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Toward System Change to Tackle Antimicrobial Resistance:

Improving the Voluntary Stewardship of Antimicrobials in US Agriculture



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Executive Summary

This report presents the details of a research study looking at the potential for improving voluntary stewardship of antimicrobials in US agriculture, in the interests of tackling antimicrobial resistance (AMR). Failure to address AMR could lead to significant impacts on both human and animal health. Voluntary stewardship is an approach that relies on the willingness of food-animal producers and supportive industries (e.g., veterinary services and pharmaceutical companies), as well as broader stakeholders (e.g., public health policymakers and consumer advocates), to ensure the judicious use of antimicrobials without the need for regulation, legislation, mandatory compliance or statutory enforcement.

Design workshops were conducted with four separate stakeholder groups: beef producers, dairy industry representatives, public health policymakers, and consumer advocates. The participants were asked to imagine that all current projects and programs to address AMR had been stopped, and their task was to propose new, creative designs that would be unconstrained by what currently exists. However, to prevent the proposal of unattainable utopias, all the designs had to be *technologically feasible* (either using current technology or technology that could be developed in a timely manner), *viable* (affordable and socio-environmentally sustainable), and *adaptable* (capable of flexing, or being revised, in response to future, emerging challenges).

There were some common views across the beef, dairy, public-health and consumer-advocate stakeholder groups on what a voluntary stewardship program should look like. There were also differences of perspective that would have to be addressed in order to make voluntary stewardship fully operational. The common views, or emerging consensus, can be summarized in a list of the major characteristics of a potential voluntary stewardship scheme:

- The aim of a program should be the judicious use of antimicrobials, not zero use (less is better, but for animal-welfare reasons, zero is not an option).
- Multi-stakeholder governance should be put in place, with industry in a lead role, and other diverse stakeholders included (either as full decision-makers, external partners or experts to be consulted).
- The governing body should oversee training and information provision for producers and other key decision-makers, and promote education in wider society about AMR and stewardship.
- The program should be strongly science-informed, with research driving development and change.
- The governing body should also oversee the certification of good stewardship practice by producers.
- The results of certifications (and indeed monitoring information more generally) should be publicly accessible, to enable peer pressure, benchmarking, producer self-reflection and informed action.
- There are existing governance and certification programs for other purposes that could readily be built upon.
- Certification should be linked to marketing, so financial benefits for producers flow from engagement in the program.
- Over-uses or misuses of antimicrobials mostly stem from operational and communication issues in wider agricultural production systems, so judicious use means *changing those systems*, thereby reducing disease and antimicrobial use. This should be the focus of certification, and participants said it would involve taking a systems approach.

- In line with the last point, governance should be focused on improving overall system performance, rather than control over clinical judgments made by veterinarians who decide whether to prescribe antimicrobials to individual animals. If action for systems change successfully reduces disease, then decreases in the use of antibiotics will follow, together with lowering the risk of AMR.
- Funding should come from checkoff dollars collected by industry organizations and professional associations that work for the collective benefit of their members.

It is striking that this model conforms in almost every respect to the principles in Elinor Ostrom's Nobel-prize-winning approach to governing common-pool, natural resources. Antibiotic-susceptible bacteria need to be viewed as a common-pool resource, as they are integral to the ecosystems used by human beings when they raise food animals, and Ostrom's model could provide a useful template when designing an actual, effective voluntary-stewardship program.

Ostrom's research shows that, when dealing with a common-pool resource, government-enforced regulation and laissez-faire policies can both meet strong stakeholder resistance, resulting in conflict that damages businesses and undermines sustainability. A more effective approach is often the collective governance of the resource by relevant stakeholders, who need to make decisions in relation to a broad set of economic, social, and environmental values. All these values must be managed simultaneously, and it is unacceptable to put off considering one while another is exclusively focused upon – prioritizing values and focusing on them one at a time generally results in the continual discounting of longer-term needs (such as combatting AMR) in favor of addressing shorter-term concerns (such as profitability). Governance is enabled by a strong focus on the collection of data on activities and impacts, and the provision of information in a way that makes it immediately transparent when important values are being compromised, so peer pressure can be applied and remedial action taken.

The above consensus, and its alignment with Ostrom's model, are encouraging for the potential utility of voluntary stewardship. Nevertheless, some difficult issues and important differences between the views of stakeholder groups were identified, and these need to be addressed in the development of an actual voluntary stewardship system:

- There are structural differences between some food-animal industries. For instance, there is a fair amount of vertical integration in the dairy industry: co-operatives buy milk from the producers, and they have the power to set standards to mitigate AMR. Producers have to conform to these standards if they want to sell their milk to that cooperative. In contrast, there is little vertical integration in the beef industry: many small producers sell calves to the feedlots, often through intermediaries such as auction marts and cattle buyers, and then the feedlots compete to sell meat to wholesalers and retailers via meat packers (slaughterhouses or abattoirs). The beef producers are particularly concerned that husbandry standards among the small producers are variable (and these standards are typically unknown prior to the purchase of calves), which accounts for the majority of the perceived need for antimicrobials. However, there is no single body (e.g., a cooperative) able to strongly influence husbandry standard-setting. Different kinds of programs, each with different emphases, will therefore be needed for different food-animal industries.
- The beef industry participants mostly focused on local-scale governance, while the dairy participants primarily looked at the national scale. There is a useful model of an adaptive, multi-scale organization, the Viable System Model (VSM), that can reconcile these foci. It is possible to identify three or more 'levels' of governance: national-level (establishing general

parameters for stewardship in a science-informed manner), program-level (ensuring each industry certification program meets the specific needs in that industry, as mentioned earlier), and business-level (looking in each company at how to implement stewardship and secure certification).

- The participants in the four workshops identified different stakeholder groups when it came to inclusion in governance. There is an opportunity for synergy here, because the industry participants mainly looked at the key professions who would need to be involved in implementing voluntary stewardship in agriculture, while the public-health policymakers and consumer advocates mainly discussed beneficiaries in wider society. Referring again to the VSM and the three levels of governance mentioned above (national-, program-, and business-level), different stakeholders might be involved at each of the three different levels. Also, the researchers offer a new method for stakeholder analysis that could be useful in the design of an actual voluntary stewardship scheme, as it counters two biases that are common in stakeholder analysis: bias to the status quo, and bias to those who already have a voice in the system.
- There was a discussion of shaming and stigmatization, with some public-health policymakers saying that these are good things to encourage when producers opt out of voluntary stewardship. Peer pressure is certainly necessary, but if the stigmatization is perceived by industry as coming from regulatory authorities, it could undermine voluntary stewardship. The right kind of peer pressure comes about when all industry players can see their own performance in relation to the performance of others, so those who are more successful in addressing AMR then encourage others to make improvements.

Ultimately, the findings from this research (and indeed the Ostrom governance model and the VSM) should be considered a *useful resource*, not a blueprint for implementation. This is important because multi-stakeholder trust and collaboration can be undermined by attempts to impose top-down 'solutions.' For the design of an actual voluntary stewardship system, it may be useful to replicate the workshops process used in this research, as it was highly participative – except that more time would be needed, after initial workshops with separate stakeholder groups, to bring stakeholders together and develop a fully collaborative vision. Also, there will no doubt be technical questions about antimicrobials and their use (put beyond the boundaries of this research) that will need to be addressed once voluntary stewardship is established.

The research team would be very interested in supporting any industry or policy organization that wants to take forward this vision of voluntary stewardship. Please feel free to make contact.

1. Introduction

The problem of antimicrobial resistance (AMR) is summarized by Dadgostar (2019, p. 3903) as follows:

“Antimicrobial resistance (AMR) has developed as one of the major urgent threats to public health, ... [impacting] successful prevention and treatment of persistent diseases. In spite of different actions taken in recent decades to tackle this issue, the trends of global AMR demonstrate no signs of slowing down. Misusing and overusing different antibacterial agents in the health care setting as well as in the agricultural industry are considered the major reasons behind the emergence of antimicrobial resistance”.

However, having provided this definition of the problem, the research team needs to acknowledge that *any* use of antimicrobials could increase the risk of resistance if the systemic context enables two things: first, resistant bacteria multiplying at the expense of non-resistant bacteria; and second, the spread of genetic characteristics favoring resistance to other bacteria and their host organisms (O’Brien, 2002). Therefore, a key issue in managing AMR is what constitutes an acceptable level of risk, given the need for food security, food safety, animal welfare, and the viability of food-production businesses.

Because similar antimicrobials are used in both animal and human populations, and also because some bacteria are zoonotic (able to move between animals and humans), the AMR generated through agricultural practices can affect human medicine, and vice versa. This is why many scientists advocate a ‘One Health’ approach when it comes to understanding the ecology of AMR and its impacts on society. A One Health approach involves collaborating across disciplinary and sectoral boundaries to account for the systemic interactions between human and animal health (e.g., Zinsstag et al, 2011; Robinson et al, 2016; Destoumieux-Garzón et al, 2018; McEwen & Collignon, 2018; Hernando-Amado et al, 2019; MacKenzie & Jeggo, 2019).

While a great deal of research has been focused on *understanding the problem* of AMR (either focusing on human health, agriculture, wild animals or all three), the large majority of it has been undertaken by natural scientists who have characterized the biological phenomenon. Comparatively few studies have involved social scientists (Frid-Nielsen et al, 2019; Lu et al, 2020), even though it is well known that economic, political, socio-cultural, and public-perception factors are implicated in both AMR policymaking and on-the-ground decision making on the use of antimicrobials in medicine and agriculture (e.g., Collignon et al, 2015, 2018; Scott et al, 2015; Rönnerstrand & Lapuente, 2017; Collignon & Beggs, 2019; Dutescu, 2021; Hughes et al, 2021; Broom et al, 2022; Glover et al, 2022; Regan et al, 2022). Likewise, there are governance and organizational enablers and inhibitors of AMR (e.g., Joshi et al, 2021; Poizat et al, 2022; Spruijt & Petersen, 2022).

If we start to look beyond characterizing the problem and focus on the design of stewardship programs to tackle it, then the social sciences become even more relevant. Technical knowledge from biological, medical, and veterinary scientists is obviously vital to inform such programs, but the design of their governance, organization, implementation, and evaluation is the province, not just of social scientists, but also operational researchers and systems thinkers, amongst others. Operational research and systems thinking are two transdisciplinary fields with associated research communities that have an overlapping membership (Midgley et al, 2018): both fields are concerned with methodologies and methods for intervention to address organizational, social and ecological

problems. Operational research (OR) practitioners tend to focus more on the use of analytical, quantitative methodologies (Petropoulos et al, 2023), but there is also a substantial sub-community of people interested in problem-structuring approaches (Rosenhead & Mingers, 2001). The latter provide qualitative modelling methods to help multiple stakeholders with different perspectives structure their thinking in dialogue to collectively get to grips with highly complex, messy issues that need to be managed rather than solved. Systems thinkers are likewise interested in complex problems and collective approaches for addressing them. Their methodologies and methods help stakeholders in dialogue think more systemically about problems and potential solutions (e.g., Midgley, 2000; Jackson, 2003, 2019; Kijima et al, 2021). There are systems methodologies (offering many visual modelling methods) for mapping complex causality, designing highly adaptive organizations, enabling multi-stakeholder governance, engaging in strategic and operational planning, facilitating conflict resolution, enabling values clarification, undertaking evaluations, and more (e.g., Flood & Jackson, 1991; Midgley, 2003; Cabrera et al, 2023).

AMR is clearly a highly systemic problem, making OR and systems thinking relevant for designing antimicrobial stewardship programs (including both their governance and operations), yet there are even fewer OR and systems thinking papers in the literature than social science publications. A search on Scopus for “antimicrobial resistance” and “operation* research”¹ reveals 46 papers from 2007 to 2022 (almost all in the last 2 years), and a search for “antimicrobial resistance” and “systems thinking” brings up just 10, published between 2019 and 2022.²

In the view of the research team, in order to make progress in designing and evaluating stewardship programs, it is essential to integrate these practice-oriented disciplines with the natural and social sciences. To this end, the team secured funding from the US Department of Agriculture’s National Institute for Food and Agriculture (USDA-NIFA) to bring together veterinary scientists, sociologists, economists, marketing specialists and systems/OR³ practitioners to better understand the drivers and barriers to antimicrobial stewardship, and to work with stakeholders to design an innovative way forward (Scott, 2016).

The focus was *voluntary* stewardship: i.e., stewardship approaches that do not require legislation, mandatory compliance, and statutory enforcement. While there has been a small amount of research on voluntary stewardship, particularly in France (Verliat et al, 2021), most attention has been paid to statutory regulation (e.g., Phelan & Gostin, 2017; Hoffman et al, 2019) or models that mix statutory and voluntary action (e.g., Ruckert et al, 2020). As discussed by some of the policymakers and industrial stakeholders consulted prior to the grant application, voluntary stewardship is comparatively under-researched, yet is often seen as a more attractive option by industry stakeholders than forms of stewardship mandated by governments. This is not just because industry bodies are placed in a leadership position, but also because voluntary stewardship can be more-quickly responsive to changes in industry practices, AMR, and scientific findings than regulation and legislation. This is especially likely to be the case if the programs are established on the basis of sound principles rather than the setting and following of fixed rules (see Ruckert et al, 2020, for a review of binding versus non-binding approaches).

¹ The search term “operation* research” was used because in the USA it is called *operations* research, and in Europe it is *operational* research.

² Search last updated on 3 March 2023.

³ From this point in the report, ‘systems thinking’ and ‘operational research’ are integrated into one term: ‘systems/OR’.

Rather than study an existing model of voluntary stewardship, as Verliat et al (2021) did, the focus of this research was on what stakeholders would be willing to commit to in the US context if they were to design something entirely new that is feasible to implement. A systemic design method was used, with the purpose of freeing people from restrictive assumptions that maintain status-quo operations (Ackoff et al, 2006): the idea was to liberate the creativity of the participants to see if there might be an emerging consensus between stakeholders, or whether there are deeply rooted differences of perspective that might undermine progress in the design of a voluntary stewardship scheme.

While OR and systems thinking approaches are frequently used to facilitate *actual* changes to policies and practices, in this case it needed to be clear to the participants that they were involved in a research study where the client was the US Department of Agriculture (USDA), and they wanted to know more about what might be possible. There was no commitment from the USDA to move toward implementation, and nor would this have been appropriate: as became apparent when the research team engaged with stakeholders, almost all said that leadership of voluntary stewardship needed to come from industry, and there was much discussion about different possible roles for Federal agencies such as USDA, the Food and Drug Administration (FDA) and the Centers for Disease Control and Prevention (CDC).

2. Methodology

To support participants in examining what the voluntary stewardship of antimicrobials might involve, the research team facilitated four half-day workshops. The idea was to look at how to tackle AMR from the points of view of different stakeholder groups: beef producers, dairy industry representatives, public health policymakers, and consumer advocates. A separate systemic-design workshop was held with each of these groups, rather than bringing them together, for two reasons:

1. To give the participants space to express their views freely and openly, outside the hearing of other stakeholders who they might want to criticize, making it more likely that the research would capture sincere viewpoints.
2. To create a relaxed atmosphere, so the participants would feel safe to creatively explore the potential design of voluntary stewardship, and evolve their thinking in dialogue with others. A perceived lack of safety can make people either entrench into pre-determined positions, tow 'party lines', and/or suppress differences of opinion in the interests of impression management (Midgley, 1997a; Cronin et al, 2014; Helfgott et al, 2023).

A workshop-based, systemic-design methodology is preferable to the use of interviews (the most common social science approach) because the former allows for synergistic learning between participants. New ideas can evolve out of the dialogue that is facilitated by researchers. In contrast, interviews provide limited scope for learning by the participants (only what can be achieved by isolated individuals reflecting on their answers to the interview questions) so the possibilities of experiencing an emerging consensus are slight. In addition, any synergies in the findings from interviews are inevitably produced by the researcher, so are less likely to achieve buy in from the participants than workshop outputs, where the synergies come from the participants themselves.

The first workshop was run in Texas with 14 beef producers, recruited through a professional association to eliminate bias toward those already partnering with antimicrobial-resistance researchers. Two represented a cattle-feeder's association, and had experience in quality inspection; one was a senior manager in a veterinary diagnostic laboratory; one was an agricultural extension worker; and the remaining 10 were veterinarians or nutritionists working in feedlot companies. Most

of the veterinarians were working at a senior level in close collaboration with their owners and managers, so had a good grasp of the business issues involved in beef production as well as veterinary concerns. Most were empowered decision-makers, at least in relation to clinical matters, and had considerable influence in establishing corporate antimicrobial-use policies.⁴

The second workshop was again in Texas with 5 representatives from large dairy producers, also recruited through a professional association to eliminate pro-researcher bias. Two were owners of their businesses, 1 was a senior manager, and 2 were agricultural extension workers. More participants were originally intending to participate, but an issue in one of the dairies had caused some last-minute cancellations.

Dairy and beef were selected as the agricultural sectors to focus on because they are both dealing with cattle, but the commercial structures of the two industries are very different (see later), which the team anticipated might impact what would be needed to tackle AMR.

The third workshop was in Washington DC, with 8 public health policymakers who had an interest in taking a One Health approach. Seven of the participants, recruited through the research team's policy networks, were in senior, public-sector policy roles relating to human and/or animal health, and the eighth was from an association for medical and veterinary colleges.

The fourth workshop, also in Washington DC, was with 8 consumer advocates, again recruited through the research team's networks: three representing a charity concerned with tackling AMR in the interests of human health; two from consumer rights associations; one from an activist investor alliance; one from a food-safety advocacy organization; and one from a group advocating for science in the public interest.

The aim was to have at least 8 participants at each of the 4 events, which was met or exceeded in the case of the beef, public-health and consumer-advocacy workshops, but was not achieved for the dairy workshop. Nevertheless, the smaller number of participants (5) from the dairy industry still had a rich and detailed discussion, which resulted in some critically important findings.

Within each of the workshops, an adapted version of Critical Back-Casting (Midgley, 2017) was employed, including use of the same twelve questions to structure the dialogue, so comparable results from all four workshops could be generated.⁵ The questions were originally developed by Ulrich (1994) as part of his Critical Systems Heuristics approach, and Ulrich talks about asking them in the 'is' mode (what is happening in the current system?) and the 'ought' mode (what ought to be happening in a changed system?). Only the ought questions were used in the study discussed in this report, as the team was focused on the potential for *new designs* of voluntary stewardship. Also, the questions were rephrased in plain English (see Table 1) because the originals contained some academic jargon that experience has shown is not immediately transparent to 'lay' participants.

⁴ The research team had also wanted company owners and non-veterinary managers to be involved, but they all delegated participation to their senior veterinarians.

⁵ This is a well-tested approach to systemic design. Other examples of Critical Back-Casting can be found in Cohen and Midgley (1994), Midgley et al (1997a, 1998), Midgley (1997b, 2000, 2006, 2015a) and Boyd et al (2004).

Critical Systems Heuristics Questions in the ought mode
(1) Who or what should benefit from the voluntary stewardship of antimicrobials, and how?
(2) What should be the purposes of voluntary stewardship; i.e., what goals should it aim for in order to deliver to the beneficiaries?
(3) What should be the key measures of success of voluntary stewardship?
(4) Who should be seen as the key decision makers; i.e., have the authority to change who should benefit, what the purposes should be, and how success should be measured?
(5) What components (resources, people, policies, etc.) should be under the authority of the decision makers?
(6) What is essential for delivery of the benefits and purposes, but should not be under the authority of the decision makers?
(7) Who, either in addition to or instead of the decision makers, should be involved in delivering the benefits and goals?
(8) What should count as expertise; i.e., who should be considered an expert and what should be their roles?
(9) What are the key factors that will guarantee (or increase the likelihood of) success?
(10) Who or what could be affected by the activities of voluntary stewardship, should they be represented in decision making, and (if so) how?
(11) To what extent should the affected be able to retain independence; i.e., opt out or neutralise the effects on them, and/or take actions of their own choosing?
(12) Upon what core values and assumptions should voluntary stewardship be based?

Table 1: Ulrich's (1994) Critical Systems Heuristics questions rephrased in plain English and made specifically relevant to the voluntary stewardship of antimicrobials (adapted from Midgley, 2017).

The questions are specifically focused on the *purposes* that voluntary stewardship should pursue; who should (or should not) be involved in its *governance and delivery*; what *expertise* is necessary; and what will give it *legitimacy*. They address normative/ethical issues⁶, and Midgley (1997a, 2000) notes that they are particularly useful to foster reflection on the governance of projects and programs designed to address complex social and socio-ecological problems. For each of the twelve set questions, between three and ten unplanned follow-up questions were asked too, in order to draw out all relevant viewpoints and explore them in sufficient detail.

It is important to note that, because the focus of the questions used in the workshops was on purposes, governance/delivery, expertise, and legitimacy, and each workshop had to be completed in 3.5 hours, technical questions (e.g., which antimicrobials need to be stewarded? What levels of AMR are acceptable?) were not asked. Participants did sometimes touch on technical themes in their dialogues, but mostly to note that there are open questions about them, not to make decisions on them. Stakeholder engagement on these technical questions will be necessary when designing an actual voluntary stewardship system.

Critical Back-Casting involves asking the twelve questions as part of an 'idealized design' process (Ackoff et al, 2006): the participants imagine that all current projects and programs to address a given problem (in this case AMR) have been stopped, and the participants have been recruited to join a design team to propose new solutions that do not have to be constrained by what currently exists. This is what helps participants to challenge taken-for-granted assumptions, and it liberates creativity. However, to prevent the proposal of unattainable utopias, all solutions have to be *technologically feasible* (either using current technology or technology that could be developed in a timely manner), *viable* (affordable and socio-environmentally sustainable), and *adaptable* (capable of flexing, or being revised, in response to future changes to the problem).

Usually in Critical Back-Casting and other 'idealized design' processes, no characteristics of the proposed solution are specified in advance: participants are completely free to go in any direction they like in discussing solutions. In this case, however, the research team asked the participants to focus on what *voluntary* stewardship of antimicrobials should involve. Given that there are many possible approaches to voluntary stewardship, considerable freedom for the participants remained,

⁶ The questions were developed from Kant's (1788) 'categorical imperatives.' Further details of the philosophy behind the questions will not be provided here. See Ulrich (1994) for details.

but two policy options were ruled out by this focus: designing a statutory, regulative regime with enforced compliance; and refusing any intervention at all, in the belief that unrestrained market forces will address the problem. The research team considered that this narrowing of the normative focus to voluntary stewardship was justified, on three grounds:

1. It is necessary to move beyond conflict over whether AMR is actually a problem or not, as both the natural-scientific and economic analyses are clear that it is (e.g., Naylor et al, 2018; Dadgostar, 2019; Murray et al, 2022). The researchers therefore wanted to rule out refusal of any intervention at all.
2. Several members of the team had extensive experience of research with food-animal industries, and were aware of resistance by some of these stakeholders to statutory enforcement approaches. There is a view that government interventions tend to be 'one size fits all', without sufficient sensitivity to local-industry contexts. These stakeholders were not against addressing AMR, but wanted to do so through voluntary stewardship rather than statutory regulation and enforcement.
3. The research team's pre-project consultations with industry, public-health and policy stakeholders revealed that not enough was yet known about the potential for voluntary stewardship in agriculture, especially in the US context.

Abbreviated answers to the twelve questions were recorded on flip-charts during the workshops, and most of the dialogues were also recorded, anonymized and transcribed. Unfortunately, the recording of the first half-hour of the workshop with beef producers was inaudible, and the whole of the workshop with the consumer advocates failed to record. Nevertheless, sufficiently detailed notes were made on the flip charts in these two workshops to facilitate comparisons between the views expressed by the different stakeholders, and it is usually the case in Critical Back-Casting studies that the flip-chart outputs are the sole data source (see, for example, Cohen & Midgley, 1994; Midgley, 1997b; Midgley et al, 1997a, 1998; Boyd et al, 2004).

Below, overview narratives about the discussions in each group (beef-producers, dairy industry representatives, public-health policymakers and consumer-advocates) are presented in turn, focusing on key issues and drawing out similarities and differences between the groups.⁷ In writing the overview narratives, the research team has included some information about group dynamics within each workshop, as these were often significant in the evolution of the dialogues, and will be important to note for anyone seeking to design an actual voluntary stewardship system.

3. Views from the Beef Producers

Right at the start of the first workshop, there was an angry but controlled challenge by one participant, and several others then supported what he had to say.⁸ The workshops were set up to discuss voluntary stewardship, and this had been agreed in advance with the participants, but the dissenting person expressed the view that voluntary stewardship was not the right focus.

⁷ Overview narratives have been provided rather than detailed answers to each question in turn, as experience with previous write-ups of Critical Back-Casting workshops suggests that an overview is much more useful to readers wanting to appreciate possible meanings of the similarities and differences between stakeholder perspectives. See Midgley et al (1997a, 1997b, 1998) for an example of a complete data set and associated overview narratives – comparison of them makes it clear that systematically reading the data set, even when presented in a visually appealing manner, is quite a challenge, and overviews are more useful.

⁸ The interpretation of anger was checked out by the facilitator, and mirroring the issue back to the person mounting the challenge gave him confidence that he was being heard. This helped constructive engagement moving forward.

3.1 An Alternative Focus, or One to Incorporate into Voluntary Stewardship?

Interestingly, there were two dimensions to the challenge from the above-mentioned individual, which (from the perspective of the researchers) initially appeared to be in tension with one another. On the one hand, this person argued that there is no scientific evidence of antimicrobial-resistant bacteria transferring between cattle and humans, so he claimed that the focus on stewarding antimicrobials in agriculture as an aid to preserving their effectiveness in human populations is unnecessary.

In contrast, however, he also claimed that there *is* actually a problem of AMR *in agriculture* (i.e., the effectiveness of antimicrobials used to treat animals may decline), but the large beef producers should not be blamed for it: rather, it comes about because there are hundreds of small producers raising just a handful of calves each, and selling them to the big feedlots, yet many of these small producers have low standards of animal husbandry.⁹ As a result, a lot of the calves are on their way to becoming sick when they are first bought by the large producers, and need to be given antimicrobials for prevention, control, or treatment purposes. There was wide-spread agreement amongst the participants that dealing with this problem would eliminate around 75% of the use of antimicrobials.

In the researchers' later reflections on this discussion of poor husbandry, it was noted that it is peculiar to the US context: in many other countries, beef producers raise their own calves through to slaughter, yet the US industry is structured so this early phase of production is solely the responsibility of small producers. The view was also expressed that the division between calf-rearing and fed-cattle husbandry is so engrained in US culture, and so positively valued in rural communities, that there would be strong resistance to changing it.

The discussion of this person's challenge consumed the first twenty minutes of the workshop, with contributions by other participants helping to move the dialogue forward. Four further points were made:

1. Tackling the poor animal husbandry amongst small producers could be included in the design of a stewardship system. Everybody agreed this would be worthwhile, although several people commented that it's a tough problem to solve because of the scale of it, and the geographical spread of the small producers.
2. Many of the beef producers clearly felt uncomfortable about the outright denial that there is any evidence for taking a One Health approach: a participant said that he has children and grandchildren, and *of course* he wants antimicrobials to be effective for use by the next generation. There was widespread agreement with this comment.
3. One person said that, even if there is insufficient evidence of resistant bacteria moving between animals and humans, the large majority of the public and media believe they do, so it would be bad public relations to be perceived as denying the science, and it could damage their industry commercially.
4. Finally, the person making the initial challenge acknowledged that, because he recognized that AMR *in agriculture* is still a problem, this needs to be addressed to preserve animal health and sustain the profitability of meat production.

⁹ Many large food-animal producers use the language of 'animal management' rather than the older phrase, 'animal husbandry', which is still widely used in other contexts. The research team has retained the latter phrase for use in discussing how small producers keep their cattle, and reserve 'management' for the more systemic focus on procurement, processing, nutrition, disease, etc., that the participants in this study claimed is required to reduce AMR (see later).

It was agreed to move forward with the focus on voluntary stewardship in agriculture, incorporating how to address the issue of poor husbandry amongst small producers within the model of stewardship to be designed. There would be some further defensiveness later, but not to the point of refusal to engage with the workshop remit.

3.2 Purposes and Beneficiaries

The first three questions were on proposed beneficiaries, purposes and measures (indicators) of success.^{10,11} The beneficiaries and associated benefits of voluntary stewardship were fairly straightforward for the participants to specify: beef producers (who would gain economic benefits from better public perceptions of the industry), consumers (who would have continued access to effective antimicrobials and less concern about the industry), cattle (which will benefit from the continued effectiveness of antimicrobials, and may receive better veterinary care in the context of stewardship) and various professionals (veterinarians, animal nutritionists and pharmaceutical providers). Nutritionists might not seem like an obvious beneficiary, but they were mentioned because the participants believed that a lot of the sickness found in calves came about because of their diets, and a successful stewardship system needs to prevent this through good nutritional advice.

There was a return, during the discussion of beneficiaries, to the question of whether there is actually a link between AMR in bacteria affecting cattle and those affecting humans. Also, there was some questioning of whether stewardship can be made to work, because the system in which resistance arises is so complex. These skeptical comments were noted on the flip charts, and although they indicated some continued defensiveness around the topic of stewardship, they did not derail the discussion.

During the deliberation on purposes, the point was made a number of times (clearly to head off the listing of purposes requiring government regulation) that decision making should be at the level of the feedlot, with no centralized control at either the State or Federal levels. Federal control was a perceived problem for everyone. The purposes were all about good practice in stewardship at the very local level. Taken together with the stewardship being voluntary, it was obvious that keeping governance at the feedlot scale would put the owners, managers and veterinarians in the industry in a powerful position to decide if and how to change their uses of antimicrobials. This hyper-local focus came to be tempered later in the workshop by discussions of multi-stakeholder involvement in higher-level governance (see below), which is an important finding from the point of view of designing an actual voluntary stewardship scheme that puts industry in the driving seat without alienating other stakeholders.

¹⁰ The focus in the text is on beneficiaries and purposes, as the specification of these set the initial focus of voluntary stewardship in all four workshops. In every case, the specification of measures (or metrics) was derived from the beneficiaries and purposes: i.e., the participants answered questions like, 'how will we know if X has benefited?' and 'how will we know when this purpose has been achieved?' The design of measures will therefore not be covered in this report.

¹¹ Going straight to designing solutions (e.g., a model of voluntary stewardship) tends to set participants with different, pre-existing ideas against each other. If the facilitator can support the participants in temporarily suspending judgement on solutions, their explorations of purposes, beneficiaries and measures provide a richer source of information to enable the creative design of solutions than any individual would have in their minds at the start of the workshop. Also, these explorations give the participants criteria to evaluate emergent solutions against (i.e., will the proposed solutions deliver to the beneficiaries? Will they meet the purposes that have been defined? Can success be assessed using the measures?). A broader canvas of specifications for designing a new approach is explored this way, and people can always narrow down later if some of the beneficiaries, purposes or measures come to appear less important as the dialogue unfolds.

Specific purposes discussed by participants included education and information provision about good practices to prevent animal disease, plus a certification or validation scheme, especially for geographically dispersed producers raising small numbers of calves. It was pointed out that an incentive for these small producers to engage with validation could be tying it to a marketing campaign, so the buyers of calves would know which producers follow good stewardship practices.

3.3 Governance, Authority, Expertise, and Control

When the participants were asked question four about governance (i.e., concerning who should have decision-making power on *changing* the beneficiaries, purposes and measures), they reiterated that decision making should be at the feedlot level. In a follow-up question, they were asked if other stakeholders should be involved in decision making at all, and their initial, clearly stated answer was ‘no’.

However, at this point, there was a side-track in the discussion. A veterinarian asked whether there are any models of *existing* effective governance for the industry that they could learn from. Two governance models relating to quality standards were then discussed, and one of the participants pointed out that these had very strong engagement in governance from a wide range of stakeholders, including some who were critical of the industry standards. Several people commented that these models were working really well to keep the quality of beef production high. Immediately, there was a turn-around in views on multi-stakeholder engagement in governance: it was an instant change of heart because all the participants had clearly had such positive experiences with the beef quality assurance system. Later, the workshop participants would return to this idea of multi-stakeholder governance and go into more depth on what these two governance models of quality standards involve.

This change of heart on multi-stakeholder involvement is a crucial finding, because it indicates that resistance to it in the governance of voluntary stewardship is not inevitable. The lesson for scaling up discussions on the governance of voluntary stewardship is not only that workshops need to provide a ‘safe space’, which can reduce people’s defensiveness and improve their abilities to appreciate others’ perspectives (Helfgott et al, 2023), but also that it is useful to discuss analogous positive experiences (e.g., with things like multi-stakeholder governance), as this creates an emotional climate in the discussion where the value can be seen in something that might initially be framed negatively due to fear associated with the anticipation of challenges from different perspectives.¹²

After this change of heart on multi-stakeholder participation, the participants became much more relaxed and open to listening to each other in the dialogue. Jokes were made that lightened the mood, and ideas for what antimicrobial stewardship needed to involve started to flow.

¹² Systems theories of cognition (Maturana, 1988; Maturana & Varela, 1992) and contemporary neuroscience (Barrett, 2006; Seth, 2021) both point to the value of appreciating that people change their minds (i.e., move from one linguistic framing of an issue or policy option to another) via their emotions. Effective workshops therefore *always* engage with participants’ emotions: a characteristic of *ineffective* workshops is approaching emotion as a ‘contaminant’ of rational decision-making (Bilson, 1997). Seeking to eliminate emotional engagements actually blunts the potential for people to voluntarily change their minds in dialogue with their peers, and in this sense emotional disengagement is actually *unethical* as well as ineffective, because it reduces the possibility of self-directed, beneficial change. Engaging with emotions is ethical when the feelings of the participants are *grounded in their own experiences and viewpoints* (e.g., positive experiences of multi-stakeholder governance, in the case of the voluntary stewardship of antimicrobials) rather than the unethical use by a facilitator of fear (e.g., of exclusion by the group) to induce conformity to a given viewpoint, which runs counter to the desire to establish a safe space (Helfgott et al, 2023).

In addition to including a range of stakeholders with an interest in combatting AMR, the participants had some particular points to make about inclusion in governance. First, they said that it is important to bring in “self-organizing entities within the veterinary profession” (veterinarian), as these kinds of professional societies have more independence than individual veterinarians employed by feedlot owners. Bearing in mind that the focus of the discussion of governance was local (i.e., feedlot-scale rather than national), the participation of owners and senior managers was viewed as critical, so those who have decision-making authority can hear from and be influenced by the perspectives of others. Representing the supply chain was also considered to be important – particularly meat packers and retailers.

There was some conversation about directly involving the small-scale, calf-rearing producers who have variable-quality animal husbandry standards, with a view to their representatives taking the message about calf health to their peers. However, this was deemed too difficult because they are geographically dispersed and don’t already communicate with one another. Instead, the group discussed the representation of cattlemen’s associations and veterinarians, who could take the message out to these small-scale producers (also see later, as other influential players were identified when the issue of small-scale calf producers was revisited).

A veterinarian said “we almost need something like a cattleman’s beef court with the right representation on it”. The metaphor of a court connotes a body that can make judgements on necessary calf-rearing standards that are widely perceived as legitimate, and can also hold producers to account when those standards are being neglected (see later for a discussion of whether such a body can ‘have teeth’).

When discussing what expertise is required for governance, the participants focused mainly on understanding beef production as a business (hence the knowledge of the owners and senior managers of the feedlots is essential); veterinarian input; pharmacology; and animal nutrition (because poor nutrition is a significant cause of the ill health of calves being reared by small producers).

The participants only wanted to exclude two categories of stakeholder from local governance:

1. National organizations, because they tend to advocate generic policies and are not nimble enough to be responsive to local contexts, and
2. Pharmaceutical companies, because “that’s like inviting the fox to guard the hen house” (veterinarian). Several people said that these companies need to be involved in some way, because they have access to necessary information, but not in a governance capacity: they should not be able to change who should benefit from stewardship, what goals are set for it, and how achievement of these goals should be measured.

A key question, once an initial vision of governance is established, is what the governing body should have authority over, and what should be explicitly outside its remit. Initially, there was some hesitancy on the part of participants to discuss issues of authority. Several reasons for this were explored, but the main one was that “the use of antibiotics is still going to be regulated by the VCPR [Veterinary Client-Patient Relationship] at the local level. I see the decision-makers maybe being

more in charge of information that trickles down to us...” (veterinarian).¹³ The idea was that governance should be focused on improving overall system-level performance rather than control over clinical decisions made by veterinarians who decide whether to prescribe antimicrobials to individual animals. If system change is successful, then reductions in the use of antibiotics will follow, together with lowering the risk of AMR.

There was some talk about the utility of better information, with the caveat that veterinarians already informally disseminate information, so one participant expressed doubts about adding a new layer of information provision. However, there was also a focus on whether stewardship should be about *validation* – especially validating whether good practices in animal husbandry are being followed, to prevent the need for high levels of antimicrobial prescription. The most important aspect of this, according to three of the participants (with others in agreement), would be tracing batches of sick calves back to the small producers they came from, so their animal husbandry could be evaluated, and peer pressure for change applied when necessary.

At this point in the discussion, the two specific models for the governance and delivery of quality, mentioned earlier, were revisited and discussed in more detail, with an emphasis on what could be learned from them to inform voluntary stewardship. There was strong support for them both:

1. *The US Roundtable for Sustainable Beef* (USRSB), which is “a multi-stakeholder initiative developed to advance, support and communicate continuous improvement in sustainability of the U.S. beef value chain” (USRSB, 2023). Amongst other stakeholders, this includes beef production companies, retailers, media and NGOs, all collaborating on collective leadership and innovation. While the Roundtable was initially mentioned as a model to adapt for use in tackling AMR, two participants indicated that “this could be a platform” (and others nodded). This suggests the possibility that the USRSB could be approached to actually *host* a stewardship initiative.
2. *Beef Quality Assurance* (BQA), which is “a national program that raises consumer confidence through offering proper management techniques and a commitment to quality within every segment of the beef industry” (BQA, 2023). An interesting discussion ensued about the fact that the BQA has ‘teeth’: “the primary motivation for most folks involved in our BQA program is: we've done a pretty good job of convincing them, if they don't do this, they might end up with locks on their gates” (cattle-feeder association representative). The bottom line is, a stewardship system with teeth “would be economic sense” (veterinarian), and this doesn't have to undermine the voluntary nature of the program because, at the end of the day, each company could make its own decision on whether or not to participate – but the advantages of doing so could be made very obvious. The participants emphasised that there is such strong buy in to the BQA prescriptions for maintaining quality, partly because the alternative might be catastrophic for a company, and partly because “we're competitive. You want to be the best, as a State, as a region, as a company. There's something about striving for that excellence” (cattle-feeder's association representative). Although it's a national initiative, performance at different scales (company, State, region, nation) is made visible through information provision, encouraging healthy competition.

There is a very clear synergy between these two models: the USRSB offers multi-stakeholder oversight as well as sustainability guidance, and the BQA provides prescriptions of good quality

¹³ The idea of VCPR is that veterinarians are required to have a significant relationship with their clients, and must have seen or examined the herd/animal before a prescription is issued (AVMA, 2003).

practice with buy in from industry players. One interesting feature is that both are national models, so they represent a shift from the idea that everything should be at the feedlot scale.¹⁴ However, the circle can be squared by imagining a national body with multi-stakeholder governance that produces generic guidelines for good practice in voluntary stewardship. The guidelines could then be customized for application at the feedlot scale, with the nature of the customization depending on the local issues that are most relevant. Likewise, appropriate indicators could be chosen from a wider range available. Evaluations of implementation and information provision about these, so industry performance is transparent to all, would be key: this would foster healthy competition, inform the exercise of peer pressure, and enable individual companies to act on feedback through a continuous improvement process. More details of what this approach could involve are provided in the Discussion section (see later).

3.4 Tackling Poor Animal Husbandry among Small-Scale Calf-Producers

Having settled on a viable model, the participants then revisited the issue, raised at the start, of the use of antimicrobials to correct for variable standards of animal husbandry among small-scale calf-producers. They still argued that around 75% of antimicrobial use is in response to the inadequate husbandry of calves by small producers.¹⁵

The starting point was seeing economics as a driver:

“The issue is those cattle that have lower production practices are going to go somewhere... They don't just disappear. We complain because we handle some of the bigger budgets, but when they get cheap, even our organizations get into it. Until you affect those lower production practices, then you will have antibiotic use in those cattle when they arrive at the feed yard, wherever it may be” (veterinarian).

This is important because it indicates that market forces play a part in ensuring that even the sickest animals are purchased by the feedlots when the cost/benefit ratio becomes advantageous (i.e., when the price of unhealthy calves reduces to the point where treating them with antimicrobials will be cost-effective).

There was extensive discussion about who can reach out to the small producers, given they are geographically dispersed and, for the most part, not collectively networked. Suggestions included ‘middle men’ buying calves and selling them to the large feedlots; extension agents, except they were said to reach only 20% or so of small producers; cattlemen’s associations; veterinarians, who could have considerable impact, but they would need to be incentivized; and pharmaceutical sales representatives.

One participant had been volunteering for some time on outreach to small-scale calf producers on the issue of AMR:

¹⁴ It is common for ideas produced using Critical Back-Casting to evolve in this way. The researchers’ interpretation of this evolution is that, initially, the participants were defensive and wary that there might be a bias, in the study as a whole, towards a mandatory compliance system. Therefore, they stressed voluntary stewardship at the local-company scale, saying that higher-level oversight and multi-stakeholder involvement is unnecessary. This changed when they were reminded that their quality initiatives involve multi-stakeholder oversight, and they are comfortable with it. Then, after further exploration, they deepened their consideration of the governance and delivery models described above.

¹⁵ Nevertheless, a participating veterinarian also said that he had to deal with a “big boy” (a large beef producer) wanting to use an inappropriate antibiotic, so not all of the problem exists outside the feedlots.

“I gave a talk at a producer meeting in [location deleted] last week on alternative management schemes for health improvement outside of antibiotics. There were 130 people there. I didn't get laughed out of the room, but there was a lot of interesting conversation. They're not willing yet to consider a lot of those approaches because the antibiotics have been the answer for so long. When you get to talking about management concepts that we do on a daily basis, they're virgins to all of that. They have a hard time understanding. Once you can even tell them, and not just the benefit that I get out of it, but the benefit of what you're going to see out of it, then you can start seeing some heads nod along” (veterinarian).

A key issue is identifying the incentive for small calf-producers to engage with this kind of outreach, and the above participant said that the focus should be on improving the health of their animals. It could make a difference to add this focus to the idea, mentioned earlier, of a certification or validation scheme tied to a marketing campaign, so the large beef producers are encouraged to prioritize the purchase of healthy calves. Nevertheless, it would appear that considerable investment would be needed into outreach to enable a voluntary stewardship system to engage the small producers, who are currently relatively isolated.

3.5 Who would be Affected but would not be Involved?

The most notable stakeholder who would be affected but not closely involved was the pharmaceutical industry, who could lose income if fewer antimicrobials were used. The participants were clear that this was not a concern for them. They also pointed out that the pharmaceutical companies are well aware of the need to control AMR, so have already started work on new revenue streams, especially focused on the prevention of illness so fewer antimicrobials will be required in the future: some of this is about nutrition, and “a lot of those companies are looking at nutraceuticals that enhance a gene function, so they're expecting to sell more of that instead” (agricultural extension worker).

3.6 Enhancing the Likelihood of Success

When asked what will make the most difference to the success or failure of this kind of voluntary stewardship scheme, the following criteria for success were discussed:

- Reaching the small operators rearing calves, as noted above, especially in the South-Eastern States of the USA.
- Securing the participation of the large majority of small-scale producers (as well as the large feedlots) in a certification or validation scheme.
- Having good measurement systems, so performance (in terms of both animal husbandry and antimicrobial use) is transparent to all.
- Reducing the use of antimicrobials, not just improving husbandry, and demonstrating that this has been done.
- Demonstrating to the Federal authorities that this is good self-regulation, and having them accept it.
- Proactively researching emerging problems of AMR, which implies the provision of funding for this by producers and government agencies, so new threats can be addressed before they get out of hand.

4. Views from the Dairy Industry

In contrast to the workshop with beef producers, the session with dairy industry representatives started without any significant challenges. This is not to say there was no defensiveness (more on that soon), but people were collaborative from the start, and there was no questioning of the remit of the workshop.

4.1 Purposes and Beneficiaries

As before, the workshop started with discussions of the beneficiaries and purposes of voluntary stewardship, with producers and consumers being the first beneficiaries to be mentioned. Others included “middle men” (between production and consumption), sick animals, and possibly veterinarians, who may become key advisors to a voluntary stewardship program. This was very similar to how the beef producers viewed the beneficiaries.

A critically important point was made that industry would be more likely to engage if there was value for them. There was strong agreement in the room that substantially reducing antimicrobial use could allow the differentiation of a new product commanding a premium price, but then the following exchange took place:

Facilitator: “What benefits would the consumer have?”

Participant 1: “Confidence”.

Facilitator: “Right. Are there any health benefits for the consumer?”

Participant 1: “*Perceived*, I would say”.

Participant 2: “Yeah, perceived. Obviously, everyone benefits if we can avoid creating antimicrobial-resistant bacteria. The researchers know better, but it's my understanding that we've fairly well ruled out agriculture being the primary source of those type of super bugs”.

Exactly one minute later, after further discussion, participant 2 added:

Participant 2: “In general, we're all better off as a society if we're able to limit our using of [anti]microbials. There's no argument there. Even within your dairy, you're better off. They work better”.

This is a dynamic that recurred repeatedly during the first quarter of the workshop: movement between emphasizing that the science exonerates their industry from being a prime cause of AMR in bacteria affecting humans, and then acknowledging the benefits to both the industry and wider society from limiting antimicrobials. Often the same person made both points. In addition, the participants sometimes emphasized that the main benefits from voluntary stewardship would come from marketing it to consumers, even though there were no *real* benefits for human health: “We'll milk cows upside-down if we thought the consumer would actually pay more for it. Think about all the things you're hearing about. A1/A2 milk, cows that are milked at night because of their higher levels of melatonin – there's all kinds of special markets that are out there” (senior manager). Treating stewardship as a form of marketing suggests some skepticism about the One Health rationale for it, and an explicit concern was expressed that, if dairy producers were not *seen* to be doing anything about AMR, the public might be led by animal rights activists to turn against the industry. Other times, the participants focused on the benefits to humans and animals from limiting

the use of antimicrobials (indicating acceptance of the One Health rationale): like the beef producers, the dairy industry representatives expressed a strong sentiment that they care about their families, and want effective antimicrobials to be available to their children and grandchildren.

This kind of ‘oscillation’ between two perspectives can happen when there is a fine balance between two competing emotions: in this case, hope that they could contribute to tackling a major global problem, and fear that they will be perceived as the cause of that problem. Two competing emotions bring out two associated ways of thinking about the issues that are in tension with one another.¹⁶

The implication for anyone facilitating the design of an actual voluntary stewardship system is that time and safe space needs to be provided for this kind of oscillation to happen: if the participants feel they are being pushed (even manipulated) into expressing their hope but ignoring their fear, the whole conversation could be tipped into defensiveness that could change the trajectory of people’s deliberations. In contrast, by just letting the dialogue unfold in a safe space, preferably preventing or holding off conflict between stakeholder groups by working with them separately to develop their perspectives before subsequently bringing them together (e.g., Midgley, 1997a; Boyd et al, 2004), the participants can work through the tensions and settle on the more positive outlook. In the workshop with the dairy industry, this settling did indeed take place after about thirty minutes.¹⁷

When purposes of a voluntary stewardship program were explored, the discussion was quite wide-ranging. Purposes included “getting in front of” AMR (dairy owner); “protecting antimicrobial technologies” (flip-chart summary), and ensuring that antimicrobials would continue to work in agriculture; “documenting a formula” (flip-chart summary) for creating a market for new products involving the industry in tackling AMR; managing public perceptions of the industry, including through social-media marketing; education on AMR; product differentiation of milk produced on farms with high standards of antimicrobial stewardship¹⁸; ensuring there are no antimicrobial residues in milk; reducing residues in cattle slaughtered for meat; and responsiveness to proactive research about AMR, so stewardship is informed by the science.

In marked contrast to the first thoughts of the beef producers, who (until they started to talk about good practice in the governance of quality) stressed the importance of local governance and decision-making on antimicrobials, the dairy industry participants said that the governance and design of a voluntary stewardship system should be US-wide. The reason for this will become apparent in the next subsection, and it represents a significant finding from this research.

4.2 Governance, Authority, Expertise, and Control

During the above discussion, an existing animal-welfare standards model called the FARM Program (run by the National Milk Producers) was mentioned:

¹⁶ Both systems theory (e.g., Maturana, 1988) and cognitive science (e.g., Barrett, 2006) tell us that emotions trigger different ways of thinking – what Maturana (1988) calls different “rational domains” (particular uses of language that are internally consistent in that domain, but may be different to uses of the same words and concepts in other domains). We ‘change our minds’ through the invocation of emotion, not through logical argument, because something else has become emotionally important to us, triggering a change of rational domains and hence a switch from one logic to another.

¹⁷ Also, if the participants feel comfortable about this, there are techniques that can be used at the start of a workshop to reduce anxiety levels and make it easier for people to listen to one another (e.g., Lilley et al, 2022).

¹⁸ The participants were careful not to say “antibiotic-free milk” because there will always be some sick animals requiring the use of antimicrobials, and also this phrase erroneously implies that there are usually antibiotics in regular milk.

“The FARM Program... is about responsible production, and milk production under guidelines that have been established... So, it's what we're doing with animal welfare, and having on-farm checks, and it's mandatory that once a year they go through a check, and there is being developed further verification systems. So, there could be some outside auditors” (agricultural extension worker).

It was noted that over 90% of the US dairy industry is part of the FARM Program, and one of the reasons is that animal rights activists sometimes infiltrate premises with low welfare standards and then release social-media videos of the cruel or negligent treatment of animals. This happens most frequently in slaughterhouses, which is relevant to the dairy industry because, when cows no longer produce enough milk to be economically viable, they are slaughtered for meat. “None of us want to have the video... if they infiltrate the slaughterhouse, we don't ever want it to be our ear tag up there” (dairy manager).

Interestingly, it is ‘middle men’ who can apply peer pressure for compliance with animal welfare standards: almost all milk is sold to co-operatives (owned by the dairy producers themselves), and their buyers refuse to purchase from premises with low standards because high-profile evidence of cruelty or neglect can taint the image of the whole industry. For an explanation of the history of, and reasons for, the US dairy industry organizing into co-operatives, see USDA (2005). The FARM Program is an example of voluntary stewardship “with teeth” (dairy owner) that could be used as a platform upon which to build the stewardship of antimicrobials: “I could see an antibiotics stewardship program fitting under the umbrella of something like this. Instead of starting a whole new entire deal, I could see where you could slip it in” (senior manager).

The participants noted that the co-operative economic structure of the dairy industry, which is very different from beef production, could enable those co-operatives to use their buying power to apply pressure on those who are unnecessarily over-using antimicrobials. Also, because the co-operatives are owned and run by the dairy producers themselves, most of the producers would be participants in conversations about the appropriate use of antimicrobials, so would understand why it is good for everyone to conform to high standards.

While the beef producers thought it would be challenging to set up a system to minimize illness in calves previously subjected to suboptimal husbandry, and thereby reduce antimicrobial use, the dairy industry participants were much more optimistic. They said it would be relatively straightforward for the co-operatives to apply peer pressure for the voluntary stewardship of antimicrobials, as nobody wants to be blocked from selling their milk to those co-operatives. In contrast, the beef industry is structured without co-operatives, so the operation of market forces ensures that unhealthy calves are still bought by beef producers, albeit for a lower price than healthy ones (see earlier).

Once the participants had discussed the benefits of working with co-operatives, the facilitator then asked the group to revisit the question of whether there is an existing organization that could run a national voluntary stewardship program, or whether a new body would be required. This was important for governance because, if it was to be integrated into the FARM Program, the governance arrangements would have to dovetail with what already exists. Conversely, if it was to be a new organization, more time in the remainder of the workshop would need to be spent on the design of governance. The following quotation represents the emergent consensus on this question:

“From a producer standpoint, I think to start a whole... [new] organization that we're going to have to deal with... would get a lot of push-back. Whereas you've got this program that's there already, it's established, we've been working under it for the last few years. I think it's a lot easier, and on both sides [milk producers and buyers], for everybody involved. Your buyers know what the FARM Program is, the producers know what the FARM Program is. I mean, everybody throughout the industry knows what it is, and I think to come in from outside of that and say, 'Okay guys, we're the antibiotic sustainability blah-blah-blah group', I think all of a sudden you're going to have an uphill battle of trying to convince everybody this is a good thing, or something you want to deal with” (dairy owner).

Given acceptance of this perspective, the participants then looked at who needed to be involved in decision making: i.e., who should have the authority to *change* the beneficiaries, purposes and measures. Compared with the list produced by the beef industry participants, who emphasized feedlot-level decision making until their later realization that higher-level, multi-stakeholder fora can work in their interests, the dairy representatives focused most closely on those with the power to influence voluntary compliance with collectively defined standards for antimicrobial use. Thus, “middle men” (dairy manager) in the co-operatives were seen as particularly important.

They also talked about the design of a “verification” regime (the same as the “validation” scheme proposed by the beef producers), with inspections of dairy production facilities and slaughterhouses, and they suggested that veterinarians would be key to the design and implementation of this. Expertise would also be needed from “the dairymen. Veterinarians and nutritionists or whoever, people that are involved, and have the right experience in the industry” (senior manager).

Dairymen were mentioned, not just in relation to designing the verification regime, but also as necessary participants in the governing body, because they know what is feasible on the ground: Also, when asked about other necessary participants in governance, the reply was, “it's got to be people with experience whose peers have nominated them, because of some sort of respect or admiration. From the science-research community, we're going to want veterinarians and academics from institutions that actually deal with dairy cattle” (senior manager). Other professions whose skills and expertise were needed for governance were veterinarians and marketing specialists.

Additionally, the participants discussed the role of Federal agencies and universities. With regard to Federal agencies like the US Department of Agriculture (USDA) and the Food and Drug Administration (FDA), the participants wanted them to provide expert advice and a “seal of approval” (dairy manager) rather than governance decision-making: “we don't want the USDA or FDA to tell us what to do, but it would be good to work with them, so that whatever program we came out with, this is a USDA-supported program” (dairy owner). When asked to expand on this a little, particularly in light of the differences between the dairy and beef industries (something that had been touched upon in the discussion), a senior manager replied, “the dairy industry is a different entity from beef cattle. I mean, we deal with inspections all the time from State and Federal levels, ...whereas a guy that's running some cows out on a pasture will never in his life... It's a different mentality. It's a different culture”. Likewise, a dairy owner added, “the beef side, they've got a very adversarial relationship with the government, for whatever reason”.

When it came to universities, two roles were envisaged: helping with the initial design of the verification regime and providing ongoing research to proactively identify emerging issues and

solutions, which would help to evolve the regime in line with the latest science. In this discussion of the role of universities, the beef and dairy industry participants were very closely aligned: both groups wanted a science-informed system that was scanning for threats and opportunities, which the voluntary stewardship governance and implementation systems could respond to. In reflecting on this, the research team notes that the participants' desires are fully in line with recommendations for good practice from the contemporary literature on systemic organizational design (e.g., Beer, 1984; Hoverstadt, 2008; Espejo & Reyes, 2011; Espinosa & Walker, 2017; Espinosa, 2023), and this will be revisited in the Discussion section.

The need for significant human resources for implementing the verification regime was examined. Paying for this was not considered an obstacle: "I think the funding's already there" (agricultural extension worker). The reason is the way the pricing of commodities is structured in the USA:

"In the US, each of the major agricultural commodities has some form, I don't know if you all [in the dairy industry] call it checkoff, but in beef and pork it's called 'checkoff dollars'. A certain amount per weight or whatever of product produced, or per head, goes to a quasi-governmental organization that spends it in accordance with the industry's needs... So, there is already a system in place" (veterinarian in the research team).

Further clarifications by participants revealed that Dairy Management Incorporated (DMI), which supports the industry, receives 15c from producers for every hundredweight of milk, so its annual income is over \$60m, which is spent on research¹⁹, product promotion, and other services benefiting the industry as a whole. In addition, because dairy cows not only yield milk, but are also slaughtered for meat, producers pay into the beef checkoff as well as the dairy one. There was confidence that a voluntary stewardship system was affordable from these budgets.

In terms of what the governance of a stewardship regime would have authority over, the main focus was again the verification scheme. When asked what should *not* come under the governing body's authority, the participants paused, and silence briefly descended. Then, instead of directly answering the question, one of the participants commented,

"Hopefully, your board and your co-op representatives and the people that are representing you, they're going to be there to be like, 'Hey guys, that sounds great that you want to do everything that way, but that's just not feasible, and we can't do that'. I mean, that's where I hope that you've got the right people representing you" (dairy owner).

The only other thing that was viewed as outside the scope of governance was the day to-day operational decision-making of dairymen, veterinarians, and nutritionists, who have to work in the interests of individual and collective animal health. While this decision making is certainly *relevant* to preventing AMR, and can be *informed* by a stewardship regime, it cannot and should not be *controlled* by a governing body. However, a way that policymakers involved in governance could help inform this operational decision-making is by funding research, teaching, and agricultural extension focused on the best disease-prevention practices, which could contribute to antimicrobial stewardship by reducing the use of antibiotics, thereby conserving their effectiveness. In reflecting on this, the research team observe that this is a well-accepted division between governance and

¹⁹ Research expenditure is limited by law to the innovation of dairy products, and cannot be spent on improving farm management.

operational decision making (e.g., Bockelbrink et al, 2022): the role of the former is to provide strategic direction, prevent corruption, and (in the case of stewardship in the dairy industry) ensure compliance with the verification scheme, yet veterinarians will still need to keep individual animal health and welfare at the forefront of their considerations.

4.3 Who would be Affected but would not be Involved?

Like the beef producers, the dairy industry representatives noted that the pharmaceutical companies would be the most significant external stakeholders to be impacted by successful voluntary stewardship. However, just like the beef producers, the participants in the dairy industry said this didn't concern them, and pointed out that the pharmaceutical companies are already changing direction: "There's been a lot of change in the way they view what they're doing now. I think they see the trend with antimicrobials and stuff, just like the rest of us see it. They're talking way more about vaccination protocols and stuff" (senior veterinarian). Another veterinarian added:

"I was an adviser for [name of pharmaceutical company] at the time, was pushing those big temperature-taking protocols, right? So, as soon as the cow spiked temperature, you'd give her [brand name drug produced by the pharmaceutical company]. They've seen the writing on the wall a lot faster than the industry. Every single one of them has some new direction they're going. [Name of a different pharmaceutical company] has the 'People First' thing, and the vaccinations. So, they're ahead of us by a long shot".

4.4 Enhancing the Likelihood of Success

When asked what will make the most difference to the success or failure of this kind of voluntary stewardship scheme, the following were discussed:

- "Universal participation would be important... You can't have one group going out to try to gain advantage over another group... We all need to be pulling on the same rope" (dairy owner). While this might *appear* to contradict the idea of stewardship being voluntary, near-universal participation can be enabled by the co-operatives using their purchasing power: producers would still have the right to say 'no' (there would be no law compelling stewardship), but no significant players in the industry would give up the opportunity to sell to the co-operatives.
- Continued use of the Capper-Volstead Act (USDA, 1985), which "allows [dairy industry] co-operatives to be able to work together and to price together" (dairy owner). Thus, dairy co-operatives are exempt from some elements of anti-trust legislation, and collaboration is at two levels: the producers all contributing to and owning their co-operative, and the multiple co-operatives themselves working together in the interests of their industry and wider society.
- Milk being a perishable product makes it necessary that producers sell on a daily basis: unlike people rearing calves, milk producers can't hold on for a few days and wait for a better offer from another company if they don't like the co-operative's requirement to participate in stewardship.

It is notable that all of these points relate to the structure of the industry, and all are already in place, creating a propitious context for voluntary stewardship.

5. Views from Public-Health Policymakers

It was clear right from the start of the public health workshop that the participants were keenly engaged. There was no challenge to the remit of the research, as there was in the beef workshop, and little or no defensiveness, as there was at the start of the dairy industry workshop.

5.1 Purposes and Beneficiaries

Who the public-health policymakers specified as beneficiaries, and who they didn't, is instructive. They identified some of the same, fairly obvious beneficiaries suggested by the beef and dairy participants: agricultural industries (which could charge more for a premium product, and also increase exports), consumers (who could have greater trust in the safety of their food) and animals (benefiting from the continued effectiveness of antimicrobials). However, the public-health participants didn't identify any of the categories of professionals potentially involved in antimicrobial stewardship in the beef industry (e.g., veterinarians and animal nutritionists), and nor did they talk about the 'middle men' (e.g., co-operatives buying milk from producers) who were considered to be so central to the dairy industry. This reveals a lack of knowledge of some of the fine detail of how voluntary stewardship would have to work if it was going to be accepted by the agricultural sector, and the detail is important to implementation.

However, the public-health participants discussed many other beneficiaries not mentioned by the beef and dairy participants. These included people needing antimicrobials as part of their medical treatments, global society (given that success in the USA could inform the design of stewardship in many other countries), academia (through increases in research and education for stewardship), the corporate sector beyond agriculture (because, in the words of a policymaker, a model of "robust stakeholder engagement" could be developed, which minimizes free riding), individuals working in agriculture (who would get personal satisfaction for doing the right thing), government agencies (who would see efficiencies in their data collection on AMR, if they are able to work in partnership with stewardship programs), the economy in general (because an increase in human and animal ill-health caused by AMR could be very costly), and the environment (because the spread of resistant bacteria could change ecosystems in unanticipated ways). It is notable that public health, as a discipline, is founded on the insight that health and illness need to be understood in a wider systemic context than just what is happening to individuals (Midgley, 2006), so it is arguably not surprising that these participants adopted a broader perspective than their agricultural counterparts when considering potential beneficiaries of a voluntary stewardship scheme.

When it came to moving from a discussion of beneficiaries to the proposed *purposes* of voluntary stewardship, the public-health participants were again quite wide-ranging in their deliberations. The first focus was on "optimizing the use of antibiotics for those times that we really need them for addressing animal disease" (policymaker). Within optimizing the use of antimicrobials, two sub-purposes were identified: science-informed practice (not using antimicrobials in a situation just because people always have, but systematically researching what works in what context), and identifying and eliminating inappropriate uses of antimicrobials.

The notion of optimizing the use of antimicrobials was later clarified as follows:

"I did not mean reduced use when I said optimized use. And I think when we say reduced use, yeah, we all want to reduce use, OK, but I don't think that we want to have some number that

we're all aiming to get to, because we're going to have changes in animal populations, changes in disease, outbreaks of disease. There may be legitimate times we need to increase use to address a disease. I don't think we want some number that we're all trying to obtain, we just want an overall stewardship framework. And maybe, going back to a purpose, is all the things that we could be doing beyond use of the drugs that help us help the animals that could help us not have to use these. And I think that goes back to reducing the need...Where can we reduce *inappropriate* use? And just blanketly reduce use, I think is not right" (policymaker).

While a couple of other participants agreed with this statement, one policymaker stood out against it, saying that, without goals, industry could just say "we're all doing things judiciously, so what's the problem?" In reflecting on this disagreement, three important points were raised. First, different parts of the same industry use markedly different amounts of antimicrobials: "If you look at dairy production focused on lactating cows, everything looks great, [but] if you look at all of the streams and potentially the cows, the calves, the veal calves, it doesn't look as rosy" (veterinarian on the research team answering a question from a participant about the science). This suggests the possibility of being selective in where to focus. Second, "I think that oversight is where it becomes really important, and... we have other tools that are available to us now. There are ways that we can optimize use while still reducing use by being smart and being scientific about it" (policymaker). It would, for example, be perfectly possible to expect different amounts of use in different contexts: increased use in epidemic conditions and decreased use at other times. Third,

"When I think of stewardship... I don't think of it as just antimicrobial use. I think of it as all the conditions that are operating within an environment... whether it's a production factor or a management factor, maybe it's the stock and the transportation of the animals coming onto the farm. And all of those factors really have to be considered in a systems approach. And when I think about stewardship, I tend to broaden it to more of what is the systems approach that we can [use to create a] change, rather than just looking at this one tool, which is antibiotics. Look at all the other factors as well" (policymaker).

The latter accords well with the observation in the beef industry workshop that much of the problem stems from poor animal husbandry amongst small producers rearing calves. However, the following exchange in the workshop is also relevant:

Facilitator: "So, we have two different boundaries [of a voluntary stewardship scheme] here... It should either cover just the use of antibiotics, and making sure you're optimizing those, or it should cover the whole way that animal health is created or not created in the first place. Are there any other views on that?"

Participant 1: "I just want to say, I think now you really are opening the discussion in the way it should go, and it's appropriate because now you're seeing the complexity. It's not black and white. There are huge shades of grey all the way through here, and that brings us to lead into best practices, how can we share that, how to communicate that? Flexibility to change based upon our diagnostics, rapid diagnostics, development of the science, and vaccines. Awareness is essential. So, when you come up and you say, yes, a stewardship program, ...it could be very large. But I think... that's okay, ... [and] I don't believe one size fits all... Small changes may be highly efficient in one area, and you're going to need an awful lot more in different areas".

Participant 2: “I think a narrower scope for a stewardship is more appropriate. I'm just thinking in my head it's more like a HACCP [Hazard Analysis Critical Control Program], where you have a whole bunch of prerequisite programs which would include the vaccination, the management, the nutrition, and all the bio-security, those sorts of things. And the critical point for this particular issue would be antimicrobial use”.

Participant 3 “I can see a little bit of controversy here. I do like more the systems approach... If we're looking just at ‘is this an appropriate antibiotic to use for this animal, speaking of liver abscesses?’, it's just looking at it veterinarianly... But then you sort of aren't looking further at what other things can you be doing to reduce liver abscesses. You're saying okay, yeah, we know liver abscesses can be helped by giving antibiotics, but that really doesn't get to the core problem”.

We note that even Participant 2 (above), when advocating for a narrower focus, assumed that there would be programs in place to deal with the wider systemic issues. Existing programs are clearly not adequate for this purpose, otherwise there wouldn't have been so much discussion in all the workshops of systemic problems, so it makes sense for the food-animal industries to address the factors *giving rise* to the need for antimicrobial use within the context of voluntary stewardship, rather than just set targets for reduction. If there is a narrow focus on antimicrobials alone, the inevitable result will be conflict between the aims of voluntary stewardship and the equally legitimate aim of veterinarians to provide appropriate care (including antimicrobials) to individual animals. There was agreement across all the stakeholder groups that this care needed to be maintained, and the circle can only be squared if effective action is mounted against the conditions that create avoidable sickness in animals in the first place.

It was notable that several public-health policymakers pointed out the importance of maintaining animal health, including the use of antimicrobials for treating sickness. Thakur and Panda (2017) argue that the use of antimicrobials in food animals should be phased out, leading to a total ban in order to reduce the risk to human health from AMR, but this was not a position supported by anyone in the workshop. The participants valued animal health alongside human health. This bodes well for multi-stakeholder collaboration in voluntary stewardship, as there is common ground here between the industry and public-health participants.

One participant reflected that the principles introduced at the start of the workshop (that a voluntary stewardship regime should be feasible, viable and adaptable) are good goals for defining a future, real stewardship system. Indeed, it was pointed out that adaptability would be very important because voluntary stewardship has to work across a range of industries keeping food animals, and the participants recognized that they are not all identical (which has already been demonstrated in this report through the comparison of the beef and dairy industries, and would necessarily extend to the swine and poultry sectors, at the very least).

This then led to a discussion of another general principle: a focus on education and science, which means building a knowledge-base for antimicrobial stewardship amongst the people who need to be practicing it, as well as educating the wider population, and this goes hand-in-hand with building trust between stakeholders: increased knowledge leads to increased trust, because people become more aware of the complexity of the issues and therefore come to understand the benefits of collaboration between stakeholders who bring different expertise to the table. Increased trust in turn helps to increase knowledge, because people who trust one another are more likely to listen to

others' perspectives and share their own insights. The view was expressed that the educative function could help raise awareness in society of why stewardship is necessary, and will help set a direction of travel, even for producers who opt out.

The discussion then moved to rewards and costs: "there should be recognition for people who work within this voluntary agreement that they are doing an ethically and morally positive thing" (policymaker), and the cost of participating mustn't be prohibitive – "it shouldn't essentially put them out of business" (policymaker from a different agency). These comments align well with the viewpoints expressed by participants from the beef and dairy industries, especially in light of the dairy industry perspective that institutional arrangements for paying for voluntary stewardship already exist, and it is indeed affordable. The public-health participants pointed to the same sources of revenue, citing "check-off programs" (policymaker) in the poultry and pork industries as examples.

At this point, a concrete mechanism for enacting voluntary stewardship was spontaneously proposed by a participant, and it quickly attracted assent from everyone else. Crucially, it was the *same mechanism identified by the beef and dairy industry participants*, albeit using a different word: the public-health policymakers suggested a "certification" scheme. This is what the beef producers called "validation", and the dairy industry participants called "verification". "One way to demonstrate a benefit [when marketing meat or dairy to the public] would be to actually have some sort of certification that one could attach to various kinds of agricultural products" (policymaker). Furthermore,

"Just thinking about certification and the underlying purpose of... [voluntary stewardship] is that you also identify and create a support network that's needed to demonstrate those things. So, whether that's laboratory or diagnostics for animal pathogens, as well as for antimicrobials, that system has to exist in order for people to do all of those things" (policymaker).

Discussion of certification then turned to what should happen if some people choose not to engage with such a scheme. One participant said that "I'm going to take the position that a goal should be to stigmatize those who do not participate", and another backed this up with, "wearing my former hat as a consumer advocate, shame does work". However, a third person countered with "I don't think that it's appropriate to stigmatize non-participants, but I think if we educate and engage across the spectrum, it's really important... I think it would help to make sure that producers... are able to participate". The issue of stigmatization will be revisited in the Discussion section of this report.

In the dialogue on shaming, it was noted that there are tensions in voluntary stewardship between the public interest (reducing antimicrobial use to limit AMR and thereby benefit human and animal health in the longer-term) and private interests (maintaining short- and medium-term commercial viability in food-animal industries through the use of antimicrobials at elevated levels, or longer durations, than might be desirable). However, the research reported here found no evidence that these tensions are too entrenched to prevent meaningful progress. Indeed, given that both the beef and dairy workshops revealed there are already institutional mechanisms in place to fund initiatives like voluntary stewardship, it is quite possible that the public-health participants saw cost as a bigger barrier than actually exists.

5.2 Governance, Authority, Expertise, and Control

When the public-health participants came to discuss who the governance decision-makers should be (i.e., who should have the authority to change the beneficiaries, purposes and measures of success), they went into much more detail than either the beef or dairy industry representatives. Reflecting on their list, the researchers see three principles being used: including key stakeholders (especially those who would be most directly affected by voluntary stewardship, and whose commitment is needed for implementation); ensuring the availability of requisite expertise; and valuing diversity. With regard to the latter, “If you want a voluntary stewardship program, you've got to be able to have the diversity at the table and be able to work together. Maybe you take baby steps before you start running, but I'd sooner work together and do that” (policymaker).

Their list of decision-makers, who would all be represented on a governing body (although some were later reclassified as advisory), included producers, both large and small (who are necessarily central players in voluntary stewardship); industry associations representing producers (although not to the exclusion of the producers themselves, as a variety of voices need to be heard); those with a secondary commercial interest, such as packers and retailers; consumer groups; veterinarians and their professional associations; agricultural extension workers; scientists with knowledge of AMR (who were listed on the flip-chart summary as “honest brokers”); behavioral scientists (who could advise on behavior-change interventions); economists; animal welfare experts; a bioethicist; an epidemiologist; public health experts (with an emphasis on ‘One Health’); and environmental health researchers. The importance of legal expertise was mentioned too, but not in a governance capacity – rather, providing advice as and when required.

There was equivocation around some of the suggested decision makers. First, whether “a pharmacologist or potentially even somebody from the drug industry who's a manufacturer be involved” (policymaker). The equivocation stemmed from the concern that was also expressed in both the beef and dairy workshops that the “fox” shouldn't be allowed “to guard the hen house” (beef industry veterinarian).

Another area of equivocation was on whether large retailers (like McDonalds and Wal-Mart) should be included as decision makers. One person spoke against this, saying that these companies have so much power over the producers that, when they set standards, the producers need to follow whether they like it or not if they are going to sell their produce. This means the large companies could push for watering down voluntary stewardship. However, those in favour of including these companies said that they need to be part of the discussion on voluntary stewardship, otherwise they might not learn about its importance, and then they could use their power to frustrate it from outside rather than promote it from within: “an important consequence of having them in the room... is [that] education flows up and downhill, and this is an opportunity for corporations like McDonalds to actually hear what the concerns are of producers directly” (policymaker).

A third equivocation was around the involvement of consumer groups as decision makers. One viewpoint was that there is a lot of pressure on producers to meet consumer demand, so if consumers don't value stewardship, perhaps because they want reduced-cost products, this could affect the whole program. However, the other side of this was that consumer groups would learn from becoming involved, and they could become passionate advocates for tackling AMR. This disagreement was not resolved, but the majority of those who commented supported the latter view. Also, later in the workshop, it was pointed out that those who volunteer for a governance

board are likely to be (and need to be) passionate about countering AMR. Assuming this is correct (and it is backed up by the views of consumer advocates, presented later in this report), it is likely that consumer groups will use their role to promote rather than undermine voluntary stewardship.

After the list was complete, a couple of the policymakers reflected upon it:

“I would say that there are several names or groups of people on this list that would fall in the bucket of expertise-providing, but not actually making the decisions. I think, in order to get commitment and buy in, it needs to be kind of grassroots, and primarily driven by the users, and [they] could be in conflict somewhat with other people or groups on this list. So, I do think that the retailers and vendors [for example] are important groups, but maybe not in the decision making”.

“It may help to consider the whole spectrum. So, at one end, the decision-making body is producers exclusively and nobody else, and they reach out to all of these other groups as wide as you want it to be... That's one extreme. I don't know that it would go over well, because I think you would lose trust. So, I think what's helpful to me is to think about somebody who is less self-interested. Producers absolutely have to be there because they are self-interested, but there has got to be a check on that somehow. And so, I started looking at all of those other groups we have come up with. I have a bias towards having the scientists in the room as decision makers, but I could see an argument for setting them aside... as being very close advisors, just like regulators. But who else in there would fit to put a check on the producers and bring in some other interests besides those self-interests? And a mighty one among those other groups, with a reflective bias, is academia, because that's a role of the academy: to be a convener for just these types of situations, and also to be able to provide that expertise. Reach back to the science community and bring other communities together. But I think it's got to be more than just producers, and less than the entire universe, because you can't be a decision-making body, and every stakeholder is a decision maker, so where is that fine line?”

Some work was done to separate ‘true’ decision makers from experts, but the detail will not be reported here: suffice to say that all the discussions were about balancing the need to keep industry in the driving seat with a requirement to include both diverse stakeholders (so there is broad buy in) and scientific perspectives (to temper vested interests), but no consensus was reached. Further reflections on this will undoubtedly be needed when setting up an actual voluntary stewardship system.

However, one issue falling out of this discussion is worth picking up on: several of the public-health participants were initially of the view that Federal agencies (e.g., the FDA and USDA) should be in a decision-making role. This runs counter to the desires of the beef producers, who were clearly wary of government wanting to exert top-down control (even though they opened up to the idea of multi-stakeholder governance); and it also represents a challenge to the dairy industry participants, who valued Federal agency expertise and wanted a verification regime to be USDA-approved, but were clear that people from Federal agencies shouldn't be part of governance decision making.

In reflecting on this issue, several policymakers disagreed with those who wanted the Federal agencies to be decision makers, and their reason is summed up in the following quotation:

“I think experts rather than decision makers, and part of that is who you get better buy in from. I spend enough time with cattle producers on the ground to know that they're going to like things a lot more if the government steps back and takes an expert role as opposed to actively being involved in this conversation”.

Interestingly, the discussion of this actually made the people who had initially backed the inclusion of Federal agencies in decision making change their minds. The emerging consensus was exemplified by one of the policymakers: “I will step back and say you're going to use the government agencies, in this sense, as experts”.

Clearly, the role of government needs to be handled with sensitivity when designing an actual voluntary stewardship program. The beef industry participants were aware that the best way to ensure that a mandatory regime is not imposed on them is to have government view the voluntary stewardship as robust. The question is, how to enable this? One view from the literature on systems design is that buy-in from powerful stakeholders is best achieved by involving them in the design process (Midgley & Milne, 1995), but then the potential for the alienation or marginalization of others has to be handled with great care (Boyd et al, 2004). In the case of the voluntary stewardship of antimicrobials, there are good reasons to have producers in the driving seat, because their commitment is absolutely essential to implementation. However, this doesn't mean that Federal agencies cannot be engaged, even if they are not full decision makers. As one of the participants said:

“I think, having been in government, what's nice is bringing people to the table so that you can hear from them... and if we're going to make a major change [‘we’ being producers running a voluntary stewardship scheme], you need to have them be at the table so that there is buy in. Then you need time to let them accommodate whatever changes are going to take place, and help them. That initially engages a lot of support from the government agencies, and... helps them to produce a major change. So, I'd like to keep that door open rather than not have that open. Again, working towards coming together instead of separating”.

Whether or not Federal agencies are actually involved in the initial design of an actual voluntary stewardship system²⁰, the general view across the beef, dairy and public-health stakeholders is that they should not be part of *on-going* governance. Rather, their expertise should be engaged, and they might give official approval to a certification scheme that recognizes good practice in animal husbandry, sickness prevention and antimicrobial use.

With regard to the latter, one policymaker commented, “I think we have examples of where the government is very closely tied to these [quality assurance programs]”, and another pointed out that what policymakers bring is “sort of an expertise, but also you do become a partner in what has to happen. Whether you call them decision makers or not, I think that partnership is very real”. The view from these public-health policymakers was that government agencies could partner in the design and approval of a verification scheme, and could be closely involved in dialogue without having formal decision-making authority in the voluntary stewardship system as a whole.

²⁰ The research team's view is that Federal agencies *should* be involved in the initial design of a voluntary stewardship system, because the beef producers said that Federal agencies' recognition of the robustness of the system is a critical success factor. Arguably, the best way to ensure this perception of robustness is for the Federal agencies to be involved in the design-process deliberations.

When it came to what a governing body should and should not have authority over, the participants thought it should be able to make decisions on “membership, staffing, budget, [and] policy/governance” (policymaker). Others suggested that decision making on what antimicrobials should be used needs to be a governance issue (but not whether to prescribe them, which is a veterinarian concern). Also, communications (i.e., about the stewardship program and its activities) should rest with governance. However, the governing body should *not* have any control over “the research aspects, laboratory, education, and [any] regulatory authority [approving a verification scheme]” (policymaker). “Evaluation” was then added to this list. All of these things are essential for the delivery of voluntary stewardship, but must be free from the influence of vested interests if the system is to be perceived as robust and trustworthy.

These lists of things that a governing body should and should not control are different from, but for the most part complementary to, the views of the beef and dairy participants. The public-health policymakers picked up the need for all the scientific aspects to be independent, and this was not discussed in the industry workshops, but in the view of the research team, this is sensible. The only significant difference was that the public-health participants wanted the voluntary stewardship program to have decision-making authority over which antimicrobials to use. In contrast (as reported earlier), the beef producers said “I think the use of antibiotics is still going to be regulated by the VCPR [vet-client-patient relationship] at the local level. I see the decision-makers maybe being more in charge of information that trickles down to us...” (veterinarian). Likewise, the dairy producers said that the day to-day operational decision-making of dairymen, veterinarians and nutritionists would need to be off-limits. This is a difference of opinion that needs to be handled carefully, as the cooperation of veterinarians with voluntary stewardship is critical to success, and depends on their trust that VCPRs will not be compromised. If/when an actual voluntary stewardship scheme is designed, further dialogue is required on the boundary between governance *decision-making* on what can be prescribed, and governance *recommendations*.

5.3 Who would be Affected but would not be Involved?

Much of the dialogue between the public-health participants on the question about who would be affected but would not be involved was focused on food-animal businesses that opt out of voluntary stewardship. There were two important points made in relation to these businesses:

1. It should be a voluntary stewardship responsibility to talk with business owners and managers who believe that the negatives of participation outweigh the positive. Those doing this talking should focus on explaining the benefits, but should also be open to hearing about negatives, so they can think about how those things could be addressed. Perceived negatives offer a “reality check” (policymaker) to a voluntary stewardship scheme, and need to be taken seriously, as they may not be unique to just one business.
2. If voluntary stewardship is very successful and there is a widely respected certification scheme in place, it is possible that companies opting out of certification may struggle to sell their products, and could even go out of business. This is not an impact on the companies that the participants thought should be avoided or mitigated, as business failures will send signals to others about the commercial value of certification. There was, however, recognition that farm workers who are not personally responsible for the decisions of their managers would be negatively impacted by companies going out of business.

5.4 Enhancing the Likelihood of Success

When asked what will make the most difference to the success or failure of this kind of voluntary stewardship scheme, the following were discussed by the public-health participants:

- Adequate funding.
- Flexibility to respond to emerging changes to AMR, scientific knowledge and animal-husbandry practices.
- Scalability: “I think we need to have some kind of step-wise process where you're not jumping in over your head... Make it a progressive program where it provides guideposts for groups to become more and more engaged over time” (policymaker).
- Attracting volunteers to oversee the scheme, which might require a degree of confidentiality so people don't feel they are setting themselves up to be criticized in public.
- Evaluation, with measures of success, so people know what's working and what needs rethinking.
- “I realize this is a voluntary program, but I still think there needs to be accountability and enforcement” (policymaker). The emphasis here was on anyone opting in being honest about the actions they have taken and the monitoring data they have provided – so accountability and enforcement is to prevent cheating.
- High-quality communications: “bringing it to interested groups and using all forms of the most contemporary communication we have out there, [such as] social media... [They need to really get it out to the general public so they can understand it and more actively support this movement” (policymaker).
- High-quality listening, so voluntary stewardship can be responsive to the concerns of producers (amongst others).
- Addressing problems that are real for producers, including the prevention of sickness in animals: “if it actually tackles some of those issues and makes a difference, I think it could be successful” (policymaker).
- Identifying and avoiding economic disincentives.
- “Keeping the deliberation process as open as possible... Not just transparency, but involving as many stakeholders as you possibly can, because... what we know from... [the] literature on risk communication and so forth is that, if it's not done that way, it will fail” (policymaker).

All the above points are consistent with the views from the beef- and dairy industry participants.

6. Views from Consumer Advocates

The consumer advocates were strongly engaged from the start: there were no challenges to the remit of the workshop, and there was very little defensiveness. Early on, however, a concern was expressed that the facilitator had started off by asking people to look at who should benefit before actually defining what voluntary stewardship is. The facilitator explained that this was deliberate: it helps to transcend limiting assumptions if people first explore who they want to benefit and what purposes they want to achieve, and only then start defining what stewardship needs to be. However, the concern in the room was not allayed by this answer, so the participants detoured into discussing the meaning of voluntary stewardship in between identifying the potential beneficiaries and purposes. The key points from this discussion have been integrated into the section on purposes, below.

6.1 Beneficiaries and Purposes

The first beneficiary to be mentioned was the public, and the benefit would take the form of “better public health” (flip-chart summary), given that a significant decline in the effectiveness of antimicrobials used to treat humans would increase premature mortality and suffering. The maintenance of good public health standards would also benefit doctors and future human healthcare systems, which wouldn’t have to commit additional time and financial resources to tackle bacteria that have become resistant to antimicrobials.

Most producers would also gain, but this might not be immediate, given that it would take time and resources to establish an effective voluntary stewardship system. However, once changes in animal husbandry started to bed in, the producers would begin to see benefits in the form of less spending on antimicrobials, and greater trust in the safety of meat and dairy production amongst purchasers (packers and retailers) as well as the public. This could have a positive impact on sales throughout the supply chain. The emphasis here was on *most* producers reaping longer-term rewards, but companies that opted out of participation would lose commercial ground.

Veterinarians were also viewed as beneficiaries, as their expertise would be essential for managing the judicious use of antimicrobials. This was in line with what all the other groups said. However, where the consumer advocates differed from the public-health participants was in identifying farm workers as beneficiaries: while the public-health policymakers expressed a concern that workers in companies opting out of voluntary stewardship might lose their jobs, the consumer advocates emphasized greater job security and potential financial reward, longer-term, for workers in companies that *opted in*.

When it came to the purposes and meaning of voluntary stewardship, the starting point in the discussion was encouraging “responsible” prescription, which would involve a “reduction in use” over time (flip-chart summary). However, this was later modified, when the word “reduction” was questioned: “stewardship is not equivalent to a *decrease* in antibiotics; sometimes just use of *different* antibiotics” (flip-chart summary). Also see Eggleston et al (2010) on how the *under*-use of antimicrobials can promulgate resistance.

The deliberations then shifted to a focus on the relevance of “the tragedy of the commons” (Hardin, 1968, p.1243). While Hardin’s early thinking about this ‘tragedy’ was focused on the impacts of population growth on common-pool resources (he claimed that competition for resources leads to over-exploitation to satisfy narrow self-interests, so everyone loses), the term is now used more broadly to encompass any situation in which the cumulative effects of multiple actions by individuals and groups vying for use of a resource eventually deplete it. Many of the criticisms of Hardin’s (1968) work come from people saying that the tragedy of the commons is not inevitable (e.g., Nijhuis, 2021), and it was the purpose of Ostrom’s (1990) Nobel-prize winning research to demonstrate this through many empirical examples of collective governance regimes that are able to sustainably manage resources while still meeting multiple, potentially conflicting stakeholder objectives. In less co-operative circumstances, these objectives would be irreconcilable and trigger the sacrifice of sustainability for self-interested, short-term gain. The consumer advocates made the case that the main purpose of voluntary stewardship is to manage antimicrobials as a common-pool resource. Therefore, there is a need for multi-stakeholder governance that balances meeting all the potentially conflicting stakeholder needs within sustainable limits – in this case, limits that keep AMR

at a level that does not undermine the future use of antimicrobials by any of these stakeholders or their successors. A linked purpose of voluntary stewardship, enabling multi-stakeholder engagement, is building trust between stakeholders.

This vision is entirely in line with the perspectives from the beef and dairy industries, although it took a while for the beef industry participants to arrive at this point, as they were initially resistant to anything other than the local autonomy of producers. Quite a lot of the dialogue in the public-health policymakers' workshop was focused on who should be included in governance and who should be consulted as an expert, with no consensus emerging. Nevertheless, around half the participants strongly advocated for a diverse, multi-stakeholder, partnership approach. Others argued for governance by producers and veterinarians alone because of the overriding need to ensure that the producers would commit to voluntary stewardship: the fear was that, if they were outnumbered by other stakeholders, the producers might feel threatened. However, given the findings from the beef and dairy industry workshops, the research team suggests that this fear might be misplaced, and multi-stakeholder governance could be possible as long as its design is approached sensitively, with producers at its core, and trust-building is part of the developmental process.

One of the other purposes that the consumer advocates emphasized was the measurement of progress. This again fits with the common-pool resource approach: peer pressure can be exercised on those not following good stewardship practices if there is transparent measurement in relation to all the variables that matter (Jenkins, 2018). These variables will need to go beyond just antimicrobial use to other interrelated concerns, such as animal nutrition and the prevalence of resistant bacteria. Measurements should transparently show how each participating organization is contributing (or not) to progress.

Talk of interrelated concerns brought the participants to focus on the fact that antimicrobial use is just one amongst a set of animal welfare issues that really need to be addressed in an integrated manner. The consumer advocates were the only participants who considered integration with other monitoring regimes. The research team, in reflecting on this, observe that addressing multiple, independent standards set by different industry bodies can be a lot more complex (and therefore costly) than meeting just one integrated set of standards. Nevertheless, agreeing integration could be difficult and time-consuming, and it is important to move quickly.

The consumer advocates pointed out that allowing a program to evolve from small beginnings might be easier to achieve than trying to establish a comprehensive program from the start, and the small beginnings could involve focusing on some of the worst practices that elevate antimicrobial use. This would demonstrate the success of voluntary stewardship early on, and therefore bring positive attention to the program.

Another important purpose, from a consumer-advocacy perspective, is to address antimicrobial use *systemically*. Just like many of the public-health participants, the consumer advocates wanted voluntary stewardship to be focused on changing the system that gives rise to the need for excessive antimicrobial use. There was talk of how the current design of the system "is predicated on use", and participants pointed out the need to "consider ethics at the system level" (flip-chart summary) to ensure that short-term value extraction doesn't result in longer-term harm. This not only fits with the emphases of several of the public-health policymakers, but also accords with the desire of the

beef industry participants to deal with the problem of inadequate husbandry standards amongst small producers selling calves to the feedlots.

The participants said that it would be important to learn from other voluntary stewardship schemes, both successful and unsuccessful, including overseas (the Netherlands, in particular, was mentioned). Studying other forms of certification, such as those used in organic farming, could also provide useful lessons. The consumer advocates discussed the Equitable Food Initiative (EFI, 2023a), at some length. The participants' perception was that success in stewardship has been limited so far, and a significant problem has been a lack of involvement of a full range of stakeholders. This observation fitted with their advocacy of multi-stakeholder governance of antimicrobials as a common-pool resource.

Another perceived reason for patchy success was structural: some industries are vertically integrated (i.e., everything from breeding through to meat production is under one company umbrella, or sales of the product are to a single source that therefore wields considerable power to enforce standards), and the participants cited poultry as a good example (also see Vukina, 2001). However, other industries (such as beef) are not vertically integrated at all: just as the beef participants explained in their own workshop, the consumer advocates stated that the production of calves is geographically dispersed, and there is strong competition between the feedlots, making it commercially attractive to buy cheap calves that need treatment with antimicrobials. Like the dairy producers, the consumer advocates argued that it would be much easier to implement voluntary stewardship in vertically integrated industries than in others.

There were some questions asked about purposes, such as "can financial incentives for judicious use be built in?" and "can it be used as a marketing tool?" (flip-chart summary). There was agreement that, if the answer to either of these questions is 'yes', then they are good ideas. None of the other groups talked about positive financial incentives, but both the dairy and public-health participants argued that those opting out of participation would be disadvantaged. All the groups saw benefits from marketing ethical antimicrobial use, and the dairy industry in particular saw the potential for the launch of a premium milk product marketed in this way. The consumer advocates pointed out that such a focus would augment another necessary purpose of stewardship: communicating the scientific consensus that AMR is a significant threat that needs to be tackled.

6.2 Governance, Authority, Expertise, and Control

When considering who should be involved in multi-stakeholder governance, the consumer advocates referred once again to the Equitable Food Initiative, which involves food production companies, retailers, labor unions, advocacy-oriented NGOs, an overseas-development charity, scientists, an entrepreneur, and a consultant on their Board (EFI, 2023b). Later, they added veterinarians.

Most of the participants argued that those with a conflict of interest, such as pharmaceutical companies, should be excluded from governance. However, one person challenged this, saying that true multi-stakeholder governance requires *all* interested parties to be engaged in mutual learning, and it is important not to create exclusions that might set up a counterproductive 'them and us' dynamic. As this was debated, most participants came around to the view that there might be sub-committees and expert roles involving those who would be perceived as having a conflict of interest, and this would be preferable to giving them an equal say at the highest level of governance. This

same distinction between governance and experts emerged in the beef, dairy and public-health workshops too.

The expertise that the participants said needed to be available included “medicine, bacteriology, supply chain management, marketing, data science, and economics” (flip-chart summary). Economists were said to be needed to contribute financial analysis to feasibility studies when looking at implementing new innovations. Purchasers (retailers and ‘middle men’) would also be necessary to consult, as they are “proxies for consumers” (flip-chart summary).

While the participants didn’t use terms like “validation” (beef workshop flip-charts), “verification” (dairy workshop flip-charts) or “certification” (public-health workshop flip-charts), they clearly had a similar inspection regime in mind, saying that third-party auditors would be needed to assess compliance with voluntary stewardship standards. Also, veterinarians would play a crucial advocacy role to bring industry into the scheme, and might need financial incentives to spend time on this.

The consumer advocates were the only group who pushed back a little against the premise of the research that a stewardship scheme would be 100% voluntary. One person pointed out that the system in the Netherlands is a combination of voluntary and mandatory, and that is a useful model to learn from. Another said that the governing body would need to have some “enforcement power” (flip-chart summary). This was by no means a full-bodied rebellion against the idea of voluntary stewardship. Rather, the research team interpret it as a recognition that there is a pressing need to tackle AMR, and if large numbers of producers do not engage voluntarily, there would need to be other ways to initiate change. It is worth noting that the consumer advocates did not go any further in defining “enforcement power”, while the beef and public-health participants talked about peer pressure, and the dairy participants discussed using the purchasing power of their co-operatives to ensure there were significant commercial consequences for non-compliance. In the latter case, while compliance would remain voluntary, the “enforcement power” would be real.

When it came to what the governing body would have authority over, much of the discussion focused on the business model that would need to be agreed. A fee-for-certification model was proposed by one person, so the cost would be borne by producers, and a model for this could be the Certified Responsible Antibiotic Use program (CRAU, 2023). Other participants were concerned that such a model might be off-putting for some producers, as they would see it as adding to their costs. It was observed that the business model might be different for the different food-animal sectors: e.g., the co-operatives purchasing milk could normalize the idea of the producer paying, while this might be more difficult to achieve in less vertically integrated industries. At this point, it is worth noting that the business model suggested in the dairy workshop (use of checkoff dollars) was not discussed by the consumer advocates (perhaps because they were not aware of it), and this would augment the possibilities for funding voluntary stewardship.

The other major focus for discussion in terms of the authority of the governing body was the handling of data: opting into voluntary stewardship would need to involve agreement to collect monitoring data, which the governing body would have the authority to share. An iterative approach to developing a monitoring regime was suggested, so options for data collection could be refined over time. It was noted that real-time data collection “could enable timely interventions”, and ultimately “data is a tool, not a goal” (flip-chart summary): data are essential for evaluating progress in addressing the conditions that facilitate AMR, and data transparency can also inform the exertion of peer pressure.

When it came to talking about what should *not* be under the authority of the governing body, two significant points were raised. The first was that the veterinarian-client-patient relationship has to remain separate from governance: veterinarians still need to be able to prescribe in the best interests of animals.²¹ In this respect, the consumer advocates concluded the same as the beef, dairy and public-health participants.

The second point was that it would not be realistic to think that a voluntary stewardship program could restructure whole industries (e.g., by mandating vertical integration), although it was noted that the Iowa pig industry did restructure itself at one time, so change is not impossible. It was suggested that, when restructuring an industry is being considered, the governing body would want to support this, but not have a *policy* of campaigning for this sort of change.

6.3 Who would be Affected but would not be Involved?

Compared with the beef, dairy and public-health participants, the consumer advocates produced a longer list of stakeholders who would be affected by, but not be involved in, voluntary stewardship. They started with “government regulators” (flip-chart summary), as successful voluntary stewardship might reduce the need for regulatory intervention. Conversely, failure of the approach might make regulators look again at what needs to be mandated.

There might be a considerable need for training in stewardship, especially to reach out to small businesses, like the ones breeding calves to sell to the large feedlots. Trainers would therefore be positively affected, but would not be involved in setting the voluntary stewardship standards. Farm workers were mentioned in relation to this too: it was noted that farm workers would need to be implementing changes recommended by the voluntary stewardship scheme, and could provide valuable feedback to both their managers and the scheme leadership.

It was noted that importers might be affected if certification of good practice in using antimicrobials became normalized in the USA: importers might find it difficult to compete, or they may be pressured into sourcing comparable products abroad. Likewise, other countries that either export to the US or import from the US could find that their trade is affected. There would be no expectation of importers or representatives of overseas companies being involved in US stewardship arrangements, and the approach to importers was characterized as using “a hammer not a carrot”: this means engaging in an international “race to the top” (flip-chart summary) with regard to stewardship – not incentivizing companies abroad, but instead pressurizing them through competition to adopt comparable standards.

The final stakeholders who could be affected but wouldn’t be involved (because of a conflict of interest) were pharmaceutical companies. Like the other groups, the consumer advocates noted that antimicrobial sales are likely to decline. However, they didn’t pick up on the point made by the beef- and dairy industry participants that these companies are already working on new revenue streams, especially focused on the prevention of illness so fewer antimicrobials will be required in the future.

²¹ However, questions were asked about how independent veterinarians could actually be if they were part of a stewardship system that is working well.

6.4 Enhancing the Likelihood of Success

When asked what will make the most difference to the success or failure of voluntary stewardship, the consumer advocates discussed:

- An effective auditing scheme by a third party (or third-party verification of industry reports).
- Strong commitment from producers, and (where necessary) organizational-culture change so that everybody with a responsibility for husbandry and antimicrobial use understands what needs to be done to limit AMR.
- Getting all the key stakeholders to the table: the first goal should be establishing a dialogue before any decisions are taken.
- Building trust between stakeholders, with none walking away from multi-stakeholder engagement.
- Establishing a strong identity for the program.
- Setting consistent and objectively verifiable expectations.
- Evolving the program over time, rather than having unrealistic expectations that everything can be done at once from the start.
- Consumer confidence, to establish and maintain a market.
- The traceability of animals, so investigations of the sources of problems are possible.
- The evaluation of alternatives to antimicrobials (including improved husbandry methods where appropriate).

7. Discussion

In this penultimate section, the research team will reflect on the findings just reported to explore how opportunities might be capitalized upon, and challenges addressed. There will be two subsections. The first will concentrate on broad *commonalities* in the thinking of the four stakeholder groups, which will allow the team to propose a general framework for progressing voluntary stewardship. The thinking here will move beyond what the participants discussed, but will build on it, not contradict it: the subsection will draw upon several systemic models of governance to show how the desires of the stakeholders could be operationalized.

Systemic models are the focus because AMR is itself a systemic problem²² (e.g., Woolhouse et al, 2015): i.e., it is one that is multi-dimensional, interacts with other systemic problems, morphs over time, involves diverse stakeholders and conflicting interests, is local-to-global in scope, is characterized by cumulative effects (thousands of small, seemingly harmless actions lead to emergent, potentially damaging consequences), has to be managed rather than solved, and is exceptionally challenging to address because of its scale and complexity. The systemic models highlighted in this section have been specifically designed to help decision makers tackle these kinds of problems, and they imply that ‘governance’ involves much more than just a committee of trusted stakeholders with an oversight responsibility (see below).

Subsection two in this Discussion will focus on key *differences* between the stakeholder groups, and the team will explain how the systemic models of governance can address them. A lot of small

²² The term ‘systemic problems’ has been used, as it mirrors the idea of taking ‘systemic approaches’ to enable ‘systemic management’ or even (in the case of less-complex problems than antimicrobial resistance) the generation of ‘systemic solutions’ (Umpleby, 2017). However, the language of ‘wicked problems’ (Rittel & Webber, 1973; Sydelko et al, 2021) and ‘wicked solutions’ (Williams & van ‘t Hof, 2016) could just as easily have been used.

differences were identified earlier (e.g., which stakeholders need to be part of governance, and which might be expert advisors), and most of them could be a useful focus of cross-stakeholder dialogue and learning. Only the most significant differences that have substantial design implications for a voluntary stewardship program will be covered here.

Before starting subsection one, a general point needs to be made about working with stakeholders on the design of governance to address systemic problems. If a ‘top down’ design is imposed, it is likely to be resisted by stakeholders who feel marginalized or left in a position of passivity: buy-in is best secured through meaningful, multi-stakeholder participation (Ackoff, 1979a; Churchman, 1979; Flood, 1995; Rosenhead and Mingers, 2001; Midgley et al, 2018). This poses a dilemma for researchers who want to make recommendations for change based on the expressed viewpoints of interviewees or workshop participants: the more tightly specified the recommendations are, the more likely they are to be perceived as top-down impositions by decision makers and their stakeholders whose task it is to design something for real. Therefore, the proposals in this section should be seen as a *resource to draw upon*, and not a ready-made blueprint for change. A new design team might well have similar desires and concerns to those that were expressed by the people in the four workshops reported here, but there may be important differences too – and it will be necessary to pay attention to any differences and, if necessary, deviate from the proposals in this document. One way to make this document a resource rather than a blue-print is to provide copies of it to participants in voluntary stewardship design, and then facilitate discussions of its implications as part of the design process, ensuring the participants have the final say on what gets implemented.

7.1 Major Commonalities between Stakeholder Groups and their Implications for Governance

A consensus emerged on the following vision for antimicrobial stewardship. The beef producers, dairy industry participants, public-health policymakers and consumer advocates all acknowledged the potential importance of *multi-stakeholder governance*.²³ Broadly speaking²⁴, people sought a balance between keeping industry in the driving seat, as they will ultimately have to implement voluntary stewardship, with a requirement to include diverse stakeholders, so there is broad buy in and mutual learning.

Two key roles for governance would be to oversee training and information provision for producers, which would increase their awareness of good practice in stewardship, and to promote education about AMR in society more widely. Being strongly science-informed was considered important by everyone, including in governance to temper vested interests, and all the workshops identified the need for ongoing, proactive research to investigate emerging issues in AMR, and innovative interventions to tackle them.

Governance should also oversee the certification (also called “validation” or “verification”) of producers, making it publicly known to the governing body and in local communities when they are following good practice in stewardship (or not). This will drive peer pressure. The participants all emphasized the value of certification, and the collection of data to enable both certification and effective governance. A number of existing governance and certification programs for other purposes (such as quality and animal welfare) were cited, which could either be copied or, more

²³ The beef producers took an hour or so to conclude that multi-stakeholder governance would be useful, as they were focusing on feedlot-scale decision making at first, but they ended up as committed to stakeholder engagement as all the other groups.

²⁴ Setting aside minor differences of opinion on the details of who exactly should be involved in governance.

promisingly, have antimicrobial stewardship integrated into them. Linking certification to marketing was also a feature of all the discussions, whether that is about selling calves to feedlots (marketing the calves as either healthy or in receipt of preventive management, such as vaccines, prior to their sale and purchase by feedlots), or selling milk to a co-operative that then markets its dairy products to the public as coming from well-stewarded farms.

There are some things that a governing body should *not* have any control over. One of the most important was clinical decisions made by veterinarians when deciding whether or not to prescribe antimicrobials: animal welfare is the overriding priority when individual prescription decisions are made. Everybody agreed that there are appropriate uses of antimicrobials, so eliminating them altogether should not be the aim of voluntary stewardship: it should be encouraging and enabling *judicious use*. Also, the various scientific elements of stewardship should have a degree of independence from governance: this includes research, laboratory testing and evaluation of the program.

In line with the idea of judicious use, people in all four workshops said that, in certifications, there is a need to go beyond a narrow focus on trying to reduce antimicrobial use within an otherwise-unchanged agricultural system. Rather, there is a need to address aspects of agricultural production (e.g., animal husbandry) that keep producers dependent on using too many antimicrobials. Essentially, this means taking a *systems approach* to tackling AMR: understanding that the over-use of antimicrobials is an emergent property of the way the production systems work, so reducing use means changing those systems rather than just trying to prescribe less within a system that is reliant upon the use of antimicrobials to mitigate negative health impacts on animals. Ignoring those wider systems will set up an unnecessary tension between the desire to reduce antimicrobial use for the longer-term benefit of agriculture and human health, and the desire to prescribe in the interests of individual-animal welfare. These two imperatives will not be in conflict if husbandry systems (including those being used by hard-to-reach, small producers selling calves in the beef industry) are optimized for animal health, so people can be confident that those prescriptions of antimicrobials that are still issued are absolutely necessary.

Funding of this model of voluntary stewardship was not considered an obstacle because food-animal industries are used to paying a levy (“checkoff dollars”) to industry associations that work for the collective benefit of their members. This source of money could be used to launch and run voluntary stewardship for the long-term benefit of both the industries and wider society.

7.1.1 The Use of Antimicrobials and the Management of Antibiotic-Susceptible Bacteria as a Common-Pool Resource

When this observation of a broad consensus on governance, certification and a systems approach is combined with thinking about the nature of voluntary stewardship, and especially the contrast between voluntary stewardship, statutory regulation and *laissez-faire* (free-market) approaches, a striking conclusion presents itself: the consensus is largely in line with Ostrom’s (1990) Nobel prize-winning work on the governance of common-pool resources. It is worth looking at this systemic model of governance in more detail:

It is already well known that there are significant drawbacks to purely regulative approaches: Seddon (2008) talks about the frequency with which government target-setting drives perverse behaviors, with people ‘gaming’ those targets; Jenkins (2018) discusses the power of large industries

to tie up regulators in court; and Foote et al (2021) talk about conflicts emerging between rural communities and governments in situations where those communities feel that government is imposing top-down 'solutions' and not giving them a meaningful say in managing environmental health.

In contrast, Bell (2014, 2015) gives examples from seven countries showing that unrestrained free-market approaches are equally problematic, because short-term financial gain at the local level tends to be prioritized over the prevention of longer-term harms, which are mostly experienced by others outside the locality. The research team notes that problems with laissez-faire, free-market approaches may appear in any of the following situations:

1. When each individual decision appears harmless, but there are negative, cumulative effects of thousands of such decisions, so the perceived weighting of benefits and costs are different at the individual-business and community (or wider-system) scales;
2. When negative effects are experienced by stakeholders other than those making the local decisions, so the costs and not the benefits of changing behavior are felt by the decision makers;
3. When there are time lags in the system, and the effects are not observed for many years, so people discount the longer-term costs, or argue that the benefits should be realized now, and decision-making can be changed later before the costs appear (not realizing that those costs may become inevitable if action is delayed too long); and
4. Linked to point 3, when the effects are non-linear: e.g., change may be very slow and seemingly inconsequential until a tipping point is reached, and then it becomes rapid and irreversible. For example, if the financial gain from an over-use of antimicrobials is realized many years before the cumulative AMR hits a tipping point, then the long-term cost might be discounted until it is already too late.

There is considerable evidence from the field of natural resource management, especially from Ostrom (1990) and Ostrom et al (2012), that government-enforced regulation and laissez-faire policies both meet strong stakeholder resistance and can result in conflict that damages businesses and undermines sustainability in the longer term. A more effective approach is often the collective governance of the resource by relevant stakeholders, who simultaneously make decisions in relation to a broad set of economic, social and environmental values. This is enabled by a strong focus on the collection of data on activities and impacts, and the provision of information in a way that makes it immediately transparent when important values are being compromised, so peer pressure can be applied and remedial action taken.

Antimicrobials are not a 'natural resource' (they are manufactured), and therefore the reader might question whether Ostrom's framework is really applicable. However, it is not actually the antimicrobials that are the ecological, common-pool resource: *it is antibiotic-susceptible bacteria*. To understand why Ostrom's framework can legitimately be applied, two logical steps in the argument are required:

1. Ostrom's framework applies in situations where human beings want to *use* something natural (because it is being used, that 'something' is framed as a 'resource'), but multiple, potentially competing values have to be accounted for: e.g., Jenkins (2018) discusses a range of values relevant to water management, such as the quantity available for irrigation, the quality of the water (and the consequent impacts of pollution on living organisms), the biodiversity of aquatic ecosystems, the ability to pursue recreational activities (such as

swimming, angling, and kayaking), etc. *Superficially*, it would appear that what is being used in agriculture is food animals.

2. However, food animals are not normally seen as a natural resource in the same way that water is, because they are inserted into the ecology by human beings – they are not usually regarded as an intrinsic part of that ecology, like the water in a river. The conceptual mistake that we need to avoid here is assuming that, because of this human action, somehow the food animals are merely *added into* ecological systems, without changing or being changed by those systems. Actually, the interactions with the wider ecological systems that our food animals become part of are so significant, from a human-use point of view, that the ability for us to use food animals at all, and establish viable agricultural businesses, is dependent on the health-maintaining properties of the environments in which the animals live. These properties include the bacterial ecologies within and around our food animals. If AMR were to become widespread, then it would no longer be possible to stop serious disease outbreaks with antimicrobials, resulting in large-scale fatalities amongst food animals, and hence the collapse of agricultural businesses and livelihoods. It is in this sense that antibiotic-susceptible bacteria are the ‘resource’ that needs to be managed, so they are not replaced by resistant strains: they are a natural resource because our use is *not* actually of food animals alone, but the ecological systems that maintain (or fail to maintain) those animals.²⁵ Hence, it becomes clear why Ostrom’s (1990) framework applies.

Just like water management (e.g., Jenkins, 2018), the governance of antimicrobials and the management of antibiotic-susceptible bacteria requires multiple, potentially competing values to be accounted for, which have to be addressed simultaneously in order to achieve three things: realize shorter-term benefits while preventing or minimizing longer-term harms; avoid damaging conflict; and prevent the marginalization of legitimate stakeholder concerns. For antimicrobial stewardship, these potentially competing values include, at the very minimum, the use of antibiotics to ensure human health; animal health and welfare (including nutrition and other aspects of husbandry); the commercial viability of food-animal industries; food safety; and food security for human populations, with the latter having the potential to become a real issue in future if significant animal diseases can no longer be kept in check with antimicrobial treatments.²⁶

While the voluntary stewardship of antimicrobials and the management of antibiotic-susceptible bacteria are, at present, much less well defined than Ostrom et al’s (2012) prescription for the governance of more ‘obvious’ natural resources, like water, they are similar in the sense that they *do* apply to a natural resource (as explained above), and they also represent a ‘third way’ between regulation and unrestrained market forces. Therefore, decision makers on voluntary stewardship can learn from Ostrom’s work.

The key implications of Ostrom’s ideas for voluntary stewardship are:

- There needs to be collective governance by stakeholders championing all of the relevant, potentially competing values. Given the ambivalence in all the workshops

²⁵ Moran (2019) talks about resistant organisms taking over bacterial ecologies as being equivalent to pollution entering water in terms of the implications for governance.

²⁶ The boundaries of which values matter need to be explored. For instance, those listed in the text are the most obviously relevant to antimicrobial resistance, but if managing this issue was to be integrated into a broader stewardship system to tackle other issues as well, the number of values could significantly expand. For instance, impacts on climate change might be an issue to consider in a more inclusive stewardship approach. However, given the focus of the current research on antimicrobial resistance alone, this question of a more inclusive approach will be set aside.

about who should be treated as a true governance decision-maker and who should be considered advisory experts, this point will be revisited again below.

- All the values need to be managed simultaneously. This means it is unacceptable to put off considering one value while another is focused upon – that is a recipe for continually discounting longer-term needs in favor of addressing shorter-term concerns. Jenkins (2018) explains, in the context of water management, how managing all the values simultaneously drives significant innovation as well as collegiality amongst people who otherwise might be in conflict over which values to prioritize.
- Indicators, data collection and innovative data-visualization methods²⁷ need to be employed so stakeholders can see the current state of play with all the values, thus making the impacts of collective and individual decisions transparent to everyone involved. This way, if one producer is avoiding their responsibilities, other people will know about it and will be able to offer help or apply peer pressure. As all four of the stakeholder groups proposed “certification” schemes of one kind or another, it could be made a condition of certification that appropriate data is collected and shared.

Having mentioned data collection, three important caveats need to be added to mitigate potential problems with performance management systems based on target-setting or validation:

First, a target-setting approach is frequently perverted by people ‘gaming’ the system, or it forces attention on such a narrow range of variables that it creates blinkers, so people no longer think systemically, and there can be unforeseen side effects (Seddon, 2008). In a worst-case scenario, one could imagine an unscrupulous food-animal business wanting to retain its certification, so it deliberately turns a blind eye to sick animals in order to meet a target for reduced antimicrobial use, causing a much worse disease situation than would otherwise have transpired. An alternative to targets is to set a *range* (i.e., a floor and a ceiling) of acceptable measurements (Jenkins, 2018), or just a ceiling that shouldn’t be transcended (e.g., establishing what proportion of resistant bacteria in a test sample is unacceptable). Jenkins explains that the idea of a range is consistent with Gunderson and Holling’s (2002) ‘panarchy’ theory of ecosystem cycling: in the absence of major changes to the ecosystem originating from outside, the ecosystem should continue to cycle within given constraints, unless those constraints are transgressed as a result of human activity, in which case there is a risk that the ecosystem will tip into a new state, with altered constraints. The new state might be more hostile to human needs than the old one: e.g., resistant bacteria in animals and humans might become much more widespread. The idea of a ceiling is similar to a range, except there is no floor involved, and this is most notably used in modelling planetary boundaries (Rockström et al, 2009; Steffen et al, 2015): transgressing the ceiling could tip the system into a state where human thriving is much more difficult to sustain. Setting ranges or ceilings is arguably more helpful than setting targets, not just because the latter can be gamed or cause blinkered thinking, but also because ranges and ceilings allow for the natural variability that stems from both ecosystem and economic cycling.

The second problem with performance management appears if a certification scheme is based on producers documenting their husbandry practices, and then the documents (rather than the practices themselves) are audited by assessors. Seddon (2014) argues that the assessments made in such exercises are much more strongly associated with the narrative-writing ability of the person

²⁷ A good model is Steffen et al’s (2015) visualization of the impacts of human activity on nine planetary system boundaries.

completing the documentation than any actual differences in the practices being reported upon. Alternatives to this kind of assessment include on-site inspections or use of outcome indicators (e.g., levels of antimicrobial-resistant bacteria). Outcome indicators have the added advantage of giving the producer responsibility for knowing their own context and making appropriate decisions on action (with the effects of those actions over time being made visible to other stakeholders).

This is linked with the third performance management problem: there is a need to take account of the context of any data that are generated (Yau, 2013). For instance, if there is a spike in antimicrobial resistant infections, this might be the result of a local, contained outbreak of disease and won't always indicate a longer-term, systemic deficiency in husbandry. Likewise, it was noted in the dairy industry workshop that levels of resistant bacteria are negligible in milk, but sometimes higher in meat, so the data source might matter when considering what is acceptable.

When thinking about context, an argument could be made that higher levels of resistant bacteria are acceptable in some types of production system than in others: for instance, in the beef workshop, one person suggested that higher levels might be expected in the large feedlots than in less intensively stocked agricultural facilities, so this would have to be accommodated, otherwise the whole Texas beef industry could be threatened. Such decisions need to be handled with care, as in a worst-case scenario, already-problematic levels of resistant bacteria could become a benchmark for acceptable practice, and this would undermine stewardship. It should be noted that the idea of establishing a range of acceptable measurements, or a ceiling that shouldn't be transgressed, helps with making decisions on acceptable variability, as does a focus on good practice in husbandry.

7.1.2 Involving Stakeholders in Governance

As mentioned above, there was considerable uncertainty in all the workshops, and especially amongst the public-health policy makers, about how to set the boundaries for stakeholder inclusion in governance: some people argued for inclusion of the greatest possible diversity, to prevent 'them and us' dynamics from emerging (which could undermine voluntary stewardship), while others suggested a narrower boundary (mostly involving industry participants) who could consult with a broader range of experts and advisors. As was acknowledged in all the workshops, the narrower focus would enhance perceived 'ownership' by food-animal industries, but the risks of keeping other stakeholders (e.g., government agencies, public health policymakers, and consumer advocates) at arm's length include failure to hear and respond to the full diversity of perspectives, and the emergence of skepticism outside industry about the robustness of action on AMR. This was acknowledged by the beef producers, who said that acceptance of robustness by Federal authorities is a critical success factor. Conversely, a more inclusive form of governance would enable bridges to be built between the perspectives of the different stakeholders, but there is a risk that the industry representatives on a governing body would feel outnumbered and left without sufficient decision-making authority.

The discovery in this research that there is a broad consensus on the model of voluntary stewardship that is required (despite some differences, to be discussed shortly) gives increased confidence that a more inclusive form of governance will work – as long as trust is built through the design process of an actual voluntary stewardship system, and industry representatives have their interests fully represented in the set of interrelated values to be simultaneously managed. Operationalizing the Ostrom (1990) model of governance will only work if inclusiveness is possible.

One way to advance decision-making on representation on a governing body is to first define the interrelated values that have to be addressed. Earlier, it was suggested that the minimum set would need to be antimicrobial use for human health; animal health and welfare; the commercial viability of food-animal industries; food safety; and food security for human populations. Then a stakeholder analysis could be undertaken in relation to the full set of values. The first author has recently finished the sixth and final field trial of a new, systemic stakeholder-analysis method that could be used for this purpose. Here is a summary of the process to go through:

1. Gather together a small, diverse group of already known stakeholders in a workshop, all of whom are familiar with AMR and how it relates to the values being discussed.
2. Pin a large sheet of paper on the wall, and draw three large, intersecting circles, with some space around them. The circles should be labelled 'power' (those who have the ability to significantly enable or obstruct voluntary stewardship), 'legitimacy' (those who most people would expect to be part of governance if it is to be viewed as credible), and 'urgency' (those who really want to be heard and would be 'banging on the door' if not included). The space around the three circles should be labelled 'the affected' (those who do not have power, legitimacy or urgency, but could be impacted by voluntary stewardship).²⁸ Ask the participants to write stakeholder categories on yellow sticky notes, and put them in the relevant circle(s), including in overlap areas, or in the surrounding space representing the affected.
3. Next, ask the participants to imagine that they have travelled in a time machine and have arrived five years in the future. The ideal model of voluntary stewardship has been established and is working exceptionally well. If they have trouble with imagining this, give them a little time in small groups to discuss what this future could look like, making it clear that it doesn't matter, at this stage, if they disagree. Then they should write on blue sticky notes any new stakeholders who would be involved in or would be affected by this ideal model. These go on the wall in the relevant places, alongside the yellow sticky notes. Looking to the ideal future corrects for the status-quo bias in most stakeholder analysis methods.
4. Then give the participants green sticky notes, and ask them to write on them any categories of stakeholder, including those that are not human, that do not have a voice to express themselves. For instance, these might include children, future generations, animals, and the ecosystems where food-animals are raised. As well as the stakeholder category, the participant should write on the sticky notes the name of any organization or group who could advocate for the voiceless. Again, these go on the wall in the appropriate places. Including the voiceless corrects for the bias in most stakeholder analysis methods towards adult human beings who can talk for themselves.
5. Create a full, electronic list of the stakeholder categories in a spreadsheet or word document, and circulate it to the participants (or a subset of them) after the workshop. Ask them to identify individuals and their contact details (if they know any) in each category. These are people who could be approached to participate in the design and/or governance of the voluntary stewardship scheme. Collate the list of names, associated stakeholder categories, and where they appeared in the three-circles chart.
6. Bring together a small group of leaders whose buy in is critical to success to choose from the list a set of first-choice participants in design/governance, and a set of back-up options. Ask

²⁸ The categories of power, legitimacy, and urgency come from a highly influential stakeholder analysis framework developed by Mitchell et al (1997), and the distinction between those involved and affected comes from Ulrich (1994). For a contemporary perspective on systemic stakeholder engagement, see Gregory et al (2020).

the leaders to cover as many of the categories with power, legitimacy and urgency as possible, and to ensure there is also representation from the affected.

7. Invite stakeholders to join. If there are too many to involve in an on-going governance forum, consider which could just be *consulted*, and which really *must be fully involved* if the voluntary stewardship program is going to be effective, credible and not meet stakeholder resistance. For those who are consulted, think about communication mechanisms that will allow the issues they raise to be seriously accounted for by those who are involved.

A key principle in the above method is to be as inclusive as possible in the identification of stakeholders, and then to narrow down for their recruitment. This puts the onus on the leadership group to consider the possible consequences of exclusion before making their decisions, and it mitigates the risk that only those with the same perspective as the leaders will be recruited to governance.

7.2 Major Differences between Stakeholder Groups and their Implications for Governance

There were some contrasts between the ideas coming out of the different stakeholder workshops, and those with the most potential to impact on voluntary stewardship are discussed below:

7.2.1 Structural Differences between the Various Food-Animal Industries

There are structural differences between some food-animal industries. For instance, the dairy industry participants emphasized the potential ability of well-organized co-operatives to set standards of animal husbandry to mitigate AMR, and producers would have to conform to these standards if they wanted to sell their milk to those co-operatives. In contrast, there is little comparable vertical integration in the beef industry: many small producers sell calves to the feedlots, often through intermediaries such as auction marts and cattle buyers, and then the feedlots compete to sell meat to wholesalers and retailers via meat packers (slaughterhouses or abattoirs). The operation of market forces means that higher-risk calves will be sold cheaply, and then the feedlots will have to treat them with antimicrobials to prevent, control or treat bacterial diseases. This research has only looked at beef and dairy, but there will undoubtedly be other structural differences across the range of food-animal industries.

This raises a question of whether there could be one voluntary stewardship scheme for all industries; whether there would need to be separate, industry specific schemes; or indeed whether more local-level governance would be needed to account for variability *within* an industry. This question was raised in several of the workshops, but was never definitively answered, and for good reason. Multi-industry stewardship brings economies of scale and common standards, but risks being seen as a 'one size fits all' approach that is unable to account for the differences between industries and regions. In contrast, single-industry or business-level stewardship can be responsive to the local context, but risks being seen as resource-intensive and incoherent when it comes to standards. Indeed, if some industries are allowed much greater uses of antimicrobials than others, it could disincentivize participation in those industries with stricter standards, and could lead to widespread skepticism of the value of voluntary stewardship.

Thankfully, this dilemma doesn't have to be framed as an either/or choice. There is a well-tested systems model for structuring organizations which solves this problem, and it has been specifically designed to yield the best of both the centralization and decentralization of decision making. It is

called the Viable System Model (Beer, 1984; Hoverstadt, 2008; Espejo & Reyes, 2011; Espinosa & Walker, 2017; Sydelko et al, 2017; Espinosa, 2023). In the opinion of the research team, designing stewardship as a viable system using the model could significantly improve the delivery and success of voluntary stewardship. The model is presented below, and its implications for designing a stewardship system are explained.²⁹

The Viable System Model (VSM) can be used to diagnose dysfunctions in existing organizations or to design new organizations. The model proposes that five functional systems are required for an organization to survive and thrive in a complex environment, and they need to communicate with one another. The originator of the VSM, Stafford Beer (1981), gave these functional systems numbers rather than names because they don't exactly mirror conventional management functions (e.g., strategy, human resources, and marketing), and he thought that whatever terms he borrowed from the management literature would foster misunderstandings. The five functional systems are explained overleaf, in Table 2.

A key principle of the VSM is that it is recursive (Beer, 1981) or *fractal* (Hoverstadt, 2008): viable organizations have operational subsystems that are themselves viable organizations. In other words, the VSM can be used to look at any level of organization – from teams and departments up to whole companies, multi-agency alliances and indeed global collaborations. The five functions, and effective communications between them, should be found at *every level*.

The implications for voluntary stewardship are that it would be possible to design a three-level system (or more – the number of levels needs to be determined by stakeholders involved in designing an actual system). At the highest level, oversight would be provided into what is needed to combat AMR in the whole of US agriculture.³⁰ The S1s of this would be the programs for each industry (beef, dairy, poultry, etc.), as discussed in Table 2, and they could be designed to reflect the relevant structural features of those industries, so it is not 'one size fits all'. Each of these programs could then be viewed as an autonomous, viable system in its own right, with the S1s being the various business organizations (or regional groups of businesses) that are implementing the program. Then, each business organization could be looked at as a viable system, with the various operations needed to practice stewardship being the S1s.

Another key principle is *autonomy within constraints* (Beer, 1981). This means that the organization has complete freedom to operate as it wants, but within the minimal constraints necessary to maintain viability. In the case of voluntary stewardship, this means the highest level of governance would establish the understanding of the science that would allow the various industry programs to appreciate their operating constraints. Those programs would then develop their certification schemes and other necessary operations (e.g., for the beef producers, reach-out to small cow-calf operators), tailored to the needs of their industry. Then each business organization (or group of organizations), working with its own industry program, would establish what it needs to do to gain certification.

²⁹ Note that many books have been written on this model, so inevitably the description in this report is an over-simplification.

³⁰ While the current research has only focused on the USA, there is arguably a case for thinking about global governance (Moran, 2019) as well as multi-level, local-to-global communications between governance bodies (Spruijt & Petersen, 2022). The utility of the VSM for this is worth looking into.

<p>System 1 (S1):</p>	<p>S1 is the operations of the organization, where the production of products or services happens (Beer, 1985; Espinosa et al., 2015). To be viable, an organization must meet a need in its external environment. In the case of voluntary stewardship, the need is to prevent and mitigate AMR, and the S1s might be different voluntary stewardship programs designed to meet the specific needs of different industry sectors, so there will be multiple S1s (e.g., one each for beef, dairy, poultry, etc.). The S1s remain autonomous programs (Midgley et al., 1998), but within constraints set by S3, S4 and S5 (see later in this table). It would be quite possible for the different programs to be run by different industry bodies, such as those suggested in the four research workshops discussed earlier.</p>
<p>System 2 (S2):</p>	<p>S2 deals with support for the day-to-day operation of the programs, providing shared languages, protocols, procedures and information. It is also focused on avoiding oscillations (systemic patterns where, as demands from one S1 program are satisfied, the next becomes problematic and makes demands, so it feels like there is continual crisis management). In addition, S2 provides conflict resolution when discord exists between the S1s (Espinosa & Walker, 2017). S2 is essentially a set of coordinating mechanisms needed to <i>prevent</i> conflicts and competing demands among the S1 programs. It can include already existing mechanisms that can be leveraged, and it can help to identify when new mechanisms are needed to keep the programs running smoothly. S2 might include shared resources like laboratories that could serve all the S1 programs, giving economies of scale.</p>
<p>System 3 (S3):</p>	<p>S3 is responsible for finding synergies among the System 1s: e.g., looking at how all the stewardship programs across the industries can learn from one another. It is also responsible for resource distribution to keep the S1s going, accountability for performance, and addressing any legal requirements (Espinosa & Walker, 2017). Additionally, S3 handles resource bargaining to ensure that all the programs are running in the best interests of voluntary stewardship as a whole. S3 is an especially challenging function to design because it embodies the resource bargain all stakeholders must agree to, as well as the performance management of each of the autonomous programs (S1s). For performance management, S3 uses a sporadic and informal auditing system that monitors the activities of the S1s (Hilder, 1995). Essentially, working with S2, S3 facilitates everything to do with the smooth running of ongoing operations and management across the programs.</p>
<p>System 4 (S4):</p>	<p>S4 supports adaptation. It is responsible for understanding the total relevant environment in which the organization is embedded (Hilder, 1995), appreciating that what counts as ‘relevant’ requires a values-informed boundary judgment (Ulrich, 1981). Whereas S3 is concerned with management of the operations of the organization, S4 is concerned with the outside environment in which the organization sits (Beer, 1979). It is responsible for scanning the outside environment; anticipating potential disruptions to this environment (either in terms of threats or opportunities); suggesting innovations and strategic development paths; and recommending the organizational changes needed to adapt to anticipated environmental changes. Through these mechanisms, S4 (in conjunction with S3) creates the space in the voluntary stewardship system for thinking strategically about the balance between maintaining current programs and responding to the need for change to deal with new aspects of the AMR problem (Hayward, 2004). For voluntary stewardship, S4 might include research on emerging antimicrobial-resistance challenges, anticipation of forthcoming legislation that could affect the programs, awareness of new technologies under development that could enhance husbandry or address resistant bacteria, and understanding stakeholder concerns that might undermine stewardship. All the institutional responses to these opportunities and challenges are the responsibility of S4 too.</p>
<p>System 5 (S5):</p>	<p>S5 defines the identity of the whole system and provides its ethos, purpose and policy (Leonard, 2009). S5 facilitates effective interactions between S3 and S4 to foster adaptation capabilities. This is necessary because S3 wants to maintain smooth-running operations, while S4 wants to <i>change</i> how the operations work to respond to emerging opportunities and challenges. S3 and S4 may conflict. S5 provides an essential policy overview and is responsible for ensuring that there is robust governance decision making in the interests of antimicrobial stewardship overall (not just, at a lower level, in the different programs). It does so by including S3 and S4 in policy and strategy decisions. S5 would need to ensure that the focus remains on antimicrobial stewardship and doesn’t become diverted by other concerns – or, if dovetailing with responses to other societal agendas (e.g., animal welfare) is necessary, S5 will explore how that changes the identity of the system without compromising the voluntary stewardship of antimicrobials.</p>

Table 2: The VSM Sub-Systems (adapted from Sydelko et al, 2017, 2023, and made specifically relevant to voluntary stewardship).

At every level of organization, there is as much autonomy as can be provided, while still meeting the need to combat AMR. This therefore means that it’s not a choice between centralized control and local autonomy: only the minimal constraints are determined centrally, and then there is complete

autonomy for the programs and businesses within these constraints – and structural differences between the industries can be addressed at the program level.

This model is entirely compatible with Ostrom's (1990) governance approach, because multi-stakeholder governance could constitute the S4 and S5 functions at all three of these levels. There would be a national, multi-stakeholder governance board led by industry, establishing a broad-brush, science-informed identity for voluntary stewardship and a strategy for its development. There would be governance boards doing the same for each industry program. Finally, there would be local governance boards overseeing single businesses (for large organizations), or groups of businesses collaborating together (for collections of smaller producers).

There is also a question to be raised. Looking specifically at the issue of poor husbandry standards amongst small-scale producers of calves who are selling to the large feedlots, which then have to use antimicrobials to prevent, control and treat excessive disease, it is clear that more than just a certification scheme is required for a beef stewardship program: there is also a requirement for outreach to the small producers, helping them see that they can improve the health of their animals with some key changes in husbandry. This is an issue for beef producers, but not for the dairy industry. Of course, the participants in the beef workshop didn't underestimate the challenge that an outreach program would present: the small producers are very dispersed geographically, and some don't want to hear about any need for improved standards.

Assuming there will be no change to the division between rearing calves and feeder cattle, with the feedlots only working with the latter, consideration could be given to learning from the dairy industry. It is unlikely that beef production will be reorganized into co-operative ventures, given that the dairy industry only has co-operatives because milk is so perishable, so there has to be a ready-positioned buyer (USDA, 2005). However, it would be possible for the large feedlots to co-invest in jointly owned co-operatives that would buy calves on their behalf. This would then provide a vehicle to establish standards of husbandry that small producers would have to meet in order to sell their calves. This would mitigate the worst effects of a lack of vertical integration in the beef industry, without removing the right of small producers to raise and sell calves, and without compromising the ability of the feedlots to outsource this aspect of their enterprises.

It is also possible that the current opacity in animal-health information provided with the conveyancing of calves (i.e., inadequate information about provenance, nutrition and health) could be overcome, perhaps via block-chain technologies, so that the information itself becomes part of the commodity, and those providing it are financially compensated for its recording, storage, provision, and fidelity.

7.2.2 The Role of National Organizations

A notable difference between the beef and dairy workshops was that the beef producers focused on business-level governance and did not want the involvement of national organizations, because they saw them as insufficiently responsive to local needs, yet the dairy participants talked about the design of a national program with national organizations represented.

At first sight, these would appear to be irreconcilable perspectives, but actually the VSM (discussed in section 7.2.1) unites them. Using that model, it becomes immediately apparent that the two workshops were discussing different levels of governance: the dairy industry was focused on the

highest, broad-brush level, and the development of a certification scheme under that (the second level). The beef producers were talking about the third level (the business or feedlot level), with some reach-up to the second level (their focus on “validation”). It would be entirely appropriate to involve national organizations at the highest level, but not appropriate at all to involve these people, who would not necessarily understand the needs of particular industry sectors and local businesses, in lower levels of governance.

There is also a related issue to the above: the public-health policymakers spent a lot of time debating the pros and cons of including Federal agencies in governance, while the beef producers were against this, saying that industry needs to be in control. The dairy industry participants were not keen to have agencies like the USDA and FDA on a governance board, but said that they wanted them in advisory roles; would like the USDA to endorse their certification scheme; and acknowledged that this meant a partnership approach. Again, this can be resolved with reference to the VSM: the beef producers wouldn’t need to involve Federal agencies in program-level governance at all, but the dairy program might give them a role as partners in its design. This is all about program-level autonomy.

7.2.3 Different Views on Stakeholders to be Included in Governance

It was quite noticeable that the public-health policymakers saw a range of broader societal beneficiaries who the industry participants missed, but conversely the beef and dairy workshops hosted discussions about key players in industry who would need to be involved if voluntary stewardship was going to be practically implementable. The latter were not mentioned by either the public-health policymakers or the consumer advocates. These discussions had implications for who the different stakeholder groups thought could be involved in governance.

There are two observations that can be made on this. First, differentiating the three levels of governance (see above) will help to clarify who needs to be involved at which level: wider societal beneficiaries might contribute to the highest level of governance, and industry specific actors might serve at the program and/or business levels. Second, as the industry and public-health perspectives on who should be involved are complementary, and each is unaware of the other, there is considerable scope here for mutual learning, which will provide a good foundation for building trust (perhaps in the context of using the new stakeholder-analysis method, presented earlier).

7.2.4 Stigmatization

In the public-health workshop, there was a discussion of shaming, which continued for almost ten minutes. The policymakers realized that how they approached this issue could be critical for the success or failure of voluntary stewardship. It is important to note here that both the beef and dairy producers realized that peer pressure would be important for voluntary stewardship to function effectively, and this accords with Ostrom’s (1990) work on stakeholder governance. However, the research team’s suspicion is that, if the industry participants had heard Federal policymakers use the word “stigmatization”, they would have been concerned.

Recall the worry amongst the beef producers that Federal agencies might want top-down control of stewardship: they were initially strongly set against multi-stakeholder involvement until they were reminded that quality- and sustainability-validation models with multi-stakeholder involvement were working well. Arguably, if the shaming is perceived by industry participants as coming from

their peers, it will be viewed positively; but if it is seen as being imposed from ‘outside’ – especially from a Federal agency that usually uses regulation rather than voluntary stewardship – then it could seed mistrust, fracture multi-agency collaboration, and even cause rejection of the whole idea of voluntary stewardship.

Midgley (2013, 2015b) has argued that how conflict and marginalization dynamics are handled is critical to the success of antimicrobial stewardship. Entrenched conflict and marginalization typically involve stigmatization and blame (Midgley, 1991, 1992, 2000; Foote et al, 2007, 2021; Midgley & Pinzón, 2011, 2013), and this needs to be kept in mind in the design of an actual voluntary stewardship system: time needs to be taken for trust-building to prevent the emergence of destructive conflict when the different agencies first come together, and Helfgott et al (2023) demonstrate how useful it is for participants to step out of their agency roles for a day or two and get to know each other as fellow human beings through a series of facilitated, structured exercises before they start substantive discussions on the issue at hand. Similarly, Cronin et al (2014) discuss the use of long meal breaks to build rapport between stakeholders who might initially be anticipating conflict, which carries over into people’s deliberations. Even when conflict has already been entrenched for decades, it is possible to transform a destructive conflict into a generative one using systems approaches, as long as the participants are willing to engage (Midgley, 2016).

8. Conclusions

In this report, an emergent consensus across the beef, dairy, public-health and consumer-advocate stakeholder groups has been outlined. This focuses in a broad-brush manner on the major characteristics of a potential voluntary stewardship scheme:

- The aim of a program should be the judicious use of antimicrobials, not zero use.
- Multi-stakeholder governance should be put in place, with industry in a lead role, and other diverse stakeholders included (either as full decision-makers, external partners, or experts to be consulted).
- The governing body should oversee training and information provision for producers, and promote education about AMR in wider society.
- The program should be strongly science-informed, with research driving development and change.
- The governing body should also oversee the certification or verification of good stewardship practice by producers.
- The results of certification or verification (and indeed monitoring information more generally) should be publicly accessible, to enable peer pressure.
- There are existing governance and certification programs for other purposes that could and should be built upon.
- Certification should be linked to marketing, so financial benefits for producers flow from engagement in the program.
- A systems approach should be taken: the over-use of antimicrobials stems from deficiencies in wider agricultural-production systems, so judicious use means changing those systems.
- In line with the last point, governance should be focused on improving overall system-level performance rather than control over clinical decisions made by veterinarians who decide whether to prescribe antimicrobials to individual animals.
- Funding should come from checkoff dollars collected by professional associations that work for the collective benefit of their members.

It is striking that this model conforms in almost every respect to the principles in Ostrom's (1990) Nobel-prize-winning approach to governing common-pool resources. Therefore, this will be a useful model to use as a template when designing an actual voluntary stewardship program.

The fact that a consensus emerged on all of the above is very encouraging for the potential utility of voluntary stewardship. Nevertheless, there were also some difficult issues, and differences between the views of stakeholder groups, that need to be accounted for when designing an actual voluntary stewardship scheme:

- There are structural differences between some food-animal industries. For instance, there is a fair amount of vertical integration in the dairy industry: co-ops have the power to set standards to mitigate AMR, and producers would have to conform to these standards if they wanted to sell their milk. In contrast, there is little vertical integration in the beef industry: many small producers sell calves with unknown health histories to the feedlots, and then the feedlots compete to sell meat to wholesalers and retailers. There is no single body (like a co-operative) able to strongly influence standard-setting. *Different kinds of program will therefore be needed for different food-animal industries.* Given the poor standards of husbandry amongst some small producers raising calves, and the difficulties tackling this issue, a question was asked by the researchers about whether the feedlots could collectively establish a co-operative to do the calf-buying on their behalf, thus creating a body that could set standards for husbandry and information provision.
- The beef industry mostly focused on local-scale governance, while the dairy participants primarily looked at the national scale. These emphases are reconcilable via use of the VSM: a systems model of an adaptive, multi-scale organization.
- The participants in the four workshops identified different stakeholder groups when it came to inclusion in governance. There is an opportunity for synergy here, because the industry participants mainly looked at the key professions who would need to be involved in implementing voluntary stewardship in agriculture, while the public-health policymakers and consumer advocates mainly discussed beneficiaries in wider society. Using the VSM, it is possible to identify three or more 'levels' of governance: national-level (establishing general parameters for stewardship in a science-informed manner), program-level (ensuring each industry certification program meets the needs in that industry), and business-level (looking at how to implement stewardship and secure certification). Different stakeholders might be involved at the three different levels.
- There was a discussion of shaming and stigmatization, with some public-health policymakers saying that these are good things to encourage when producers opt out of voluntary stewardship. Peer pressure is certainly necessary, but if the stigmatization is perceived by industry as coming from regulatory authorities, it could undermine voluntary stewardship. The right kind of peer pressure comes about when all industry players can see their own performance in relation to the performance of others, so those who are more successful in addressing AMR then encourage others to make improvements.

If these insights are going to be translated into the design of an actual voluntary stewardship system, then how this is to be approached is critical. The first question is who to invite onto a design team (and later, who will be part of governance at the different levels). A method for systemic stakeholder analysis has been provided, and this can help a leadership team to work out what stakeholders need to be involved.

One risk of models like the VSM and Ostrom’s approach to the governance of common-pool resources is that they could be applied in a top-down manner by ‘expert’ systems practitioners. It has been known for decades that the top-down imposition of models to address highly complex socio-ecological problems often fails due to stakeholder resistance (e.g., Lee, 1973; Ackoff, 1979b; Rosenhead & Mingers, 2001). If a top-down approach was attempted, it would almost certainly undermine trust and make voluntary stewardship difficult or even impossible to establish. While all the participants in this research made it clear that the industry players need to be in the driving seat, a collaborative, stakeholder-engaged approach is essential. There is literature on how to implement the VSM and Ostrom’s approach in a highly participative manner. The research team recommends consulting Jenkins (2018) on the use of Ostrom’s approach for water management: through extensive stakeholder and community engagement in a highly conflictual context, Jenkins was able to secure multi-stakeholder buy-in to implement Ostrom’s model. Also, consult Espinosa (2023) for a participative methodology for implementing the VSM. The first author has collaborated with both Jenkins and Espinosa, and has seen these approaches work in practice – they make a significant difference when it comes to establishing trust between stakeholders and building a collective vision for change.

Just as using the VSM and Ostrom’s model in a top-down manner carries some risks, so too does viewing the findings of the research reported here as a finished blueprint for implementation. These findings need to be seen as a *resource to draw upon*, and no more. The stakeholders in an actual design team need to feel in control of what is decided, so the recommendations in this document shouldn’t be imposed on them. Also, because voluntary stewardship needs to cover more than just the beef and dairy industries, there will almost certainly be many further insights to gain from working with stakeholders than those captured in this report.

In the work reported here, the research team facilitated the stakeholder groups separately, so they could share and develop their thinking out of the hearing of others who might have different views. This is something that could be useful to replicate at the start of an actual voluntary stewardship design process, and indeed it might be useful to use the Critical Back-Casting approach again too. This could precede bringing the stakeholders together into a design team. When the stakeholders are actually brought together, there is merit in giving them a day or two to get to know each other as human beings rather than as people occupying organizational roles. Helfgott et al (2023) provide some guidelines for facilitating this. Establishing trust and mutual appreciation is an essential part of the process.

The research team would be very interested in supporting any industry or policy organization that wants to take forward this vision of voluntary stewardship. Please feel free make contact at the email addresses listed on the first page of this document.

Acknowledgements

The authors of this report would like to thank the research participants, who were willing to volunteer their time to work on new ideas for the voluntary stewardship of antimicrobials. The data presented in this publication were derived from a project funded by USDA-NIFA AFRI (2016-68003-24607) entitled “*Voluntary Compliance in Antimicrobial Stewardship Programs: A Critical Factor for Effective Intervention*”. Any recommendations, opinions, findings or conclusions expressed in this

publication are those of the publishing authors and do not necessarily represent those of the United States Department of Agriculture.

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ISBN: 978-1-906422-43-1

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