussalam | | | |
| Bulgaria | | | |
| Burkina Faso | | | |
| Burundi | | | |
| Cambodia | | | |
| Cameroon | | | |
| Canada | | | |
| Cape Verde | | | |
| Central African Republic | | | |

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|---|---|---|---|
| Chad | | | |
| Chile | | | |
| China | | | |
| Colombia | | | |
| Comoros | | | |
| Congo | | | |
| Cook Islands | | | |
| Costa Rica | | | |
| Cote d'Ivoire | | | |
| Croatia | | | |
| Cuba | | | |
| Cyprus | | | |
| Czech Republic | | | |
| Democratic People's Republic of Korea | | | |
| Denmark | | | |
| Djibouti | | | |
| Dominica | | | |
| Dominican Republic | | | |
| Ecuador | | | |
| Egypt | R | - | |
| El Salvador | | | |
| Equatorial Guinea | | | |
| Entrea | | | |
| Estonia | | | |
| Ethiopia | | | |
| Fiji | | | |
| Finland | | | |
| France | | | |
| Gabon | | | |
| Gambia | | | |
| Georgia | | | |
| Germany | | | |
| Ghana | | | |
| Greece | | | |



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|---|---|---|---|
| Grenada | | | |
| Guatemala | | | |
| Guinea | | | |
| Guinea-Bissau | | | |
| Guyana | | | |
| Haiti | | | |
| Holy See | | | |
| Honduras | | | |
| Hungary | | | |
| Iceland | | | |
| India | R | R | |
| Indonesia | | | |
| Iran (Islamic Republic of) | | - | |
| Iraq | | | |
| Ireland | | | |
| Israel | | | |
| Italy | | | |
| Jamaica | | | |
| Japan | | | |
| Jordan | | | |
| Kazakhstan | | | |
| Kenya | | | |
| Kiribati | | | |
| Kuwait | | | |
| Kyrgyzstan | | | |
| Lao People's Democratic Republic | | | |
| Latvia | | | |
| Lebanon | | | |
| Lesotho | | | |
| Liberia | | | |
| Libyan Arab Jamahiriya | | - | |
| Liechtenstein | | | |
| Lithuania | | | |
| Luxembourg | | | |

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|---|---|---|---|
| Madagascar | | | |
| Malawi | | | |
| Malaysia | | | |
| Maldives | | | |
| Mali | | | |
| Malta | | | |
| Marshall Islands | | | |
| Mauntania | | | |
| Mauritius | | | |
| Mexico | | | |
| Micronesia (Federated State of) | | | |
| Monaco | | | |
| Mongolia | | | |
| Morocco | | | |
| Mozambique | | | |
| Myanmar | | | |
| Namibia | | | |
| Nauru | | | |
| Nepal | | | |
| Netherlands | | | |
| New Zealand | | | |
| Nicaragua | | | |
| Niger | | | |
| Nigeria | | | |
| Niue | | | |
| Norway | | | |
| Oman | | | |
| Pakistan | R | | |
| Panama | | | |
| Papua New Guinea | | | |
| Paraguay | | | |
| Peru | | | |
| Philippines | | | |
| Poland | | | |



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|---|---|---|---|
| Portugal | | | |
| Puerto Rico | | | |
| Qatar | | | |
| Republic of Korea | | | |
| Republic of Moldova | | | |
| Romania | | | |
| Russian Federation | | | |
| Rwanda | | | |
| Saint Kitts and Nevis | | | |
| Saint Lucia | | | |
| Saint Vincent and the Grenadines | | | |
| Samoa | | | |
| San Marino | | | |
| Sao Tome and Principe | | | |
| Saudi Arabia | | | |
| Senegal | | | |
| Seychelles | | | |
| Sierra Leone | | | |
| Singapore | | | |
| Slovakia | | | |
| Slovenia | | | |
| Solomon Islands | | | |
| Somalia | | | |
| South Africa | | | |
| Spain | | | |
| Sri Lanka | | | |
| Sudan | | | |
| Sunname | | | |
| Swaziland | | | |
| Sweden | | | |
| Switzerland | | | |
| Syrian Arab Republic | | | |
| Tajikistan | | | |
| Thailand | | | |
| The Former Yugoslav | | | |

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|---|---|---|---|
| Republic of Macedonia | | | |
| Togo | | | |
| Tokelau | | | |
| Tonga | | | |
| Trinidad and Tobago | | | |
| Tunisia | | | |
| Turkey | | | |
| Turkmenistan | | | |
| Tuvalu | | | |
| Uganda | | | |
| Ukraine | | | |
| United Arab Emirates | | | |
| United Kingdom of Great Britain and Northern Ireland | | | |
| United Republic of Tanzania | | | |
| United States of America | | | |
| Uruguay | | | |
| Uzbekistan | | | |
| Vanuatu | | | |
| Venezuela | | | |
| Viet Nam | | | |
| Yemen | | | |
| Yugoslavia | | | |
| Zaire | | | |
| Zambia | | | |
| Zimbabwe | | | |



# Annex II

## RESERVATIONS TO THE INTERNATIONAL HEALTH REGULATIONS (1969)[53,47]

### EGYPT

*Article3, paragraph 1, and Article4, paragraph 1*

The Government of Egypt reserves the right to consider the whole territory of a country as infected with yellow fever whenever yellow fever has been notified under Article 3, paragraph 1, or Article 4, paragraph 1.

### INDIA

*Article 3, paragraph 1, and Article 4, paragraph 1*

The Government of India reserves the right to consider the whole territory of a country as infected with yellow fever whenever yellow fever has been notified under Article 3, paragraph 1, or Article 4, paragraph 1. Article 7, paragraph 2(b)
The Government of India reserves the right to continue to regard an area as infected with yellow fever until there is definite evidence that yellow-fever infection has been completely eradicated from that area.

*Article 42*

The Government of India reserves the right immediately to disinsect on arrival an aircraft which, on its voyage over infected territory, has landed at a sanitary airport which is not itself an infected area, if an unprotected person from the surrounding infected area has boarded the aircraft and if the aircraft reaches India within a period during which such a person is likely to spread yellow-fever infection.

This reservation will not apply to aircraft fitted with an approved vapour disinsecting system which is compulsorily operated.

*Article 43*

The Government of India reserves the right to apply the terms of Article 68 to the passengers and crew on board an aircraft landing in the territory of India who have come in transit through an airport situated in a yellow-fever infected area, not equipped with a direct transit area.

*Article 81*

The Government of India shall have the right to require of persons on an international voyage arriving by air in its territory or landing there in transit, but falling under the terms of paragraph 1 of Article 69, information on their movements during the last six days prior to disembarkation.

### PAKISTAN

*Article 3, paragraph 1, and Article 4, paragraph 1*

The Government of Pakistan reserves the right to consider the whole territory of a country as infected with yellow fever whenever yellow fever has been notified under Article 3, paragraph 1, or Article 4, paragraph 1.

*Article 7, paragraph 2 (b)*

The Government of Pakistan reserves the right to continue to regard an area as infected with yellow fever until there is definite evidence that yellow-fever infection has been completely eradicated from that area.

*Article 42*

The Government of Pakistan reserves the right to disinsect immediately on arrival an aircraft which, on its voyage over infected territory, has landed at a sanitary airport which is not itself an infected area.

*Article 43*

The Government of Pakistan reserves the right to apply the terms of Article 68 to the passengers and crew on board an aircraft landing in the territory of Pakistan who have come in transit through any airport situated in a yellow-fever infected area, not equipped with a direct transit area.

*Article 81*

The Government of Pakistan shall have the right to require of persons on an international voyage arriving by air in its territory or landing there in transit, but falling under the terms of paragraph 1 of Article 69, information on their movements during the last six days prior to disembarkation.



## Annex III

## OBLIGATIONS OF HEALTH ADMINISTRATIONS UNDER THE INTERNATIONAL HEALTH REGULATIONS (1969)

*Notifications, epidemiological information, and other data which, in application of the International Health Regulations, are to be sent to the World Health Organization*

| Nature of information to be sent by the health administration | Article under which required | How and when to be sent to WHO |
|---|---|---|
| | | |
| 1. Notification of the first case of a disease subject to the Regulations that is neither an imported nor a transferred case | Article 3, paragraph 1 | By telegram or telex, within 24 hours of the health administration being informed. |
| 2. Notification of the extent of the infected area | Article 3, paragraph 1 | By telegram or telex, within 24 hours after notification of the first case. |
| 3. Notification of one or more cases of a disease subject to the Regulations imported or transferred into a non-infected area, together with all information available on the origin of infection | Article 3, paragraph 2*(a)* | By telegram or telex, within 24 hours of the health administration being informed. |
| 4. Notification that a ship or aircraft has arrived with one or more cases of a disease subject to the Regulations on board, together with the name of the ship or flight number of the aircraft, previous and subsequent ports of call, and the health measures taken with respect to the ship or aircraft | Article 3, paragraph 2 *(b)* | By telegram or telex, *within* 24 hours of the health administration being informed. |
| 5. Notification that the diagnosis of the disease notified under paragraphs 1 and 2 of Article 3 has been confirmed by laboratory examination | Article 3, paragraph 3 | By telegram or telex, on confirmation. |
| 6. Notification of evidence of the pre-sence of yellow fever virus, including the virus found in | Article 4, paragraph 1 | Notification by telegram or telex, as soon as evidence has been established. Report |

| | | |
|---|---|---|
| mosquitos or in vertebrates other than man, or the plague bacillus, in any part of its territory. This notification is to be followed by a report indicating the extent of the area involved | | by airmail[54]48 as soon as extent of area has been extent of area has been determined. |
| 7. Notification of rodent plague, wild- rodent plague being distinguished from domestic rodent plague. In the case of wild-rodent plague, description of the epidemiological circumstances and of the area involved | Article 4, paragraph 2 | Notification by air mail, [55]49 promptly Report by airmail, [56]50 as soon as extent of area has been determined |
| 8. In respect of areas notified under paragraph 1 of Article 3, supplementary information as to the source and type of the disease, the number of cases and deaths, conditions affecting the spread of the disease, and the prophylactic measures taken | Article 5 | By airmail, [57]51 promptly. |
| 9. During an epidemic, detailed communications, subsequent to the notifications and information required under Articles 3 and 5, on the number of cases and deaths, measures taken to prevent the spread of the disease to other territories measures of control over rodents, insect vectors, etc., as specified in paragraph 2 of Article 6 | Article 6, paragraphs 1 and 2 | By airmail, [58]52 as frequently as possible. The number of cases and deaths to be communicated at least once weekly. |
| 10. Notification of the date when an area which, under paragraph 1 of Article 3, and paragraphs 1 and 2 of Article 4, has been notified as an infected area is free from infection | Article 7, paragraph 1 | By the most rapid route. |
| 11. Notification of the measures which it has decided to apply to arrivals from an infected area, indicating the date of application | Article 8, paragraphs 1 (a) and 2 | By telegram or telex and, wherever possible, in advance of the application of any such measure. |
| 12. Notification of the withdrawal of the measures it had applied to arrivals from an infected area, indicating the date of withdrawal | Article 8, paragraphs 1 (a) and 2 | By telegram or telex and, wherever possible, in advance of the withdrawal of any such measure. |
| 13. Notification of any change in its vaccination requirements for travellers on an international voyage | Article 8, paragraphs 1 (b) and 2 | By telegram or telex and, wherever possible, in advance of any such change. |
| 14. Recapitulation of its vaccination requirements for travellers on an international voyage | Article 8. paragraph 3 | By airmail, [59]53 once yearly. |
| 15. Report of the number of cases of diseases subject | Article 9 (a) | By telegram or telex, once weekly, when |



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| to the Regulations and deaths therefrom during the previous week in each of its towns and cities adjacent to a port or an airport, including any imported or transferred cases | | such cases and deaths occur. |
| 16. During the periods referred to in subparagraphs (a), *(b)* and (c) of paragraph 2 of Article 7, report of the absence of cases of diseases subject to the Regulations prom each of its towns and cities adjacent to a port or an airport | Article 9 (b) | By airmail, once weekly, until the periods stated in subparagraphs (a), *(b)* and (c) of paragraph 2 of Article 7 have elapsed. |
| 17. Information concerning the occurrence of any case of a disease subject to the Regulations due to or carried by international traffic, as well as on the action taken under the Regulations or bearing upon their application | Article 13, paragraph 1 | By airmail, [60]54 once yearly |
| 18. Data on the extent to which its ports and airports are kept free from vectors of epidemiological significance in international traffic | Article 19, paragraph 4 | By airmail, [61]55 once yearly |
| 19. List of its ports approved under Article 17 for the issue of Deratting Exemption Certificates only | Article 20, paragraph 1 (i) and 2 | By airmail, [62]56 as soon as the ports have been designated, and as soon as any change in the list of such ports has been made. |
| 20. List of its ports approved under Article 17 for the issue of Deratting Certificates and Deratting Exemption Certificates | Article 20, paragraph 1 (ii) and 2 | By airmail, [63]57 as soon as the ports have been designated, and as soon as any change in the list of such ports has been made. |
| 21. Notification of its frontier posts on railway lines, on roads and on inland waterways where facilities for applying the measures provided for in the Regulations are available, indicating when and where such facilities are provided | Article 22, paragraphs 1 and 2 | By airmail, [64]58 as soon as such facilities have been provided. |
| 22. Notification of arrangements for the detention of persons, under certain conditions, who are in transit to areas where the vector of yellow fever is present | Article 69, paragraphs 1 and 2 | By airmail, [65]59 as soon as arrangements have been made or terminated. |
| 23. Notification of its tariff of charges made for | Article 82, paragraphs 2 and 4 | By airmail, [66]60 immediately. |

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| applying the measures provided for in the Regulations, and of any amendment thereto | | |
| 24. Notification of any agreement con cluded with a State or States, and of the provisions of any laws and regulations on additional health measures applied to migrants, nomads, seasonal workers and persons taking part in periodic mass congregations, and to their means of transport | Article 84, paragraphs 1 and 2 | By airmail, [67]61 as soon as agreements have been concluded, and as soon as laws and regulations have been adopted. |
| 25. Notification of special treaties or arrangements concluded with a State or States in order to facilitate the application of the Regulations | Article 85, paragraphs 1 and 3 | By airmail, [68]62 as soon as the special treaties or arrangements have been concluded. |

*The submission to WHO by health administrations of the following data not specifically required under the Regulations is also necessary for application of the Regulations*

| Nature of information to be sent by the health administration | Article under which required | How and when to be sent to WHO |
|---|---|---|
| | | |
| 26. List of vaccinating centres designated for the administration of yellow fever vaccine and for the issue of International Certificates of Vaccination or Revaccination against Yellow Fever | Article 1 "valid certificate" and Appendix 2; Article 66, paragraph 4 | By airmail, on the designation of each such centre. |
| 27. Submission of applications for approval of yellow fever vaccines in tended to be used for the issue of international certificates | Article 1 "valid certificate" and Appendix 2; Article 66, paragraph 4 | By airmail, when application is made. |
| 28. Notification of the area or areas where *Aedes aegypti* has been eradicated | Article 67, paragraphs 3 and 4 | By airmail, as soon as conditions are known. |
| 29. Notification of the area or areas where the vector of yellow fever is present | Articles 68; 69, paragraph 1; 71, paragraphs *1* (a) and *(b)*; 74 and 75 | By airmail, as soon as conditions are known. |
| 30. List of airports in an area where the vector of yellow fever is present at which aircr*aft coming from a yellow fever* infected area may land | Article 73 | By airmail, as soon as the airports have been specified for the purpose. |
| *31. Text of national laws and regulations dealing* | - | By airmail, as soon as laws and |



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| *with the application of the Regulations, and of amendments to such laws and regulations* | | regulations have been adopted, and as soon as amendments have been made. |

## Annex IV

## WHO EPIDEMIOLOGICAL INFORMATION SERVICE TO MEMBER STATES

**Automatic telex reply service**

In order to make available to Member States as promptly as possible Epidemiological information on diseases subject to the International Health Regulations (1969) and other communicable diseases of international importance, the Organization has established an automatic telex reply service.

Epidemiological information of importance received each day at WHO headquarters is recorded on punch tape and fed into the machine for automatic transmission to any national health administration calling the appropriate telex number. As soon as the message is ended, the machine is ready to transmit to the next caller.

Each Friday, important information received during the week and intended for publication in the Weekly Epidemiological Record is summarized and fed into the machine for automatic transmission. This enables national health administrations to obtain the information well before the Weekly Epidemiological Record reaches them.

Details of the call procedure are published periodically in the Weekly Epidemiological Record.

**Weekly Epidemiological Record**

The Weekly Epidemiological Record is published in English and French every Friday morning. One copy of this publication is sent to each national health administration by the fastest possible means. In addition, copies are dispatched by airmail to all subscribers.

The Weekly Epidemiological Record contains all the information that the Organization is required to provide under the International Health Regulations (1969), including the information already made available by the telex service mentioned above. It also contains Epidemiological notes and brief reviews of communicable diseases of international importance.



## Annex V

## STANDARDS OF HYGIENE ON SHIPS AND AIRCRAFT CARRYING PERSONS TAKING PART IN PERIODIC MASS CONGREGATIONS[69][63]

**Ships**

1. Ships to which these standards apply when carrying passengers shall comply with the requirements of Part II of the Annex to the Protocol on Space Requirements for Special Trade Passenger Ships, 1973.

2. The requirements of the following paragraphs are minimum requirements and shall apply to all ships. With respect to existing ships[70][64] the requirements may be relaxed as provided in paragraph 11 of these standards.

3.1 Every ship shall be provided with wash places for the exclusive use of passengers. Potable or wash water [71][65] is to be piped under pressure to washbasins, showers or taps fitted to the following scale:

(a) voyages of a duration of 48 hours or more—one washbasin for every 50 passengers, or part thereof, and one shower or tap for every 50 passengers, or part thereof which the ship is certified to carry;

(b) voyages of a duration of 24 hours to 48 hours—one washbasin for every 100 passengers of part thereof and one shower or tap for every 100 passengers of part thereof which the ship is certified to carry;

(c) voyages of a duration of less than 24 hours—at least two wash places each fitted with a washbasin.

For voyages in the category of (a) and (b) above at least two of the required showers or taps shall be supplied with hot water.

3.2 Wash places shall be adequately lighted, ventilated and drained and so arranged as to afford privacy to the user.

4.1 Every ship shall be provided with a dining space or spaces equipped with sufficient number of tables and chairs to the following scale:

(a) voyages of a duration of 24 hours or more—10 square metres for every 100 passengers or part thereof which the ship is certified to carry;

(b) voyages of a duration of less than 24 hours—5 square metres for every 100 passengers or part thereof which the ship is certified to carry.

4.2 Every ship, in addition to the requirements contained in paragraph 3.1, shall be provided with washbasins with hot and cold waters under pressure adjacent to the dining space or spaces to the following scale:

(a) voyages of a duration of 24 hours or more—one washbasin for every 100 passengers or part thereof which the ship is certified to carry;

(b) voyages of a duration of less than 24 hours—one wash-basin for every 200 passengers or part thereof which the ship is certified to carry.

5.1 Every ship shall be provided with latrines fitted with piped pressure flushing arrangements to the following scale:

(a) voyages of a duration of 24 hours or more—four latrines for every 100 passengers or part thereof which the ship is certified to carry;

(b) voyages of a duration of less than 24 hours—three latrines for every 100 passengers or part thereof which the ship is certified to carry.

5.2 Latrine spaces shall be adequately lighted, ventilated and drained and so arranged as to afford privacy to the user. Exhaust ventilation shall be independent of ventilation to other passenger spaces.

6.1 A sufficient supply of potable water shall be hygienically stored and made available at all times to passengers in addition to water supplied for other purposes.[72][66]

6.2 There shall be on board a supply of wholesome food, hygienically stored, sufficient for the voyage.[73][67]

7. On every ship, suitable provision shall be made for the hygienic collection and disposal of both solid and liquid wastes.

8.1 Every ship shall be provided with a room of sufficient size to undertake medical examination and treatment of passengers and the storage of medicaments, medical supplies and equipment referred to in paragraph 9.2.

8.2 In addition to the provisions of paragraph 8.1, every ship shall have a permanent hospital accommodation of sufficient size to provide:

(a) for voyages in excess of 24 hours' duration one hospital bed for every 200 passengers or part thereof which the ship is certified to carry;

(b) for voyages in excess of 48 hours' duration one hospital bed for every 100 passengers or part thereof which the ship is certified to carry and in addition an isolation hospital fitted with at least two beds.

8.3 Hospital accommodation shall be properly equipped, adequately lighted and fitted with mechanical ventilation or air conditioning capable of effective separation from other passenger or crew space ventilation.

8.4 Each hospital shall have an adjacent latrine and a bathroom provided with hot and cold potable or wash water, [74][68] with discharges



independent of any discharges from other crew or passenger accommodation.

9.1 For voyages in excess of 12 hours' duration every ship carrying more than 100 passengers shall carry one properly qualified and registered medical practitioner as well as a nursing attendant. If the ship is carrying more than 1000 passengers, there shall be two such medical practitioners and two nursing attendants.

9.2 The health administration shall ensure that every ship carries sufficient medicaments and medical supplies and equipment for the treatment of passengers,[75][69] and maintenance of hygienic standards.

9.3 Medical attendance and treatment including medicaments shall be provided free of charge to passengers.

10.1 The master and the medical practitioner shall be responsible for ensuring at all times that the necessary standard of ship's hygiene and cleanliness is maintained.

10.2 During the voyage the medical practitioner or in His absence the master of the ship shall satisfy himself that in particular:

(a) the ship, including passenger spaces and dining spaces, is kept thoroughly clean and in a hygienic condition and is properly ventilated;

(b) the food is hygienically stored, prepared and served and that the water supplied to the passengers is of potable quality and sufficient in quantity;

(c) the latrines, wash places and bathrooms are kept clean, disinfected in perfect working order;

(d) solid and liquid wastes are hygienically collected and disposed of;

(e) in the case of occurrence of any disease of infectious nature all appropriate steps have been taken to contain the infection.

10.3 During the voyage the medical practitioner or in his absence the master shall maintain health records and report in accordance with Article 77 of the Regulations.

11. In the case of existing ships[76][70] the health administration of the country in which the ship is registered may permit relaxations from the requirements contained in paragraphs 3.1(b), 5.1(b), 8.2(a) and 8.2(b) if it is satisfied that full compliance would be impracticable, provided that the ship at least fully complies with the pertinent provisions of the previous Annex V[77][71] which these standards supersede.

12. The health or other appropriate authority of the port of departure should satisfy itself that the minimum standards of these provisions have been met prior to the departure of the ship.

**Aircraft**

1. The provisions of the Convention on International Civil Aviation (Chicago, 1944) and of the Annexes thereto, governing the transport of

passengers by air, the application of which may affect the health of such passengers, shall be equally enforced whether an aircraft is carrying persons taking part in periodic mass congregations or other passengers.

2. A health administration may require aircraft carrying persons taking part in periodic mass congregations to land only at airports in its territory designated by it for the disembarking of such passengers.



## Annex VI

## MODEL OF A CORRECTLY COMPLETED INTERNATIONAL CERTIFICATE OF VACCINATION

*To be valid in international traffic, vaccination certificates must be* ***printed in English and French****; a third language may be added. The certificate must be fully and correctly* ***completed in English and French****; completion in another language in addition is not excluded.- Pour être valables dans les voyages internationaux, les certificats de vaccination doivent être* ***imprimés en français et en anglais****; une troisième langue peut être ajoutée. Le certificat doit être complètement et correctement* ***rempli en français ou en anglais****, avec addition facultative d'une autre langue.*

Click here to see the
INTERNATIONAL CERTIFICATE OF VACCINATION OR REVACCINATION
AGAINST YELLOW FEVER
CERTIFICAT INTERNATIONAL DE VACCINATION OU DE REVACCINATION
CONTRE LA FIEVRE JAUNE

This certificate is valid only if the vaccine used has been approved by the World Health Organization and if the vaccinating centre has been designated by the health administration for the territory in which that centre is situated.

The validity of this certificate shall extend for a period of ten years, beginning ten days after of vaccination or in the event of a revaccination within such period of ten years, from the date of that revaccination

This certificate must be signed in his own hand by a medical practitioner or other person authorized by the national health administration: his official stamp is not an accepted substitute for his signature.

Any amendment of this certificate, or erasure, or failure to complete any part of it, may render it invalid.

Ce certificat n 'est valable que si le vaccin employé a été approuvé par l'Organisation mondiale de la Santé et si le centre de vaccination a été habilité par l'administration sanitaire du territoire dans lequel ce centre est situé.

La validité de ce certificat couvre une periode de dix ans commencant dix jours après la date de la vaccination ou, dans le cas d'une revaccination au cours de cette période de dix ans, le jour de cette revaccination.

Ce certificat doit être signé de sa propre main par un médecin ou une autre personne habilitée par l'administration sanitaire nationale, un cachet officiel ne pouvant être considéré comme tenant lieu de signature.

Toute correction ou rature sur le certificat ou l'omission d'une quelconque des mentions qu'il comporte peut affecter sa validité.

## WHO PUBLICATIONS OF RELATED INTEREST

**Weekly Epidemiological Record**

An essential weekly instrument for the collation and dissemination of epidemiological data useful in disease surveillance and control. The WER also serves as a medium for reporting experiences in WHO-sponsored programmes on AIDS, diarrhoeal diseases, expanded immunization, and the eradication of poliomyelitis and guinea-worm disease. The subscription includes a copy of International Travel and Health.

**1995 subscription rate: Sw.fr. 209.-**
**Bilingual English/French**

**International Travel and Health**

Vaccination Requirements and Health Advice
Situation as on 1 January 1995

An annual publication issuing authoritative advice on the medical and personal precautions needed to protect the health of travellers. Updated each January, the book presents the latest information on general precautions to be taken by all travellers, health risks specific to different geographical areas, vaccinations recommended or advised by WHO, and vaccinations legally required for entry into each country in the world. Advice on malaria prophylaxis and chemotherapy is especially detailed and up-to-date.

**1995 edition: Swsb. 15.-**
**Separate English and French editions**

**Yellow Fever Vaccinating Centres for International Travel**

Situation as on 1 January 1991

A country-by-country directory of centres where valid international certificates of vaccination against yellow fever can be obtained. Vaccinating centres are officially designated by countries in accordance with the *International Health Regulations.*

**1991 edition: Sw fr. 14.-**
**Bilingual English/French**

**Ports Designated in Application of the International Health Regulations**

Lists all ports approved and designated by health administrations, under the *International Health Regulations,* for the issue of Deratting Certificates and Deratting Exemption Certificates.

**1992 edition: Sw fr. 10.**
**Bilingual English/French**

**International Certificate of Vaccination**

A booklet reproducing the model certificate, as prescribed by the *International Health Regulations*, for recording vaccination or revaccination against yellow fever and other vaccinations recommended or advised by WHO. The booklets are sold at cost price, including despatch by surface mail; prices apply only to orders sent directly to WHO.

Orders for 5,000 copies or more can be overprinted with the name of the distributing agency at cost.

| Number of copies | Price (Sw.fr.) Bilingual (E/F) | Trilingual (Ar/F) |
|---|---|---|
| 50 | 10.— | 12.50 |
| 100 | 20.— | 25.— |
| 500 | 95.— | 120.— |
| 1 100 | 180.— | 230.— |
| 5000 | 850.— | 1 100.— |
| 50 000 | 8 000.— | 10 500.— |

1[1] See WHO Official Records, No. 176, 1969, p. 22 (resolution WHA22.46) and p. 37 for the text as it was reproduced in the first annotated edition.

2[2] See WHO Official Records, No. 209, 1973, p. 29. (resolution WHA26.55)

3[3] See document WHA34/1981/REC/1. p. 10 (resolution WHA34.13); see also WHO Official Records, No. 217, 1974, pp. 21, 71 and 81, and document EB67/1981/REC/1, p. 55.

4[4] See WHO Official Records, No. 217, 1974, p. 73. The Regulations of the Committee were amended in 1977, although not in respect of this provision. (WHO Official Records No. 240, 1977, p. 62)

5[5] Where appropriate, editorial changes have been made to the interpretations and recommendations which originally referred to the International Sanitary Regulations.

6[6] See Annex IV.

7[7] If it is not practicable to examine all the houses in an area, examination should be made of a random sample of a size not less than that indicated in the table below:

CONFIDENCE INTERVAL FOR THE *ANDES AEGYPTI* INDEX OF ONE PER CENT,



IN RELATION TO SIZE OF LOCALITY AND SAMPLE

(95 PER CENT. PROBABILITY LEVEL)

| Number of houses: Locality | Sample | Confidence interval |
|---|---|---|
| 700 | 500 | 0.7 to 1.7% |
| 1000 | 700 | 0.7 to 1.5% |
| 1500 | 1000 | 0.7 to 1.5% |
| 2000 | 1000 | 0.7 to 1.6% |
| over 2000 | 1500 | 0.6 to 1.6% |

A minimum of two inspections should be carried out; any additional inspection would increase the validity of the results. (WHO Official Records, No. 95, 1959, p. 474)

8[8] The public health facilities would include those listed in Articles 14 and 18 of the International Health Regulations (1969). (WHO Official Records, No. 209, 1973, p. 74)

9[9] Small parcels and boxes shall not be considered as containers. (WHO Official Records, No. 177, 1969, p. 554)

10[10] (1) A direct transit area may be established in an airport which is not a sanitary airport. (WHO Official Records, No. 72, 1956, p. 36)

(2) Transfers of passengers between an airport and a direct transit area outside the precincts of the airport will be in conformity with the Regulations if they are made under the direct supervision and control of the health authority. (WHO Official Records, No. 56, 1954, p. 54)

11[11] (1) Countries receiving travellers from infected areas should keep the measures applied to a necessary minimum. (WHO Official Records, No. 217, 1974, p. 55)

(2) A list of infected areas notified by health administrations is published in the Organization's *Weekly Epidemiological Record.*

(3) See notes to Article 3, pp. 10 and 11.

12[12] "Preliminary examination" may include:

(1) the physical examination of any person, but the exercise of that right should depend on the circumstances of each individual case. (WHO Official Records, No. 56, 1954, p. 46)

(2) questioning travellers on their movements prior to disembarkation. (WHO Official Records, No. 87,1958 p.411)

(3) inspection of the passport, as being probably the best source of information when tracing the movements of a passenger during the course of a voyage which has involved changes in the mode of transportation. (WHO Official Records, No. 56, 1954, p. 57)

13[13] *(1) The notification of an infected area by a health administration must be limited to the territory of that health administration. The initial notification of the extent of the infected area may in certain cases be provisional in nature. When, on epidemiological investigation, redefinition of the infected area is indicated the health administration should inform the Organization as soon as possible of any change in the initial notification. (WHO Official Records, No. 177, 1969, p. 554)*

*(2) In the absence of information on the origin of infection, as required under subparagraph 2 (a), a negative report is in conformity with the Regulations. It is then for the health administration to follow up the notification with such information as may later become available, as soon as possible. (WHO Official Records, No. 135, 1964, p. 32)*

*(3) In an effort to avoid delays, health administrations might consider having certain health authorities e.g., those at towns and cities adjacent to a port or an airport, notify the Organization directly. (WHO Official Records, No. 135, 1964, p. 36, and No. 143, 1965, p. 45)*

*(4) See note to Article 1, definition of "infected area", p. 9.*

14[14] *( 1) See Article 1, definition of "infected area", p. 9.*

*(2) One of the following criteria should be used in determining activity of the virus in vertebrates other than man:*

*(i) the discovery of the specific lesions of yellow fever in the liver of vertebrates indigenous to the area or*

*(ii) the isolation of yellow fever virus from any indigenous vertebrates. (WHO Official Records, No. 64, 1955, p. 69)*

*(3) Measures need not normally be taken against an area which has been notified as infected with wild-rodent plague, unless there is evidence that the wild-rodent plague has infiltrated or is tending to infiltrate into the domestic rodent population, and thus threatens international traffic. (WHO Official Records, No. 56, 1954, p. 47, and No. 64, 1955, p. 38)*

[15] *(1) The period stipulated in paragraph 2 should begin when the last case is identified as a case, irrespective of the time at which the person may have been isolated. (WHO Official Records, No. 127, 1963, P. 33)*

*(2) The time-limits in paragraph 2 (a), equal to twice the incubation period of the disease, are minimum limits and health administrations may extend them before declaring an infected area in their territory free from infection and continue for a longer period their measures of prophylaxis to prevent the recurrence of the disease or its spread to other areas. (WHO Official Records, No. 72, 1956, p. 38, and No. 79, 1957, p. 499)*

[16] *(1) The requirements of countries, as notified by health administrations, are published in International Travel and Hea/th.Vaccv~ation Requirements and Health Advice*, a WHO annual publication. Amendments to this publication appear in the *Weekly Epidemiological Record.*

(2) Measures believed to be in excess of the Regulations shall be published by the Organization, accompanied by the phrase: "It appears that conformity of this measure with the Regulations may be open to question and the Organization is in communication with the health administration concerned." (WHO Official Records, No. 56, 1954, p. 55, and No. 79, 1957, p. 499)

[17] *Notification to health administrations by means of the Weekly Epidemiological Record* and the automatic telex reply service discharges the Organization's responsibilities for notification under Articles 11 (first sentence), 20, 21, 22, 69 and 85. (WHO Official Records, No. 56, 1954, pp. 55 and 66) (See also Annex IV)

[18] *All health administrations should report, even negative information, on the occurrence of diseases subject to the Regulations and other matters relative to the functioning of the Regulations. (WHO Official Records, No. 217, 1974, p. 58, and No. 240, 1977, p. 45)*

[19] *(1) Microbiological sampling of drinking-water and food should be part of an overall sanitation programme. (WHO Official Records, No. 217, 1974, p. 58)*

*(2) All national health administrations should ensure the quality of food and water provided in airports and aircraft. (WHO Official Records, No. 240, 1977, p. 45)*

*(3) See the following WHO publications: Guide to Ship Sanitation* (1967) *Vector Control in International Health* (1972); *Guide to Hygiene and Sanitation in Aviation*, 2nd ed., (1977); *Guidelines for drinking-water quality*, Second edition. *Volume 1. Recommendations* (1993), *Volume 2. Health criteria and other supporting information* (in press), *Volume 3. Surveillance and control of community supplies* (in preparation)

[20] *Health administrations are urged to make from time to time a review of the ports designated under the Regulations in order to determine whether such designations meet the conditions of traffic. (WHO Official Records, No. 127, 1963, p. 35)*

[21] *There are no provisions of the Regulations which exempt travellers with diplomatic status from the application of the Regulations. Health measures—e.g., examination of vaccination certificates—carried out in accordance with the Regulations have as thdr object the protection of health and are to be dissociated Tom other measures of an administrative or police nature regulating entry into and sojourn in a country and from which persons with diplomatic status may be exempt. As a consequence, the Regulations are applicable to travellers with diplomatic status and, depending on the circumstances, such travellers may be placed under medical surveillance or isolation if, for example, they do not possess the necessary certificates of vaccination. (WHO Official Records, No. 143, 1965, p. 49)*

[22] *See note to Article 46, p. 25.*

[23] *enforcement of surveillance must rely on national legislation. (WHO Official Records, No. 56, 1954,p. 56, and No. 143,1965, p. 49)*

[24] *enforcement of surveillance must rely on national legislation. (WHO Official Records, No. 56, 1954,p. 56, and No. 143,1965, p. 49)*

[25] *(1) Health administrations are urged to take all practical measures to inform the travelling public and travel agencies of the vaccination requirements of all countries to which a traveller is proceeding. They should advise travellers that these requirements are related not only to the health conditions prevailing in the country*



*of departure but also to conditions in countries in which the traveller disembarks or transits during his journey, except in so far as he follows the provisions of Article 34. (WHO Offcial Records, No. 127, 1963, p. 45, and No. 143,1965, p. 49)*

*(2) "Operators shall take precautions to the end that passengers hold any control documents required by Contracting States." (Standard 3.36, eighth edition of the ICAO Annex 9 to the Convention on International Civil Aviation; WHO Official Records, No. 143, 1965, p. 49)*

*(3) "Public authorities should invite shipowners to take all reasonable precautions to the end that passengers hold any control documents required by Contracting Governments." (Recommended Practice 3.15.1, Convention on Facilitation of International Maritime Traffc, Inter-Governmental Maritime Consultative Organization, 1965)*

*(4) Health administrations should take the steps necessary for embassies abroad to be informed of their country's health requirements, so that potential travellers could obtain up-to-date information. Airlines and travel agents should continue to improve their efforts to inform their customers of the health requirements of countries to be visited. (WHO Official Records, No. 217,1974, pp. 55 and 63, and No. 240, 1977, p. 60)*

*(5) See Article 83, p. 36*

[26] *See notes to Article I, definition of "medical examination", p. 9.*

[27] *See notes to Article I, definition of "medical examination", p. 9.*

[28] *(1) Officers in command of aircraft and ships should make known as long as possible before arrival to airport and port authorities any case of illness on board, in the interests of the patient and the health authority and to facilitate the clearance of the aircraft or ship. (WHO Of ficial Records, No. 209, 1973, p. 78)*

*(2) As radio pratique has been extensively used without endangering public health, serious consideration should be given to expanding that practice. (WHO Of ficial Records, No. 217, 1974, p. 64)*

[29] *(1) Officers in command of aircraft and ships should make known as long as possible before arrival to airport and port authorities any case of illness on board, in the interests of the patient and the health authority and to facilitate the clearance of the aircraft or ship. (WHO Of ficial Records, No. 209, 1973, p. 78)*
*(2) As radio pratique has been extensively used without endangering public health, serious consideration should be given to expanding that practice. (WHO Of ficial Records, No. 217, 1974, p. 64)*

[30] *See notes to Article I, definition of "medical examination", p. 9.*

[31] *Compulsory removal of infected persons should not be insisted upon in ports where adequate facilities for the reception of such persons cannot be expected to be available. (WHO Official Records, No. 64, 1955, p. 34)*

[32] *The duty of the health authority at the port of export is to take all practicable measures under the terms of paragraph I (b) of Article 30 to prevent the introduction on board a ship, an aircraft, a train, a road vehicle or other means of transport of possible agents of infection or vectors of a disease subject to the Regulations. Whenever disinfection has been carried out by the health authority, it is required to furnish a certificate to that effect, if requested to do so, in accordance with the terms of paragraph 2 (b) of Article 26. If no measures have been carried out, the implication is that the health authority did not consider them necessary, but it is not required under Article 26 to furnish a certificate to that effect. (WHO Official Records, No. 56, 1954, p. 47)*

[33] *(l) Deratting Certificates and Deratting Exemption Certificates are valid for a maximum Of six months but, under certain conditions, the validity Of such certificates may be extended only once by a period Of one month. (WHO Official Records, No. 79, 1957, p. 502, No. 87, 1958, p. 404, and No. 95, 1959, p. 482)*

*(2) If inspection Of a ship, carried out at the end Of the period of validity Of its Deratting Exemption Certificate, proves that the ship is still entitled to a Deratting Exemption Certificate, a new certificate should be issued. Periodic deratting Of ships is not necessary if inspection proves that the ship is entitled to a Dcratting Exemption Certificate. (WHO Official Records, No. 87,1958, p. 405)*

*(3) There is no provision in the Regulations for endorsement by a port health authority Of a valid Deratting Certificate or Deratung Exemption Certificate to the effect that inspection Of the ship has confirmed the accuracy Of the information elves on the certificate. (WHO Offcial Rccords, No. 79, 1957, p. 502)*

[34] **(1) Vaccination, while it provides limited individual protection to the traveller, is irrelevant to the problem of protecting a community from importation of the vibrio. (WHO Official Records, No. 209, 1973, p. 91, and No. 240, 1977, p. 53)**

**(2) Restrictive measures would not prevent the international spread of the disease. (WHO Official Records, No. 217, 1974, p. 60)**

35 The previous text of this article referred expressly to the following foodstuffs: fish, shellfish, fruit, vegetables or beverages.

36 *(1) The recommendations concerning the disinsecting of aircraft contained in Annex VI to the Second Annotated Edition of the Regulations are under review in the light of technical developments. Current information may be obtained from the Division of Control of Tropical Diseases, World Health Organization.*

37 *The two conditions indicated in paragraph 2 must be fulfilled before a health authority may consider an aircraft as suspected. (WHO Offficial Records, No. 118, 1962, p. 49)*

38 *(1) A certificate not printed in the proper form or not completed in the English or French language is not a valid certificate under the Regulations. (WHO Official Records, No. 102, 1960, p. 48, and No. 118, 1962, p. 54)*

*(2) The date on certificates of vaccination should be recorded in the following sequence: day, month, year—the month to be written in letters and not in figures (example: 5 January 1982) (WHO Official Records, No. 56, 1954, p. 54, and No. 118, 1962, p. 54)*

*(3) Health administrations should take all reasonable steps to ensure that the certificates issued in their territories are in conformity with the Regulations and the interpretations thereon of the Health Assembly, and particularly that certificates are fully completed and all entries on them are legible. (WHO Official Records, No. 102, 1960, p. 50, and No. 118, 1962, p. 54)*

*See also the notes to Appendix 2 (p. 45).*

*For model Or a correctly completed cerdficate, see Annex VI, pp. 64-65.*

39 *No health certificate may be required from persons on an international voyage. In the case of travellers who, though not immigrants, are nevertheless intending to reside in a country for a protracted period (such as students), the provision of a health certificate should preferably be a condition of the granting of the visa rather than be required as a travel document on arrival. (WHO Of ficial Records, No. 72, 1956, p. 37)*

40 *(1) It is not permissible to exact or receive payment for medical examination carried out at any time of the day or night. The terms of Article 24 require that health measures shall be initiated forthwith and completed without delay. Arrangements should be made to enable quarantine services to do this at all times, particularly in airports and the larger ports. (WHO Official Records, No. 56, 1954, p. 56, and No. 72, 1956, p. 37)*

*(2) An aircraft operator, as the employer of the disembarking crew, might be held responsible for isolation expenses of its own employees (crew). However, isolation expenses for other international travellers cannot be the subject of a charge against the carrier; these expenses are for the traveller himself or for the country of disembarkation to pay. (WHO Official Records, No. 135, 1964, p. 39, and No. 143, 1965, p. 57)*

*(3) Fines such as those imposed on a ship for not hoisting on arrival a flag requesting free pratique, and any other charges not covered by the Regulations, such as port dues, are matters of maritime practice and the Regulations are not applicable. (WHO Official Records, No. 72, 1956, p. 37)*

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42 *(1) Health administrations of countries which are approaching or have already reached the phases of consolidation or maintenance of a malaria eradication programme may need to take measures to~prevent the importation of malaria. (WHO Official Records, No. 87, 1958, p. 413)*

*(2) (i) Persons originating in malarious areas and proceeding to areas from which malaria has been eradicated and where conditions for transmission persist (recipient areas) who would probably Give in towns and therefore present Gttle danger for transmission, should be advised to take sporontocidal treatment if they plan to spend nights in the countryside. A suitable information or warning card should be given to these individuals on entry.*

*(ii) The medical officers responsible for crews of ships and aircraft should be adequately trained in the diagnosis and treatment of malaria and in measures of personal prophylaxis. Operators and shipowners should ensure that all members of crews of ships and aircraft touching ports and airports in malarious areas are subjected*



*to supervised suppressant treatment during a suitable period of time. (WHO Official Records, No. 135, 1964, p. 34*

*(3) Persons on an international voyage (other than those mentioned in Article 84) should not be subjected to any special measures in respect of malaria. Special attention should be given to individuals or groups of travellers specified under Article 84. (WHO 00cial Records, No. 87, 1958, p. 413, and No. 135, 1964, p. 34)*

*(4) Efforts to disseminate information on malaria risk to travellers, through physicians, travel agents, airlines, shipping companies and other appropriate means, should be intensified. (WHO 00cial Records, No. 217, 1974, p. 63)*

*(5) The Weekly Epidemiological Record publishes every year information on the malaria situation in the world, particularly referring to malaria-free countries/areas, incidence of the disease in malarious countries/areas, malaria imported into malaria-free countries/areas, occurrence of drug resistant malaria, and including a map showing the malaria distribution in the world.*

*(6) The recommendations concerning the disinsecting of aircraft, contained in Annex VI to the Second Annotated Edition of the Regulations, are under review in the light of technical developments. Current information may be obtained from the Division of Control of Tropical Diseases, World Health Organization. For special measures applicable to certain categories of travellers, see Article 84.*

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44 *(1) (i) To prevent the introduction of malaria into recipient areas, special measures should be applied to individuals or groups of persons specified under Article 84 arriving from areas where malaria transmission occurs.*

*(ii) Appropriate steps should be taken against mosquitos in frontier zones in the centres where the above-mentioned groups assemble.*

*(iii) In international frontier zones, common control measures should be adopted by the countries concerned to avoid the carrying of malaria from one country to another.*

*(iv) Full exchange of information on the movement of population groups and on the susceptibility and resistance of anopheline vectors to insecticides should be instituted. (WHO 00cial Records, No. 135, 1964,p.33)*

*(2) For WHO recommended standards of hygiene on ships and aircraft carrying persons taking part in periodic mass congregations, see Annex V, page 61.*

45 See Article 35 and the WHO publication *Vector Control in International Health* (1972)

46 **(1) It rests with each country to decide whether a certificate of vaccination against yellow fever shall be required for infants under one year of age, after weighing the risk of importation of yellow fever by unvaccinated infants against the risk to the infant arising from the vaccination. In case of a decision to vaccinate, the dose of vaccine should be the same for infants as for adults and should not, under any circumstances, be reduced. (WHO Official Records, No. 64,**

**1955, p. 36)**

(2) In the case of a revaccination being recorded on a new certificate, travellers are advised to retain the old certificate for ten days, until the new certificate is valid by itself. (WHO Official Records, No. 87, 1958, p. 414)

(3) Medical services on board merchant ships (even where the ships' surgeons are officials of the public health service) should not be designated as approved centres for the issue of international certificates of vaccination against yellow fever; they would not comply with the requirements set out in Appendix 2 since they would not be situated at all times in the territory of the State designating them. (WHO Official Records, No. 72, 1956, p. 37, and No. 79, 1957, p. 512)

**See also notes to Article 79, p. 34.**

[47][41] If more than four weeks have elapsed since the voyage began, it will surhce to give particulars for the last four weeks.

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[51]* State whether recovered, still ill, died.

[52]** State whether still on board, landed at (give name of port), buried at sea.

[53][47] **Only the reservations to the unamended International Health Regulations (1969) are included in this annex.**

[54][48] Although the mode of transmission is not specified in the Regulations, airmail transmission should be used by countries outside Europe.

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[69][63] **Adopted by the twenty-seventh World Health Assembly in resolution WHA27.45 (WHO Official Records, No. 217, 1974, pp. 21, 68, and 71). See Article 84, pare. 3, p. 38.**

[70][64] An existing ship is one for which the keel was laid or which is in service prior to the date of publication of these standards (26 July 1974; see *Weekly Epidemiological Record, 49:* 256-258 ( 1974)).

[71][65] 3 For all aspects of food and water supply, see World Health Organization (1967) *Gulde to Ship Sanitation,* Geneva.



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[73][67] For all aspects of food and water supply, see World Health Organization (1967) *Gulde to Ship Sanitation,* Geneva.

[74][68] For all aspects of food and water supply, see World Health Organization (1967) *Guade to Ship Sanitation,* Geneva.

[75][69] The WHO publication International Medical Guidefor Ships, 2nd ed. (Geneva, *1988) may serve as a basis* for minimum requirements.

[76][70] An existing ship is one for which the keel was laid or which is in service prior to the date of publication of these standards (26 July 1974; see *Weekly Epidemiological Record 49:* 256-258 ( 1974)).

[77][71] Second Annotated Edition of the International Health Regulations (1969).

**FIFTY-EIGHTH WORLD HEALTH ASSEMBLY** **WHA58.3**

**Agenda item 13.1** **23 May 2005**

# Revision of the International Health Regulations

The Fifty-eighth World Health Assembly,

Having considered the draft revised International Health Regulations;[1]

Having regard to articles 2(*k*), 21(*a*) and 22 of the Constitution of WHO;

Recalling references to the need for revising and updating the International Health Regulations in resolutions WHA48.7 on revision and updating of the International Health Regulations, WHA54.14 on global health security: epidemic alert and response, WHA55.16 on global public health response to natural occurrence, accidental release or deliberate use of biological and chemical agents or radionuclear material that affect health, WHA56.28 on revision of the International Health Regulations, and WHA56.29 on severe acute respiratory syndrome (SARS), with a view to responding to the need to ensure global public health;

Welcoming resolution 58/3 of the United Nations General Assembly on enhancing capacity building in global public health, which underscores the importance of the International Health Regulations and urges that high priority should be given to their revision;

Affirming the continuing importance of WHO's role in global outbreak alert and response to public health events, in accordance with its mandate;

Underscoring the continued importance of the International Health Regulations as the key global instrument for protection against the international spread of disease;

Commending the successful conclusion of the work of the Intergovernmental Working Group on Revision of the International Health Regulations,

[1] See document A58/4.



1. ADOPTS the revised International Health Regulations attached to this resolution, to be referred to as the "International Health Regulations (2005)";

2. CALLS UPON Member States and the Director-General to implement fully the International Health Regulations (2005), in accordance with the purpose and scope set out in Article 2 and the principles embodied in Article 3;

3. DECIDES, for the purposes of paragraph 1 of Article 54 of the International Health Regulations (2005), that States Parties and the Director-General shall submit their first report to the Sixty-first World Health Assembly, and that the Health Assembly shall on that occasion consider the schedule for the submission of further such reports and the first review on the functioning of the Regulations pursuant to paragraph 2 of Article 54;

4. FURTHER DECIDES that, for the purposes of paragraph 1 of Article 14 of the International Health Regulations (2005), the other competent intergovernmental organizations or international bodies with which WHO is expected to cooperate and coordinate its activities, as appropriate, include the following: United Nations, International Labour Organization, Food and Agriculture Organization, International Atomic Energy Agency, International Civil Aviation Organization, International Maritime Organization, International Committee of the Red Cross, International Federation of Red Cross and Red Crescent Societies, International Air Transport Association, International Shipping Federation, and *Office International des Epizooties*;

5. URGES Member States:

(1) to build, strengthen and maintain the capacities required under the International Health Regulations (2005), and to mobilize the resources necessary for that purpose;

(2) to collaborate actively with each other and WHO in accordance with the relevant provisions of the International Health Regulations (2005), so as to ensure their effective implementation;

(3) to provide support to developing countries and countries with economies in transition if they so request in the building, strengthening and maintenance of the public health capacities required under the International Health Regulations (2005);

(4) to take all appropriate measures, pending entry into force of the International Health Regulations (2005), for furthering their purpose and eventual implementation, including development of the necessary public health capacities and legal and administrative provisions, and, in particular, to initiate the process for introducing use of the decision instrument contained in Annex 2;

6. REQUESTS the Director-General:

(1) to give prompt notification of the adoption of the International Health Regulations (2005) in accordance with paragraph 1 of Article 65 thereof;

(2) to inform other competent intergovernmental organizations or international bodies of the adoption of the International Health Regulations (2005) and, as appropriate, to cooperate with them in the updating of their norms and standards and to coordinate with them the activities of WHO under the International Health Regulations (2005) with a view to ensuring the application

of adequate measures for the protection of public health and strengthening of the global public-health response to the international spread of disease;

(3) to transmit to the International Civil Aviation Organization (ICAO) the recommended changes to the Health Part of the Aircraft General Declaration,[1] and, after completion by ICAO of its revision of the Aircraft General Declaration, to inform the Health Assembly and replace Annex 9 of the International Health Regulations (2005) with the Health Part of the Aircraft General Declaration as revised by ICAO;

(4) to build and strengthen the capacities of WHO to perform fully and effectively the functions entrusted to it under the International Health Regulations (2005), in particular through strategic health operations that provide support to countries in detection and assessment of, and response to, public health emergencies;

(5) to collaborate with States Parties to the International Health Regulations (2005), as appropriate, including through the provision or facilitation of technical cooperation and logistical support;

(6) to collaborate with States Parties to the extent possible in the mobilization of financial resources to provide support to developing countries in building, strengthening and maintaining the capacities required under the International Health Regulations (2005);

(7) to draw up, in consultation with Member States, guidelines for the application of health measures at ground crossings in accordance with Article 29 of the International Health Regulations (2005);

(8) to establish the Review Committee of the International Health Regulations (2005) in accordance with Article 50 of these Regulations;

(9) to take steps immediately to prepare guidelines for the implementation and evaluation of the decision instrument contained in the International Health Regulations (2005), including elaboration of a procedure for the review of its functioning, which shall be submitted to the Health Assembly for its consideration pursuant to paragraph 3 of Article 54 of these Regulations;

(10) to take steps to establish an IHR Roster of Experts and to invite proposals for its membership, pursuant to Article 47 of the International Health Regulations (2005).

[1] Document A58/41 Add.2.

# INTERNATIONAL HEALTH REGULATIONS (2005)

## PART I – DEFINITIONS, PURPOSE AND SCOPE, PRINCIPLES AND RESPONSIBLE AUTHORITIES

*Article 1 Definitions*

1. For the purposes of the International Health Regulations (hereinafter the "IHR" or "Regulations"):

"affected" means persons, baggage, cargo, containers, conveyances, goods, postal parcels or human remains that are infected or contaminated, or carry sources of infection or contamination, so as to constitute a public health risk;

"affected area" means a geographical location specifically for which health measures have been recommended by WHO under these Regulations;

"aircraft" means an aircraft making an international voyage;

"airport" means any airport where international flights arrive or depart;

"arrival" of a conveyance means:

(a) in the case of a seagoing vessel, arrival or anchoring in the defined area of a port;

(b) in the case of an aircraft, arrival at an airport;

(c) in the case of an inland navigation vessel on an international voyage, arrival at a point of entry;

(d) in the case of a train or road vehicle, arrival at a point of entry;

"baggage" means the personal effects of a traveller;

"cargo" means goods carried on a conveyance or in a container;

"competent authority" means an authority responsible for the implementation and application of health measures under these Regulations;

"container" means an article of transport equipment:

(a) of a permanent character and accordingly strong enough to be suitable for repeated use;

(b) specially designed to facilitate the carriage of goods by one or more modes of transport, without intermediate reloading;

(c) fitted with devices permitting its ready handling, particularly its transfer from one mode of transport to another; and





(d) specially designed as to be easy to fill and empty;

"container loading area" means a place or facility set aside for containers used in international traffic;

"contamination" means the presence of an infectious or toxic agent or matter on a human or animal body surface, in or on a product prepared for consumption or on other inanimate objects, including conveyances, that may constitute a public health risk;

"conveyance" means an aircraft, ship, train, road vehicle or other means of transport on an international voyage;

"conveyance operator" means a natural or legal person in charge of a conveyance or their agent;

"crew" means persons on board a conveyance who are not passengers;

"decontamination" means a procedure whereby health measures are taken to eliminate an infectious or toxic agent or matter on a human or animal body surface, in or on a product prepared for consumption or on other inanimate objects, including conveyances, that may constitute a public health risk;

"departure" means, for persons, baggage, cargo, conveyances or goods, the act of leaving a territory;

"deratting" means the procedure whereby health measures are taken to control or kill rodent vectors of human disease present in baggage, cargo, containers, conveyances, facilities, goods and postal parcels at the point of entry;

"Director-General" means the Director-General of the World Health Organization;

"disease" means an illness or medical condition, irrespective of origin or source, that presents or could present significant harm to humans;

"disinfection" means the procedure whereby health measures are taken to control or kill infectious agents on a human or animal body surface or in or on baggage, cargo, containers, conveyances, goods and postal parcels by direct exposure to chemical or physical agents;

"disinsection" means the procedure whereby health measures are taken to control or kill the insect vectors of human diseases present in baggage, cargo, containers, conveyances, goods and postal parcels;

"event" means a manifestation of disease or an occurrence that creates a potential for disease;

"*free pratique*" means permission for a ship to enter a port, embark or disembark, discharge or load cargo or stores; permission for an aircraft, after landing, to embark or disembark, discharge or load cargo or stores; and permission for a ground transport vehicle, upon arrival, to embark or disembark, discharge or load cargo or stores;

"goods" mean tangible products, including animals and plants, transported on an international voyage, including for utilization on board a conveyance;

"ground crossing" means a point of land entry in a State Party, including one utilized by road vehicles and trains;

"ground transport vehicle" means a motorized conveyance for overland transport on an international voyage, including trains, coaches, lorries and automobiles;

"health measure" means procedures applied to prevent the spread of disease or contamination; a health measure does not include law enforcement or security measures;

"ill person" means an individual suffering from or affected with a physical ailment that may pose a public health risk;

"infection" means the entry and development or multiplication of an infectious agent in the body of humans and animals that may constitute a public health risk;

"inspection" means the examination, by the competent authority or under its supervision, of areas, baggage, containers, conveyances, facilities, goods or postal parcels, including relevant data and documentation, to determine if a public health risk exists;

"international traffic" means the movement of persons, baggage, cargo, containers, conveyances, goods or postal parcels across an international border, including international trade;

"international voyage" means:

(a) in the case of a conveyance, a voyage between points of entry in the territories of more than one State, or a voyage between points of entry in the territory or territories of the same State if the conveyance has contacts with the territory of any other State on its voyage but only as regards those contacts;

(b) in the case of a traveller, a voyage involving entry into the territory of a State other than the territory of the State in which that traveller commences the voyage;

"intrusive" means possibly provoking discomfort through close or intimate contact or questioning;

"invasive" means the puncture or incision of the skin or insertion of an instrument or foreign material into the body or the examination of a body cavity. For the purposes of these Regulations, medical examination of the ear, nose and mouth, temperature assessment using an ear, oral or cutaneous thermometer, or thermal imaging; medical inspection; auscultation; external palpation; retinoscopy; external collection of urine, faeces or saliva samples; external measurement of blood pressure; and electrocardiography shall be considered to be non-invasive;

"isolation" means separation of ill or contaminated persons or affected baggage, containers, conveyances, goods or postal parcels from others in such a manner as to prevent the spread of infection or contamination;

"medical examination" means the preliminary assessment of a person by an authorized health worker or by a person under the direct supervision of the competent authority, to determine the person's health status and potential public health risk to others, and may include the scrutiny of health documents, and a physical examination when justified by the circumstances of the individual case;





"National IHR Focal Point" means the national centre, designated by each State Party, which shall be accessible at all times for communications with WHO IHR Contact Points under these Regulations;

"Organization" or "WHO" means the World Health Organization;

"permanent residence" has the meaning as determined in the national law of the State Party concerned;

"personal data" means any information relating to an identified or identifiable natural person;

"point of entry" means a passage for international entry or exit of travellers, baggage, cargo, containers, conveyances, goods and postal parcels as well as agencies and areas providing services to them on entry or exit;

"port" means a seaport or a port on an inland body of water where ships on an international voyage arrive or depart;

"postal parcel" means an addressed article or package carried internationally by postal or courier services;

"public health emergency of international concern" means an extraordinary event which is determined, as provided in these Regulations:

(i) to constitute a public health risk to other States through the international spread of disease and

(ii) to potentially require a coordinated international response;

"public health observation" means the monitoring of the health status of a traveller over time for the purpose of determining the risk of disease transmission;

"public health risk" means a likelihood of an event that may affect adversely the health of human populations, with an emphasis on one which may spread internationally or may present a serious and direct danger;

"quarantine" means the restriction of activities and/or separation from others of suspect persons who are not ill or of suspect baggage, containers, conveyances or goods in such a manner as to prevent the possible spread of infection or contamination;

"recommendation" and "recommended" refer to temporary or standing recommendations issued under these Regulations;

"reservoir" means an animal, plant or substance in which an infectious agent normally lives and whose presence may constitute a public health risk;

"road vehicle" means a ground transport vehicle other than a train;

"scientific evidence" means information furnishing a level of proof based on the established and accepted methods of science;

"scientific principles" means the accepted fundamental laws and facts of nature known through the methods of science;

"ship" means a seagoing or inland navigation vessel on an international voyage;

"standing recommendation" means non-binding advice issued by WHO for specific ongoing public health risks pursuant to Article 16 regarding appropriate health measures for routine or periodic application needed to prevent or reduce the international spread of disease and minimize interference with international traffic;

"surveillance" means the systematic ongoing collection, collation and analysis of data for public health purposes and the timely dissemination of public health information for assessment and public health response as necessary;

"suspect" means those persons, baggage, cargo, containers, conveyances, goods or postal parcels considered by a State Party as having been exposed, or possibly exposed, to a public health risk and that could be a possible source of spread of disease;

"temporary recommendation" means non-binding advice issued by WHO pursuant to Article 15 for application on a time-limited, risk-specific basis, in response to a public health emergency of international concern, so as to prevent or reduce the international spread of disease and minimize interference with international traffic;

"temporary residence" has the meaning as determined in the national law of the State Party concerned;

"traveller" means a natural person undertaking an international voyage;

"vector" means an insect or other animal which normally transports an infectious agent that constitutes a public health risk;

"verification" means the provision of information by a State Party to WHO confirming the status of an event within the territory or territories of that State Party;

"WHO IHR Contact Point" means the unit within WHO which shall be accessible at all times for communications with the National IHR Focal Point.

2. Unless otherwise specified or determined by the context, reference to these Regulations includes the annexes thereto.

*Article 2 Purpose and scope*

The purpose and scope of these Regulations are to prevent, protect against, control and provide a public health response to the international spread of disease in ways that are commensurate with and restricted to public health risks, and which avoid unnecessary interference with international traffic and trade.





*Article 3 Principles*

1. The implementation of these Regulations shall be with full respect for the dignity, human rights and fundamental freedoms of persons.

2. The implementation of these Regulations shall be guided by the Charter of the United Nations and the Constitution of the World Health Organization.

3. The implementation of these Regulations shall be guided by the goal of their universal application for the protection of all people of the world from the international spread of disease.

4. States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to legislate and to implement legislation in pursuance of their health policies. In doing so they should uphold the purpose of these Regulations.

*Article 4 Responsible authorities*

1. Each State Party shall designate or establish a National IHR Focal Point and the authorities responsible within its respective jurisdiction for the implementation of health measures under these Regulations.

2. National IHR Focal Points shall be accessible at all times for communications with the WHO IHR Contact Points provided for in paragraph 3 of this Article. The functions of National IHR Focal Points shall include:

(a) sending to WHO IHR Contact Points, on behalf of the State Party concerned, urgent communications concerning the implementation of these Regulations, in particular under Articles 6 to 12; and

(b) disseminating information to, and consolidating input from, relevant sectors of the administration of the State Party concerned, including those responsible for surveillance and reporting, points of entry, public health services, clinics and hospitals and other government departments.

3. WHO shall designate IHR Contact Points, which shall be accessible at all times for communications with National IHR Focal Points. WHO IHR Contact Points shall send urgent communications concerning the implementation of these Regulations, in particular under Articles 6 to 12, to the National IHR Focal Point of the States Parties concerned. WHO IHR Contact Points may be designated by WHO at the headquarters or at the regional level of the Organization.

4. States Parties shall provide WHO with contact details of their National IHR Focal Point and WHO shall provide States Parties with contact details of WHO IHR Contact Points. These contact details shall be continuously updated and annually confirmed. WHO shall make available to all States Parties the contact details of National IHR Focal Points it receives pursuant to this Article.

## PART II – INFORMATION AND PUBLIC HEALTH RESPONSE

*Article 5 Surveillance*

1. Each State Party shall develop, strengthen and maintain, as soon as possible but no later than five years from the entry into force of these Regulations for that State Party, the capacity to detect, assess, notify and report events in accordance with these Regulations, as specified in Annex 1.

2. Following the assessment referred to in paragraph 2, Part A of Annex 1, a State Party may report to WHO on the basis of a justified need and an implementation plan and, in so doing, obtain an extension of two years in which to fulfil the obligation in paragraph 1 of this Article. In exceptional circumstances, and supported by a new implementation plan, the State Party may request a further extension not exceeding two years from the Director-General, who shall make the decision, taking into account the technical advice of the Committee established under Article 50 (hereinafter the "Review Committee"). After the period mentioned in paragraph 1 of this Article, the State Party that has obtained an extension shall report annually to WHO on progress made towards the full implementation.

3. WHO shall assist States Parties, upon request, to develop, strengthen and maintain the capacities referred to in paragraph 1 of this Article.

4. WHO shall collect information regarding events through its surveillance activities and assess their potential to cause international disease spread and possible interference with international traffic. Information received by WHO under this paragraph shall be handled in accordance with Articles 11 and 45 where appropriate.

*Article 6 Notification*

1. Each State Party shall assess events occurring within its territory by using the decision instrument in Annex 2. Each State Party shall notify WHO, by the most efficient means of communication available, by way of the National IHR Focal Point, and within 24 hours of assessment of public health information, of all events which may constitute a public health emergency of international concern within its territory in accordance with the decision instrument, as well as any health measure implemented in response to those events. If the notification received by WHO involves the competency of the International Atomic Energy Agency (IAEA), WHO shall immediately notify the IAEA.

2. Following a notification, a State Party shall continue to communicate to WHO timely, accurate and sufficiently detailed public health information available to it on the notified event, where possible including case definitions, laboratory results, source and type of the risk, number of cases and deaths, conditions affecting the spread of the disease and the health measures employed; and report, when necessary, the difficulties faced and support needed in responding to the potential public health emergency of international concern.

*Article 7 Information-sharing during unexpected or unusual public health events*

If a State Party has evidence of an unexpected or unusual public health event within its territory, irrespective of origin or source, which may constitute a public health emergency of international concern, it shall provide to WHO all relevant public health information. In such a case, the provisions of Article 6 shall apply in full.





*Article 8 Consultation*

In the case of events occurring within its territory not requiring notification as provided in Article 6, in particular those events for which there is insufficient information available to complete the decision instrument, a State Party may nevertheless keep WHO advised thereof through the National IHR Focal Point and consult with WHO on appropriate health measures. Such communications shall be treated in accordance with paragraphs 2 to 4 of Article 11. The State Party in whose territory the event has occurred may request WHO assistance to assess any epidemiological evidence obtained by that State Party.

*Article 9 Other reports*

1. WHO may take into account reports from sources other than notifications or consultations and shall assess these reports according to established epidemiological principles and then communicate information on the event to the State Party in whose territory the event is allegedly occurring. Before taking any action based on such reports, WHO shall consult with and attempt to obtain verification from the State Party in whose territory the event is allegedly occurring in accordance with the procedure set forth in Article 10. To this end, WHO shall make the information received available to the States Parties and only where it is duly justified may WHO maintain the confidentiality of the source. This information will be used in accordance with the procedure set forth in Article 11.

2. States Parties shall, as far as practicable, inform WHO within 24 hours of receipt of evidence of a public health risk identified outside their territory that may cause international disease spread, as manifested by exported or imported:

(a) human cases;

(b) vectors which carry infection or contamination; or

(c) goods that are contaminated.

*Article 10 Verification*

1. WHO shall request, in accordance with Article 9, verification from a State Party of reports from sources other than notifications or consultations of events which may constitute a public health emergency of international concern allegedly occurring in the State's territory. In such cases, WHO shall inform the State Party concerned regarding the reports it is seeking to verify.

2. Pursuant to the foregoing paragraph and to Article 9, each State Party, when requested by WHO, shall verify and provide:

(a) within 24 hours, an initial reply to, or acknowledgement of, the request from WHO;

(b) within 24 hours, available public health information on the status of events referred to in WHO's request; and

(c) information to WHO in the context of an assessment under Article 6, including relevant information as described in that Article.

3. When WHO receives information of an event that may constitute a public health emergency of international concern, it shall offer to collaborate with the State Party concerned in assessing the potential for international disease spread, possible interference with international traffic and the adequacy of control measures. Such activities may include collaboration with other standard-setting organizations and the offer to mobilize international assistance in order to support the national authorities in conducting and coordinating on-site assessments. When requested by the State Party, WHO shall provide information supporting such an offer.

4. If the State Party does not accept the offer of collaboration, WHO may, when justified by the magnitude of the public health risk, share with other States Parties the information available to it, whilst encouraging the State Party to accept the offer of collaboration by WHO, taking into account the views of the State Party concerned.

*Article 11 Provision of information by WHO*

1. Subject to paragraph 2 of this Article, WHO shall send to all States Parties and, as appropriate, to relevant intergovernmental organizations, as soon as possible and by the most efficient means available, in confidence, such public health information which it has received under Articles 5 to 10 inclusive and which is necessary to enable States Parties to respond to a public health risk. WHO should communicate information to other States Parties that might help them in preventing the occurrence of similar incidents.

2. WHO shall use information received under Articles 6 and 8 and paragraph 2 of Article 9 for verification, assessment and assistance purposes under these Regulations and, unless otherwise agreed with the States Parties referred to in those provisions, shall not make this information generally available to other States Parties, until such time as:

(a) the event is determined to constitute a public health emergency of international concern in accordance with Article 12; or

(b) information evidencing the international spread of the infection or contamination has been confirmed by WHO in accordance with established epidemiological principles; or

(c) there is evidence that:

(i) control measures against the international spread are unlikely to succeed because of the nature of the contamination, disease agent, vector or reservoir; or

(ii) the State Party lacks sufficient operational capacity to carry out necessary measures to prevent further spread of disease; or

(d) the nature and scope of the international movement of travellers, baggage, cargo, containers, conveyances, goods or postal parcels that may be affected by the infection or contamination requires the immediate application of international control measures.

3. WHO shall consult with the State Party in whose territory the event is occurring as to its intent to make information available under this Article.

4. When information received by WHO under paragraph 2 of this Article is made available to States Parties in accordance with these Regulations, WHO may also make it available to the public if





other information about the same event has already become publicly available and there is a need for the dissemination of authoritative and independent information.

*Article 12 Determination of a public health emergency of international concern*

1. The Director-General shall determine, on the basis of the information received, in particular from the State Party within whose territory an event is occurring, whether an event constitutes a public health emergency of international concern in accordance with the criteria and the procedure set out in these Regulations.

2. If the Director-General considers, based on an assessment under these Regulations, that a public health emergency of international concern is occurring, the Director-General shall consult with the State Party in whose territory the event arises regarding this preliminary determination. If the Director-General and the State Party are in agreement regarding this determination, the Director-General shall, in accordance with the procedure set forth in Article 49, seek the views of the Committee established under Article 48 (hereinafter the "Emergency Committee") on appropriate temporary recommendations.

3. If, following the consultation in paragraph 2 above, the Director-General and the State Party in whose territory the event arises do not come to a consensus within 48 hours on whether the event constitutes a public health emergency of international concern, a determination shall be made in accordance with the procedure set forth in Article 49.

4. In determining whether an event constitutes a public health emergency of international concern, the Director-General shall consider:

(a) information provided by the State Party;

(b) the decision instrument contained in Annex 2;

(c) the advice of the Emergency Committee;

(d) scientific principles as well as the available scientific evidence and other relevant information; and

(e) an assessment of the risk to human health, of the risk of international spread of disease and of the risk of interference with international traffic.

5. If the Director-General, following consultations with the State Party within whose territory the public health emergency of international concern has occurred, considers that a public health emergency of international concern has ended, the Director-General shall take a decision in accordance with the procedure set out in Article 49.

*Article 13 Public health response*

1. Each State Party shall develop, strengthen and maintain, as soon as possible but no later than five years from the entry into force of these Regulations for that State Party, the capacity to respond promptly and effectively to public health risks and public health emergencies of international concern as set out in Annex 1. WHO shall publish, in consultation with Member States, guidelines to support States Parties in the development of public health response capacities.

2 Following the assessment referred to in paragraph 2, Part A of Annex 1, a State Party may report to WHO on the basis of a justified need and an implementation plan and, in so doing, obtain an extension of two years in which to fulfil the obligation in paragraph 1 of this Article. In exceptional circumstances and supported by a new implementation plan, the State Party may request a further extension not exceeding two years from the Director-General, who shall make the decision, taking into account the technical advice of the Review Committee. After the period mentioned in paragraph 1 of this Article, the State Party that has obtained an extension shall report annually to WHO on progress made towards the full implementation.

3. At the request of a State Party, WHO shall collaborate in the response to public health risks and other events by providing technical guidance and assistance and by assessing the effectiveness of the control measures in place, including the mobilization of international teams of experts for on-site assistance, when necessary.

4. If WHO, in consultation with the States Parties concerned as provided in Article 12, determines that a public health emergency of international concern is occurring, it may offer, in addition to the support indicated in paragraph 3 of this Article, further assistance to the State Party, including an assessment of the severity of the international risk and the adequacy of control measures. Such collaboration may include the offer to mobilize international assistance in order to support the national authorities in conducting and coordinating on-site assessments. When requested by the State Party, WHO shall provide information supporting such an offer.

5. When requested by WHO, States Parties should provide, to the extent possible, support to WHO-coordinated response activities.

6. When requested, WHO shall provide appropriate guidance and assistance to other States Parties affected or threatened by the public health emergency of international concern.

*Article 14 Cooperation of WHO with intergovernmental organizations and international bodies*

1. WHO shall cooperate and coordinate its activities, as appropriate, with other competent intergovernmental organizations or international bodies in the implementation of these Regulations, including through the conclusion of agreements and other similar arrangements.

2. In cases in which notification or verification of, or response to, an event is primarily within the competence of other intergovernmental organizations or international bodies, WHO shall coordinate its activities with such organizations or bodies in order to ensure the application of adequate measures for the protection of public health.

3. Notwithstanding the foregoing, nothing in these Regulations shall preclude or limit the provision by WHO of advice, support, or technical or other assistance for public health purposes.

## PART III – RECOMMENDATIONS

*Article 15 Temporary recommendations*

1. If it has been determined in accordance with Article 12 that a public health emergency of international concern is occurring, the Director-General shall issue temporary recommendations in accordance with the procedure set out in Article 49. Such temporary recommendations may be





modified or extended as appropriate, including after it has been determined that a public health emergency of international concern has ended, at which time other temporary recommendations may be issued as necessary for the purpose of preventing or promptly detecting its recurrence.

2. Temporary recommendations may include health measures to be implemented by the State Party experiencing the public health emergency of international concern, or by other States Parties, regarding persons, baggage, cargo, containers, conveyances, goods and/or postal parcels to prevent or reduce the international spread of disease and avoid unnecessary interference with international traffic.

3. Temporary recommendations may be terminated in accordance with the procedure set out in Article 49 at any time and shall automatically expire three months after their issuance. They may be modified or extended for additional periods of up to three months. Temporary recommendations may not continue beyond the second World Health Assembly after the determination of the public health emergency of international concern to which they relate.

*Article 16 Standing recommendations*

WHO may make standing recommendations of appropriate health measures in accordance with Article 53 for routine or periodic application. Such measures may be applied by States Parties regarding persons, baggage, cargo, containers, conveyances, goods and/or postal parcels for specific, ongoing public health risks in order to prevent or reduce the international spread of disease and avoid unnecessary interference with international traffic. WHO may, in accordance with Article 53, modify or terminate such recommendations, as appropriate.

*Article 17 Criteria for recommendations*

When issuing, modifying or terminating temporary or standing recommendations, the Director-General shall consider:

(a) the views of the States Parties directly concerned;

(b) the advice of the Emergency Committee or the Review Committee, as the case may be;

(c) scientific principles as well as available scientific evidence and information;

(d) health measures that, on the basis of a risk assessment appropriate to the circumstances, are not more restrictive of international traffic and trade and are not more intrusive to persons than reasonably available alternatives that would achieve the appropriate level of health protection;

(e) relevant international standards and instruments;

(f) activities undertaken by other relevant intergovernmental organizations and international bodies; and

(g) other appropriate and specific information relevant to the event.

With respect to temporary recommendations, the consideration by the Director-General of subparagraphs (e) and (f) of this Article may be subject to limitations imposed by urgent circumstances.

*Article 18 Recommendations with respect to persons, baggage, cargo, containers, conveyances, goods and postal parcels*

1. Recommendations issued by WHO to States Parties with respect to persons may include the following advice:

- no specific health measures are advised;
- review travel history in affected areas;
- review proof of medical examination and any laboratory analysis;
- require medical examinations;
- review proof of vaccination or other prophylaxis;
- require vaccination or other prophylaxis;
- place suspect persons under public health observation;
- implement quarantine or other health measures for suspect persons;
- implement isolation and treatment where necessary of affected persons;
- implement tracing of contacts of suspect or affected persons;
- refuse entry of suspect and affected persons;
- refuse entry of unaffected persons to affected areas; and
- implement exit screening and/or restrictions on persons from affected areas.

2. Recommendations issued by WHO to States Parties with respect to baggage, cargo, containers, conveyances, goods and postal parcels may include the following advice:

- no specific health measures are advised;
- review manifest and routing;
- implement inspections;
- review proof of measures taken on departure or in transit to eliminate infection or contamination;
- implement treatment of the baggage, cargo, containers, conveyances, goods, postal parcels or human remains to remove infection or contamination, including vectors and reservoirs;
- the use of specific health measures to ensure the safe handling and transport of human remains;





- implement isolation or quarantine;
- seizure and destruction of infected or contaminated or suspect baggage, cargo, containers, conveyances, goods or postal parcels under controlled conditions if no available treatment or process will otherwise be successful; and
- refuse departure or entry.

## PART IV – POINTS OF ENTRY

*Article 19 General obligations*

Each State Party shall, in addition to the other obligations provided for under these Regulations:

(a) ensure that the capacities set forth in Annex 1 for designated points of entry are developed within the timeframe provided in paragraph 1 of Article 5 and paragraph 1 of Article 13;

(b) identify the competent authorities at each designated point of entry in its territory; and

(c) furnish to WHO, as far as practicable, when requested in response to a specific potential public health risk, relevant data concerning sources of infection or contamination, including vectors and reservoirs, at its points of entry, which could result in international disease spread.

*Article 20 Airports and ports*

1. States Parties shall designate the airports and ports that shall develop the capacities provided in Annex 1.

2. States Parties shall ensure that Ship Sanitation Control Exemption Certificates and Ship Sanitation Control Certificates are issued in accordance with the requirements in Article 39 and the model provided in Annex 3.

3. Each State Party shall send to WHO a list of ports authorized to offer:

(a) the issuance of Ship Sanitation Control Certificates and the provision of the services referred to in Annexes 1 and 3; or

(b) the issuance of Ship Sanitation Control Exemption Certificates only; and

(c) extension of the Ship Sanitation Control Exemption Certificate for a period of one month until the arrival of the ship in the port at which the Certificate may be received.

Each State Party shall inform WHO of any changes which may occur to the status of the listed ports. WHO shall publish the information received under this paragraph.

4. WHO may, at the request of the State Party concerned, arrange to certify, after an appropriate investigation, that an airport or port in its territory meets the requirements referred to in paragraphs 1

and 3 of this Article. These certifications may be subject to periodic review by WHO, in consultation with the State Party.

5. WHO, in collaboration with competent intergovernmental organizations and international bodies, shall develop and publish the certification guidelines for airports and ports under this Article. WHO shall also publish a list of certified airports and ports.

*Article 21 Ground crossings*

1. Where justified for public health reasons, a State Party may designate ground crossings that shall develop the capacities provided in Annex 1, taking into consideration:

(a) the volume and frequency of the various types of international traffic, as compared to other points of entry, at a State Party's ground crossings which might be designated; and

(b) the public health risks existing in areas in which the international traffic originates, or through which it passes, prior to arrival at a particular ground crossing.

2. States Parties sharing common borders should consider:

(a) entering into bilateral or multilateral agreements or arrangements concerning prevention or control of international transmission of disease at ground crossings in accordance with Article 57; and

(b) joint designation of adjacent ground crossings for the capacities in Annex 1 in accordance with paragraph 1 of this Article.

*Article 22 Role of competent authorities*

1. The competent authorities shall:

(a) be responsible for monitoring baggage, cargo, containers, conveyances, goods, postal parcels and human remains departing and arriving from affected areas, so that they are maintained in such a condition that they are free of sources of infection or contamination, including vectors and reservoirs;

(b) ensure, as far as practicable, that facilities used by travellers at points of entry are maintained in a sanitary condition and are kept free of sources of infection or contamination, including vectors and reservoirs;

(c) be responsible for the supervision of any deratting, disinfection, disinsection or decontamination of baggage, cargo, containers, conveyances, goods, postal parcels and human remains or sanitary measures for persons, as appropriate under these Regulations;

(d) advise conveyance operators, as far in advance as possible, of their intent to apply control measures to a conveyance, and shall provide, where available, written information concerning the methods to be employed;





(e) be responsible for the supervision of the removal and safe disposal of any contaminated water or food, human or animal dejecta, wastewater and any other contaminated matter from a conveyance;

(f) take all practicable measures consistent with these Regulations to monitor and control the discharge by ships of sewage, refuse, ballast water and other potentially disease-causing matter which might contaminate the waters of a port, river, canal, strait, lake or other international waterway;

(g) be responsible for supervision of service providers for services concerning travellers, baggage, cargo, containers, conveyances, goods, postal parcels and human remains at points of entry, including the conduct of inspections and medical examinations as necessary;

(h) have effective contingency arrangements to deal with an unexpected public health event; and

(i) communicate with the National IHR Focal Point on the relevant public health measures taken pursuant to these Regulations.

2. Health measures recommended by WHO for travellers, baggage, cargo, containers, conveyances, goods, postal parcels and human remains arriving from an affected area may be reapplied on arrival, if there are verifiable indications and/or evidence that the measures applied on departure from the affected area were unsuccessful.

3. Disinsection, deratting, disinfection, decontamination and other sanitary procedures shall be carried out so as to avoid injury and as far as possible discomfort to persons, or damage to the environment in a way which impacts on public health, or damage to baggage, cargo, containers, conveyances, goods and postal parcels.

## PART V – PUBLIC HEALTH MEASURES

### Chapter I – General provisions

*Article 23 Health measures on arrival and departure*

1. Subject to applicable international agreements and relevant articles of these Regulations, a State Party may require for public health purposes, on arrival or departure:

(a) with regard to travellers:

(i) information concerning the traveller's destination so that the traveller may be contacted;

(ii) information concerning the traveller's itinerary to ascertain if there was any travel in or near an affected area or other possible contacts with infection or contamination prior to arrival, as well as review of the traveller's health documents if they are required under these Regulations; and or

(iii) a non-invasive medical examination which is the least intrusive examination that would achieve the public health objective;

(b) inspection of baggage, cargo, containers, conveyances, goods, postal parcels and human remains.

2. On the basis of evidence of a public health risk obtained through the measures provided in paragraph 1 of this Article, or through other means, States Parties may apply additional health measures, in accordance with these Regulations, in particular, with regard to a suspect or affected traveller, on a case-by-case basis, the least intrusive and invasive medical examination that would achieve the public health objective of preventing the international spread of disease.

3. No medical examination, vaccination, prophylaxis or health measure under these Regulations shall be carried out on travellers without their prior express informed consent or that of their parents or guardians, except as provided in paragraph 2 of Article 31, and in accordance with the law and international obligations of the State Party.

4. Travellers to be vaccinated or offered prophylaxis pursuant to these Regulations, or their parents or guardians, shall be informed of any risk associated with vaccination or with non-vaccination and with the use or non-use of prophylaxis in accordance with the law and international obligations of the State Party. States Parties shall inform medical practitioners of these requirements in accordance with the law of the State Party.

5. Any medical examination, medical procedure, vaccination or other prophylaxis which involves a risk of disease transmission shall only be performed on, or administered to, a traveller in accordance with established national or international safety guidelines and standards so as to minimize such a risk.

## Chapter II – Special provisions for conveyances and conveyance operators

*Article 24 Conveyance operators*

1. States Parties shall take all practicable measures consistent with these Regulations to ensure that conveyance operators:

(a) comply with the health measures recommended by WHO and adopted by the State Party;

(b) inform travellers of the health measures recommended by WHO and adopted by the State Party for application on board; and

(c) permanently keep conveyances for which they are responsible free of sources of infection or contamination, including vectors and reservoirs. The application of measures to control sources of infection or contamination may be required if evidence is found.

2. Specific provisions pertaining to conveyances and conveyance operators under this Article are provided in Annex 4. Specific measures applicable to conveyances and conveyance operators with regard to vector-borne diseases are provided in Annex 5.





*Article 25 Ships and aircraft in transit*

Subject to Articles 27 and 43 or unless authorized by applicable international agreements, no health measure shall be applied by a State Party to:

(a) a ship not coming from an affected area which passes through a maritime canal or waterway in the territory of that State Party on its way to a port in the territory of another State. Any such ship shall be permitted to take on, under the supervision of the competent authority, fuel, water, food and supplies;

(b) a ship which passes through waters within its jurisdiction without calling at a port or on the coast; and

(c) an aircraft in transit at an airport within its jurisdiction, except that the aircraft may be restricted to a particular area of the airport with no embarking and disembarking or loading and discharging. However, any such aircraft shall be permitted to take on, under the supervision of the competent authority, fuel, water, food and supplies.

*Article 26 Civilian lorries, trains and coaches in transit*

Subject to Articles 27 and 43 or unless authorized by applicable international agreements, no health measure shall be applied to a civilian lorry, train or coach not coming from an affected area which passes through a territory without embarking, disembarking, loading or discharging.

*Article 27 Affected conveyances*

1. If clinical signs or symptoms and information based on fact or evidence of a public health risk, including sources of infection and contamination, are found on board a conveyance, the competent authority shall consider the conveyance as affected and may:

(a) disinfect, decontaminate, disinsect or derat the conveyance, as appropriate, or cause these measures to be carried out under its supervision; and

(b) decide in each case the technique employed to secure an adequate level of control of the public health risk as provided in these Regulations. Where there are methods or materials advised by WHO for these procedures, these should be employed, unless the competent authority determines that other methods are as safe and reliable.

The competent authority may implement additional health measures, including isolation of the conveyances, as necessary, to prevent the spread of disease. Such additional measures should be reported to the National IHR Focal Point.

2. If the competent authority for the point of entry is not able to carry out the control measures required under this Article, the affected conveyance may nevertheless be allowed to depart, subject to the following conditions:

(a) the competent authority shall, at the time of departure, inform the competent authority for the next known point of entry of the type of information referred to under subparagraph (b); and

(b) in the case of a ship, the evidence found and the control measures required shall be noted in the Ship Sanitation Control Certificate.

Any such conveyance shall be permitted to take on, under the supervision of the competent authority, fuel, water, food and supplies.

3. A conveyance that has been considered as affected shall cease to be regarded as such when the competent authority is satisfied that:

(a) the measures provided in paragraph 1 of this Article have been effectively carried out; and

(b) there are no conditions on board that could constitute a public health risk.

*Article 28 Ships and aircraft at points of entry*

1. Subject to Article 43 or as provided in applicable international agreements, a ship or an aircraft shall not be prevented for public health reasons from calling at any point of entry. However, if the point of entry is not equipped for applying health measures under these Regulations, the ship or aircraft may be ordered to proceed at its own risk to the nearest suitable point of entry available to it, unless the ship or aircraft has an operational problem which would make this diversion unsafe.

2. Subject to Article 43 or as provided in applicable international agreements, ships or aircraft shall not be refused *free pratique* by States Parties for public health reasons; in particular they shall not be prevented from embarking or disembarking, discharging or loading cargo or stores, or taking on fuel, water, food and supplies. States Parties may subject the granting of *free pratique* to inspection and, if a source of infection or contamination is found on board, the carrying out of necessary disinfection, decontamination, disinsection or deratting, or other measures necessary to prevent the spread of the infection or contamination.

3. Whenever practicable and subject to the previous paragraph, a State Party shall authorize the granting of *free pratique* by radio or other communication means to a ship or an aircraft when, on the basis of information received from it prior to its arrival, the State Party is of the opinion that the arrival of the ship or aircraft will not result in the introduction or spread of disease.

4. Officers in command of ships or pilots in command of aircraft, or their agents, shall make known to the port or airport control as early as possible before arrival at the port or airport of destination any cases of illness indicative of a disease of an infectious nature or evidence of a public health risk on board as soon as such illnesses or public health risks are made known to the officer or pilot. This information must be immediately relayed to the competent authority for the port or airport. In urgent circumstances, such information should be communicated directly by the officers or pilots to the relevant port or airport authority.

5. The following shall apply if a suspect or affected aircraft or ship, for reasons beyond the control of the pilot in command of the aircraft or the officer in command of the ship, lands elsewhere than at the airport at which the aircraft was due to land or berths elsewhere than at the port at which the ship was due to berth:





(a) the pilot in command of the aircraft or the officer in command of the ship or other person in charge shall make every effort to communicate without delay with the nearest competent authority;

(b) as soon as the competent authority has been informed of the landing it may apply health measures recommended by WHO or other health measures provided in these Regulations;

(c) unless required for emergency purposes or for communication with the competent authority, no traveller on board the aircraft or ship shall leave its vicinity and no cargo shall be removed from that vicinity, unless authorized by the competent authority; and

(d) when all health measures required by the competent authority have been completed, the aircraft or ship may, so far as such health measures are concerned, proceed either to the airport or port at which it was due to land or berth, or, if for technical reasons it cannot do so, to a conveniently situated airport or port.

6. Notwithstanding the provisions contained in this Article, the officer in command of a ship or pilot in command of an aircraft may take such emergency measures as may be necessary for the health and safety of travellers on board. He or she shall inform the competent authority as early as possible concerning any measures taken pursuant to this paragraph.

*Article 29 Civilian lorries, trains and coaches at points of entry*

WHO, in consultation with States Parties, shall develop guiding principles for applying health measures to civilian lorries, trains and coaches at points of entry and passing through ground crossings.

## Chapter III – Special provisions for travellers

*Article 30 Travellers under public health observation*

Subject to Article 43 or as authorized in applicable international agreements, a suspect traveller who on arrival is placed under public health observation may continue an international voyage, if the traveller does not pose an imminent public health risk and the State Party informs the competent authority of the point of entry at destination, if known, of the traveller's expected arrival. On arrival, the traveller shall report to that authority.

*Article 31 Health measures relating to entry of travellers*

1. Invasive medical examination, vaccination or other prophylaxis shall not be required as a condition of entry of any traveller to the territory of a State Party, except that, subject to Articles 32, 42 and 45, these Regulations do not preclude States Parties from requiring medical examination, vaccination or other prophylaxis or proof of vaccination or other prophylaxis:

(a) when necessary to determine whether a public health risk exists;

(b) as a condition of entry for any travellers seeking temporary or permanent residence;

(c) as a condition of entry for any travellers pursuant to Article 43 or Annexes 6 and 7; or

(d) which may be carried out pursuant to Article 23.

2. If a traveller for whom a State Party may require a medical examination, vaccination or other prophylaxis under paragraph 1 of this Article fails to consent to any such measure, or refuses to provide the information or the documents referred to in paragraph 1(a) of Article 23, the State Party concerned may, subject to Articles 32, 42 and 45, deny entry to that traveller. If there is evidence of an imminent public health risk, the State Party may, in accordance with its national law and to the extent necessary to control such a risk, compel the traveller to undergo or advise the traveller, pursuant to paragraph 3 of Article 23, to undergo:

(a) the least invasive and intrusive medical examination that would achieve the public health objective;

(b) vaccination or other prophylaxis; or

(c) additional established health measures that prevent or control the spread of disease, including isolation, quarantine or placing the traveller under public health observation.

*Article 32 Treatment of travellers*

In implementing health measures under these Regulations, States Parties shall treat travellers with respect for their dignity, human rights and fundamental freedoms and minimize any discomfort or distress associated with such measures, including by:

(a) treating all travellers with courtesy and respect;

(b) taking into consideration the gender, sociocultural, ethnic or religious concerns of travellers; and

(c) providing or arranging for adequate food and water, appropriate accommodation and clothing, protection for baggage and other possessions, appropriate medical treatment, means of necessary communication if possible in a language that they can understand and other appropriate assistance for travellers who are quarantined, isolated or subject to medical examinations or other procedures for public health purposes.

## Chapter IV – Special provisions for goods, containers and container loading areas

*Article 33 Goods in transit*

Subject to Article 43 or unless authorized by applicable international agreements, goods, other than live animals, in transit without transhipment shall not be subject to health measures under these Regulations or detained for public health purposes.

*Article 34 Container and container loading areas*

1. States Parties shall ensure, as far as practicable, that container shippers use international traffic containers that are kept free from sources of infection or contamination, including vectors and reservoirs, particularly during the course of packing.





2. States Parties shall ensure, as far as practicable, that container loading areas are kept free from sources of infection or contamination, including vectors and reservoirs.

3. Whenever, in the opinion of a State Party, the volume of international container traffic is sufficiently large, the competent authorities shall take all practicable measures consistent with these Regulations, including carrying out inspections, to assess the sanitary condition of container loading areas and containers in order to ensure that the obligations contained in these Regulations are implemented.

4. Facilities for the inspection and isolation of containers shall, as far as practicable, be available at container loading areas.

5. Container consignees and consignors shall make every effort to avoid cross-contamination when multiple-use loading of containers is employed.

## PART VI – HEALTH DOCUMENTS

*Article 35 General rule*

No health documents, other than those provided for under these Regulations or in recommendations issued by WHO, shall be required in international traffic, provided however that this Article shall not apply to travellers seeking temporary or permanent residence, nor shall it apply to document requirements concerning the public health status of goods or cargo in international trade pursuant to applicable international agreements. The competent authority may request travellers to complete contact information forms and questionnaires on the health of travellers, provided that they meet the requirements set out in Article 23.

*Article 36 Certificates of vaccination or other prophylaxis*

1. Vaccines and prophylaxis for travellers administered pursuant to these Regulations, or to recommendations and certificates relating thereto, shall conform to the provisions of Annex 6 and, when applicable, Annex 7 with regard to specific diseases.

2. A traveller in possession of a certificate of vaccination or other prophylaxis issued in conformity with Annex 6 and, when applicable, Annex 7, shall not be denied entry as a consequence of the disease to which the certificate refers, even if coming from an affected area, unless the competent authority has verifiable indications and/or evidence that the vaccination or other prophylaxis was not effective.

*Article 37 Maritime Declaration of Health*

1. The master of a ship, before arrival at its first port of call in the territory of a State Party, shall ascertain the state of health on board, and, except when that State Party does not require it, the master shall, on arrival, or in advance of the vessel's arrival if the vessel is so equipped and the State Party requires such advance delivery, complete and deliver to the competent authority for that port a Maritime Declaration of Health which shall be countersigned by the ship's surgeon, if one is carried.

2. The master of a ship, or the ship's surgeon if one is carried, shall supply any information required by the competent authority as to health conditions on board during an international voyage.

3. A Maritime Declaration of Health shall conform to the model provided in Annex 8.

4. A State Party may decide:

(a) to dispense with the submission of the Maritime Declaration of Health by all arriving ships; or

(b) to require the submission of the Maritime Declaration of Health under a recommendation concerning ships arriving from affected areas or to require it from ships which might otherwise carry infection or contamination.

The State Party shall inform shipping operators or their agents of these requirements.

*Article 38 Health Part of the Aircraft General Declaration*

1. The pilot in command of an aircraft or the pilot's agent, in flight or upon landing at the first airport in the territory of a State Party, shall, to the best of his or her ability, except when that State Party does not require it, complete and deliver to the competent authority for that airport the Health Part of the Aircraft General Declaration which shall conform to the model specified in Annex 9.

2. The pilot in command of an aircraft or the pilot's agent shall supply any information required by the State Party as to health conditions on board during an international voyage and any health measure applied to the aircraft.

3. A State Party may decide:

(a) to dispense with the submission of the Health Part of the Aircraft General Declaration by all arriving aircraft; or

(b) to require the submission of the Health Part of the Aircraft General Declaration under a recommendation concerning aircraft arriving from affected areas or to require it from aircraft which might otherwise carry infection or contamination.

The State Party shall inform aircraft operators or their agents of these requirements.

*Article 39 Ship sanitation certificates*

1. Ship Sanitation Control Exemption Certificates and Ship Sanitation Control Certificates shall be valid for a maximum period of six months. This period may be extended by one month if the inspection or control measures required cannot be accomplished at the port.

2. If a valid Ship Sanitation Control Exemption Certificate or Ship Sanitation Control Certificate is not produced or evidence of a public health risk is found on board a ship, the State Party may proceed as provided in paragraph 1 of Article 27.

3. The certificates referred to in this Article shall conform to the model in Annex 3.

4. Whenever possible, control measures shall be carried out when the ship and holds are empty. In the case of a ship in ballast, they shall be carried out before loading.





5. When control measures are required and have been satisfactorily completed, the competent authority shall issue a Ship Sanitation Control Certificate, noting the evidence found and the control measures taken.

6. The competent authority may issue a Ship Sanitation Control Exemption Certificate at any port specified under Article 20 if it is satisfied that the ship is free of infection and contamination, including vectors and reservoirs. Such a certificate shall normally be issued only if the inspection of the ship has been carried out when the ship and holds are empty or when they contain only ballast or other material, of such a nature or so disposed as to make a thorough inspection of the holds possible.

7. If the conditions under which control measures are carried out are such that, in the opinion of the competent authority for the port where the operation was performed, a satisfactory result cannot be obtained, the competent authority shall make a note to that effect on the Ship Sanitation Control Certificate.

## PART VII – CHARGES

*Article 40 Charges for health measures regarding travellers*

1. Except for travellers seeking temporary or permanent residence, and subject to paragraph 2 of this Article, no charge shall be made by a State Party pursuant to these Regulations for the following measures for the protection of public health:

(a) any medical examination provided for in these Regulations, or any supplementary examination which may be required by that State Party to ascertain the health status of the traveller examined;

(b) any vaccination or other prophylaxis provided to a traveller on arrival that is not a published requirement or is a requirement published less than 10 days prior to provision of the vaccination or other prophylaxis;

(c) appropriate isolation or quarantine requirements of travellers;

(d) any certificate issued to the traveller specifying the measures applied and the date of application; or

(e) any health measures applied to baggage accompanying the traveller.

2. State Parties may charge for health measures other than those referred to in paragraph 1 of this Article, including those primarily for the benefit of the traveller.

3. Where charges are made for applying such health measures to travellers under these Regulations, there shall be in each State Party only one tariff for such charges and every charge shall:

(a) conform to this tariff;

(b) not exceed the actual cost of the service rendered; and

(c) be levied without distinction as to the nationality, domicile or residence of the traveller concerned.

4. The tariff, and any amendment thereto, shall be published at least 10 days in advance of any levy thereunder.

5. Nothing in these Regulations shall preclude States Parties from seeking reimbursement for expenses incurred in providing the health measures in paragraph 1 of this Article:

(a) from conveyance operators or owners with regard to their employees; or

(b) from applicable insurance sources.

6. Under no circumstances shall travellers or conveyance operators be denied the ability to depart from the territory of a State Party pending payment of the charges referred to in paragraphs 1 or 2 of this Article.

*Article 41 Charges for baggage, cargo, containers, conveyances, goods or postal parcels*

1. Where charges are made for applying health measures to baggage, cargo, containers, conveyances, goods or postal parcels under these Regulations, there shall be in each State Party only one tariff for such charges and every charge shall:

(a) conform to this tariff;

(b) not exceed the actual cost of the service rendered; and

(c) be levied without distinction as to the nationality, flag, registry or ownership of the baggage, cargo, containers, conveyances, goods or postal parcels concerned. In particular, there shall be no distinction made between national and foreign baggage, cargo, containers, conveyances, goods or postal parcels.

2. The tariff, and any amendment thereto, shall be published at least 10 days in advance of any levy thereunder.

## PART VIII – GENERAL PROVISIONS

*Article 42 Implementation of health measures*

Health measures taken pursuant to these Regulations shall be initiated and completed without delay, and applied in a transparent and non-discriminatory manner.

*Article 43 Additional health measures*

1. These Regulations shall not preclude States Parties from implementing health measures, in accordance with their relevant national law and obligations under international law, in response to specific public health risks or public health emergencies of international concern, which:

(a) achieve the same or greater level of health protection than WHO recommendations; or





(b) are otherwise prohibited under Article 25, Article 26, paragraphs 1 and 2 of Article 28, Article 30, paragraph 1(c) of Article 31 and Article 33,

provided such measures are otherwise consistent with these Regulations.

Such measures shall not be more restrictive of international traffic and not more invasive or intrusive to persons than reasonably available alternatives that would achieve the appropriate level of health protection.

2. In determining whether to implement the health measures referred to in paragraph 1 of this Article or additional health measures under paragraph 2 of Article 23, paragraph 1 of Article 27, paragraph 2 of Article 28 and paragraph 2(c) of Article 31, States Parties shall base their determinations upon:

(a) scientific principles;

(b) available scientific evidence of a risk to human health, or where such evidence is insufficient, the available information including from WHO and other relevant intergovernmental organizations and international bodies; and

(c) any available specific guidance or advice from WHO.

3. A State Party implementing additional health measures referred to in paragraph 1 of this Article which significantly interfere with international traffic shall provide to WHO the public health rationale and relevant scientific information for it. WHO shall share this information with other States Parties and shall share information regarding the health measures implemented. For the purpose of this Article, significant interference generally means refusal of entry or departure of international travellers, baggage, cargo, containers, conveyances, goods, and the like, or their delay, for more than 24 hours.

4. After assessing information provided pursuant to paragraph 3 and 5 of this Article and other relevant information, WHO may request that the State Party concerned reconsider the application of the measures.

5. A State Party implementing additional health measures referred to in paragraphs 1 and 2 of this Article that significantly interfere with international traffic shall inform WHO, within 48 hours of implementation, of such measures and their health rationale unless these are covered by a temporary or standing recommendation.

6. A State Party implementing a health measure pursuant to paragraph 1 or 2 of this Article shall within three months review such a measure taking into account the advice of WHO and the criteria in paragraph 2 of this Article.

7. Without prejudice to its rights under Article 56, any State Party impacted by a measure taken pursuant to paragraph 1 or 2 of this Article may request the State Party implementing such a measure to consult with it. The purpose of such consultations is to clarify the scientific information and public health rationale underlying the measure and to find a mutually acceptable solution.

8. The provisions of this Article may apply to implementation of measures concerning travellers taking part in mass congregations.

*Article 44 Collaboration and assistance*

1. States Parties shall undertake to collaborate with each other, to the extent possible, in:

(a) the detection and assessment of, and response to, events as provided under these Regulations;

(b) the provision or facilitation of technical cooperation and logistical support, particularly in the development, strengthening and maintenance of the public health capacities required under these Regulations;

(c) the mobilization of financial resources to facilitate implementation of their obligations under these Regulations; and

(d) the formulation of proposed laws and other legal and administrative provisions for the implementation of these Regulations.

2. WHO shall collaborate with States Parties, upon request, to the extent possible, in:

(a) the evaluation and assessment of their public health capacities in order to facilitate the effective implementation of these Regulations;

(b) the provision or facilitation of technical cooperation and logistical support to States Parties; and

(c) the mobilization of financial resources to support developing countries in building, strengthening and maintaining the capacities provided for in Annex 1.

3. Collaboration under this Article may be implemented through multiple channels, including bilaterally, through regional networks and the WHO regional offices, and through intergovernmental organizations and international bodies.

*Article 45 Treatment of personal data*

1. Health information collected or received by a State Party pursuant to these Regulations from another State Party or from WHO which refers to an identified or identifiable person shall be kept confidential and processed anonymously as required by national law.

2. Notwithstanding paragraph 1, States Parties may disclose and process personal data where essential for the purposes of assessing and managing a public health risk, but State Parties, in accordance with national law, and WHO must ensure that the personal data are:

(a) processed fairly and lawfully, and not further processed in a way incompatible with that purpose;

(b) adequate, relevant and not excessive in relation to that purpose;

(c) accurate and, where necessary, kept up to date; every reasonable step must be taken to ensure that data which are inaccurate or incomplete are erased or rectified; and

(d) not kept longer than necessary.





3. Upon request, WHO shall as far as practicable provide an individual with his or her personal data referred to in this Article in an intelligible form, without undue delay or expense and, when necessary, allow for correction.

*Article 46 Transport and handling of biological substances, reagents and materials for diagnostic purposes*

States Parties shall, subject to national law and taking into account relevant international guidelines, facilitate the transport, entry, exit, processing and disposal of biological substances and diagnostic specimens, reagents and other diagnostic materials for verification and public health response purposes under these Regulations.

## PART IX – THE IHR ROSTER OF EXPERTS, THE EMERGENCY COMMITTEE AND THE REVIEW COMMITTEE

### Chapter I – The IHR Roster of Experts

*Article 47 Composition*

The Director-General shall establish a roster composed of experts in all relevant fields of expertise (hereinafter the "IHR Expert Roster"). The Director-General shall appoint the members of the IHR Expert Roster in accordance with the WHO Regulations for Expert Advisory Panels and Committees (hereinafter the "WHO Advisory Panel Regulations"), unless otherwise provided in these Regulations. In addition, the Director-General shall appoint one member at the request of each State Party and, where appropriate, experts proposed by relevant intergovernmental and regional economic integration organizations. Interested States Parties shall notify the Director-General of the qualifications and fields of expertise of each of the experts they propose for membership. The Director-General shall periodically inform the States Parties, and relevant intergovernmental and regional economic integration organizations, of the composition of the IHR Expert Roster.

### Chapter II - The Emergency Committee

*Article 48 Terms of reference and composition*

1. The Director-General shall establish an Emergency Committee that at the request of the Director-General shall provide its views on:

(a) whether an event constitutes a public health emergency of international concern;

(b) the termination of a public health emergency of international concern; and

(c) the proposed issuance, modification, extension or termination of temporary recommendations.

2. The Emergency Committee shall be composed of experts selected by the Director-General from the IHR Expert Roster and, when appropriate, other expert advisory panels of the Organization. The Director-General shall determine the duration of membership with a view to ensuring its continuity in the consideration of a specific event and its consequences. The Director-General shall select the members of the Emergency Committee on the basis of the expertise and experience required for any particular session and with due regard to the principles of equitable geographical representation. At

least one member of the Emergency Committee should be an expert nominated by a State Party within whose territory the event arises.

3. The Director-General may, on his or her own initiative or at the request of the Emergency Committee, appoint one or more technical experts to advise the Committee.

*Article 49 Procedure*

1. The Director-General shall convene meetings of the Emergency Committee by selecting a number of experts from among those referred to in paragraph 2 of Article 48, according to the fields of expertise and experience most relevant to the specific event that is occurring. For the purpose of this Article, "meetings" of the Emergency Committee may include teleconferences, videoconferences or electronic communications.

2. The Director-General shall provide the Emergency Committee with the agenda and any relevant information concerning the event, including information provided by the States Parties, as well as any temporary recommendation that the Director-General proposes for issuance.

3. The Emergency Committee shall elect its Chairperson and prepare following each meeting a brief summary report of its proceedings and deliberations, including any advice on recommendations.

4. The Director-General shall invite the State Party in whose territory the event arises to present its views to the Emergency Committee. To that effect, the Director-General shall notify to it the dates and the agenda of the meeting of the Emergency Committee with as much advance notice as necessary. The State Party concerned, however, may not seek a postponement of the meeting of the Emergency Committee for the purpose of presenting its views thereto.

5. The views of the Emergency Committee shall be forwarded to the Director-General for consideration. The Director-General shall make the final determination on these matters.

6. The Director-General shall communicate to States Parties the determination and the termination of a public health emergency of international concern, any health measure taken by the State Party concerned, any temporary recommendation, and the modification, extension and termination of such recommendations, together with the views of the Emergency Committee. The Director-General shall inform conveyance operators through States Parties and the relevant international agencies of such temporary recommendations, including their modification, extension or termination. The Director-General shall subsequently make such information and recommendations available to the general public.

7. States Parties in whose territories the event has occurred may propose to the Director-General the termination of a public health emergency of international concern and/or the temporary recommendations, and may make a presentation to that effect to the Emergency Committee.





## Chapter III – The Review Committee

*Article 50 Terms of reference and composition*

1. The Director-General shall establish a Review Committee, which shall carry out the following functions:

(a) make technical recommendations to the Director-General regarding amendments to these Regulations;

(b) provide technical advice to the Director-General with respect to standing recommendations, and any modifications or termination thereof;

(c) provide technical advice to the Director-General on any matter referred to it by the Director-General regarding the functioning of these Regulations.

2. The Review Committee shall be considered an expert committee and shall be subject to the WHO Advisory Panel Regulations, unless otherwise provided in this Article.

3. The Members of the Review Committee shall be selected and appointed by the Director-General from among the persons serving on the IHR Expert Roster and, when appropriate, other expert advisory panels of the Organization.

4. The Director-General shall establish the number of members to be invited to a meeting of the Review Committee, determine its date and duration, and convene the Committee.

5. The Director-General shall appoint members to the Review Committee for the duration of the work of a session only.

6. The Director-General shall select the members of the Review Committee on the basis of the principles of equitable geographical representation, gender balance, a balance of experts from developed and developing countries, representation of a diversity of scientific opinion, approaches and practical experience in various parts of the world, and an appropriate interdisciplinary balance.

*Article 51 Conduct of business*

1. Decisions of the Review Committee shall be taken by a majority of the members present and voting.

2. The Director-General shall invite Member States, the United Nations and its specialized agencies and other relevant intergovernmental organizations or nongovernmental organizations in official relations with WHO to designate representatives to attend the Committee sessions. Such representatives may submit memoranda and, with the consent of the Chairperson, make statements on the subjects under discussion. They shall not have the right to vote.

*Article 52 Reports*

1. For each session, the Review Committee shall draw up a report setting forth the Committee's views and advice. This report shall be approved by the Review Committee before the end of the

session. Its views and advice shall not commit the Organization and shall be formulated as advice to the Director-General. The text of the report may not be modified without the Committee's consent.

2. If the Review Committee is not unanimous in its findings, any member shall be entitled to express his or her dissenting professional views in an individual or group report, which shall state the reasons why a divergent opinion is held and shall form part of the Committee's report.

3. The Review Committee's report shall be submitted to the Director-General, who shall communicate its views and advice to the Health Assembly or the Executive Board for their consideration and action.

*Article 53 Procedures for standing recommendations*

When the Director-General considers that a standing recommendation is necessary and appropriate for a specific public health risk, the Director-General shall seek the views of the Review Committee. In addition to the relevant paragraphs of Articles 50 to 52, the following provisions shall apply:

(a) proposals for standing recommendations, their modification or termination may be submitted to the Review Committee by the Director-General or by States Parties through the Director-General;

(b) any State Party may submit relevant information for consideration by the Review Committee;

(c) the Director-General may request any State Party, intergovernmental organization or nongovernmental organization in official relations with WHO to place at the disposal of the Review Committee information in its possession concerning the subject of the proposed standing recommendation as specified by the Review Committee;

(d) the Director-General may, at the request of the Review Committee or on the Director-General's own initiative, appoint one or more technical experts to advise the Review Committee. They shall not have the right to vote;

(e) any report containing the views and advice of the Review Committee regarding standing recommendations shall be forwarded to the Director-General for consideration and decision. The Director-General shall communicate the Review Committee's views and advice to the Health Assembly;

(f) the Director-General shall communicate to States Parties any standing recommendation, as well as the modifications or termination of such recommendations, together with the views of the Review Committee;

(g) standing recommendations shall be submitted by the Director-General to the subsequent Health Assembly for its consideration.





## PART X – FINAL PROVISIONS

*Article 54 Reporting and review*

1. States Parties and the Director-General shall report to the Health Assembly on the implementation of these Regulations as decided by the Health Assembly.

2. The Health Assembly shall periodically review the functioning of these Regulations. To that end it may request the advice of the Review Committee, through the Director-General. The first such review shall take place no later than five years after the entry into force of these Regulations.

3. WHO shall periodically conduct studies to review and evaluate the functioning of Annex 2. The first such review shall commence no later than one year after the entry into force of these Regulations. The results of such reviews shall be submitted to the Health Assembly for its consideration, as appropriate.

*Article 55 Amendments*

1. Amendments to these Regulations may be proposed by any State Party or by the Director-General. Such proposals for amendments shall be submitted to the Health Assembly for its consideration.

2. The text of any proposed amendment shall be communicated to all States Parties by the Director-General at least four months before the Health Assembly at which it is proposed for consideration.

3. Amendments to these Regulations adopted by the Health Assembly pursuant to this Article shall come into force for all States Parties on the same terms, and subject to the same rights and obligations, as provided for in Article 22 of the Constitution of WHO and Articles 59 to 64 of these Regulations.

*Article 56 Settlement of disputes*

1. In the event of a dispute between two or more States Parties concerning the interpretation or application of these Regulations, the States Parties concerned shall seek in the first instance to settle the dispute through negotiation or any other peaceful means of their own choice, including good offices, mediation or conciliation. Failure to reach agreement shall not absolve the parties to the dispute from the responsibility of continuing to seek to resolve it.

2. In the event that the dispute is not settled by the means described under paragraph 1 of this Article, the States Parties concerned may agree to refer the dispute to the Director-General, who shall make every effort to settle it.

3. A State Party may at any time declare in writing to the Director-General that it accepts arbitration as compulsory with regard to all disputes concerning the interpretation or application of these Regulations to which it is a party or with regard to a specific dispute in relation to any other State Party accepting the same obligation. The arbitration shall be conducted in accordance with the Permanent Court of Arbitration Optional Rules for Arbitrating Disputes between Two States applicable at the time a request for arbitration is made. The States Parties that have agreed to accept arbitration as compulsory shall accept the arbitral award as binding and final. The Director-General shall inform the Health Assembly regarding such action as appropriate.

4. Nothing in these Regulations shall impair the rights of States Parties under any international agreement to which they may be parties to resort to the dispute settlement mechanisms of other intergovernmental organizations or established under any international agreement.

5. In the event of a dispute between WHO and one or more States Parties concerning the interpretation or application of these Regulations, the matter shall be submitted to the Health Assembly.

*Article 57 Relationship with other international agreements*

1. States Parties recognize that the IHR and other relevant international agreements should be interpreted so as to be compatible. The provisions of the IHR shall not affect the rights and obligations of any State Party deriving from other international agreements.

2. Subject to paragraph 1 of this Article, nothing in these Regulations shall prevent States Parties having certain interests in common owing to their health, geographical, social or economic conditions, from concluding special treaties or arrangements in order to facilitate the application of these Regulations, and in particular with regard to:

(a) the direct and rapid exchange of public health information between neighbouring territories of different States;

(b) the health measures to be applied to international coastal traffic and to international traffic in waters within their jurisdiction;

(c) the health measures to be applied in contiguous territories of different States at their common frontier;

(d) arrangements for carrying affected persons or affected human remains by means of transport specially adapted for the purpose; and

(e) deratting, disinsection, disinfection, decontamination or other treatment designed to render goods free of disease-causing agents.

3. Without prejudice to their obligations under these Regulations, States Parties that are members of a regional economic integration organization shall apply in their mutual relations the common rules in force in that regional economic integration organization.

*Article 58 International sanitary agreements and regulations*

1. These Regulations, subject to the provisions of Article 62 and the exceptions hereinafter provided, shall replace as between the States bound by these Regulations and as between these States and WHO, the provisions of the following international sanitary agreements and regulations:

(a) International Sanitary Convention, signed in Paris, 21 June 1926;

(b) International Sanitary Convention for Aerial Navigation, signed at The Hague, 12 April 1933;





(c) International Agreement for dispensing with Bills of Health, signed in Paris, 22 December 1934;

(d) International Agreement for dispensing with Consular Visas on Bills of Health, signed in Paris, 22 December 1934;

(e) Convention modifying the International Sanitary Convention of 21 June 1926, signed in Paris, 31 October 1938;

(f) International Sanitary Convention, 1944, modifying the International Sanitary Convention of 21 June 1926, opened for signature in Washington, 15 December 1944;

(g) International Sanitary Convention for Aerial Navigation, 1944, modifying the International Sanitary Convention of 12 April 1933, opened for signature in Washington, 15 December 1944;

(h) Protocol of 23 April 1946 to prolong the International Sanitary Convention, 1944, signed in Washington;

(i) Protocol of 23 April 1946 to prolong the International Sanitary Convention for Aerial Navigation, 1944, signed in Washington;

(j) International Sanitary Regulations, 1951, and the Additional Regulations of 1955, 1956, 1960, 1963 and 1965; and

(k) the International Health Regulations of 1969 and the amendments of 1973 and 1981.

2. The Pan American Sanitary Code, signed at Havana, 14 November 1924, shall remain in force with the exception of Articles 2, 9, 10, 11, 16 to 53 inclusive, 61 and 62, to which the relevant part of paragraph 1 of this Article shall apply.

*Article 59 Entry into force; period for rejection or reservations*

1. The period provided in execution of Article 22 of the Constitution of WHO for rejection of, or reservation to, these Regulations or an amendment thereto, shall be 18 months from the date of the notification by the Director-General of the adoption of these Regulations or of an amendment to these Regulations by the Health Assembly. Any rejection or reservation received by the Director-General after the expiry of that period shall have no effect.

2. These Regulations shall enter into force 24 months after the date of notification referred to in paragraph 1 of this Article, except for:

(a) a State that has rejected these Regulations or an amendment thereto in accordance with Article 61;

(b) a State that has made a reservation, for which these Regulations shall enter into force as provided in Article 62;

(c) a State that becomes a Member of WHO after the date of the notification by the Director-General referred to in paragraph 1 of this Article, and which is not already a party to these Regulations, for which these Regulations shall enter into force as provided in Article 60; and

(d) a State not a Member of WHO that accepts these Regulations, for which they shall enter into force in accordance with paragraph 1 of Article 64.

3. If a State is not able to adjust its domestic legislative and administrative arrangements fully with these Regulations within the period set out in paragraph 2 of this Article, that State shall submit within the period specified in paragraph 1 of this Article a declaration to the Director-General regarding the outstanding adjustments and achieve them no later than 12 months after the entry into force of these Regulations for that State Party.

*Article 60 New Member States of WHO*

Any State which becomes a Member of WHO after the date of the notification by the Director-General referred to in paragraph 1 of Article 59, and which is not already a party to these Regulations, may communicate its rejection of, or any reservation to, these Regulations within a period of twelve months from the date of the notification to it by the Director-General after becoming a Member of WHO. Unless rejected, these Regulations shall enter into force with respect to that State, subject to the provisions of Articles 62 and 63, upon expiry of that period. In no case shall these Regulations enter into force in respect to that State earlier than 24 months after the date of notification referred to in paragraph 1 of Article 59.

*Article 61 Rejection*

If a State notifies the Director-General of its rejection of these Regulations or of an amendment thereto within the period provided in paragraph 1 of Article 59, these Regulations or the amendment concerned shall not enter into force with respect to that State. Any international sanitary agreement or regulations listed in Article 58 to which such State is already a party shall remain in force as far as such State is concerned.

*Article 62 Reservations*

1. States may make reservations to these Regulations in accordance with this Article. Such reservations shall not be incompatible with the object and purpose of these Regulations.

2. Reservations to these Regulations shall be notified to the Director-General in accordance with paragraph 1 of Article 59 and Article 60, paragraph 1 of Article 63 or paragraph 1 of Article 64, as the case may be. A State not a Member of WHO shall notify the Director-General of any reservation with its notification of acceptance of these Regulations. States formulating reservations should provide the Director-General with reasons for the reservations.

3. A rejection in part of these Regulations shall be considered as a reservation.

4. The Director-General shall, in accordance with paragraph 2 of Article 65, issue notification of each reservation received pursuant to paragraph 2 of this Article. The Director-General shall:





(a) if the reservation was made before the entry into force of these Regulations, request those Member States that have not rejected these Regulations to notify him or her within six months of any objection to the reservation, or

(b) if the reservation was made after the entry into force of these Regulations, request States Parties to notify him or her within six months of any objection to the reservation.

States objecting to a reservation should provide the Director-General with reasons for the objection.

5. After this period, the Director-General shall notify all States Parties of the objections he or she has received with regard to reservations. Unless by the end of six months from the date of the notification referred to in paragraph 4 of this Article a reservation has been objected to by one-third of the States referred to in paragraph 4 of this Article, it shall be deemed to be accepted and these Regulations shall enter into force for the reserving State, subject to the reservation.

6. If at least one-third of the States referred to in paragraph 4 of this Article object to the reservation by the end of six months from the date of the notification referred to in paragraph 4 of this Article, the Director-General shall notify the reserving State with a view to its considering withdrawing the reservation within three months from the date of the notification by the Director-General.

7. The reserving State shall continue to fulfil any obligations corresponding to the subject matter of the reservation, which the State has accepted under any of the international sanitary agreements or regulations listed in Article 58.

8. If the reserving State does not withdraw the reservation within three months from the date of the notification by the Director-General referred to in paragraph 6 of this Article, the Director-General shall seek the view of the Review Committee if the reserving State so requests. The Review Committee shall advise the Director-General as soon as possible and in accordance with Article 50 on the practical impact of the reservation on the operation of these Regulations.

9. The Director-General shall submit the reservation, and the views of the Review Committee if applicable, to the Health Assembly for its consideration. If the Health Assembly, by a majority vote, objects to the reservation on the ground that it is incompatible with the object and purpose of these Regulations, the reservation shall not be accepted and these Regulations shall enter into force for the reserving State only after it withdraws its reservation pursuant to Article 63. If the Health Assembly accepts the reservation, these Regulations shall enter into force for the reserving State, subject to its reservation.

*Article 63 Withdrawal of rejection and reservation*

1. A rejection made under Article 61 may at any time be withdrawn by a State by notifying the Director-General. In such cases, these Regulations shall enter into force with regard to that State upon receipt by the Director-General of the notification, except where the State makes a reservation when withdrawing its rejection, in which case these Regulations shall enter into force as provided in Article 62. In no case shall these Regulations enter into force in respect to that State earlier than 24 months after the date of notification referred to in paragraph 1 of Article 59.

2. The whole or part of any reservation may at any time be withdrawn by the State Party concerned by notifying the Director-General. In such cases, the withdrawal will be effective from the date of receipt by the Director-General of the notification.

*Article 64 States not Members of WHO*

1. Any State not a Member of WHO, which is a party to any international sanitary agreement or regulations listed in Article 58 or to which the Director-General has notified the adoption of these Regulations by the World Health Assembly, may become a party hereto by notifying its acceptance to the Director-General and, subject to the provisions of Article 62, such acceptance shall become effective upon the date of entry into force of these Regulations, or, if such acceptance is notified after that date, three months after the date of receipt by the Director-General of the notification of acceptance.

2. Any State not a Member of WHO which has become a party to these Regulations may at any time withdraw from participation in these Regulations, by means of a notification addressed to the Director-General which shall take effect six months after the Director-General has received it. The State which has withdrawn shall, as from that date, resume application of the provisions of any international sanitary agreement or regulations listed in Article 58 to which it was previously a party.

*Article 65 Notifications by the Director-General*

1. The Director-General shall notify all States Members and Associate Members of WHO, and also other parties to any international sanitary agreement or regulations listed in Article 58, of the adoption by the Health Assembly of these Regulations.

2. The Director-General shall also notify these States, as well as any other State which has become a party to these Regulations or to any amendment to these Regulations, of any notification received by WHO under Articles 60 to 64 respectively, as well as of any decision taken by the Health Assembly under Article 62.

*Article 66 Authentic texts*

1. The Arabic, Chinese, English, French, Russian and Spanish texts of these Regulations shall be equally authentic. The original texts of these Regulations shall be deposited with WHO.

2. The Director-General shall send, with the notification provided in paragraph 1 of Article 59, certified copies of these Regulations to all Members and Associate Members, and also to other parties to any of the international sanitary agreements or regulations listed in Article 58.

3. Upon the entry into force of these Regulations, the Director-General shall deliver certified copies thereof to the Secretary-General of the United Nations for registration in accordance with Article 102 of the Charter of the United Nations.





# ANNEX 1

## A. CORE CAPACITY REQUIREMENTS FOR SURVEILLANCE AND RESPONSE

1. States Parties shall utilize existing national structures and resources to meet their core capacity requirements under these Regulations, including with regard to:

(a) their surveillance, reporting, notification, verification, response and collaboration activities; and

(b) their activities concerning designated airports, ports and ground crossings.

2. Each State Party shall assess, within two years following the entry into force of these Regulations for that State Party, the ability of existing national structures and resources to meet the minimum requirements described in this Annex. As a result of such assessment, States Parties shall develop and implement plans of action to ensure that these core capacities are present and functioning throughout their territories as set out in paragraph 1 of Article 5 and paragraph 1 of Article 13.

3. States Parties and WHO shall support assessments, planning and implementation processes under this Annex.

4. At the local community level and/or primary public health response level

The capacities:

(a) to detect events involving disease or death above expected levels for the particular time and place in all areas within the territory of the State Party; and

(b) to report all available essential information immediately to the appropriate level of health-care response. At the community level, reporting shall be to local community health-care institutions or the appropriate health personnel. At the primary public health response level, reporting shall be to the intermediate or national response level, depending on organizational structures. For the purposes of this Annex, essential information includes the following: clinical descriptions, laboratory results, sources and type of risk, numbers of human cases and deaths, conditions affecting the spread of the disease and the health measures employed; and

(c) to implement preliminary control measures immediately.

5. At the intermediate public health response levels

The capacities:

(a) to confirm the status of reported events and to support or implement additional control measures; and

(b) to assess reported events immediately and, if found urgent, to report all essential information to the national level. For the purposes of this Annex, the criteria for urgent events include serious public health impact and/or unusual or unexpected nature with high potential for spread.

6. At the national level

*Assessment and notification*. The capacities:

(a) to assess all reports of urgent events within 48 hours; and

(b) to notify WHO immediately through the National IHR Focal Point when the assessment indicates the event is notifiable pursuant to paragraph 1 of Article 6 and Annex 2 and to inform WHO as required pursuant to Article 7 and paragraph 2 of Article 9.

*Public health response*. The capacities:

(a) to determine rapidly the control measures required to prevent domestic and international spread;

(b) to provide support through specialized staff, laboratory analysis of samples (domestically or through collaborating centres) and logistical assistance (e.g. equipment, supplies and transport);

(c) to provide on-site assistance as required to supplement local investigations;

(d) to provide a direct operational link with senior health and other officials to approve rapidly and implement containment and control measures;

(e) to provide direct liaison with other relevant government ministries;

(f) to provide, by the most efficient means of communication available, links with hospitals, clinics, airports, ports, ground crossings, laboratories and other key operational areas for the dissemination of information and recommendations received from WHO regarding events in the State Party's own territory and in the territories of other States Parties;

(g) to establish, operate and maintain a national public health emergency response plan, including the creation of multidisciplinary/multisectoral teams to respond to events that may constitute a public health emergency of international concern; and

(h) to provide the foregoing on a 24-hour basis.





## B. CORE CAPACITY REQUIREMENTS FOR DESIGNATED AIRPORTS, PORTS AND GROUND CROSSINGS

1. At all times

The capacities:

(a) to provide access to (i) an appropriate medical service including diagnostic facilities located so as to allow the prompt assessment and care of ill travellers, and (ii) adequate staff, equipment and premises;

(b) to provide access to equipment and personnel for the transport of ill travellers to an appropriate medical facility;

(c) to provide trained personnel for the inspection of conveyances;

(d) to ensure a safe environment for travellers using point of entry facilities, including potable water supplies, eating establishments, flight catering facilities, public washrooms, appropriate solid and liquid waste disposal services and other potential risk areas, by conducting inspection programmes, as appropriate; and

(e) to provide as far as practicable a programme and trained personnel for the control of vectors and reservoirs in and near points of entry.

2. For responding to events that may constitute a public health emergency of international concern

The capacities:

(a) to provide appropriate public health emergency response by establishing and maintaining a public health emergency contingency plan, including the nomination of a coordinator and contact points for relevant point of entry, public health and other agencies and services;

(b) to provide assessment of and care for affected travellers or animals by establishing arrangements with local medical and veterinary facilities for their isolation, treatment and other support services that may be required;

(c) to provide appropriate space, separate from other travellers, to interview suspect or affected persons;

(d) to provide for the assessment and, if required, quarantine of suspect travellers, preferably in facilities away from the point of entry;

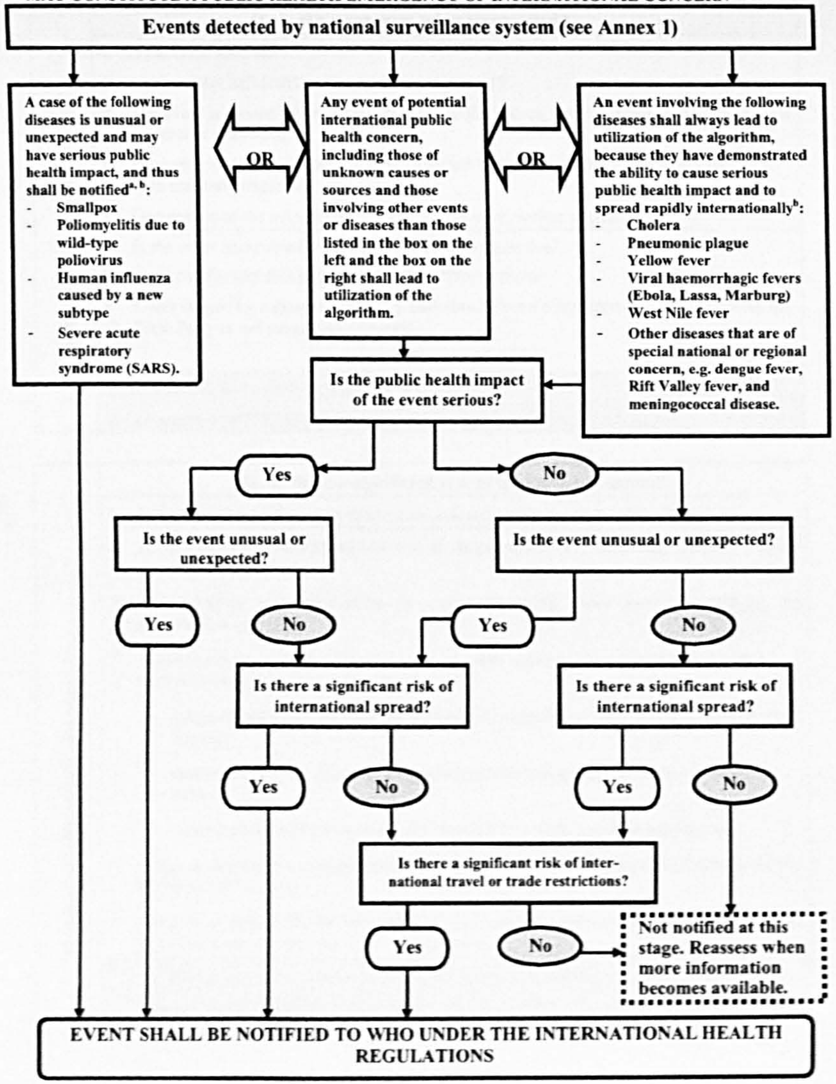
(e) to apply recommended measures to disinsect, derat, disinfect, decontaminate or otherwise treat baggage, cargo, containers, conveyances, goods or postal parcels including, when appropriate, at locations specially designated and equipped for this purpose;

(f) to apply entry or exit controls for arriving and departing travellers; and

(g) to provide access to specially designated equipment, and to trained personnel with appropriate personal protection, for the transfer of travellers who may carry infection or contamination.

ANNEX 2

## DECISION INSTRUMENT FOR THE ASSESSMENT AND NOTIFICATION OF EVENTS THAT MAY CONSTITUTE A PUBLIC HEALTH EMERGENCY OF INTERNATIONAL CONCERN




[a] As per WHO case definitions.
[b] The disease list shall be used only for the purposes of these Regulations.





## EXAMPLES FOR THE APPLICATION OF THE DECISION INSTRUMENT FOR THE ASSESSMENT AND NOTIFICATION OF EVENTS THAT MAY CONSTITUTE A PUBLIC HEALTH EMERGENCY OF INTERNATIONAL CONCERN

***The examples appearing in this Annex are not binding and are for indicative guidance purposes to assist in the interpretation of the decision instrument criteria.***

### DOES THE EVENT MEET AT LEAST TWO OF THE FOLLOWING CRITERIA?

| | |
|---|---|
| **Is the public health impact of the event serious?** | **I. Is the public health impact of the event serious?** |
| | 1. *Is the number of cases and/or number of deaths for this type of event large for the given place, time or population?* |
| | 2. *Has the event the potential to have a high public health impact?*<br>THE FOLLOWING ARE EXAMPLES OF CIRCUMSTANCES THAT CONTRIBUTE TO HIGH PUBLIC HEALTH IMPACT:<br>✓ Event caused by a pathogen with high potential to cause epidemic (infectiousness of the agent, high case fatality, multiple transmission routes or healthy carrier).<br>✓ Indication of treatment failure (new or emerging antibiotic resistance, vaccine failure, antidote resistance or failure).<br>✓ Event represents a significant public health risk even if no or very few human cases have yet been identified.<br>✓ Cases reported among health staff.<br>✓ The population at risk is especially vulnerable (refugees, low level of immunization, children, elderly, low immunity, undernourished, etc.).<br>✓ Concomitant factors that may hinder or delay the public health response (natural catastrophes, armed conflicts, unfavourable weather conditions, multiple foci in the State Party).<br>✓ Event in an area with high population density.<br>✓ Spread of toxic, infectious or otherwise hazardous materials that may be occurring naturally or otherwise that has contaminated or has the potential to contaminate a population and/or a large geographical area. |
| | 3. *Is external assistance needed to detect, investigate, respond and control the current event, or prevent new cases?*<br>THE FOLLOWING ARE EXAMPLES OF WHEN ASSISTANCE MAY BE REQUIRED:<br>✓ Inadequate human, financial, material or technical resources – in particular:<br>– Insufficient laboratory or epidemiological capacity to investigate the event (equipment, personnel, financial resources)<br>– Insufficient antidotes, drugs and/or vaccine and/or protective equipment, decontamination equipment, or supportive equipment to cover estimated needs<br>– Existing surveillance system is inadequate to detect new cases in a timely manner. |
| | **IS THE PUBLIC HEALTH IMPACT OF THE EVENT SERIOUS?**<br>**Answer "yes" if you have answered "yes" to questions 1, 2 or 3 above.** |

| Is the event unusual or unexpected? | **II. Is the event unusual or unexpected?** |
|---|---|
| | 4. *Is the event unusual?*<br>THE FOLLOWING ARE EXAMPLES OF UNUSUAL EVENTS:<br>✓ The event is caused by an unknown agent or the source, vehicle, route of transmission is unusual or unknown.<br>✓ Evolution of cases more severe than expected (including morbidity or case-fatality) or with unusual symptoms.<br>✓ Occurrence of the event itself unusual for the area, season or population. |
| | 5. *Is the event unexpected from a public health perspective?*<br>THE FOLLOWING ARE EXAMPLES OF UNEXPECTED EVENTS:<br>✓ Event caused by a disease/agent that had already been eliminated or eradicated from the State Party or not previously reported. |
| | **IS THE EVENT UNUSUAL OR UNEXPECTED?**<br>**Answer "yes" if you have answered "yes" to questions 4 or 5 above.** |

| Is there a significant risk of international spread? | **III. Is there a significant risk of international spread?** |
|---|---|
| | 6. *Is there evidence of an epidemiological link to similar events in other States?* |
| | 7. *Is there any factor that should alert us to the potential for cross border movement of the agent, vehicle or host?*<br>THE FOLLOWING ARE EXAMPLES OF CIRCUMSTANCES THAT MAY PREDISPOSE TO INTERNATIONAL SPREAD:<br>✓ Where there is evidence of local spread, an index case (or other linked cases) with a history within the previous month of:<br>– international travel (or time equivalent to the incubation period if the pathogen is known)<br>– participation in an international gathering (pilgrimage, sports event, conference, etc.)<br>– close contact with an international traveller or a highly mobile population.<br>✓ Event caused by an environmental contamination that has the potential to spread across international borders.<br>✓ Event in an area of intense international traffic with limited capacity for sanitary control or environmental detection or decontamination. |
| | **IS THERE A SIGNIFICANT RISK OF INTERNATIONAL SPREAD?**<br>**Answer "yes" if you have answered "yes" to questions 6 or 7 above.** |





| Risk of international restrictions ? | **IV. Is there a significant risk of international travel or trade restrictions?** |
|---|---|
| | 8. *Have similar events in the past resulted in international restriction on trade and/or travel?* |
| | 9. *Is the source suspected or known to be a food product, water or any other goods that might be contaminated that has been exported/imported to/from other States?* |
| | 10. *Has the event occurred in association with an international gathering or in an area of intense international tourism?* |
| | 11. *Has the event caused requests for more information by foreign officials or international media?* |
| | **IS THERE A SIGNIFICANT RISK OF INTERNATIONAL TRADE OR TRAVEL RESTRICTIONS?**<br>**Answer "yes" if you have answered "yes" to questions 8, 9, 10 or 11 above.** |

**States Parties that answer "yes" to the question whether the event meets any two of the four criteria (I-IV) above, shall notify WHO under Article 6 of the International Health Regulations.**

# ANNEX 3

## MODEL SHIP SANITATION CONTROL EXEMPTION CERTIFICATE/SHIP SANITATION CONTROL CERTIFICATE

Port of………. Date: …………..

This Certificate records the inspection and 1) exemption from control or 2) control measures applied

Name of ship or inland navigation vessel…......................Flag…...................... Registration/IMO No. ………......

At the time of inspection the holds were unladen/laden with ...... tonnes of ......................... cargo

Name and address of inspecting officer…………………..

**Ship Sanitation Control Exemption Certificate**

| Areas , [systems, and services] inspected | Evidence found[1] | Sample results[2] | Documents reviewed |
|---|---|---|---|
| Galley | | | Medical log |
| Pantry | | | Ship's log |
| Stores | | | Other |
| Hold(s)/cargo | | | |
| Quarters: | | | |
| - crew | | | |
| - officers | | | |
| - passengers | | | |
| - deck | | | |
| Potable water | | | |
| Sewage | | | |
| Ballast tanks | | | |
| Solid and medical waste | | | |
| Standing water | | | |
| Engine room | | | |
| Medical facilities | | | |
| Other areas specified - see attached | | | |
| Note areas not applicable, by marking N/A. | | | |

No evidence found. Ship/vessel is exempted from control measures.

**Ship Sanitation Control Certificate**

| Control measures applied | Re-inspection date | Comments regarding conditions found |
|---|---|---|
| | | |
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Control measures indicated were applied on the date below.

Name and designation of issuing officer ………………………………........... Signature and seal …………………………… Date ………………..

[1] (a) Evidence of infection or contamination, including: vectors in all stages of growth; animal reservoirs for vectors; rodents or other species that could carry human disease, microbiological, chemical and other risks to human health; signs of inadequate sanitary measures. (b) Information concerning any human cases (to be included in the Maritime Declaration of Health).

[2] Results from samples taken on board. Analysis to be provided to ship's master by most expedient means and, if re-inspection is required, to the next appropriate port of call coinciding with the re-inspection date specified in this certificate.

Sanitation Control Exemption Certificates and Sanitation Control Certificates are valid for a maximum of six months, but the validity period may be extended by one month if inspection cannot be carried out at the port and there is no evidence of infection or contamination.







## ATTACHMENT TO MODEL SHIP SANITATION CONTROL EXEMPTION CERTIFICATE/SHIP SANITATION CONTROL CERTIFICATE

| Areas/facilities/systems inspected | Evidence found | Sample results | Documents reviewed | Control measures applied | Re-inspection date | Comments regarding conditions found |
|---|---|---|---|---|---|---|
| **Food** | | | | | | |
| Source | | | | | | |
| Storage | | | | | | |
| Preparation | | | | | | |
| Service | | | | | | |
| **Water** | | | | | | |
| Source | | | | | | |
| Storage | | | | | | |
| Distribution | | | | | | |
| **Waste** | | | | | | |
| Holding | | | | | | |
| Treatment | | | | | | |
| Disposal | | | | | | |
| **Swimming pools/spas** | | | | | | |
| Equipment | | | | | | |
| Operation | | | | | | |
| **Medical facilities** | | | | | | |
| Equipment and medical devices | | | | | | |
| Operation | | | | | | |
| Medicines | | | | | | |
| **Other areas inspected** | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

*Indicate when the areas listed are not applicable by marking N/A.*

ANNEX 4

## TECHNICAL REQUIREMENTS PERTAINING TO CONVEYANCES AND CONVEYANCE OPERATORS

Section A Conveyance operators

1. Conveyance operators shall facilitate:

(a) inspections of the cargo, containers and conveyance;

(b) medical examinations of persons on board;

(c) application of other health measures under these Regulations; and

(d) provision of relevant public health information requested by the State Party.

2. Conveyance operators shall provide to the competent authority a valid Ship Sanitation Control Exemption Certificate or a Ship Sanitation Control Certificate or a Maritime Declaration of Health, or the Health Part of an Aircraft General Declaration, as required under these Regulations.

Section B Conveyances

1. Control measures applied to baggage, cargo, containers, conveyances and goods under these Regulations shall be carried out so as to avoid as far as possible injury or discomfort to persons or damage to the baggage, cargo, containers, conveyances and goods. Whenever possible and appropriate, control measures shall be applied when the conveyance and holds are empty.

2. States Parties shall indicate in writing the measures applied to cargo, containers or conveyances, the parts treated, the methods employed, and the reasons for their application. This information shall be provided in writing to the person in charge of an aircraft and, in case of a ship, on the Ship Sanitation Control Certificate. For other cargo, containers or conveyances, States Parties shall issue such information in writing to consignors, consignees, carriers, the person in charge of the conveyance or their respective agents.





ANNEX 5

## SPECIFIC MEASURES FOR VECTOR-BORNE DISEASES

1. WHO shall publish, on a regular basis, a list of areas where disinsection or other vector control measures are recommended for conveyances arriving from these areas. Determination of such areas shall be made pursuant to the procedures regarding temporary or standing recommendations, as appropriate.

2. Every conveyance leaving a point of entry situated in an area where vector control is recommended should be disinsected and kept free of vectors. When there are methods and materials advised by the Organization for these procedures, these should be employed. The presence of vectors on board conveyances and the control measures used to eradicate them shall be included:

(a) in the case of aircraft, in the Health Part of the Aircraft General Declaration, unless this part of the Declaration is waived by the competent authority at the airport of arrival;

(b) in the case of ships, on the Ship Sanitation Control Certificates; and

(c) in the case of other conveyances, on a written proof of treatment issued to the consignor, consignee, carrier, the person in charge of the conveyance or their agent, respectively.

3. States Parties should accept disinsecting, deratting and other control measures for conveyances applied by other States if methods and materials advised by the Organization have been applied.

4. States Parties shall establish programmes to control vectors that may transport an infectious agent that constitutes a public health risk to a minimum distance of 400 metres from those areas of point of entry facilities that are used for operations involving travellers, conveyances, containers, cargo and postal parcels, with extension of the minimum distance if vectors with a greater range are present.

5. If a follow-up inspection is required to determine the success of the vector control measures applied, the competent authorities for the next known port or airport of call with a capacity to make such an inspection shall be informed of this requirement in advance by the competent authority advising such follow-up. In the case of ships, this shall be noted on the Ship Sanitation Control Certificate.

6. A conveyance may be regarded as suspect and should be inspected for vectors and reservoirs if:

(a) it has a possible case of vector-borne disease on board;

(b) a possible case of vector-borne disease has occurred on board during an international voyage; or

(c) it has left an affected area within a period of time where on-board vectors could still carry disease.

7. A State Party should not prohibit the landing of an aircraft or berthing of a ship in its territory if the control measures provided for in paragraph 3 of this Annex or otherwise recommended by the Organization are applied. However, aircraft or ships coming from an affected area may be required to land at airports or divert to another port specified by the State Party for that purpose.

8. A State Party may apply vector control measures to a conveyance arriving from an area affected by a vector-borne disease if the vectors for the foregoing disease are present in its territory.





# ANNEX 6

## VACCINATION, PROPHYLAXIS AND RELATED CERTIFICATES

1. Vaccines or other prophylaxis specified in Annex 7 or recommended under these Regulations shall be of suitable quality; those vaccines and prophylaxis designated by WHO shall be subject to its approval. Upon request, the State Party shall provide to WHO appropriate evidence of the suitability of vaccines and prophylaxis administered within its territory under these Regulations.

2. Persons undergoing vaccination or other prophylaxis under these Regulations shall be provided with an international certificate of vaccination or prophylaxis (hereinafter the "certificate") in the form specified in this Annex. No departure shall be made from the model of the certificate specified in this Annex.

3. Certificates under this Annex are valid only if the vaccine or prophylaxis used has been approved by WHO.

4. Certificates must be signed in the hand of the clinician, who shall be a medical practitioner or other authorized health worker, supervising the administration of the vaccine or prophylaxis. The certificate must also bear the official stamp of the administering centre; however, this shall not be an accepted substitute for the signature.

5. Certificates shall be fully completed in English or in French. They may also be completed in another language, in addition to either English or French.

6. Any amendment of this certificate, or erasure, or failure to complete any part of it, may render it invalid.

7. Certificates are individual and shall in no circumstances be used collectively. Separate certificates shall be issued for children.

8. A parent or guardian shall sign the certificate when the child is unable to write. The signature of an illiterate shall be indicated in the usual manner by the person's mark and the indication by another that this is the mark of the person concerned.

9. If the supervising clinician is of the opinion that the vaccination or prophylaxis is contraindicated on medical grounds, the supervising clinician shall provide the person with reasons, written in English or French, and where appropriate in another language in addition to English or French, underlying that opinion, which the competent authorities on arrival should take into account. The supervising clinician and competent authorities shall inform such persons of any risk associated with non-vaccination and with the non-use of prophylaxis in accordance with paragraph 4 of Article 23.

10. An equivalent document issued by the Armed Forces to an active member of those Forces shall be accepted in lieu of an international certificate in the form shown in this Annex if:

(a) it embodies medical information substantially the same as that required by such form; and

(b) it contains a statement in English or in French and where appropriate in another language in addition to English or French recording the nature and date of the vaccination or prophylaxis and to the effect that it is issued in accordance with this paragraph.

## MODEL INTERNATIONAL CERTIFICATE OF VACCINATION OR PROPHYLAXIS

This is to certify that [name] ................................, date of birth ..................., sex ..............................,

nationality ..................................., national identification document, if applicable ............................

whose signature follows ......................................................

has on the date indicated been vaccinated or received prophylaxis against:

(name of disease or condition) ........................................................

in accordance with the International Health Regulations.

| Vaccine or prophylaxis | Date | Signature and professional status of supervising clinician | Manufacturer and batch No. of vaccine or prophylaxis | Certificate valid from ...... until ...... | Official stamp of administering centre |
|---|---|---|---|---|---|
| 1. | | | | | |
| 2. | | | | | |

This certificate is valid only if the vaccine or prophylaxis used has been approved by the World Health Organization.

This certificate must be signed in the hand of the clinician, who shall be a medical practitioner or other authorized health worker, supervising the administration of the vaccine or prophylaxis. The certificate must also bear the official stamp of the administering centre; however, this shall not be an accepted substitute for the signature.

Any amendment of this certificate, or erasure, or failure to complete any part of it, may render it invalid.

The validity of this certificate shall extend until the date indicated for the particular vaccination or prophylaxis. The certificate shall be fully completed in English or in French. The certificate may also be completed in another language on the same document, in addition to either English or French.





## ANNEX 7

## REQUIREMENTS CONCERNING VACCINATION OR PROPHYLAXIS FOR SPECIFIC DISEASES

1. In addition to any recommendation concerning vaccination or prophylaxis, the following diseases are those specifically designated under these Regulations for which proof of vaccination or prophylaxis may be required for travellers as a condition of entry to a State Party:

Vaccination against yellow fever.

2. Recommendations and requirements for vaccination against yellow fever:

(a) For the purpose of this Annex:

(i) the incubation period of yellow fever is six days;

(ii) yellow fever vaccines approved by WHO provide protection against infection starting 10 days following the administration of the vaccine;

(iii) this protection continues for 10 years; and

(iv) the validity of a certificate of vaccination against yellow fever shall extend for a period of 10 years, beginning 10 days after the date of vaccination or, in the case of a revaccination within such period of 10 years, from the date of that revaccination.

(b) Vaccination against yellow fever may be required of any traveller leaving an area where the Organization has determined that a risk of yellow fever transmission is present.

(c) If a traveller is in possession of a certificate of vaccination against yellow fever which is not yet valid, the traveller may be permitted to depart, but the provisions of paragraph 2(h) of this Annex may be applied on arrival.

(d) A traveller in possession of a valid certificate of vaccination against yellow fever shall not be treated as suspect, even if coming from an area where the Organization has determined that a risk of yellow fever transmission is present.

(e) In accordance with paragraph 1 of Annex 6 the yellow fever vaccine used must be approved by the Organization.

(f) States Parties shall designate specific yellow fever vaccination centres within their territories in order to ensure the quality and safety of the procedures and materials employed.

(g) Every person employed at a point of entry in an area where the Organization has determined that a risk of yellow fever transmission is present, and every member of the crew of a conveyance using any such point of entry, shall be in possession of a valid certificate of vaccination against yellow fever.

(h) A State Party, in whose territory vectors of yellow fever are present, may require a traveller from an area where the Organization has determined that a risk of yellow fever transmission is present, who is unable to produce a valid certificate of vaccination against yellow fever, to be quarantined until the certificate becomes valid, or until a period of not more than six days, reckoned from the date of last possible exposure to infection, has elapsed, whichever occurs first.

(i) Travellers who possess an exemption from yellow fever vaccination, signed by an authorized medical officer or an authorized health worker, may nevertheless be allowed entry, subject to the provisions of the foregoing paragraph of this Annex and to being provided with information regarding protection from yellow fever vectors. Should the travellers not be quarantined, they may be required to report any feverish or other symptoms to the competent authority and be placed under surveillance.





# ANNEX 8

# MODEL OF MARITIME DECLARATION OF HEALTH

To be completed and submitted to the competent authorities by the masters of ships arriving from foreign ports.

Submitted at the port of................................................. .. Date...........
Name of ship or inland navigation vessel........................ Registration/IMO No.................arriving from ..............sailing to ...............
(Nationality)(Flag of vessel)........................................ Master's name ..........................................................................
Gross tonnage (ship)................
Tonnage (inland navigation vessel)....................
Valid Sanitation Control Exemption/Control Certificate carried on board? yes........... no........... Issued at.................. date...................
Re-inspection required? yes....... no.......
Has ship/vessel visited an affected area identified by the World Health Organization? yes..... no.....
Port and date of visit ...................................................
List ports of call from commencement of voyage with dates of departure, or within past thirty days, whichever is shorter:
..........................................................................................................................................................................

Upon request of the competent authority at the port of arrival, list crew members, passengers or other persons who have joined ship/vessel since international voyage began or within past thirty days, whichever is shorter, including all ports/countries visited in this period (add additional names to the attached schedule):

(1) Name ....................................joined from: (1)............................(2)............................(3)..................................
(2) Name ....................................joined from: (1)............................(2)............................(3)..................................
(3) Name.....................................joined from: (1)............................(2)............................(3)..................................

Number of crew members on board...........
Number of passengers on board...............

## Health questions

(1) Has any person died on board during the voyage otherwise than as a result of accident? yes.... no.....
If yes, state particulars in attached schedule. Total no. of deaths .........

(2) Is there on board or has there been during the international voyage any case of disease which you suspect to be of an infectious nature? yes........ no........ If yes, state particulars in attached schedule.

(3) Has the total number of ill passengers during the voyage been greater than normal/expected? yes.... no.....
How many ill persons? .........

(4) Is there any ill person on board now? yes........ no........ If yes, state particulars in attached schedule.

(5) Was a medical practitioner consulted? yes....... no...... If yes, state particulars of medical treatment or advice provided in attached schedule.

(6) Are you aware of any condition on board which may lead to infection or spread of disease? yes........ no........
If yes, state particulars in attached schedule.

(7) Has any sanitary measure (e.g. quarantine, isolation, disinfection or decontamination) been applied on board? yes ....... no......
If yes, specify type, place and date..........................................................................................................

(8) Have any stowaways been found on board? yes ....... no...... If yes, where did they join the ship (if known)? ..............................

(9) Is there a sick animal or pet on board? yes ......... no.......

Note: In the absence of a surgeon, the master should regard the following symptoms as grounds for suspecting the existence of a disease of an infectious nature:

(a) fever, persisting for several days or accompanied by (i) prostration; (ii) decreased consciousness; (iii) glandular swelling; (iv) jaundice; (v) cough or shortness of breath; (vi) unusual bleeding; or (vii) paralysis.

(b) with or without fever: (i) any acute skin rash or eruption; (ii) severe vomiting (other than sea sickness); (iii) severe diarrhoea; or (iv) recurrent convulsions.

I hereby declare that the particulars and answers to the questions given in this Declaration of Health (including the schedule) are true and correct to the best of my knowledge and belief.

Signed .............................................

Master

Countersigned .............................................

Ship's Surgeon (if carried)

Date.............................................

## ATTACHMENT TO MODEL OF MARITIME DECLARATION OF HEALTH

| Name | Class or rating | Age | Sex | Nationality | Port, date joined ship/vessel | Nature of illness | Date of onset of symptoms | Reported to a port medical officer? | Disposal of case* | Drugs medicines or other treatment given to patient | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | |

* State: (1) whether the person recovered, is still ill or died; and (2) whether the person is still on board, was evacuated (including the name of the port or airport), or was buried at sea.





ANNEX 9

## THIS DOCUMENT IS PART OF THE AIRCRAFT GENERAL DECLARATION, PROMULGATED BY THE INTERNATIONAL CIVIL AVIATION ORGANIZATION[1]

## HEALTH PART OF THE AIRCRAFT GENERAL DECLARATION

*Declaration of Health*

Persons on board with illnesses other than airsickness or the effects of accidents (including persons with symptoms or signs of illness such as rash, fever, chills, diarrhoea) as well as those cases of illness disembarked during the flight ....................................................................

....................................................................................................

Any other condition on board which may lead to the spread of disease

....................................................................................................

Details of each disinsecting or sanitary treatment (place, date, time, method) during the flight. If no disinsecting has been carried out during the flight, give details of most recent disinsecting

....................................................................................................

....................................................................................................

Signature, if required: ..........................................................................

Crew member concerned

Eighth plenary meeting, 23 May 2005
A58/VR/8

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[1] An informal working group met during the second session of the Intergovernmental Working Group and recommended changes to this document which WHO will transmit to the International Civil Aviation Organization for appropriate consideration.

# Protecting the Nation's Health in an Era of Globalization:

# CDC's Global Infectious Disease Strategy

Atlanta, Georgia, 2002

*For additional copies of this booklet, write to*

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or visit the website: www.cdc.gov/globalidplan.htm

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# PREFACE

Since 1994, CDC has been engaged in a nationwide effort to revitalize national capacity to protect the public from infectious disease. Progress continues to be made in the areas of disease surveillance and outbreak response; applied research; prevention and control; and infrastructure-building and training. These efforts are intended to provide protection against endemic diseases like tuberculosis and hepatitis C, as well as against whatever new or drug-resistant diseases arise.

Although safeguarding U.S. health is a domestic goal, its achievement requires international action and cooperation. This is because U.S. health and global health are inextricably linked. As the AIDS epidemic has illustrated, a disease that emerges or reemerges anywhere in the world can spread far and wide. With increased rates of air travel and international trade, infectious microbes have many opportunities to spread across borders, whether carried by businessmen and tourists, by mosquitos that "hitchhike" on airplanes, or by exotic animals imported as pets or livestock. Microbes have additional opportunities for spread on international shipments of fruits, meats, fish, or vegetables.

The international dimension of the effort to combat infectious diseases is reflected in CDC's growing international role. Whenever a new, highly dangerous, drug-resistant, or reemerging disease is detected anywhere on the globe, U.S. citizens, as well as foreign governments, have come to rely on CDC to provide assistance and public health information. Established diseases such as HIV/AIDS, tuberculosis, and malaria, as well as vaccine-preventable diseases such as polio, demand increasing attention and resources as well. This increased international engagement has stimulated CDC to rethink its infectious disease priorities, keeping in mind that it is far more effective to help other countries control or prevent dangerous diseases at their source than try to prevent their importation.

This document, *Protecting the Nation's Health in an Era of Globalization: CDC's Global Infectious Disease Strategy,* represents an important advance in defining CDC's evolving global mission and in considering how CDC and its international partners can work together to improve global capacity for disease surveillance and outbreak response. We look forward to working with our many partners throughout the nation and the world as we put this strategy into practice.

**Jeffrey P. Koplan, M.D., M.P.H.**
*Director*
*Centers for Disease Control and Prevention*



# EXECUTIVE SUMMARY

It is not possible to adequately protect the health of our nation without addressing infectious disease problems that occur elsewhere in the world. In an age of expanding air travel and international trade, infectious microbes are transported across borders every day, carried by infected people, animals, and insects, and contained within commercial shipments of contaminated food. "Old" diseases such as malaria, measles, and food-borne illnesses are endemic in many parts of the globe, and new diseases such as acquired immunodeficiency syndrome (AIDS; caused by the human immunodeficiency virus (HIV))—as well as new forms of old diseases such as multidrug-resistant tuberculosis (TB)—can emerge in one region and spread throughout the world.

Moreover, unforeseen disease problems continue to appear. Recent examples include vancomycin-resistant infections of *Staphylococcus aureus* in the United States and Japan, avian influenza in Hong Kong, a new disease called Nipah virus encephalitis in Malaysia, and outbreaks of dengue fever in Texas and West Nile encephalitis in New York. Increased CDC engagement in efforts to improve global disease surveillance and outbreak response will help us detect new or unusual diseases of any kind and respond to health emergencies of any kind—including both naturally occurring and intentionally caused outbreaks.

Left unchecked, today's emerging diseases can become the endemic diseases of tomorrow. This is what happened with HIV/AIDS, which spread from a remote part of Africa to all other continents 20 years ago, and is now entrenched all over the world, necessitating a major international control effort.

Because U.S. and international health are inextricably linked, the fulfillment of CDC's domestic mission—to protect the health of the U.S. population—requires global awareness and strategic thinking. This document, *Protecting the Nation's Health in an Era of Globalization: CDC's Global Infectious Disease Strategy,* describes how CDC and its international partners can collaborate to prevent the emergence and spread of infectious diseases.

## U.S. Investment in Global Public Health

The United States must participate more fully in combating infectious disease threats around the world. These efforts will yield multiple benefits:

- **Protecting the health of U.S. citizens at home and abroad.** Controlling disease outbreaks as well as dangerous endemic diseases wherever they occur prevents those diseases from spreading internationally, saving lives and dollars. U.S. citizens cannot be adequately protected from diseases such as measles, HIV/AIDS, and tuberculosis if our public health efforts are restricted to persons residing within our borders.

- **Furthering U.S. humanitarian efforts.** The potential for saving human lives by preventing infectious diseases overseas is tremendous. Every year, an estimated three million infant and child deaths are prevented by vaccination and other preventive health measures. Many families and communities, including refugees and displaced people, also benefit from international investigations that lead to prompt control of outbreaks.
- **Providing diplomatic and economic benefits.** Because health is an area of concern for all nations, international projects that address infectious disease issues can open avenues of communication and ease tensions between the United States and other nations. Improvements in global health will also enhance the U.S. economy and contribute to global prosperity. Reductions in disease burden will promote economic growth in nations that represent growing markets for U.S. products. Investments in global health will also reduce U.S. healthcare costs by decreasing the number of cases of imported diseases and by eradicating diseases currently included in childhood vaccination programs.
- **Enhancing security.** Slowed economic growth fueled by poor health and disease can impede democratic development and political transitions in poor and former communist nations, contributing to military conflicts and humanitarian emergencies. The HIV/AIDS pandemic is already destabilizing poorer nations, damaging their economic, social, political, military, and educational infrastructures, and creating vast numbers of orphans. The recent intentional releases of biologic agents in the United States have also intensified international concerns about bioterrorism. Due to the ease and frequency of modern travel, an intentionally-caused outbreak that begins anywhere in the world can quickly become an international problem. A contagious bioterrorist agent such as smallpox can spread rapidly from person to person and from country to country. A noncontagious agent such as anthrax can be spread by unexpected methods, including international mail. The United States must be prepared to work with other nations to prevent illness and deaths caused by acts of bioterrorism.

Although the United States participates in health projects in many parts of the world, much more can be done, at relatively low cost, with political will, national leadership, and a clearly articulated global strategy.

## CDC's Role in Promoting Global Public Health

CDC, which is dedicated to the prevention and control of disease and the promotion of health, works by invitation in many different jurisdictions, including U.S. states and cities and other nations. Throughout its history, CDC has provided international leadership in public health, serving as a technical consultant to the World Health Organization (WHO) and ministries of health on projects that address infectious disease problems related to endemic diseases, wars, famines, or other disasters. Many of these projects have been funded and coordinated by the U.S. Agency for International Development (USAID). CDC has also supported research and public health education on diseases of regional or international importance, provided resources and leadership for the smallpox eradication effort, and established long-term collaborative research partnerships with several developing nations. While considerable effort has been devoted to these international activities, CDC's primary focus has remained on domestic health.

In recent years, however, CDC's overseas role has expanded rapidly. Global polio eradication (http://www.cdc.gov/nip/global) and HIV/AIDS control programs (http://www.cdc.gov/nchstp/od/gap) have led to substantial investments of CDC personnel and financial resources, as have a succession of complex international emergencies. Between 1990 and 2000, CDC provided outbreak assistance on an ad hoc basis to nations in Asia, Africa, Europe, and Latin America to help investigate outbreaks of unknown, highly dangerous, and highly infectious diseases, and provided diagnostic support for hundreds of local investigations around the globe.

Although there are no formal structures and designated resources for international outbreak response, U.S. citizens—as well as foreign governments—have come to rely on CDC to provide outbreak assistance and public health information whenever a new or reemerging disease threat is detected anywhere on the globe. Oubreak assistance by CDC would also be required if an intentionally caused outbreak occurred at home or abroad.

CDC's growing presence overseas presents new opportunities and new challenges. This document—developed in consultation with public and private sector partners, at home and abroad—represents an active effort to further define CDC's evolving global mission. It considers how CDC and its international partners can work together over the long term to improve the capacity to detect, control, and prevent infectious diseases. CDC's ongoing efforts to strengthen U.S. domestic public health infrastructure are critical to the success of these international collaborations.

## Six Priority Areas

*Protecting the Nation's Health in an Era of Globalization: CDC's Global Infectious Disease Strategy* defines CDC's global infectious disease priorities in six areas, selected in consultation with global public health partners. In looking towards the future, CDC envisions increased activity and progress in each area:

### 1. International Outbreak Assistance.

An underlying principle of the global strategy is the recognition that international outbreak assistance is an integral function of CDC. Supporting this function will require augmenting, updating, and strengthening CDC's diagnostic facilities, as well as its capacity for epidemiologic investigation overseas. In the future, CDC must also be prepared, as a matter of routine, to offer follow-up assistance after each acute emergency response. Such follow-up will assist host-country ministries of health to maintain control of new pathogens when an outbreak is over.

### 2. A Global Approach to Disease Surveillance.

In the years ahead, regional surveillance networks should expand, interact, and evolve into a global "network of networks" that provides early warning of emerging health threats and increased capacity to monitor the effectiveness of public health control measures. CDC will help stimulate this process by providing technical assistance, evaluating regional progress, and working with many partners to strengthen the networks' telecommunications capacities and encourage the use of common software tools and harmonized standards for disease reporting.

### 3. Applied Research on Diseases of Global Importance.

A research program on diseases that are of global importance, including some that are uncommon in the United States, is a valuable resource, both for humanitarian reasons and because of the dangers represented by some imported diseases. CDC's laboratorians, epidemiologists, and behavioral scientists will maintain an active research program to develop tools to detect, diagnose, predict, and eliminate diseases of global or regional importance. When a new disease threat is reported anywhere in the world, CDC's laboratorians and field investigators will be available to help answer questions about disease transmission, treatment, control, and prevention.

### 4. Application of Proven Public Health Tools.

There is often a long delay between the development of a new public health tool and its widespread use. CDC will intensify efforts to couple applied research with research on ways to promote the use of newly developed tools for disease control ("implementation research"). CDC will help identify the most effective tools and actively encourage their international use, applying expertise and resources in laboratory research, public health policy, program management, and health communications to overcome scientific, financial, and cultural barriers.

5. Global Initiatives for Disease Control.

CDC will make sustained contributions to global initiatives to reduce the prevalence of HIV/AIDS in young people by 25% and reduce deaths from tuberculosis and malaria by 50% by 2010. CDC will also work with the Global Alliance for Vaccines and Immunization to reduce infant mortality through enhanced delivery and use of new and underutilitzed vaccines against respiratory illnesses and other childhood diseases. CDC and its partners will also consult on future international priorities for disease control, elimination, and eradication efforts—as well on monitoring for antimicrobial resistance and planning for pandemic influenza—and help evaluate progress through the collection and analysis of disease surveillance data.

6. Public Health Training and Capacity Building.

CDC will encourage and support the establishment of International Emerging Infections Programs (IEIPs) in developing countries—centers of excellence that integrate disease surveillance, applied research, prevention, and control activities. The IEIP sites will partner with Field Epidemiology Training Programs (FETPS) and other institutions to strengthen national public health capacity and provide hands-on training in public health. Over time, they may help to strengthen capacity in neighboring countries as well as within the host country.

Implementation of specific objectives in these six areas will help realize CDC's vision of a world in which U.S. citizens and people throughout the world are better protected from infectious diseases.

## Partnerships and Implementation

CDC's global infectious disease strategy was prepared by the National Center for Infectious Diseases, in collaboration with other CDC centers and offices, including the Office of Global Health, the National Center for HIV, STD, and TB Prevention, the National Immunization Program, the Epidemiology Program Office, and the Public Health Practice Program Office. Many global health organizations and agencies provided consultation and assistance during its development.

The strategy will be implemented incrementally over the next five years, as funds become available, beginning with the highest priorities for 2001-2002 (Box 1). As CDC carries out this strategy, it will coordinate with foreign governments, international organizations (including WHO, the Joint United Nations Programme on AIDS [UNAIDS], and the United Nations Children's Fund [UNICEF]), other U.S. agencies (including USAID, the National Institutes of Health [NIH], the Food and Drug Administration [FDA], the Department of Defense [DoD], the Department of State, the Department of Veterans Affairs [DVA], the U.S. Department of Agriculture [USDA], the National Oceanic and Atmospheric Administration [NOAA], and the National Aeronautics and Space Agency [NASA]), professional societies, research institutions, and schools of public health, medicine, nursing, and veterinary science. CDC will also participate in international coalitions that support disease eradication efforts and other regional and global health initiatives. These coalitions may include national and local nongovernmental organizations, community-based and faith-based organizations, and communities of color. Other implementation partners will include pharmaceutical and biotechnology companies, non-governmental organizations that address health problems, and development agencies, development banks, foundations, and other organizations that aim to reduce poverty by reducing the incidence of endemic diseases. Website addresses for selected organizations and health publications and reports referred to in this document are provided in Appendix A.



Box 1

### Implementation Priorities, 2001-2002

**International Outbreak Assistance**
Dedicate specific resources—epidemiologic, diagnostic, and logistic—to international outbreak investigations.

**A Global Approach to Disease Surveillance**
Work with WHO and other partners to provide technical assistance to regional networks in Africa, Asia, and Latin America that can fill gaps in global disease surveillance and become components of a global network of networks.

**Applied Research on Diseases of Global Importance**
Establish two or more long-term, on-site research collaborations in developing countries to test new strategies for disease control and prevention.

**Application of Proven Public Health Tools**
Work with a developing-country partner to launch a demonstration project that employs three or more proven public health tools to prevent and control infectious diseases, depending on local priorities.

**Global Initiatives for Disease Control**
Work with foreign ministries of health and WHO to complete the eradication of polio and guinea worm disease.

Help implement HIV/AIDS control programs on all continents through CDC's Global AIDS Program.

Work with the Roll Back Malaria partnership to help implement and monitor disease control and prevention programs in areas with high rates of transmission.

Work with the Stop TB Initiative to improve global surveillance, prevention, and medical management of TB, including multidrug-resistant TB, in areas with high rates of transmission.

Establish population-based surveillance centers to monitor the impact of vaccine use on diseases targeted by the Global Alliance for Vaccines and Immunization. These surveillance centers may become the nuclei of future International Emerging Infections Program sites.

**Public Health Training and Capacity Building**
Establish the first International Emerging Infections Program as a partnership among a ministry of health, CDC, a Field Epidemiology Training Program, and one or more local universities or medical research institutes. An initial priority will be to establish training in field epidemiology, applied laboratory science, and public health management.

# INTRODUCTION

It is not possible to adequately protect the health of our nation without addressing infectious disease problems that are occurring elsewhere in the world. In an age of expanding air travel and international trade, infectious microbes are transported across borders every day, carried by infected people, animals, and insects (Box 2), and contained within commercial shipments of contaminated food (Box 3). "Old" diseases such as malaria, measles, and foodborne illnesses are endemic in many parts of the globe, and new diseases such as acquired immunodeficiency syndrome (AIDS; caused by the human immunodeficiency virus (HIV))—as well as new forms of old diseases such as multidrug-resistant tuberculosis (TB)—can emerge in one region and spread throughout the world.

Old diseases, as well as new ones, can travel. For example, between July 1999 and January 2000, 56 people in southern Texas fell ill with dengue fever, a mosquitoborne tropical disease endemic to South and Central America and parts of Asia. Seventeen of those people acquired their illness in the United States. In 1999, two Boy Scouts in New York State acquired malaria—eliminated as an endemic disease problem in the United States a half century earlier—from mosquitos at a summer camp in a rural area of Suffolk County. In August and September, 1999, six people in the northeastern United States and a Canadian visiting New York City died from West Nile encephalitis, a viral disease also transmitted by mosquitos. The West Nile virus, which is carried by migratory birds in Asia, Africa, and Europe, had never before been reported in the Western Hemisphere.

These outbreaks present new challenges for U.S. public health agencies at the local, state, and federal levels. They also remind us that millions of people live in tropical areas where mosquitoborne diseases like malaria and dengue are a fact of everyday life.

**Because U.S. and international health are inextricably linked, fulfilling CDC's domestic mission—to protect the health of the U.S. population—requires global awareness and strategic thinking. This document, *Protecting the Nation's Health in an Era of Globalization: CDC's Global Infectious Disease Strategy*, describes how CDC and its international partners can collaborate to prevent the emergence and spread of infectious diseases.**

The urgency of the situation is illustrated by the emergence of unforeseen disease problems in recent years. These include multidrug-resistant *Streptococcus pneumoniae* throughout the world and vancomycin-resistant *Staphylococcus aureus* in the United States and



Box 2

### Infectious Diseases Do Not Recognize Borders

From a public health point of view, domestic and international health are inextricably linked. Examples of disease spread from continent to continent include

- **HIV/AIDS**—This disease apparently emerged in central Africa in the 1950s or earlier[1] and spread through most of Africa, Asia, Europe, and the Americas during the 1970s and 1980s.

  Because the AIDS virus weakens an individual's immune defenses, an individual with HIV/AIDS may become coinfected with malaria, tuberculosis (TB), or pathogens that cause diarrhea or pneumonia.

- **TB**—During the 1980s, this age-old scourge, which had been nearly eliminated in the West by antibiotic treatment, reemerged–sometimes in a multidrug-resistant form—in cities around the world, including in the United States. By 2000, approximately 46% of newly identified U.S. TB cases originated in other countries.

  The spread of TB has been hastened by lack of public health surveillance for this disease and by the concurrent HIV/AIDS epidemic.

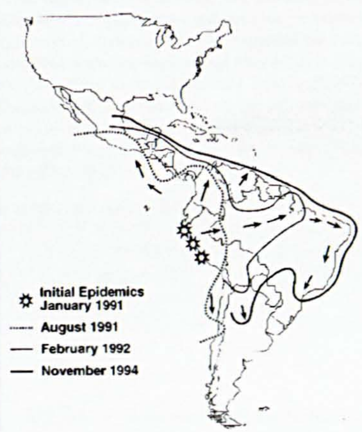
- **Malaria**—Although malaria was eliminated in the United States as an endemic disease by the 1960s (through swamp-draining and vector control programs), approximately 1,500 cases of malaria are reported in the United States each year. One-half occur in U.S. travelers to malaria-endemic countries and the other half occur among foreign nationals who enter the United States already infected.

  Over the past 15 years, more than 80 people in the United States were infected by local transmission within our borders. In other countries, the spread of malaria has been augmented by the spread of antimalarial drug resistance, and many parasite strains are increasingly resistant to preventive antimalarial drugs taken by travelers.

- **West Nile encephalitis**—This mosquitoborne viral disease carried by migratory birds in Asia, Africa, and Europe, caused 79 cases of encephalitis and 7 deaths in the northeastern United States in 1999.

  Because the West Nile virus had never before been detected in the Americas—and because it had been mentioned by an Iraqi defector as an organism of interest to the Iraqi bioweapons program—it was speculated that a strain of West Nile virus isolated in New York City might have been deliberately engineered and disseminated to harm U.S. citizens. However, the scientific evidence suggests that the outbreak was caused by a naturally occurring viral strain.[2]

- ***Vibrio cholerae* O1**, El Tor biotype—A virulent strain of cholera has caused an ongoing pandemic that has lasted 40 years and affected more than 75 countries.




**Geographic extent of the Latin American cholera epidemic over time, since its beginning in January 1991.** Lines represent the advancing front of the epidemic at different times. Since 1995, most Latin American countries have reported diminishing numbers of cases. Cholera has not yet reached the Caribbean.

*Adapted from:* Tauxe RV, Mintz ED, Quick RE. Epidemic cholera in the New World: translating field epidemiology into new prevention strategies. Emerging Infectious Diseases 1:141-6, 1995.

Box 2

Beginning in 1961, *Vibrio cholerae* O1, El Tor biotype spread from Indonesia through most of Asia into eastern Europe and Africa. From North Africa it spread to the Iberian Peninsula and into Italy in 1973. In the late 1970s, small outbreaks occurred in Japan and in the South Pacific.

In January, 1991, epidemic cholera appeared in Peru and spread rapidly through most of Latin America, causing over 1,000,000 cases by 1994. This was the first time in 100 years that a cholera pandemic had reached the New World.

- **Salmonellosis**—A multistate outbreak carried by contaminated mangoes grown in Brazil caused 79 cases of *Salmonella* Newport infections in 13 states in 1999.

  The outbreak was detected and investigated using PulseNet, the U.S. early warning system for foodborne diseases (page 36). PulseNet linked 78 cases in 22 states by comparing the molecular fingerprints of the isolates. Once mangoes were implicated as the common exposure for these cases, FDA traced the source of the mangoes back to a single farm in Brazil. The mangoes had been dipped in warm water in a new process designed to kill fruit-fly larvae before exportation. Unfortunately, the processing water may have been contaminated with *Salmonella*.

- **Coccidioidomycosis**—Outbreaks caused by *Coccidioides immitis*, a soil-dwelling fungus common in arid and semiarid parts of the Western Hemisphere, were reported in 1996 in Washington State and in 2000 in Pennsylvania.

  The outbreaks occurred among church mission groups who visited endemic regions of northern Mexico to undertake construction projects. Infected individuals experienced a severe influenzalike disease with fever, chills and cough. Fungal disease was not initially suspected.

- **Influenza spread on cruise ships**—A 1997 outbreak of the A/Sydney strain of influenza occurred among people on a cruise that made stops in Canada and New England.

  The A/Sydney strain had been isolated in Australia too late in the year to be included in the vaccine formulated for the fall/winter flu season in the Northern Hemisphere. Therefore, the cruise ship passengers had not been immunized against it.

- **Measles**—Fifty-six of the 87 cases of measles identified in the United States in 2000 were traced to importations of the virus from outside our borders. Twenty-six were direct importations, 18 were secondary cases, and 8 involved viruses whose DNA sequences suggested a foreign origin.

  Comprehensive surveillance and genetic sequencing of all identified strains of the virus allow for tracing of the outbreak strains to the country of origin. The finding that indigenous measles transmission can be interrupted in the United States is an important impetus for supporting a global measles elimination campaign.

- **Polio**—Eliminated from the Western Hemisphere since 1991, paralytic polio was again identified in Haiti and the Dominican Republic in 2000, and attributed to waning immunization coverage rates in those countries.

  Unless immunization coverage can be strengthened in other neighboring countries, diseases thought no longer to be a risk for U.S. children may be imported by travelers.



Box 3

## Factors That Facilitate the International Spread of Foodborne Disease

- **Globalization of the food supply, particularly of perishable foods, like fresh produce**
  U.S. citizens can now eat fresh fruits and vegetables all year round, produced in both Northern and Southern Hemispheres. However, some fresh foods may be contaminated during picking, packaging, transport, or delivery. CDC and FDA are working together to reduce the risk to U.S. consumers.

- **The development of new food production industries in developing nations to meet the needs of the export market**
  This includes growing nonindigenous fruits and vegetables that may be susceptible to contamination by indigenous microbes. For example, raspberries were recently introduced into Guatemala with U.S. support as a potentially valuable commercial crop. Some of the exported raspberries were found to be contaminated with *Cyclospora,* a waterborne protozoan parasite not previously associated with foodborne disease. *Cyclospora* outbreaks associated with these raspberries were reported in the United States and Canada.

- **Centralized processing of human and animal foods, followed by widespread distribution**
  If an ingredient used in an animal feed, for example, is contaminated with a strain of *Salmonella,* that strain can be quickly disseminated to food animals around the world. Or, if ground beef is contaminated with *E. coli* O157:H7 at a factory, hamburgers sold at fast-food restaurants in many locations (as well as packages of frozen meat sold at grocery stores) may transmit infection.

- **Expanded U.S. market for "ethnic" foods**
  There is increased familiarity with—and preferences for—foods from different countries, due to international travel by U.S. citizens, the growing ethnic diversity of our population, and our many immigrant communities. A recent outbreak of typhoid fever was associated with imported frozen mamey fruit pulp, popular among Central Americans living in Florida. Outbreaks of gastroenteritis caused by antibiotic-resistant *Salmonella* have occurred in people who are traditionally-prepared Mexican cheese made from raw milk and sold informally.

- **Increased international travel**
  International tourists and business travelers often develop "traveler's diarrhea," caused by foodborne bacteria that generally do not affect local adults, most of whom have acquired immunity from repeated childhood exposures.

Japan (Box 4), avian influenza in Hong Kong (Box 5), a new disease called Nipah virus encephalitis identified in Malaysia, as well as the introduction of West Nile encephalitis into North America (Box 2).

Windows of opportunity for disease control may also close. For example, had smallpox not been eradicated before the global HIV/AIDS epidemic, one of the world's crowning public health successes might have been impossible to achieve. There is now evidence that immune suppression such as that caused by HIV/AIDS may lead to a lack of response to smallpox vaccination or (in some cases) to disseminated vaccinal infection that may be life-threatening.

Left unchecked, today's emerging diseases can become the endemic diseases of tomorrow. This is what happened with HIV/AIDS, which emerged in a remote part of Africa during the 1970s, spread throughout the world during the 1980s, and is now entrenched on all continents, creating widespread devastation. During the 2000s, HIV/AIDS has become the target of a major international control effort (Box 6).

Box 4

### International Spread of Antimicrobial Resistance

Drug-resistant pathogens are a growing menace to all people, regardless of age, sex, or socioeconomic background. They endanger people in affluent, industrial societies like the United States, as well as those in less developed nations. Many pathogens of international importance are becoming resistant to standard therapies, including bacteria that cause pneumonia, ear infections, and meningitis (e.g., *Streptococcus pneumoniae*); food and waterborne infections (e.g., *Salmonella* and *Shigella*); sexually transmitted diseases (e.g., *Neisseria gonorrhoeae*); the human immunodeficiency virus that causes AIDS; and the parasites that cause malaria (*Plasmodium* spp.). Other examples of clinically important microbes that are rapidly developing drug-resistance include *Mycobacterium tuberculosis;* bacteria that cause skin, bone, lung, and bloodstream infections (e.g., *Staphylococcus aureus*) and urinary tract infections (e.g., *Escherichia coli*); and pathogens transmitted in health care settings (e.g., enterococci and *Klebsiella*).

CDC is working with many partners to help improve global capacity to detect and control drug-resistant infections. These efforts include working with WHO to provide quality control and proficiency testing for clinical laboratories in support of surveillance for emerging resistance problems. CDC is also working with FDA, NIH, USAID, DoD, USDA, and other U.S. agencies to develop Part II of the U.S. Public Health Action Plan to Combat Antimicrobial Resistance (http://www.cdc.gov/drugresistance/actionplan), which will serve as a blueprint for U.S. government activities to address international antimicrobial resistance issues. U.S. agencies and their partners will implement this blueprint in the context of WHO's *Global Strategy for the Containment of Antimicrobial Resistance* (http://www.who.int/emc/globalstrategy/strategy.html).

## International Cooperation To Combat Infectious Diseases

The United States must participate more fully in combating infectious disease threats around the world. The urgency of expanding our contributions to infectious disease control was emphasized by an interagency working group of the National Science and Technology Council[3] (http://www.ostp.gov/CISET/html/toc.html).

There has also been an outpouring of interest in infectious disease issues in other nations, both in the developed and the developing world (Appendix B). In July 2000, at the summit meeting in Okinawa the Group of Eight Industrialized Nations pledged to reduce deaths from infectious diseases in poor countries, agreeing to a set of time-limited objectives (http://usinfo.state.gov/topical/econ/group8/summit00). The aim is to reduce the prevalence of HIV/AIDS among young people by 25%, and reduce the number of deaths due to TB and to malaria by 50% by 2010. These goals are based on global health initiatives endorsed by the World Health Organization (WHO) in its effort to address "diseases of poverty" in developing countries (Box 6). Another major initiative, spearheaded by the Global Alliance for Vaccines and Immunization (GAVI; http://www.vaccinealliance.org/), aims to increase developing country access to new and underutilitzed vaccines against hepatitis B, *Haemophilus influenzae* type b, and yellow fever, and to improve delivery of traditional childhood vaccines against measles and other diseases.



Box 5

### Avian Influenza in Hong Kong

Influenza viruses are constantly mutating and evolving, and new strains keep emerging. Because few people have immunity to a new strain—and because influenza spreads easily from person to person—new strains can travel quickly around the world. If a strain is particularly virulent, it may cause a pandemic, like the 1918-19 "Spanish flu," which killed 20 million people, including 500,000 Americans.

The WHO International Influenza Surveillance Network, which includes 110 laboratories throughout the world (including a CDC-based WHO Collaborating Centre), gathers influenza isolates on all continents and collects data on new strains that have the potential for pandemic spread. In 1997, the government of Hong Kong made use of this network to identify a dangerous strain of avian influenza transmitted from chickens to humans that infected 18 persons and killed 6. The authorities feared that the strain (H5N1) might recombine with a human strain and become capable of human-to-human transmission and invited a CDC team to assist with control of the outbreak. Transmission stopped after the government of Hong Kong ordered the destruction of all chickens in Hong Kong that might be carrying the virus (see also Box 15).

This episode suggests that it may be possible to prevent influenza pandemics before they begin, or to mitigate the global impact of an influenza pandemic through early identification of a virulent strain and formulation of a strain-specific vaccine. What is required is continued international vigilance and cooperation (i.e., a global network) and—at the national level—the political will and resources to act on epidemiological and diagnostic evidence. Had the WHO network not been in place, or had the Hong Kong government been unable or unwilling to act, a virulent hybrid chicken/human strain of influenza for which virtually all people lack immunity—and for which there is no vaccine and few drug treatments—might have caused a massive global pandemic.

Our confidence that nations can come together to improve global health is reinforced by the success of the effort to eradicate smallpox, the interruption of measles transmission in the Americas, and the substantial progress made toward the worldwide eradication of polio (Box 7) and guinea worm disease.

## U.S. Investment in Global Public Health

Promoting international cooperation to address emerging infectious diseases is a natural role for the United States, whose scientists and business leaders are important members of the biomedical research and telecommunications communities that provide the technical and scientific underpinning for infectious disease surveillance and control. The United States can continue to lead from its strengths in medical science and technology to help protect American and global health.

Moreover, our nation now has a window of opportunity to make public health investments that will pay increasingly valuable dividends in the years to come. As noted in the 1997 Institute of Medicine report, *America's Vital Interest in Global Health*[4] (http://www.nap.edu/books/0309058341/html), investments in international efforts to detect, control, and prevent infectious diseases can yield multiple benefits:

Box 6

### Global Health Initiatives

Four major global health initiatives were launched between 1998 and 2000:

- **Roll Back Malaria,** a global strategy to reduce deaths from malaria by increasing access to prompt and effective treatment (including protective intermittent therapy for pregnant women) and prevention tools (including insecticide-treated bednets); by facilitating rapid response to malaria outbreaks; and by developing new products for the prevention and treatment of malaria.
- **Stop TB,** a global strategy to stop the spread of TB around the world. One of its objectives is to promote implementation of the directly observed therapy short-course strategy (DOTS). The effective implementation of DOT in NYC, in response to the epidemic in the late 1980s and early 1990s, has served as a model in this country and around the world.
- **International Partnership Against AIDS in Africa,** a UNAIDS-led effort to mitigate the effects of the growing HIV/AIDS epidemic. In 1999, as part of this effort, the U.S. government launched the Leadership and Investment for Fighting an Epidemic (LIFE) Initiative, which provides support to the hardest-hit countries for reducing HIV transmission, improving treatment of HIV/AIDS and opportunistic infections, and strengthening national capacities to collect disease surveillance data and manage national HIV/AIDS programs. The Global AIDS Program is the CDC component of the LIFE Initiative (see Box 21).
- **Global Alliance for Vaccines and Immunization (GAVI),** a global effort to strengthen childhood immunization programs and bring a new generation of recently licensed vaccines into use in developing countries. These include vaccines against hepatitis B, childhood meningitis, yellow fever, and respiratory infections, which are the leading cause of death in children under age five. Substantial resources for this purpose have been pledged by the Bill and Melinda Gates Foundation and the governments of Norway, Netherlands and the United States.

**Targets for Disease Reduction**

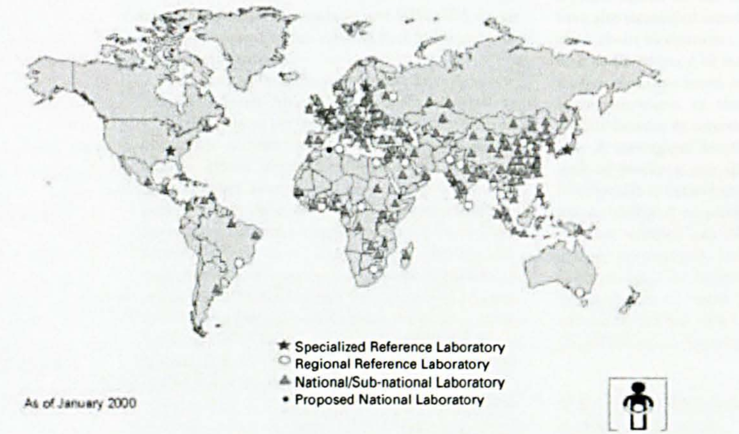
These targets for disease reduction were endorsed at the Group of Eight Industrialized Nations Summit in Okinawa in July 2000:

| | |
|---|---|
| **HIV/AIDS:** | 25% reduction in prevalence in young people by 2010 |
| **TB:** | 50% reduction in deaths by 2010 |
| **Malaria:** | 50% reduction in deaths by 2010 |



Box 7

### The World Health Organization Global Polio Laboratory Network




Ascertaining whether a disease is still present in a given area (and, therefore, that further prevention efforts are needed) is a critical part of any disease eradication effort. The WHO Global Polio Laboratory Network uses molecular techniques to determine whether wild-type polio is circulating in areas undergoing eradication efforts. Since the worldwide campaign began, cases of polio have declined by 99% (from 350,000 cases to less than 3,000), and the number of countries in which polio is endemic has decreased from 125 to 20.

CDC began training Network virologists in 1986, soon after the Pan American Health Organization declared its goal of eliminating polio from the Americas. CDC will continue to train Network virologists for several more years, as new diagnostic methods are developed to meet the stringent surveillance criteria necessary to obtain certification of global polio eradication.

***Protecting the health of U.S. citizens at home and abroad.*** Seeking to control disease outbreaks as well as dangerous endemic diseases wherever they occur prevents those diseases from spreading internationally, saving lives and dollars. In addition, CDC's support for outbreak investigations provides U.S. scientists with opportunities to focus on new or drug-resistant pathogens and consider how best to control, prevent, and treat them before they arrive on our shores. Outbreaks and endemic diseases in other countries also endanger U.S. travelers abroad.

In terms of U.S. health, it is far more effective to help other countries control or prevent dangerous diseases than try to prevent their importation, because it is neither efficient nor feasible to examine each person who enters or returns to the United States for evidence of infection, or to examine all imported goods for evidence of contamination. Some infections are asymptomatic, and some infected individuals may enter the country during the incubation period of a disease (the time between infection and the appearance of symptoms). Thus, diseases such as measles and TB continue to be imported.

***Furthering U.S. humanitarian efforts.*** Disease prevention is an investment in the young people of the world and in our collective future. Every year, millions of infant and child deaths are prevented by vaccination and other preventive health measures. Many families and communities also benefit from international investigations that lead to prompt control of outbreaks. These include communities of refugees and displaced persons, who may be especially vulnerable to infectious diseases (see Box 13). CDC is also a major contributor to global efforts to eradicate polio (http://www.cdc.gov/nip/global) and dracunculiasis (guinea worm disease; http://www.cdc.gov/ncidod/dpd/parasites/guineaworm and http://www.cartercenter.org/guineaworm.html).

The potential for saving human lives by preventing infectious diseases overseas is tremendous. For example, an additional three million deaths could be prevented annually by wider worldwide use of childhood vaccines. Although the United States participates in international health projects in many parts of the world, much more can be done, at relatively low cost, with political will, national leadership, and a clearly articulated global strategy.

Investing in global health is an area in which global humanitarian needs and U.S. national interests coincide. For example, U.S. efforts to help the states of the former Soviet Union rebuild their collapsing public health infrastructures[5] will also help prevent the resurgence of dangerous diseases (e.g., polio, diphtheria, and drug-resistant TB) that can spread to the Americas. Similarly, U.S. efforts to help China improve surveillance for new strains of influenza may be crucial in preventing or controlling the next influenza pandemic (see Box 5).

***Providing economic and diplomatic benefits.*** Improvements in global health can also enhance the U.S. economy in direct and indirect ways. Domestic health care costs can be reduced by decreasing the number of cases of imported diseases and by eradicating diseases currently included in childhood vaccination programs. For example, the U.S. saved $3 billion after investing $32 million in smallpox eradication, and promises to gain even greater cost savings if the global polio eradication effort is successful. Moreover, a reduction in the infectious disease burden in other countries helps improve the economic well-being of developing nations, which represent the fastest growing markets for U.S. products.

Organizations concerned with economic development, including the World Bank and the World Trade Organization (www.worldbank.org and www.who.int.inf-pr-2000/en/note 2000-wha02.html), have concluded that disease reduction efforts are a necessary part of global development strategies (Box 8). Infectious diseases can sap the strength of a nation's workforce and deplete its medical resources, making it more difficult to participate in the global economy. Promoting political stability and sustainable development in developing nations is a major goal of U.S. foreign policy.

Because health is an area of concern for all nations, international projects that address infectious disease issues can open avenues of communication and ease tensions between the United States and other nations (Box 9). Investments in global health can also help advance specific U.S. foreign policy objectives, such as improving bilateral relationships with Vietnam, China, and the Palestinian Territories, and converting biological weapons plants in the Russian Federation and the newly independent states of the former Soviet Union to peaceful uses.

***Enhancing security.*** Security experts, including members of the U.S. National Intelligence Council[6] (http://www.cia.gov/cia/publications/nie/report/nie 99-17d.html) are concerned that large outbreaks like the HIV/AIDS pandemic may destabilize poorer nations. Slowed economic growth fueled by poor health and disease in developing and former communist countries may challenge democratic development and political transitions and contribute to





Box 8

### Infectious Diseases and Economic Development

Infectious diseases like malaria and HIV/AIDS act as a massive societal brake, slowing both economic and human development.

Each year, malaria slows economic growth in several sub-Saharan African countries by as much as 1.3% per person per year.[7] Besides interfering with individuals' abilities to earn a living or attend school, malaria affects national economies by impeding trade, foreign investment, and commerce. It also interferes with children's mental and physical development and may encourage population growth when parents decide to have bigger families, knowing that some of their children may die young. According to one estimate,[8] if malaria had been eliminated 35 years ago, Africa's current annual gross domestic product would be $400 billion, rather than $300 billion—a loss that is nearly five times greater than all development aid provided to Africa last year.

According to a World Bank report,[9] HIV/AIDS may subtract an additional 1% a year from GDP growth in some sub-Saharan African countries, due to the continuing loss of skilled and unskilled workers in the prime of life. In South Africa, for example, HIV/AIDS may depress GDP by as much as 17% over the next decade, which is a dangerous burden for a young democracy. The HIV/AIDS pandemic is destabilizing several other hard-hit nations, damaging their economic, social, political, military, and educational infrastructures, and creating vast numbers of orphans.

humanitarian emergencies and military conflicts.

The recent intentional releases of biologic agents in the United States have also intensified international concerns about bioterrorism. Due to the ease and frequency of modern travel, an intentionally-caused outbreak that begins anywhere in the world can quickly become an international problem. A contagious bioterrorist agent such as smallpox can spread rapidly from person to person and from country to country. A noncontagious agent such as anthrax can be spread by unexpected methods, including international mail. The United States must be prepared to work with other nations to prevent illness and deaths caused by acts of bioterrorism.

## CDC's Role in Promoting Global Public Health

As its name implies, CDC is dedicated to the control and prevention of disease. The agency grew out of efforts to control malaria in the southern United States and today retains a critical role in addressing domestic infectious disease threats. CDC is known in the United States for

- Working with state and local public health agencies to conduct disease surveillance
- Providing national leadership in times of public health crisis

Box 9

### International Disease Control Efforts Can Create New Alliances

Mutual interest in addressing an outbreak or an ongoing infectious disease problem may provide the impetus for collaborations with countries who have not historically cooperated with the United States on public health projects, or with countries whose relationship to the United States is uncertain. One example is Hong Kong during the transfer of sovereignty from the United Kingdom to China (see Box 5).

At times, concern about disease outbreaks may be sufficiently strong to allow national antagonisms to be set aside in the interests of disease control. During the outbreak of Marburg hemorrhagic fever in 1998, for example, an international investigative team was permitted to enter a contested part of the Democratic Republic of the Congo. Similarly, an international guinea worm eradication team sponsored by the Carter Center received safe passage in southern Sudan in 1995, due to a specially negotiated cease-fire between the government of Sudan and rebel forces. Moreover, a polio eradication team was allowed to operate in civil war–torn Sri Lanka during 2 "Days of Peace for National Immunization" that were separated by 30 days of warfare. Three decades earlier, during the height of the Cold War, the United States and the Soviet Union agreed on the need to provide coordinated financial and technical support to the smallpox eradication effort.

- Diagnosing rare, highly dangerous, and previously unknown diseases
- Responding rapidly to requests for outbreak assistance
- Researching public health issues and translating the findings into practical tools for disease control and prevention
- Using surveillance data to drive public health action and inform strategic planning
- Integrating epidemiologic and laboratory expertise to address infectious disease problems
- Implementing programs for disease prevention and control
- Training public health workers

CDC works by invitation in many different jurisdictions, including U.S. states and cities and other nations. Throughout its history, CDC has also provided international leadership in public health, serving as a technical consultant to WHO and ministries of health on projects that address infectious disease problems related to endemic diseases, wars, famines, or other disasters. Many of these projects were funded and coordinated by the U.S. Agency for International Development (USAID). Through the Field Epidemiology Training Programs (see Box 24), the Epidemic Intelligence Service (http://www.cdc.gov/epo/dapht/eis), and other programs, CDC has





also supported research and public health education on diseases of regional or international importance. CDC helped lead the smallpox eradication effort in the 1960s, and established collaborative research stations (see Box 10) in Côte D'Ivoire, Guatemala, and Kenya in the 1980s and in Guinea, Botswana, Thailand, and Uganda in the 1990s. Although considerable effort has been devoted to these international activities, CDC's primary focus has remained on domestic health.

***An evolving mission.*** In recent years, CDC's overseas role has expanded rapidly. Global polio eradication and HIV/AIDS control programs have led to substantial investments of CDC personnel and financial resources, as have a succession of complex international emergencies. Between 1990 and 2000, CDC provided rapid response teams to nations in Asia, Africa, Europe, and Latin America to help investigate outbreaks of unknown, highly dangerous, and highly infectious diseases (Appendix C), and provided diagnostic support for hundreds of local investigations around the globe. Some of these investigations involved epidemic diseases and others involved diseases that afflict refugees and other displaced persons. In many cases, CDC epidemiologists served as members of WHO-coordinated investigative teams supported by CDC-based WHO Collaborating Centre laboratories (Appendix D). In addition to helping with outbreak control, CDC provides on-going public health consultation by placing resident advisors and assignees with key partner agencies and by working with coalitions of national groups on emerging infectious disease issues.

CDC's growing presence overseas presents new opportunities and new challenges. This document, *Protecting the Nation's Health in an Era of Globalization: CDC's Global Infectious Disease Strategy,* represents an active effort to further define CDC's evolving global mission. It was developed in consultation with public and private sector partners at home and abroad. It considers how CDC and its international partners can work together over the long-term to improve capacity to detect, control, and prevent infectious diseases. This document builds on two ongoing efforts. First, it augments and amplifies the international component of the 1998 CDC plan *Preventing Emerging Infectious Diseases: A Strategy for the 21st Century*[10] (http://www.cdc.gov/ncidod/emergplan). CDC's ongoing efforts to strengthen U.S. domestic public health infrastructure are critical to the success of our international collaborations. Second, it fits within the larger framework of CDC's efforts to improve international health, as described in *Working with Partners To Improve Global Health: A Strategy for CDC and ATSDR*[11] (http://www.cdc.gov/ogh/pub/strategy.htm).

Box 10

## Examples of CDC's Long-term Research Collaborations Overseas

CDC manages research collaborations (sometimes referred to as "field stations") in Côte D'Ivoire, Guatemala, Uganda, Guinea, Kenya, Botswana, and Thailand, and is establishing long-term collaborative projects that may form the basis for a permanent center in Vietnam. In general, CDC provides core funding for the field stations, and USAID and other donors provide additional support for both core activities and special projects.

The field station in Kenya is a collaborative effort between CDC and the Kenya Medical Research Institute (KEMRI). Most of the research takes place in western Kenya, in an area of intense, year-round malaria transmission and high incidence of HIV/AIDS. Major studies have

- Demonstrated that presumptive malaria treatment of pregnant women decreases the number of low birth-weight babies born.
- Demonstrated that use of insecticide-impregnated bednets reduces mortality among children less than 2 years of age in areas of high transmission.
- Provided critical information about the immune response to malaria that is being used to design vaccines.

The field station is also studying the impact of coinfection with HIV and malaria, particularly in pregnancy. Other ongoing activities concern the development of immunity to vaccines among HIV-positive children, defining local spectrum of diarrheal diseases and antimicrobial resistance among diarrheal pathogens, and addressing the consequences of coinfection with HIV and schistosomiasis.

The field station in Guatemala–the Medical Entomology Research and Training Unit/Guatemala, or MERTU/G, is integrated into the Universidad del Valle and works closely with the Guatemalan Ministry of Health. MERTU/G has helped evaluate national prevention and control efforts related to malaria and onchocerchiasis. Research on leishmaniasis has led to improved clinical treatment regimens, and research on foodborne and waterborne diseases such as cholera has led to improved prevention methods. To reduce deaths due to Chagas disease—a significant health problem in Guatemala—the Guatemalan Ministry of Health and MERTU/G are conducting nationwide surveys to determine prevalence and risk factors; supporting field and molecular studies of the triatomine insect that carries the disease; and evaluating blood bank practices that may contribute to transmission through blood transfusions.

**Future Directions: Capacity Building**

The field stations have provided valuable opportunities for CDC scientists to participate in long-term, on-site research on selected diseases of importance in developing countries. Expansion of the field stations and strengthened ties with local ministries of health would facilitate additional opportunities to investigate endemic diseases, respond to new or emerging diseases, and provide a stable training center for epidemiologists and laboratory scientists from CDC and the local region. As part of CDC's global strategy, one of the existing field stations may also provide the nucleus of the first International Emerging Infections Program (page 53).



# VISION FOR THE FUTURE

This document defines CDC's global infectious disease priorities in six areas, keeping in mind the intimate relationship between international and U.S. health, selected in consultation with global public health partners. In looking towards the future, CDC envisions increased activity and progress in each area:

### 1 International Outbreak Assistance.

CDC will maintain the capacity to identify and investigate a broad spectrum of human diseases and serve as an internationally recognized resource that helps maintain global awareness of new and emerging threats.

### 2 A Global Approach to Disease Surveillance.

Regional and disease-specific surveillance and response networks will increase in number and geographical area until they cover all parts of the world and monitor all infectious diseases of regional or global importance. The networks will link up with each other and evolve into a global "network of networks" that provides early warning of new health threats—including drug-resistant diseases—and increased capacity to monitor the effectiveness of public health control measures.

### 3 Applied Research on Diseases of Global Importance.

CDC's laboratorians, epidemiologists, and behavioral scientists will maintain an active research program to develop tools to detect, diagnose, predict, and eliminate infectious diseases of global or regional importance. When a new disease threat is reported anywhere in the world, CDC's laboratorians and field investigators will be available to help answer questions about disease transmission, treatment, control, and prevention.

### 4 Application of Proven Public Health Tools.

The worldwide burden of infectious diseases will be significantly reduced as currently available tools with documented efficacy are rapidly disseminated to the most severely affected populations. Research discoveries will be translated into practical treatments, vaccines, diagnostic tests, and disease prevention strategies that are ready for use by ministries of health and public health agencies. CDC's resources will be effectively marshaled to assist its partners in applying these tools in many countries, saving millions of lives.

### 5 Global Initiatives for Disease Control.

Sustained global efforts will reduce the prevalence of HIV/AIDS in young people by 25% and reduce deaths from TB and malaria by 50% by 2010. Infant mortality will be reduced in the poorest countries through enhanced delivery and use of vaccines against respiratory illnesses and other childhood diseases. Polio and dracunculiasis will be eradicated worldwide, paving the way for future efforts to eliminate such diseases as measles, lymphatic filariasis, onchocerchiasis, Chagas disease, trachoma, rubella, and hepatitis B.

### 6 Public Health Training and Capacity Building.

An interconnected group of International Emerging Infectious Disease Programs (IEIPs) will integrate disease surveillance, laboratory studies, and prevention activities, and provide hands-on public health training in disease detection, program management, and outbreak investigation. The IEIP sites will partner with Field Epidemiology Training Programs (FETPS) and other institutions to perform population-based research on transmission of endemic and emerging diseases and conduct emergency surveillance whenever a new threat appears. The long-term goal of the IEIPs will be to develop sustainable, in-country human capacity to participate in national and regional efforts for disease surveillance and outbreak response.

Implementation of specific objectives in these six areas will help realize CDC's vision of a world in which U.S. citizens and all people everywhere are better protected from infectious diseases.



# PARTNERSHIPS AND IMPLEMENTATION

This plan was prepared by CDC's National Center for Infectious Diseases, in collaboration with other major CDC centers and programs involved in addressing emerging infectious diseases. These include the Office of Global Health, the National Center for HIV, STD, and TB Prevention, the National Immunization Program, the Epidemiology Program Office, and the Public Health Practice Program Office. CDC has also worked with global organizations and agencies to develop this strategy. Website addresses providing additional information about partner organizations and health publications and reports referred to in this document are provided in Box 2 and throughout the text of the document.

The strategy will be implemented incrementally over the next five years, as funds become available, beginning with the highest priorities for 2001-2002 (Box 1). As CDC carries out this strategy, it will coordinate with foreign governments, international organizations (including WHO, the Joint United Nations Programme on AIDS [UNAIDS], and the United Nations Children's Fund [UNICEF]), other U.S. agencies (including USAID, the National Institutes of Health [NIH], the Food and Drug Administration [FDA], the Department of Defense [DoD], the Department of Veterans Affairs [DVA], the U.S. Department of Agriculture [USDA], the National Oceanic and Atmospheric Administration [NOAA], and the National Aeronautics and Space Agency [NASA]), professional societies, research institutions, and schools of public health, medicine, nursing, and veterinary science.

CDC will also participate in international coalitions that support disease eradication efforts and other regional and global health initiatives. These coalitions may include national and local nongovernmental organization (NGOs; e.g., Rotary International and CARE), community-based and faith-based organizations, and communities of color. In addition, CDC will work closely with groups that conduct or promote regional disease surveillance, such as the Caribbean Epidemiology Center (CAREC), the Asia-Pacific Economic Cooperation (APEC; see also Appendix E), and the Training in Epidemiology and Public Health Interventions Network (TEPHINET).

Other implementation partners include

- Pharmaceutical and biotechnology companies that develop vaccines, drugs, and rapid diagnostic tests
- NGOs that address related health problems (e.g., maternal and child health, environmental health, occupational health, and chronic illnesses)
- Development agencies, development banks, foundations, and other organizations that aim to reduce poverty by reducing the incidence of endemic diseases

As emphasized in *CDC's Working with Partners To Improve Global Health: A Strategy for CDC and ATSDR*[11] (http://www.cdc.gov/ogh/pub/strategy.htm), CDC's collaborative work overseas will be based on five approaches:

- CDC's activities will be rooted in sound science, bioethical principles, and local needs.
- The primary modality for action will be through partnerships with other institutions.
- CDC will work in technical areas in which it has established expertise and capability.
- CDC will pursue long-term bilateral relationships, because of their enhanced productivity.
- CDC will ensure that it has the workforce and administrative mechanisms required for full implementation of the infectious disease strategy.



# PRIORITIES AND OBJECTIVES

## Priority Area 1: International Outbreak Assistance

When a new, highly dangerous, or reemerging disease is detected anywhere on the globe—whether in a developing or industrialized country, in a close ally or a "nation of concern"—U.S. citizens, as well as foreign governments, often rely on CDC to provide outbreak assistance and public health information. CDC is unusual among public health institutions in its comprehensive capacity to identify a wide range of infectious bacteria, viruses, fungi, parasites, and rickettsia.

In past years, however, maintaining this capacity has not always been a priority. Attempts have been made to cut costs by reducing support for laboratory expertise on diseases that are currently uncommon in the United States, including zoonotic diseases like plague and leptospirosis. However, CDC's repeated experience with outbreaks of diseases once thought to be archaic or obscure—including a 1994 outbreak of plague in India, a 1995 outbreak of a virulent pulmonary form of leptospirosis in Nicaragua, and a 2000 outbreak of leptospirosis in Malaysian Borneo among athletes at an international competition (Box 11)—has underscored the value of having a comprehensive, integrated ability to identify and investigate most human diseases and to recognize new threats. However, gaps remain in CDC's repertoire of diagnostic tools in such areas as diseases caused by prions (e.g., new variant Creutzfeldt-Jakob

**Outbreak of Ebola hemorrhagic fever, Uganda, 2000.** The isolation ward of Gulu Municipal Hospital, Gulu, Uganda, during an outbreak of Ebola hemorrhagic fever in October 2000. There is no known drug treatment or vaccine for this disease, which is transmitted person-to-person through contact with infected bodily fluids and has a case-fatality ratio of 50–90%.

At the invitation of the Ugandan Ministry of Health, CDC sent several teams of scientists to Gulu to participate in a multinational WHO-coordinated response team. The response team helped bring the epidemic under control by providing assistance and consultation to help rapidly identify cases, provide safe care, and interrupt the spread of the virus.

Photographer: Daniel Bausch, Division of Viral and Rickettsial Diseases, National Center for Infectious Diseases, CDC

Box 11

### An Outbreak of Leptopirosis Affecting Athletes from 26 Countries Reported by the GeoSentinel Disease Surveillance System

In September 2000, several athletes returning home from the EcoChallenge-Sabah 2000 multisport expedition race in Malaysian Borneo fell ill with leptospirosis, apparently contracted while swimming in a contaminated river. Leptospirosis causes severe fever, headache, chills, muscle pain, and cramps. Left untreated, it can lead to kidney and liver failure, meningitis, and death.

Three clinics that participate in GeoSentinel, the global surveillance network of the International Society of Travel Medicine (Appendix E), reported a cluster of acute febrile illness among Eco-Challenge racers and helped identity its cause. A clinic in London, England, reported four instances of suspected leptospirosis and queried other GeoSentinel sites for similar cases. Clinics in New York City and Toronto responded with reports of five more cases among the same group of athletes, and all communicated their findings to CDC. Further evaluation indicated that all cases were clinically compatible with leptospirosis.

Leptospirosis is contracted by coming into contact with or swallowing water contaminated with animal urine. During the 12-day Eco-Challenge race, approximately 300 athletes from 26 countries sailed on open ocean and then bicycled and hiked through torrential jungle rain and mud. After that, the racers swam and canoed in a storm-swollen river and waded through caves filled with bat guano. Analysis by CDC suggested that participating in the river swim was significantly associated with illness. At least 44% of the 155 U.S. participants were affected. Additional cases of leptospirosis were identified in athletes from several other countries as well.

disease, the human consequence of infection with bovine spongiform encephalopathy, or "mad cow disease"), and some areas require upgrading to remain effective (e.g., leptospirosis, yellow fever, diphtheria, anthrax, and helminthic diseases).

**CDC frequently collaborates on international outbreak investigations conducted in partnership with host nations. CDC participation occurs on an ad hoc basis, in response to requests for assistance from foreign governments or WHO. There is no formal structure for this activity, nor are there designated resources. An underlying principle of the global strategy is the recognition that international outbreak assistance is an integral function of CDC. Supporting this function will require augmenting, updating, and strengthening CDC's diagnostic facilities, including laboratories that participate in the WHO Collaborating Centre network, as well as capacity for epidemiologic investigation overseas, including field logistics and data management.**

***Outbreak follow-up.*** In the future, as part of the global strategy, CDC will routinely offer to assist host-country ministries of health and WHO in assessing the public health situation in the aftermath of a major outbreak. If requested, CDC will send a dedicated prevention team to revisit the outbreak site and suggest additional strategies to improve disease surveillance and outbreak response. The team will share clinical and epidemiologic outbreak data with health authorities and work to strengthen local laboratories. The team may also sponsor local workshops or conferences to consider lessons learned from the outbreak, review local hospital resources, and discuss long-term surveillance efforts. These follow-up efforts will help maintain mutually beneficial relationships and research partnerships between CDC, WHO, and local health authorities (Box 12 and Priority Area 2).



Box 12

### Follow-up Activities in the Aftermath of the 1994 Plague Outbreak in India

In September, 1994, rumored outbreaks of bubonic and pneumonic plague in western India caused widespread panic and extensive disruptions in international travel and trade. The Indian Ministry of Health authorized an investigation by a WHO international team that included scientists from CDC, the Russian Federation, and by the WHO South East Asia Regional Office. The work of this team was severely compromised by the inability of Indian laboratories to confirm plague cases by using standard diagnostic methods.

The lack of diagnostic capabilities arose because the Indian Ministry of Health, a former world leader in plague vaccines and diagnosis, believing that plague no longer existed in the country, had allowed its laboratory diagnostic infrastructure to deteriorate. At the suggestion of WHO, the government of India invited CDC team members to return to conduct field training exercises with Indian epidemiologists and hold workshops in plague microbiology at India's National Institute for Communicable Diseases (NICD). Later that year, microbiologists from NICD, the All-India Institute of Medical Science, and the Haffkine Institute in Bombay came to CDC's laboratory in Fort Collins, Colorado, as visiting scientists to learn techniques for confirming infection with *Yersinia pestis* (the causative agent of plague), procedures for preparing standardized diagnostic reagents, and new and advanced molecular methods for identifying and characterizing *Y. pestis* strains.

The relationships that developed among U.S. and Indian scientists during the 1994 outbreak and subsequent collaborations had lasting scientific and diplomatic effects. During the Cold War, India had maintained few contacts with the U.S. public health community, preferring to collaborate with Russian health officials, who (up until 1989) had sent regular shipments of plague diagnostic reagents to NICD. After 1994, however, India was more open to public health collaboration with the United States. For example, the Indian Ministry of Health worked closely with CDC when it renovated and modernized its national plague laboratory during the late 1990s, and also when it reorganized and computerized its national communicable disease surveillance system. The Indian Ministry of Health also played an active role in two regional and two global workshops on plague organized by WHO and CDC between 1996 and 2000.

International contacts made during the 1994 plague outbreak also led to working relationships with the Kazakh Institute for Research on Plague Control in Almaty, Kazakhstan, the Chinese Academy of Preventive Medicine in Beijing, and the Institute of Endemic Diseases Control and Research in Yunnan, China.

## Objectives for Priority Area 1

#### Dedicate Resources to International Outbreak Assistance

- Facilitate CDC participation in international outbreak investigations by
  - Developing standard operating procedures for responding to governments' requests for outbreak assistance, in coordination with WHO
  - Identifying and purchasing equipment and reagents and increasing capacity for logistical support
  - Establishing standard procedures for distributing and tracking specimens for efficient testing at more than one CDC laboratory when the cause of an outbreak is unknown.
  - Maintaining an inventory of CDC personnel with expertise in diseases of regional or global importance
  - Maintaining a registry of disease specialists outside of CDC who have expertise in diseases of regional or global importance ("Active Reserves")
  - Developing research protocols that might be used during outbreak investigations for controlled trials of drug treatments or other public health interventions (see Priority Area 3)

Box 13

### Outbreaks Among Refugees in Kosovo and the Sudan

**Tularemia in Kosovo**
In April and May, 2000, an epidemiologist and ecologist from CDC joined a WHO-led investigation of an outbreak of tularemia among displaced persons returning to damaged homes and farms in rural Kosovo. The illness, which affected 500 to 1,000 people, was characterized by fever, severe sore throat, enlarged lymph nodes in the neck, and abscess formation.

The people who fled from Kosovo in March 1999 had left behind unharvested crops and homes with unprotected stocks of food. Over the following months, the local populations of field mice and domestic rats increased exponentially. Returning refugees became ill after ingesting food and water contaminated with rodent excrement and carcasses containing the bacteria *Francisella tularensis*. The epidemic was halted by instituting simple sanitation measures.

**Louseborne Relapsing Fever in the Sudan**
In April, 1999, epidemiologists from CDC assisted WHO in investigating an apparent outbreak of hemorrhagic fever in southern Sudan among seminomadic tribes displaced by famine, civil war, and intertribal strife. The causative agent proved to be the spirochete *Borrelia recurrentis*, which is transmitted by body lice. The outbreak affected about 20,000 people and caused about 2,000 deaths before the diagnosis was established and disease control measures were implemented.

- Strengthening the capacity of developing countries to identify outbreaks and to request WHO, CDC, or other outside assistance as needed

#### Strengthen Diagnostic Capacity

- Strengthen CDC laboratories (including CDC-based WHO Collaborating Centres) that can identify diseases that are rare or unknown, drug-resistant, or highly dangerous.

  This effort will include strengthening CDC's capacity to identify animal diseases that can affect humans, working in conjunction with USDA and other partners.

- Strengthen national public health laboratories in developing countries by providing diagnostic reference reagents, laboratory manuals, and training opportunities for laboratory scientists.

#### Strengthen Investigative Capacity at CDC

- Rebuild CDC's capacity to respond to international outbreaks.
- Maintain and expand epidemiologic expertise in a wide range of pathogens, helping to create a new generation of experts in infectious disease prevention and control.
- Strengthen international collaboration during investigations, working with many partners, including
  - WHO Global Alert and Response Network (Box 14; http://www.who.int/emc-documents/surveillance/docs/whocdscsr2003.pdf and http://www.who.int/emc-documents/surveillance/docs/whocdscsr2002.pdf).
  - European Programme for Intervention Epidemiology Training (EPIET; http://www.epiet.org/epiet).
  - U.S.-Mexico Border Infectious Disease Surveillance system (BIDS; http://www.r10.tdh.state.tx.us/obh/bids.htm).
  - Training Programs in Epidemiology and Public Health Interventions Network (TEPHINET http://asclepius.ic.gc.ca/tephinet/.
- Improve coordination among the Department of State, CDC, state and local agencies during investigations of infectious disease threats at U. S. ports of entry.



Box 14

### WHO and CDC: Collaboration on International Outbreak Assistance

WHO and CDC work in close partnership to help control outbreaks that involve diseases of unknown cause, diseases with high fatality rates, and diseases that are likely to spread across borders:

- As an international entity, WHO is a critical partner in opening doors to U.S. scientists, facilitating U.S. participation in international efforts to identify new threats and contain potential pandemics. WHO also plays a special role in international press management, encouraging nations to share outbreak information while helping to minimize false rumors that cause damage to the trade and tourism industries of affected countries.
- CDC provides WHO with technical guidance, including diagnostic and epidemiologic support. Because WHO does not maintain laboratory resources of its own, it relies upon an international network of Collaborating Centres that includes more than 30 diagnostic laboratories located at CDC (Appendix D)

At the present time, WHO is strengthening its ability to facilitate international outbreak response efforts, as well as to support global health initiatives that address infectious diseases (see Box 6). As part of this effort, WHO is establishing a Global Alert and Response Network to promote prompt reporting of disease outbreaks and help coordinate offers of outbreak assistance—e.g., supplies, consultation, or on-site support—from public and private sector partners.

- Ensure that the United States is prepared to assist in investigations of international bioterrorist incidents.
- Continue to work with WHO and other partners to investigate epidemics that occur among refugees and displaced persons (Box 13).

#### Strengthen Control Efforts

- Strengthen CDC's capacity to provide prompt and effective epidemic control, by assigning epidemiologists to help monitor disease spread overseas, laboratory scientists to provide rapid diagnostic testing, and social and behavioral scientists to design and implement community education and mobilization efforts.
- Support efforts to provide supplies during outbreak emergencies by partners such as FDA, WHO, NGOs, pharmaceutical companies, multinational corporations, and other members of the private sector.

#### Offer Follow-Up

- Offer to conduct follow-up activities at the site of an outbreak, in collaboration with ministries of health, WHO, International Emerging Infections Programs (IEIPs; page 53), and existing national or donor-supported disease control programs. Activities may include
  - Sharing data to guide ongoing control programs
  - Improving infection control practices
  - Building laboratory capacity
  - Establishing ongoing surveillance for the outbreak pathogen
  - Implementing long-term prevention strategies through the application of proven health tools (see also Priority Area 4)

## Priority Area 2: A Global Approach to Disease Surveillance

Stimulated in part by the AIDS pandemic, national and international groups, including the National Science and Technology Council in 1995 and the Group of Eight in 1997, have called for the establishment of a global system for disease surveillance and outbreak response. U.S. agencies are working with international partners to help achieve this goal.

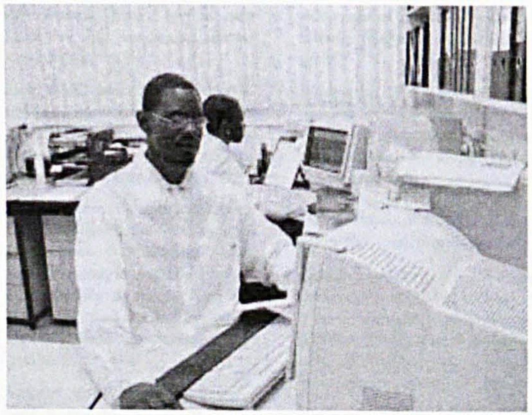
Despite advances in public health telecommunications, however, the global implementation of this goal has not been straightforward. Notable progress has been made at the regional level, with the establishment of such international programs as the Caribbean Epidemiology Center's disease surveillance network, the Amazon and Southern Cone networks in South America, the Integrated Disease Surveillance and Epidemic Preparedness and Response Project in Africa, the Mekong Basin Disease Surveillance system in Southeast Asia, and the International Circumpolar Surveillance system in Alaska, Canada, Greenland, and the circumpolar regions of Europe. These and other fledgling networks (Appendix E) represent pioneering attempts to work across borders to enhance detection and control of outbreaks of known diseases while maintaining the flexibility to recognize new disease problems. The networks are testing many different approaches (e.g., syndromic surveillance, laboratory-confirmed disease-specific surveillance, hospital-based surveillance, and district-level surveillance), depending on local needs, cultural preferences, and human and technological resources.

**In the years ahead, regional disease surveillance networks will grow in number and geographical scope. In the long run, regional and disease-specific networks should expand, interact, and evolve into a global "network of networks" that helps ensure early warning of new and reemerging threats and increased capacity to monitor the effectiveness of public health control measures**

CDC can stimulate this process by providing technical assistance, evaluating regional progress, and working with WHO, other U.S. agencies, and other interested groups to strengthen the networks' telecommunications capacities and encourage the use of common software tools and harmonized standards for disease reporting. CDC can also help revise the International Health Regulations, which describe internationally-reportable diseases and syndromes. In addition, CDC will encourage linkages between regional networks and veterinary surveillance systems that monitor illnesses and epidemics among agricultural and feral animals. Several major outbreaks of zoonotic diseases (diseases of animals that also affect humans) involving agricultural animals have occurred in recent years (Box 15). CDC will also support disease surveillance efforts in tropical or heavily forested areas that are likely sources of human infection with unknown zoonotic or vectorborne diseases.

CDC's priorities in global surveillance will be balanced with the priorities of collaborating countries, and CDC's programs will be coordinated with the ongoing efforts of development agencies and NGOs that build disease surveillance capacity at the national level. CDC can best support both national and regional efforts by providing state-of-the-art diagnostic and epidemiologic tools; by developing surveillance standards and guidelines, and by creating new methods for predicting disease risk. CDC can also increase training opportunities by helping establish new or expanded Field Epidemiology Training Programs (FETPs), Public





**Disease surveillance personnel at the Caribbean Surveillance System (CARISURV) of the Carribean Epidemiology Center (CAREC).** CARISURV is an electronic disease surveillance system that serves 21 nations: Anguilla, Antigua & Barbuda, Aruba, Bahamas, Barbados, Belize, Bermuda, British Virgin Islands, Cayman Islands, Dominica, Grenada, Guyana, Jamaica, Montserrat, Netherlands Antilles, St. Kitts & Nevis, St. Lucia, St. Vincent & Grenadines, Suriname, Trinidad & Tobago (host country), Turks & Caicos Islands.

CARISURV employs computer-based modules to:

- Track cases of measles as part of PAHO's campaign to eliminate measles in the Americas
- Track cases of HIV/AIDS
- Track cases of unusual or unexplained diseases reported by CAREC's Physician-Based Sentinel Surveillance system
- Compile weekly reports of notifiable diseases
- Maintain a database of deaths caused by infectious agents
- Help provide distance-learning courses for public health and medical personnel

A new module that facilitates hotel-based disease surveillance is under development.

CDC and the Walter Reed Army Institute of Research have worked with CAREC to provide CARISURV members with bioinformatics training, technical support, computer equipment, and public health software, including the Public Health Laboratory Information System (PHLIS) for reporting laboratory-confirmed cases of infectious disease. PHLIS was originally developed at CDC for use by U.S. state health departments.

Information Services Unit, CAREC.

Health Schools Without Walls (PHSWOW; http://www.tulane.edu/~phswow/), and Sustainable Management Development Programs (Priority Area 6, Boxes 16 and 24).

The surveillance data gathered by the regional networks will be used not only to detect outbreaks but also to evaluate global health initiatives (Priority Area 5) and to drive national public health programs and decision-making. Disease surveillance data are crucial, for example, in assessing the effectiveness of vaccination programs and the risk factors for underimmunization in a given area.

### Objectives for Priority Area 2

#### Facilitate Regional Disease Surveillance

- Work with WHO and other partners to identify gaps in global disease surveillance by conducting a health situation analysis.
- Provide technical and material assistance to regional networks that can fill global gaps in disease surveillance.
- Host meetings that bring the leaders of regional surveillance networks together on a periodic basis to exchange experiences and methods and facilitate collaboration.
- Develop surveillance modules that can facilitate standardization of disease reporting among regional disease surveillance networks.

Box 15

**Agricultural Costs of Controlling Zoonotic Diseases Carried by Food Animals**

When a dangerous animal-borne disease spills over into the human population, a government may be forced to slaughter large numbers of food animals as a control measure, despite considerable economic costs.

This happened in 1999 when Malaysian health authorities were faced with an outbreak of encephalitis among farm workers that had a nearly 50% mortality rate. The cause of the outbreak turned out to be a previously unknown paramyxovirus called the Nipah virus, which is carried by swine. To control the outbreak, millions of pigs were slaughtered within a few weeks, severely harming the Malaysian meat industry. Two years before, a similar precautionary measure was taken by the government of Hong Kong, which arranged the culling of all 1.6 million chickens on Hong Kong Island and the New Territories to prevent chicken-to-human transmission of a virulent avian form of influenza (Box 5).

The costs of measures to control the outbreak of bovine spongiform encephalopathy (BSE, or "mad cow disease") in the United Kingdom and continental Europe, and the related outbreak of an invariably fatal human neurodegenerative disease (new variant Creutzfeldt-Jakob disease [nvCJD]) have also been high. Ingestion of beef containing the causative agent of BSE (a prion) can result in the development of nvCJD many years later. The export of live cattle and cattle products (other than milk) from the UK has been temporarily banned by the European Commission, and trade in these products has been affected on a global basis. Government officials have come under fire, and consumers across Europe have changed their eating habits due to concern over the spread of BSE. Control measures, including the slaughter of affected cows, have thus far cost the U.K. government an estimated 3.5 billion pounds (about 5 billion U.S. dollars).

The rapidly spreading outbreak of foot-and-mouth disease in Great Britain and continental Europe in 2001 threatens to dwarf the economic costs of the BSE epidemic and devastate the centuries-old British livestock industry. Foot-and-mouth disease does not infect humans but can be spread by travelers who have contaminated soil on their shoes or clothing or who carry contaminated food products. The St. Patrick's Day parade in Ireland was cancelled due to concerns about spreading the virus, and the British army has been drafted to help bury the carcasses of animals slaughtered because of potential exposure to the disease. Officials credit high-quality animal health surveillance and importation restrictions for the absence of foot-and-mouth disease in the United States, but remain concerned because similar measures have failed to contain the spread of the disease in continental Europe.

These examples demonstrate the potential impact an infectious disease outbreak can have on commerce as well as on human and animal health. If the United States were forced to destroy a significant number of cattle, sheep, pigs, or chickens to control an epidemic, the costs might easily rise into the billions.



Modules may cover sentinel disease surveillance, disease-specific surveillance, and syndromic disease surveillance.

- Help WHO strengthen WHO country and regional offices by providing CDC scientists, as needed, to assist with national and regional disease surveillance efforts.
- Assign epidemiologists and laboratory scientists from CDC to DoD laboratories in Indonesia, Kenya, and Thailand, in addition to those already in Egypt and Peru, to support DoD efforts to help strengthen regional disease surveillance (Appendix E).
- Engage nontraditional partners, such as medical missionary organizations and multinational corporations, in regional disease surveillance activities, particularly in regions that lack adequate public health infrastructures.

### Use State-of-the-Art Tools

- Work with DoD, USAID, development banks, foundations, and other partners to provide public health agencies in developing countries with hardware (e.g., hand-held computers for field use), specialized software (e.g., EPI INFO 2000, PHLIS, and LITS+), and reliable Internet access to facilitate participation in regional infectious disease networks and training activities.
- Work with many partners to provide regional networks with field-friendly diagnostic tests (e.g., dipsticks).
- Work with WHO and other partners to develop laboratory standards for diagnostic testing and data standards for disease and syndrome reporting.

### Promote New Paradigms for Global Disease Surveillance

- Establish mechanisms for regular information exchange between veterinary and agricultural organizations and public health agencies on new and re-emerging animal diseases that might affect humans.
- Work with NOAA, NASA, DoD, NIH, the National Science Foundation, and many other partners to create models that predict the risk of zoonotic and vectorborne disease by integrating climatic, environmental, veterinary, entomologic, and epidemiologic data. CDC can play a major role in providing epidemiologic data.
- Encourage the use of molecular methods for microbial subtyping and outbreak detection, such as PulseNet methods for the detection of foodborne disease outbreaks (see Surveillance for Foodborne and Waterborne Diseases).

### Strengthen WHO's Disease-Specific Global Surveillance Networks

- Provide technical assistance to WHO-sponsored networks that monitor specific diseases of global importance, such as polio, measles, influenza, and TB (Appendix E).
- Work with WHO to help establish a global network for surveillance and control of plague, using the WHO Influenza Surveillance Network as a model.
- Work with WHO and other partners to help draft a new set of International Health Regulations (IHR) that includes a set of internationally-reportable diseases or disease syndromes.

### Facilitate Surveillance for Foodborne and Waterborne Diseases

- Improve global surveillance for foodborne and waterborne diseases by
  - Establishing sentinel surveillance sites for foodborne and waterborne disease at International Emerging Infections Programs (IEIPs; page 53).
  - Working with PAHO and FDA to expand PulseNet—the U.S. early warning system for foodborne diseases—into a regional system for detecting outbreaks of foodborne disease throughout

the Americas. PulseNet compares the molecular fingerprints of bacterial isolates from many different sources. It can trace the source of an outbreak to shipments of contaminated food bought and consumed at different geographic locations. (See Box 2.)

- Establishing a mechanism for the regular exchange of surveillance information on foodborne diseases (e.g., salmonellosis, shigellosis, and *E. coli* O157:H7 infection), including PulseNet fingerprinting data, with European Union partners.

- Seek WHO approval for establishing a CDC-based WHO Collaborating Center for Salmonella Surveillance that provides support to WHO's Global Salmonella Surveillance system (Global Salm-Surv).

### Facilitate Surveillance for Antimicrobial Resistance

- Provide technical assistance to help implement WHO's Global Strategy for the Containment of Antimicrobial Resistance (http://www.who.int/emc/globalstrategy/strategy.html).
- Work with other U.S. agencies to draft and implement Part II of the U.S. Public Health Action Plan To Combat Antimicrobial Resistance (Box 4), which will consider the role of the U.S. Government in addressing global resistance problems, such as the spread of multidrug-resistant TB.
- Increase the number of regional laboratories that conduct state-of-the-art testing for drug resistance, working through the WHO External Quality Assurance System and the WHO Collaborating Centre for Antimicrobial Resistance and using the new WHO/CDC laboratory manual for standardized susceptibility testing.
- In collaboration with WHO, the European Union, and other partners, explore the possibility of establishing an expert working group that sets international standards for detecting and reporting drug-resistant threats.

Box 16

### A Growing Community of International Public Health Leaders

By fostering contacts between CDC staff and scientists from other countries (during outbreak investigations, scientific conferences, training courses, and disease prevention projects), CDC is helping build an international community of epidemiologists and laboratory scientists who are prepared to respond to emerging infectious disease threats, whenever and wherever they arise. Often linked by e-mail, as well as by phone and fax, these individuals are part of an informal network that shares outbreak alerts and research data and provides assistance and consultation during infectious disease emergencies.

In addition to these informal exchanges, CDC offers formal training programs in epidemiology (e.g., through Field Epidemiology Training Programs, the Public Health Schools Without Walls, and the Epidemic Intelligence Service), laboratory diagnostics (e.g., through fellowships and disease-specific training workshops), and public health management (e.g., through the Sustainable Management Development Program) that support the development of public health leaders around the world.



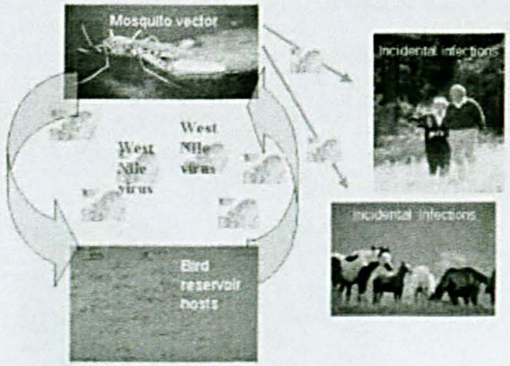
## Priority Area 3: Applied Research on Diseases of Global Importance

CDC's researchers have a dual role. They not only identify the microbes, risk factors, and epidemiologic conditions that lead to outbreaks, but also conduct applied research on ways to detect, prevent, and control them. Maintaining a comprehensive diagnostic and investigative capacity goes hand-in-hand with maintaining a broad-based research program on endemic and epidemic diseases that includes studies in applied epidemiology, microbiology, and behavioral and social science.

**A research program on diseases that are uncommon in the United States is a valuable resource, both for humanitarian reasons and because of the dangers represented by some imported diseases. Had scientists begun to study "slim disease"—now known as AIDS—when the syndrome was described in central Africa in the late 1970s,[12] the world health community might have learned much earlier how HIV is acquired and what can be done to prevent its spread.**

An in-depth knowledge of a wide range of infectious pathogens can also facilitate the identification and characterization of new microbes that emerge in the United States. One example concerns hantavirus pulmonary syndrome (HPS), an often-fatal disease first identified in 1993 in the Four Corners region of the United States. In 1993 hantavirus research was a low priority in the United States, because hantavirus-associated disease had never before been recognized in the Western Hemisphere. However, a few laboratories supported by DoD had continued to collect information on a hantaviral disease called Korean hemorrhagic fever or hemorrhagic fever with renal syndrome (HFRS) that killed a significant number of United Nations troops during the Korean Conflict. Because of these HFRS studies, the CDC outbreak team in Four Corners was armed with sophisticated serologic and molecular tools that allowed them to diagnose HPS in a short time. Because it was known that the HFRS hantavirus is transmitted by rodents, the team rapidly honed in on the animal reservoir of the HPS virus and provided disease prevention guidelines to the people in the area.

Several fundamental precepts inform CDC's infectious disease




**Life cycle of West Nile virus.** West Nile encephalitis—which is carried by birds in Asia, Africa, and Europe and spread to humans by mosquito bite—has been recognized as a U.S. health threat since 1999. CDC is working with colleagues in Australia, the Czech Republic, France, Israel, Romania, and Russia to study the epidemiology, ecology, and pathogenesis of the West Nile virus and find ways to prevent and control its transmission.

From the CDC website: http://www.cdc.gov/ncidod/dvbid/westnile/birds&mammals.htm

research collaborations with other countries. First, the overriding purpose of CDC's research work overseas is to lead the way in demonstrating how individuals and governments can best prevent and control disease. Second, it is important for CDC to help strengthen international research capacity by supporting extramural research at home and abroad, through collaborations, cooperative agreements, and peer-reviewed grants. Third, CDC's research activities must be rooted in bioethical principles, respecting the needs and rights of human research subjects. Fourth, CDC must strive to engage new research partners, in addition to its traditional partners at universities and schools of public health. Research collaborators may include scientists from private companies, NGOs, and other U.S. agencies (e.g., NIH, FDA, DoD, NASA, NOAA, and USDA).

Long-term, on-site research collaborations are especially important, because it is often very difficult to study new and hazardous pathogens while an outbreak is in progress. Long-term partnerships with in-country research institutions may be mutually beneficial, facilitating collaborative field research and clinical studies, providing opportunities for technology transfer and training, and building international friendships and trust within the scientific and public health communities.

## Objectives for Priority Area 3

### Strengthen Overseas Research Collaborations by Establishing IEIPs

- Establish an inventory of existing and potential sites for long-term, on-site research collaborations to address infectious disease problems of regional importance. The inventory should evaluate:
  - How the site might fill geographical and disease-specific research gaps
  - The site's potential as a center for research training
  - Opportunities to engage multiple partners, including in-country partners (e.g., public health agencies and universities) and U.S. agency partners (e.g., NIH and DoD)
  - Opportunities to leverage resources and ensure sustainability
- Create International Emerging Infections Programs (IEIPs), using the information from the inventory described above. (See also Priority Area 6.)

### Conduct Research on Vector-borne and Zoonotic Diseases

- Support the development of field-friendly diagnostic tests for the detection of zoonotic and vector-borne disease, as well as new methods for animal and vector control.
- Support research on the epidemiology, ecology, and pathogenesis of vectorborne and zoonotic diseases of current international concern, including malaria, West Nile fever, dengue fever, Nipah virus encephalitis, rabies, Q fever, leishmaniasis, typhus, plague, and Chagas disease.
- Search for the animal or insect reservoirs of Ebola and Marburg hemorrhagic fevers, working through the CDC-based WHO Collaborating Centre for Viral Hemorrhagic Fevers and collaborating with the South African National Institute of Virology and other partners.
- Investigate the relationship between environmental conditions and the emergence of zoonotic and vector-borne diseases.



### Conduct Vaccine Research

- Encourage and support the development and evaluation of vaccines against diseases of global health importance (Boxes 17 and 18).
- Support research on ways to decrease the cost of expensive vaccines like conjugate *Haemophilus influenzae* type b and pneumococcal vaccines in developing countries (e.g., administering them less frequently or in lower doses).
- Help define the epidemiology and public health burden (illness, mortality, and cost) of vaccine-preventable diseases in developing countries, and monitor the declining burden of disease associated with widespread vaccination. (See also the next section.)

### Conduct Research in Support of Global Initiatives for Disease Control

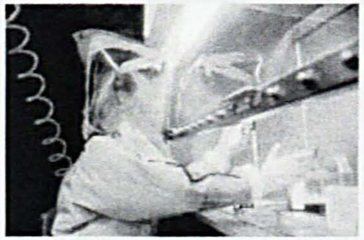
- Encourage and support basic research to improve our understanding of the genetics, physiology, and pathogenesis of parasites, bacteria, and viruses that cause illnesses targeted by global initiatives for disease control.

Box 17

### CDC's Role in the Development of Vaccines Against Diseases of Global Importance

CDC supports the vaccine development goals of the Global Alliance for Vaccines and Immunization (GAVI), the International AIDS Vaccine Initiative, the DHHS Blueprint for TB Vaccine Development, and the Malaria Vaccine Initiative. Over the next 5 years, CDC will work with NIH, FDA, USAID, DoD, and many other public and private partners to help develop:

- A multistage vaccine against malaria, as part of the Malaria Vaccine Initiative, funded by the Bill and Melinda Gates Children's Vaccine Program
- A DNA-based vaccine against HIV/AIDS, in collaboration with the Emory Vaccine Center in Atlanta, Georgia
- Strain-specific vaccines against dengue and dengue hemorrhagic fever, in collaboration with Mahidol University in Salaya, Nakhonpathom, Thailand
- Conjugate vaccines against meningococcal meningitis group A, in collaboration with WHO and the Bill and Melinda Gates Children's Vaccine Program
- An Ebola vaccine, in collaboration with NIH
- Third generation vaccines against *Streptococcus pneumoniae* using proteins common to all pneumococcal serotypes. (Second generation conjugate vaccines are currently under evaluation [see Box 18].)



**CDC vaccine researcher working in a biosafety level 4 (BSL-4) containment facility.** BSL-4 laboratories are used for work on infectious agents for which there are no current vaccines or treatments (e.g., Ebola virus).

Box 18

**CDC's Role in the Evaluation of Vaccines Against Diseases of Global Importance**

Over the next 5 years, CDC will work with many different partners to help implement:

- Phase III trials in Thailand of an HIV vaccine based on the glycoprotein-20 antigen developed by the VaxGen company
- Studies to evaluate the effectiveness of 7-valent pneumoccocal conjugate vaccines on
  - Herd immunity among Native American communities that have high rates of invasive disease. This is a phase III, cluster-randomized trial of conjugate pneumococcal vaccine conducted in collaboration with Johns Hopkins School of Public Health.
  - Nasopharyngeal carriage of pneumococci in Alaska
  - Invasive pneumococcal disease throughout the United States, using the Active Bacterial Core Surveillance (ABCs) system.
- Phase III trial in the Gambia of a 9-valent conjugate pneumococcal vaccine against all-cause mortality and acute-respiratory-infection-specific mortality, conducted in collaboration with the Medical Research Council-Gambia, USAID, NIH, the Bill and Melinda Gates Children's Vaccine Program, and WHO's Vaccine Development, Vaccines and Biologicals program.
- USAID-supported Phase I trials of two vaccines against *Schistosomiasis mansoni,* conducted by the Schistosome Vaccine Development Project, a partnership involving the Government of Egypt, CDC, NIH/NIAID, NAMRU-3, academic centers, and private industry.
- A multisite rotavirus vaccine trial in Southeast Asian countries using an attenuated human rotavirus vaccine produced in India.

- Help develop and evaluate
  - Tools and strategies to prevent transmission of TB, malaria, and HIV/AIDS
  - Treatments for drug-resistant cases of TB, malaria, and HIV/AIDS
  - Improved methods for the detection of TB, HIV/AIDS-related opportunistic infections, and early-stage HIV infections
- Assess the impact of coinfection with HIV and malaria and with HIV and TB on disease control efforts.

### Conduct Research on Foodborne and Waterborne Diseases

- Evaluate diagnostic strategies for foodborne and waterborne infections that are common in developing countries, but for which current diagnostic procedures are slow, expensive, or difficult.
- Conduct targeted research studies in sentinel IEIP sites (page 53) to determine the sources of, and risk factors for, specific foodborne and waterborne infections so that appropriate prevention measures can be developed.
- In collaboration with WHO and others, assess the efficacy, safety, and utility of vaccination to prevent selected foodborne and waterborne infections (e.g., typhoid fever) in combination with other prevention strategies. (See also Conduct Vaccine Research.)





### Conduct Research on Diseases of Pregnant Women and Newborns

- Develop point-of-care diagnostic methods suitable for use in prenatal and obstetric healthcare settings in developing countries and provide quality assurance programs for their use.
- Field test new treatments and prevention measures, such as
  - Drug combinations for the treatment or prophylaxis of malaria in infants and in pregnant women, for use in areas in which chloroquine-resistance is common.
  - Simple and inexpensive regimens for the treatment and prevention of HIV/AIDs that can be administered to mothers and babies during labor and the first week of life.
- Explore ways to extend the benefits of intrapartum or neonatal prophylaxis (e.g., for prevention of HIV/AIDS and hepatitis C infection) to pregnant women with little or no prenatal care.
- Explore the effectiveness of perinatal application of topical antimicrobial agents in preventing neonatal sepsis and tetanus.
- Assess the relationship between particular maternal infections and low birthweight or preterm babies.

### Conduct Research on Antimicrobial Resistance

- Encourage and support the development of drug susceptibility tests and surveillance systems to detect emerging resistance problems.
- Evaluate the impact of new vaccines (such as the conjugate pneumococcal vaccines) on the control of antimicrobial resistance and infection. (See also Conduct Vaccine Research.)
- Determine how disease prevention programs that include mass chemotherapeutic treatments can be optimized to minimize potential for the emergence of drug resistance. Examples include the use of praziquantel to prevent schistosomiasis, albendazole to prevent lymphatic filariasis, ivermectin to prevent onchocerchiasis, azithromycin to prevent trachoma, trimethoprim-sulfamethoxazole to prevent AIDS-associated opportunistic infections, and nevirapine or zidovudine to prevent mother-to-child transmission of HIV/AIDS.
- Encourage efforts by WHO and other partners to
  - Evaluate the quality of commercially available antibiotic stocks and determine whether low-potency stocks are hastening the emergence of drug-resistant strains of pneumococci, *Mycobacterium tuberculosis, Plasmodium* spp., *Neisseria gonorrhoeae,* or other pathogens.
  - Determine whether antibiotics purchased over the counter in developing countries (and often used in subtherapeutic doses) are hastening the emergence of drug resistance.

FDA supports these efforts.

### Conduct Research on Healthcare-Acquired (Nosocomial) Infections

- Develop methods for identifying nosocomial infections and reducing their transmission in hospitals with limited resources for infection control.
- Provide technical assistance to hospital staff in assessing risk factors for acquiring
  - *Mycobacterium tuberculosis* (e.g., transmitted from patients to health care workers or to other patients).
  - Nosocomial respiratory and enteric infections (e.g., inadequate barrier nursing practices)
  - Nosocomial bloodborne infections (e.g., re-use of medical devices or surgical equipment)

### Conduct Research on Infectious Causes of Chronic Diseases

- Conduct research on infectious agents of international importance that cause or may cause chronic diseases (e.g., hepatitis B and C viruses and hepatocellular carcinoma, *Helicobacter pylori* and peptic ulcer disease or gastric carcinoma, *Chlamydia pneumoniae* and cardiovascular disease, and human papillomaviruses and cervical cancer)

### Conduct Research on Sexually Transmitted Diseases

- Study the contribution of herpes simplex virus type 2 infection and other genital ulcer diseases on HIV transmission, and devise appropriate intervention strategies.
- Develop more standardized diagnostic reagents and assays for syphilis to enhance the capacity to control neonatal syphilis worldwide.
- Monitor the development of antimicrobial resistance among strains of *Chlamydia trachomatis* and devise appropriate alternative treatments.



## Priority Area 4: Application of Proven Public Health Tools

Another major priority for CDC is to translate research innovations into practical public health tools and ensure that they are disseminated widely and rapidly for the benefit of people all over the world. Examples of public health tools that have had a major impact on global infectious disease control are antibiotics, childhood vaccines, oral rehydration therapy, and vitamin supplements.

There is often a long delay between the development of a new public health tool and its widespread implementation. A country may lack the means to buy a new medical product or it may lack a public health delivery system and trained workers to administer it. There may be low demand, because the public is not informed about a new drug or vaccine, or low political interest, because the national government is not convinced that the drug or vaccine will be cost-effective.

CDC can use its experience in disease surveillance to demonstrate the value of public health tools to ministries of health and finance and to the public, using pilot studies, demonstration projects, and health education campaigns (Box 19). For example, CDC will continue to work with USAID, WHO, and other partners to demonstrate that mechanisms for the prevention or control of malaria (via vector control, chemotherapy, and insecticide-treated bednets) are ready for national or regional implementation, pending the availability of resources and political commitment (see Priority Area 5). CDC can also help development agencies, NGOs, and other partners address problems related to public health training and to drug or vaccine delivery (see also Priority Area 6).

**Bednets protect children from malaria.** Nightly use of insecticide-impregnated bednets[13] reduces childhood mortality by 20–30%, and use in one village protects children in neighboring villages by reducing the number of infectious mosquitos. Nevertheless, bednets are used by fewer than 10% of persons at risk, due to lack of knowledge, unavailability of bednets, and other logistical constraints.

**As part of the global strategy, CDC will intensify efforts to couple applied research with research on ways to promote the use of newly developed tools for disease control ("implementation research"). CDC will help identify the most effective tools and actively encourage their international use, applying expertise and resources in laboratory research, public health policy, program management, and health communications to overcome scientific, financial, and cultural barriers.**

Examples of new tools with the potential for significant worldwide impact include point-of-use disinfection and safe water storage to prevent waterborne diseases; auto-disable (one-use) syringes to prevent bloodborne transmission of hepatitis B and C viruses and HIV; and diethylcarbamazine and albendazole therapy to eliminate lymphatic filariasis.

### Objectives for Priority Area 4

#### Promote Effective Drug Use

- Conduct implementation research and demonstration projects to promote the use of therapeutic drugs such as
  - Ivermectin to eliminate onchocerchiasis in West Africa and Central America
  - Diethylcarbamazine and albendazole or mebendazole therapy to eliminate lymphatic filariasis in the Americas
  - Single-dose azithromycin to eliminate blinding trachoma in endemic regions in Africa, Middle East, Asia, and Central America

- Single-dose nevirapine to prevent perinatal HIV transmission. (See also Priority Area 5.)
- Praziquantel to treat schistosomiasis

- Promote the widespread use of the directly observed therapy short-course strategy (DOTS) to treat TB. (See also Priority Area 5.)

### Improve Immunization

- Use CDC resources to strengthen routine immunization services and to encourage the introduction of new and underutilized vaccines, including vaccines against hepatitis B, yellow fever, *Haemophilus influenzae* type b, and other childhood diseases. (See also Priority Area 5.)

### Promote the Use of Proven Disease Prevention Strategies

- Work with ministries of health and PAHO to encourage the adoption of vector control measures to eliminate Chagas disease from Central America and reduce morbidity and mortality from dengue and dengue hemorrhagic fever (http://www.cdc.gov/ncidod/dpd/parasites/chagasdisease and http://www.cdc.gov/ncidod/dvbid/dengue).
- Work with private and public sector partners to promote widespread implementation of CDC's Safe Water System, which uses point-of-use disinfection and safe water storage to prevent cholera, dysentery, and other waterborne diseases (Box 20; http://www.cdc.gov/safewater).

**Box 19**

## Narrowing the Interval Between the Invention and Use of an Effective Public Health Tool

In the past, the time between the development of a new public health tool and its widespread use was often extremely long. For example, the tetanus toxoid vaccine, developed in 1926 and used to protect soldiers during World War II, was not widely administered to children in industrialized countries until the 1940s and 1950s, and did not reach high levels of coverage in developing countries until the mid-1980s, a 60-year interval.

Today, this gap is narrowing. After the hepatitis B vaccine was licensed in 1981, universal infant hepatitis B vaccination projects were initiated in many countries, including five U.S.-affiliated Pacific islands where HBV infection is highly endemic and HBV-induced chronic liver disease is a leading cause of death. After a decade of successful demonstration projects, routine childhood hepatitis B vaccination was recommended by the World Health Assembly for all countries. During the 1990s, more than 100 countries (including the United States) implemented hepatitis B immunization programs, although lack of financing hindered vaccine use in the poorest countries. In 2000, financial assistance for the purchase of hepatitis B vaccine became available through The Vaccine Fund, and the Global Alliance for Vaccines and Immunization (GAVI) targeted hepatitis B vaccine for universal introduction into developing countries by 2007.

The history of the hepatitis B vaccine provides a good example of how the gap in time between introduction and widespread use of a new public health tool can be shortened through strategic planning, a rapid sequence of efficacy studies and demonstration projects, active advocacy and funding. As future vaccines and other public health innovations are developed, it should be possible to narrow the gap further. CDC can play an important role in this area.

**A man being immunized against hepatitis B virus.** Expanded use of the hepatitis B vaccine will decrease mortality from cirrhosis, liver failure, and hepatocellular carcinoma, which is the 4th leading cause of cancer death worldwide.

*Adapted from:* Centers for Disease Control and Prevention. Preventing emerging infectious diseases: Addressing the issue of vaccine development and use. Atlanta, GA: U.S. Department of Health and Human Services, 2001.



**Box 20**

## CDC's Safe Water System

In the poorest, least industrialized nations, diarrheal diseases caused by contaminated food and water remain a leading cause of death in childhood. Many of these deaths could be prevented by simple sanitation measures.

With assistance from ministries of health, funding from USAID and Rotary International, and special expertise from nongovernmental organizations and the private sector, CDC has developed a sustainable way to improve the safety of household drinking water. The components of CDC's sate water system, as implemented in pilot projects in Zambia, include

- **Water disinfection.** Population Services International (PSI) has marketed a locally produced disinfectant solution for water treatment (CLORIN) to communities in the southern, eastern, and western regions of Zambia. A CDC case-control study documented a 65% reduction of risk of cholera in Zambian households that use CLORIN.
- **Safe storage of water.** CDC, the Procter and Gamble Company, and Rotary International have contributed to the design of a narrow-mouthed vessel for safe storage of water. The mold for the new vessel was shipped to South Africa in January 2000, where vessels have been produced for use in Zambia, Madagascar, Kenya, Côte d'Ivoire, and Pakistan.
- **Social marketing.** PSI has trained public health workers in Lusaka, Kitwe, and Ndola, Zambia, on how to involve their communities in the safe-water effort.

USAID has increased funding for the safe water project in Zambia to permit nationwide coverage within the next few years, and the CARE/CDC Health Initiative is funding similar projects in western Kenya and in Antananarivo, Madagascar. Each CARE/CDC Health Initiative project will target a population of 200,000 people and combine the methods of the Zambian project with the community organizing techniques of CARE.

In the future, the elements of the Safe Water System may also be used to promote:

- Safe preparation of foods and beverages by street vendors
- Safe preparation of medications, such as oral rehydration solutions to treat cholera
- Safe preparation of formula for use by HIV-infected women who choose not to breast-feed their infants
- Handwashing and improvements in hygiene
- The addition of nutritional supplements to drinking water

**A safe water storage vessel employed by participants in an ongoing Safe Water System implementation project in Homa Bay, Kenya, initiated in October 2000 in collaboration with CARE Kenya.** The vessel was designed to eliminate a major source of diarrheal disease contamination that results when hands, cups, ladles, or other objects are dipped into open buckets to remove water for drinking. Because the local population in Homa Bay preferred to use vessels made of clay rather than plastic, CDC and CARE Kenya incorporated a narrow mouth, lid, and spigot into traditional clay pots to ensure safe water storage. The use of plastic vessels with similar characteristics, in combination with water disinfectants, has reduced diarrheal diseases by 30–50% in communities in Zambia, Pakistan, and Bolivia.[14]

Photographer: Bobbie Person, Office of Health Communication, National Center for Infectious Diseases, CDC

- Work with WHO and ministries of health in central African countries to provide training in hospital barrier nursing practices that prevent nosocomial spread of viral hemorrhagic fevers like Ebola and Marburg.
- Continue to support the Safe injection Global Network (SIGN) and work with development agencies and other partners to promote safe injection practices to prevent the spread of hepatitis B and C, HIV/AIDS, and other bloodborne diseases.
- Work with the Roll Back Malaria partnership to promote the use of insecticide-impregnated bednets for the prevention of malaria and other mosquitoborne diseases. (See Priority Area 5.)
- Work with ministries of health and WHO to provide public health education and mobilize communities to use proven public health tools.

### Disseminate Diagnostic Tests

- Work through the WHO Collaborating Centre laboratory network to provide proven diagnostic reagents for the detection of endemic diseases to national public health laboratories and regional surveillance networks. (See Priority Area 1.)
- Work with WHO and donor agencies to provide national public health laboratories with state-of-the-art laboratory tests that measure antimicrobial resistance in *Mycobacterium tuberculosis* and other common bacterial pathogens, as well as in malaria parasites and in the AIDS virus. (See Priority Area 5.)
- Work with ministries of health to transfer technology for molecular subtyping of common bacterial pathogens (e.g., PulseNet techniques; page 36) to national public health laboratories for use in detecting outbreaks of foodborne diseases).

### Use Surveillance Data To Direct Public Health Policy

- Work with ministries of health and ministries of finance, WHO, and NGOs to
  - Conduct disease surveillance to assess national public health needs and recommend specific public health tools to address them.
  - Demonstrate the use of specific surveillance methods for detecting outbreaks, for evaluating public health programs, and for driving public health decision-making.
- Work with global partners to evaluate the progress of global initiatives to combat malaria, TB, AIDS, and vaccine-preventable diseases. (See Priority Area 5.)



## Priority Area 5: Global Initiatives for Disease Control

Dr. Gro Bruntland, Director-General of WHO, has said that "solutions, like problems, have to be global in scope." In accord with this idea, WHO is helping to coordinate major global initiatives to reduce deaths from malaria, TB, and HIV/AIDS—diseases that contribute to poverty and economic stagnation. This approach was endorsed by the Group of Eight Industrialized Nations at the Okinawa summit in July 2000. WHO is also helping to coordinate global initiatives to increase developing-country access to vaccines against acute respiratory diseases, yellow fever, hepatitis B, and other diseases, through the Global Alliance for Vaccines and Immunization (GAVI; http://www.vaccinealliance.org).

Although these global initiatives have clearly stated goals and are supported by multiple private and public sector partners (Box 6), the details of their implementation are still under discussion. Previous efforts to eradicate malaria by using a narrow approach to vector control ended in failure. Because no proven vaccines are yet available against malaria, TB, or AIDS, "one-shot" solutions are not feasible, and it will be necessary to employ multiple control strategies, including behavioral interventions that require a high degree of cooperation and trust in affected communities. The incidence of TB, HIV/AIDS, and acute respiratory infections is high in poor, war-torn, or post-Communist countries in which public health infrastructures have deteriorated. Moreover, emerging drug resistance complicates the treatment and control of each of these diseases.

**A new priority for CDC will be to elevate the level of its participation in these and other global initiatives (Box 6). CDC and its partners will also consult on future international priorities for disease control, elimination, and eradication efforts—as well as for antimicrobial resistance monitoring and pandemic influenza preparedness planning—and help evaluate progress through the collection and analysis of disease surveillance data.**

Increased participation in global health initiatives will require long-term partnerships with host countries, as well as improved coordination with public health partners throughout the world. CDC will build on its strengths in disease surveillance, laboratory science, and program evaluation to assist development agencies, international organizations, NGOs, and development banks that support international programs to strengthen healthcare systems and control disease. As a partner in the Global AIDS alliance (Boxes 6

**Children from villages hard-hit by AIDS.** Thirteen million children in sub-Saharan Africa have lost one or both parents to AIDS, and the number is expected to reach 40 million by 2010.[15] The number of AIDS orphans is also growing in Asia and Latin America.

Global efforts are underway to help these children and prevent further devastation from HIV/AIDS and other infectious diseases. These global initiatives involve complex alliances among public and private groups, health and trade experts, and national and international donor organizations.

Photographer: Bobbie Person, Office of Health Communication, National Center for Infectious Diseases, CDC and 21), for example, CDC has a special opportunity to work with UNAIDS and USAID to implement HIV/AIDS control programs on all continents (http://www.unaids.org/africapartnership/files/mrpretoria.doc). As a partner in Roll Back Malaria (http://www.rbm.who.int), Stop TB (http://www.stoptb.org), and GAVI, CDC can contribute to the Shared Agenda for Health in the Americas (http://wbln0018.worldbank.org/external/lac/lac.nsf)[16] developed by PAHO, the Inter-American Development Bank, and the World Bank.

Increased participation in global health initiatives also will require additional staff to work on projects overseas, as well as to provide diagnostic support from CDC laboratories in the United States. Full participation in GAVI, for example, will require increased programmatic support and technical expertise in acute respiratory diseases, yellow fever, hepatitis B, and meningococcal meningitis. There remains a shortage of U.S. and world expertise in many infectious disease areas. (See also Priority Area 6.)

CDC staff will also continue to work with ministries of health, WHO, PAHO, USAID, and other partners on disease elimination or eradication campaigns. In addition, CDC staff will help further efforts to reduce illness and death from acute respiratory diseases and diarrheal diseases, which—in addition to HIV/AIDS, TB, and malaria—are the leading infectious causes of death, worldwide. CDC will also continue to conduct applied research to improve our understanding of the genetics, physiology, and pathogenesis of microbes that cause illnesses targeted by global initiatives for disease control. (See Priority Area 3.)

Box 21

### The Global AIDS Program

Thirty-six million people worldwide have been infected with HIV, the virus that causes AIDS, and more than 21.8 million have died. Eighty-five percent of all AIDS deaths have occurred in the countries of sub-Saharan Africa. In at least five of these countries, more than 20% of adults are HIV-positive. Infection rates are also climbing in parts of Asia, Latin America, the Caribbean, and the former Soviet Union countries and Eastern Europe. Only a concerted global effort coordinated by WHO and led by the United States and other industrialized countries can stop this pandemic.

Through the Global AIDS Program (GAP), CDC is working with USAID and other DHHS agencies to assist ministries of health. In 2001, the program targeted 17 of the hardest-hit African countries (Angola, Botswana, Côte d'Ivoire, the Democratic Republic of the Congo, Ethiopia, Kenya, Malawi, Mozambique, Namibia, Nigeria, Rwanda, Senegal, South Africa, Tanzania, Uganda, Zambia, and Zimbabwe), as well as India, Brazil, Cambodia, Guyana, Haiti, Thailand, and Vietnam. GAP's mission is to implement the U.S. Leadership and Investment for Fighting an Epidemic (LIFE) Initiative, which is the U.S. contribution to the International Partnership Against AIDS in Africa and to AIDS efforts on other continents.

The goals of the Global AIDS program are to

- Reduce HIV transmission through primary prevention of sexual, mother-to-child, and bloodborne transmission
- Improve community and home-based care and treatment of HIV/AIDS, sexually transmitted infections, and opportunistic infections
- Strengthen national capacities to collect and use surveillance data and manage national HIV/AIDS programs

Additional information on the Global AIDS Program is available at http://www.cdc.gov/nchstp/od/gap



## Objectives for Priority Area 5

### Establish a Solid Foundation for Global Initiatives

- Expand the cohort of public health professionals at CDC who have international expertise and can provide support for global initiatives to combat infectious diseases. (See also Priority Area 6)
- Help suggest international priorities for current and future global initiatives for disease control. Future initiatives might include antimicrobial resistance monitoring, pandemic influenza preparedness planning, and campaigns to control or eliminate measles, lymphatic filariasis, onchocerchiasis, trachoma, rubella, neonatal tetanus, or hepatitis B.
- Provide technical assistance to national health authorities in public health management of diseases targeted by global health initiatives, working through the Sustainable Management Development Program and other mechanisms. In some countries this will include integrating specialized HIV, TB, and STD surveillance programs into national surveillance and laboratory service systems for infectious diseases.
- Improve coordination among CDC personnel who work overseas in the same country or region.

### Enhance Support for Disease Control, Elimination, and Eradication Programs

- Help complete the eradication of polio by 2005. The global effort to eradicate polio is led by WHO, in partnership with an international coalition that includes CDC, Rotary International, UNICEF, and the governments of many countries (http://www.cdc.gov/nip/global). The WHO Global Polio Laboratory Network (Box 7), which uses molecular techniques to determine whether wild-type polio is circulating in areas undergoing eradication efforts, should be expanded to include monitoring for other vaccine-preventable diseases, such as measles and rubella.
- Help complete the eradication of dracunculiasis, working in partnership with the Carter Center's Global 2000 Program, UNICEF, WHO, and other groups (http://www.cdc.gov/ncidod/dpd/parasites/guineaworm and http://www.cartercenter.org/guineaworm.html).
- Work with PAHO to complete the elimination of indigenous (i.e., non-imported) cases of measles in the Americas, and work with WHO, UNICEF, the UN Foundation, USAID, the American Red Cross, the International Federation of Red Cross and Red Crescent Societies (IFRC), and other partners to reduce by 50% by 2005 the nearly 900,000 annual measles deaths worldwide.[17]

### Participate in the Roll Back Malaria Initiative

- Contribute to Roll Back Malaria (RBM; http://www.rbm.who.int) through full endorsement and active promotion of RBM strategies in malaria-endemic countries in sub-Saharan Africa, Southeast Asia, and the Americas. Although RBM strategies vary by region and by local malaria transmission dynamics, 90% of the world's malaria is in sub-Saharan Africa, where the strategies for malaria prevention and control include
  - Prompt effective case management of malaria illness
  - Prevention of malaria and its consequences in pregnancy, through prophylaxis or preventive intermittent treatment regimens with an effective antimalarial drug
  - Widespread use of insecticide-treated bednets, particularly by young children and pregnant women
  - Prompt recognition and management of malaria epidemics

- Conduct operations research on
  - Antimalarial drug efficacy and the management and prevention of antimalarial drug resistance
  - Malaria prevention in pregnancy
  - Transmission reduction through the use of insecticide-treated bednets and other strategies
  - Malaria assessment in complex emergencies, such as outbreaks that occur among refugees or outbreaks that occur after hurricanes or other natural disasters
  - Malaria diagnostics
  - Social attitudes and practices that facilitate or hinder the effectiveness of malaria control programs
  - Malaria surveillance, monitoring, and evaluation strategies
- Provide technical assistance to the African Integrated Malaria Initiative (http://www.usaid.gov/regions/afr/abic/sddev/sddspr96/sddspr96.htm; see also Appendix A), a USAID-sponsored initiative that enhances integrated malaria treatment and prevention in Kenya, Malawi, Zambia, and Benin by promoting the use of interventions in the home (e.g., insecticide-impregnated bednets), in healthcare facilities (e.g., chemoprophylaxis), and among pregnant women (e.g., protective intermittent chloroquine therapy, as recommended by the USAID Safe Motherhood Initiative). During 2001, the African Integrated Malaria Initiative will be extended to the Democratic Republic of the Congo, Nigeria, Senegal, and Uganda.
- Assist ministries of health in malaria control efforts and in the monitoring and evaluation of antimalarial drug efficacy. CDC is currently working on national malaria control programs in Kenya, Tanzania, Peru, and Nepal.

### Strengthen the Stop TB Program

- Contribute to Stop TB (http://www.stoptb.org) by
  - Assigning an epidemiologist to WHO's Stop TB secretariat
  - Providing technical assistance to facilitate the use of the directly observed therapy short-course strategy (DOTS) for TB. (See also Priority Area 4)
  - Strengthening TB treatment programs in LIFE Initiative/Global AIDS Program countries (see below)
  - Supporting demonstration projects on the medical management of drug-resistant TB
  - Providing technical assistance to improve hospital TB control and detect hospital and community outbreaks in communities with high HIV prevalence
  - Assigning a medical officer to the International Union Against TB and Lung Diseases (IUATLD) to train a cadre of international TB experts, as a joint effort with USAID and WHO
  - Providing technical assistance and laboratory support to implement global antituberculosis drug resistance surveys
- Consult with ministries of health in Russia, Vietnam, and other countries on training issues related to TB diagnosis and treatment.
- Conduct operations research on
  - TB surveillance, program management, and program evaluation strategies
  - Multidrug-resistant TB treatment approaches and evaluation strategies
  - Treatment strategies for latent TB among persons with HIV infection
  - Factors that improve adherence to antituberculosis therapy
  - New diagnostic methods, drugs, and vaccine for TB

### Expand the LIFE Initiative and Other International Efforts To Address HIV/AIDS

CDC will work with foreign ministries of health and public and private sector partners in countries targeted by the LIFE Initiative/Global AIDS Program (Boxes 6 and 21; http://www.cdc.gov/nchstp/od/gap) to

- Prevent primary transmission of HIV by
  - Expanding voluntary counseling and testing programs for youth and other vulnerable populations





  - Building large-scale programs to reduce mother-to-child transmission
  - Strengthening programs to reduce bloodborne HIV transmission
  - Strengthening medical management of sexually transmitted infections (STIs)
  - Supporting and strengthening national education and mobilization efforts for disease prevention
- Improve community and home-based care and treatment by
  - Expanding and strengthening TB prevention and care
  - Enhancing care and treatment of HIV/AIDS and AIDS-related opportunistic infections
  - Exploring the innovative use of antiretroviral therapy
- Build public health and medical infrastructure by
  - Expanding and strengthening surveillance for HIV, STIs, and TB
  - Providing laboratory support for diagnosis and surveillance of HIV, STIs, TB, and opportunistic infections, as well as for HIV screening of blood supplies
  - Expanding and strengthening public health information systems
  - Providing training in managing and implementing HIV treatment and prevention programs (see also page 55).
  - Enhancing evaluation of HIV/AIDS prevention and care programs.

### Support Global Vaccine Initiatives

- Help GAVI partners (http://www.vaccinealliance.org/) develop and implement strategies to strengthen routine immunization services and monitor their effectiveness.
- Provide assistance to GAVI in assessing the burden of hepatitis B, yellow fever, *Haemophilus influenzae* type b, pneumococcus, rotavirus, meningococcus A, measles, and congenital rubella syndrome in developing countries and use this information to design, implement, and evaluate immunization programs against these infections.
- Support efforts by GAVI partners—including pharmaceutical companies, foundations and development banks—to develop and evaluate new vaccines that are needed in developing countries, and to promote their availability. (See also Priority 3.)

## Priority Area 6: Public Health Training and Capacity Building

CDC's growing visibility as an international outbreak consultant has also led to increased participation in efforts to build global public health capacity. Although CDC is not a development agency, CDC has traditionally assisted USAID with the public health and research components of development projects (Box 22) and has consulted with private foundations and development banks on efforts to strengthen public health infrastructures (Box 23). Over the past decade, CDC has also helped strengthen healthcare systems in developing countries, working with hospital administrators and physicians to improve infection control practices and ensure safe blood supplies. CDC has also managed overseas field stations that facilitate on-site collaborative research on diseases of regional and global importance (Box 10). In addition, several foreign scientists enroll each year in CDC's Epidemic Intelligence Service and the Emerging Infectious Disease Laboratory Fellowship Program, which is a joint effort between CDC and the Association of Public Health Laboratories (APHL).

In recent years, in the aftermath of outbreaks and other infectious disease crises, CDC has responded to requests from more than 80 foreign governments for epidemiologic, laboratory, or research assistance to ensure preparedness for future emergencies. However, most of these efforts—which included training courses, research collaborations, program evaluations, health education campaigns, and the provision of laboratory reference support—were limited in scope and duration and were not integrated into a larger effort to build public health capacity.

**As part of the global strategy, CDC will propose the establishment of a series of International Emerging Infections Programs (IEIPs) in developing countries—centers of excellence that will integrate disease surveillance, applied research, prevention, and control activities. Each site will represent a partnership between a ministry of health and CDC, with additional partnerships involving local Field Epidemiology Training Programs (FETPs) and one or more local universities or medical research institutes. The IEIP sites will build on existing CDC overseas activities to strengthen national public health capacity and provide hands-on training in public health. Over time, they may have a regional as well as a national impact on health.**

The IEIPs will be broad-based public health collaborations between the ministry of health of the host country and CDC, with both parties contributing resources and reaching agreement on the priorities of the program. Each site will be built on existing CDC field capacity in that country. Some IEIPs may be based at research institutions where CDC has long-standing collaborations. Others may be based at CDC field stations or adjacent to other U.S. institutions abroad, such as NIH's Tropical Medicine Research Centers or DoD's overseas laboratories. Each site will maintain close ties with WHO country and regional offices, and, if possible, will collaborate with one of the Field Epidemiology Training Programs (FETPs) that CDC has helped establish in more than 16 countries (Box 24).

The IEIPs will be modeled in part on the U.S. Emerging Infections Program (EIP; http://www.cdc.gov/ncidod/osr/EIP.htm) whose nine sites conduct population-based surveillance, provide emergency outbreak assistance, invest in cutting-edge research, and address new problems whenever they arise. Because the EIP sites combine specialized epidemiologic and laboratory expertise, they are able to go beyond the routine functions of local health departments to address important issues in infectious diseases and public health. For example, when "mad cow disease" was reported in the United Kingdom in 1996, the EIP surveillance sites were able to reassure the U.S. public within a short time that the disease had not spread to the United States.

Like the domestic EIPs, the International EIP sites will perform multiple functions, including research on endemic diseases and emergency surveillance when a new threat appears.


**Presentation of certificates: Workshop on HIV/AIDS Epidemiology, Surveillance, and Prevention, May 2000, Nha Trang City, Khanh Hoa Province, Vietnam.** Since Vietnam and United States renewed diplomatic relations, Vietnamese and U.S. scientists and public health workers have collaborated on workshops, training courses, and research projects that build national capacity to detect and prevent HIV/AIDS, TB, malaria, typhoid fever, influenza, hospital-acquired infections, plague, and dengue and dengue hemorrhagic fever.

Photographer: Nguyen Thi Thu Hong, HHS/CDC/Hanoi

Box 22

### USAID and CDC: Collaboration on Capacity Building

The U.S. Agency for International Development (USAID) and CDC are longstanding partners in the effort to combat emerging diseases overseas. Twenty years ago, CDC and USAID collaborated with WHO and other partners to eradicate smallpox. Today, CDC and USAID are helping eradicate polio; reduce deaths from malaria, HIV/AIDs, TB, and acute respiratory infections; and improve global surveillance for emerging threats.

In many countries, CDC partners with USAID on evaluations of infectious disease problems related to wars, famines, or other disasters, as well as on development projects that involve epidemiologic or diagnostic research. CDC also helps implement USAID-supported programs in the four key areas of USAID's emerging infectious disease initiative:

- **Antimicrobial resistance:** Developing and implementing strategies and interventions for detecting, studying, and containing emerging resistance problems.
- **TB:** Working for a sustainable reduction in the incidence of TB among key populations in selected countries through by the introduction of directly observed therapy short-course strategy (DOTS; see Box 6).
- **Malaria:** Improving the diagnosis and treatment of malaria; promoting effective preventive strategies; addressing the challenges of malaria in pregnancy; containing malaria outbreaks; responding to malaria during complex emergencies; slowing the emergence and spread of drug-resistant malaria; and accelerating the development of tools for malaria control.
- **Disease surveillance and response:** Improving public health capacity to obtain and use good quality data for disease surveillance and effective response to infectious diseases.

As part of the global strategy, CDC will intensify its efforts to work with USAID to develop mutually reinforcing ways of working together at the country level to maximize the impact of U.S. investments in global health.

They will also provide disease surveillance data to ministries of health and finance to help assess the burden of specific diseases and evaluate the cost-effectiveness of national public health programs. Also like the EIPs, the IEIPs will incorporate preexisting sites (e.g., U.S. institutions, public health agencies, research institutions, and nongovernmental organizations); use the sites in an integrated fashion; and establish an international steering committee to provide guidance for core projects conducted at all of the IEIP network sites. Areas in which IEIP sites might play an especially important role are in surveillance for drug-resistant forms of malaria, TB, pneumonia, and dysentery. All of the sites will be linked by electronic communications to keep health experts around the world in close contact with one another.

The long-term goal of the IEIPs will be to develop sustainable, in-country capacity for disease surveillance, outbreak investigation, and research on diseases of regional or global importance by fostering the next generation of international public health leaders (Box 16). The implementation of this goal will require extensive scientific, human, and financial resources from both private and public sources, as well as sustained efforts over many years. However, the costs will be low in relation to potential benefits, in terms of both human health and increased global prosperity.

## Objectives for Priority Area 6

### Establish International Emerging Infections Programs (IEIPs)

- Help create International Emerging Infections Programs (IEIPs) that
  - Train local scientists and CDC personnel
  - Provide diagnostic and epidemiologic resources when outbreaks occur
  - Serve as platforms for regional infectious disease control activities
  - Conduct public health research of global importance
  - Disseminate proven health tools

### Expand Training in Epidemiology, Public Health Management, and Laboratory Diagnostics

- Increase training opportunities for foreign scientists in epidemiology, public health management, and state-of-the-art laboratory techniques. For example, CDC will provide training in
  - PulseNet's methods for fingerprinting strains of foodborne bacteria (page 36)
  - Methods for identifying foodborne viruses
  - Drug susceptibility testing of pathogens of public health importance
  - DPDx, an Internet-based system to help confirm diagnoses of parasitic diseases
  - International public health management
  - Managing and implementing HIV treatment and prevention programs in Global AIDS Program countries (see page 52)
- Work through TEPHINET and other mechanisms to provide technical assistance to health authorities in countries that are establishing or expanding national schools of public health, new Field Epidemiology Training Programs (FETPs), new Sustainable Management Development Programs, or the Rockefeller Foundation-supported Public Health Schools Without Walls (PHSWOW). TEPHINET is a public health network network that links FETP and PHSWOW staff.
- Help increase the number of public health workers in developing countries who are trained in vaccine work by
  - Encouraging training efforts by foreign governments, foundations, and donor organizations (e.g., the WHO public health training project in Lyon, France)
  - Incorporating training components into such projects as the U.S.-India Vaccine Plan, the Egyptian Schistosomiasis Vaccine Development Project, and the HIV vaccine trials in Kenya and Côte D'Ivoire (Box 18)



Box 23

### The World Bank and CDC Sign a Memorandum of Understanding

Infectious diseases are not just a result of, but also a *cause* of, poverty (see Box 8). In recognition of this fact, the World Bank, a leading global development lender, signed a memorandum of understanding with CDC in February 2001, to intensify joint efforts to prevent and control diseases that take a heavy toll in developing countries.

Under the agreement, CDC and the World Bank will collaborate on a broad range of global health activities, related to nutrition, maternal and child health, endemic diseases such as HIV/AIDS, TB, and malaria, public health, health surveillance, health policy and statistics, research, and healthcare technology. Over the next year, for example, CDC will transfer technical experts to the World Bank to help design, implement, and evaluate projects to control the spread of malaria in Africa and promote worldwide use of vaccines against many childhood diseases.

The memorandum will also facilitate previously established collaborations between the World Bank and CDC, including an ongoing project to upgrade the surveillance infrastructure for infectious diseases in Argentina and Brazil, from the local to the national level. That effort includes

- Training public health workers in epidemiology, management, and laboratory science
- Establishing electronic reporting networks and sentinel sites for disease surveillance
- Enhancing laboratory capacity
- Strengthening outbreak response
- Instituting measures to prevent the spread of TB and other priority diseases

  - Training national and regional health workers in vaccine program planning, monitoring, and evaluation as part of GAVI's effort to improve routine immunization services and to introduce new and underutilized vaccines into developing countries
- Provide training opportunities that increase international expertise in the detection and treatment of prenatal and perinatal infections.
- Expand the cohort of public health professionals at CDC who have international infectious disease expertise, by
  - Creating an inventory of CDC staff to identify gaps in international expertise
  - Developing an international infectious disease training program or seminar series for CDC staff, in collaboration with public health and medical schools
  - Establishing an exchange program that enables visiting scientists from other countries to work at CDC and vice versa
  - Working with the Association of Schools of Public Health and the Association of Teachers of Preventive Medicine to increase the number of graduate courses that cover global infectious disease issues
- Expand opportunities for training in-hospital infection control and clinical surveillance by providing
  - Train-the-trainer courses in hospital epidemiology
  - Technical assistance to hospital staff in designing and implementing programs to reduce transmission of nosocomial pathogens

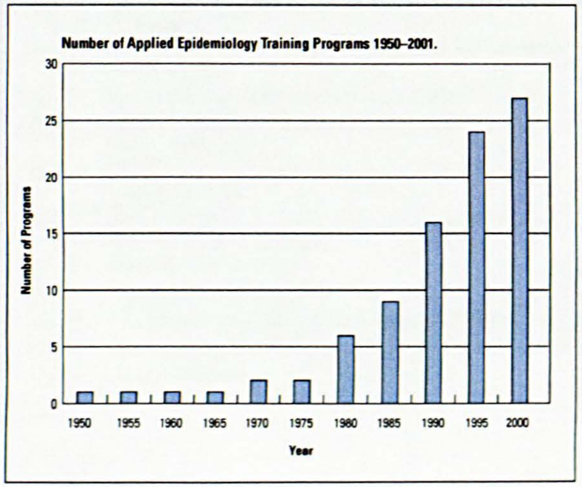
Box 24

### Applied Field Epidemiology Training Programs

For more than 20 years, CDC has collaborated with ministries of health around the world to establish Field Epidemiology Training Programs (FETPs) for specialists in epidemiology. These programs are modeled on the Epidemic Intelligence Service, CDC's primary applied epidemiology training program, which was founded in 1951. Canada established a field epidemiology training program in 1975, and Thailand launched one in 1980, in collaboration with CDC and WHO. CDC partners who have helped establish other FETPs include the World Bank (Brazil), PAHO (a regional FETP in Central America), and USAID (Egypt, Jordan, Peru, Philippines, and Central America).

CDC has also provided consultants to **Public Health Schools Without Walls (PHSWOW)**, which helps post-graduate-level public health personnel attain the epidemiologic, managerial and leadership competencies required to run increasingly decentralized health systems. The PHSWOWs are funded by the Rockefeller Foundation with technical support from Tulane University. The first PHSWOW was launched in Zimbabwe in 1993 at the University of Zimbabwe; the second in Uganda in 1994 at Makerere University; and the third in Ghana in 1995 at the University of Ghana. In 1997, Vietnam started a PHSWOW in collaboration with the Hanoi School of Public Health.

As of 2000, in addition to EIS, there were 27 Applied Epidemiology Training Programs, including 20 FETPs, 4 PHSWOWs, and 3 other Applied Epidemiology Training Programs (the European Programme for Intervention Epidemiology Training [EPIET], the WHO Global Health Leadership Officers Programme [GHLOP], and the WHO/AFRO Programme d'Epidemiologie Pratique [PEP]). Of 19 programs over 4 years old, 18 (95%) continue to produce graduates. Thus far, it is estimated that the 27 Applied Epidemiology Training Programs have trained more than 900 international public health leaders in epidemiology and outbreak investigation. Approximately 420 more are currently in training.






- Consultation to USAID and other donor organizations on infectious disease projects that build infrastructure to improve the provision of prenatal and perinatal care in developing countries.

#### Enhance Availability of Guidelines and Other Publications

- In collaboration with WHO and international experts, draft regional health care guidelines on the judicious use of antibiotics, including antibiotics that are purchased over-the-counter. Regional health care guidelines can be used to mount public health education campaigns on antibiotic usage to help retard the development of drug resistance.
- Provide consultation to ministries of health in developing national guidelines for
  - Hospital infection control, including prevention of hospital-acquired pneumonia, TB, HIV/AIDS, and other nosocomial infections of local concern.
  - Management of exposures to bloodborne pathogens like HIV and hepatitis B and C.
- Disseminate new information on infectious disease issues through the *Morbidity and Mortality Weekly Report (MMWR)*, the *Emerging Infectious Diseases* journal, and the CDC website.

## LIST OF BOXES





## ACRONYMS

| | |
|---|---|
| AFRIMS | Armed Forces Research Institute of Medical Science, Bangkok, Thailand |
| AIDS | acquired immunodeficiency syndrome |
| AIMI | African Integrated Malaria Initiative |
| AMREF | African Medical and Research Foundation |
| APEC | Asia-Pacific Economic Cooperation |
| APHL | Association of Public Health Laboratories |
| ATSDR | Agency for Toxic Substances and Disease Registry |
| BIDS | U.S.-Mexico Border Infectious Disease Surveillance system |
| CAREC | Caribbean Epidemiology Center |
| DoD | Department of Defense |
| DOTS | directly observed therapy short-course strategy |
| DVA | Department of Veterans Affairs |
| ELISA | enzyme-linked immunosorbent assay |
| EPI | Expanded Programme on Immunization |
| EPIET | European Programme for Intervention Epidemiology Training |
| EIP | Emerging Infections Program |
| EWORS | Early Warning Outbreak Recognition System |
| FDA | Food and Drug Administration |
| FETP | Field Epidemiology Training Program |
| GAP | Global AIDS Program |
| GAVI | Global Alliance for Vaccines and Immunization |
| GHLOP | WHO Global Health Leadership Officers Programme |
| HIV | human immunodeficiency virus |
| HIV/AIDS | human immunodeficiency virus infection/acquired immunodeficiency syndrome |
| HFRS | hemorrhagic fever with renal syndrome |
| HPS | hantavirus pulmonary syndrome |
| IFRC | International Federation of Red Cross and Red Crescent Societies |
| IHR | International Health Regulations |
| IPAA | International Partnership Against AIDS in Africa |
| IUATLD | International Union Against TB and Lung Diseases |
| KEMRI | Kenya Medical Research Institute |
| LIFE | Leadership and Investment for Fighting an Epidemic initiative |
| LITS | Laboratory Information Tracking System |

| | |
|---|---|
| **MERTU/G** | Medical Entomology Research and Training Unit/Guatemala |
| **NAMRU-2** | Naval Medical Research Unit No. 2, Jakarta, Indonesia |
| **NAMRU-3** | Naval Medical Research Unit No. 3, Cairo, Egypt |
| **NASA** | National Aeronautics and Space Agency |
| **NGO** | nongovernmental organization |
| **NIH** | National Institutes of Health |
| **NMRCD** | Naval Medical Research Center Detachment, Lima, Peru |
| **NOAA** | National Oceanic and Atmospheric Administration |
| **PacNET** | Pacific Public Health Surveillance Network |
| **PAHO** | Pan American Health Organization |
| **PEP** | WHO/AFRO Programme d'Epidemiologie Pratique |
| **PHLIS** | Public Health Laboratory Information System |
| **PHSWOW** | Public Health Schools Without Walls |
| **RBM** | Roll Back Malaria initiative |
| **SIGN** | Safe Injection Global Network |
| **STD** | sexually transmitted diseases |
| **STI** | sexually transmitted infections |
| **TB** | tuberculosis |
| **TEPHINET** | Training in Epidemiology and Public Health Interventions Network |
| **UNAIDS** | Joint United Nations Programme on AIDS |
| **UNESCO** | United Nations Educational, Scientific, and Cultural Organization |
| **UNICEF** | United Nations Children's Fund |
| **USAID** | United States Agency for International Development |
| **USAMRU-K** | United States Army Medical Research Unit, Nairobi, Kenya |
| **USDA** | United States Department of Agriculture |
| **WHO** | World Health Organization |
| **WHO/AFRO** | World Health Organization Regional Office for Africa |
| **WHO/EMRO** | World Health Organization Regional Office for the Eastern Mediterranean |



## APPENDIX A

# GLOBAL HEALTH WEBSITES

| Organization | Publication | Web Address |
|---|---|---|
| Carter Center | Guinea Worm Eradication Program | http://www.cartercenter.org/guineaworm.html |
| Center for Strategic and International Studies | Contagion and Conflict: Health as a Global Security Challenge | http://www.csis.org |
| Centers for Disease Control and Prevention | The HIV/AIDS Collaboration, CDC and The Ministry of Public Health Thailand | http://www.hac.or.th/ |
| Centers for Disease Control and Prevention | Global Polio Eradication Initiative | http://www.cdc.gov/nip/global |
| Centers for Disease Control and Prevention | Guinea Worm Disease Fact Sheet | http://www.cdc.gov/ncidod/dpd/parasites/guineaworm |
| Centers for Disease Control and Prevention | Global AIDS Program | http://www.cdc.gov/nchstp/od/gap |
| Centers for Disease Control and Prevention | Working with Partners to Improve Global Health: A Strategy for CDC and ATSDR | http://www.cdc.gov/ogh/pub/strategy.htm |
| Centers for Disease Control and Prevention | International Health Data Reference Guide, 1999 | http://www.cdc.gov/nchs/data/ihdrg99.pdf |
| Centers for Disease Control and Prevention | U.S.-Mexico Border Infectious Diseases Surveillance | http://www.r10.tdh.state.tx.us/obh/bids.htm |
| Centers for Disease Control and Prevention | Preventing Emerging Infectious Diseases: A Strategy for the 21st Century | http://www.cdc.gov/ncidod/emergplan |
| Centers for Disease Control and Prevention | Biological and ChemicalTerrorism: Strategic Plan for Preparedness and Response | http://bt.cdc.gov/documents/btstratplan.pdf |
| Centers for Disease Control and Prevention | Protecting the Nation's Health in an Era of Globalization: CDC's Global Infectious Disease Strategy | http://cdc.gov/globalidplan.htm |
| Council on Foreign Relations and Milbank Memorial Fund | Why Health Is Important to U.S. Foreign Policy | http://www.cfr.org//public/pubs/Kassalow_Health_Paper.htm |
| Department of Defense | Global Emerging Infections System | http://www.geis.ha.osd.mil |
| Department of Health and Human Services | DHHS Global Health Website | http://www.globalhealth.gov |
| Bill and Melinda Gates Foundation | | www.gatesfoundation.org |
| Global Alliance for Vaccines and Immunization | | http://www.vaccinealliance.org/ |
| Institute of Medicine | Emerging Infections from the Global to Local Perspective | http://www4.nationalacademies.org/iom/iomhome.nsf |
| Institute of Medicine | America's Vital Interest in Global Health | http://www.nap.edu/books/0309058341/html |
| Joint United Nations Programme for AIDS (UNAIDS) | | http://www.unaids.org |
| National Institute of Allergy and Infectious Diseases, National Institutes of Health | Global Research Plan for HIV/AIDS, Malaria, and Tuberculosis | http://www.niaid.nih.gov/publications/globalhealth / global.pdf |
| National Intelligence Council | The Global Infectious Disease Threat and Its Implications for the United States | http://www.cia.gov/cia/publications/nie/report/nie99-17d.html |

| Organization | Publication | Web Address |
|---|---|---|
| National Science and Technology Council, Committee on International Science, Engineering, and Technology, Working Group on Emerging and Reemerging Diseases | Infectious Disease—A Global Health Threat | http://www.ostp.gov/CISET/html/toc.html |
| Rockefeller Foundation | Program on Health Equity | http://www.rockfound.org/display.asp? context=3& SectionTypeID=18 |
| Roll Back Malaria | | http://www.rbm.who.int |
| Safe injection Global Network | | http://www.injectionsafety.org |
| Stop TB Initiative | | http://www.stoptb.org |
| United Nations Foundation | | http://www.unfoundation.org |
| United States Agency for International Development | Infectious Disease Strategy | http://www.usaid.gov/pop.health/ID/index/html |
| World Bank, Pan- American Health Organization, and Inter- American Development Bank | Shared Agenda for Health in the Americas | http://wbln0018.worldbank.org/external/lac/lac.nsf |
| World Bank | World Development Report 2000/2001 | http://www.worldbank.org/poverty/wdrpoverty/report |
| World Health Organization | Removing Obstacles to Healthy Development | http://www.who.int/infectious-disease- report/index-rpt99.html |
| World Health Organization | WHO Antimicrobial Resistance Infobank | http://oms2.b3e.jussieu.fr/arinfobank |
| World Health Organization | WHO Report on Global Surveillance of Epidemic-prone Infectious Diseases | http://www.who.int/emc- documents/surveillance/ docs/whocdscsrisr2001.ht ml/Tableofcontents/about.htm |
| World Health Organization | Overcoming Antimicrobial Resistance | http://www.who.int/infectious-disease-report/2000/ index.html |
| World Health Organization | Global Strategy for the Containment of Antimicrobial Resistance | http://www.who.int/emc/globalstrategy/ strategy.html |
| World Health Organization | The World Health Report 2000 | http://www.who.int/whr/2000/en/report.htm |
| World Health Organization, Rotary International, Centers for Disease Control and Prevention, United Nations Children Fund (UNICEF) | Global Polio Eradication Initiative | http://www.polioeradication.org |
| World Health Organization, UNICEF, UNAIDS, World Bank, United Nations Educational, Scientific, and Cultural Organization (UNESCO), United Nations Population Fund | Health a Key to Prosperity | http://www.who.int/inf-new/ |



# APPENDIX B
# DIPLOMATIC FORUMS THAT ADDRESS EMERGING INFECTIOUS DISEASE ISSUES

Emerging infectious diseases are a topic of discussion at many high-level international meetings, including

**Group of Eight Industrialized Nations (G8)**[a]
http://usinfo.state.gov/topical/econ/group8

**Asia-Pacific Economic Cooperation (APEC)**[b]
http://www.apecsec.org.sg

**Common Agenda with Japan**
http://www.mofa.go.jp/region/n-america/us/agenda

**Transatlantic Agenda with the European Union**
http://www.eurunion.org/partner/agenda.htm

**U.S.-Mexico Binational Commission**
http://www.r10.tdh.state.tx.us/obh/bids.htm

**The Arctic Council**
http://www.arctic-council.org

a. The Group of Eight Industrialized Nations includes: Canada, France, Germany, Italy, Japan, the Russian Federation, the United States, and the United Kingdom.

b. The economies of the Asia-Pacific Economic Cooperation include Australia, Brunei, Canada, Chile, China, Hong Kong China, Indonesia, Japan, Republic of Korea, Malaysia, Mexico, New Zealand, Papua New Guinea, Peru, the Philippines, Russia, Singapore. Chinese Taipei, Thailand, the United States, and Vietnam.

c. The Arctic Council includes: Canada, Finland, Greenland/Denmark, Iceland, Norway, Russia, Sweden, and the United States.

APPENDIX C

# EXAMPLES OF INTERNATIONAL OUTBREAK ASSISTANCE

During the 1990s, CDC participated in numerous outbreak investigations in other countries, sometimes as part of an international WHO team and sometimes in direct response to a request from an affected nation. These investigations included

| | |
|---|---|
| **1990** | Japanese encephalitis in Saipan |
| **1990** | Epidemic dysentery in Burundi |
| **1991** | Hepatitis E in Kenya and Somalia |
| **1991-92** | Epidemic dysentery in Zambia |
| **1991** | Cholera in Bolivia, Ecuador, El Salvador, Guatemala, and Peru |
| **1991** | Cholera in Brazil |
| **1991** | Polio in Romania |
| **1991** | Polio in Bulgaria |
| **1992** | Polio in Jordan |
| **1992-96** | Diphtheria in Ukraine |
| **1993-96** | Diphtheria in Russia |
| **1993** | Polio in Namibia |
| **1993** | Polio in Uzbekistan |
| **1994** | Dengue in Nicaragua |
| **1994** | Plague in India |
| **1994-95** | Measles in Palau, Guam, and the Federated States of Micronesia |
| **1995** | Diphtheria in Georgia, Kyrgyzstan, Kazakhstan, Uzbekistan, and Turkmenistan |
| **1995** | Leptosporosis in Nicaragua |
| **1995** | Ebola fever in the Democratic Republic of the Congo (then Zaire) |
| **1996** | Epidemic dysentery in South Africa |
| **1996** | West Nile encephalitis in Romania |
| **1996** | Typhoid fever in Tadjikistan |
| **1996** | *E. coli* O157:H7 infection in Japan |
| **1996** | Polio in Albania |
| **1997** | Polio in Turkey |
| **1997** | Botulism in Argentina |
| **1997** | Cholera in Kenya |
| **1997** | Avian influenza in Hong Kong |
| **1997** | Rift Valley fever in Kenya |
| **1997** | O'nyong-nyong fever in Uganda |
| **1997** | Nosocomial HIV-associated multidrug-resistant TB in Argentina |
| **1997** | Multidrug-resistant TB in Colombia |
| **1998** | Measles in Romania |
| **1998** | Bolivian hemorrhagic fever in Bolivia |
| **1999** | Louseborne relapsing fever in southern Sudan |
| **1998** | Plague in Ecuador |
| **1998** | Dengue in Palau |
| **1998** | Dengue in Yap |
| **1998** | Amebiasis in the Republic of Georgia |
| **1998-99** | Influenza outbreaks on cruise ships (U.S.-Canada) |
| **1999** | Dengue fever on U.S.-Mexico border |
| **1999** | Epidemic poststreptococcal glomerulonephritis in Brazil |
| **1999** | Typhoid fever in Nauru |
| **1999** | Nipah virus encephalitis in Malaysia |
| **1999** | Marburg fever in the Democratic Republic of the Congo |
| **1999** | Polio in Angola |
| **1999** | Measles in Costa Rica |
| **1999-2000** | Hantavirus pulmonary syndrome in Panama |
| **2000** | Polio in the Democratic Republic of the Congo |
| **2000** | Tularemia in Kosovo |
| **2000** | Cholera in Pohnpei State, Federated States of Micronesia |
| **2000** | Rift Valley fever in Saudi Arabia and Yemen |
| **2000** | Ebola hemorrhagic fever in Uganda |
| **2000** | Measles in Haiti, Dominican Republic, Bolivia |
| **2000** | Polio in Haiti and the Dominican Republic |
| **2000** | Measles in Zambia |
| **2000** | Diphtheria in Latvia |
| **2000** | Dengue hemorrhagic fever in El Salvador |

## APPENDIX D

# WHO COLLABORATING CENTRES (WHOCCS) BASED AT CDC

WHOCC for Antimicrobial Resistance
WHOCC for Arthropod-Borne Viruses in the Western Hemisphere
WHOCC for *Clostridium botulinum*
WHOCC for Dengue and Dengue Hemorrhagic Fever
WHOCC for Research, Training, and Eradication of Dracunculiasis
WHOCC for HIV/AIDs
WHOCC for Reference and Reagents for Human Immunoglobulin Subclasses
WHOCC for Foodborne Disease Surveillance
WHOCC for Surveillance, Epidemiology, and Control of Influenza
WHOCC for Evaluating and Testing New Insecticides
WHOCC for Leptospirosis
WHOCC for Control and Elimination of Lymphatic Filariasis
WHOCC for Malaria Control in Africa
WHOCC for Production and Distribution of Malaria Sporozoite ELISAs
WHOCC for Mycoses in North America
WHOCC for Reference and Research on Plague Control
WHOCC for Poliovirus and Enterovirus Surveillance
WHOCC for Reference and Research on Rabies
WHOCC for Respiratory Viruses Other Than Influenza
WHOCC for Rickettsial Diseases
WHOCC for *Shigella*
WHOCC for Smallpox and Other Poxvirus Infections
WHOCC for Reference and Research in Syphilis Serology
WHOCC for Viral Hemorrhagic Fevers
WHOCC for Reference and Research on Viral Hepatitis

**Tentative WHO Approval:**

WHOCC for Lyme Borreliosis
WHO/PAHO Collaborating Center for Rotavirus and the Agents of Viral Gastroenteritus
WHOCC for Public Health Systems and Practice

**Proposed New Centers:**

WHOCC for Cysticercosis
WHOCC for Molecular Identification and Typing of Insect Disease Vectors
WHOCC for Measles Virus Diagnostics (also serves as the PAHO Regional Measles Reference Laboratory)
WHOCC for Prevention and Control of Epidemic Meningitis
WHOCC for Prevention and Control of *Mycobacterium ulcerans* (Buruli ulcer)
WHOCC for Insecticide Resistance
WHOCC for Infectious Disease Pathology
WHOCC for Salmonella Surveillance
WHOCC for Streptococcus
WHOCC for *Vibrio cholerae* O1 and O139



## APPENDIX E

# REGIONAL AND DISEASE-SPECIFIC SURVEILLANCE NETWORKS

### A. Regional Networks for Disease Surveillance & Outbreak Response

#### Africa

- Integrated Disease Surveillance and Epidemic Preparedness and Response Project, led by WHO/AFRO
- International Disease Survey for diseases of epidemic potential (e.g., meningitis, yellow fever, cholera, measles, and polio), supported by USAID

**Other disease surveillance activities in Africa:**
The disease surveillance component of UNAIDS' International Partnership Against HIV/AIDS in Africa (IPAA) monitors progress in reducing infection rates and deaths from HIV/AIDS, TB, and opportunistic infections.

As part of USAID's African Integrated Malaria Initiative (AIMI), CDC helps ministries of health in Benin, Kenya, Malawi, and Zambia monitor progress in reducing illness and deaths from malaria. During 2001, AIMI surveillance activities will also be conducted in collaboration with the ministries of health of the Democratic Republic of the Congo, Nigeria, Senegal, and Uganda.

The U.S. Army Medical Research Unit in Nairobi (USAMRU-Kenya) is coordinating an effort to enhance surveillance for HIV/AIDS, malaria, yellow fever, and enteric illnesses in east Africa. Partners include ministries of health in Kenya and Uganda. the Kenya Medical Research Institute (KEMRI), the African Medical and Research Foundation (AMREF), and CDC's Kenya Field Station.

#### The Americas and the Caribbean

- Amazon Basin Network
  Includes 7 laboratories from 5 nations
- Southern Cone Network
  Includes 8 laboratories from 6 nations
- Caribbean Epidemiology Center (CAREC) disease surveillance system
  Includes the 21 members of CAREC
- Middle America Network
- U.S.-Mexico Border Infectious Disease Surveillance System
- U.S./Canada International Circumpolar Surveillance project to enhance surveillance for invasive bacterial infections among indigenous peoples in subarctic regions of northern Canada and Alaska. This project is conducted in association with the International Circumpolar Surveillance project in Europe (see: **Europe**).

**Other disease surveillance activities in the Americas and the Carribean:**
The U.S. Naval Medical Research Center Detachment (NMRCD) in Lima is coordinating an effort to enhance surveillance for malaria, yellow fever, dengue, and other hemorrhagic fevers in South America. Planners include ministries of

health of Peru, Ecuador, and Bolivia, WHO/PAHO, and CDC. An epidemiologist from CDC is currently stationed at NMRCD.

### Asia

- Mekong Delta Surveillance Network.
  Includes China (Yunan), Cambodia, Laos, Thailand, Myanmar, and Vietnam
- Pacific Public Health Surveillance Network (PacNet)
  Includes 20 Pacific Islands
- Early Warning Outbreak Recognition System (EWORS)
  A collaboration between the Indonesian Ministry of Health and U.S. Naval Medical Research Unit No. 2 (NAMRU-2). It currently involves hospitals throughout Indonesia and is expanding to include hospitals in Cambodia.

**Other disease surveillance activities in Asia:**
Disease Surveillance and Electronic Networking are two of six "pillars" in a strategy to fight HIV/AIDS and infectious diseases endorsed at the 2001 summit meeting of the Asia Pacific Economic Cooperation (APEC). (The other pillars are: Outbreak Response, Capacity Building, Partnering Across Sectors, and Political and Economic Leadership.) As part of this effort, work has begun toward the creation of an Asia-Pacific network of networks that will knit together existing electronic infectious disease networks and facilitate timely transmission of public health information across APEC economies. The cooperative system will build on existing APEC projects that enhance surveillance for influenza, *E. coli* O157 infection, dengue, and dengue hemorrhagic fever.

The first International Emerging Infectious Program (IEIP) was established in Bangkok in September 2001, as a collaboration between CDC and the Ministry of Health of Thailand. This IEIP site will serve as a resource for infectious disease surveillance networks in Asia.

The United States participates in binational projects to improve disease surveillance with Vietnam, Thailand, and Cambodia. These collaborations are coordinated by CDC, the Armed Forces Research Institute of Medical Science (AFRIMS-Thailand) in Bangkok, and NAMRU-2 in Jakarta. For example, an epidemiologist from CDC stationed at NAMRU-2 and a satellite laboratory in Phnom Pen is working with the Cambodian Ministry of Health to establish a school of public health. An epidemiologist from CDC has also been assigned to China to facilitate collaborative projects that address the prevention and control of viral hepatitis, which is a mjor public health concern in China.

### Europe

- E.U.'s EnterNet system for surveillance of international foodborne outbreaks
- International Circumpolar Surveillance project to enhance monitoring of invasive bacterial infections in the circumpolar regions of Europe (Iceland, Greenland [Denmark], Norway, Sweden, Finland and Russia). This project is conducted in association with the U.S./Canada International Circumpolar Surveillance project (see: **The Americas and the Caribbean**).



### The Middle East

- WHO Middle East Initiative to enhance disease surveillance in Israel and the Palestinian territories

**Other disease surveillance activities in the Middle East:**
The U.S. Naval Medical Research Unit No. 3 (NAMRU-3) in Cairo is coordinating a collaborative effort to enhance surveillance for diseases of importance in the Middle East (e.g., meningitis, influenza, acute febrile illnesses, and antibiotic-resistant enteric organisms). Partners include the Egyptian Ministry of Health and Population, health authorities in Yemen, Pakistan, and the Palestinian Territories, WHO/EMRO, and CDC. An epidemiologist from CDC is currently stationed at NAMRU-3.

## B. Selected Global Networks for Infectious Disease Surveillance & Outbreak Response

- WHO Influenza Surveillance Network
- WHO Global Network for Polio Eradication/Measles Elimination
- WHO Supranational Reference Laboratory Network for Antituberculosis Drug Resistance
- WHO Global Salmonella Surveillance (Global Salm-Surv)
- WHO Global Alert and Response Network (see Box 14)
- Surveillance in support of the worldwide eradication of guinea worm disease
- Surveillance for vaccine-preventable diseases under the Expanded Programme on Immunization (EPI)
- GeoSentinel, the global surveillance network of the International Society of Travel Medicine
  Includes 26 travel and tropical medicine clinics, 15 in the United States, 2 in the United Kingdom, 2 in Australia, and 1 each in Canada, Germany, Israel, Italy, Nepal, New Zealand, and Switzerland

As mentioned above, the first International Emerging Infectious Program (IEIP) was established in 2001 in Thailand. As new IEIP sites are founded (see page 53), they will provide technical assistance to local disease surveillance networks and become members of a global IEIP network.

## ACKNOWLEDGMENTS

Fred Angulo, Felice Apter, Ray Arthur, Judith Bale, Daniel Bausch, David Bell, Sue Binder, Stephen Blount, Queta Bond, Joel Breman, Jennifer Brooks, Bruce Brown, Donald S. Burke, Jay Butler, Gail Cassell, Martin Cetron, Mitchell Cohen, Stephen Corber, Kenneth Castro, Patrick S. Chong, Gary G. Clark, Stephen Cochi, Daniel Colley, Carol Crawford, Nils Daulaire, Jonathan Davis, David T. Dennis, Frances L. de Peyster, Deborah Deppe, Lynn DiFato, Cedric Dumont, Laura Efros, Judith F. English, Charles Ericsson, David Fleming, Anna Flisser, Julie Gerberding, Jerry Gibson, Jesse Goodman, Thomas Gomez, Duane Gubler, Richard Guerrant, Stephen Hadler, Wendy Hall, Margaret Hamburg, Walter Hierholzer, David Heymann, Allen Hightower, Nguyen Thi Thu Hong, Don Hopkins, James Hospedales, Harold Jaffe, Stephanie James, William Jarvis, Warren Johnson, Gregory Jones, Marsha Jones, Bradford Kay, Robert Keegan, Richard Keenlyside, Patrick Kelley, Keith Klugman, Christopher E. Laxton, James W. LeDuc, Michael Levine, Arthur Liang, Scott Lillibridge, Lavinia M. Limon, Earl Long, Michael Malison, Eric Mast, Alison Mawle, Jay McAuliffe, Patrick J. McConnon, Eugene McCray, Joseph McDade, John McGowan, Martin Meltzer, Eric Mintz, Thomas Monath, Melinda Moore, Anthony Moulton, Stephen Ostroff, Mark Papania, Alan Parkinson, Anthony Perez, Robert Perry, Bradley Perkins, Bobbie Person, Francisco Pinheiro, Gabriel Ponce de Leon, Robert Quick, Rosemary Ramsey, Arthur Reingold, Joy Riggs-Perla, Nancy Rosenstein, Ronald St. John, Anne Schuchat, Ben Schwartz, Larry Slutsker, Carol Snarey, Richard Steketee, Mary Grace Stobierski, Charles Stokes, Susan Stout, Robert Tauxe, Ralph Timperi, Laura Trent, Juli Trtanj, Mark Walkup, J. Todd Weber, Mark White, Gillian Woollett, Michael Zeilinger.

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***Suggested Citation***
Centers for Disease Control and Prevention. Protecting the National's Health in an Era of Globalization: CDC's Global Infectious Disease Strategy. Atlanta, GA: U.S. Department of Health and Human Services, 2001.