Geriatric assessment prior to cancer treatment: a health economic evaluation

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ABSTRACT

Introduction: To address uncertainty regarding the cost-effectiveness of implementing geriatric assessment (GA) in oncology practice, we undertook a synthetic, model-based economic evaluation.

Materials and Methods: A decision-analytic model with embedded Markov chains was developed to simulate a cost-effectiveness analysis of implementing GA within standard oncological care compared to current practice. This was for patients aged 77 years (the mean age in included trials) receiving chemotherapy or surgery as first-line treatment. Assumptions were made about model parameters, based on available literature, to calculate the incremental net health benefit (INHB) of GA, using a data synthesis.

Results: GA has additional costs over standard care alone of between £390 and £576, depending upon implementation configuration. When major assumptions about the effectiveness of GA were modelled, INHB was marginally positive (0.09-0.12) at all cost-effectiveness thresholds (CETs). If no reduction in postoperative complications was assumed, the intervention was shown not to be cost-effective (INHB negative at all CETs). When used before chemotherapy, with minimal healthcare staffing inputs and technological assistance, GA is cost-effective (INHB positive between 0.06-0.07 at all CETs).

Discussion: Considering emerging evidence that GA improves outcomes in oncology, GA may not be a cost-effective intervention when used for *all* older adults with cancer. However, with judicious selection of implementation models, GA has the potential to be cost-effective. Due to significant heterogeneity and centre dependent success in implementation and effectiveness, GA is difficult to study in oncology settings. Stakeholders could take a pragmatic approach towards GA introduction with local evaluation favoured over generalisable research. Because GA tends towards utilitarianism and has no safety issues, it is a suitable intervention for more widespread implementation.

KEYWORDS: Cost-Benefit Analysis, Cancer, Geriatric Assessment, Decision Support Techniques, Frailty

INTRODUCTION

With an aging and growing population, the number of older adults undergoing treatment for cancer is projected to continue increasing.[1] Compared with younger people, older adults with cancer have worse outcomes with higher postoperative complications, chemotherapy toxicity, and supportive care treatment allocation.[2, 3] The spectrum of ageing phenotypes means that clinicians can struggle to assess, select, and counsel older adults appropriately for different cancer treatments.[4,5] One solution proposed to counter this problem is use of geriatric assessment (GA) in oncology practice.[6] Numerous studies of the predictive ability of GA,[7] and the therapeutic efficacy of GA as a complex intervention in oncology have been reported.[8, 9] GA is delivered within oncology with significant heterogeneity, precluding meta-analyses.[7] Moreover, complex, whole-system implementation issues limit widespread introduction[10] and mixed results from randomised controlled trials (RCTs) have created uncertainty regarding its value.[8, 11] The perceived benefit-cost ratio is a frequently perceived barrier.[10] Without robust cost-effectiveness data, alongside a national shortage of geriatricians, stakeholders may struggle to justify widespread adoption.[10] It is therefore important to demonstrate cost-effectiveness evidence for GA in general oncology practice. The lack of trials capturing health-related quality of life (HRQoL), precludes a traditional evaluation of single (or multiple) trial data. A pragmatic approach utilising the available evidence to explore the cost-consequences of GA in oncology practice is therefore desirable, in terms of time and cost constraints. At a time of complex pressures on health services following the COVID-19 pandemic, economic justification for expansion of services is heightened. This can inform stakeholders and researchers of the potential monetary value afforded by implementation. Using wide-ranging literature sources, this study presents a model-based cost-effectiveness analysis. We aim to evaluate the cost-effectiveness of different implementation configurations of GA within oncology practice compared to standard care.

METHODS

Study design

A decision-analytic model was developed to compare different implementation configurations for the inclusion or exclusion of GA within standard oncology care. The perspective throughout this economic evaluation concerned implementation of GA within National Health Service (NHS) oncology departments within the United Kingdom (UK). We modelled the patient population for the most common cancer multi¬disciplinary team (MDT) setup in the NHS, where chemotherapy and/or surgery are treatment options. This scenario was selected to provide the most relevance to stakeholders. We follow the latest guidance published by the National Institute of Health and Care Excellence (NICE).[12] See Supplementary Data Methods for additional explanation throughout.

Evidence informing economic evaluation

Strategy and assumptions

Non-systematic, targeted searches using PubMed identified the evidence used to inform the assumptions of this economic evaluation. Research was selected from the geriatric oncology evidence-base, including grey literature and wider cancer and aging literature, including perioperative and community settings. The levels of evidence provided by the Oxford Centre for Evidence-Based Medicine 13 guided inclusion. The major studies included are summarised in Supplementary Data Table 1.

Intervention and standard care

We attempted to model two alternative implementation strategies: a) a highly optimised GA undertaken using patient-led, technologically-assisted reporting and a trained healthcare worker, with minimal geriatric input and a “screen, predict and refer model”; and b) the gold-standard geriatrician-led service with a dedicated MDT. The former is rationalised based on the emerging evidence of the implementation benefits of utilising non-geriatricians[10] and technology[14] in GA within oncology. The latter reflects higher resources, but generally a more desirable approach in surveys of oncology practitioners.[10] The latter could also encompass the use of screening to select patients for full GA.[15] Standard care does not currently include GA and the assessment and optimisation relies on the responsible surgical or oncological consultant, sometimes supported by a registrar-level clinician.

Patients are referred to their general practitioner or other specialties according to need. It has been recognised that older adults have unmet needs in standard oncological care.[16]

Health care utilisation

The main resource input in GA is the staff time and effort required to deliver the service and the expected individual patient-facing interactions necessary. These costs can be estimated using assumptions of typical interaction durations, considering the unit costs per minute for each clinician. For model (a), there is the additional cost of the technology to enable patient- or carer-reported GA.

Unit costs

Units of healthcare resource inputs were calculated using NHS reference costs and available estimates of unit costs for health and social care services and professionals (Supplementary Data Table 2). All costs are reported in British Pounds (£) and uprated to 2019/2020 financial year prices where necessary using the Hospital and Community Health Services and NHS cost inflation indices, and then further inflated to 2021 prices using the geometric mean of indices from 2007-2020.[17]

Health-related quality of life

Few published studies for GA in oncology practice report a suitable HRQoL measure for calculation of quality-adjusted life years (QALYs). A QALY represents a utility value ranging from 1 (full health) to 0 (representing death, or potentially less than zero for states worse than death), derived from health state preferences from a representative population.[18] QALYs provide a singular representation of improvement in life years lived and/or their quality and are favoured by NICE.[12] Baseline QALY data was calculated using the sample size weighted mean and standard deviation of the means of all malignant conditions reported in a database of EQ-5D data (Supplementary Data Table 3).[19]

Economic analysis

Analytical framework

The potential utility in terms of QALYs for GA was calculated, representing cost-effectiveness, providing a common comparator against other interventions for stakeholders to consider. Given that the cost-effectiveness analysis is derived from disparate data, this evaluation also serves as a cost consequences analysis. Costs and outcomes are presented in a disaggregated form to inform different stakeholders regarding the domains relevant to their own budgets (Table 1). To compare the use of GA versus standard care, the incremental net health benefit (INHB) was estimated to model potential gains in QALYs.[20] INHB conceptualises that health spending forgone elsewhere represents an opportunity cost to fund a new intervention. The INHB of GA is calculated as the incremental costs of GA above standard care divided by the opportunity cost, subtracted by the incremental gain in QALYs per patient, calculated as the area under the curve, from using GA over standard care. The opportunity cost represents a cost-effectiveness threshold (CET), which is a predetermined level of excess healthcare system cost sufficient to redirect one QALY from an alternative clinical opportunity.[21] Where INHB is positive, the net benefit in terms of QALYs would be greater than the opportunity cost, meaning that GA is more cost-effective than standard practice. A negative INHB would imply that the potential health benefits of GA are insufficient to redirect resources from other clinical activities.[21] To address uncertainty for the value of the CET in NHS health economics, cost-effectiveness for CGA was calculated for several possible CET values.

Modelling approach

A decision analytic model (Figure 1) with Markov chains (Figures 2-4) were utilised to estimate the INHB for a 77-year-old patient undergoing cancer treatment, based on the median age of patients in a large exemplar study.[22] Markov chains are simple to construct and widely used in decision-analytic economic modelling of the health state transitions common in oncology.[23] According to this model (Figure 1), a patient may receive a GA in addition to standard oncological care. The GA may take one of four main implementation configurations (Table 2), which are individually modelled. A patient may then receive surgery or chemotherapy as the first-line treatment, with a risk of developing postoperative or chemotoxicity complications (Figure 2). Additional pre-treatment costs result from undergoing GA with standard care, although standard care may still generate some pre-treatment costs (Supplementary Data Table 3). Posttreatment mortality, QALYs (Figure 3) and costs relate to posttreatment complications. GA data can also change cancer MDT treatment decision making in approximately 28% of cases to higher, or more commonly, lower intensity treatment.[24] An exemplar study was modelled (Figure 4) that reported the changes in management for 375 patients when GA data was used by the cancer MDT.25

Estimating model parameters

The main model parameters were prevalence figures for referrals to other departments or specialities, expressed as mean and standard deviation percentages derived from the literature (Supplementary Data Table 3), which were modelled using a Beta distribution. Baseline QALY values were represented by a Beta distribution. A Gamma distribution represented length of hospital stay following admission for chemotherapy toxicity, recognising the skewedness of the original data[26] and that the upper limit tends towards infinity. Cancer treatment allocation required a Dirichlet distribution to describe mutually exclusive outcomes as a probability. Finally, log-normal distributions were used for the potential effects of GA on outcomes, modelled as risk ratios derived from exemplar studies (Supplementary Data Table 1), as described in a previous study.[27] See Supplementary Data Equations 1-10 for further details.

Modelling QALYs and mortality

Any effects on long-term QALYs in favour of GA are likely the result of improved survival, either mediated through the intervention itself or reduced postoperative complications.[28, 29] Ten-year QALYs were estimated using a two-state, annually cycling Markov chain (Alive and Dead) (Figure 3). Patients begin in the Alive state and face an annual mortality risk, transitioning to the absorbing Dead state. During every Markov cycle in the Alive state patients accrue QALYs. QALYs are summed cyclically to estimate QALYs for GA and usual care respectively. Where chemotherapy was selected, a decrement of 0.32 QALYs for the first year was incurred.[30] Only one study demonstrated a decrement of 0.07 QALYs at 12 months following colorectal cancer surgery.[31] We therefore assumed that there was no persistent decrement following surgery, as colorectal surgery represents a fair median between the relative extremes of different tumour site procedures (e.g., breast versus pancreatic surgery). QALYs were discounted at 3.5% per annum, as recommended by NICE.[12]

The baseline annual transition probabilities were generated based on predicted estimates of net cancer survival data.[32] Weighted mean 1-, 5- and 10-year survival data for 29 common cancers combined were calculated. Mean survival data were imputed between the calculated values from the UK Office of National Statistics (ONS) data[32] using piecewise cubic Hermite interpolating polynomial (Supplementary Data Figure 1). We assumed that those with an uneventful postoperative course would adopt the

survival probability curve related to cancer. Significant long-term effects on 10-year mortality following surgical complications have been reported previously.[33]

Moonsinghe et al.[33] undertook a study of 1,382 surgical patients with a mean age of 63 years undergoing major non-cardiac and non-neurosurgical operations, including cancer procedures. The cumulative 10-year mortality rate reported in their study was recently used in a health economic evaluation of CGA for elective arterial surgical patients.[28] Using data from the Moonsinghe et al.[33] study, we created specific, annually adjusting transition probabilities for patients undergoing surgery who developed postoperative complications.

Probabilistic sensitivity analysis

To address uncertainty in the parameters used within the model, a probabilistic sensitivity analysis (PSA) was undertaken using Monte Carlo simulations, generating probability distributions for all parameters.[23] PSA is used to generate a confidence level for the outputs of the model by reflecting the uncertainty in the input parameters. Monte Carlo simulations are repetitive runs of a model, where parameters are drawn from probability distributions.[23] Fixed parameters were unit costs, mean length of patient-facing consultations with clinicians, and yearly mortality probabilities with/without surgical complications. For each implementation configuration, 5,000 simulations were conducted, generating a distribution of parameter values and estimates of INHB for GA compared to standard care. The mean and its associated probability distribution were used to evaluate the cost-effectiveness of GA and its uncertainty. Three separate CET values were utilized to manage the uncertainty of the desired threshold for NHS health programs: (i) £30,000; (ii) £20,000; and (iii) £13,000.34. [35] These values represent the upper and lower limit of the range utilised by NICE and a more recently proposed conservative CET, respectively.[34, 35]

The two main implementation configurations (models A and B, Table 2) solely reflect different levels of pre-treatment human resources and therefore pre-treatment costs. It is assumed that the other costs and treatment outcomes are the same regardless of the implementation. Two other models were also used to represent recent RCTs. Model C only includes patients selected for chemotherapy and model D only includes for those selected for surgery (Table 2). The one-way PSA of the neutral effect of GA on postoperative[8] or other outcomes represented an additional sensitivity analysis for each implementation configuration. For models C and D specifically, the human resources can be varied by basing the pre-treatment costs on models A and B respectively.

The model was developed and statistically evaluated using the Python programming language (v3.7.3, Python Software Foundation). All code and open-source software, dependencies utilized can be found at https://github.com/gordonmckenzie/oncogeriatrics-health-economics. The Equator network CHEERS guidelines for reporting health economic evaluations were adhered to when reporting this study.36

RESULTS

Table 3 and **Figure 3** presents the cost-effectiveness findings for each implementation configuration.

Implementation configuration A – The geriatric oncology model

The mean difference (£576) in pre-treatment cost of a geriatric oncology model was higher than standard care alone. The 2.5th percentile of pre-treatment costs is negative, whereby usual care costs more than the addition of GA. This is explained by the rare scenario where usual care uncovers more unmet need than GA. The addition of GA reduces post-treatment costs by £78 per patient, leading to a total cost per patient of £497. Costs associated with changes in management (£373) are balanced against a reduction in costs arising from expected post-operative excess bed days (£356), Intensive Therapy Unit (ITU) admissions and 30-day surgical readmissions (£77), due to fewer operations being undertaken. A small reduction in costs (£20) arising from reduction in chemotherapy toxicity is also noted.

Slightly positive INHBs were found at all CETs, meaning that GA would be considered cost-effective if the effect sizes and management changes were reproducible at centres implementing GA. One-way PSA was undertaken by neutralising the effect of GA on post-surgical complications and GA was not cost-effective (INHB < 0 across all CETs). One-way PSA, retaining the effect on post-surgical complications but removing the effect on chemotherapy toxicity rates or treatment changes at the MDT-level, was also modelled. GA remained cost-effective at all CETs, therefore highlighting that the perioperative component of GA in cancer care is an important effect.

As reported by Partridge et al.,[28] a registrar-led configuration of GA is also possible. A senior (e.g., seven years post primary medical qualification) non-consultant doctor, specialising in geriatric medicine undertakes the GA (lasting 90 minutes), with

consultant support available as required. This had lower total costs than the consultant-led model (£402 vs £497, or a 19.1% reduction), but exhibits a similar cost-effectiveness profile with PSA.

Implementation configuration B – The 'screen, predict and refer' model

The reduction in resources required to undertake the GA using this model reduces pre-treatment costs by 32.3% to £390 per patient. Assuming all beneficial effects of GA are present, the post-treatment cost profile follows model B and GA is again cost-effective at all CETs (INHB 0.03-0.05). One-way PSA demonstrated that GA is no longer cost-effective when the perioperative effect is neutral. Further one-way PSA removing the pre-treatment cost of using technology, (e.g., using a screening tool instead) did not affect the cost-effectiveness. Overall, this model has lower pre-treatment costs and a similar cost-effectiveness profile to model A.

Implementation configuration C – Pre-chemotherapy model

This model is cost-effective at all CETs. It is marginally cost-effective (INHB = 0.01) at higher CETs, if the effect on chemotherapy toxicity reduction is neutralised. One-way PSA demonstrates that GA is no longer cost-effective when the staff input is increased.

Implementation configuration D – Preoperative model

This model is cost-effective with INHB consistently above zero at all CETs, regardless of human resources. Table 3 includes the results for a configuration based on model B. When the effect of GA on post-operative complications is neutralised, GA is no longer shown to be cost-effective.

Uncertainty

There was a consistently high probability (0.44) that INHB was less than zero, coupled with a high expected cost of uncertainty, between 2.81-2.91 QALYs.

DISCUSSION

The addition of GA to standard care in the management of older adults with cancer may be cost-effective, if assumptions based on the potential for GA to reduce surgical complications hold true. Implementation and other complex system factors will likely limit centre-dependent results in achieving the effects that have been reported in research studies. A recent meta-analysis[8] did not demonstrate positive effects of GA on postoperative outcomes, and numerous underpowered studies reporting neutral results within oncology settings exist. When implemented with minimal healthcare staff input and assisted with technology, GA is potentially cost-effective for pre-chemotherapy optimisation. This finding holds even if GA has no effect on reducing chemotherapy toxicity, although the relationship between healthcare staffing inputs and outcomes following GA is uncertain. Due to the uncertainty in model parameters, the probability of decision error (INHB < 0) and the expected cost of uncertainty was high.

Examining the available evidence and the results of this study, GA may not be a cost-effective intervention for all older adults within oncology settings. This is principally due to the lack of evidence in recent meta-analyses and trials that GA consistently reduces chemotherapy toxicity and postoperative complications. The latter effect appears imperative to cost-effectiveness through consequent mortality reduction and increased QALYs favouring GA. The demonstrable efficacy of GA may be challenged by a myriad of factors including: i) complex implementation issues; ii) expedition of treatment in cancer treatment pathways with national targets; iii) QALY decrements with treatment; and iv) intensely competing causes of mortality. One could argue that GA is not required to be cost-effective because it will tend towards utilitarianism.[37] By offering deeper insight into older adults' health, which may be unavailable in standard care, GA can change clinical decision-making in a direction most appropriate for a given patient. Furthermore, GA realises unmet needs and promotes general health optimisation where appropriate.

The limitations of this study arise from the assumptions made about the efficacy of GA to improve certain outcomes, principally chemotherapy toxicity and postoperative complications. One-way PSA was used extensively to demonstrate where cost-effectiveness is sensitive to a particular assumption. Due to competing causes of mortality within oncology and highly differential mortality rates between different cancers, mortality differences between those with and without postoperative complications were difficult to resolve. The assumption that GA reduces postoperative complications and therefore long-term mortality appears imperative for cost-effectiveness. This assumption was utilised in a recent health economic evaluation by Partridge et al.,[28] and our analysis found a lower effect than proposed by them. The concept of unmet needs is difficult to model in an economic framework. Synthesising multiple data sources aided this, but expert opinion guided the amount of addressed unmet need in

standard care, supported by the combined, varied and senior NHS experience of three of the authors over several decades. A geriatric oncology model (model A in this study) may offer superior effectiveness over a model not involving geriatricians. The provision of GA in cancer care differs widely across the NHS38 and the relationship between different implementation configurations and outcomes is unknown. This study was a macrosimulation and therefore cannot account for all nuances of oncogeriatric care (e.g., chemotherapy toxicity grading). Notable exclusions were radiotherapy, immunotherapy, endocrine therapy and best supportive care pathways. However, there is less, or sometimes, no evidence available that GA offers any therapeutic benefit in these management options. We were also limited by the available data and wished to avoid making speculative assumptions. For example, we do not have sufficient data for a third arm of Figure 1, where a patient uses GA to decide not to have chemotherapy or surgery. Data was also lacking in the available literature for chemotherapy or surgery-related rehospitalisation and discharge to dependent care settings. Finally, our model applies only to UK-based NHS health practice and the cost data reflects this.

Nevertheless, this study has several strengths, including a robust synthetic modelling approach drawing assumptions from multiple studies across GA literature. The use of numerous validated statistical techniques maximized data whilst encapsulating uncertainty wherever possible. We utilized detailed modelling architecture with three Markov chains embedded within a decision tree. Furthermore, we have released our source code for others to examine and use freely. We have provided a range of implementation-specific cost figures to inform stakeholders when commissioning services.

Implications for clinical practice

The decision to implement GA could be based on centre-level economics, with consideration to the cost-effectiveness and cost-consequences reported here. Health organisations must consider implementation factors to successfully embed GA services in cancer care. Our study suggests that the most cost-effective model for centres cautious of the true cost-effectiveness of GA, is a prechemotherapy optimisation model with a nurse-led configuration. This could be assisted by technology where possible. For centres with dedicated geriatricians looking to start a geriatric oncology service, our results indicate that this should also include perioperative geriatric medicine.

Implications for future research

There are many trials protocolised, still in progress, or recently reported in abstract. The results and subsequent meta-analysis of these may further support the cost-effectiveness of GA or neutral results may leave it in doubt. This raises questions about the value of further research into the (cost-) effectiveness of GA, given that it is entirely safe and works towards utilitarianism. Future research should always include HRQoL as an outcome and a like-for-like comparison of unmet needs in standard care and GA arms to aid cost-effectiveness studies. The dose-response relationship between health staffing inputs and clinical effectiveness must be ascertained through further research. Although complex and computationally expensive, microsimulation may be useful for oncogeriatric care models, including further examination of implementation models utilising screening and additional outcomes. Our group are currently working on a microsimulation model using machine learning, and a data pipeline could be created to inform a cost-effectiveness model.

Conclusions

This study and supporting evidence show that the use of GA in cancer care for all older adults may or may not be cost-effective. Where organisations can replicate the findings from centres of excellence, GA may be cost-effective when used preoperatively for patients undergoing cancer surgery. GA may also be cost-effective when used with a minimization of staff inputs and technological assistance before chemotherapy. A large amount of further trial data is pending, and this model can be used for future simulations. With judicious selection of implementation strategy, GA has potential cost-effectiveness in cancer care and tends towards utilitarianism with no safety issues, making it suitable for more widespread local implementation.

DECLARATIONS

Ethics approval and consent to participate

Not required.

Consent for publication

Not required.

Availability of data and materials

All data, code and open-source software dependencies utilised can be found at https://github.com/gordonmckenzie/oncogeriatrics-health-economics.

Competing interests

No actual or personal competing interest are declared.

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Authors' contributions

Conception and Design: GM; Data Collection: GM; Analysis and Interpretation of Data: GM, SK, SP, MJ, ML; Manuscript Writing: GM; Approval of Final Article: GM, SK, SP, MJ, ML.

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TABLES

Consequences of geriatric assessment

Prediction of adverse outcomes to assist shared decision-making [6]
Improved data on risk/benefit ratio for procedural informed consent [6]
Opportunity to undertake holistic optimisation prior to treatment [6]
Identification of candidates for surgical or chemotherapy prehabilitation [39]
Recognising and fulfilling unmet needs [6]
Reduction in falls following chemotherapy [40]
Increased medication discontinuation [40]
Improved patient and caregiver satisfaction with communication [41]
Mitigation of future medico-legal risk
Improved quality of life in geriatric specific domains [42]
Reduced early treatment discontinuation [43]
Reduced chemotherapy treatment modification [44]
Increased advanced directive completion [9]
Big data collection for research and development [45]
Potential positive effects on a range of outcomes, which are centre dependent [8]

Table 1 – Consequences of geriatric assessment. The consequences of undertaking GA can be considered by decision-makers separate to or alongside cost-utility evaluation.

Model	Description	Assumptions	Additional probabilistic sensitivity analysis (PSA)
A	The most resource intense implementation configuration, requiring a dedicated MDT, representing a geriatric oncology service. A nurse will undertake an initial GA (60 minutes) and a consultant will also review the patient in person (30 minutes), amounting to the highest possible pre-treatment costs from human resources. A technological solution is not employed to aid GA data collection.	• The potential effects of reducing chemotherapy toxicity and surgical complications are modelled using data from exemplar studies. • Differences in costs arising from treatment changes are included by modelling treatment changes from using GA results within the cancer MDT.	• One-way PSA neutralising the effect of GA on post-surgical complications • One-way retaining the effect on post-surgical complications but removing the effect on chemotherapy toxicity rates. • One-way removing the effects of treatment changes at the MDT-level but maintaining the perioperative effects
B	A nurse or other trained healthcare worker is primarily involved in ensuring the GA is undertaken, supported by technology, to reduce the number of clinician-led GAs that need to be undertaken. A Band 6 nurse must dedicate 30 minutes of time to each patient.	• **As for Model A**	• One-way PSA removing the positive perioperative and chemotherapy effects
C	A replica of model B but exclusively for patients selected to undergo chemotherapy. The pretreatment costs mirror those of model B. Any effect on cancer treatment changes would be lost and the sole intention of this model would be for optimisation prior to chemotherapy, in attempt to reduce toxicity.	• GA would no longer influence the treatment decision-making at the cancer MDT-level. • The potential effects of reducing chemotherapy toxicity are modelled using data from an exemplar study.	• One-way PSA removing the potential effects on chemotherapy toxicity • One-way PSA increasing the human resources (i.e. undertaking model A as a prechemotherapy geriatric oncology model).
D	Like the preoperative CGA model reported by Partridge *et al.*[46] and could take either the form of model A or B. Only patients selected for surgery would undergo a preoperative GA. Like model C, this would essentially be a preoperative optimisation service.	• **As for model C**, but considering potential effects of reducing surgical complications	• One-way PSA removing the potential effects on surgical complications • One-way PSA increasing the human resources

Table 2 – Different models of implementation configurations. *Abbreviations: GA = geriatric assessment; CGA = comprehensive geriatric assessment; MDT = multi-disciplinary team; PSA = probabilistic sensitivity analysis.*

	Implementation configuration Mean (2.5th and 97.5th percentile values)			
	A	**B**	**C**	**D**
Differences in cost per patient				
Pretreatment (£)	576 (-735 to 1,486)	390 (-924 to 1,324)	389 (-924 to 1,324)	405 (-924 to 1,324)
Posttreatment (£)	-78 (-6,151 to 6,929)	-102 (-6,270 to 6,929)	-67 (-3,437 to 3,437)	45 (-5,994 to 5,758)
Chemotherapy toxicity (£)	-19 (0 to 0)	-8 (0 to 0)	-68 (-3,437 to 3,437)	0
Postoperative bed days (£)	-356 (-4,679 to 3,893)	-381 (-4,980 to 3,629)	0	49 (-4,661 to 4,728)
Other postoperative costs (£)	-77 (-3,523 to 2,160)	-113 (-3,523 to 2,160)	0	-4 (-3,523 to 3,523)
Treatment changes (£)	420 (0 to 6,929)	401 (0 to 6,929)	0	0
Total pre- and post-treatment (£)	497 (-5,602 to 7421)	287 (-6,100 to 7,151)	322 (-3,275 to 3508)	451 (-5,723 to 6,382)
Discounted QALYs over 10 years	0.13 (-6.47 to 6.54)	0.06 (-6.5 to 6.51)	0.09 (-6.52 to 6.52)	0.07 (-6.5 to 6.52)
INHB of GA compared to standard care (QALYs)				
CET = £13,000	**0.09 (-6.04 to 5.97)**	**0.03 (-6.03 to 5.96)**	**0.06 (-6.27 to 6.25)**	**0.04 (-6.06 to 6.03)**
CET = £20,000	**0.11 (-6.19 to 6.17)**	**0.04 (-6.19 to 6.15)**	**0.07 (-6.36 to 6.35)**	**0.05 (-6.21 to 6.2)**
CET = £30,000	**0.12 (-6.28 to 6.29)**	**0.05 (-6.3 to 6.27)**	**0.07 (-6.41 to 6.41)**	**0.06 (-6.31 to 6.31)**
Probability INHB < 0 (decision error)	0.44	0.44	0.44	0.44
Expected cost of uncertainty per patient (QALYs)	2.82	2.81	2.86	2.91

Table 3 – Economic evaluation results for various implementation configurations. *Abbreviations: QALYs = quality adjusted life years; INHB = incremental net health benefit; GA = geriatric assessment; CET = cost-effectiveness threshold.*

FIGURES

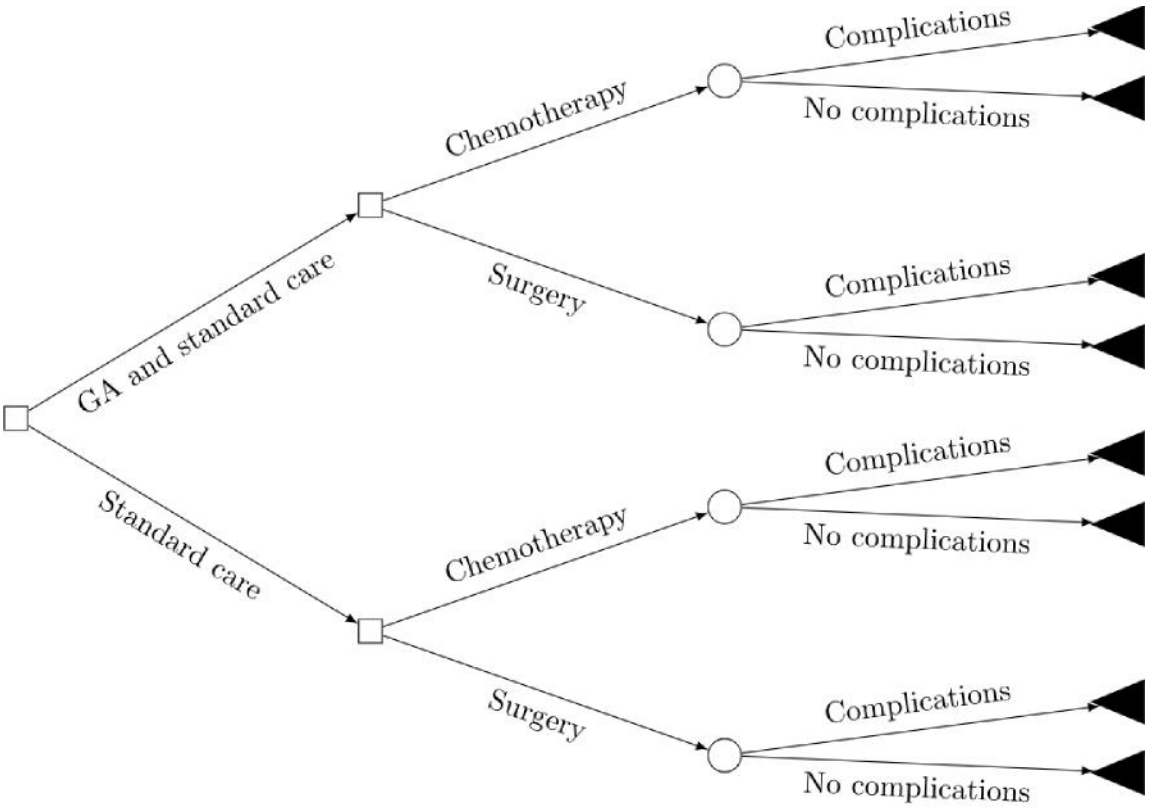

Figure 1 – Decision analytic model. Patients enter the pathway and either receive GA in addition to standard care or standard care only. Each patient is allocated a first-line treatment, either chemotherapy or surgery and has a risk of developing complications.

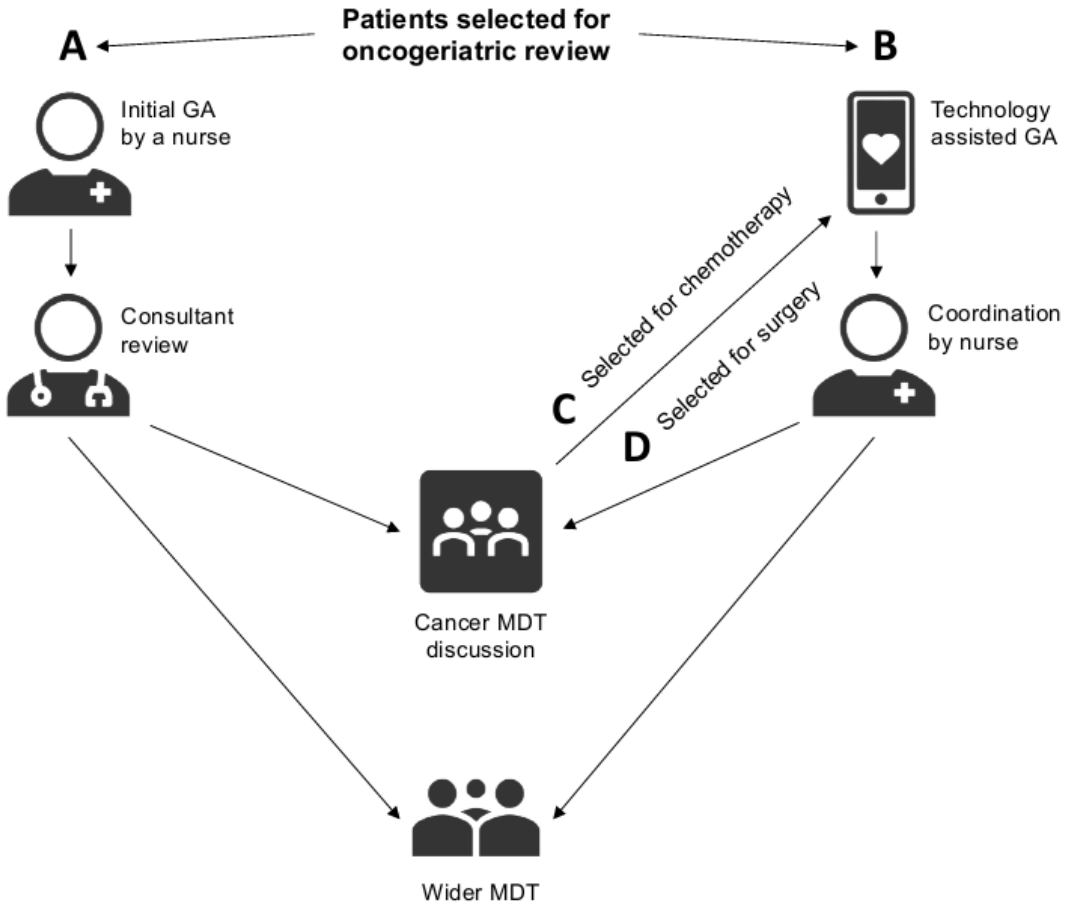

Figure 2 – Diagram illustrating the differences in implementation models in Table 2. A represents a geriatric oncology model; B a screen, predict and refer' model; C a prechemotherapy model; and D is a preoperative model. *Abbreviations: GA = geriatric assessment; MDT = multi-disciplinary team.*

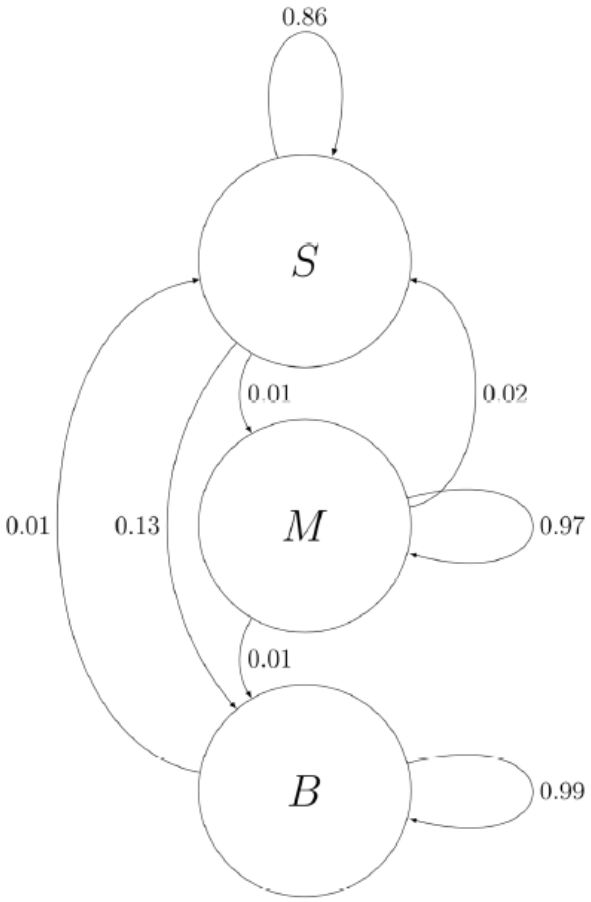

Figure 3 – Homogenous Markov chain state transition diagram for changes in management following geriatric assessment. Patients start in one of the following initial states derived from national data on treatment allocation for this age group: single modality (*S*) treatment (e.g. surgery only); multi-modality (*M*) treatment (e.g. chemotherapy and surgery); or best supportive care (*B*). Geriatric assessment may cause a change in management according to the transition probabilities above. This change in management is associated with a cost difference.

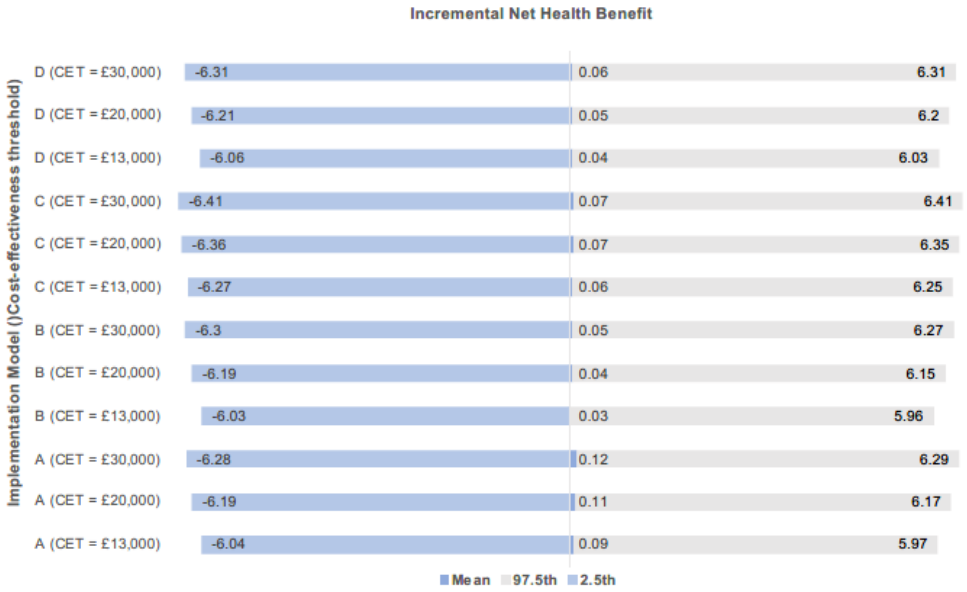

Figure 4 – Tornado diagram representing the difference (mean, 2.5th and 97.5th percentile) in incremental net health benefit between different implementation models according to three cost-effectiveness thresholds (CETs).

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