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Cost-effectiveness analysis of the Geriatric Fracture Center (GFC) concept: a prospective multicentre cohort study

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ABSTRACT

Introduction Geriatric Fracture Centers (GFCs) are dedicated treatment units where care is tailored towards elderly patients who have suffered fragility fractures. The primary objective of this economic analysis was to determine the cost-utility of GFCs compared with usual care centres.

Methods The primary analysis was a cost-utility analysis that measured the cost per incremental quality-adjusted life-year gained from treatment of hip fracture in GFCs compared with treatment in usual care centres from the societal perspective over a 1-year time horizon. The secondary analysis was a cost-utility analysis from a societal perspective over a lifetime time horizon. We evaluated these outcomes using a cost-utility analysis using data from a large multicentre prospective cohort study comparing GFCs versus usual care centres that took place in Austria, Spain, the USA, the Netherlands, Thailand and Singapore.

Results GFCs may be cost-effective in the long term, while providing a more comprehensive care plan. Patients in usual care centre group were slightly older and had fewer comorbidities. For the 1-year analysis, the costs per patient were slightly lower in the GFC group (–$646.42), while the quality-adjusted life-years were higher in the usual care centre group (+0.034). The incremental cost-effectiveness ratio was $18 863.34 (US$/quality-adjusted life-year). The lifetime horizon analysis found that the costs per patient were lower in the GFC group (–$7210.35), while the quality-adjusted life-years were higher in the usual care centre group (+0.02). The incremental cost-effectiveness ratio was $320 678.77 (US$/quality-adjusted life-year).

Conclusions This analysis found that GFCs were associated with lower costs compared with usual care centres. The cost-savings were greater when the lifetime time horizon was considered. This comprehensive cost-effectiveness analysis, using data from an international prospective cohort study, found that GFC may be cost-effective in the long term, while providing a more comprehensive care plan. A greater number of major adverse events were reported at GFC, nevertheless a lower mortality rate associated with these adverse events at GFC. Due to the minor utility benefits, which may be a result of greater adverse event detection within the GFC group and much greater costs of usual care centres, the GFC may be cost-effective due to the large cost-savings it demonstrated over the lifetime time horizon, while potentially identifying and treating adverse events more effectively. These findings suggest that the GFC may be a cost-effective option over the lifetime of a geriatric patient with hip fracture, although future research is needed to further validate these findings.

Level of evidence Economic, level 2.

Trial registration number NCT02297581.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ This study is strengthened by the thorough use of sensitivity analyses to evaluate the robustness of the results. In conducting multiple forms of sensitivity analysis across many variables in the model, there is greater confidence that the results seen are not a result of arbitrary choices of parameters in the model.

⇒ A limitation is that there are prognostic differences between the two patient populations, which is seen by reviewing the Charlson Comorbidity Index between treatment groups. Although sensitivity analysis was aimed to help account for the apparent prognostic imbalance between the groups, this is not a complete resolution of the issues that arise due to this imbalance.

⇒ A number of assumptions were plausibly implemented within the model. For example, the health state utility values were considered the same within each country, although it is possible that there is cultural heterogeneity within each country that impacts patient perceptions of their health state.

⇒ Finally, missing data for the EQ-5D scores within the observational study may also have affected the results. This limitation was mitigated by using multiple imputation to address the missing EQ-5D data.

INTRODUCTION

Orthogeriatric co-management in patients with fragility fractures was first introduced in Australia and the UK in the 1950s.[1] This concept has evolved to the current Geriatric Fracture Centers (GFCs) where dedicated and specialised care is provided to patients with fragility fracture. In these centres, an interdisciplinary team follows standardised pathways to provide comprehensive care for the medical and surgical needs of this population.[2–4] Efficacy studies have reported that patients treated in GFCs experience significantly fewer complications, have a shorter length of hospital stay and are operated on sooner than patients treated at usual care centres (UCCs).[5–8]

Few economic analyses have been conducted to evaluate the cost-effectiveness of the orthogeriatric model of care for elderly hip fracture; however, these preliminary economic studies have indicated that GFC models could potentially provide cost-effective orthogeriatric care.[5 9 10]

These previous studies set a foundation for understanding the cost-effectiveness of the GFC model in limited populations. The aforementioned studies took place using cohorts in single tertiary centres in a single country. To adequately support health intervention selection at the practice and policy level, unit costs from multiple centres and many geographical regions should be considered in cost-effectiveness studies. To address this gap in the literature, we conducted a multicentre prospective cost-effectiveness analysis comparing the GFC model versus UCC.

METHODS

Study design

A cost-utility analysis was performed using data from a large multicentre prospective cohort study comparing GFC versus UCC that took place at six GFCs and six UCCs in Austria, Spain, the USA, the Netherlands, Thailand and Singapore. UCC refers to 'usual' or 'conventional' orthopaedic trauma care, while GFCs provided specific orthogeriatric care. This prospective multicentre cohort study was conducted in six GFCs and six UCCs from Austria, Spain, the USA, the Netherlands, Thailand and Singapore. Accounting for local variations, the same number of GFCs and UCCs from a given country was included. To qualify as GFC, centres needed to have a predefined treatment path for geriatric patients, guaranteeing a fast track in the emergency room, daily communication among involved specialists, regular visits of a geriatrician preoperatively and postoperatively, daily physiotherapy and access to social workers, whereas UCCs would follow their usual procedures, not involving these features as a standard. Main inclusion criteria were an age of 70 years or older and an operatively treated proximal femur fracture. All patients were treated per standard of local care. The complete clinical methods and results of this study were published elsewhere.[11]

Primarily, a cost-utility analysis measured the cost per incremental quality-adjusted life-year (QALY) gained from treatment of hip fracture in a GFC compared with treatment in a UCC from the societal perspective over a 1-year time horizon. The secondary analysis was a cost-utility analysis that assessed the cost per QALY gained from treatment of hip fracture in a GFC compared with treatment in the UCC from a societal perspective over a lifetime time horizon.

Patient and public involvement

Patients were not involved in the design of this study. The study was designed to directly benefit patients by providing insights into optimal care for a complex patient population.

Resource use and associated costs

In-hospital resources were collected for both the initial hospitalisation and for any subsequent hospitalisation that were related to the hip fracture. Each participant recorded healthcare resources used, out-of-pocket expenses and the total costs (if known) associated with each item in a cost diary. In cases of missing resource utilisation data, we obtained values from the literature, using resource use estimates for first osteoporotic hip fracture reported in Caeiro *et al*.[12] Resource utilisation by geographical region is provided in online supplemental tables A1 and A2.

Costs were calculated for the base case using costs provided by each participating clinical site. Region-specific costs for Europe, North America and Asia were obtained from the available literature. When we encountered missing unit cost data, we substituted costs from countries in the study with similar economic characteristics. When this was not possible, unit costs from the USA corrected to 2016 were used. Unit costs and their reference are included within online supplemental tables A3 and A4. The CCEMG-EPPI-Centre Cost Converter was used to convert all unit costs into US$ 2016 values for each resource, where unit costs were provided in a different currency or different price year.[13] Costs associated with adverse events (AEs) are included in online supplemental table A5.

Utilities

Utility scores were derived from the EQ-5D-3L, which was administered at 12 weeks and at 12 months post-fracture as part of the observational study. Utility scores for health states beyond what was captured in our 1-year follow-up were drawn from the hip fracture literature.[14–17] Multiple imputation was used for missing EQ-5D-3L scores at the index level using scores for the same treatment group.[18]

Decision tree parameters

The probability of experiencing a health state (ie, healed fracture, major AE (MAE), serious AEs, other AEs, mortality) within the 1-year time horizon was determined using data from the cohort study. MAEs included: delirium, congestive heart failure, pneumonia, deep vein thrombosis, pulmonary embolism, pressure ulcers and myocardial infarction. The decision model was built using Treeage Pro (V.2011, Williamstown, Massachusetts, USA).

Cost-utility analysis

An incremental cost-effectiveness ratio (ICER) was calculated for the base case (data provided by all of the clinical sites) and subgroup analysis for Europe, North America and Asia. A probabilistic Markov model was developed to estimate expected values for costs and QALYs for both treatment groups over a base case time horizon of 1 year. Results were obtained with a Monte Carlo simulation of the developed Markov model with 1000 iterations. The model parameters were drawn from the clinical study data at 12-month follow-up for costs, utilities and probabilities, with multiple imputation performed to obtain a complete utility dataset.

An analysis of a lifetime time horizon was also conducted. A Markov state-transition decision analytical model was used to represent these processes that evolve over time using 1-year cycle lengths. All costs and utilities were discounted using an annual rate of 3.5%. A number of assumptions were made for the model including the following: the average age of patients considered in the model was 83 years, which was the average age of the observational study participants. Within the lifetime time horizon, patients who healed and did not incur an additional fracture were considered to not have additional risk of mortality or morbidity compared with the general population of this age group.[19 20] The probability of mortality in this group was assumed to be 0.37.[19] Cost per QALY gained analyses were assessed under a willingness-to-pay threshold of US$50 000, which is a conservative convention within cost-utility analyses. Finally, a half-cycle correction was used for all costs and utilities to account for transitions that occurred gradually throughout each cycle.

Sensitivity analyses

One-way and probabilistic sensitivity analyses (PSAs) were conducted to address the uncertainty around base case results. The following variables were included in the sensitivity analyses: total direct costs, cost of index hospital stay, cost of outpatient care, cost of AEs and revisions, cost of readmission, total indirect costs, total cost, utility for a healed fracture, utility for revision, utility for an MAE with no persistent damage, utility for an MAE with persistent damage, utility for an AE with no persistent damage, utility for an AE with persistent damage, regional ICER values and rates for the following: overall complications in patients with comorbid conditions, 1-year mortality, readmission to hospital, revision surgery mortality, healed fracture, successful revision and assisted living. The PSA was performed using a Monte Carlo simulation of 100 000 iterations. Costs were assumed to have a gamma distribution. Utilities and probabilities were assumed to have beta distributions.

RESULTS

Study participants

A total of 281 patients were enrolled, with 142 being enrolled at GFCs and 139 being enrolled at UCCs. The age of patients within the UCC group was slightly older than the GFC group (83.9 vs 81.9, p=0.01). The demographic characteristics between participants enrolled at GFCs and UCCs were similar, apart from the baseline Charlson Comorbidity Index (CCI), which was significantly greater within the GFC group (p>0.01) (table 1).

Model structure

The 1-year time horizon model decision tree is provided in figure 1, which shows the structure of the decision tree used for the cost-utility analysis.

Cost-utility analysis

Within a 1-year time horizon, utilities were higher in the UCC group compared with the GFC group, with a difference of 0.034. Costs were lower in the GFC group by $646.42 per participant. The ICER for UCC use was $18 863.34 (US$/QALY) (table 2). The ICER for UCC use for Europe was $4657.67 (US$/QALY).

Within a lifetime time horizon, the GFC was seen to provide cost-savings of $7210.35, with a slightly lower utility (−0.02). The ICER for UCC use was $320 678.77 (US$/QALY) (table 2). Compared with a willingness-to-pay threshold of $50 000, the GFC model is cost-effective over this lifetime time horizon.

Sensitivity analyses

The impact of uncertainty in single parameters on the uncertainty of the ICER of being treated at a GFC compared with a UCC was depicted using a tornado plot (online supplemental figure A1). The one-way sensitivity ICER values ranged from −$3492.73 to $41 219.30 for UCC, with indirect costs, cost of GFC treatment (above the costs of UCC) and other AE treatment being the model variables with the largest impact on the ICER. The PSA provided an inconclusive assessment of the cost-effectiveness, as the ellipsis is almost equally on the positive and negative sides of the willingness-to-pay threshold for GFC (figure 2). A summary of the base case total costs per patient 1 year post-fracture associated with each treatment centre (GFC/UCC) and ranges used in sensitivity analysis are summarised in online supplemental table A6.

Adverse events

Clinical parameters, event probabilities and health state utilities used within the decision tree model are summarised in online supplemental table A7. The all-cause mortality rate in patients treated at a GFC was 14.1% compared with 10.8% in those treated in a UCC. Mortality in patients treated at a GFC with MAEs, however, was 32.5% (13 of 40) compared with 45.5% (5 of 11) in patients treated at a UCC. In contrast, the mortality rate in patients with other AEs was 13.5% in patients treated at a GFC compared with 15.8% in patients treated at a UCC. The most common MAEs identified were delirium, followed by pneumonia. In participants with these AEs occurring at any time, 47.4% and 52.9% of participants died, respectively.

Table 1 Participant demographics

	GFC N=142	UCC N=139	Total N=281	P value
Gender, n (%)				
Female	100 (70.4)	107 (77.0)	207 (73.7)	0.212*
Male	42 (29.6)	32 (23.0)	74 (26.3)	
Age (years)				
Mean (SD)	81.9 (6.6)	83.9 (6.9)	82.9 (6.8)	0.013†
Race, n (%)				
Caucasian	91 (64.1)	84 (60.4)	175 (62.3)	
Black	2 (1.4)	1 (0.7)	3 (1.1)	0.543‡
Asian	49 (34.5)	52 (37.4)	101 (35.9)	
Mixed	0 (0.0)	0 (0.0)	0 (0.0)	
Other	0 (0.0)	2 (1.4)	2 (0.7)	
Smoking status, n (%)				
No	132 (93.0)	132 (95.0)	264 (94.0)	0.481*
Yes	10 (7.0)	7 (5.0)	17 (6.0)	
Falls in the previous 3 months, n (%)				
Yes	63 (48.1)	35 (26.1)	98 (34.9)	<0.001*
No	68 (51.9)	99 (73.9)	167 (59.4)	
Residential status (at baseline), n (%)				
Non-facility	122 (85.9)	122 (87.8)	244 (86.8)	0.646*
Facility	20 (14.1)	17 (12.2)	37 (13.2)	
Charlson Comorbidity Index				
Mean (SD)	2.0 (2.1)	1.2 (1.5)	1.6 (1.8)	0.001†

The Charlson Comorbidity Index was calculated for each patient as a weighted sum of the 20 questions on the 'Charlson Comorbidity Index' form. The following comorbid conditions were mutually exclusive: diabetes with chronic complications and diabetes without chronic complications; mild liver disease and moderate or severe liver disease; and any malignancy and metastatic solid tumour. As such, lymphoma, leukaemia and solid tumour were combined for calculating the total score, and the combined response set to 'no' if metastatic solid tumour was 'yes'; diabetes should be set to 'no' if diabetes with end-organ damage was 'yes'; mild liver disease should be set to 'no' if moderate or severe liver disease was 'yes'. This resulted in a Charlson Comorbidity Index that ranges from 0 to 29 with higher scores indicating a greater burden of comorbid conditions.
*X^2 test.
†t-test.
‡Fisher's exact test.
GFC, Geriatric Fracture Center; UCC, usual care centre.

DISCUSSION

The base case analysis from the payer's perspective found that the GFC was associated with a lower mean cost per patient and a lower utility compared with patients treated in UCC. Sensitivity analysis found that the 1-year base case analysis results were not robust under alterations through PSA. These findings suggest uncertainty in the 1-year base case findings, as there is no apparent difference in GFC or UCC cost-effectiveness in the 1-year time horizon.

Results of the lifetime horizon demonstrated more apparent cost-savings of the GFC model. Additionally, the utility benefits of UCC were 0.02 over the lifetime horizon, which does not meet the minimally clinically important difference for this measure.[21] The ICER value for the additional 0.02 utility gained in the UCC did not meet the willingness-to-pay threshold of $50 000, which suggests that the GFC may be a more cost-effective option over the longer term.

These results need to be interpreted cautiously due to differences in prognostic variables between the two treatment options. In the current study, the CCI was used to assess baseline comorbidity differences between treatment groups. The GFC group scored significantly higher scores on the CCI compared with the UCC group, demonstrating that the proportion of participants with comorbid conditions included in the CCI at the time of hip fracture treatment was significantly higher in this group. To account for this difference, the sensitivity analyses included an assessment that varied based on the inclusion of participants with comorbid conditions at the time of hip fracture treatment. Sensitivity analyses showed that this adjustment resulted in ICERs more favourable

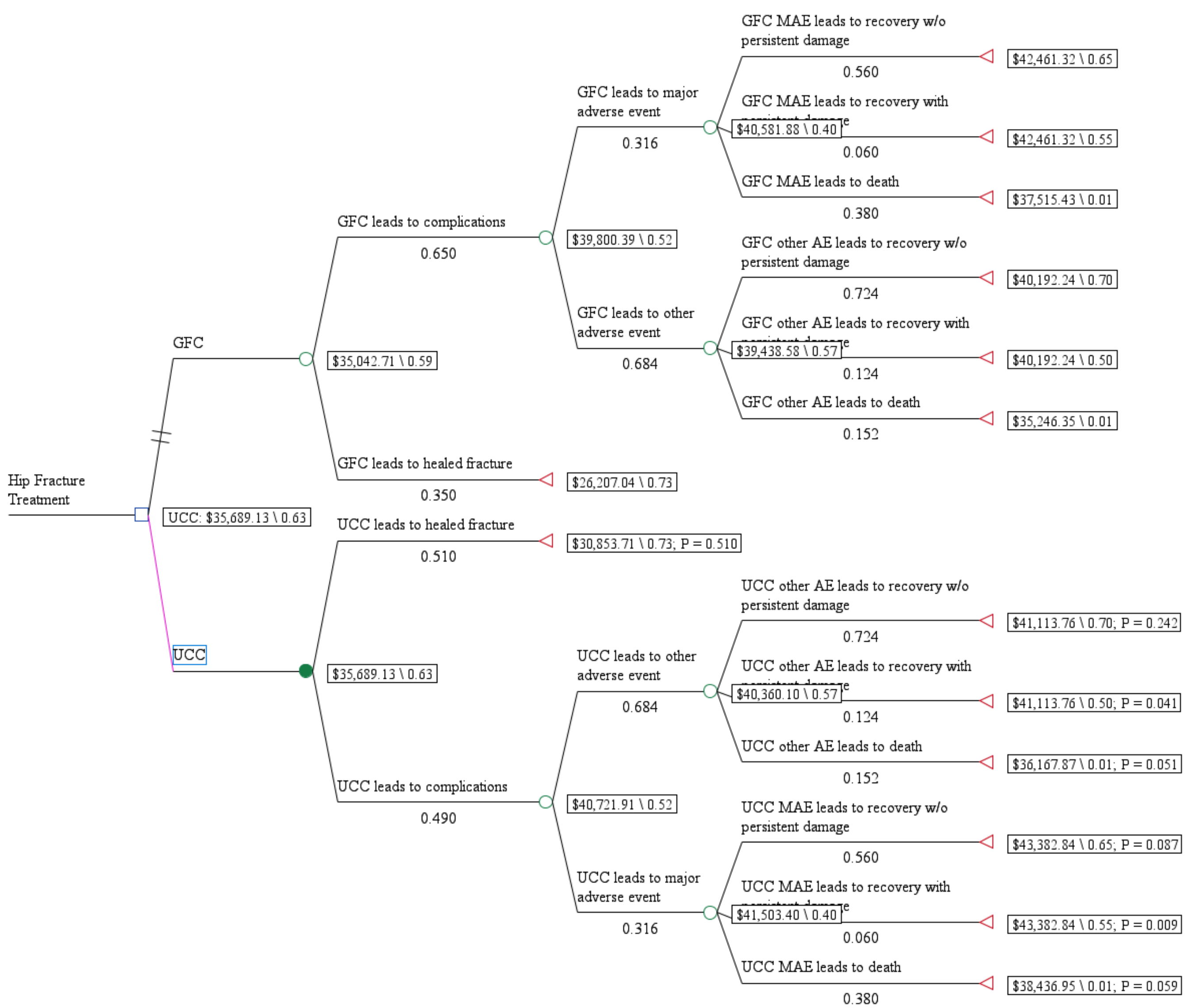

Figure 1 One-year time horizon decision tree. AEs, adverse events; GFC, Geriatric Fracture Center; MAE, major AE; UCC, usual care centre.

towards treatment at a GFC but did not change conclusions of the base case model. Other studies evaluating outcome after hip fracture treatment that adjusted for comorbid conditions at baseline also found that it has a modest impact on findings.[22 23]

The GFC group also had a higher reporting of MAEs, which likely is reflected in the lower mean utility. It is plausible that GFCs may better detect MAEs in this population. It is expected that patients attending the GFC are receiving more comprehensive care instead of solely providing management of fracture-related outcomes, which may result in an increased detection of MAEs. These events may also be occurring within the UCC patient population but may not have been detected due to different interactions with healthcare professionals.

Additionally, there is evidence that there is elevated risk of mortality following geriatric hip fracture with the presence of serious concomitant illness and marked delirium,[24 25] which may impact on a heightened awareness of risk of MAEs at GFCs. This is supported by the significantly higher CCI found in patients treated at GFCs compared with patients treated at UCCs. While sensitivity analysis aimed to account for pre-existing comorbidities, this approach cannot fully account for the prognostic imbalances between these groups.

Previous studies have suggested that orthogeriatric care may provide cost-savings, which is a similar finding to the current study.[9 20] A cost-effectiveness study of the orthogeriatric model administered to treat hip fractures in an academic trauma centre in the USA showed that patients treated in the orthogeriatric setting required less total days of hospitalisation and less intensive care unit (ICU) admission than patients treated in the control group.[9] Results in the current study are consistent with these findings, as our study found that patients treated for hip fracture in a GFC had shorter length of hospital stay

Table 2 Base case cost-utility and cost-utility by geographical region

Treatment	Cost in US$ Mean	Total QALYs Mean	Difference in QALYs Mean	Difference in costs Mean	ICER US$/QALYs
Base case					
GFC	$35 042.71	0.59	–	–	–
UCC	$35 689.13	0.63	0.034	$646.42	$18 863.34
Europe					
GFC	$33 563.04	0.59	–	–	–
UCC	$33 722.64	0.63	0.034	$159.61	$4657.67
North America					
GFC	$55 262.68	0.59			
UCC	$55 204.14	0.63	0.034	$–58.54	Dominates
Asia					
GFC	$33 174.51	0.59	–	–	–
UCC	$29 545.56	0.63	0.034	$–3,628.95	Dominates
Lifetime time horizon					
GFC	$85 752.66	1.81	–	–	–
UCC	$92 963.01	1.83	0.02	$7210.35	$320 678.77

GFC, Geriatric Fracture Center; ICER, incremental cost-effectiveness ratio; QALYs, quality-adjusted life-years; UCC, usual care centre.

for the index hospitalisation, but similar length of stay in the ICU.

A comprehensive cost-effectiveness analysis of the orthogeriatric model in the UK conducted to establish National Health Service costs found that patients with hip fracture treated in orthogeriatric facilities are associated with reductions in mortality rates and are cost-effective, though differences reported are small in magnitude.[20] Our study found an overall mortality rate of 12.5%, which is lower than that typically seen within other studies of the population with geriatric fracture.[26 27] This will have impacted on group differences being observed in utility scores and shifts in cost-effectiveness, when type of AE was considered. Nevertheless, the mortality rate of patients with MAEs was higher in UCC.

This study is strengthened by the thorough use of sensitivity analyses to evaluate the robustness of the results. In conducting multiple forms of sensitivity analysis across many variables in the model, there is greater confidence that the results seen are not a result of arbitrary choices of parameters in the model.

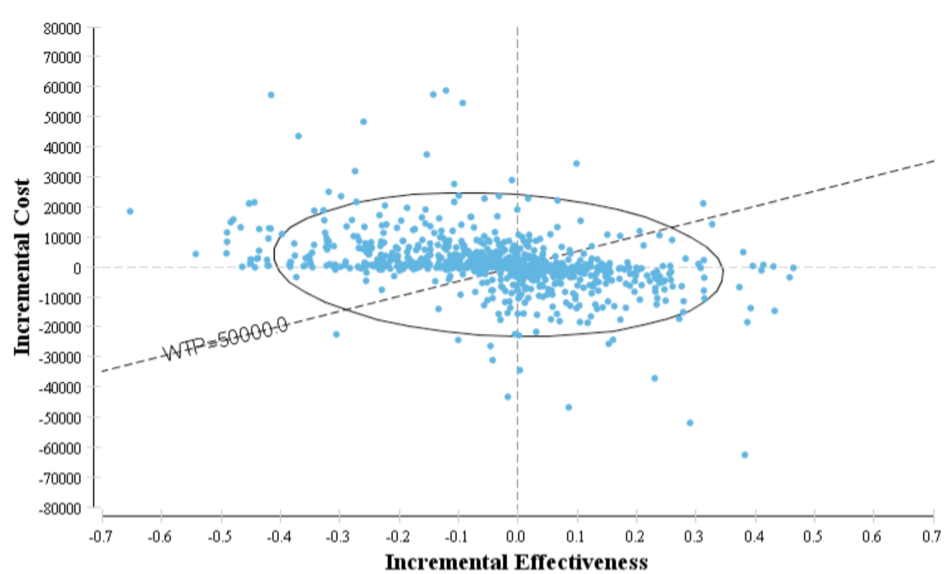

Figure 2 One-year probabilistic sensitivity analysis for Geriatric Fracture Center versus usual care centre. WTP, willingness-to-pay.

Despite these strengths, there are several limitations. The first limitation is that study participants were not randomised to treatment centre (GFC vs UCC). Without randomisation, it is likely that there are prognostic differences between the two patient populations, which is seen by reviewing the CCI between treatment groups. Although sensitivity analysis was aimed to help account for the apparent prognostic imbalance between the groups, this is not a complete resolution of the issues that arise due to this imbalance. Second, the indirect and outpatient costs used in the model were provided within a cost diary that was not reliably completed by participants. Third, a number of assumptions were plausibly implemented within the model. For example, the health state utility values were considered the same within each country, although it is possible that there is cultural heterogeneity within each country that impacts patient perceptions of their health state. Finally, missing data for the EQ-5D scores within the observational study may also have affected the results. This limitation was mitigated by using multiple imputation to address the missing EQ-5D data.

Conclusions

This comprehensive cost-effectiveness analysis, using data from an international prospective cohort study, found that GFC may be cost-effective in the long term, while providing a more comprehensive care plan. A greater number of MAEs were reported at GFC, nevertheless a lower mortality rate associated with these AEs at GFC. GFC had slightly lower utility than UCC at one and lifetime time points; however, utility penalties in the model were assigned upon detection of an AE. Due to the minor utility benefits, which may be a result of greater AE detection within the GFC group and much greater costs of UCC, the GFC may be cost-effective due to the large cost-savings it demonstrated over the 10-year period, while potentially identifying and treating AEs more effectively. These findings suggest that the GFC may be a cost-effective option over the lifetime of a geriatric patient with hip fracture, although future research is needed to further validate these findings.

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Competing interests AJ—employed by AO Foundation. SS—paid employee of Global Research Solutions. JHH—board member of the Dutch Society for Trauma Surgery; chairman of the Dutch Hip Fracture Audit. EG—fees to institution to support research by AO Foundation; member of the EFFORT European Federation Orthopaedic and Trauma; former president of SECOT Spanish Orthopaedic and Trauma Society. TJR—support for presenting manuscript by AO Foundation. RJ—honoraria from regional faculty for AO Trauma. MB—grants and fees from Depuy Synthes. MG—honoraria from Amgen, advisory board with UCB Pharma, president elect of the German Geriatric Society. MP—paid employee of Global Research Solutions. PW, MP, EBKK, MKW, CP-U, SZ, DJ—no conflicts.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not required.

Ethics approval Ethics approval was not required for this study.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement All data relevant to the study are included in the article or uploaded as supplemental information.

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