ABSTRACT

Objective

To estimate threshold prices for computer and robot-assisted knee and hip replacement.

Methods

A lifetime cohort Markov model provided the framework for analysis. Linked primary care and inpatient hospital records informed estimates of outcomes under current practice. Outcomes under a range of hypothetical relative improvements in quality of life if unrevised and in revision risk following computer or robot-assisted surgery were then estimated. Threshold prices, a price at which the net health benefit from funding the intervention would be zero, for these improvements were estimated for a cost-effectiveness threshold of £20,000 per additional QALY gained.

Results

For average patient profiles under current knee and hip replacement practice, lifetime QALYs were 10.3 (9.9 to 10.7) and 11.0 (10.6 to 11.4), with costs of £6060 (£5947 to £6203) and £6506 (£6335 to £6710) for knee and hip replacement, respectively. A combined 50% relative reduction in risk of revision and 5% improvement in post-operative quality of life if unrevised would, for example. result in QALYs increasing to 10.9 (10.4 to 11.3) and 11.6 (11.2 to 12.0), and costs falling to £5880 (£5816 to £5956) and £6258 (£6149 to £6376) after knee and hip replacement, respectively. These particular improvements would have an associated threshold price of £11182 (£10691 to £11721) for knee replacement and £12134 (£11616 to £12701) for hip replacement.

Conclusions

At current prices, computer and robot-assisted knee and hip replacement will likely need to lead to improvements in patient-reported outcomes in addition to any reduction in the risk revision.

HIGHLIGHTS

- This study provides estimates of threshold prices for a range of potential improvements in the effectiveness of knee and hip replacement that could be realised from the adoption of computer and robot-assisted knee and hip replacement.

At a cost-effectiveness threshold of £20,000 per additional QALY, the threshold price for a 5% improvement in post-primary unrevised quality of life (approximately equivalent to an additional two points in post-operative OKS/ OHS) would be £10,000. The threshold price for a 50% reduction in the risk of revision would be £1,000 per procedure.

INTRODUCTION

Knee and hip replacement typically lead to substantial improvements in pain, function, and overall health-related quality of life. As a result, both procedures are considered to be cost-effective when compared with non-surgical alternatives for patients with symptoms that are refractory to non-surgical treatment.[1,2] Patients typically achieve more than 60% and 80% of their potential improvement in patient-reported outcomes after knee and hip replacement, respectively. There is, though, substantial variation in outcomes, with 16% and 8% of patients reporting either the same or worse patient-reported outcomes after knee and hip replacement, respectively.[3] In addition, after surgery there remains an enduring risk of revision, where implant components are removed, added, or exchanged. While the risk of revision is relatively low for older patients, the lifetime risk of revision may be as high as 35% for men in their early 50s.[4] Undergoing a revision procedure is associated with a substantial drop in quality of life,[5] and revisions are even more costly for providers than primary procedures.[6]

There has been a long and continuing history of innovation in knee and hip replacement. One area of innovation has been around the development of computer-navigated and robotic-assisted systems, which have been developed to control component positioning and, in some cases, improve surgical precision.[7] While such systems are now used in around 7% of knee replacements in the US,[8] uptake in other contexts, such as the English NHS, has been limited.

The evidence base around the effectiveness of computer and robot-assisted systems in knee replacement is limited. While there is some evidence that they can lead to better implant positioning, evidence that these systems lead to meaningful improvements in long-term clinical outcomes is lacking.[9–11] While economic evaluations have been performed,[12–14] with one, for example, finding robot-assisted unicompartmental knee replacement to have an incremental cost of $47,180 per quality-adjusted life- years,[13] any such definitive conclusion is likely to be premature given the strong assumptions around the effectiveness underpinning these analyses.

A more general early stage economic evaluation of computer and robot-assisted knee and hip replacement can be used to help to inform current considerations around their potential cost-effectiveness, and for future decision-making as further evidence on the effectiveness of these systems emerges. The threshold price for computer and robot-assisted knee and hip replacement is the price at which the health benefits gained from their use will be offset by equivalent health displaced due to opportunity cost (i.e. where the net health benefit from funding them would be zero).[15] For a given health improvement, if the price of computer and robot-assisted knee and hip replacement fell below the associated threshold price, they would be considered cost-effective. Or, conversely, for a given increase in cost due to the technologies, threshold prices for health improvements would indicate the minimum improvement required for the additional cost to be considered acceptable.

In the absence of good evidence on their long-term effectiveness, threshold prices can be estimated for a plausible range of potential improvements. In this study, we estimate threshold prices for potential improvements in both quality of life after surgery and reductions in the revision risk following knee and hip replacement from the use of computer and robot-assisted systems.

METHODS

Costs and outcomes of knee and hip replacement under current practice were based on an analysis of routinely-collected data from the English NHS, with a state-based Markov model used to combine and extrapolate estimates over the lifetime of patients. The potential gains from improvements in the effectiveness of surgery was assessed by re-running the analysis for given improvements in the risk of revision (up to a 50% relative reduction), and quality of life after surgery if unrevised (up to a 5% relative improvement). Threshold prices were then estimated based on the willingness to pay for improvements in health outcomes.

Comparators

In this analysis we compared the costs and health care outcomes following knee and hip replacement under current practice with the costs and health care outcomes that would be expected for a range of hypothetical improvements due to the use of computer or robot-assisted surgery in 1) quality of life following surgery if unrevised (up to a 50% relative improvement), and 2) the annual risk of revision following surgery (up to a 5% relative improvement).

Setting and study perspective

The threshold prices estimated in this study are relevant for the National Health Service (NHS) of England and Wales, which has an explicit cost-effectiveness threshold set at between £20,000 and £30,000 per additional quality-adjusted life year (QALY) at the margin. This threshold can be seen as representing the opportunity cost of healthcare spending, with a given intervention being cost-effective if it leads to greater health gains than could have been generated by spending the money required to fund it on something else.[16] For the purposes of this study, threshold prices were estimated in the base case analysis at the lower bound of £20,000. As sensitivity analyses, threshold prices were also estimated at 30,000 and at 13,000, with the latter thought to be closer to the true opportunity cost of healthcare spending in the English NHS.[17] A health care system perspective is taken, with only the costs incurred by the NHS considered. Under the assumption that other health system care would be unaffected by changes in the effectiveness of surgery, only differences in hospital costs (from primary and revision surgeries) were incorporated in the analysis.

Target population and assessment of patient heterogeneity

The study population was those individuals undergoing knee and hip replacements in the UK. Threshold prices were first estimated for the average profile of patients undergoing these surgeries, based on the characteristics observed in the routinely collected data used in the analysis. We then considered how age and sex affect threshold prices, holding other patient characteristics fixed.

Time horizon and discount rate

Costs and health outcomes were estimated over patients remaining lifetimes. In line with guidelines,[18] both health outcomes and costs were discounted by 3.5% annually.

Decision analytic model

Knee and hip replacement were analysed separately, with a cohort state-based Markov model used as the framework for the analyses (Appendix Figure A1). The study cohort began by having a knee or hip replacement at time zero and were then at risk of revision or death. As yearly cycles passed individuals remained in the unrevised state, moved to the revision state, or died. After one year in the revision state they either moved to the revised state or died. Individuals who reached the revised state either remained there or died. The key modelling assumption was that individuals could only have one revision procedure.

Choice of health outcomes

Health outcomes were estimated in terms of QALYs, which combine both quality and quantity of life. The use of QALYs allows for the cost-effectiveness of interventions across disease areas to be assessed in the same manner and hence for resource allocation decisions to be made across the health system. As a result, the cost-effectiveness threshold was estimated in terms of cost per additional QALY gained.

Costs and health outcomes under current practice

A summary of model inputs is provided in Table 1 and are described in detail below.

Risk of revision

The decision model described above required estimates of two key transition probabilities: 1) risk of revision, and 2) risk of death. Both of these probabilities were based on an analysis of routinely collected English NHS data. Primary care data were extracted from practices within the Clinical Practice Research Datalink (CPRD), which is a large, representative database of anonymised records from general practices.[19] These data were linked to inpatient hospital records in England, provided by Hospital Episode Statistics Admitted Patient Care (HES APC), and mortality data from the Office for National Statistics (ONS). The linked dataset covered 1997 to 2014. A previous analysis of the lifetime risk of revision based on these data has been published, and the models used here were the same as reported in that paper.[20] 10,260 and 10,961 patients were included in the knee and hip replacement cohorts, respectively. Risk of revision and mortality were estimated using parametric survival models which were then combined and extrapolated, with long-term risk of revision estimated based on an extrapolation of the parametric survival model. Risk of mortality was expected to revert to age- and sex-specific UK lifetable risks after 10 years. Spline-based distributions were used for these models as they provided both the best fit to observed data, based on Akaike information criterion, and, where required, gave plausible extrapolations.[21] For the average patient profile, lifetime risk of revision was estimated to be 5.8% and 8.0% following knee and hip replacement, respectively. This is broadly in line with previous estimates of lifetime risks of revision.[4] Aside from age at surgery, other patient characteristics appeared to have relatively little impact on the lifetime risk of revision. These risks informed the estimation of risk of revision under current practice for this study.

Health-related quality of life

Routinely-collected patient reported outcome measures (PROMs) data from the NHS in England were used to inform estimates of health-related quality of life before and after knee and hip replacement. PROMs are completed before and approximately six months after surgery, with all patients undergoing knee and hip replacement funded by the English NHS invited to participate.[22] The EuroQol 5-dimension 3-level (EQ-5D-3L) questionnaire is one of the PROMs collected. The EQ-5D-3L questionnaire measures overall health-related quality of life, with questions covering five dimensions (mobility, self-care, usual activities, pain/discomfort, and anxiety/depression) with three possible response levels (no problems, some problems or extreme problems).[23] The combination of these dimensions and responses can be summarised as an index value or health utility estimate, which ranges from -0.59 (worst) to 1 (best) after applying preference-based utility weights obtained from the general UK population.[24] These health utility estimates are then multiplied by the length of time they are experienced to obtain QALYs. To contextualise the results, the predicted EQ-5D-3L index values were also mapped to Oxford Knee Score (OKS) and Oxford Hip Score (OHS).[25,26] OKS and OHS are joint-specific patient-reported outcome measures and range from 0 (worst) to 48 (best).[27]

HES PROMs data were linked to HES APC and CPRD records, allowing for an analysis of the relationship between patient characteristics with post-operative scores. This analysis has previously been published.[28] 2,212 and 2,128 individuals were included in the study cohorts for knee and hip replacement, respectively. Ordinary least square regressions were estimated with post-operative EQ-5D-3L index as the outcome and patient characteristics and pre-operative EQ-5D-3L index as explanatory variables. Pre-operative scores were associated with the largest impact on post-operative scores, with post-operative scores expected to improve as pre-operative scores increased. In general, older age, being male, having a lower socioeconomic status (as measured by the index of multiple deprivation (IMD)), having comorbidities, higher BMI and being a smoker were associated with worse post-operative scores.

Based on the patient profile at diagnosis (which included a given pre-operative EQ-5D-3L index), post-operative EQ-5D-3L index was predicted based on these regression models. In the year following a primary, patients were expected to steadily progress from their pre-operative score (specified as part of the patient profile) to their post-operative score at six months, at which they would remain for the rest of year. As scores have been seen to remain fairly stable over time,[29] those who remained unrevised were expected to stay at their post-operative score in subsequent years. The trajectory of quality of life following revision was assumed to be similar to that following primary procedures, with patients expected to progress from their pre-operative score to their post-operative score over six months, at which point they were expected to remain. Based on previous research,[30] quality of life before and after revision was assumed to be 75% of the corresponding scores for the primary procedure.

Costs

The CPRD and HES APC records used to estimate transition probabilities were also used to estimate costs of primary and revision procedures from a healthcare service perspective. This analysis of resource use has previously been published.[31] Hospital spells were assigned to Healthcare Resource Groups (HRGs), which group clinically similar treatments using common levels of healthcare resources and form the basis of hospital reimbursement. 2015/16 NHS reference costs (including the direct, indirect and overhead costs of providing one unit of care in a given financial year) were used to estimate procedure costs.[32] Generalised linear models (GLMs) with a gamma distribution and a log-link were used to estimate the effect of patient characteristics on these costs. Costs were predicted based on the patient profile at diagnosis and assigned to the relevant model state, with all of the cohort incurring the primary cost and the proportion who went on to undergoing a revision incurring a related cost based on their characteristics at time of revision.

Estimating threshold prices for improved effectiveness of surgery

After estimating the costs and QALYs associated with current practice, models were re-run for a relative reduction (improvement) in the risk of revision, a relative improvement in post-operative quality of life if unrevised, or a combination of both. Relative risks reductions for revision were incorporated by reducing the annual transition probability for revision by some given proportion, with reductions ranging from 0% (i.e. no change in the probability of revision) to 50% (i.e. halving the annual probability of revision). Relative improvements in post-operative quality of life if unrevised were incorporated by increasing the estimated health utility at six months following surgery for those in the unrevised health state in the model by a given amount, while health utility estimates for other health states remained unchanged. Relative improvements in post-operative quality of life if unrevised ranged from 0% to a 5% improvement. The 50% reduction in risk of revision and 5% improvement in quality of life if unrevised were specified as the upper limit for improvements as anything above this was considered to be implausible,

Threshold prices were then calculated for each given improvement in comparison to current practice for the given cost-effectiveness threshold. This was done by estimating the incremental net health benefit for the improvement at the cost-effectiveness threshold. Confidence intervals around these estimates were calculated through bootstrapping, with regression models re-estimated for bootstrap samples and the Markov models for current practice and given improvements re-run. Threshold prices were estimated for the average patient characteristics (median if continuous, mode if categorical) at time of surgery. The partial effect of age and sex on threshold prices was estimated by running models for varying values of age and sex, while other explanatory factors were held fixed at their average.

RESULTS

Under current practice lifetime risk of revision was estimated at 5.3% (3.7% to 7.3%) for the average patient profile (with a diagnosis of knee osteoarthritis, 71 years old, female, in the second least deprived IMD quintile, a Charlson score of 0, a BMI of 30, and a non-smoker) for knee replacement and 8.2% (5.5% to 11.5%) for the average patient profile (with a diagnosis of hip osteoarthritis, 70 years old, female, in the second least deprived IMD quintile, a Charlson score of 0, a BMI of 28, and a non-smoker) for hip replacement. Pre-operative health utility was specified as 0.52 for knee replacement and 0.36 for hip replacement. These are approximately equivalent to an OKS of 24.8 and OHS of 19.5 based on the mapping algorithms. Under current practice, post-operative health utility at six months was expected to increase to 0.82 (0.79 to 0.85) and 0.86 (0.83 to 0.88) after knee and hip replacement, approximately equivalent to an OKS of 38.3 and OHS of 41.7 (Appendix Figure A2). Current practice lifetime QALYs and costs for knee replacement were 10.3 (9.9 to 10.7) and £6060 (£5947 to £6203), and 11.0 (10.6 to 11.4) and £6506 (£6335 to £6710) for hip replacement.

The impact of a 50% relative reduction in risk of revision on transition probabilities is shown in Appendix Figure A3. This would result in lifetime risk of revision falling to 2.7% (1.8% to 3.7%) and 4.2% (2.8% to 6.0%), QALYs being 10.4 (9.9 to 10.7) and 11.0 (10.7 to 11.4), and costs falling to £5880 (£5816 to £5956) and £6258 (£6149 to £6376) after knee and hip replacement, respectively, over the cohort's lifetime. The corresponding threshold prices for a 50% relative reduction in risk of revision were £1094 (£788 to £1488) for knee replacement and £1347 (£961 to £1842) for hip replacement (Figure 1).

A 5% relative improvement in quality of life if unrevised, with risk of revision unchanged, was expected to result in post-operative health utility at six months increasing to 0.86 (0.83 to 0.89) and 0.90 (0.87 to 0.93) after knee and hip replacement, respectively. This was approximately equivalent to an improvement in post-operative OKS from 38.3 to 40.1 after knee replacement, and an improvement in post-operative OHS from 41.7 to 43.6. This led to lifetime QALYs increasing to 10.8 (10.4 to 11.2) and 11.5 (11.1 to 11.9) for knee and hip replacement, respectively, while costs remained unchanged. The corresponding threshold prices for a 5% improvement in post-operative quality of life if unrevised were £9911 (£9476 to £10296) for knee replacement and £10578 (£10171 to £10982) for hip replacement (Figure 1).

A combined 5% improvement in post-operative health utility if unrevised and 50% relative reduction in risk of revision would result in lifetime risks of revision falling to 2.7% (1.8% to 3.7%) and 4.2%

(2.8% to 6.0%), QALYs increasing to 10.9 (10.4 to 11.3) and 11.6 (11.2 to 12.0), with costs falling to £5880 (£5816 to £5956) and £6258 (£6149 to £6376) after knee and hip replacement, respectively. This had associated threshold prices of £11182 (£10691 to £11721) for knee replacement and £12134 (£11616 to £12701) for hip replacement (Appendix Figure 4).

While lifetime risks of revision were similar regardless of sex, younger age at surgery was associated with an increased lifetime risk. For example, with other characteristics held at their average, estimated lifetime risk of revision went from 17.9% (11.9% to 26.2%) and 18.5% (12.0% to 29.2%) for a 55-year-old male to 3.5% (2.4% to 4.9%) and 5.2% (3.6% to 7.8%) for an 80-year-old male after knee and hip replacement, respectively, under current practice. Consequently, the absolute reduction in lifetime risk of revision for a given relative risk reduction and the corresponding threshold prices were larger for younger patients. Gains in health utility were similar regardless of age and sex after knee and hip replacement. However, those at a younger age had a longer life expectancy and so more time to accrue improvements in quality of life. As a result, relative improvements in health utility were associated with higher threshold prices for younger patients, as shown in Figure 2 and Appendix Figure A5.

Threshold prices would necessarily change for different cost-effectiveness thresholds, see Appendix Figure A6. For example, threshold prices for a 5% improvement in post-operative quality of life if unrevised would be £14866 (£14214 to £15444) for knee replacement and £15867 (£15257 to £16473) for hip replacement at a cost-effectiveness threshold of £30,000 per additional quality-adjusted life year (QALY), but £6442 (£6159 to £6692) and £6876 (£6611 to £7138) at a cost-effectiveness threshold of 13,000.

DISCUSSION

Summary of key findings

The threshold prices estimated provide a clear indication of what improvements computer and robot assisted knee and hip replacement would have to deliver to be considered cost-effective in the English NHS over that achieved by knee and hip replacements currently.

Improvements in post-operative quality of life would be particularly valuable with, at a cost-effectiveness threshold of £20,000 per additional QALY, the NHS willing to pay up to an additional £10,000 for the technology if post-primary unrevised quality of life was improved by 5% for the average patient profile. This is approximately equivalent to an additional two points in post-operative OKS/ OHS. Meanwhile, the NHS would be willing to pay around £1,000 extra for the technology if it proved able to halve the risk of revision currently achieved by conventional surgeries for a similar individual. Threshold prices would be higher if the use of computer and robot-assisted surgery was concentrated among younger patients.

Findings in context

A range of computer navigation and robotic-assisted systems have been developed to control component positioning and, in some cases, improve surgical precision.[7] These systems have been found to lead to better implant positioning in both knee and hip replacement.[33] However, as yet, there is relatively little evidence that these improvements have translated into better clinical outcomes, either in short-term patient reported outcomes or long-term risk of revision.[7] However, one large study of computer navigation in knee replacement in Australia, where over 20% of procedures are computer-assisted, was able to assess revision risk using data from the national joint replacement registry. In this study it was found that while revision risk was similar for older patients regardless of whether their knee replacement was computer-assisted or conventional, computer-assistance led to a 20% relative reduction in the risk of revision for patients aged less than 65 years of age.[34]

The current cost of purchasing a robot system ranges from £290,000 to £2,000,000.[35] In addition to the fixed cost of purchasing a robot assisted system, the consumables for each procedure cost around £1,400 and annual maintenance fees could cost as much as £140,000,[35] and they may also extend operating time. Even setting aside the upfront cost of purchasing the robot system, the adoption of the system could increase the cost of the knee replacement by £2,800 if used for an annual case volume of 100 procedures. The findings from this study suggest that a reduction in the risk of revision would not on its own be sufficient for this additional cost to be considered acceptable, with some improvement in quality of life if unrevised also being necessary. Even in high volume centres, these systems will therefore likely need to have a large impact on clinical outcomes to be considered cost-effective at current prices. As prices fall over time, the scale of improvement in effectiveness required will necessarily fall. However, robust evidence that some improvement is gained will still be required.

Strengths and limitations

This study has been informed by routinely-collected health data on risks revision and mortality, quality of life after surgery, and costs incurred for surgical conventional procedures within the English NHS. This has allowed for robust estimates of the current costs and health outcomes after knee and hip replacement under current practice. In the absence of much data on the effectiveness or costs of computer and robot-assisted knee and hip replacement, threshold prices have been estimated. These threshold prices can help inform a consideration of the potential cost-effectiveness of these technologies, however definitive answers will need to be made when robust evidence becomes available on both relative effectiveness and costs.

The threshold prices estimated in this study are specific to the English NHS, with model inputs derived from routinely-collected data from the health system and improvements measured against the cost-effectiveness threshold used by the National Institute for Health and Care Excellence (NICE). Both the current consequences of knee and hip replacement and the willingness to pay for improvements in outcomes can be expected to vary across countries. While differences may be relatively small in other publicly funded health systems in high-income countries, threshold prices can be expected to be considerably higher in the US, given fewer restraints on the costs of interventions that are adopted, while threshold prices may be lower in low- and middle-income countries where the ability to pay for improvements is more restricted.

Conclusion

While there remains room for improvement in knee and hip replacement, there is a limit to what costs will be borne by health care providers. Innovations, such as computer and robot-assisted surgery, need to demonstrate that they lead to meaningful improvements in outcomes and are cost-effective before they become part of standard practice. The threshold prices estimated in this study summarise the health gains required for computer and robot-assisted knee and hip replacement to be cost-effective at a given price. Reductions in the risk of revision will likely need to be accompanied by improvements in patient-reported outcomes for these technologies to be considered cost-effective at current prices.

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TABLES

Table 1: Summary model inputs

Model inputs	Source of data	Statistical model	Application in decision model
Transition probabilities			
Risk of revision	CPRD-HES APC	Parametric survival models fit to up to 10-year of follow-up.	Estimates based on predicted survival curves from parametric model.
Risk of death	CPRD-HES APC	Parametric survival models fit to up to 10-year of follow-up.	Estimates up to 10 years based on predicted survival curves from parametric model, with estimates after 10 years based on age- and sex-specific UK lifetables.
Quality of life			
Post-operative health utility if unrevised	CPRD-HES APC-HES PROMS.	Ordinary least square models with post-operative EQ-5D-3L index as dependent variable.	1) Knee/ hip replacement state: Patients assumed to steadily increase from pre-operative score to post-operative quality of life if unrevised over first six months, and then remain at post-operative quality of life for subsequent 6 months. 2) Unrevised state: Assumed to remain at post-operative quality of life. 3) Revision state: Assumed to be 75% of knee/ hip replacement state quality of life. 4) Revised state: Assumed to be 75% of unrevised state quality of life.
Costs			

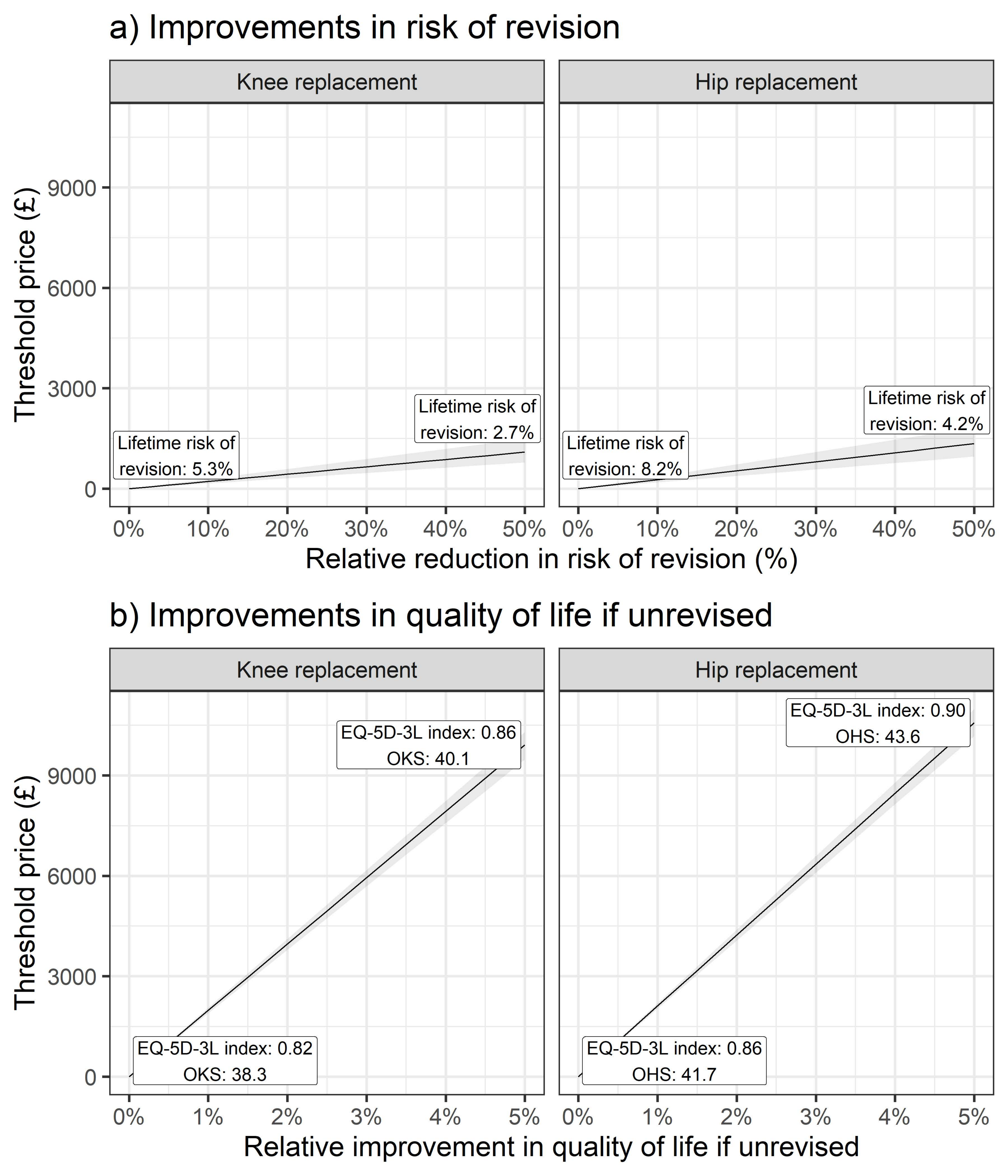
Knee or hip replacement	CPRD-HES APC	Generalised linear model with 2015/16 NHS reference costs as dependent variable.	Estimates of cost based on generalised linear model, which is incurred by all patients in study cohort.
Revision of knee or hip replacement	CPRD-HES APC	Generalised linear model with 2015/16 NHS reference cost as dependent variable.	Estimates of cost based on generalised linear model, which is incurred by those who enter the revision state.

CPRD: Clinical Practice Research Datalink; HES APC: Hospital Episode Statistics Admitted Patient Care; PROMs: patient-reported outcome measures; EQ-5D-3L: EuroQol 5-dimension 3-level. CPRD is a database of records from general practices, HES APC contains data on inpatient hospital admission, while HES PROMs includes responses to the EQ-5D-3L questionnaire completed before and six months after knee and hip replacement.

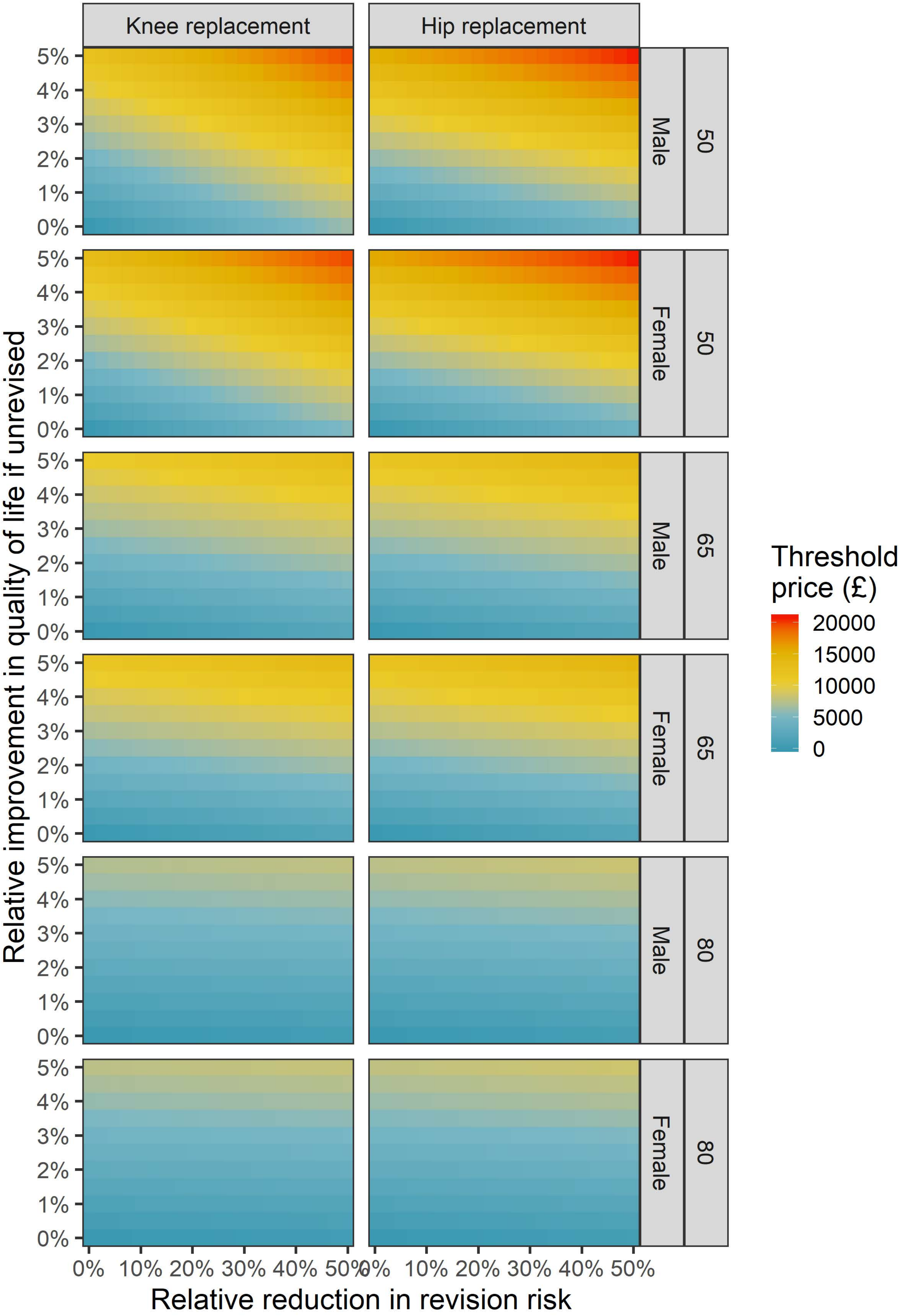
FIGURES

Figure 1. Threshold prices for improvements in risk of revision or in quality of life if unrevised after knee and hip replacement

Figure 2. Partial effect of age and sex on the threshold prices for given improvements in the both quality of life and risk of revision after knee and hip replacement at a cost-effectiveness threshold of £20,000 per additional QALY



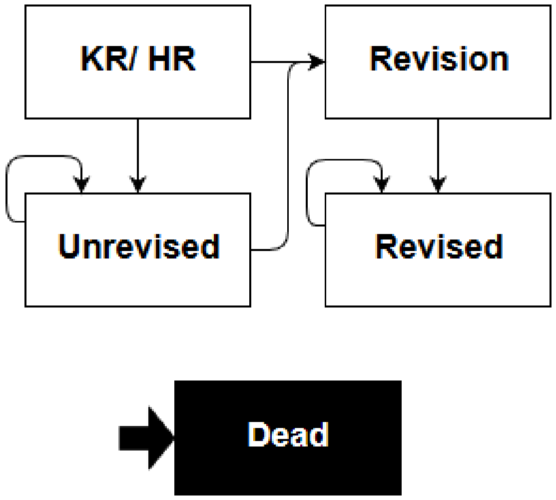
a) Improvements in risk of revision
Knee replacement
Hip replacement
Threshold price (£)
9000
6000
3000
0
Lifetime risk of revision: 5.3%
Lifetime risk of revision: 2.7%
Lifetime risk of revision: 8.2%
Lifetime risk of revision: 4.2%
0%
10%
20%
30%
40%
50%
Relative reduction in risk of revision (%)
b) Improvements in quality of life if unrevised
Knee replacement
Hip replacement
Threshold price (£)
EQ-5D-3L index: 0.86
OKS: 40.1
EQ-5D-3L index: 0.82
OKS: 38.3
EQ-5D-3L index: 0.90
OHS: 43.6
EQ-5D-3L index: 0.86
OHS: 41.7
0%
1%
2%
3%
4%
5%
Relative improvement in quality of life if unrevised


Knee replacement
Hip replacement
Male
50
Female
50
Male
65
Female
65
Male
80
Female
80
5%
4%
3%
2%
1%
0%
Relative improvement in quality of life if unrevised
0%
10%
20%
30%
40%
50%
Relative reduction in revision risk
Threshold price (£)
20000
15000
10000
5000
0

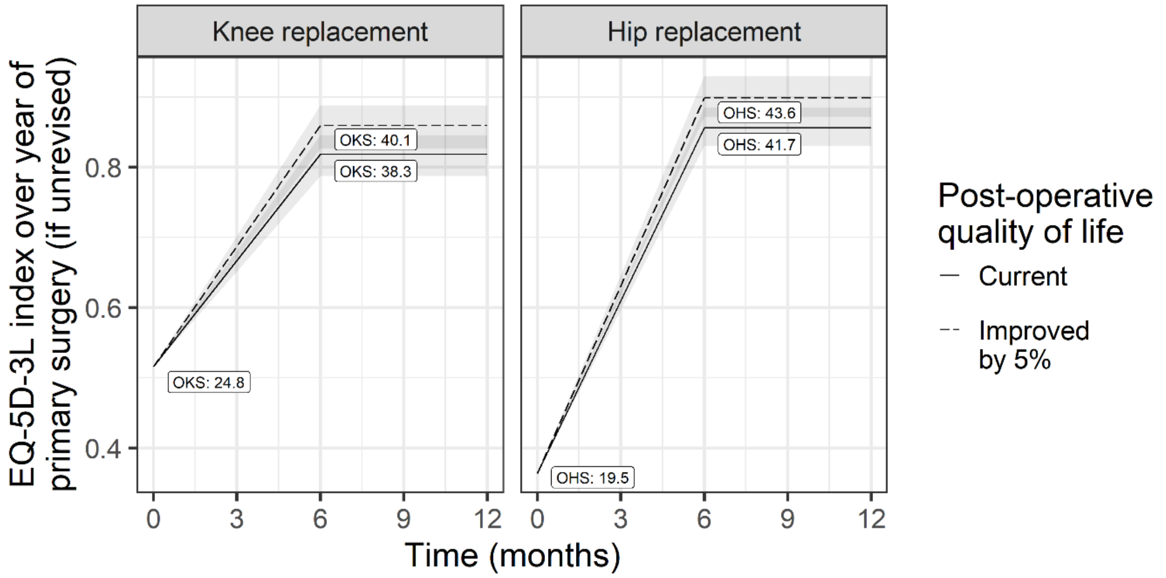
Appendix

Contents

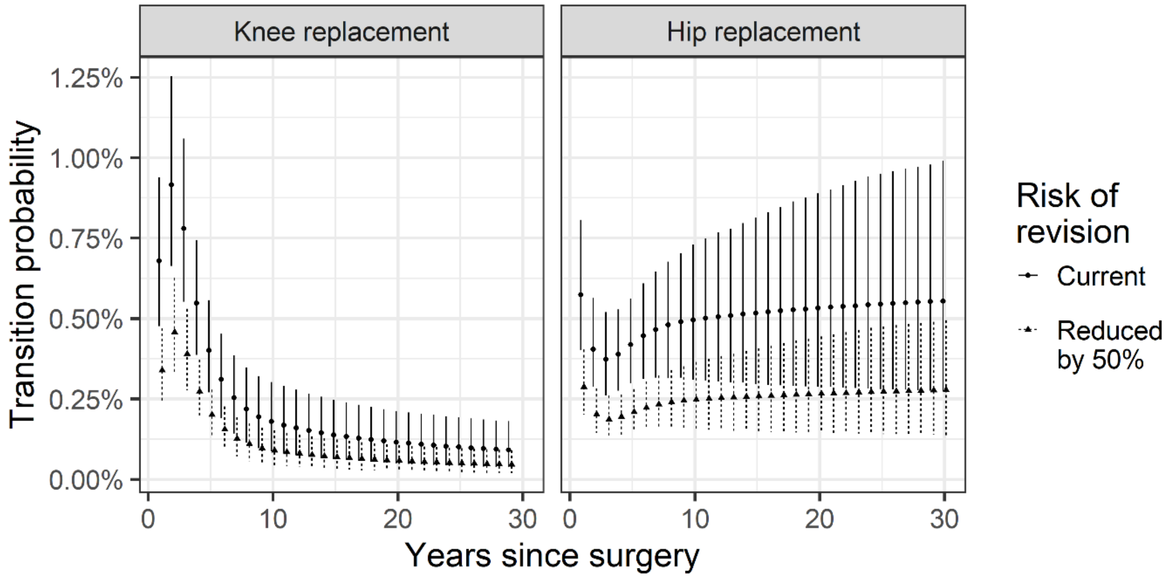
Appendix Figure A1. Decision analytic model structure for knee replacement (KR) and hip replacement (HR)



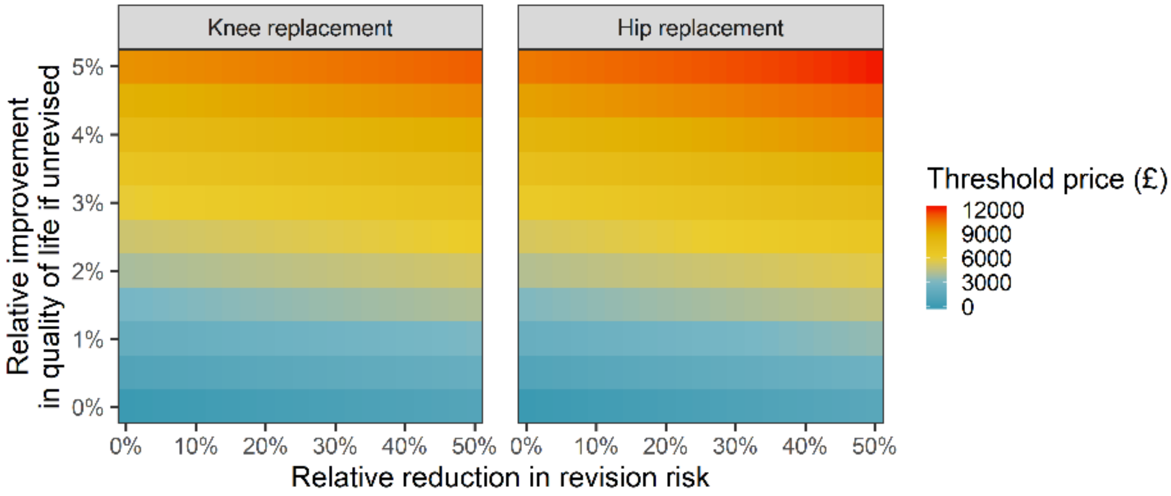
Appendix Figure A2. Post-operative health utility if unrevised under current practice and with a 50% reduction in risk for the average patient profile. Labels refer to Oxford Knee Score (OKS) or Oxford Hip Score (OHS) mapped from EQ-5D-3L index



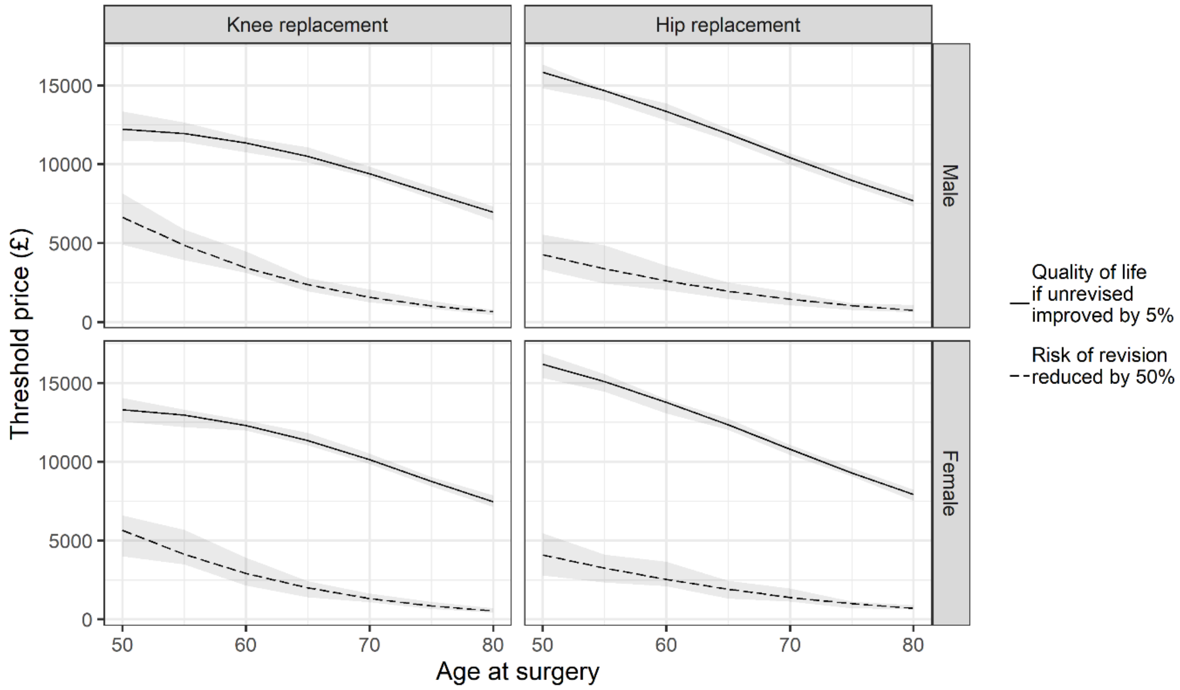
Appendix Figure A3. Transition probabilities for revision under current practice and with a 50% reduction in risk for the average patient profile



Appendix Figure A4. Heatmap of threshold prices for improvements in both quality of life if unrevised and risk of revision after knee and hip replacement at a cost-effectiveness threshold of £20,000 per additional QALY



Appendix Figure A5. Partial effect of age and sex on the threshold prices for given improvements in the effectiveness of knee and hip replacement



Appendix Figure A6. Threshold prices for improvements in risk of revision or in quality of life if unrevised after knee and hip replacement at different cost-effectiveness (CE) thresholds