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# **BMJ Open**

# Cost -effectiveness of unicompartmental compared to total knee replacement: a population-based study using data from the National Joint Registry for England and Wales

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#### KEYWORDS

Knee; Osteoarthritis; Arthroplasty; Unicompartmental knee replacement; Total knee replacement

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3	4	
4	1	ABSTRACT
5	2	Objectives
6	3	To assess the value for money of unicompartmental knee replacement (UKR) compared to total knee
/ 8	4	replacement (TKR).
9	5	Design
10	6	A lifetime Markov model provided the framework for the analysis.
11		
12	7	Setting
13	8	Data from the National Joint Registry (NJR) for England and Wales primarily informed the analysis.
14	0	
15	9	
16	10	Propensity score matched patients in the NJR who received either a UKR or TKR.
10	11	Interventions
10	10	LIKE is a loss invasive alternative to TKP, where only the compartment affected by esteparthritic is
20	12	own is a less invasive alternative to Two, where only the compartment affected by osteoartificities is
20	13	
21	14	Primary outcome measures
22	15	Incremental Quality-Adjusted Life Years (QALYs) and health system costs
23	15	indicinental quality hajasted ene reals (arens) and nearth system costs.
25	16	Results
26	17	The provision of UKR is expected to lead to a gain in QALYs compared to TKR for all age and gender
27	18	subgroups (Male <60: 0.12, 60-75: 0.20, 75+: 0.19, Female <60: 0.10, 60-75: 0.28, 75+: 0.44) and a
28	19	reduction in costs (Male <60: -f1.223, 60-75: -f1.355, 75+: -f2.005, Female <60: -f601, 60-75: -f935,
29	20	75+: -f1 102 per patient over the lifetime) LIKR is expected to lead to a reduction in OALVs
30	20	compared to TKP when performed by surgeons with low LIKP utilication, but an increase among
31	21	these with high utilization (210% median C% 0.04 >10% median 27% 0.26). Descended of
32	22	those with high utilisation (<10%, median 6%: -0.04, 210%, median 27%: 0.26). Regardless of
33	23	surgeon usage, costs associated with UKR are expected to be lower than those of TKR (<10%: -£127,
34	24	≥10%: -£758).
35	25	Conclusions
36	26	LIKB can be expected to generate better bealth outcomes and lower lifetime costs than TKB. Surgeon
3/	20	usage of LIKP door, though, have a significant impact on the cost offectiveness of the procedure. To
38	27	usage of OKK uses, though, have a significant impact on the cost-effectiveness of the procedure. To
39 40	28	achieve the best results, surgeons need to perform a sufficient proportion of knee replacements as
40	29	UKR, hence low-usage surgeon may need to broaden their indications of UKR to achieve this.
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Page 3 of 56		BMJ Open
1 2 3 4 5 6 7 8 9	31 32 33 34	ARTICLE SUMMARY Strengths and limitations of this study Routinely collected data provided real-world evidence of costs and health outcomes following UKR and TKR.
10 11 12	35 36	Differences between comparator groups may have remained in unobserved characteristics, such as
13	37	pre-operative radiographs.
14	38	Assumptions were required to extrapolate quality of life and risk of revision over patient lifetimes.
16	39	
17 18 19	40	
20 21	41	
22 23 24 25 26 27 28 29 30 31 32	42	
<ul> <li>33</li> <li>34</li> <li>35</li> <li>36</li> <li>37</li> <li>38</li> <li>39</li> <li>40</li> <li>41</li> <li>42</li> <li>43</li> <li>44</li> <li>45</li> <li>46</li> <li>47</li> <li>48</li> <li>49</li> <li>50</li> <li>51</li> <li>52</li> <li>53</li> <li>54</li> <li>55</li> <li>56</li> <li>57</li> <li>58</li> <li>59</li> </ul>		

# 43 INTRODUCTION

For individuals with end-stage symptomatic osteoarthritis of the knee, total knee replacement (TKR) relieves pain and improves function.<sup>1</sup> In a substantial proportion of cases, by some estimates up to 50%, patients could receive a unicompartmental knee replacement (UKR) instead. UKR is less invasive than TKR, sparing the normal joint surfaces and cruciate ligaments,<sup>2,3</sup> and consequently is associated with a faster recovery and lower risk of post-operative complications and mortality.<sup>4, 5</sup> In early and late comparisons of patient-reported outcomes (PROMs), UKR has also been shown to result in superior outcomes overall, with a higher proportion of patients reporting an excellent result.<sup>6,7</sup> However, UKR is also associated with a higher risk of revision than TKR,<sup>4</sup> with this due in 

52 large part to a lower threshold for revision.<sup>8</sup>

The choice between UKR and TKR also has economic implications. Given that the procedure is quicker and length of stay is reduced, undertaking a UKR can be expected to require fewer health system resources than a TKR. This upfront cost-saving could, however, be offset by the cost of additional reoperations and revisions. Differences in outcomes, in terms of pain and function, may also lead to differences in primary health care utilisation which would further affect the overall costs of the procedures.

The relative merit of each procedure can be expected to vary depending on patient and surgical
factors. Outcomes following UKR, in particular, are impacted by surgical factors. Surgeons' caseload
(the number of UKR performed) and usage of UKR (the percentage of their primary knee

replacements that are UKRs) has been shown to have a substantial impact on the success of UKR
 with those performed by high usage surgeons expected to have comparable reoperation rates to
 TKR.<sup>9</sup>

Cost-effectiveness analyses offer a means of reducing decision uncertainty by providing a
comparative analysis of both the costs and health outcomes of UKR and TKR. The aim of this study
was to estimate the cost-effectiveness of UKR compared to TKR based on routinely-collected data
from the UK and, in particular, to assess how cost-effectiveness varies depending on i) the age and
gender of patients and ii) surgeon usage of UKR.

### 70 MATERIALS AND METHODS

# 71 Target population and subgroups

The study population for this analysis are those patients who could receive either a UKR or TKR. We
use propensity score matching to identify those patients who received a TKR who were similar in all
relevant observable characteristics to patients who received a UKR and assume both groups to be
eligible for a UKR but ultimately receiving either a TKR or a UKR. We consider the cost-effectiveness
of UKR compared to TKR in terms of six subgroups based on age (<60, 60 to 75, and >75) and gender.
In a further analysis, we consider the effect of surgeon 'usage' of UKR on cost-effectiveness for two
subgroups (<10 and ≥10%).</li>

# 79 Decision model

A lifetime Markov model, shown in Figure 1, provides the framework for the analysis, with patients passing through clinically and economically important health states as time passes.<sup>10</sup> Patients begin by having a primary UKR or TKR, after which they have a revision operation or remain unrevised. After a revision, patients can have a further revision (re-revised) or remain 'revised'. Following a re-revision, patients remain as 're-revised' until death. From all health states patients have a risk of death and the model goes through consecutive cycles until all patients have died. Patients can transition between states on a yearly basis. The key simplifying assumptions of the model are that patients can have only two revisions and that only one revision can occur in a year. While

reoperations are not incorporated as a model state, their likelihood and costs are incorporated in the unrevised state. **Study perspective** This evaluation has been undertaken from a healthcare system perspective, hence only the costs incurred by the health system are included. These costs relate to surgical procedures being undertaken and primary care utilisation by patients. For health care interventions to be considered cost-effective (i.e. providing sufficient value for money to merit their provision) in the UK they should have an incremental cost per additional quality-adjusted life year (QALY) of less than £20,000 to £30,000.<sup>11</sup> For this analysis the cost-effectiveness of UKR is considered at the lower threshold of £20,000. Measurement of effectiveness An extract of data from the National Joint Registry (NJR) for England and Wales linked to the Hospital Episode Statistics (HES) database and the Office for National Statistics (ONS) informed estimates of the effectiveness of UKR and TKR. This data was previously used to compare adverse events following the procedures, with propensity scores used to match 25,334 UKRs to 75,996 comparable TKRs who received their primary procedure between 2003 and 2012.<sup>9</sup> These same matched patients were split into the age and gender subgroups for this analysis. As surgeon usage of UKR was not a variable in the original propensity score matching, matching was re-run to achieve balance within usage subgroups (see Appendix). This ensured that the comparator groups, UKR performed by surgeons with usage under 10% against TKR, and UKR by surgeons with usage equal to or over 10% against TKR, were balanced in their observable characteristics. Parametric models were specified independently for each treatment subgroup to estimate the risk of revision and death. For the base case analysis, the Weibull distribution was used for both. The risk of revision was extrapolated using estimates from the models, and risk of death was assumed to return to that given by age- and gender-specific UK life tables after the period of follow up.<sup>12</sup> Sensitivity analyses were performed for the risk of revision with the analysis re-run using the log-normal and exponential distributions instead of the Weibull. Further details of the estimated parametric models are provided in the Appendix. Risk of re-revision was based on evidence from the NJR which reported that in the first year following a revision patients have a 2.7% probability of a re-revision, and a 1.4% chance in subsequent years.<sup>13</sup> With risk of re-revision being similar following a revision of UKR and TKR,<sup>14</sup> these risks were applied in the same manner for both procedures. Risk of mortality following a revision and re-revision was assumed to be equal to that of those unrevised. Estimating resource use and costs The hospital costs associated with the primary procedures and revisions were based on patients' Healthcare Resource Group (HRG) codes (which classify episodes with similar levels of resource consumption into the same group) and length of stay, with costs estimated using the 2014/15 National Tariff Payment System.<sup>15</sup> In addition, the costs of any implant-retaining reoperations over the five years following each surgery were also incorporated. The cost of a re-revision was assumed to be the same as a revision in the base case analysis. The effect of this assumption on the results was tested by re-running the analysis with a re-revision expected to have a cost 50% higher than that of a revision. For primary care costs an extract of the Clinical Practice Research Datalink (CPRD) was used where 335 UKRs were matched with 1,005 TKRs based on propensity scores. These patients and their costs

are summarised in the Appendix. The choice of procedure was found to have no significant effect on

resource use and so the costs of treatment groups were pooled and single estimates extracted for

 

134	each age and gender subgroup.	
135	Future costs and health outcomes were discounted by an annual rate of 3.5%, in line with guideline	S
136	for England and Wales. <sup>16</sup> Costs are in British pounds, in 2014 prices. Estimated hospital and primary	,
137	care costs are detailed in the Appendix.	
138	Measurement and valuation of preference-based outcomes	
139	As patient-reported outcome measures (PROMs) have only been collected since 2009, a separate	
140	propensity score matched cohort of 3,519 UKRs and 10,557 TKRs for whom these data were	
141	available were used to inform estimates of health-related quality of life for each subgroup	
142	considered. Again, these patients and the process of matching have been previously described in	
143	detail, <sup>6</sup> and matching was re-run for usage subgroups (see Appendix).	
144	In the year following a primary, patients were expected to steadily progress from their pre-operativ	e
145	score to their post-operative score at six months, at which they would remain for the rest of year. A	١S
146	EQ-5D following UKR and TKR remains stable over ten years following surgery for those who remain	۱
147	unrevised, <sup>7</sup> in the absence of any further procedure those unrevised were expected to remain at	
148	their post-operative score. A similar approach was used for revision, with patients expected to	
149	progress from their pre-operative score to their post-operative score over six months, at which poir	۱t
150	they were expected to remain unless they went on to have a re-revision. However, due to the small	1
151	number of individuals with a revision and scores available, subgroups were pooled for revision	
152	parameters. Quality-of-life for a re-revision was assumed to fall in the same proportion as they did	
153	from primary to a revision procedure. To test the impact of this assumption, a sensitivity analysis	
154	was conducted where the quality of life for a re-revision was assumed instead to remain equal to	
155	that of revision. Estimates of health-related quality-of-life were based on EQ-5D collected prior to	
156	and six-month following surgery (see Appendix).	
157	Analytic methods	
158	Expected (mean) costs and QALYs were estimated for each subgroup receiving either UKR or TKR.	
159	The effect of parameter uncertainty was assessed using probabilistic sensitivity analysis, with input	
160	parameters assigned from probability distributions and 1,000 Monte Carlo simulations conducted for	or
161	each subgroup. Probability distributions were based on the type of data, with gamma distributions	
162	used for costs as well as pre-operative quality of life so as to allow values below zero, beta	<b>.</b> .
163	distributions used for post-operative quality of life, and normal distributions used for the coefficient of a set of activated parts and $OALV$ from each of 1 000 Month	ts
164	of parametric models and age. The sets of estimated costs and QALYS from each of 1,000 Mont	е
105	cano simulations are presented, alongside the expected results, on a cost-effectiveness plane.	
166	RESULTS	
167	Compared to TKR, UKR was found to be associated with a greater likelihood of revision over	
168	individuals remaining lifetimes for each of the subgroups. UKR though was associated with better	
169	post-operative quality of life following the primary procedure that TKR for all age and gender	
170	subgroups, with the difference most pronounced for older patients. Moreover, those undergoing	
171	revision following UKR had better quality of life prior to and following revision than those who had	
172	TKR. For all subgroups, the hospital costs of primary and revision surgery were lower for UKR than	
173	TKR. See Appendix for further details.	
174	UKR was found to be cost-saving and health improving compared to TKR for all age and gender	
175	subgroups, making UKR the 'dominant' treatment choice for those individuals eligible for either	
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3	176	procedure (see Table 1). The largest expected savings were for males over 75 while the biggest
4	177	improvement in quality of life was for females over 75. For those aged over 60 years of age,
5	178	parameter uncertainty had little effect on the conclusion that UKR was cost-effective. However, for
6	179	those under 60 there was some uncertainty, with a 13% and 28% probability that TKR was cost-
7	180	effective for males and females under 60, respectively. Figure 2 presents the estimated mean and
8	181	probabilistic sets of incremental costs and QALYs associated with the provision of UKR rather than
9	182	TKR for each age and gender subgroup. These findings were broadly robust to changes in modelling
10	183	assumptions (see Table 2 and Appendix for full results from each scenario analysis)
11 12	105	
12	184	When UKR was performed by surgeons with a usage of the procedure equal to or above 10%
14	185	(median usage of 27%), UKR was found to be unequivocally cost-saving and health improving
15	186	compared to TKR, as shown in Table 3. When performed by surgeons with a usage of less than 10%
16	187	(median usage of 6%), however, UKR no longer led to better health outcomes than TKR and TKR was
17	188	the cost-effective procedure. Figure 3 presents the estimated means and sets of costs and QALYs for
18	189	both usage subgroups.
19		
20	190	DISCUSSION
21 22	191	Principal findings
22	192	For patients who are eligible for either procedure, the provision of UKR rather than TKR has been
24	193	estimated to lead to a gain in QALYs and a reduction in costs for all age and gender subgroups. There
25	194	is little uncertainty around this conclusion for older patients. Such patients have, given their lower
26	195	life expectancy, a lower lifetime risk of revision and report greater improvements in post-operative
27	196	guality of life compared to TKR than younger patients. Significant uncertainty does surround
28	197	whether UKR would be health-improving for younger patients for whom even relatively small
29	198	differences in annual revision rates lead to substantial differences in lifetime revision rates
30	200	
31	199	Surgeon usage of UKR, the percentage of the knee replacements they perform that were UKRs, had
3Z 22	200	a significant impact on the cost-effectiveness of the procedure. UKR was expected to be cost-
33	201	effective when compared to TKR with 100% probability (given parameter uncertainty) when
35	202	performed by surgeons with usage at or above 10%, with these surgeons having a median usage of
36	203	27%. However, when UKR performed by low usage surgeons were compared against TKR, TKR was
37	204	the cost-effective option.
38		
39	205	Limitations of the study
40	206	This analysis was based on routinely-collected data from the NHS in England and Wales. While this
41	207	dataset has the advantage of providing real-world evidence for costs and health outcomes following
42	208	LIKE and TKE, it also has the notential nitfalls of any such observational data. In particular

UKR and TKR, it also has the potential pitfalls of any such observational data. In particular,

confounding by indication can be expected with treatment selection based on patient and surgical characteristics. Propensity score matching was used to achieve balance in a wide range of observed characteristics, however imbalances may still exist in unobserved factors which could bias the findings of the study. 

With costs and health outcomes estimated over the remaining lifetimes of patients, modelling assumptions were unavoidable. Individuals' risk of revision over their remaining lifetimes were based on observed revisions over the eight years following surgery. In addition, quality of life was based on scores recorded prior to and six month following primary and revision procedures and, based on previous research,<sup>7</sup> it was assumed that individuals would remain at their post-operative scores following both a primary and a revision in this analysis. Furthermore, quality of life associated with re-revision was assumed to have dropped by the same proportion as that observed from primary to revision and the cost of a re-revision was assumed to be equivalent to that of a revision. 

These assumptions were necessarily subjective; however, scenario analyses showed the findings of the study to be robust to changes in these assumptions. Study findings in context In line with findings from previous economic evaluations of UKR and TKR,<sup>19</sup> in this study we found UKR to be less costly than TKR.<sup>7</sup> Furthermore, consistent with previous research, UKR was also found to lead to better health outcomes for patients aged 65 and over. Little uncertainty surrounds this conclusion for older patients, who benefit most from a less-invasive procedure and have a low lifetime risk of revision. For younger patients, where findings regarding health outcomes are mixed,<sup>20-22</sup> this analysis found that UKR was also expected to lead to better health outcomes than TKR, although there was significant uncertainty in this conclusion. The variation in findings for younger patients across studies appears to be driven by differences in estimates for both the risk of revision and the expected effect of revision on quality of life.<sup>7</sup> This study has also highlighted the importance of surgeon usage of UKR on the cost-effectiveness of the procedure. In the high usage group, with a median usage of 27%, UKR was found, with no parameter uncertainly, to lead to better health outcomes and cost-savings compared to TKR. In contrast, in the low usage group UKR provided worse health outcomes and only small cost savings. The poor results of those with low usage are likely to be due to both less experience with the procedure and inappropriate patient selection. High usage surgeons, therefore, should be supported while low usage surgeons should consider changing their practice. If surgeons with low or no usage of UKR learnt and applied the indications and techniques of current high usage surgeons, they can be expected to achieve similar results. **CONCLUSIONS** For those patients with appropriate indications, UKR provides an alternative to TKR which is less costly for the health system to provide and leads to overall lifetime health outcomes. If surgeons performing UKR achieved sufficient usage of the procedure, future economic and population health gains would likely be increased even further. Additional work is needed to identify the optimal usage of UKR, which may depend on the type of implants used. Surgeons should not have a low usage and be performing UKR in less than 10% of their knee replacements. The median usage in the high usage group was 27% so it would be reasonable for surgeons to aim for a quarter of their knee replacements to be UKR. However it has been shown that up to 50% of replacements could be UKR, so the optimal usage may be higher.<sup>23</sup> 

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8	259	represent those of the authors and do not necessarily reflect those of the National Joint Registry					
9 10	260	Steering Committee or the Healthcare Quality Improvement Partnership (HQIP) who do not vouch					
11	261	for how the information is presented. HES data copyright © 2013, Re-used with the permission of					
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27	272	All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf					
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30 21	275	hold various patents related to Total and Unicompartmental Knee Replacement.					
21 22							
33	276	ETHICAL APPROVAL					
34	277	Not required.					
35							
36	278	DATA SHARING					
37	279	Access to data is available from the National Joint Registry for England and Wales.					
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# TABLE 1: BASE CASE COST-EFFECTIVENESS RESULTS FOR AGE AND GENDER SUBGROUPS

	TKR		UKR		-			
	QALYs	Costs	QALYs	Costs	Δ QALYs	Δ Costs	ICER (probability cost- effective*)	
Male, <60	10.28	15,357	10.39	14,134	0.12	-1,223	UKR dominant (87%)	
	(10.07 to 10.47)	(14,704 to 16,019)	(10.11 to 10.70)	(13,489 to 14,810)	(-0.19 to 0.47)	(-1,439 to -1,014)		
Male, 60-75	8.61	13,307	8.81	11,952	0.20	-1,355	UKR dominant (100%)	
	(8.50 to 8.70)	(12,584 to 14,037)	(8.63 to 8.97)	(11,246 to 12,704)	(0.01 to 0.39)	(-1,610 to -1,122)		
Male, 75+	5.61	11,454	5.80	9,450	0.19	-2,005	UKR dominant (100%)	
	(5.49 to 5.73)	(10,506 to 12,511)	(5.64 to 5.97)	(8,442 to 10,631)	(0.02 to 0.37)	(-2,361 to -1,521)		
Female, <60	10.68	16,961	10.78	16,360	0.10	-601	UKR dominant (72%)	
	(10.50 to 10.89)	(16,101 to 17,899)	(10.42 to 11.09)	(15,514 to 17,273)	(-0.33 to 0.47)	(-887 to -350)		
Female, 60-75	8.96	13,814	9.24	12,878	0.28	-935	UKR dominant (100%)	
	(8.84 to 9.06)	(13,089 to 14,602)	(9.04 to 9.43)	(12,068 to 13,702)	(0.05 to 0.50)	(-1,186 to -710)		
Female, 75+	6.02	11,410	6.46	10,308	0.44	-1,102	UKR dominant (100%)	
	(5.82 to 6.15)	(10,541 to 12,378)	(6.20 to 6.69)	(9,312 to 11,378)	(0.18 to 0.71)	(-1,646 to -695)		
Expected (mean) values with 95% confidence intervals in parentheses. UKR is considered 'dominant' if it is expected to improve health outcomes and reduce health care costs. *Given a cost-effectiveness threshold of £20,000.								

#### **TABLE 2: SCENARIO ANALYSES**

	Age and gender	r subgroups				
	Male, <60	Male, 60-75	Male, 75+	Female, <60	Female, 60-75	Female, 75+
Base case assumptions	UKR dominant	UKR dominant	UKR dominant	UKR dominant	UKR dominant	UKR dominant
	(87%)	(100%)	(100%)	(72%)	(100%)	(100%)
Distribution of parametric model for revisio	n risk					
Exponential	UKR dominant (92%)	UKR dominant (100%)	UKR dominant (100%)	UKR dominant (78%)	UKR dominant (100%)	UKR dominant (100%)
Log-normal	UKR dominant (89%)	UKR dominant (100%)	UKR dominant (100%)	UKR dominant (77%)	UKR dominant (100%)	UKR dominant (100%)
Health utility						
Re-revision equal to revision	UKR dominant (95%)	UKR dominant (100%)	UKR dominant (100%)	UKR dominant (91%)	UKR dominant (100%)	UKR dominant (100%)
Cost						
Cost of re-revision 50% higher than revision	UKR dominant (83%)	UKR dominant (100%)	UKR dominant (100%)	UKR dominant (73%)	UKR dominant (100%)	UKR dominant (100%)

ICER with probability of being cost-effective, based on probabilistic sensitivity analysis and given a cost-effectiveness threshold of £20,000, in parentheses. UKR is considered 'dominant' if it is expected to improve health outcomes and reduce health care costs. Full results for each scenario analysis are detailed in the Appendix.

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reduce health care costs. \*Given a cost-effectiveness threshold of £20,000.

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Figure 1: Model outline. The decision-analytic model provides the framework for the analysis.

Figure 2: Cost-effectiveness plane for age and gender subgroups. The sets of estimated incremental costs and QALYs associated with the provision of UKR rather than TKR from each of the Monte Carlo simulations are shown as points with the expected results as triangles.

Figure 3: Cost-effectiveness plane for usage subgroups. The sets of estimated incremental costs and QALYs associated with the provision of UKR rather than TKR from each of the Monte Carlo simulations are shown as points with the expected results as triangles.

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Figure 3: Cost-effectiveness plane for usage subgroups. The sets of estimated incremental costs and QALYs associated with the provision of UKR rather than TKR from each of the Monte Carlo simulations are shown as points with the expected results as triangles.

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# **APPENDIX**

#### PATIENT COUNTS FOR EACH SUBGROUP

### Table A1.1: Patient counts for each subgroup

	NJR-HES		HES-PROM	S	CPRD
	TKR	UKR	TKR	UKR	All
Age and gender subgroups					
Male, <60	11156	3677	1487	473	82
Male, 60-75	11616	4268	3456	1155	175
Male, 75+	22979	7468	641	241	57
Female, <60	19320	6118	1613	592	54
Female, 60-75	5305	1914	2850	882	164
Female, 75+	5371	1805	510	176	62
Usage subgroups					
UKR <10%	13690	4564	2052	684	-
UKR 10+%	60544	20682	8379	2793	-

NJR linked to HES was used to estimate initial transition probabilities and hospital costs. HES-PROMs was used to estimate quality of life following primary

procedure. CPRD was used to estimate primary care costs.

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#### **PROPENSITY SCORE MATCHING FOR USAGE SUBGROUPS**

#### Table A2.1 Patient characteristics before and after matching low usage UKRs (<10%) with TKRs for transition probabilities and hospital costs

	Before matching			After matching		
	TKR	UKR (usage <10%)	SMD	TKR	UKR (usage <10%)	SMD
Number of patients	75753	4564		13690	4564	
Age at surgery (mean (sd))	64.72 (9.30)	62.42 (9.11)	0.25	62.54 (9.40)	62.42 (9.11)	0.014
Unit type (%)			0.133			0.001
Public hospital	63990 (84.5)	4011 (87.9)		12030 (87.9)	4011 (87.9)	
Independent hospital	9098 (12.0)	480 (10.5)		1443 (10.5)	480 (10.5)	
Independent sector treatment centre	2665 ( 3.5)	73 ( 1.6)		217 ( 1.6)	73 ( 1.6)	
Thromboprophylaxis						
Drugs (%)			0.081			0.013
Aspirin	9498 (12.5)	487 (10.7)		1472 (10.8)	487 (10.7)	
Direct thrombin inhibitor	2622 ( 3.5)	161 ( 3.5)		458 ( 3.3)	161 ( 3.5)	
Unfractionated or low molecular weight heparin	397 ( 0.5)	21 ( 0.5)		59 ( 0.4)	21 ( 0.5)	
None/Unspecified	9325 (12.3)	606 (13.3)		1847 (13.5)	606 (13.3)	
Other	53187 (70.2)	3265 (71.5)		9786 (71.5)	3265 (71.5)	
Warfarin	724 ( 1.0)	24 ( 0.5)		68 ( 0.5)	24 ( 0.5)	
Mechanical (%)			0.053			0.022
None/Unspecified	9034 (11.9)	604 (13.2)		1767 (12.9)	604 (13.2)	
Foot pumps	7474 ( 9.9)	458 (10.0)		1359 ( 9.9)	458 (10.0)	
Intermittent calf compression	9166 (12.1)	508 (11.1)		1465 (10.7)	508 (11.1)	
Thromboembolic deterrent stockings	49069 (64.8)	2920 (64.0)		8856 (64.7)	2920 (64.0)	
Other	1010 ( 1.3)	74 ( 1.6)		243 ( 1.8)	74 ( 1.6)	
Gender (%)			0.017			0.016
Μ	39440 (52.1)	2403 (52.7)		7318 (53.5)	2403 (52.7)	
American Society of Anesthesiologists score (%)			0.104			0.024
1	16018 (21.1)	1152 (25.2)		3568 (26.1)	1152 (25.2)	
2	53087 (70.1)	3077 (67.4)		9181 (67.1)	3077 (67.4)	

3+	6648 ( 8.8)	335 ( 7.3)		941 ( 6.9)	335 ( 7.3)	
Comorbidities (Charlson index) (%)			0.028			0.00
None	60768 (80.2)	3681 (80.7)		11013 (80.4)	3681 (80.7)	
Mild	12511 (16.5)	755 (16.5)		2303 (16.8)	755 (16.5)	
Moderate	1967 (2.6)	99 ( 2.2)		291 ( 2.1)	99 ( 2.2)	
Severe	507 ( 0.7)	29 ( 0.6)		83 ( 0.6)	29 ( 0.6)	
Hypertension (mean (sd))	0.35 (0.48)	0.31 (0.46)	0.084	0.30 (0.46)	0.31 (0.46)	0.0
Ethnicity (%)			0.083			0.0
Undefined	9958 (13.1)	640 (14.0)		1933 (14.1)	640 (14.0)	
British (White)	61524 (81.2)	3661 (80.2)		10946 (80.0)	3661 (80.2)	
Irish (White)	411 ( 0.5)	32 ( 0.7)		103 ( 0.8)	32 ( 0.7)	
Any other White background	1401 ( 1.8)	101 ( 2.2)		323 ( 2.4)	101 ( 2.2)	
White and Black Caribbean (Mixed)	29 ( 0.0)	0 ( 0.0)		0 ( 0.0)	0 ( 0.0)	
White and Black African (Mixed)	11 ( 0.0)	1 ( 0.0)		4 ( 0.0)	1 ( 0.0)	
White and Asian (Mixed)	42 ( 0.1)	7 ( 0.2)		14 ( 0.1)	7 ( 0.2)	
Any other Mixed background	31 ( 0.0)	1 ( 0.0)		7 ( 0.1)	1 ( 0.0)	
Indian (Asian or Asian British)	1068 ( 1.4)	47 ( 1.0)		151 ( 1.1)	47 ( 1.0)	
Pakistani (Asian or Asian British)	351 ( 0.5)	11 ( 0.2)		32 ( 0.2)	11 ( 0.2)	
Bangladeshi (Asian or Asian British)	26 ( 0.0)	1 ( 0.0)		3 ( 0.0)	1 ( 0.0)	
Any other Asian background	195 ( 0.3)	12 ( 0.3)		33 ( 0.2)	12 ( 0.3)	
Caribbean (Black or Black British)	259 ( 0.3)	17 ( 0.4)		54 ( 0.4)	17 ( 0.4)	
African (Black or Black British)	146 ( 0.2)	11 ( 0.2)		31 ( 0.2)	11 ( 0.2)	
Any other Black background	64 ( 0.1)	4 ( 0.1)		15 ( 0.1)	4 ( 0.1)	
Chinese (other ethnic group)	25 ( 0.0)	4 ( 0.1)		6 ( 0.0)	4 ( 0.1)	
Any other ethnic group	212 ( 0.3)	14 ( 0.3)		35 ( 0.3)	14 ( 0.3)	
IMD decile (mean (sd))	6.25 (2.67)	6.08 (2.71)	0.062	6.12 (2.70)	6.08 (2.71)	0.0
Fixation (%)			0.135			0.0
Cementless	5677 ( 7.5)	200 ( 4.4)		636 ( 4.6)	200 ( 4.4)	
Cemented	68544 (90.5)	4287 (93.9)		12814 (93.6)	4287 (93.9)	
Hybrid	1532 ( 2.0)	77 ( 1.7)		240 ( 1.8)	77 ( 1.7)	
Cases per consultant per year (mean (sd))	84.74 (58.78)	82.14 (56.83)	0.045	81.49 (56.53)	82.14 (56.83)	0.0

# Table A2.2 Patient characteristics before and after matching low usage UKRs (<10%) with TKRs for quality of life

Before matching	5		After matching		
TKR	UKR (usage <10%)	SMD	TKR	UKR (usage <10%)	SMD
10441	684		2052	684	
64.38 (8.60)	61.96 (8.58)	0.281	62.19 (8.68)	61.96 (8.58)	0.027
		0.108			0.006
7726 (74.0)	535 (78.2)		1601 (78.0)	535 (78.2)	
2267 (21.7)	129 (18.9)		389 (19.0)	129 (18.9)	
448 ( 4.3)	20 ( 2.9)		62 ( 3.0)	20 ( 2.9)	
		0.029			0.028
2065 (19.8)	134 (19.6)		421 (20.5)	134 (19.6)	
203 ( 1.9)	11 ( 1.6)		30 ( 1.5)	11 ( 1.6)	
2171 (20.8)	144 (21.1)		419 (20.4)	144 (21.1)	
5908 (56.6)	388 (56.7)		1162 (56.6)	388 (56.7)	
94 ( 0.9)	7 ( 1.0)		20 ( 1.0)	7 ( 1.0)	
		0.091			0.024
2428 (23.3)	151 (22.1)		451 (22.0)	151 (22.1)	
887 ( 8.5)	69 (10.1)		213 (10.4)	69 (10.1)	
845 ( 8.1)	43 ( 6.3)		118 ( 5.8)	43 ( 6.3)	
6154 (58.9)	412 (60.2)		1242 (60.5)	412 (60.2)	
127 ( 1.2)	9 ( 1.3)		28 ( 1.4)	9 ( 1.3)	
		0.021			0.007
5511 (52.8)	354 (51.8)		1055 (51.4)	354 (51.8)	
		0.083			0.065
2183 (20.9)	154 (22.5)		431 (21.0)	154 (22.5)	
	Before matching TKR 10441 64.38 (8.60) 7726 (74.0) 2267 (21.7) 448 (4.3) 2065 (19.8) 203 (1.9) 2171 (20.8) 5908 (56.6) 94 (0.9) 2428 (23.3) 887 (8.5) 845 (8.1) 6154 (58.9) 127 (1.2) 5511 (52.8) 2183 (20.9)	Before matchingTKRUKR (usage <10%)10441 $684$ $64.38$ (8.60) $61.96$ (8.58)7726 (74.0) $535$ (78.2)2267 (21.7)129 (18.9)448 (4.3)20 (2.9)2065 (19.8)134 (19.6)203 (1.9)11 (1.6)2171 (20.8)144 (21.1)5908 (56.6)388 (56.7)94 (0.9)7 (1.0)2428 (23.3)151 (22.1)887 (8.5)69 (10.1)845 (8.1)43 (6.3)6154 (58.9)412 (60.2)127 (1.2)9 (1.3)5511 (52.8)354 (51.8)2183 (20.9)154 (22.5)	Before matching         UKR (usage <10%)         SMD           10441         684         64.38 (8.60)         61.96 (8.58)         0.281           64.38 (8.60)         61.96 (8.58)         0.281         0.108           7726 (74.0)         535 (78.2)         2267 (21.7)         129 (18.9)           448 (4.3)         20 ( 2.9)         0.029           2065 (19.8)         134 (19.6)         0.029           2065 (19.8)         134 (19.6)         0.029           2065 (19.8)         134 (19.6)         0.029           2065 (19.8)         134 (19.6)         0.029           2065 (19.8)         134 (19.6)         0.029           2065 (19.8)         134 (19.6)         0.029           2065 (19.8)         134 (21.1)         5908 (56.6)           388 (56.7)         94 (0.9)         7 (1.0)           0.091           2428 (23.3)         151 (22.1)           887 (8.5)         69 (10.1)         845 (8.1)           43 (6.3)         6154 (58.9)         412 (60.2)           127 (1.2)         9 (1.3)         0.021           5511 (52.8)         354 (51.8)         0.083           2183 (20.9)         154 (22.5)         0.083	Before matching         After matching           TKR         UKR (usage <10%)	Before matchingAfter matchingTKRUKR (usage <10%)SMDTKRUKR (usage <10%)10441684205268464.38 (8.60)61.96 (8.58)0.28162.19 (8.68)61.96 (8.58)0.1080.1080.1080.1087726 (74.0)535 (78.2)1601 (78.0)535 (78.2)2267 (21.7)129 (18.9)389 (19.0)129 (18.9)448 (4.3)20 ( 2.9)62 ( 3.0)20 ( 2.9)0.0292065 (19.8)134 (19.6)30 ( 1.5)11 ( 1.6)203 ( 1.9)11 ( 1.6)30 ( 1.5)11 ( 1.6)2171 (20.8)144 (21.1)419 (20.4)144 (21.1)5908 (56.6)388 (56.7)1162 (56.6)388 (56.7)94 ( 0.9)7 ( 1.0)20 ( 1.0)7 ( 1.0)0.0912428 (23.3)151 (22.1)451 (22.0)151 (22.1)283 ( 6.3)118 ( 5.8)431 ( 58.9)412 (60.2)1242 (60.5)127 ( 1.2)9 ( 1.3)28 ( 1.4)9 ( 1.3)0.021248 (23.3)151 (22.1)28 ( 1.4)9 ( 1.3)6154 (58.9)412 (60.2)1242 (60.5)412 (60.2)127 ( 1.2)9 ( 1.3)28 ( 1.4)9 ( 1.3)0.0212183 (20.9)154 (22.5)

2	7585 (72.6)	474 (69.3)		1479 (72.1)	474 (69.3)	
3+	673 ( 6.4)	56 ( 8.2)		142 ( 6.9)	56 (8.2)	
Comorbidities (Charlson index) (%)			0.054			0
None	8622 (82.6)	564 (82.5)		1685 (82.1)	564 (82.5)	
Mild	1496 (14.3)	103 (15.1)		313 (15.3)	103 (15.1)	
Moderate	240 ( 2.3)	11 ( 1.6)		31 ( 1.5)	11 ( 1.6)	
Severe	83 ( 0.8)	6 ( 0.9)		23 ( 1.1)	6 ( 0.9)	
Hypertension (mean (sd))	0.35 (0.48)	0.36 (0.48)	0.025	0.35 (0.48)	0.36 (0.48)	0
Ethnicity (%)			0.099			0
Undefined	2253 (21.6)	148 (21.6)		470 (22.9)	148 (21.6)	
British (White)	7643 (73.2)	505 (73.8)		1494 (72.8)	505 (73.8)	
Irish (White)	52 ( 0.5)	4 ( 0.6)		15 ( 0.7)	4 ( 0.6)	
Any other White background	225 ( 2.2)	14 ( 2.0)		43 ( 2.1)	14 ( 2.0)	
White and Black Caribbean (Mixed)	7 ( 0.1)	0 ( 0.0)		0 ( 0.0)	0 ( 0.0)	
White and Black African (Mixed)	0 ( 0.0)	0 ( 0.0)		0 ( 0.0)	0 ( 0.0)	
White and Asian (Mixed)	1(0.0)	0 ( 0.0)		0 ( 0.0)	0 ( 0.0)	
Any other Mixed background	1(0.0)	0 ( 0.0)		0 ( 0.0)	0 ( 0.0)	
Indian (Asian or Asian British)	114 ( 1.1)	7 ( 1.0)		22 ( 1.1)	7 ( 1.0)	
Pakistani (Asian or Asian British)	34 ( 0.3)	1(0.1)		1 ( 0.0)	1(0.1)	
Bangladeshi (Asian or Asian British)	6 ( 0.1)	0 ( 0.0)		0 ( 0.0)	0 ( 0.0)	
Any other Asian background	10 ( 0.1)	1(0.1)		1 ( 0.0)	1(0.1)	
Caribbean (Black or Black British)	44 ( 0.4)	1(0.1)		2 ( 0.1)	1(0.1)	
African (Black or Black British)	15 ( 0.1)	1(0.1)		1 ( 0.0)	1(0.1)	
Any other Black background	12 ( 0.1)	0 ( 0.0)		0 ( 0.0)	0 ( 0.0)	
Chinese (other ethnic group)	0 ( 0.0)	0 ( 0.0)		0 ( 0.0)	0 ( 0.0)	
Any other ethnic group	24 ( 0.2)	2 ( 0.3)		3 ( 0.1)	2 ( 0.3)	
IMD decile (mean (sd))	5.75 (2.70)	5.88 (2.71)	0.049	5.98 (2.68)	5.88 (2.71)	0
Fixation (%)			0.244			0
Cementless	932 ( 8.9)	26 ( 3.8)		70 ( 3.4)	26 ( 3.8)	
Cemented	9411 (90.1)	640 (93.6)		1936 (94.3)	640 (93.6)	
Hybrid	98 ( 0.9)	18 ( 2.6)		46 ( 2.2)	18 ( 2.6)	

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			0.024		0.005
Cases per consultant per year (mean (sd))	91.12 (60.34)	89.63 (64.68)	0.024 89.96 (58.38)	89.63 (64.68)	0.005
າວເຮັດເດຍແດດນ ເສຍແມັກລະນາຍ	ernaview as her bitter /	minnenbricant	بنطير عمديناها بمراجع عظو		

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# Table A2.3 Patient characteristics before and after matching high usage UKRs (10+%) with TKRs for transition probabilities and hospital costs

	Before matching			After matching		_
	TKR	UKR (usage 10+%)	SMD	TKR	UKR (usage 10+%)	
Number of patients	75753	20686		60544	20682	
Age at surgery (mean (sd))	64.72 (9.30)	65.17 (9.41)	0.048	64.99 (9.27)	65.17 (9.41)	
Unit type (%)			0.051			
Public hospital	63990 (84.5)	17476 (84.5)		51198 (84.6)	17472 (84.5)	
Independent hospital	9098 (12.0)	2302 (11.1)		6852 (11.3)	2302 (11.1)	
Independent sector treatment centre	2665 ( 3.5)	908 ( 4.4)		2494 ( 4.1)	908 ( 4.4)	
Thromboprophylaxis						
Drugs (%)			0.118			
Aspirin	9498 (12.5)	3364 (16.3)		9038 (14.9)	3362 (16.3)	
Direct thrombin inhibitor	2622 ( 3.5)	880 ( 4.3)		2444 ( 4.0)	879 ( 4.3)	
Unfractionated or low molecular weight heparin	397 ( 0.5)	92 ( 0.4)		281 ( 0.5)	92 ( 0.4)	
None/Unspecified	9325 (12.3)	2339 (11.3)		6989 (11.5)	2339 (11.3)	
Other	53187 (70.2)	13829 (66.9)		41248 (68.1)	13828 (66.9)	
Warfarin	724 ( 1.0)	182 ( 0.9)		544 ( 0.9)	182 ( 0.9)	
Mechanical (%)			0.099			
None/Unspecified	9034 (11.9)	2486 (12.0)		7301 (12.1)	2486 (12.0)	
Foot pumps	7474 ( 9.9)	1659 ( 8.0)		5205 ( 8.6)	1659 ( 8.0)	
Intermittent calf compression	9166 (12.1)	3007 (14.5)		8319 (13.7)	3006 (14.5)	
Thromboembolic deterrent stockings	49069 (64.8)	13343 (64.5)		39144 (64.7)	13340 (64.5)	
Other	1010 ( 1.3)	191 ( 0.9)		575 ( 0.9)	191 ( 0.9)	
Gender (%)			0.017			
Μ	39440 (52.1)	10656 (51.5)		31335 (51.8)	10655 (51.5)	
American Society of Anesthesiologists score (%)			0.033			
1	16018 (21.1)	4299 (20.8)		12397 (20.5)	4299 (20.8)	
2	53087 (70.1)	14372 (69.5)		42685 (70.5)	14368 (69.5)	
3+	6648 ( 8.8)	2015 ( 9.7)		5462 ( 9.0)	2015 ( 9.7)	

None	60768 (80.2)	16551 (80.0)	01007	48502 (80 1)	16548 (80.0)	0.000
Mild	12511 (16 5)	3459 (16 7)		10047 (16.6)	3459 (16 7)	
Moderate	1967 ( 2 6)	531 (26)		1584 ( 2 6)	530 ( 2 6)	
Severe	507 (07)	145(07)		411 ( 0 7)	145(0.7)	
Hypertension (mean (sd))	0 35 (0 48)	0 36 (0 48)	0.018	0.36 (0.48)	0 36 (0 48)	0 004
Ethnicity (%)			0.07	0.00 (01.0)		0.035
Undefined	9958 (13.1)	2944 (14.2)	0.07	8311 (13.7)	2944 (14.2)	0.000
British (White)	61524 (81.2)	16506 (79.8)		48783 (80.6)	16505 (79.8)	
Irish (White)	411 ( 0.5)	123 ( 0.6)		355 ( 0.6)	123 ( 0.6)	
Any other White background	1401 (1.8)	440 (2.1)		1207 ( 2.0)	440 ( 2.1)	
White and Black Caribbean (Mixed)	29 ( 0.0)	13 ( 0.1)		29 ( 0.0)	13 (0.1)	
White and Black African (Mixed)	11 ( 0.0)	2 ( 0.0)		7 ( 0.0)	2 ( 0.0)	
White and Asian (Mixed)	42 ( 0.1)	16 ( 0.1)		42 ( 0.1)	16 ( 0.1)	
Any other Mixed background	31 ( 0.0)	11 ( 0.1)		30 ( 0.0)	11(0.1)	
Indian (Asian or Asian British)	1068 ( 1.4)	265 ( 1.3)		802 ( 1.3)	265 ( 1.3)	
Pakistani (Asian or Asian British)	351 ( 0.5)	97 ( 0.5)		281 ( 0.5)	97 ( 0.5)	
Bangladeshi (Asian or Asian British)	26 ( 0.0)	6 ( 0.0)		23 ( 0.0)	6 ( 0.0)	
Any other Asian background	195 ( 0.3)	69 ( 0.3)		184 ( 0.3)	69 ( 0.3)	
Caribbean (Black or Black British)	259 ( 0.3)	52 ( 0.3)		175 ( 0.3)	52 ( 0.3)	
African (Black or Black British)	146 ( 0.2)	19 ( 0.1)		58 ( 0.1)	19 ( 0.1)	
Any other Black background	64 ( 0.1)	13 ( 0.1)		45 ( 0.1)	13 ( 0.1)	
Chinese (other ethnic group)	25 ( 0.0)	2 ( 0.0)		8 ( 0.0)	2 ( 0.0)	
Any other ethnic group	212 ( 0.3)	108 ( 0.5)		204 ( 0.3)	105 ( 0.5)	
IMD decile (mean (sd))	6.25 (2.67)	6.26 (2.68)	0.004	6.26 (2.67)	6.26 (2.68)	0.001
Fixation (%)			0.044			0.018
Cementless	5677 ( 7.5)	1704 ( 8.2)		4767 ( 7.9)	1704 ( 8.2)	
Cemented	68544 (90.5)	18461 (89.2)		54367 (89.8)	18459 (89.3)	
Hybrid	1532 ( 2.0)	521 ( 2.5)		1410 ( 2.3)	519 ( 2.5)	
Cases per consultant per year (mean (sd))	84.74 (58.78)	85.36 (55.18)	0.011	84.84 (58.89)	85.37 (55.18)	0.009

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# Table A2.4 Patient characteristics before and after matching high usage UKRs (10+%) with TKRs for quality of life

	Before matching			After matching		
	TKR	UKR (usage 10+%)	SMD	TKR	UKR (usage 10+%)	SMD
Number of patients	10441	2793		8379	2793	
Age at surgery (mean (sd))	64.38 (8.60)	65.01 (8.79)	0.073	64.96 (8.65)	65.01 (8.79)	0.005
Unit type (%)			0.079			0.024
Public hospital	7726 (74.0)	2072 (74.2)		6243 (74.5)	2072 (74.2)	
Independent hospital	2267 (21.7)	558 (20.0)		1692 (20.2)	558 (20.0)	
Independent sector treatment centre	448 ( 4.3)	163 ( 5.8)		444 ( 5.3)	163 ( 5.8)	
Thromboprophylaxis						
Drugs (%)			0.027			0.012
Aspirin	2065 (19.8)	538 (19.3)		1619 (19.3)	538 (19.3)	
Unfractionated or low molecular weight heparin	203 ( 1.9)	54 ( 1.9)		151 ( 1.8)	54 ( 1.9)	
None/Unspecified	2171 (20.8)	560 (20.1)		1694 (20.2)	560 (20.1)	
Other	5908 (56.6)	1614 (57.8)		4829 (57.6)	1614 (57.8)	
Warfarin	94 ( 0.9)	27 ( 1.0)		86 ( 1.0)	27 ( 1.0)	
Mechanical (%)			0.042			0.007
None/Unspecified	2428 (23.3)	635 (22.7)		1902 (22.7)	635 (22.7)	
Foot Pumps	887 ( 8.5)	226 ( 8.1)		677 ( 8.1)	226 ( 8.1)	
Intermittent calf compression	845 ( 8.1)	203 ( 7.3)		611 ( 7.3)	203 ( 7.3)	
Thromboembolic deterrent stockings	6154 (58.9)	1697 (60.8)		5087 (60.7)	1697 (60.8)	
Other	127 ( 1.2)	32 ( 1.1)		102 ( 1.2)	32 ( 1.1)	
Gender (%)			0.012			0.003
Μ	5511 (52.8)	1491 (53.4)		4462 (53.3)	1491 (53.4)	
American Society of Anesthesiologists score (%)			0.055			0.053
1	2183 (20.9)	605 (21.7)		1725 (20.6)	605 (21.7)	
2	7585 (72.6)	1973 (70.6)		6099 (72.8)	1973 (70.6)	
3+	673 ( 6.4)	215 ( 7.7)		555 ( 6.6)	215 ( 7.7)	
Comorbidities (Charlson index) (%)			0.063			0.017

None	8622 (82.6)	2296 (82.2)		6904 (82.4)	2296 (82.2)	
Mild	1496 (14.3)	398 (14.2)		1199 (14.3)	398 (14.2)	
Moderate	240 ( 2.3)	86 ( 3.1)		235 ( 2.8)	86 ( 3.1)	
Severe	83 ( 0.8)	13 ( 0.5)		41 (0.5)	13 ( 0.5)	
Hypertension (mean (sd))	0.35 (0.48)	0.36 (0.48)	0.025	0.35 (0.48)	0.36 (0.48)	0.008
Ethnicity (%)			0.064			0.016
Undefined	2253 (21.6)	606 (21.7)		1824 (21.8)	606 (21.7)	
British (White)	7643 (73.2)	2046 (73.3)		6129 (73.1)	2046 (73.3)	
Irish (White)	52 ( 0.5)	11 ( 0.4)		39 ( 0.5)	11 ( 0.4)	
Any other White background	225 ( 2.2)	66 ( 2.4)		201 ( 2.4)	66 ( 2.4)	
White and Black Caribbean (Mixed)	7 ( 0.1)	1 ( 0.0)		4 ( 0.0)	1(0.0)	
White and Black African (Mixed)	0 ( 0.0)	0 ( 0.0)		0 ( 0.0)	0 ( 0.0)	
White and Asian (Mixed)	1 ( 0.0)	0 ( 0.0)		0 ( 0.0)	0 ( 0.0)	
Any other Mixed background	1 ( 0.0)	0 ( 0.0)		0 ( 0.0)	0 ( 0.0)	
Indian (Asian or Asian British)	114 ( 1.1)	31 ( 1.1)		88 ( 1.1)	31 ( 1.1)	
Pakistani (Asian or Asian British)	34 ( 0.3)	10 ( 0.4)		28 ( 0.3)	10 ( 0.4)	
Bangladeshi (Asian or Asian British)	6(0.1)	0 ( 0.0)		0 ( 0.0)	0 ( 0.0)	
Any other Asian background	10(0.1)	2 ( 0.1)		5 ( 0.1)	2 ( 0.1)	
Caribbean (Black or Black British)	44 ( 0.4)	7 ( 0.3)		21 ( 0.3)	7 ( 0.3)	
African (Black or Black British)	15 ( 0.1)	4 ( 0.1)		12 ( 0.1)	4 ( 0.1)	
Any other Black background	12 ( 0.1)	1 ( 0.0)		4 ( 0.0)	1(0.0)	
Chinese (other ethnic group)	0 ( 0.0)	0 ( 0.0)		0 ( 0.0)	0 ( 0.0)	
Any other ethnic group	24 ( 0.2)	8 ( 0.3)		24 ( 0.3)	8 ( 0.3)	
IMD decile (mean (sd))	5.75 (2.70)	5.73 (2.75)	0.009	5.74 (2.72)	5.73 (2.75)	0.006
Fixation (%)			0.137			0.085
Cementless	932 ( 8.9)	322 (11.5)		912 (10.9)	322 (11.5)	
Cemented	9411 (90.1)	2409 (86.3)		7369 (87.9)	2409 (86.3)	
Hybrid	98 ( 0.9)	62 ( 2.2)		98 ( 1.2)	62 ( 2.2)	
Cases per consultant per year (mean (sd))	91.12 (60.34)	91.04 (54.59)	0.001	90.85 (60.48)	91.04 (54.59)	0.003



Procedure	Distribution	AIC
TKR	Exponential	5,143
TKR	Weibull	5,145
TKR	Log-normal	5,123
UKR	Exponential	2,964
UKR	Weibull	2,957
UKR	Log-normal	2,949



n for te. Table A3.2 AIC of parametric models for revision for female, <60 subgroups

Procedure	Distribution	AIC
TKR	Exponential	4,826
TKR	Weibull	4,826
TKR	Log-normal	4,799
UKR	Exponential	3,564
UKR	Weibull	3,548
UKR	Log-normal	3,525

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### Table A3.3 AIC of parametric models for revision for male, 60 to 75 subgroups

Procedure	Distribution	AIC
TKR	Exponential	7,258
TKR	Weibull	7,237
TKR	Log-normal	7,197
UKR	Exponential	3,863
UKR	Weibull	3,863
UKR	Log-normal	3,833

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#### Table A3.4 AIC of parametric models for revision for female, 60 to 75 subgroups

Procedure	Distribution	AIC
TKR	Exponential	5,379
TKR	Weibull	5,380
TKR	Log-normal	5,359
UKR	Exponential	3,626
UKR	Weibull	3,622
UKR	Log-normal	3,608





#### Table A3.5 AIC of parametric models for revision for male, 75+ subgroups

TKRExponential1,020TKRWeibull1,011TKRLog-normal1,004UKRExponential507UKRWeibull507UKRLog-normal503	Procedure	Distribution	AIC
TKRWeibull1,011TKRLog-normal1,004UKRExponential507UKRWeibull507UKRLog-normal503	TKR	Exponential	1,020
TKRLog-normal1,004UKRExponential507UKRWeibull507UKRLog-normal503	TKR	Weibull	1,011
UKR Exponential 507 UKR Weibull 507 UKR Log-normal 503	TKR	Log-normal	1,004
UKR Weibull 507	UKR	Exponential	507
LIKE Log-normal 503	UKR	Weibull	507
	UKR	Log-normal	503



#### Table A3.6 AIC of parametric models for revision for female, 75+ subgroups

Procedure	Distribution	AIC	
TKR	Exponential	997	
TKR	Weibull	991	
TKR	Log-normal	985	
UKR	Exponential	949	
UKR	Weibull	951	
UKR	Log-normal	949	




Procedure	Distribution	AIC
TKR	Exponential	4,615
TKR	Weibull	4,614
TKR	Log-normal	4,591
UKR	Exponential	3,566
UKR	Weibull	3,563
UKR	Log-normal	3,534

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#### Table A3.8 AIC of parametric models for revision for usage, 10+ subgroups

Procedure	Distribution	AIC
TKR	Exponential	19,665
TKR	Weibull	19,657
TKR	Log-normal	19,563
UKR	Exponential	12,028
UKR	Weibull	12,010
UKR	Log-normal	11,956



Table A3.9 AIC of parametric models for	mortality for male,	<60 subgroups
---	---------------------	---------------

Procedure	Distribution	AIC
TKR	Exponential	2110
TKR	Weibull	2093
TKR	Log-normal	2096
UKR	Exponential	666
UKR	Weibull	657
UKR	Log-normal	662



#### Table A3.10 AIC of parametric models for mortality for female, <60 subgroups

TKRExponential1657TKRWeibull1637TKRLog-normal1635UKRExponential357UKRWeibull348UKRLog-normal349	Procedure	Distribution	AIC
TKRWeibull1637TKRLog-normal1635UKRExponential357UKRWeibull348UKRLog-normal349	TKR	Exponential	1657
TKRLog-normal1635UKRExponential357UKRWeibull348UKRLog-normal349	TKR	Weibull	1637
UKRExponential357UKRWeibull348UKRLog-normal349	TKR	Log-normal	1635
UKR Weibull 348 UKR Log-normal 349	UKR	Exponential	357
UKR Log-normal 349	UKR	Weibull	348
	UKR	Log-normal	349

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Table A3.11 AIC of parametric models for mortality for male, 60 to 75 subgroups

Procedure	Distribution	AIC
TKR	Exponential	9758
TKR	Weibull	9617
TKR	Log-normal	9676
UKR	Exponential	3050
UKR	Weibull	2996
UKR	Log-normal	3010



Table A3.12 AIC of parametric models for mortality for female, 60 to 75 subgroups

Procedure	Distribution	AIC
TKR	Exponential	5852
TKR	Weibull	5736
TKR	Log-normal	5764
UKR	Exponential	1638
UKR	Weibull	1606
UKR	Log-normal	1610

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#### Table A3.13 AIC of parametric models for mortality for male, 75+ subgroups

Procedure	Distribution	AIC
TKR	Exponential	5758
TKR	Weibull	5645
TKR	Log-normal	5712
UKR	Exponential	2057
UKR	Weibull	1998
UKR	Log-normal	2026



Procedure	Distribution	AIC
TKR	Exponential	4482
TKR	Weibull	4415
TKR	Log-normal	4462
UKR	Exponential	1306
UKR	Weibull	1272
UKR	Log-normal	1293



Table A3.15 AIC of parametric models for mortality for usage, <10 subgroups

Procedure	Distribution	AIC
TKR	Exponential	5164
TKR	Weibull	5069
TKR	Log-normal	5103
UKR	Exponential	1389
UKR	Weibull	1355
UKR	Log-normal	1366



Table A3.16 AIC of parametric models for mortality for usage, 10+ subgroups

Procedure	Distribution	AIC
TKR	Exponential	25418
TKR	Weibull	25025
TKR	Log-normal	25187
UKR	Exponential	8262
UKR	Weibull	8094
UKR	Log-normal	8146

### COSTS

Table A4.1 Hospital costs

	Procedure	Subgroup	N	Mean	SD	SE
Primary						
	TKR	<60, Female	10287	5968	1070	3
	UKR	<60, Female	3270	3910	2259	4
	TKR	<60, Male	10856	5965	1107	3
	UKR	<60, Male	3857	3935	2274	4
	TKR	60 to 70, Female	21480	6013	992	3
	UKR	60 to 70, Female	6567	3996	2257	4
	TKR	60 to 70, Male	18249	6047	988	3
	UKR	60 to 70, Male	5493	3996	2226	4
	TKR	>75, Female	5033	6186	1266	3
	UKR	>75, Female	1702	4035	2276	4
	TKR	>75, Male	5098	6131	1126	3
	UKR	>75, Male	1619	3993	2249	4
	TKR	<10	53832	6041	991	3
	UKR	<10	4210	4070	2224	4
	TKR	10+	15542	6002	1223	3
	UKR	10+	18213	3947	2260	4
Reoperation						
	TKR	<60, Female	497	2384	1979	4
	UKR	<60, Female	171	1822	1558	3
	TKR	<60, Male	549	2122	1776	4
	UKR	<60, Male	206	1680	1183	3
	TKR	60 to 70, Female	689	2361	2124	4
	UKR	60 to 70, Female	203	2220	2036	4
	TKR	60 to 70, Male	590	2258	2188	4
	UKR	60 to 70, Male	148	1929	1817	4

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3							
4							
5	TKR	>75, Female	114	2962	3158	56	
6	UKR	>75. Female	27	2496	2772	53	
7	ТКВ	>75 Male	107	2174	2045	45	
8	LIKB	>75 Male	40	1973	2353	49	
9	тир	<10	40 810	1373	2333	45	
10		<10	72	2525	1267	40	
11 12		<10	73	1577	1367	37	
13	IKR	10+	240	2291	2008	45	
14	UKR	10+	276	2104	1957	44	
15	Revision	1 1					
16	TKR	<60, Female	470	8154	2775	53	
17	UKR	<60, Female	300	6385	2507	50	
18	TKR	<60, Male	428	7937	2534	50	
19	UKR	<60, Male	367	6210	2379	49	
20	TKR	60 to 70, Female	598	7866	3748	61	
21	UKR	60 to 70, Female	347	6607	2365	49	
23	TKR	60 to 70, Male	428	8045	2684	52	
24	UKR	60 to 70, Male	326	6492	2364	49	
25	TKR	>75, Female	73	7820	3079	55	
26	UKR	>75, Female	39	6876	1824	43	
27	TKR	>75, Male	72	8049	2742	52	
28	UKR	>75, Male	85	6844	2145	46	
29 30	TKR	<10	643	7924	3541	60	
30	UKB	<10	189	6867	2410	49	
32	ткв	10+	216	8233	2443	49	
33	ПКВ	10+	541	6491	2352	48	
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#### Table A4.2 Primary care costs

#### Patient characteristics

	Before matching			After matching		
	TKR	UKR	SMD	TKR	UKR	SMD
Number of individuals	23,290	335		1,005	335	
Age at primary (mean (sd))	70.86 (8.79)	66.58 (9.74)	0.462	66.69 (9.26)	66.58 (9.74)	0.012
Gender: female (%)	13409 (57.6)	168 (50.1)	0.149	481 (47.9)	168 (50.1)	0.046
Year of primary (median [IQR])	2005 [2001, 2008]	2006 [2004, 2008]	0.469	2007 [2004, 2009]	2006 [2004, 2008]	0.004
Pain-related prescription costs in year prior to primary (median [IQR])	21 [2, 84]	16 [2, 59]	0.166	17 [2, 65]	16 [2, 59]	0.021
Consultation costs in year prior to primary (median [IQR])	322 [176, 552]	368 [184, 598]	0.142	368 [184, 644]	368 [184, 598]	0.007
Comorbidities at index date						
Chronic pulmonary disease (mean (sd))	0.20 (0.40)	0.15 (0.36)	0.132	0.16 (0.37)	0.15 (0.36)	0.025
Rheumatological disease (mean (sd))	0.07 (0.25)	0.05 (0.22)	0.068	0.05 (0.22)	0.05 (0.22)	0.005
Cerebrovascular disease (mean (sd))	0.05 (0.22)	0.03 (0.16)	0.135	0.03 (0.17)	0.03 (0.16)	0.012
Diabetes (mean (sd))	0.10 (0.30)	0.10 (0.29)	0.005	0.09 (0.29)	0.10 (0.29)	0.017
Myocardial infarction (mean (sd))	0.04 (0.21)	0.03 (0.18)	0.059	0.04 (0.19)	0.03 (0.18)	0.027
Congestive heart disease (mean (sd))	0.03 (0.17)	0.02 (0.13)	0.078	0.01 (0.12)	0.02 (0.13)	0.032
Renal disease (mean (sd))	0.07 (0.25)	0.07 (0.26)	0.029	0.07 (0.26)	0.07 (0.26)	< 0.001
Cancer (mean (sd))	0.08 (0.27)	0.05 (0.21)	0.123	0.05 (0.22)	0.05 (0.21)	0.009
Metastatic tumour (mean (sd))	0.00 (0.05)	0.00 (0.05)	< 0.001	0.00 (0.06)	0.00 (0.05)	0.017
Diabetes with complications (mean (sd))	0.02 (0.13)	0.02 (0.13)	0.016	0.02 (0.13)	0.02 (0.13)	< 0.001
Peptic ulcer disease (mean (sd))	0.06 (0.23)	0.05 (0.22)	0.024	0.06 (0.24)	0.05 (0.22)	0.035
Peripheral vascular disease (mean (sd))	0.03 (0.17)	0.01 (0.12)	0.11	0.02 (0.14)	0.01 (0.12)	0.031
Dementia (mean (sd))	0.00 (0.05)	0.00 (0.00)	0.066	0.00 (0.00)	0.00 (0.00)	-
Mild liver disease (mean (sd))	0.00 (0.06)	0.01 (0.08)	0.042	0.01 (0.08)	0.01 (0.08)	< 0.001
Hemiplegia (mean (sd))	0.00 (0.05)	0.00 (0.00)	0.066	0.00 (0.00)	0.00 (0.00)	-
Liver disease (mean (sd))	0.00 (0.02)	0.00 (0.00)	0.032	0.00 (0.00)	0.00 (0.00)	-

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					0.00 (0.01)	0.00 (0.00)	0.009	0.00 (0.00)	0.00 (0.00)	-
Costs										
	Ν	Mean	SD	SE						
<60, Male	82	328	301	33						
60 to 70, Male	175	431	334	25						
>75, Male	57	640	497	66						
<60, Female	54	503	431	59						
60 to 70, Female	164	478	406	32						
>75, Female	62	554	418	53						
All	594	471	396	16						
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#### QUALITY OF LIFE

#### Table A5.1 EQ-5D index scores

				Pre-op			Post-op		
	Procedure	Subgroup	Ν	Mean	SD	SE	Mean	SD	SE
Primary									
	TKR	<60, Male	1,487	0.44	0.30	0.008	0.70	0.28	0.007
	TKR	<60, Female	1,613	0.39	0.31	0.008	0.69	0.28	0.007
	TKR	60 to 70, Male	3,456	0.54	0.27	0.005	0.78	0.23	0.004
	TKR	60 to 70, Female	2,850	0.47	0.29	0.005	0.76	0.23	0.004
	TKR	>75, Male	641	0.56	0.25	0.010	0.79	0.21	0.008
	TKR	>75, Female	510	0.47	0.29	0.013	0.77	0.22	0.010
	UKR	<60, Male	473	0.44	0.30	0.014	0.71	0.29	0.013
	UKR	<60, Female	592	0.39	0.32	0.013	0.69	0.30	0.012
	UKR	60 to 70, Male	1,155	0.53	0.27	0.008	0.81	0.21	0.006
	UKR	60 to 70, Female	882	0.49	0.28	0.009	0.78	0.24	0.008
	UKR	>75, Male	241	0.54	0.25	0.016	0.84	0.18	0.012
	UKR	>75, Female	176	0.47	0.30	0.023	0.81	0.20	0.015
	TKR	<10	2,052	0.46	0.30	0.007	0.74	0.26	0.006
	UKR	<10	684	0.45	0.29	0.011	0.73	0.27	0.010
	TKR	10+	8,379	0.49	0.29	0.000	0.75	0.24	0.003
	UKR	10+	2,793	0.49	0.29	0.010	0.78	0.24	0.005
Revision									
	TKR		686	0.31	0.32	0.012	0.55	0.32	0.012
	UKR		248	0.38	0.31	0.020	0.61	0.27	0.017

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### SENSITIVITY ANALYSES.

#### Distribution of parametric model for revision risk: exponential

	TKR		UKR				
	QALYs	Costs	QALYs	Costs	Δ QALYs	Δ Costs	ICER (probability cost- effective*)
Male, <60	10.28	15,367	10.43	13,701	0.16	-1,666	UKR dominant (92%)
	(10.06 to 10.47)	(14,690 to 16,020)	(10.13 to 10.72)	(12,986 to 14,370)	(-0.17 to 0.50)	(-1,931 to -1,411)	
Male, 60-75	8.58	13,455	8.82	11,877	0.24	-1,578	UKR dominant (100%)
	(8.49 to 8.68)	(12,710 to 14,286)	(8.66 to 8.97)	(11,114 to 12,696)	(0.05 to 0.41)	(-1,796 to -1,382)	
Male, 75+	5.60	11,529	5.80	9,503	0.19	-2,026	UKR dominant (100%)
	(5.48 to 5.71)	(10,591 to 12,639)	(5.64 to 5.95) 🧹	(8,515 to 10,620)	(0.01 to 0.37)	(-2,214 to -1,833)	
Female <i>,</i> <60	10.70	16,794	10.81	15,743	0.11	-1,050	UKR dominant (78%)
	(10.48 to 10.90)	(15,959 to 17,745)	(10.46 to 11.12)	(14,831 to 16,688)	(-0.28 to 0.45)	(-1,384 to -747)	
Female, 60-75	8.97	13,764	9.27	12,664	0.30	-1,100	UKR dominant (100%)
	(8.86 to 9.08)	(12,993 to 14,538)	(9.07 to 9.47)	(11,831 to 13,500)	(0.08 to 0.51)	(-1,320 to -874)	
Female, 75+	6.01	11,483	6.46	10,264	0.45	-1,220	UKR dominant (100%)
	(5.81 to 6.16)	(10,584 to 12,437)	(6.19 to 6.70)	(9,265 to 11,236)	(0.16 to 0.75)	(-1,495 to -940)	
Expected (mear	n) values with 95%	confidence intervals	in parentheses. UP	(R is considered 'dom	ninant' if it is exp	ected to improve he	alth outcomes and
reduce health c	are costs. *Given a	a cost-effectiveness tl	hreshold of £20,00	0.			

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	TKR			UKR				
	Proportio n revised	QALYs	Costs	QALYs	Costs	Δ QALYs	∆ Costs	ICER (probab cost-effective
Male, <60	19.2%	10.35	14,812	10.49	13,071	0.14	-1,742	UKR dominar (89%)
	(16.9% to 21.8%)	(10.14 to 10.56)	(14,135 to 15,507)	(10.16 to 10.82)	(12,350 to 13,798)	(-0.22 to 0.47)	(-2,018 to - 1,447)	()
Male, 60-75	8.6%	8.62	13,186	8.86	11,643	0.23	-1,544	UKR dominar
	(7.3% to 10.1%)	(8.53 to 8.71)	(12,471 to 13,977)	(8.69 to 9.00)	(10,936 to 12,441)	(0.04 to 0.40)	(-1,779 to - 1,292)	(10070)
Male, 75+	3.3%	5.61	11,438	5.81	9,421	0.19	-2,017	UKR dominar (100%)
	(1.6% to 6.4%)	(5.50 to 5.72)	(10,519 to 12,541)	(5.63 to 5.96)	(8,456 to 10,529)	(0.01 to 0.36)	(-2,358 to - 1,613)	(10070)
Female, <60	20.1%	10.75	16,367	10.84	15,081	0.08	-1,286	UKR dominaı (77%)
	(17.5% to 22.6%)	(10.54 to 10.95)	(15,426 to 17,302)	(10.50 to 11.15)	(14,165 to 15,958)	(-0.29 to 0.45)	(-1,615 to -958)	(
Female, 60- 75	9.9%	8.99	13,621	9.31	12,364	0.32	-1,257	UKR dominaı (100%)
	(8.2% to 11.9%)	(8.88 to 9.10)	(12,870 to 14,439)	(9.10 to 9.50)	(11,581 to 13,152)	(0.08 to 0.54)	(-1,524 to - 1,013)	,
Female, 75+	3.4%	6.02	11,389	6.47	10,108	0.45	-1,281	UKR dominai (100%)
	(1.8% to 6.5%)	(5.80 to 6.16)	(10,524 to 12.368)	(6.16 to 6.70)	(9,168 to 11.159)	(0.16 to 0.73)	(-1,685 to -897)	(10070)

reduce health care costs. \*Given a cost-effectiveness threshold of £20,000.

	TKR		UKR		-		
	QALYs	Costs	QALYs	Costs	Δ QALYs	Δ Costs	ICER (probability cost- effective*)
Mala (CO	10.22	15 257	10.40	14404	0.10	1 222	
Male, <60	10.32	15,357 (14,706 to 16,016)	10.49	14,134	0.10	-1,223	UKR dominant (95%)
Mala 60 75	(10.00 10 10.47)		(10.18 to 10.82)	(13,472 10 14,795)	(-0.11 (0 0.57)	(-1,417 (0 -966)	LIKE dominant (100%)
Iviale, 60-75	0.02	13,307	(0.03)	11,952	0.21	-1,333	UKK dominant (100%)
	(8.51 (0 8.70)		(8.68 (0 8.98)		(0.04 (0 0.41)	(-1,594 (0 -1,131)	LIKE dominant (100%)
Male, 75+	5.01 (F 40 to F 72)	11,454	5.81	9,450	$(0.01 \pm 0.28)$	-2,005	UKR dominant (100%)
Fomale (60	(5.49 10 5.72)	(10,515 to 12,505)	(5.64 (0 5.96)	(8,476 10 10,614)	(0.01 (0 0.38)	(-2,457 t0 -1,480)	LIKE dominant (01%)
remale, <00	10.73	10,901	10.90	10,300	$(0.14 \pm 0.62)$	-001	OKK dominant (91%)
Fomala 60 7E		(10,099 (0 17,907)	(10.57 to 11.22)	(15,480 t0 17,287)	(-0.14 (0 0.62)	(-867 10 -346)	LIKE dominant (100%)
remale, 00-75	0.90 (9 95 to 0.07)	13,014	9.28	12,070 (12,109 to 12,711)	$(0.00 \pm 0.054)$	-933 ( 1 102 to 695)	UKK dominant (100%)
Fomalo 75	(8.85 (0 9.07)		(9.09 (0 9.47)	(12,108 to 15,711)	(0.09 (0 0.34)	(-1,192 (0 -065)	LIKP dominant (100%)
remale, 75+	0.05 (E 91 to 6 17)	11,410 (10.497 to 12 E00)	0.50 (6.24 to 6.72)	10,500	(0.47)	-1,102	

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	TKR		UKR		-		
	QALYs	Costs	QALYs	Costs	Δ QALYs	Δ Costs	ICER (probability cos effective*)
Male. <60	10.28	13.638	10.39	12.415	0.12	-1.223	UKR dominant (83%)
,	(10.06 to 10.47)	(13.060 to 14.237)	(10.09 to 10.69)	(11.859 to 13.039)	(-0.23 to 0.45)	(-1.432 to -1.028)	
Male 60-75	8.61	13 307	8 81	11 952	0.20	-1 355	UKR dominant (100%
Wale, 00 75	(8 50 to 8 70)	$(12571 \pm 014151)$	(8 66 to 8 96)	(11 210 to 12 817)	(0.03 to 0.39)	$(-1.598 \pm 0.1.103)$	
Malo 75	(8.30 t0 8.70) E 61	(12,571 (0 14,151)	(8.00 10 8.90)	0 450	(0.03 (0 0.33)	2 005	LIKE dominant (1009
iviale, 75+	5.01 /F 49 to F 72)	(10.460 to 12.626)	$(E, G_2 + 0, E, 0, G)$	9,450 (9,502 to 10,670)	$(0.00 \pm 0.027)$	-2,003	OKK UOIIIIIaiit (1007
Formala (CO	(5.48 (0 5.72)	(10,460 to 12,626)	(5.03 10 5.90)	(8,503 (0 10,079)	(0.00 (0.0.37)	(-2,445 (0 -1,542)	LIKD dominant (720/)
remale, <00	10.08	10,901	10.78	10,300	(0.22 + 0.40)	-001 ( 002 to 240)	UKK UUIIIInant (73%)
F	(10.48 to 10.88)	(15,994 to 17,808)	(10.44 to 11.06)	(15,406 to 17,199)	(-0.33 to 0.46)	(-893 to -348)	LIKE de set se et (4000
Female, 60-75	8.96	13,814	9.24	12,878	0.28	-935	UKR dominant (100%
	(8.85 to 9.08)	(13,026 to 14,588)	(9.05 to 9.44)	(12,050 to 13,727)	(0.04 to 0.51)	(-1,168 to -705)	
Female, 75+	6.02	11,410	6.46	10,308	0.44	-1,102	UKR dominant (100%
reduce health c	care costs. *Given a	a cost-effectiveness t	hreshold of £20,00	0.	O		
reduce health c	care costs. *Given a	a cost-effectiveness t	hreshold of £20,00	0.			

<b>Consolio</b> Items	<b>lated H</b> to incl	<b>ealth Econ</b> o ude when r
Section/Topic	ltem No	Recomme
Title and abstrac	t	

#### **Consolidated Health Economic Evaluation Reporting Standards (CHEERS) Checklist** Items to include when reporting economic evaluations of health interventions

Section/Topic	ltem No	Recommendation	Reported on page No / Line No
Title and abstrac	t		
Title	1	Identify the study as an economic evaluation or use more specific terms such as "cost-effectiveness analysis", and describe the interventions compared.	Title page
Abstract	2	Provide a structured summary of objectives, perspective, setting, methods (including study design and inputs), results (including base case and uncertainty analyses), and conclusions.	Page 1, lines 1- 29
Introduction			
Background	3	Provide an explicit statement of the broader context for the study.	Page 3, lines 46- 68
and objectives	5	Present the study question and its relevance for health policy or practice decisions.	Page 3, lines 68- 71
Methods	_		
Target population and subgroups	4	Describe characteristics of the base case population and subgroups analysed, including why they were chosen.	Page 3, lines 73- 80
Setting and location	5	State relevant aspects of the system(s) in which the decision(s) need(s) to be made.	Page 3, lines 95- 99
Study perspective	6	Describe the perspective of the study and relate this to the costs being evaluated.	Page 4, lines 92- 99
Comparators	7	Describe the interventions or strategies being compared and state why they were chosen.	Page 3, lines 46- 60
Time horizon	8	State the time horizon(s) over which costs and consequences are being evaluated and say why appropriate.	Page 3, lines 82- 83
Discount rate	9	Report the choice of discount rate(s) used for costs and outcomes and say why appropriate.	Page 5, lines 137-145
Choice of health outcomes	10	Describe what outcomes were used as the measure(s) of benefit in the evaluation and their relevance for the type of analysis performed.	Page 5, lines 141-158
Measurement of	11a	<i>Single study-based estimates:</i> Describe fully the design features of the single effectiveness study and why the single study was a sufficient source of clinical effectiveness data.	Page 4, lines 100-122
effectiveness	11b	<i>Synthesis-based estimates:</i> Describe fully the methods used for identification of included studies and synthesis of clinical	

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		effectiveness data.	
Measurement and valuation of preference- based outcomes	12	If applicable, describe the population and methods used to elicit preferences for outcomes.	Page lines 140-
Estimating	13a	Single study-based economic evaluation: Describe approaches used to estimate resource use associated with the alternative interventions. Describe primary or secondary research methods for valuing each resource item in terms of its unit cost. Describe any adjustments made to approximate to opportunity costs.	
costs	13b	Model-based economic evaluation: Describe approaches and data sources used to estimate resource use associated with model health states. Describe primary or secondary research methods for valuing each resource item in terms of its unit cost. Describe any adjustments made to approximate to opportunity costs.	Page 55, li 123-
Currency, price data, and conversion	14	Report the dates of the estimated resource quantities and unit costs. Describe methods for adjusting estimated unit costs to the year of reported costs if necessary. Describe methods for converting costs into a common currency base and the exchange rate.	Page lines 138-
Choice of model	15	Describe and give reasons for the specific type of decision- analytical model used. Providing a figure to show model structure is strongly recommended.	Page 4, lin 81-9
Assumptions	16	Describe all structural or other assumptions underpinning the decision-analytical model.	Page 5, lin 88-9
Analytic methods	17	Describe all analytical methods supporting the evaluation. This could include methods for dealing with skewed, missing, or censored data; extrapolation methods; methods for pooling data; approaches to validate or make adjustments (such as half cycle corrections) to a model; and methods for handling population heterogeneity and uncertainty.	Page lines 159-
Results	1		1
Study parameters	18	Report the values, ranges, references, and, if used, probability distributions for all parameters. Report reasons or sources for distributions used to represent uncertainty where appropriate. Providing a table to show the input values is strongly recommended.	Арре
Incremental costs and outcomes	19	For each intervention, report mean values for the main categories of estimated costs and outcomes of interest, as well as mean differences between the comparator groups. If applicable, report incremental cost-effectiveness ratios.	Table and
Characterizing uncertainty	20a	Single study-based economic evaluation: Describe the effects of sampling uncertainty for the estimated incremental cost and incremental effectiveness parameters, together with the impact of methodological assumptions (such as discount rate, study perspective).	

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20b <i>Model-based economic evaluation:</i> Describe the effects on the results of uncertainty for all input parameters, and uncertainty related to the structure of the model and assumptions.						
Characterizing heterogeneity	haracterizing eterogeneity 21 If applicable, report differences in costs, outcomes, or cost- subgroups of patients with different baseline characteristics or other observed variability in effects that are not reducible by more information.					
Discussion						
Study findings, limitations, generalizability, and current knowledge	22	Summarise key study findings and describe how they support the conclusions reached. Discuss limitations and the generalisability of the findings and how the findings fit with current knowledge.	Pages 6- 7, lines 192-253			
Other						
Source of funding	23	Describe how the study was funded and the role of the funder in the identification, design, conduct, and reporting of the analysis. Describe other non-monetary sources of support.	Page 8, lines 265-267			
Conflicts of interest	24	Describe any potential for conflict of interest of study contributors in accordance with journal policy. In the absence of a journal policy, we recommend authors comply with International Committee of Medical Journal Editors recommendations.	Page 8, lines 273-277			

# **BMJ Open**

# Cost-effectiveness of unicompartmental compared to total knee replacement: a population-based study using data from the National Joint Registry for England and Wales

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<b>Primary Subject Heading</b> :	Health economics		
Secondary Subject Heading:	Surgery		
Keywords:	Osteoarthritis, Unicompartmental knee replacement, Total knee replacement, Knee < ORTHOPAEDIC & TRAUMA SURGERY		

SCHOLARONE<sup>™</sup> Manuscripts

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#### KEYWORDS

Knee; Osteoarthritis; Arthroplasty; Unicompartmental knee replacement; Total knee replacement

1	ABSTRACT
2	Objectives
3	To assess the value for money of unicompartmental knee replacement (UKR) compared to total knee
4	replacement (TKR).
5	Design
6	A lifetime Markov model provided the framework for the analysis.
7	Setting
8	Data from the National Joint Registry (NJR) for England and Wales primarily informed the analysis.
9	Participants
10	Propensity score matched patients in the NJR who received either a UKR or TKR.
11	Interventions
12	UKR is a less invasive alternative to TKR, where only the compartment affected by osteoarthritis is
13	replaced.
14	Primary outcome measures
15	Incremental Quality-Adjusted Life Years (QALYs) and healthcare system costs.
16	Results
17	The provision of UKR is expected to lead to a gain in QALYs compared to TKR for all age and gender
18	subgroups (Male <60: 0.12, 60-75: 0.20, 75+: 0.19, Female <60: 0.10, 60-75: 0.28, 75+: 0.44) and a
19	reduction in costs (Male <60: -£1,223, 60-75: -£1,355, 75+: -£2,005, Female <60: -£601, 60-75: -£935,
20	75+: -£1,102 per patient over the lifetime). UKR is expected to lead to a reduction in QALYs
21	compared to TKR when performed by surgeons with low UKR utilisation, but an increase among
22	those with high utilisation (<10%, median 6%: -0.04, ≥10%, median 27%: 0.26). Regardless of
23	surgeon usage, costs associated with UKR are expected to be lower than those of TKR (<10%: -£127,
24	≥10%: -£758).
25	Conclusions
26	UKR can be expected to generate better health outcomes and lower lifetime costs than TKR. Surgeon
27	usage of UKR does, however, have a significant impact on the cost-effectiveness of the procedure.
28	To achieve the best results, surgeons need to perform a sufficient proportion of knee replacements
29	as UKR, hence low-usage surgeon may need to broaden their indications of UKR to achieve this.
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2	31	ARTICLE SUMMARY
4	32	Strengths and limitations of this study
5	33	Routinely collected data provided real-world evidence of costs and health outcomes following LIKR
6 7	24	
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9	35	Propensity score matching was used to identify comparable individuals who received UKR or TKR.
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12	36	Differences between comparator groups may have remained in unobserved characteristics, such as
13 14	37	pre-operative radiographs.
15	38	Assumptions were required to extrapolate quality of life and risk of revision over patient lifetimes.
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#### 43 INTRODUCTION

For individuals with end-stage symptomatic osteoarthritis of the knee, total knee replacement (TKR) relieves pain and improves function.<sup>1</sup> In a substantial proportion of cases, by some estimates up to 50%, patients could receive an unicompartmental knee replacement (UKR) instead. UKR is less invasive than TKR, sparing the normal joint surfaces and cruciate ligaments,<sup>23</sup> and consequently is associated with a faster recovery and lower risk of post-operative complications and mortality.<sup>45</sup> In early and late comparisons of patient-reported outcomes (PROMs), UKR has also been shown to result in superior outcomes overall, with a higher proportion of patients reporting an excellent result.<sup>67</sup> However, UKR is also associated with a higher risk of revision than TKR,<sup>4</sup> with this due in 

52 large part to a lower threshold for revision.<sup>8</sup>

53 The choice between UKR and TKR also has economic implications. Given that typical length of stay is 54 lower for UKR,<sup>4</sup> undertaking a UKR can be expected to require fewer healthcare system resources 55 than a TKR. This upfront cost-saving could, however, be offset by the cost of additional reoperations 56 and revisions. Differences in outcomes, in terms of pain and function, may also lead to differences in 57 primary health care utilisation which would further affect the overall costs of the procedures.

The relative merit of each procedure can be expected to vary depending on patient and surgical
factors. Outcomes following UKR, in particular, are impacted by surgical factors. Surgeons' caseload
(the number of UKR performed) and usage of UKR (the percentage of their primary knee
replacements that are UKRs) have been shown to have a substantial impact on the success of UKR
with those performed by high usage surgeons expected to have comparable reoperation rates to
TKR.<sup>9</sup>

64 Cost-effectiveness analyses offer a means of reducing decision uncertainty by providing a

- comparative analysis of both the costs and health outcomes of UKR and TKR. Our aim in this study
   was to estimate the cost-effectiveness of UKR compared to TKR based on routinely-collected data
   from the UK and, in particular, to assess how cost-effectiveness varies depending on i) the age and
- 68 gender of patients, and ii) surgeon usage of UKR.

#### 69 MATERIALS AND METHODS

#### 70 Target population and subgroups

The study population for this analysis is comprised of those patients who could receive either a UKR or TKR. We use propensity score matching to identify those patients who received a TKR who were similar in all relevant observable characteristics to patients who received a UKR and assume both groups to be eligible for a UKR but ultimately receiving either a TKR or a UKR. We consider the cost-effectiveness of UKR compared to TKR in terms of six subgroups based on age (<60, 60 to 75, and >75) and gender. In a further analysis, we consider the effect of surgeon 'usage' of UKR on cost-effectiveness for two subgroups (<10% and ≥10%).</p>

#### 78 Decision model

A lifetime Markov model, shown in Figure 1, provides the framework for the analysis, with patients passing through clinically and economically important health states as time passes.<sup>10</sup> Patients begin by having a primary UKR or TKR, after which they have a revision operation or remain unrevised. After a revision, patients can have a further revision (re-revised) or remain 'revised'. Following a re-revision, patients remain as 're-revised' until death. From all health states patients have a risk of death and the model goes through consecutive cycles until all patients have died. Patients can transition between states on a yearly basis. The key simplifying assumptions of the model are that patients can have only two revisions and that only one revision can occur in a year. While

reoperations are not incorporated as a model state, their likelihood and costs are incorporated into the unrevised state. **Study perspective** This evaluation has been undertaken from a healthcare system perspective, hence only the costs incurred by the health system are included. These costs relate to surgical procedures being undertaken and primary care utilisation by patients. For health care interventions to be considered cost-effective (i.e. providing sufficient value for money to merit their provision) in England they should have an incremental cost per additional quality-adjusted life year (QALY) of less than £20,000 to £30,000.<sup>11</sup> For this analysis the cost-effectiveness of UKR is considered at the lower threshold of £20,000. Measurement of effectiveness An extract of data from the National Joint Registry (NJR) for England and Wales linked to the Hospital Episode Statistics (HES) database and the Office for National Statistics (ONS) informed estimates of the effectiveness of UKR and TKR. This data were previously used to compare adverse events following the procedures, with propensity scores used to match 25,334 UKRs to 75,996 comparable TKRs who received their primary procedure between 2003 and 2012.<sup>9</sup> These same matched patients were split into the age and gender subgroups for this analysis. As surgeon usage of UKR was not a variable in the original propensity score matching, matching was re-run to achieve balance within usage subgroups (see Appendix). This ensured that the comparator groups, UKR performed by surgeons with usage under 10% against TKR, and UKR by surgeons with usage equal to or over 10% against TKR, were balanced in their observable characteristics. Parametric models were specified independently for each treatment subgroup to estimate the risk of revision and death. For the base case analysis, the Weibull distribution was used for both. The risk of revision was extrapolated using estimates from the models, and risk of death was assumed to return to that given by age- and gender-specific UK life tables after the period of follow up.<sup>12</sup> Sensitivity analyses were performed for the risk of revision with the analysis re-run using the log-normal and exponential distributions instead of the Weibull. Further details of the estimated parametric models are provided in the Appendix. Risk of re-revision was based on evidence from the NJR which reported that in the first year following a revision patients have a 2.7% probability of a re-revision, and a 1.4% chance in subsequent years.<sup>13</sup> With risk of re-revision being similar following a revision of UKR and TKR,<sup>14</sup> these risks were applied in the same manner for both procedures. Risk of mortality following a revision and re-revision was assumed to be equal to that of those unrevised. Estimating resource use and costs The hospital costs associated with the primary procedures and revisions were based on patients' Healthcare Resource Group (HRG) codes (which classify episodes with similar levels of resource consumption into the same group) and length of stay, with costs estimated using the 2014/15 National Tariff Payment System.<sup>15</sup> In addition, the costs of any implant-retaining reoperations over the five years following each surgery were also incorporated. We assumed the cost of a re-revision was the same as a revision in the base case analysis. The effect of this assumption on the results was tested by re-running the analysis with a re-revision expected to have a cost 50% higher than that of a revision.

For primary care costs an extract of the Clinical Practice Research Datalink (CPRD) was used where
335 UKRs were matched with 1,005 TKRs based on propensity scores. These patients and their costs

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are summarised in the Appendix. The choice of procedure was found to have no significant effect on resource use and so the costs of treatment groups were pooled and single estimates extracted for each age and gender subgroup. Future costs and health outcomes were discounted by an annual rate of 3.5%, in line with guidelines for England and Wales.<sup>16</sup> Costs are in British pounds, in 2014 prices. Estimated hospital and primary care costs are detailed in the Appendix. Measurement and valuation of preference-based outcomes As patient-reported outcome measures (PROMs) have only been collected since 2009, a separate propensity score matched cohort of 3,519 UKRs and 10,557 TKRs for whom these data were available were used to inform estimates of health-related quality of life for each subgroup considered. Again, these patients and the process of matching have been previously described in detail,<sup>6</sup> and matching was re-run for usage subgroups (see Appendix). EuroQol 5D (EQ-5D) is a generic measure of health-related quality of life, which ranges from -0.59 (worst) to 1 (best), with 0 representing death and 0.074 considered a minimally important difference.<sup>17</sup> In the year following a primary, patients were expected to steadily progress from their pre-operative score to their post-operative score at six months, at which they would remain for the rest of year. As EQ-5D following UKR and TKR remains stable over ten years following surgery for those who remain unrevised,  $^{7}$  in the absence of any further procedure those unrevised were expected to remain at their post-operative score. The trajectory of quality of life following revision was assumed to be similar to 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 unless they went on to have a re-revision. However, due to the small number of individuals with a revision and scores available, subgroups were pooled for revision parameters. We assumed quality-of-life for a re-revision would fall in the same proportion as they did from primary to a revision procedure. To test the impact of this assumption, we conducted a sensitivity analysis where the quality of life for a re-revision was assumed instead to remain equal to that of revision. Estimates of health-related quality-of-life were based on EQ-5D collected prior to and six-month following surgery (see Appendix). Analytic methods Expected (mean) costs and QALYs were estimated for each subgroup receiving either UKR or TKR. The resulting incremental cost-effectiveness ratio (ICER) was then calculated (equal to the difference in costs divided by the difference in QALYs), with an intervention being considered dominant if it both reduced costs and increased QALYs.<sup>18</sup> The effect of parameter uncertainty was assessed using probabilistic sensitivity analysis, with input parameters assigned from probability distributions and 1,000 Monte Carlo simulations conducted for each subgroup. Probability distributions were based on the type of data, with gamma distributions used for costs as well as pre-operative quality of life so as to allow values below zero, beta distributions used for post-operative quality of life, and normal distributions used for the coefficients of parametric models and age.<sup>19 20</sup> The sets of estimated costs and QALYs from each of 1,000 Monte Carlo simulations are presented, alongside the 

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 expected results, on a cost-effectiveness plane.

171 Patient and public involvement

172 No patients were involved in the development of the research question or the outcome measures

nor the design of the study. There are no plans to disseminate the results of the research to studyparticipants.

#### RESULTS Compared to TKR, UKR was found to be associated with a greater likelihood of revision over individuals remaining lifetimes for each of the subgroups. UKR was, however, associated with better post-operative quality of life following the primary procedure than TKR for all age and gender subgroups, with the difference most pronounced for older patients. Moreover, those undergoing revision following UKR had better quality of life prior to and following revision than those who had TKR. For all subgroups, the hospital costs of primary and revision surgery were lower for UKR than TKR. See Appendix for further details. UKR was found to be cost-saving and health improving compared to TKR for all age and gender subgroups, making UKR the dominant treatment choice for those individuals eligible for either procedure (see Table 1). The largest expected savings were for males over 75 while the biggest improvement in quality of life was for females over 75. For those aged over 60 years of age, parameter uncertainty had little effect on the conclusion that UKR was cost-effective. However, for those under 60 there was some uncertainty, with a 13% and 28% probability that TKR was cost-effective for males and females under 60, respectively. Figure 2 presents the estimated mean and probabilistic sets of incremental costs and QALYs associated with the provision of UKR rather than TKR for each age and gender subgroup. These findings were broadly robust to changes in modelling assumptions (see Table 2 and Appendix for full results from each scenario analysis). When UKR was performed by surgeons with a usage of the procedure equal to or above 10% (median usage was 27%), UKR was found to be unequivocally cost-saving and health improving compared to TKR, as shown in Table 3. When performed by surgeons with usage of less than 10% (median usage was 6%), however, UKR no longer led to better health outcomes than TKR and TKR was the cost-effective procedure. Figure 3 presents the estimated means and sets of costs and QALYs for both usage subgroups. DISCUSSION **Principal findings** For patients who are eligible for either procedure, the provision of UKR rather than TKR has been estimated to lead to a gain in QALYs and a reduction in costs for all age and gender subgroups. There is little uncertainty around this conclusion for older patients. Such patients have, given their lower life expectancy, a lower lifetime risk of revision and report greater improvements in post-operative quality of life compared to TKR than younger patients. Significant uncertainty does surround whether UKR would be health-improving for younger patients for whom even relatively small

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   differences in annual revision rates lead to substantial differences in lifetime revision rates.
- Surgeon usage of UKR, i.e. the percentage of the knee replacements they perform that were UKRs, had a significant impact on the cost-effectiveness of the procedure. UKR was expected to be cost-effective when compared to TKR with 100% probability (given parameter uncertainty) when performed by surgeons with usage at or above 10%, with these surgeons having a median usage of 27%. However, when UKR performed by low usage surgeons were compared against TKR, TKR was the cost-effective option.
- 51 214 Limitations of the study
- 52215Our analysis was based on routinely-collected data from the NHS in England and Wales. While this53216dataset has the advantage of providing real-world evidence for costs and health outcomes following
- 54 217 UKR and TKR, it also has the potential pitfalls of any such observational data. In particular,
- 55 218 confounding by indication can be expected with treatment selection based on patient and surgical
  - 219 characteristics. Propensity score matching was used to achieve balance in a wide range of observed

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characteristics, however imbalances may still exist in unobserved factors which could bias the
 findings of the study. In particular, it was not possible to include pre-operative radiographs, which
 would provide a better assessment of patients eligible to have either procedure, hence differences
 in these may have persisted between matched groups.

With costs and health outcomes estimated over the remaining lifetimes of patients, modelling assumptions were unavoidable. Individuals' risk of revision over their remaining lifetimes were based on observed revisions over the eight years following surgery. In addition, quality of life estimates were based on scores recorded prior to and six months following primary and revision procedures and we assumed that, in the absence of further procedures, individuals would remain at their post-operative scores into the future. This assumption appears to be plausible following primary procedures,<sup>7</sup> however it is uncertain whether a similar pattern would be seen following revisions. If quality of life following revision steadily returned to comparable levels observed after primary procedures, the cost-effectiveness of UKR, which has a higher risk of revision, will have been somewhat underestimated. Furthermore, we assumed quality of life associated with re-revision would have dropped by the same proportion as that observed from primary to revision and the cost of a re-revision was assumed to be equivalent to that of a revision. These assumptions were necessarily subjective; however, scenario analyses showed the findings of the study to be robust to changes in these assumptions.

# 238 Study findings in context

In line with findings from previous economic evaluations of UKR and TKR,<sup>21</sup> in this study we found UKR to be less costly than TKR.<sup>7</sup> Furthermore, consistent with previous research, UKR was also found to lead to better health outcomes for patients aged 65 and over. Little uncertainty surrounds this conclusion for older patients, who benefit most from a less-invasive procedure and have a low lifetime risk of revision. For younger patients, whose health outcomes are mixed, <sup>22-24</sup> this analysis found that UKR was also expected to lead to better health outcomes than TKR, although there was significant uncertainty in this conclusion. The variation in findings for younger patients across studies appears to be driven by differences in estimates for both the risk of revision and the expected effect of revision on quality of life.<sup>7</sup> 

This study has also highlighted the importance of surgeon usage of UKR on the cost-effectiveness of the procedure. In the high usage group, with a median usage of 27%, UKR was found, with no parameter uncertainly, to lead to better health outcomes and to cost-savings compared to TKR. In contrast, in the low usage group UKR provided worse health outcomes and only small cost savings. High usage surgeons appear to achieve good results following UKR regardless of their caseload of the procedure, and so the poor results of those with low usage appear to be primarily due to inappropriate patient selection.<sup>25</sup> In particular, low usage surgeons seem more likely to offer UKR to patients with partial-thickness cartilage loss (PTCL). PTCL is associated with poor outcomes following UKR and so it has been recommended that UKR should only be undertaken for individuals with bone-on-bone arthritis.<sup>9</sup> High usage surgeons, therefore, should be supported while low usage surgeons should consider changing their practice. If surgeons with low or no usage of UKR learnt and applied the indications and techniques of current high usage surgeons, they can be expected to achieve similar results. 

# 261 CONCLUSIONS

For those patients with appropriate indications, UKR provides an alternative to TKR which is less
costly for the healthcare system to provide and leads to greater improvements in their overall health
outcomes over their lifetime. If surgeons performing UKR achieved sufficient usage of the

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procedure, future economic and population health gains would likely be increased even further.

Additional work is needed to identify the optimal usage of UKR, which may depend on the type of

implants used. Surgeons should not have a low usage and be performing UKR in less than 10% of

reasonable for surgeons to aim for a quarter of their knee replacements to be UKR. However it has

been shown that up to 50% of replacements could be UKR, so the optimal usage may be higher.<sup>26</sup>

to perteries only

their knee replacements. The median usage in the high usage group was 27% so it would be

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- 277 conformed to the NJR's standard protocol for data access and publication. The views expressed
- 278 represent those of the authors and do not necessarily reflect those of the National Joint Registry
- 279 Steering Committee or the Healthcare Quality Improvement Partnership (HQIP) who do not vouch
- 280 for how the information is presented. HES data copyright © 2013, Re-used with the permission of
- 281 the Health & Social Care Information Centre. All rights reserved.

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# 285 CONTRIBUTORS

EB, ADL, TWH, AJ, HGP, DWM and RPV all made substantial contributions to conception and design
of the study. EB, ADL and RPV undertook the statistical analysis. EB, DWM and RPV drafted the
manuscript with ADL, TWH, AJ and HGP revising it for important intellectual content. All authors
read and approved the final manuscript.

# 290 COMPETING INTERESTS

All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi\_disclosure.pdf and declare: financial support for the submitted work from Zimmer Biomet; HGP and DWM have received consultancy fees and DWM has received royalties from Zimmer Biomet; TWH and DWM

294 hold various patents related to Total and Unicompartmental Knee Replacement.

# 295 ETHICAL APPROVAL

#### Permission to access data was given by the National Information Governance Board, now the Confidentiality Advisory Group (application number ECC 1-02 (FT3)/2013).

# 298 DATA SHARING

299 Access to data is available from the National Joint Registry for England and Wales.

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#### TABLE 1: BASE CASE COST-EFFECTIVENESS RESULTS FOR AGE AND GENDER SUBGROUPS

	TKR		UKR				
	QALYs	Costs (£)	QALYs	Costs (£)	Δ QALYs	Δ Costs (£)	ICER (probability cost- effective*)
Male, <60	10.28	15,357	10.39	14,134	0.12	-1,223	UKR dominant (87%)
	(10.07 to 10.47)	(14,704 to 16,019)	(10.11 to 10.70)	(13,489 to 14,810)	(-0.19 to 0.47)	(-1,439 to -1,014)	
Male, 60-75	8.61	13,307	8.81	11,952	0.20	-1,355	UKR dominant (100%)
	(8.50 to 8.70)	(12,584 to 14,037)	(8.63 to 8.97)	(11,246 to 12,704)	(0.01 to 0.39)	(-1,610 to -1,122)	
Male, 75+	5.61	11,454	5.80	9,450	0.19	-2,005	UKR dominant (100%)
	(5.49 to 5.73)	(10,506 to 12,511)	(5.64 to 5.97)	(8,442 to 10,631)	(0.02 to 0.37)	(-2,361 to -1,521)	
Female, <60	10.68	16,961	10.78	16,360	0.10	-601	UKR dominant (72%)
	(10.50 to 10.89)	(16,101 to 17,899)	(10.42 to 11.09)	(15,514 to 17,273)	(-0.33 to 0.47)	(-887 to -350)	
Female, 60-75	8.96	13,814	9.24	12,878	0.28	-935	UKR dominant (100%)
	(8.84 to 9.06)	(13,089 to 14,602)	(9.04 to 9.43)	(12,068 to 13,702)	(0.05 to 0.50)	(-1,186 to -710)	
Female, 75+	6.02	11,410	6.46	10,308	0.44	-1,102	UKR dominant (100%)
	(5.82 to 6.15)	(10,541 to 12,378)	(6.20 to 6.69)	(9,312 to 11,378)	(0.18 to 0.71)	(-1,646 to -695)	
Expected (mean) values with 95% confidence intervals in parentheses. UKR is considered 'dominant' if it is expected to improve health outcomes and							

reduce health care costs. \*Given a cost-effectiveness threshold of £20,000. ICER: incremental cost-effectiveness ratio.
#### **TABLE 2: SCENARIO ANALYSES**

	Age and gende	r subgroups				
	Male, <60	Male, 60-75	Male, 75+	Female, <60	Female, 60-75	Female, 75+
Base case assumptions	UKR dominant	UKR dominant	UKR dominant	UKR dominant	UKR dominant	UKR dominant
	(87%)	(100%)	(100%)	(72%)	(100%)	(100%)
Distribution of parametric model for revisio	n risk					
Exponential	UKR dominant	UKR dominant	UKR dominant	UKR dominant	UKR dominant	UKR dominant
	(92%)	(100%)	(100%)	(78%)	(100%)	(100%)
Log-normal	UKR dominant	UKR dominant	UKR dominant	UKR dominant	UKR dominant	UKR dominant
	(89%)	(100%)	(100%)	(77%)	(100%)	(100%)
Health utility						
Re-revision equal to revision	UKR dominant	UKR dominant	UKR dominant	UKR dominant	UKR dominant	UKR dominant
	(95%)	(100%)	(100%)	(91%)	(100%)	(100%)
Cost						
Cost of re-revision 50% higher than revision	UKR dominant	UKR dominant	UKR dominant	UKR dominant	UKR dominant	UKR dominant
	(83%)	(100%)	(100%)	(73%)	(100%)	(100%)

Incremental cost-effectiveness ratio (ICER) with probability of being cost-effective, based on probabilistic sensitivity analysis and given a cost-effectiveness threshold of £20,000, in parentheses. UKR is considered 'dominant' if it is expected to improve health outcomes and reduce health care costs. Full results for each scenario analysis are detailed in the Appendix.

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( UKR <10% ٤ UKR ≥10% ٤ Expected (me reduce health	QALYs 8.67 (8.53 to 8.80) 8.81 (8.73 to 8.88) ean) values wit th care costs. *(	Costs (£) 13,267 (12,834 to 13,731) 13,170 (12,726 to 13,614) th 95% confidence in Given a cost-effective	QALYs 8.62 (8.38 to 8.84) 9.06 (8.94 to 9.18) tervals in parent eness threshold	Costs (£) 13,140 (12,643 to 13,614) 12,411 (11,978 to 12,856) heses. UKR is considered of £20,000.	Δ QALYs -0.04 (-0.32 to 0.21) 0.26 (0.12 to 0.40) erred 'dominant' in	Δ Costs (£) -127 (-429 to 127) -758 (-939 to -579) f it is expected to	ICER (probability cost-effective*) £3,000/QALY (37%) UKR dominant (100%) to improve health outcomes and
UKR <10% { ( UKR ≥10% { Expected (me reduce health	8.67 (8.53 to 8.80) 8.81 (8.73 to 8.88) ean) values wit ch care costs. *(	13,267 (12,834 to 13,731) 13,170 (12,726 to 13,614) th 95% confidence in Given a cost-effective	8.62 (8.38 to 8.84) 9.06 (8.94 to 9.18) tervals in parent eness threshold	13,140 (12,643 to 13,614) 12,411 (11,978 to 12,856) heses. UKR is conside of £20,000.	-0.04 (-0.32 to 0.21) 0.26 (0.12 to 0.40) ered 'dominant' it	-127 (-429 to 127) -758 (-939 to -579) f it is expected to	£3,000/QALY (37%) UKR dominant (100%) to improve health outcomes and
( UKR ≥10% Expected (me reduce health	(8.53 to 8.80) 8.81 (8.73 to 8.88) ean) values wit ch care costs. *(	(12,834 to 13,731) 13,170 (12,726 to 13,614) th 95% confidence in Given a cost-effective	(8.38 to 8.84) 9.06 (8.94 to 9.18) tervals in parent eness threshold	(12,643 to 13,614) 12,411 (11,978 to 12,856) heses. UKR is conside of £20,000.	(-0.32 to 0.21) 0.26 (0.12 to 0.40) erred 'dominant' in	(-429 to 127) -758 (-939 to -579) f it is expected to	UKR dominant (100%)
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Expected (me reduce health	ean) values wit	th 95% confidence in Given a cost-effective	tervals in parent eness threshold	heses. UKR is conside of £20,000.	ered 'dominant' in	f it is expected to	o improve health outcomes and
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Figure 1: Model outline. The decision-analytic model provides the framework for the analysis.

 Figure 2: Cost-effectiveness plane for age and gender subgroups. The sets of estimated incremental costs and QALYs associated with the provision of UKR rather than TKR from each of the Monte Carlo simulations are shown as points with the expected results as triangles.

Figure 3: Cost-effectiveness plane for usage subgroups. The sets of estimated incremental costs and QALYs associated with the provision of UKR rather than TKR from each of the Monte Carlo simulations are shown as points with the expected results as triangles.

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Cost-effectiveness plane for age and gender subgroups. The sets of estimated incremental costs and QALYs associated with the provision of UKR rather than TKR from each of the Monte Carlo simulations are shown as points with the expected results as triangles.

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## **APPENDIX**

## PATIENT COUNTS FOR EACH SUBGROUP

## Table A1.1: Patient counts for each subgroup

	NJR-HES		HES-PROM	S	CPRD	
	TKR	UKR	TKR	UKR	All	
Age and gender subgroups						
Male, <60	11156	3677	1487	473	82	
Male, 60-75	11616	4268	3456	1155	175	
Male, 75+	22979	7468	641	241	57	
Female, <60	19320	6118	1613	592	54	
Female, 60-75	5305	1914	2850	882	164	
Female, 75+	5371	1805	510	176	62	
Usage subgroups						
UKR <10%	13690	4564	2052	684	-	
UKR 10+%	60544	20682	8379	2793	-	

NJR linked to HES was used to estimate initial transition probabilities and hospital costs. HES-PROMs was used to estimate quality of life following primary ich only procedure. CPRD was used to estimate primary care costs.

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#### PROPENSITY SCORE MATCHING FOR USAGE SUBGROUPS

#### Table A2.1 Patient characteristics before and after matching low usage UKRs (<10%) with TKRs for transition probabilities and hospital costs

	Before matching			After matching		
	TKR	UKR (usage <10%)	SMD	TKR	UKR (usage <10%)	SMD
Number of patients	75753	4564		13690	4564	
Age at surgery (mean (sd))	64.72 (9.30)	62.42 (9.11)	0.25	62.54 (9.40)	62.42 (9.11)	0.014
Unit type (%)			0.133			0.001
Public hospital	63990 (84.5)	4011 (87.9)		12030 (87.9)	4011 (87.9)	
Independent hospital	9098 (12.0)	480 (10.5)		1443 (10.5)	480 (10.5)	
Independent sector treatment centre	2665 ( 3.5)	73 ( 1.6)		217 ( 1.6)	73 ( 1.6)	
Thromboprophylaxis						
Drugs (%)			0.081			0.013
Aspirin	9498 (12.5)	487 (10.7)		1472 (10.8)	487 (10.7)	
Direct thrombin inhibitor	2622 ( 3.5)	161 ( 3.5)		458 ( 3.3)	161 ( 3.5)	
Unfractionated or low molecular weight heparin	397 ( 0.5)	21 ( 0.5)		59 ( 0.4)	21 ( 0.5)	
None/Unspecified	9325 (12.3)	606 (13.3)		1847 (13.5)	606 (13.3)	
Other	53187 (70.2)	3265 (71.5)		9786 (71.5)	3265 (71.5)	
Warfarin	724 ( 1.0)	24 ( 0.5)		68 ( 0.5)	24 ( 0.5)	
Mechanical (%)			0.053			0.022
None/Unspecified	9034 (11.9)	604 (13.2)		1767 (12.9)	604 (13.2)	
Foot pumps	7474 ( 9.9)	458 (10.0)		1359 ( 9.9)	458 (10.0)	
Intermittent calf compression	9166 (12.1)	508 (11.1)		1465 (10.7)	508 (11.1)	
Thromboembolic deterrent stockings	49069 (64.8)	2920 (64.0)		8856 (64.7)	2920 (64.0)	
Other	1010 ( 1.3)	74 ( 1.6)		243 ( 1.8)	74 ( 1.6)	
Gender (%)			0.017			0.016
Μ	39440 (52.1)	2403 (52.7)		7318 (53.5)	2403 (52.7)	
American Society of Anesthesiologists score (%)			0.104			0.024
1	16018 (21.1)	1152 (25.2)		3568 (26.1)	1152 (25.2)	
2	53087 (70.1)	3077 (67.4)		9181 (67.1)	3077 (67.4)	

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3+	6648 ( 8.8)	335 ( 7.3)		941 ( 6.9)	335 ( 7.3)	
Comorbidities (Charlson index) (%)			0.028			0.009
None	60768 (80.2)	3681 (80.7)		11013 (80.4)	3681 (80.7)	
Mild	12511 (16.5)	755 (16.5)		2303 (16.8)	755 (16.5)	
Moderate	1967 ( 2.6)	99 ( 2.2)		291 ( 2.1)	99 ( 2.2)	
Severe	507 ( 0.7)	29 ( 0.6)		83 ( 0.6)	29 ( 0.6)	
Hypertension (mean (sd))	0.35 (0.48)	0.31 (0.46)	0.084	0.30 (0.46)	0.31 (0.46)	0.014
Ethnicity (%)			0.083			0.034
Undefined	9958 (13.1)	640 (14.0)		1933 (14.1)	640 (14.0)	
British (White)	61524 (81.2)	3661 (80.2)		10946 (80.0)	3661 (80.2)	
Irish (White)	411 ( 0.5)	32 ( 0.7)		103 ( 0.8)	32 ( 0.7)	
Any other White background	1401 ( 1.8)	101 ( 2.2)		323 ( 2.4)	101 ( 2.2)	
White and Black Caribbean (Mixed)	29 ( 0.0)	0 ( 0.0)		0 ( 0.0)	0 ( 0.0)	
White and Black African (Mixed)	11 ( 0.0)	1 ( 0.0)		4 ( 0.0)	1 ( 0.0)	
White and Asian (Mixed)	42 ( 0.1)	7 ( 0.2)		14 ( 0.1)	7 ( 0.2)	
Any other Mixed background	31 ( 0.0)	1 ( 0.0)		7 ( 0.1)	1 ( 0.0)	
Indian (Asian or Asian British)	1068 ( 1.4)	47 ( 1.0)		151 ( 1.1)	47 ( 1.0)	
Pakistani (Asian or Asian British)	351 ( 0.5)	11 ( 0.2)		32 ( 0.2)	11 ( 0.2)	
Bangladeshi (Asian or Asian British)	26 ( 0.0)	1 ( 0.0)		3 ( 0.0)	1 ( 0.0)	
Any other Asian background	195 ( 0.3)	12 ( 0.3)		33 ( 0.2)	12 ( 0.3)	
Caribbean (Black or Black British)	259 ( 0.3)	17 ( 0.4)		54 ( 0.4)	17 ( 0.4)	
African (Black or Black British)	146 ( 0.2)	11 ( 0.2)		31 ( 0.2)	11 ( 0.2)	
Any other Black background	64 ( 0.1)	4 ( 0.1)		15 ( 0.1)	4 ( 0.1)	
Chinese (other ethnic group)	25 ( 0.0)	4 ( 0.1)		6 ( 0.0)	4 ( 0.1)	
Any other ethnic group	212 ( 0.3)	14 ( 0.3)		35 ( 0.3)	14 ( 0.3)	
IMD decile (mean (sd))	6.25 (2.67)	6.08 (2.71)	0.062	6.12 (2.70)	6.08 (2.71)	0.015
Fixation (%)			0.135			0.014
Cementless	5677 ( 7.5)	200 ( 4.4)		636 ( 4.6)	200 ( 4.4)	
Cemented	68544 (90.5)	4287 (93.9)		12814 (93.6)	4287 (93.9)	
Hybrid	1532 ( 2.0)	77 ( 1.7)		240 ( 1.8)	77 ( 1.7)	
Cases per consultant per year (mean (sd))	84.74 (58.78)	82.14 (56.83)	0.045	81.49 (56.53)	82.14 (56.83)	0.012

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20	Independent sector t
20	Thromboprophylaxis
21	Drugs (%)
23	Aspirin
24	Unfractionated or low
25	None/Unspecified
26	Other
27	Other
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29	Mechanical (%)
30	None/Unspecified
31	Foot Pumps
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### racteristics before and after matching low usage UKRs (<10%) with TKRs for quality of life

	Before matching			After matching		
	TKR	UKR (usage <10%)	SMD	TKR	UKR (usage <10%)	SMD
Number of patients	10441	684		2052	684	
Age at surgery (mean (sd))	64.38 (8.60)	61.96 (8.58)	0.281	62.19 (8.68)	61.96 (8.58)	0.027
Unit type (%)			0.108			0.006
Public hospital	7726 (74.0)	535 (78.2)		1601 (78.0)	535 (78.2)	
Independent hospital	2267 (21.7)	129 (18.9)		389 (19.0)	129 (18.9)	
Independent sector treatment centre	448 ( 4.3)	20 ( 2.9)		62 ( 3.0)	20 ( 2.9)	
Thromboprophylaxis						
Drugs (%)			0.029			0.028
Aspirin	2065 (19.8)	134 (19.6)		421 (20.5)	134 (19.6)	
Unfractionated or low molecular weight heparin	203 ( 1.9)	11 ( 1.6)		30 ( 1.5)	11 ( 1.6)	
None/Unspecified	2171 (20.8)	144 (21.1)		419 (20.4)	144 (21.1)	
Other	5908 (56.6)	388 (56.7)		1162 (56.6)	388 (56.7)	
Warfarin	94 ( 0.9)	7 ( 1.0)		20 ( 1.0)	7 ( 1.0)	
Mechanical (%)			0.091			0.024
None/Unspecified	2428 (23.3)	151 (22.1)		451 (22.0)	151 (22.1)	
Foot Pumps	887 ( 8.5)	69 (10.1)		213 (10.4)	69 (10.1)	
Intermittent calf compression	845 ( 8.1)	43 ( 6.3)		118 ( 5.8)	43 ( 6.3)	
Thromboembolic deterrent stockings	6154 (58.9)	412 (60.2)		1242 (60.5)	412 (60.2)	
Other	127 ( 1.2)	9 ( 1.3)		28 ( 1.4)	9 ( 1.3)	
Gender (%)			0.021			0.007
Μ	5511 (52.8)	354 (51.8)		1055 (51.4)	354 (51.8)	
American Society of Anesthesiologists score (%)			0.083			0.065
1	2183 (20.9)	154 (22.5)		431 (21.0)	154 (22.5)	

2	7585 (72.6)	474 (69.3)		1479 (72.1)	474 (69.3)	
3+	673 ( 6.4)	56 ( 8.2)		142 ( 6.9)	56 ( 8.2)	
Comorbidities (Charlson index) (%)			0.054			0.026
None	8622 (82.6)	564 (82.5)		1685 (82.1)	564 (82.5)	
Mild	1496 (14.3)	103 (15.1)		313 (15.3)	103 (15.1)	
Moderate	240 ( 2.3)	11 ( 1.6)		31 ( 1.5)	11 ( 1.6)	
Severe	83 ( 0.8)	6 ( 0.9)		23 ( 1.1)	6 ( 0.9)	
Hypertension (mean (sd))	0.35 (0.48)	0.36 (0.48)	0.025	0.35 (0.48)	0.36 (0.48)	0.017
Ethnicity (%)			0.099			0.073
Undefined	2253 (21.6)	148 (21.6)		470 (22.9)	148 (21.6)	
British (White)	7643 (73.2)	505 (73.8)		1494 (72.8)	505 (73.8)	
Irish (White)	52 ( 0.5)	4 ( 0.6)		15 ( 0.7)	4 ( 0.6)	
Any other White background	225 ( 2.2)	14 ( 2.0)		43 ( 2.1)	14 ( 2.0)	
White and Black Caribbean (Mixed)	7 ( 0.1)	0 ( 0.0)		0 ( 0.0)	0 ( 0.0)	
White and Black African (Mixed)	0 ( 0.0)	0 ( 0.0)		0 ( 0.0)	0 ( 0.0)	
White and Asian (Mixed)	1 ( 0.0)	0 ( 0.0)		0 ( 0.0)	0 ( 0.0)	
Any other Mixed background	1 ( 0.0)	0 ( 0.0)		0 ( 0.0)	0 ( 0.0)	
Indian (Asian or Asian British)	114 ( 1.1)	7 ( 1.0)		22 ( 1.1)	7 ( 1.0)	
Pakistani (Asian or Asian British)	34 ( 0.3)	1 ( 0.1)		1 ( 0.0)	1(0.1)	
Bangladeshi (Asian or Asian British)	6 ( 0.1)	0 ( 0.0)		0 ( 0.0)	0 ( 0.0)	
Any other Asian background	10 ( 0.1)	1(0.1)		1 ( 0.0)	1(0.1)	
Caribbean (Black or Black British)	44 ( 0.4)	1(0.1)		2 ( 0.1)	1(0.1)	
African (Black or Black British)	15 ( 0.1)	1(0.1)		1 ( 0.0)	1(0.1)	
Any other Black background	12 ( 0.1)	0 ( 0.0)		0 ( 0.0)	0 ( 0.0)	
Chinese (other ethnic group)	0 ( 0.0)	0 ( 0.0)		0 ( 0.0)	0 ( 0.0)	
Any other ethnic group	24 ( 0.2)	2 ( 0.3)		3 ( 0.1)	2 ( 0.3)	
IMD decile (mean (sd))	5.75 (2.70)	5.88 (2.71)	0.049	5.98 (2.68)	5.88 (2.71)	0.037
Fixation (%)			0.244			0.033
Cementless	932 ( 8.9)	26 ( 3.8)		70 ( 3.4)	26 ( 3.8)	
Cemented	9411 (90.1)	640 (93.6)		1936 (94.3)	640 (93.6)	
Hybrid		18 ( 2 6)		16(22)	18 ( 2 6)	

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Cases	s per consultant	t per year (mean (	sd))	91.12 (60.34)	89.63 (64.68)	0.024	89.96 (58.38)	89.63 (64.68)	0.005
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#### Table A2.3 Patient characteristics before and after matching high usage UKRs (10+%) with TKRs for transition probabilities and hospital costs

	Before matching			After matching		
	TKR	UKR (usage 10+%)	SMD	TKR	UKR (usage 10+%)	SMD
Number of patients	75753	20686		60544	20682	
Age at surgery (mean (sd))	64.72 (9.30)	65.17 (9.41)	0.048	64.99 (9.27)	65.17 (9.41)	0.019
Unit type (%)			0.051			0.014
Public hospital	63990 (84.5)	17476 (84.5)		51198 (84.6)	17472 (84.5)	
Independent hospital	9098 (12.0)	2302 (11.1)		6852 (11.3)	2302 (11.1)	
Independent sector treatment centre	2665 ( 3.5)	908 ( 4.4)		2494 ( 4.1)	908 ( 4.4)	
Thromboprophylaxis 🧹						
Drugs (%)			0.118			0.039
Aspirin	9498 (12.5)	3364 (16.3)		9038 (14.9)	3362 (16.3)	
Direct thrombin inhibitor	2622 ( 3.5)	880 ( 4.3)		2444 ( 4.0)	879 ( 4.3)	
Unfractionated or low molecular weight heparin	397 ( 0.5)	92 ( 0.4)		281 ( 0.5)	92 ( 0.4)	
None/Unspecified	9325 (12.3)	2339 (11.3)		6989 (11.5)	2339 (11.3)	
Other	53187 (70.2)	13829 (66.9)		41248 (68.1)	13828 (66.9)	
Warfarin	724 ( 1.0)	182 ( 0.9)		544 ( 0.9)	182 ( 0.9)	
Mechanical (%)			0.099			0.029
None/Unspecified	9034 (11.9)	2486 (12.0)		7301 (12.1)	2486 (12.0)	
Foot pumps	7474 ( 9.9)	1659 ( 8.0)		5205 ( 8.6)	1659 ( 8.0)	
Intermittent calf compression	9166 (12.1)	3007 (14.5)		8319 (13.7)	3006 (14.5)	
Thromboembolic deterrent stockings	49069 (64.8)	13343 (64.5)		39144 (64.7)	<b>13340 (64.5)</b>	
Other	1010 ( 1.3)	191 ( 0.9)		575 ( 0.9)	191 ( 0.9)	
Gender (%)			0.017			0.005
Μ	39440 (52.1)	10656 (51.5)		31335 (51.8)	10655 (51.5)	
American Society of Anesthesiologists score (%)			0.033			0.027
1	16018 (21.1)	4299 (20.8)		12397 (20.5)	4299 (20.8)	
2	53087 (70.1)	14372 (69.5)		42685 (70.5)	14368 (69.5)	
2		2015(0.7)		5462 ( 9 0)	2015 ( 0 7)	

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2							
3							
4							
5	Comorbidities (Charlson index) (%)			0.007			0.005
6	None	60768 (80.2)	16551 (80.0)		48502 (80.1)	16548 (80.0)	
/	Mild	12511 (16.5)	3459 (16.7)		10047 (16.6)	3459 (16.7)	
8 0	Moderate	1967 ( 2.6)	531 ( 2.6)		1584 ( 2.6)	530 ( 2.6)	
9 10	Severe	507 ( 0.7)	145 ( 0.7)		411 ( 0.7)	145 ( 0.7)	
10	Hypertension (mean (sd))	0.35 (0.48)	0.36 (0.48)	0.018	0.36 (0.48)	0.36 (0.48)	0.004
12	Ethnicity (%)			0.07			0.035
13	Undefined	9958 (13.1)	2944 (14.2)		8311 (13.7)	2944 (14.2)	
14	British (White)	61524 (81.2)	16506 (79.8)		48783 (80.6)	16505 (79.8)	
15	Irish (White)	411 ( 0.5)	123 ( 0.6)		355 ( 0.6)	123 ( 0.6)	
16 17	Any other White background	1401 ( 1.8)	440 ( 2.1)		1207 ( 2.0)	440 ( 2.1)	
17 18	White and Black Caribbean (Mixed)	29 ( 0.0)	13 ( 0.1)		29 ( 0.0)	13 ( 0.1)	
10	White and Black African (Mixed)	11 ( 0.0)	2 ( 0.0)		7 ( 0.0)	2 ( 0.0)	
20	White and Asian (Mixed)	42 ( 0.1)	16 ( 0.1)		42 ( 0.1)	16 ( 0.1)	
21	Any other Mixed background	31 ( 0.0)	11 ( 0.1)		30 ( 0.0)	11 ( 0.1)	
22	Indian (Asian or Asian British)	1068 ( 1.4)	265 ( 1.3)		802 ( 1.3)	265 ( 1.3)	
23	Pakistani (Asian or Asian British)	351 ( 0.5)	97 ( 0.5)		281 ( 0.5)	97 ( 0.5)	
24	Bangladeshi (Asian or Asian British)	26 ( 0.0)	6 ( 0.0)		23 ( 0.0)	6 ( 0.0)	
25	Any other Asian background	195 ( 0.3)	69 ( 0.3)		184 ( 0.3)	69 ( 0.3)	
20	Caribbean (Black or Black British)	259 ( 0.3)	52 ( 0.3)		175 ( 0.3)	52 ( 0.3)	
28	African (Black or Black British)	146 ( 0.2)	19 ( 0.1)		58 ( 0.1)	19 ( 0.1)	
29	Any other Black background	64 ( 0.1)	13 ( 0.1)		45 ( 0.1)	13 ( 0.1)	
30	Chinese (other ethnic group)	25 ( 0.0)	2 ( 0.0)		8 ( 0.0)	2 ( 0.0)	
31	Any other ethnic group	212 ( 0.3)	108 ( 0.5)		204 ( 0.3)	105 ( 0.5)	
32	IMD decile (mean (sd))	6.25 (2.67)	6.26 (2.68)	0.004	6.26 (2.67)	6.26 (2.68)	0.001
33	Fixation (%)			0.044			0.018
34 35	Cementless	5677 ( 7.5)	1704 ( 8.2)		4767 ( 7.9)	1704 ( 8.2)	
36	Cemented	68544 (90.5)	18461 (89.2)		54367 (89.8)	18459 (89.3)	
37	Hybrid	1532 ( 2.0)	521 ( 2.5)		1410 ( 2.3)	519 ( 2.5)	
38	Cases per consultant per year (mean (sd))	84.74 (58.78)	85.36 (55.18)	0.011	84.84 (58.89)	85.37 (55.18)	0.009
39		. ,	. ,		. ,	. ,	

## Table A2.4 Patient characteristics before and after matching high usage UKRs (10+%) with TKRs for quality of life

	Before matching			After matching		
	TKR	UKR (usage 10+%)	SMD	TKR	UKR (usage 10+%)	SMD
Number of patients	10441	2793		8379	2793	
Age at surgery (mean (sd))	64.38 (8.60)	65.01 (8.79)	0.073	64.96 (8.65)	65.01 (8.79)	0.005
Unit type (%)			0.079			0.024
Public hospital	7726 (74.0)	2072 (74.2)		6243 (74.5)	2072 (74.2)	
Independent hospital	2267 (21.7)	558 (20.0)		1692 (20.2)	558 (20.0)	
Independent sector treatment centre	448 ( 4.3)	163 ( 5.8)		444 ( 5.3)	163 ( 5.8)	
Thromboprophylaxis						
Drugs (%)			0.027			0.012
Aspirin	2065 (19.8)	538 (19.3)		1619 (19.3)	538 (19.3)	
Unfractionated or low molecular weight heparin	203 ( 1.9)	54 ( 1.9)		151 ( 1.8)	54 ( 1.9)	
None/Unspecified	2171 (20.8)	560 (20.1)		1694 (20.2)	560 (20.1)	
Other	5908 (56.6)	1614 (57.8)		4829 (57.6)	1614 (57.8)	
Warfarin	94 ( 0.9)	27 ( 1.0)		86 ( 1.0)	27 ( 1.0)	
Mechanical (%)			0.042			0.007
None/Unspecified	2428 (23.3)	635 (22.7)		1902 (22.7)	635 (22.7)	
Foot Pumps	887 ( 8.5)	226 ( 8.1)		677 ( 8.1)	226 ( 8.1)	
Intermittent calf compression	845 ( 8.1)	203 ( 7.3)		611 ( 7.3)	203 ( 7.3)	
Thromboembolic deterrent stockings	6154 (58.9)	1697 (60.8)		5087 (60.7)	1697 (60.8)	
Other	127 ( 1.2)	32 ( 1.1)		102 ( 1.2)	32 ( 1.1)	
Gender (%)			0.012			0.003
Μ	5511 (52.8)	1491 (53.4)		4462 (53.3)	1491 (53.4)	
American Society of Anesthesiologists score (%)			0.055			0.053
1	2183 (20.9)	605 (21.7)		1725 (20.6)	605 (21.7)	
2	7585 (72.6)	1973 (70.6)		6099 (72.8)	1973 (70.6)	
3+	673 ( 6.4)	215 ( 7.7)		555 ( 6.6)	215 ( 7.7)	
Comorbidities (Charlson index) (%)			0.063			0.017

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None	8622 (82.6)	2296 (82.2)		6904 (82.4)	2296 (82.2)	
Mild	1496 (14.3)	398 (14.2)		1199 (14.3)	398 (14.2)	
Moderate	240 ( 2.3)	86 ( 3.1)		235 ( 2.8)	86 ( 3.1)	
Severe	83 ( 0.8)	13 ( 0.5)		41 ( 0.5)	13 ( 0.5)	
Hypertension (mean (sd))	0.35 (0.48)	0.36 (0.48)	0.025	0.35 (0.48)	0.36 (0.48)	0.00
Ethnicity (%)			0.064			0.01
Undefined	2253 (21.6)	606 (21.7)		1824 (21.8)	606 (21.7)	
British (White)	7643 (73.2)	2046 (73.3)		6129 (73.1)	2046 (73.3)	
Irish (White)	52 ( 0.5)	11 ( 0.4)		39 ( 0.5)	11 ( 0.4)	
Any other White background	225 ( 2.2)	66 ( 2.4)		201 ( 2.4)	66 ( 2.4)	
White and Black Caribbean (Mixed)	7 ( 0.1)	1 ( 0.0)		4 ( 0.0)	1 ( 0.0)	
White and Black African (Mixed)	0 ( 0.0)	0 ( 0.0)		0 ( 0.0)	0 ( 0.0)	
White and Asian (Mixed)	1 ( 0.0)	0 ( 0.0)		0 ( 0.0)	0 ( 0.0)	
Any other Mixed background	1 ( 0.0)	0 ( 0.0)		0 ( 0.0)	0 ( 0.0)	
Indian (Asian or Asian British)	114 ( 1.1)	31 ( 1.1)		88 ( 1.1)	31 ( 1.1)	
Pakistani (Asian or Asian British)	34 ( 0.3)	10 ( 0.4)		28 ( 0.3)	10 ( 0.4)	
Bangladeshi (Asian or Asian British)	6 ( 0.1)	0 ( 0.0)		0 ( 0.0)	0 ( 0.0)	
Any other Asian background	10 ( 0.1)	2 ( 0.1)		5 ( 0.1)	2(0.1)	
Caribbean (Black or Black British)	44 ( 0.4)	7 ( 0.3)		21 ( 0.3)	7 ( 0.3)	
African (Black or Black British)	15 ( 0.1)	4 ( 0.1)		12 ( 0.1)	4 ( 0.1)	
Any other Black background	12 ( 0.1)	1 ( 0.0)		4 ( 0.0)	1 ( 0.0)	
Chinese (other ethnic group)	0 ( 0.0)	0 ( 0.0)		0 ( 0.0)	0 ( 0.0)	
Any other ethnic group	24 ( 0.2)	8 ( 0.3)		24 ( 0.3)	8 ( 0.3)	
IMD decile (mean (sd))	5.75 (2.70)	5.73 (2.75)	0.009	5.74 (2.72)	5.73 (2.75)	0.00
Fixation (%)			0.137			0.08
Cementless	932 ( 8.9)	322 (11.5)		912 (10.9)	322 (11.5)	
Cemented	9411 (90.1)	2409 (86.3)		7369 (87.9)	2409 (86.3)	
Hybrid	98 ( 0.9)	62 ( 2.2)		98 ( 1.2)	62 ( 2.2)	
Cases per consultant per year (mean (sd))	91.12 (60.34)	91.04 (54.59)	0.001	90.85 (60.48)	91.04 (54.59)	0.00

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# PARAMETRIC MODELS FOR REVISION AND MORTALITY Figure A3.2 Parametric models for revision for male, <60 subgroups Male, <60 1.00 Cumulative probability unrevised (%) 0.75 Exponential Weibull Log-normal 0.50 TKR ---- UKR 0.25 0.00 ò Years from surgery Table A3.3 AIC of parametric models for revision for male, <60 subgroups

Procedure	Distribution	AIC
TKR	Exponential	5,143
TKR	Weibull	5,145
TKR	Log-normal	5,123
UKR	Exponential	2,964
UKR	Weibull	2,957
UKR	Log-normal	2,949



Table A3.2 AIC of parametric models for revision for female, <60 subgroups

Table A3.2 AIC of p	parametric mode	els for rev	vision for female, <60 subgroups
Procedure	Distribution	AIC	
TKR	Exponential	4,826	
TKR	Weibull	4,826	
TKR	Log-normal	4,799	
UKR	Exponential	3,564	
UKR	Weibull	3,548	
UKR	Log-normal	3,525	
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#### Table A3.3 AIC of parametric models for revision for male, 60 to 75 subgroups

Procedure	Distribution	AIC
TKR	Exponential	7,258
TKR	Weibull	7,237
TKR	Log-normal	7,197
UKR	Exponential	3,863
UKR	Weibull	3,863
UKR	Log-normal	3,833



#### Table A3.4 AIC of parametric models for revision for female, 60 to 75 subgroups

Procedure	Distribution	AIC	
TKR	Exponential	5,379	
TKR	Weibull	5,380	
TKR	Log-normal	5,359	
UKR	Exponential	3,626	
UKR	Weibull	3,622	
UKR	Log-normal	3,608	

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#### Table A3.5 AIC of parametric models for revision for male, 75+ subgroups

Figure A3.5 Parametric models for revision for male, 75+ subgroups

TKRExponential1,020TKRWeibull1,011TKRLog-normal1,004UKRExponential507UKRWeibull507	Procedure	Distribution	AIC
TKRWeibull1,011TKRLog-normal1,004UKRExponential507UKRWeibull507UKRLog-normal502	TKR	Exponential	1,020
TKRLog-normal1,004UKRExponential507UKRWeibull507UKRLog pormal502	TKR	Weibull	1,011
UKR Exponential 507 UKR Weibull 507	TKR	Log-normal	1,004
UKR Weibull 507	UKR	Exponential	507
LIKE Log normal EO2	UKR	Weibull	507
UKK LUg-HUHHai 505	UKR	Log-normal	503



#### Table A3.6 AIC of parametric models for revision for female, 75+ subgroups

Procedure	Distribution	AIC	
TKR	Exponential	997	
TKR	Weibull	991	
TKR	Log-normal	985	
UKR	Exponential	949	
UKR	Weibull	951	
UKR	Log-normal	949	_
			_







#### Table A3.8 AIC of parametric models for revision for usage, 10+ subgroups

Procedure	Distribution	AIC
TKR	Exponential	19,665
TKR	Weibull	19,657
TKR	Log-normal	19,563
UKR	Exponential	12,028
UKR	Weibull	12,010
UKR	Log-normal	11,956

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Procedure	Distribution	AIC
TKR	Exponential	2110
TKR	Weibull	2093
TKR	Log-normal	2096
UKR	Exponential	666
UKR	Weibull	657
UKR	Log-normal	662



#### Table A3.10 AIC of parametric models for mortality for female, <60 subgroups

Procedure	Distribution	AIC
TKR	Exponential	1657
TKR	Weibull	1637
TKR	Log-normal	1635
UKR	Exponential	357
UKR	Weibull	348
UKR	Log-normal	349

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Table A3.11 AIC of parametric models for mortality for male, 60 to 75 subgroups

Procedure	Distribution	AIC
TKR	Exponential	9758
TKR	Weibull	9617
TKR	Log-normal	9676
UKR	Exponential	3050
UKR	Weibull	2996
UKR	Log-normal	3010



Table A3.12 AIC of parametric models for mortality for female, 60 to 75 subgroups

Procedure	Distribution	AIC	
TKR	Exponential	5852	
TKR	Weibull	5736	
TKR	Log-normal	5764	
UKR	Exponential	1638	
UKR	Weibull	1606	
UKR	Log-normal	1610	

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## Table A3.13 AIC of parametric models for mortality for male, 75+ subgroups

Procedure	Distribution	AIC
TKR	Exponential	5758
TKR	Weibull	5645
TKR	Log-normal	5712
UKR	Exponential	2057
UKR	Weibull	1998
UKR	Log-normal	2026

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Procedure	Distribution	AIC
TKR	Exponential	4482
TKR	Weibull	4415
TKR	Log-normal	4462
UKR	Exponential	1306
UKR	Weibull	1272
UKR	Log-normal	1293



Exponential

Log-normal

Weibull

TKR

Usage <10 1.00 ...... Cumulative probability alive (%) 0.75 0.50 ---- UKR 0.25 0.00 ò Years from surgery

Figure A3.15 Parametric models for mortality for usage, <10 subgroups

Table A3.15 AIC of parametric models for mortality for usage, <10 subgroups

Procedure	Distribution	AIC
TKR	Exponential	5164
TKR	Weibull	5069
TKR	Log-normal	5103
UKR	Exponential	1389
UKR	Weibull	1355
UKR	Log-normal	1366



Table A3.16 AIC of parametric models for mortality for usage, 10+ subgroups

Procedure	Distribution	AIC
TKR	Exponential	25418
TKR	Weibull	25025
TKR	Log-normal	25187
UKR	Exponential	8262
UKR	Weibull	8094
UKR	Log-normal	8146

#### COSTS

 Table A4.1 Hospital costs

	Procedure	Subgroup	N	Mean	SD	SE
Primary						
	TKR	<60, Female	10287	5968	1070	3
	UKR	<60, Female	3270	3910	2259	4
	TKR	<60, Male	10856	5965	1107	3
	UKR	<60, Male	3857	3935	2274	4
	TKR	60 to 70, Female	21480	6013	992	3
	UKR	60 to 70, Female	6567	3996	2257	4
	TKR	60 to 70, Male	18249	6047	988	3
	UKR	60 to 70, Male	5493	3996	2226	4
	TKR	>75, Female	5033	6186	1266	3
	UKR	>75, Female	1702	4035	2276	4
	TKR	>75, Male	5098	6131	1126	3
	UKR	>75, Male	1619	3993	2249	4
	TKR	<10	53832	6041	991	3
	UKR	<10	4210	4070	2224	4
	TKR	10+	15542	6002	1223	3
	UKR	10+	18213	3947	2260	4
Reoperation						
	TKR	<60, Female	497	2384	1979	4
	UKR	<60, Female	171	1822	1558	3
	TKR	<60, Male	549	2122	1776	4
	UKR	<60, Male	206	1680	1183	3
	TKR	60 to 70, Female	689	2361	2124	4
	UKR	60 to 70, Female	203	2220	2036	4
	TKR	60 to 70, Male	590	2258	2188	4
	UKR	60 to 70, Male	148	1929	1817	4

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5		TKR	>75, Female	114	2962	3158	56	
6		UKR	>75, Female	27	2496	2772	53	
/		TKR	>75, Male	107	2174	2045	45	
0 9		UKR	>75, Male	40	1973	2353	49	
10		TKR	<10	819	2323	2138	46	
11		UKR 🔨	<10	73	1577	1367	37	
12		TKR	10+	240	2291	2008	45	
13		UKR	10+	276	2104	1957	44	
14 15	Revision							
15 16		TKR	<60, Female	470	8154	2775	53	
17		UKR	<60, Female	300	6385	2507	50	
18		TKR	<60. Male	428	7937	2534	50	
19		UKR	<60, Male	367	6210	2379	49	
20		TKR	60 to 70. Female	598	7866	3748	61	
21		UKR	60 to 70. Female	347	6607	2365	49	
22		TKR	60 to 70. Male	428	8045	2684	52	
25 24		UKR	60 to 70. Male	326	6492	2364	49	
25		TKR	>75 Female	73	7820	3079	55	
26		UKR	>75. Female	39	6876	1824	43	
27		TKR	>75 Male	72	8049	2742	52	
28		LIKR	>75 Male	85	6844	2145	46	
29		TKR	<10	643	7924	3541	60	
30 31			<10	180	6867	2/10	10	
32		TKR	10+	216	8733	2410	45 70	
33			10+	5/1	6/01	2445	49	
34		UKN	10+	541	0491	2332	40	
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45		and similar technologies.		ຂາງ ຂອຍກາດໃຫຍ່ເປັນອີເຊັ່ນໃຫຍ່ເປັນເປັນເປັນເປັນເປັນເປັນເປັນເປັນເປັນເປັນ	Protected by			
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#### Table A4.2 Primary care costs

#### Patient characteristics

	Before matching			After matching		
	TKR	UKR	SMD	TKR	UKR	SMD
Number of individuals	23,290	335		1,005	335	
Age at primary (mean (sd))	70.86 (8.79)	66.58 (9.74)	0.462	66.69 (9.26)	66.58 (9.74)	0.012
Gender: female (%)	13409 (57.6)	168 (50.1)	0.149	481 (47.9)	168 (50.1)	0.046
Year of primary (median [IQR])	2005 [2001, 2008]	2006 [2004, 2008]	0.469	2007 [2004, 2009]	2006 [2004, 2008]	0.004
Pain-related prescription costs in year prior to primary (median [IQR])	21 [2, 84]	16 [2, 59]	0.166	17 [2, 65]	16 [2, 59]	0.021
Consultation costs in year prior to primary (median [IQR])	322 [176, 552]	368 [184, 598]	0.142	368 [184, 644]	368 [184, 598]	0.007
Comorbidities at index date						
Chronic pulmonary disease (mean (sd))	0.20 (0.40)	0.15 (0.36)	0.132	0.16 (0.37)	0.15 (0.36)	0.025
Rheumatological disease (mean (sd))	0.07 (0.25)	0.05 (0.22)	0.068	0.05 (0.22)	0.05 (0.22)	0.005
Cerebrovascular disease (mean (sd))	0.05 (0.22)	0.03 (0.16)	0.135	0.03 (0.17)	0.03 (0.16)	0.012
Diabetes (mean (sd))	0.10 (0.30)	0.10 (0.29)	0.005	0.09 (0.29)	0.10 (0.29)	0.017
Myocardial infarction (mean (sd))	0.04 (0.21)	0.03 (0.18)	0.059	0.04 (0.19)	0.03 (0.18)	0.027
Congestive heart disease (mean (sd))	0.03 (0.17)	0.02 (0.13)	0.078	0.01 (0.12)	0.02 (0.13)	0.032
Renal disease (mean (sd))	0.07 (0.25)	0.07 (0.26)	0.029	0.07 (0.26)	0.07 (0.26)	<0.001
Cancer (mean (sd))	0.08 (0.27)	0.05 (0.21)	0.123	0.05 (0.22)	0.05 (0.21)	0.009
Metastatic tumour (mean (sd))	0.00 (0.05)	0.00 (0.05)	< 0.001	0.00 (0.06)	0.00 (0.05)	0.017
Diabetes with complications (mean (sd))	0.02 (0.13)	0.02 (0.13)	0.016	0.02 (0.13)	0.02 (0.13)	< 0.001
Peptic ulcer disease (mean (sd))	0.06 (0.23)	0.05 (0.22)	0.024	0.06 (0.24)	0.05 (0.22)	0.035
Peripheral vascular disease (mean (sd))	0.03 (0.17)	0.01 (0.12)	0.11	0.02 (0.14)	0.01 (0.12)	0.031
Dementia (mean (sd))	0.00 (0.05)	0.00 (0.00)	0.066	0.00 (0.00)	0.00 (0.00)	-
Mild liver disease (mean (sd))	0.00 (0.06)	0.01 (0.08)	0.042	0.01 (0.08)	0.01 (0.08)	<0.001
Hemiplegia (mean (sd))	0.00 (0.05)	0.00 (0.00)	0.066	0.00 (0.00)	0.00 (0.00)	-
Liver disease (mean (sd))	0.00 (0.02)	0.00 (0.00)	0.032	0.00 (0.00)	0.00 (0.00)	-

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AIDS (mean (sd))					0.00 (0.01)	0.00 (0.00)	0.009	0.00 (0.00)	0.00 (0.00)	-
Costs										
0313	N	Mean	SD	SF						
<60. Male	82	328	301	33						
60 to 70, Male	175	431	334	25						
>75, Male	57	640	497	66						
<60, Female	54	503	431	59						
60 to 70, Female	164	478	406	32						
>75, Female	62	554	418	53						
All	594	471	396	16						
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#### **QUALITY OF LIFE**

# Table A5.1 EQ-5D index scores

			Pre-op				Post-op		
	Procedure	Subgroup	Ν	Mean	SD	SE	Mean	SD	SE
Primary									
	TKR	<60, Male	1,487	0.44	0.30	0.008	0.70	0.28	0.007
	TKR	<60, Female	1,613	0.39	0.31	0.008	0.69	0.28	0.007
	TKR	60 to 70, Male	3,456	0.54	0.27	0.005	0.78	0.23	0.004
	TKR	60 to 70, Female	2,850	0.47	0.29	0.005	0.76	0.23	0.004
	TKR	>75, Male	641	0.56	0.25	0.010	0.79	0.21	0.008
	TKR	>75, Female	510	0.47	0.29	0.013	0.77	0.22	0.010
	UKR	<60, Male	473	0.44	0.30	0.014	0.71	0.29	0.013
	UKR	<60, Female	592	0.39	0.32	0.013	0.69	0.30	0.012
	UKR	60 to 70, Male	1,155	0.53	0.27	0.008	0.81	0.21	0.006
	UKR	60 to 70, Female	882	0.49	0.28	0.009	0.78	0.24	0.008
	UKR	>75, Male	241	0.54	0.25	0.016	0.84	0.18	0.012
	UKR	>75, Female	176	0.47	0.30	0.023	0.81	0.20	0.015
	TKR	<10	2,052	0.46	0.30	0.007	0.74	0.26	0.006
	UKR	<10	684	0.45	0.29	0.011	0.73	0.27	0.010
	TKR	10+	8,379	0.49	0.29	0.000	0.75	0.24	0.003
	UKR	10+	2,793	0.49	0.29	0.010	0.78	0.24	0.005
Revision									
	TKR		686	0.31	0.32	0.012	0.55	0.32	0.012
	UKR		248	0.38	0.31	0.020	0.61	0.27	0.017

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# SENSITIVITY ANALYSES.

## Distribution of parametric model for revision risk: exponential

	TKR		UKR		-			
	QALYs	Costs	QALYs	Costs	Δ QALYs	Δ Costs	ICER (probability cost- effective*)	
Male, <60	10.28	15,367	10.43	13,701	0.16	-1,666	UKR dominant (92%)	
	(10.06 to 10.47)	(14,690 to 16,020)	(10.13 to 10.72)	(12,986 to 14,370)	(-0.17 to 0.50)	(-1,931 to -1,411)		
Male, 60-75	8.58	13,455	8.82	11,877	0.24	-1,578	UKR dominant (100%)	
	(8.49 to 8.68)	(12,710 to 14,286)	(8.66 to 8.97)	(11,114 to 12,696)	(0.05 to 0.41)	(-1,796 to -1,382)		
Male, 75+	5.60	11,529	5.80	9,503	0.19	-2,026	UKR dominant (100%)	
	(5.48 to 5.71)	(10,591 to 12,639)	(5.64 to 5.95) 🧹	(8,515 to 10,620)	(0.01 to 0.37)	(-2,214 to -1,833)		
Female, <60	10.70	16,794	10.81	15,743	0.11	-1,050	UKR dominant (78%)	
	(10.48 to 10.90)	(15,959 to 17,745)	(10.46 to 11.12)	(14,831 to 16,688)	(-0.28 to 0.45)	(-1,384 to -747)		
Female, 60-75	8.97	13,764	9.27	12,664	0.30	-1,100	UKR dominant (100%)	
	(8.86 to 9.08)	(12,993 to 14,538)	(9.07 to 9.47)	(11,831 to 13,500)	(0.08 to 0.51)	(-1,320 to -874)		
Female, 75+	6.01	11,483	6.46	10,264	0.45	-1,220	UKR dominant (100%)	
	(5.81 to 6.16)	(10,584 to 12,437)	(6.19 to 6.70)	(9,265 to 11,236)	(0.16 to 0.75)	(-1,495 to -940)		
Expected (mean	) values with 95% o	confidence intervals i	n parentheses. UK	R is considered 'domi	inant' if it is expe	cted to improve hea	Ith outcomes and	
reduce health ca	ire costs. *Given a	cost-effectiveness th	reshold of £20,000	).				

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	TKR			UKR		_		
	Proportio n revised	QALYs	Costs	QALYs	Costs	Δ QALYs	Δ Costs	ICER (probability cost-effective*)
Male, <60	19.2%	10.35	14,812	10.49	13,071	0.14	-1,742	UKR dominant (89%)
	(16.9% to 21.8%)	(10.14 to 10.56)	(14,135 to 15,507)	(10.16 to 10.82)	(12,350 to 13,798)	(-0.22 to 0.47)	(-2,018 to - 1,447)	(0070)
Male, 60-75	8.6%	8.62	13,186	8.86	11,643	0.23	-1,544	UKR dominant (100%)
	(7.3% to 10.1%)	(8.53 to 8.71)	(12,471 to 13,977)	(8.69 to 9.00)	(10,936 to 12,441)	(0.04 to 0.40)	(-1,779 to - 1,292)	(100,0)
Male, 75+	3.3%	5.61	11,438	5.81	9,421	0.19	-2,017	UKR dominant (100%)
	(1.6% to 6.4%)	(5.50 to 5.72)	(10,519 to 12,541)	(5.63 to 5.96)	(8,456 to 10,529)	(0.01 to 0.36)	(-2,358 to - 1,613)	()
Female, <60	20.1%	10.75	16,367	10.84	15,081	0.08	-1,286	UKR dominant (77%)
	(17.5% to 22.6%)	(10.54 to 10.95)	(15,426 to 17,302)	(10.50 to 11.15)	(14,165 to 15,958)	(-0.29 to 0.45)	(-1,615 to -958)	(1770)
Female, 60- 75	9.9%	8.99	13,621	9.31	12,364	0.32	-1,257	UKR dominant (100%)
15	(8.2% to 11.9%)	(8.88 to 9.10)	(12,870 to 14,439)	(9.10 to 9.50)	(11,581 to 13,152)	(0.08 to 0.54)	(-1,524 to - 1,013)	(100,0)
Female, 75+	3.4%	6.02	11,389	6.47	10,108	0.45	-1,281	UKR dominant (100%)
	(1.8% to 6.5%)	(5.80 to 6.16)	(10,524 to 12,368)	(6.16 to 6.70)	(9,168 to 11,159)	(0.16 to 0.73)	(-1,685 to -897)	(10070)

Expected (mean) values with 95% confidence intervals in parentheses. UKR is considered 'dominant' if it is expected to improve health outcomes and reduce health care costs. \*Given a cost-effectiveness threshold of £20,000.

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	TKR		UKR				
	QALYs	Costs	QALYs	Costs	Δ QALYs	Δ Costs	ICER (probability cos effective*)
Male <60	10.32	15 357	10.49	14 134	0.16	-1 223	LIKB dominant (95%
Male, voo	(10.06  to  10.47)	(14,706 to 16,016)	(10.18 to 10.82)	(13 /72 to 1/ 795)	(-0.11 to 0.57)	(_1 /17 to _988)	enn dominant (55%
Male 60-75	(10.00 to 10.47) 8.62	(14,700 to 10,010)	(10.18 to 10.82)	11 052	(-0.11 (0 0.37)	(-1,417 to -988) _1 255	LIKR dominant (100
Wale, 00-75	$(9.51 \pm 0.70)$	$(12 E 62 \pm 0.14 0 E 2)$	0.05	11,332 (11,100 to 12,717)	$(0.04 \pm 0.041)$	-1,333	
	(8.51 (0 8.70)		(8.68 (0 8.98)	(11,199 (0 12,717)	(0.04 (0 0.41)	(-1,594 (0 -1,131)	
iviale, 75+	5.01	11,454	5.81	9,450	0.19	-2,005	UKR dominant (100)
	(5.49 to 5.72)	(10,515 to 12,565)	(5.64 to 5.96)	(8,476 to 10,614)	(0.01 to 0.38)	(-2,457 to -1,480)	
Female, <60	10.73	16,961	10.90	16,360	0.1/	-601	UKR dominant (91%
	(10.46 to 10.86)	(16,099 to 17,907)	(10.57 to 11.22)	(15,480 to 17,287)	(-0.14 to 0.62)	(-867 to -346)	
Female, 60-75	8.98	13,814	9.28	12,878	0.30	-935	UKR dominant (1009
	(8.85 to 9.07)	(13,019 to 14,606)	(9.09 to 9.47)	(12,108 to 13,711)	(0.09 to 0.54)	(-1,192 to -685)	
Female, 75+	6.03	11,410	6.50	10,308	0.47	-1,102	UKR dominant (100
Expected (mean reduce health ca	(5.81 to 6.17) ) values with 95% c are costs. *Given a	(10,487 to 12,500) confidence intervals i cost-effectiveness th	(6.24 to 6.72) n parentheses. UKI reshold of £20,000	(9,377 to 11,399) R is considered 'domi ).	(0.21 to 0.75) nant' if it is expe	(-1,622 to -667) cted to improve hea	lth outcomes and
Expected (mean reduce health ca	(5.81 to 6.17) ) values with 95% o are costs. *Given a	(10,487 to 12,500) confidence intervals i cost-effectiveness th	(6.24 to 6.72) n parentheses. UKI reshold of £20,000	(9,377 to 11,399) R is considered 'domi ).	(0.21 to 0.75) nant' if it is expe	(-1,622 to -667) cted to improve hea	lth outcomes and
Expected (mean reduce health ca	(5.81 to 6.17) ) values with 95% d are costs. *Given a	(10,487 to 12,500) confidence intervals i cost-effectiveness th	(6.24 to 6.72) n parentheses. UKI reshold of £20,000	(9,377 to 11,399) R is considered 'domi	(0.21 to 0.75) nant' if it is expe	(-1,622 to -667) cted to improve hea	lth outcomes and
Expected (mean reduce health ca	(5.81 to 6.17) ) values with 95% d are costs. *Given a	(10,487 to 12,500) confidence intervals i cost-effectiveness th	(6.24 to 6.72) n parentheses. UKI reshold of £20,000	(9,377 to 11,399) R is considered 'domi ).	(0.21 to 0.75) nant' if it is expe	(-1,622 to -667) cted to improve hea	lth outcomes and
Expected (mean reduce health ca	(5.81 to 6.17) ) values with 95% o are costs. *Given a	(10,487 to 12,500) confidence intervals i cost-effectiveness th	(6.24 to 6.72) n parentheses. UKI reshold of £20,000	(9,377 to 11,399) R is considered 'domi ).	(0.21 to 0.75) nant' if it is expe	(-1,622 to -667) cted to improve hea	lth outcomes and
Expected (mean reduce health ca	(5.81 to 6.17) ) values with 95% d are costs. *Given a	(10,487 to 12,500) confidence intervals i cost-effectiveness th	(6.24 to 6.72) n parentheses. UKI reshold of £20,000	(9,377 to 11,399) R is considered 'domi ).	(0.21 to 0.75) nant' if it is expe	(-1,622 to -667) cted to improve hea	lth outcomes and
Expected (mean reduce health ca	(5.81 to 6.17) ) values with 95% d are costs. *Given a	(10,487 to 12,500) confidence intervals i cost-effectiveness th	(6.24 to 6.72) n parentheses. UKI reshold of £20,000	(9,377 to 11,399) R is considered 'domi	(0.21 to 0.75) nant' if it is expe	(-1,622 to -667) cted to improve hea	lth outcomes and
Expected (mean reduce health ca	(5.81 to 6.17) ) values with 95% d are costs. *Given a	(10,487 to 12,500) confidence intervals i cost-effectiveness th	(6.24 to 6.72) n parentheses. UKI reshold of £20,000	(9,377 to 11,399) R is considered 'domi ).	(0.21 to 0.75) nant' if it is expe	(-1,622 to -667) cted to improve hea	lth outcomes and
Expected (mean reduce health ca	(5.81 to 6.17) ) values with 95% d are costs. *Given a	(10,487 to 12,500) confidence intervals i cost-effectiveness th	(6.24 to 6.72) n parentheses. UKI reshold of £20,000	(9,377 to 11,399) R is considered 'domi ).	(0.21 to 0.75) nant' if it is expe	(-1,622 to -667) cted to improve hea	lth outcomes and
Expected (mean reduce health ca	(5.81 to 6.17) ) values with 95% d are costs. *Given a	(10,487 to 12,500) confidence intervals i cost-effectiveness th	(6.24 to 6.72) n parentheses. UKI reshold of £20,000	(9,377 to 11,399) R is considered 'domi ).	(0.21 to 0.75) nant' if it is expe	(-1,622 to -667) cted to improve hea	lth outcomes and
Expected (mean reduce health ca	(5.81 to 6.17) ) values with 95% d are costs. *Given a	(10,487 to 12,500) confidence intervals i cost-effectiveness th	(6.24 to 6.72) n parentheses. UKI reshold of £20,000	(9,377 to 11,399) R is considered 'domi ).	(0.21 to 0.75) nant' if it is expe	(-1,622 to -667) cted to improve hea	lth outcomes and
Expected (mean reduce health ca	(5.81 to 6.17) ) values with 95% d are costs. *Given a	(10,487 to 12,500) confidence intervals i cost-effectiveness th	(6.24 to 6.72) n parentheses. UKI reshold of £20,000	(9,377 to 11,399) R is considered 'domi ).	(0.21 to 0.75) nant' if it is expe	(-1,622 to -667) cted to improve hea	lth outcomes and

	TKR		UKR				
	QALYs	Costs	QALYs	Costs	Δ QALYs	Δ Costs	ICER (probability cost effective*)
Male, <60	10.28	13,638	10.39	12,415	0.12	-1,223	UKR dominant (83%)
·	(10.06 to 10.47)	(13,060 to 14,237)	(10.09 to 10.69)	(11,859 to 13,039)	(-0.23 to 0.45)	(-1,432 to -1,028)	ζ,
Male, 60-75	8.61	13,307	8.81	11,952	0.20	-1,355	UKR dominant (100%
	(8.50 to 8.70)	(12,571 to 14,151)	(8.66 to 8.96)	(11,219 to 12,817)	(0.03 to 0.39)	(-1,598 to -1,103)	· ·
Male, 75+	5.61	11,454	5.80	9,450	0.19	-2,005	UKR dominant (100%
,	(5.48 to 5.72)	, (10,460 to 12,626)	(5.63 to 5.96)	, (8,503 to 10,679)	(0.00 to 0.37)	, (-2,445 to -1,542)	, , , , , , , , , , , , , , , , , , ,
Female, <60	10.68	16,961	10.78	16,360	0.10	-601	UKR dominant (73%)
·	(10.48 to 10.88)	(15,994 to 17,808)	(10.44 to 11.06)	(15,406 to 17,199)	(-0.33 to 0.46)	(-893 to -348)	ζ, γ
Female, 60-75	8.96	13,814	9.24	12,878	0.28	-935	UKR dominant (100%
	(8.85 to 9.08)	(13,026 to 14,588)	(9.05 to 9.44)	(12,050 to 13,727)	(0.04 to 0.51)	(-1,168 to -705)	·
Female, 75+	6.02	11,410	6.46	10,308	0.44	-1,102	UKR dominant (100%
	(5.82 to 6.16)	(10,541 to 12,425)	(6.17 to 6.68)	(9,362 to 11,339)	(0.15 to 0.73)	(-1,623 to -683)	
educe health ca	are costs. *Given a	cost-effectiveness th	reshold of £20,000		0		

#### **Consolidated Health Economic Evaluation Reporting Standards (CHEERS) Checklist** Items to include when reporting economic evaluations of health interventions

Section/Topic	ltem No	Recommendation	Reported on page No / Line No
Title and abstrac	t		
Title	1	Identify the study as an economic evaluation or use more specific terms such as "cost-effectiveness analysis", and describe the interventions compared.	Title page
Abstract	2	Provide a structured summary of objectives, perspective, setting, methods (including study design and inputs), results (including base case and uncertainty analyses), and conclusions.	Page 1, lines 1- 29
Introduction			
Background	2	Provide an explicit statement of the broader context for the study.	Page 3, lines 46- 68
and objectives	3	Present the study question and its relevance for health policy or practice decisions.	Page 3, lines 68- 71
Methods		<u> </u>	
Target population and subgroups	4	Describe characteristics of the base case population and subgroups analysed, including why they were chosen.	Page 3, lines 73- 80
Setting and location	5	State relevant aspects of the system(s) in which the decision(s) need(s) to be made.	Page 3, lines 95- 99
Study perspective	6	Describe the perspective of the study and relate this to the costs being evaluated.	Page 4, lines 92- 99
Comparators	7	Describe the interventions or strategies being compared and state why they were chosen.	Page 3, lines 46- 60
Time horizon	8	State the time horizon(s) over which costs and consequences are being evaluated and say why appropriate.	Page 3, lines 82- 83
Discount rate	9	Report the choice of discount rate(s) used for costs and outcomes and say why appropriate.	Page 5, lines 137-145
Choice of health outcomes	10	Describe what outcomes were used as the measure(s) of benefit in the evaluation and their relevance for the type of analysis performed.	Page 5, lines 141-158
Measurement of	11a	Single study-based estimates: Describe fully the design features of the single effectiveness study and why the single study was a sufficient source of clinical effectiveness data.	Page 4, lines 100-122
effectiveness	11b	<i>Synthesis-based estimates:</i> Describe fully the methods used for identification of included studies and synthesis of clinical	

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		effectiveness data.	
Measurement and valuation of preference- based outcomes	12	If applicable, describe the population and methods used to elicit preferences for outcomes.	Page 5, lines 140-158
Estimating	13a	Single study-based economic evaluation: Describe approaches used to estimate resource use associated with the alternative interventions. Describe primary or secondary research methods for valuing each resource item in terms of its unit cost. Describe any adjustments made to approximate to opportunity costs.	
costs	13b	<i>Model-based economic evaluation:</i> Describe approaches and data sources used to estimate resource use associated with model health states. Describe primary or secondary research methods for valuing each resource item in terms of its unit cost. Describe any adjustments made to approximate to opportunity costs.	Pages 4- 55, lines 123-136
Currency, price data, and conversion	14	Report the dates of the estimated resource quantities and unit costs. Describe methods for adjusting estimated unit costs to the year of reported costs if necessary. Describe methods for converting costs into a common currency base and the exchange rate.	Page 5, lines 138-139
Choice of model	15	Describe and give reasons for the specific type of decision- analytical model used. Providing a figure to show model structure is strongly recommended.	Pages 3- 4, lines 81-91
Assumptions	16	Describe all structural or other assumptions underpinning the decision-analytical model.	Pages 4- 5, lines 88-91
Analytic methods	17	Describe all analytical methods supporting the evaluation. This could include methods for dealing with skewed, missing, or censored data; extrapolation methods; methods for pooling data; approaches to validate or make adjustments (such as half cycle corrections) to a model; and methods for handling population heterogeneity and uncertainty.	Page 5, lines 159-167
Results			
Study parameters	18	Report the values, ranges, references, and, if used, probability distributions for all parameters. Report reasons or sources for distributions used to represent uncertainty where appropriate. Providing a table to show the input values is strongly recommended.	Appendix
Incremental costs and outcomes	19	For each intervention, report mean values for the main categories of estimated costs and outcomes of interest, as well as mean differences between the comparator groups. If applicable, report incremental cost-effectiveness ratios.	Tables 1 and 3
Characterizing uncertainty	20a	Single study-based economic evaluation: Describe the effects of sampling uncertainty for the estimated incremental cost and incremental effectiveness parameters, together with the impact of methodological assumptions (such as discount rate, study perspective).	

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	20b	<i>Model-based economic evaluation:</i> Describe the effects on the results of uncertainty for all input parameters, and uncertainty related to the structure of the model and assumptions.	Tables 1, 2 and 3
Characterizing heterogeneity	21	If applicable, report differences in costs, outcomes, or cost- effectiveness that can be explained by variations between subgroups of patients with different baseline characteristics or other observed variability in effects that are not reducible by more information.	Tables 1, 2 and 3
Discussion	•		
Study findings, limitations, generalizability, and current knowledge	22	Summarise key study findings and describe how they support the conclusions reached. Discuss limitations and the generalisability of the findings and how the findings fit with current knowledge.	Pages 6- 7, lines 192-253
Other			
Source of funding	23	Describe how the study was funded and the role of the funder in the identification, design, conduct, and reporting of the analysis. Describe other non-monetary sources of support.	Page 8, lines 265-267
Conflicts of interest	24	Describe any potential for conflict of interest of study contributors in accordance with journal policy. In the absence of a journal policy, we recommend authors comply with International Committee of Medical Journal Editors recommendations.	Page 8, lines 273-277

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