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Waiting time prioritisation: Evidence from England

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1 **Waiting time prioritisation - Evidence from England**

2 **Abstract**

3 A number of OECD countries have introduced waiting time prioritisation policies which give
4 explicit priority to severely ill patients with high marginal disutility of waiting. There is
5 however little empirical evidence on how patients are actually prioritised. We exploit a
6 unique opportunity to investigate this issue using a large national dataset with accurate
7 measures of severity on nearly 400,000 patients. We link data from a national patient-
8 reported outcome measures survey to administrative data on all patients waiting for a
9 publicly funded hip and knee replacement in England during the years 2009-14. We find that
10 patients suffering the most severe pain and immobility have shorter waits than those
11 suffering the least, by about 24% for hip replacement and 11% for knee replacement, and
12 that the association is approximately linear. These differentials are more closely associated
13 with pain than immobility, and are larger in hospitals with longer average waiting times.
14 These result suggests that doctors prioritise patients according to severity even when no
15 formal prioritisation policy is in place and average waiting times are short.

16
17 *Keywords:* England; waiting times; severity; prioritisation; patient-reported outcome
18 measures.

19 **1 Introduction**

20 Waiting times are a major health policy concern in several OECD countries (Siciliani,
21 Borowitz, & Moran, 2013). Patients seeking publicly funded care have to wait weeks or
22 months for common elective (i.e. non-emergency) procedures such as cataract surgery and
23 hip replacement. For example, in 2012 average waiting times for hip replacement were
24 above 80 days in several OECD countries (Siciliani, Moran, & Borowitz, 2014). Waiting times
25 may generate discontent amongst patients as benefits from treatment get postponed and
26 suffering and uncertainty are prolonged (Lindsay & Feigenbaum, 1984).

27 In the presence of constraints on capacity combined with public health insurance and
28 limited co-payments, demand for treatment is likely to exceed supply, so that not all
29 patients can be treated immediately. Patients are therefore added to a waiting list and wait
30 for public treatment unless they are willing to pay for private care. Waiting times can be
31 thought of as a non-monetary price which brings together the demand for and the supply of
32 treatments in a public healthcare system (Iversen & Siciliani, 2011; Martin & Smith, 1999,
33 2003).

34 Several countries have experimented with policies to reduce waiting times, either by
35 increasing capacity, e.g. by allowing privately-operated providers to treat publicly-funded
36 patients (Naylor & Gregory, 2009), incentivising providers through maximum waiting time
37 targets or guarantees (Propper, Sutton, Whitnall, & Windmeijer, 2008), or by limiting
38 demand through more stringent admission policies. These policies have shown varying
39 degree of success (Siciliani et al., 2013; Siciliani & Hurst, 2005).

40 Waiting time prioritisation policies are intended to improve the management of the waiting
41 list - rather than affect demand or supply - and are common across OECD countries (Siciliani

42 et al., 2013). The key idea is simple. Given that waiting lists are unavoidable, they should be
43 prioritised efficiently to reduce suffering among more severely ill patients with higher
44 marginal disutility of waiting. From a theoretical perspective, it has been shown that such
45 policies are welfare improving even in settings where severity is only partially observable,
46 since prioritisation reduces the overall deadweight loss from waiting (Gravelle & Siciliani,
47 2008, 2009; see also Siciliani & Iversen, 2012 for a simpler model).

48 Countries differ in the way prioritisation operates. Some countries have developed formal
49 prioritisation tools based on detailed scores following a specialist visit (e.g. in Canada and
50 New Zealand for selected procedures) while others rely on relatively informal and generic
51 tools (e.g. Australia and Italy, which recommend different maximum waiting times based on
52 three or four groups of patients). As part of the Western Canada Waiting List project,
53 scoring tools have been developed that integrate objective and subjective clinical and social
54 measures to calculate an overall priority score. For hip and knee replacement surgery this
55 priority score is determined based on patients' pain on motion (e.g. bending, up to 13
56 points), pain at rest (e.g. sitting, up to 11 points), ability to walk without pain (up to 7
57 points), other functional limitations (e.g. putting shoes on, managing stairs, up to 19 points),
58 among other factors. Similar tools are used in New Zealand to prioritise patients for several
59 procedures (e.g. for coronary bypass, hip and knee joint replacements) and specialties (e.g.
60 in general and vascular surgery, orthopaedics, ophthalmology and plastic surgery). In
61 Norway, a recent policy has introduced a maximum waiting time guarantee where patients
62 are eligible to treatment within an individually determined waiting time. National guidelines
63 were developed to stipulate maximum medically acceptable waits for a range of diagnoses
64 (see Siciliani et al. (2013) for a review of prioritization policies).

65 The English NHS does not implement a formal prioritisation policy. Hospital trusts and
66 consultants are allowed to manage the waiting list as they see fit, which gives rise to local
67 variation in admission policies. In some instances waiting lists may be managed according to
68 a *first-come-first-serve* rule, whereas in others management may take into account severity.
69 For example, Leeds Teaching Hospitals NHS Trust sets out the requirement to treat patients
70 '*in order by clinical priority, and then in strict chronological order*' (Leeds Teaching Hospitals
71 NHS Trust, 2014, p. 4). All hospitals are, however, subject to maximum waiting time targets,
72 currently set at 18 weeks from referral to treatment (Department of Health, 2015).
73 Hospitals are routinely assessed with regard to their performance and may have up to 5% of
74 their revenues withheld when targets are not met. While prioritisation may be considered
75 to be more important when waits are long, hospitals at risk of breaching the target may
76 focus on the time individual patients have waited already. Hence, the degree to which
77 prioritisation policies are implemented locally may differ by average waiting time, although
78 it is *a priori* unclear in which direction.

79 Despite the substantial interest in waiting-time prioritisation by policymakers and
80 healthcare managers, there is very limited empirical evidence about the degree of waiting
81 time prioritisation for patients affected by a common condition. It is therefore not evident
82 a) to what extent patients are prioritised on the waiting list, b) how steep the severity
83 gradient in waiting is, c) whether waits reduce linearly or non-linearly with severity, and d)
84 whether prioritisation differs between hospitals with short and long average waiting time.
85 Without this information it is difficult for decision-makers to determine whether further
86 prioritisation should be encouraged. We fill this gap in knowledge.

87 The lack of empirical studies may be explained by the absence of accurate measures of
88 severity in large-scale administrative databases. These are typically limited to measures of
89 comorbidity burden, which are poor proxies for general health status (Gutacker, Siciliani,
90 Moscelli, & Gravelle, 2015). We take advantage of a new dataset containing detailed
91 measures of patient self-reported health status collected alongside routine surgery as part
92 of the national patient-reported outcome measures (PROM) programme. Since April 2009,
93 all patients undergoing four elective surgical procedures (unilateral hip replacement,
94 unilateral knee replacement, groin hernia repair and varicose vein surgery) in the English
95 National Health Service (NHS) have been invited to report their health status before and
96 several months after surgery (Department of Health, 2008). The pre-operative health status
97 of the patient is measured through condition-specific instruments (such as the Oxford Hip
98 Score) and the generic EuroQol-5D instrument.

99 We focus on hip and knee replacement, which are common elective procedures and are the
100 focus of waiting time prioritisation policies in a number of OECD countries (e.g. Canada,
101 New Zealand). We contribute to the literature in two ways: First, we test the extent to
102 which more severely ill patients (as measured by the Oxford Hip and Knee Scores (OHS/OKS)
103 which capture patients' joint-related pain and degree of mobility and autonomy) in the
104 English NHS wait less. To our knowledge, this is the first study to estimate the degree of
105 waiting time prioritisation using a large, multi-centre dataset of linked administrative and
106 detailed patient-reported information on severity. As such it provides a policy-relevant
107 assessment of the current status quo. Second, we explore the differential role of pain and
108 mobility on waiting time by splitting the Oxford scores into sub-components. The general
109 public often considers pain to have a more important impact on health-related quality of life

110 (HRQoL) than mobility (Devlin, 2016; Dolan, 1997; Szende, Oppe, & Devlin, 2007) but it is
111 unclear whether these dimensions of health are taken into account differentially by
112 clinicians when prioritising patients. We estimate Poisson models to allow for the discrete
113 measure of inpatient waits (in days) and its skewed distribution. Critically, we control for
114 hospital fixed effects which are allowed to vary across years. Therefore, the effect of
115 severity on waiting time is identified from patients with different severity within the same
116 hospital in a given year, and is not confounded by differences in efficiency and production
117 environment across hospitals and over time.

118 Our key result is that patients with higher severity tend to wait less but the effect appears
119 modest. Hip replacement patients in the top severity group wait approximately 9% (7 days)
120 less than those with average severity, and the total gap between the most and least severe
121 patient groups is 23% (20 days). There is heterogeneity across treatments: the gradient for
122 patients in need of knee replacement is substantially flatter, with no discernible
123 prioritisation taking place between patients in above average severity. Moreover, while
124 both mobility and pain affect patients' wait for hip replacement patients, only pain matters
125 for knee replacement.

126 When we split the sample between hospitals with high (above median) and low (below
127 median) waits, we find that the gradient between severity and waiting is more pronounced
128 in hospitals with longer waits. This suggests that doctors enhance prioritisation when waits
129 increase to reduce the overall disutility from waiting. Overall we find that prioritisation is
130 currently limited in scope and therefore we suggest that governments could do more to
131 further encourage waiting time prioritisation.

132 1.1 Related literature

133 The study contributes to the existing literature on the role of waiting times. A key focus has
134 been the estimation of demand and supply elasticities to waiting times, typically finding that
135 demand is inelastic to waiting times (elasticity of about -0.1) while supply elasticity
136 estimates vary depending on study design (see Iversen & Siciliani, 2011 for a review; Martin,
137 Rice, Jacobs, & Smith, 2007; Martin & Smith, 1999, 2003). Some studies focus on specific
138 policies such as the introduction of maximum waiting-time guarantees combined with
139 penalties for non-compliance (e.g. Dimakou, Parkin, Devlin, & Appleby, 2009; Propper,
140 Sutton, et al., 2008) or competition (Propper, Burgess, & Gossage, 2008; Siciliani & Martin,
141 2007). Other studies focus on waiting-time inequalities by socioeconomic status. Cooper,
142 McGuire, Jones, and Grand (2009) find that people living in more affluent areas waited less
143 than those in more deprived areas for cataract, hip and knee replacement surgery
144 performed in the English NHS (see also Laudicella, Siciliani, & Cookson, 2012, who focus on
145 variations in waiting times within hospitals). Similarly, Monstad, Engesæter, and Espehaug
146 (2014) find that in Norway richer men and more educated women wait less for hip
147 replacement (see also Kaarboe & Carlsen, 2014). Similar evidence for Australia is provided
148 by Sharma, Siciliani, and Harris (2013) and Johar, Jones, Keane, Savage, and Stavrunova
149 (2013). There are also a number of studies that estimate the effect of longer waiting time on
150 pre- and post-operative patient health. Hoogeboom et al. (2009) provide a systematic
151 review of the medical literature and find that longer waiting time is not associated with
152 deteriorations in health status while waiting up to six months. Using observational data
153 from the national PROM programme in England, Nikolova, Harrison, and Sutton
154 (forthcoming) estimate that patients' post-operative health status deteriorates by 0.1% of
155 the outcome measure range per additional week of wait.

156 Some recent studies focus on prioritisation. Askildsen, Holmås, and Kaarboe (2011) compare
157 recommended maximum waiting times by medical guidelines with actual waiting times in
158 Norway. These guidelines recommend a differential waiting time across different conditions
159 rather than within a given condition. They find that patients with most severe conditions
160 receive lower priority than recommended. The related study by Januleviciute, Askildsen,
161 Kaarboe, Holmås, and Sutton (2013) suggests that the introduction of such guidelines had
162 no effect on improving waiting time prioritisation across four major severity groups (see also
163 Askildsen, Holmås, & Kaarboe, 2010). Using data from New South Wales, Johar (2014)
164 estimates that the introduction of (non-compulsory) waiting time recommendations may
165 have reduced the priority given to most severe patients, thereby *increasing* their waiting
166 time.

167 **2 Methods**

168 **2.1 Data**

169 We use patient-level data from Hospital Episode Statistics (HES) for all elective admissions
170 for patients aged 18 or over who underwent NHS-funded primary (i.e. non-revision) hip or
171 knee replacement surgery between April 2009 and March 2014 in NHS or private providers
172 (see Department of Health (2008) for procedure codes). HES contains rich information on
173 patients' demographic and medical characteristics, small area of residence and on the
174 hospital stay itself. Privately-funded patients treated in private hospitals are not included in
175 HES and are therefore absent from our analysis. We also exclude patients who waited
176 longer than one year.

177 We extract data on a number of patient characteristics from HES, including patients' age,
178 gender, the number of emergency admissions in the year prior to their joint replacement
179 surgery, as well as the number of Elixhauser comorbid conditions recorded in all admissions
180 in the previous year or the current admission (Elixhauser, Steiner, Harris, & Coffey, 1998;
181 Gutacker, Bloor, & Cookson, 2015). We measure waiting time for each patient as the time
182 (in days) between the specialist's decision to add the patient to the waiting list and their
183 admission. We use the 2010 Index of Deprivation (McLennan et al., 2011) to attribute to
184 each patient the proportion of residents claiming means-tested social security benefits in
185 their Lower Super Output Area (LSOA, average population of 1,500 inhabitants), which we
186 interpret as a proxy of income deprivation.

187 We link these data to information obtained as part of the national PROM programme
188 (Department of Health, 2008). Since April 2009, all NHS-funded hip and knee replacement
189 patients are invited to report their health status and health related quality of life before and
190 six months after surgery using a paper-based questionnaire. The pre-operative
191 questionnaire is administered by the hospital providing the surgery, either on admission or
192 during the last outpatient appointment preceding admission. The paper questionnaires are
193 then collated and sent to a central agency to be scanned and linked to the inpatient records
194 using a linkage algorithm developed by the Health & Social Care Information Centre. The
195 post-operative questionnaire is posted to patients by the central agency six months after
196 surgery. Participation in the PROM survey is compulsory for providers but optional for
197 patients. Complete pre- and post-operative questionnaires can be linked to HES records for
198 about 60% of patients. We provide characteristics of responders and non-responders in
199 Table 2 in the results section.

200 Each PROM questionnaire includes a condition-specific and a generic instrument. The
201 Oxford Hip or Knee Scores (OHS/OKS) are condition-specific instruments with 12 questions
202 on joint-related functioning and pain (Dawson, Fitzpatrick, Carr, & Murray, 1996; Dawson,
203 Fitzpatrick, Murray, & Carr, 1998). Each item is scored on a five-point scale, ranging from
204 four (no problems) to zero (severe problems). The overall score ranges from zero (worst) to
205 48 (best) and is calculated by simple summation across items. For our main analysis we split
206 this score into eleven groups, composed of twelve equally sized groups of four points each
207 with the top two groups merged due to low numbers of patients (coded as 0-4, 5-8, 9-12,
208 13-16, 17-20, 21-24, 25-28, 29-32, 33-36, 37-40, 41-48). This allows for a flexible estimation
209 of a (potentially) non-linear relationship between severity and waiting times. In further
210 analysis we also use two sub-scores based on items relating to mobility and pain (see
211 Appendix for how items are matched to sub-scores); again coded as groups of four points.
212 The PROM questionnaire also includes the EQ-5D, a generic measure of HRQoL that can be
213 applied to different health conditions (Brooks, 1996) and can be converted into utility scores
214 using the UK general population tariff with one indicating full health and zero indicating a
215 health state equivalent to being dead (Dolan, 1997). We focus on the Oxford scores
216 throughout this paper because i) we expect them to be more sensitive to differences in
217 severity as considered by the consultant than the EQ-5D, ii) we do not wish to make
218 comparisons across conditions, and iii) their focus on pain and mobility mirrors the criteria
219 used for prioritisation of hip replacement patients in the Canadian context (see
220 Introduction). The correlation between the condition-specific and generic measures is high,
221 with $\rho = 0.74$ for OHS and the EQ-5D utility score and $\rho = 0.71$ for OKS and EQ-5D utility
222 score. We estimate that, on average, a 4 point increase on the pre-operative Oxford scores
223 is associated with a utility increase of 0.114 (SE=0.0005) for both hip and knee replacement

224 patients, adjusted for case-mix (see Appendix). To put this into context, based on the
 225 current NICE cost-effectiveness thresholds value of around £30,000 per quality-adjusted life
 226 year the NHS in England would be willing to spend up to £3,420 to allow one patient to
 227 spend a year in a 0.114 utility points (=4 OHS points) better health state (NICE, 2008).

228 No ethical approval was required for secondary data analysis.

229 2.2 Empirical analysis

230 We estimate fixed effects Poisson regression models to relate the number of days on the
 231 waiting list w_{ijt} for patient i in hospital j in year t to observed patient characteristics and
 232 the provider of care (Cameron & Trivedi, 1998). The use of Poisson regression is preferable
 233 over (log-transformed) linear regression because it accounts for the skewed distribution of
 234 waiting time and does not suffer from re-transformation bias (Gould, 2011; Manning, 1998).

235 Our model is specified as

$$w_{ijt} = \exp(\beta_1' s_{ijt} + \beta_2' x_{ijt} + h_{jt})$$

236 Coefficient estimates are semi-elasticities, representing the proportionate change in the
 237 dependent variable resulting from a one unit change in the independent variable. We also
 238 report average partial effects (APEs) on the untransformed scale. We obtained cluster-
 239 robust Huber-White standard errors to account for potential over-dispersion (Cameron &
 240 Trivedi, 1998).

241 The variable s_{ijt} is our key variable of interest. It measures severity in terms of patients'
 242 pain at rest or in movement, and their ability to move about. This information is available
 243 from a national census of all patients undergoing elective hip or knee replacement (more
 244 details are provided in the data section). The vector β_1 thus provides an estimate of the

245 degree of waiting-time prioritisation on the list according to severity as measured by pain
246 and immobility. We allow for the relationship between severity and waiting time to be non-
247 linear by splitting severity into eleven bands, thus allowing for a potentially non-linear
248 ‘severity gradient’ in waiting time.

249 There may be a number of other patient characteristics that are used for prioritisation and
250 are correlated with unobserved components of severity. We explore the robustness of the
251 estimated severity gradient in β_1 to the inclusion of these characteristics. The vector x_{ijt}
252 includes the patient’s age (coded as 0-44, 45-54, 55-64, 65-74, 75-84 and 85+), sex and age-
253 sex interactions as well as the number of emergency admissions to hospital during the past
254 365 days, indicators for Elixhauser co-morbid conditions and approximate socio-economic
255 status (in quintile groups). *A priori*, age should affect only the eligibility criteria for a hip (or
256 knee) replacement within the NHS, not whether they are prioritised on the list conditional
257 on being added to the list. However, age may be correlated with other factors of severity
258 not already accounted for through patients’ self-reported health. Similarly, patients may be
259 prioritised according to their co-morbidity burden and general health status as
260 approximated by past emergency admissions.

261 All models include hospital-year-specific fixed effects h_{jt} to control for differences in waiting
262 times across hospitals which may arise from (potentially time-varying) unobserved supply
263 factors (e.g. availability of beds, staffing, infrastructure, management and organization, and
264 quality) and unobserved regional demand factors such as overall health of the population.
265 This modelling strategy captures general time trends and differences across hospitals in
266 each year and over time so that the coefficients of on severity and other control variables
267 are estimated from within provider-year variation only.

268 All analyses were conducted in Stata version 13.

269 **3 Results**

270 **3.1 Descriptive statistics**

271 Over the five-year period considered there have been about 297,000 publicly funded hip
272 replacement procedures and about 325,000 knee replacement procedures in the English
273 NHS. Pre-operative PROM data are available for approximately 64% of hip replacement
274 patients and 62% of knee replacement patients. Descriptive statistics for these patients are
275 provided in Table 1.

276 For hip replacement patients, the average observed waiting time (our dependent variable) is
277 82 days. Patients are on average 68 years old and nearly 60% of patients are female. The
278 average pre-operative OHS is 17.5 points (on a range from 0 to 48). Patients had an average
279 of 0.1 emergency admissions in the year proceeding hospital admission for an elective hip
280 replacement. Only 66% of patients had at least one comorbid condition with only 7%
281 reporting five or more. Approximately 17% of patients are treated in privately-operated
282 hospitals. The average waiting time for knee replacement surgery is slightly higher than for
283 hip replacement surgery (86 vs 82 days). The other patient characteristics are comparable to
284 those of hip replacement patients and are not repeated here (but see Table 1 for details).
285 The distributions of pre-operative OHS and OKS are shown in Figure 1 and Figure 2.

286 [Table 1 here]

287 [Figure 1 and Figure 2 here]

288 Not all patients respond to the PROM survey. Table 2 compares the characteristics of
289 responders and non-responders as derived from HES. The gap in average waiting time
290 between responders and non-responders is two days for hip replacement patients and three
291 days for knee replacement patients. Given that the average waiting time is above 80 days,
292 these differences are negligible. Similarly, while non-responders tend to be slightly older,
293 have a higher comorbidity burden and have been admitted more often to hospital as an
294 emergency in the preceding year, these differences are small in clinical and economic terms
295 and unlikely to induce bias.

296 [Table 2 here]

297 There are substantial differences in waiting time across hospitals. For example, hip
298 replacement patients attending one of the 131 private hospitals wait on average 46.2 days
299 compared with 89.8 days in one of the 153 public NHS hospitals (all based on responders
300 and non-responders). This illustrates the need to control for hospital fixed effects in
301 estimating the severity gradient in waiting times.

302 **3.2 Estimates of the severity gradient in waiting time**

303 Table 3 and Table 4 provide our key results for patients in need of hip and knee
304 replacement, respectively. All specifications include hospital-year fixed effects (not
305 reported). Differences in waiting times across patients with different severity are therefore
306 unlikely to be confounded by differences in local supply or demand factors. The model in
307 Column (1) only includes the Oxford Score. The model in Column (2) extends this to account
308 for patient's age and gender, and the model in Column (3) contains a full set of control
309 variables. The severity gradient is formed by the coefficients on each of the Oxford Score

310 groups. It is robust to the inclusion of additional control variables. We therefore focus our
311 discussion on the results in Column (3).

312 Table 3 suggests that hip replacement patients with lower severity, as measured by the
313 Oxford Hip Score, wait longer. The quantitative effect appears to be modest. Compared to
314 patients in the top severity group (0-4 points) patients of average severity (17-20 points)
315 wait 9% (or about 7 days) longer. Patients with least severity (with a score above 41 points)
316 wait approximately 24% (20 days) longer. Figure 3 plots the average partial effect of Oxford
317 Hip Scores on waiting times in terms of days waited. The severity gradient increases linearly
318 across the entire range, suggesting a simple prioritisation mechanism.

319 [Table 3 here]

320 [Figure 3 here]

321 Several other patient characteristics are also predictive of waiting time. For a given level of
322 severity, older patients tend to wait less. Patients aged 65 years or older wait about 14-17%
323 less than patients below 45 years (and about 8-11% less than patients aged 45-54). Male
324 patients wait 7% less. The age gradient is not statistically significantly different for men and
325 women and it is therefore not reported. Patients who had been admitted to hospital as an
326 emergency within the last year wait less than those who had not. Only few Elixhauser
327 comorbidities have a statistically significant effect on observed waiting time (not reported).
328 Finally, there remains a statistically significant but very small socio-economic gradient in
329 waiting time even after conditioning on pre-operative severity and other patient
330 characteristics. Patients in the most income-deprived fifth of neighbourhoods wait
331 approximately 1% longer than those in the least deprived fifth of neighbourhoods. If some

332 of these patient characteristics pick up unobserved severity differences, our severity
333 gradient should be considered a lower bound estimate of the true gradient.

334 Table 4 reports results for knee replacement. The results are analogous to those for hip
335 replacement, though the gradient associated with OKS is notably flatter at about half the
336 slope. Patients below 21 OKS points do not differ significantly in waiting times. Patients with
337 scores in the range of 21 to 48 wait about 3-11% longer compared to patients with a score
338 below 21. The overall effect of severity on waiting time is small and different severity groups
339 differ by no more than 10 days (see Figure 3). Again, prioritisation appears to be almost
340 linear. Patients 65 years or older wait about 7-10% less than younger patients. There is no
341 statistically significant difference across genders or socio-economic groups.

342 [Table 4 here]

343 **3.3 Different dimensions of severity: pain or mobility**

344 We now explore whether prioritisation differs by pain and mobility. The results in Table 5
345 show that, for hip replacement surgery, both pain and mobility matter but the effect of pain
346 on prioritisation is larger. For example, a patient who scores 13-16 points on the pain score
347 (higher scores indicate lower pain) is expected to wait 8% (7 days) longer than a patient of
348 extreme pain, for a given level of mobility (see also Figure 4). Conversely, a patient who
349 scores 13-16 points on the mobility score is only expected to wait 4% (3 days) longer than
350 the most immobile patient.

351 The results are different for knee replacement. Here, it is mainly different degrees of pain
352 that generate differences in waiting times and account for most of the gradient. Variations
353 in severity due to mobility have generally no effect on prioritisation (Figure 4).

354 [Table 5 here]

355 [Figure 4 here]

356 **3.4 Hospitals with long and short waiting times**

357 We also test whether prioritisation is more pronounced when waiting times are longer. To
358 do so we split the sample into two groups, hospitals with an average wait above the median
359 and hospitals below the median. The median hospital level waiting time is calculated on all
360 patients undergoing elective hip or knee replacement surgery, i.e. including those that did
361 not participate in the PROM survey, and is 77 days for hip replacement surgery and 81 days
362 for knee replacement surgery.

363 Table 6 provides the results. We focus on our preferred specification, which includes all
364 controls. It shows that the prioritisation gradient is comparable among the two groups when
365 differences in waits are measured in percentage points (with possibly a stronger gradient in
366 long-wait hospitals for low OHS scores, i.e. high severity, and a weaker gradient for high
367 scores). However, the underlying levels are different.

368 Figure 5 plots the gradients in days. The least severe patients (OHS score 41-48) wait up to
369 23 days longer than severe patients in high-wait hospitals. Conversely, similar patients in
370 low-wait hospitals wait only up to 14 days longer. Therefore waiting time prioritisation is
371 more pronounced in absolute terms in hospitals with longer average waiting times.

372 A similar picture arises when looking at knee replacement patients (Figure 6). Prioritisation
373 is more pronounced in long-wait hospitals. In short-wait hospitals there are very little
374 discernible differences between different severity groups. In high-wait hospitals,

375 prioritisation tends to be linear and patients with lower severity wait up to about 12 days
376 longer.

377 [Table 6 here]

378 [Figure 5 and Figure 6 here]

379 **4 Discussion**

380 Many OECD countries are either faced with cuts to their healthcare budgets or small
381 nominal growth, in part driven by efforts to reduce budget deficits in the aftermath of the
382 global economic crisis. This is likely to affect the supply of care, which can no longer keep up
383 with the increasing demand for care due to e.g. increased expectations, cost-increasing
384 medical innovation and people living longer with multiple chronic conditions. As a result,
385 many healthcare systems are seeing and will see increases in waiting time for elective
386 surgery.

387 Waiting time prioritisation policies are one way to optimise the management of the waiting
388 list and thus maximise patients' welfare. A number of countries have adopted formal or
389 informal processes by which patients are prioritised according to their observed severity, i.e.
390 the need for timely care. Yet, there is little empirical evidence on the degree to which
391 prioritisation policies are implemented or how steep the severity gradient in waiting time is
392 in practice.

393 Using data on waiting time and self-reported pre-operative health status for over 200,000
394 patients undergoing elective hip and knee replacement in the English NHS, we demonstrate
395 a statistically significant, albeit modest severity gradient in waiting time. For every four
396 points on the Oxford Hip Score (ranging from 0 (worst) to 48 (best)) we see an increase in

397 waiting time of approximately two days. This applies across the entire range of severity.
398 Conversely, waiting times increase by approximately 1-2 days for every four points increase
399 on the Oxford Knee Score for knee replacement patients with pre-operative scores above
400 20. There is no discernible gradient among more severe patients. Prioritisation for hip and
401 knee replacement surgery is driven primarily by the amount of pain patients receive from
402 their joint, with less importance given to mobility.

403 The overall severity gradient in waiting time seems modest in absolute terms but is not
404 negligible relative to the average waiting time: The gap between the most and least severe
405 groups of patients is approximately 25% (=20/82 days) of the average waiting time for hip
406 replacement patients, and 12% (=10/87 days) for knee replacement patients. One reason
407 why we do not observe more prioritisation may be because the English NHS has not
408 adopted a formal model of prioritisation for hip and knee replacement surgery, i.e. it largely
409 implements a 'first-come-first-serve' model, or because average waiting times are now at a
410 historic low so that prioritisation is considered less important.

411 Prioritisation is enhanced when waits are longer. This is supported by our finding that
412 hospitals with above median waiting times tend to show stronger prioritisation in absolute
413 terms than hospitals with below median waiting times. It also suggests that hospitals more
414 at risk of breaching maximum waiting time targets are not necessarily less inclined to take
415 severity into account when managing their waiting list. Indeed, one might argue that the
416 benefits of prioritisation are larger when waiting times are longer, so that hospitals with
417 above median waiting time should indeed engage more intensively in prioritising waiting
418 lists by severity as we observe in our data. If so, as waiting times begin to gradually increase
419 again in the English NHS, we would expect to see more prioritisation taking place.

420 Several other patient characteristics are associated with differences in waiting time. For
421 example we observe an age gradient. This may be considered as pro-elderly evidence of
422 inequality in access to care. However, it may also be a selection issue in terms of which
423 patients are able and willing to choose privately funded treatment – for example, if elderly
424 patients are wealthier than younger patients with severe osteoarthritis. We also cannot rule
425 out that our measure of severity is imperfect and that these variables capture some
426 unobserved component of severity. In this case, our estimate of the severity gradient is a
427 lower bound.

428 More generally, our study has a number of possible limitations. First, our pre-operative
429 health status measures are taken at the time of admission, not when the specialist makes
430 the decision to add the patient to the waiting list. This may potentially overestimate the
431 severity of some patients if the patients' health status deteriorates during long waits.
432 However, a recent systematic review by Hoozeboom et al. (2009) finds that the degree of
433 deterioration in health during waiting times <6 months is likely to be minimal and we
434 therefore do not expect this to be a serious concern for our study. Second, not all patients
435 respond to the PROM questionnaire, which may give rise to possible selection bias. We did
436 not pursue to model sample selection explicitly due to a lack of valid exclusion restrictions.
437 However, any sample selection bias is likely to be small as we find only very small difference
438 in the average waiting time for responders and non-responders.

439 **5 Conclusions**

440 Hip and knee replacement patients in the English NHS are being prioritised according to
441 severity, even though no formal national prioritisation policy is currently in place. However,
442 the degree of prioritisation may be considered modest, especially for knee replacement

443 surgery with a gap of only 10 days (12% of the mean waiting time) between patients with
444 the most and least severe problems of pain and immobility. The modest slope of the
445 severity gradient in waiting time suggests that those responsible for the waiting list either
446 believe that the marginal disutility of waiting for surgery does not vary substantially across
447 patients, or that they find it difficult (perhaps even unethical) to prioritise patients according
448 to their pain and limitations to mobility. There is a clear rationale for prioritising patients on
449 the list: the overall pain and limitations to mobility can be reduced by letting more severely
450 incapacitated patients wait less. This is important even if waiting has no negative impact on
451 patients' long-term prognosis. Policy makers in the English NHS may wish to follow the
452 example of other OECD countries and consider implementing formal policies to encouraging
453 further prioritisation on the list if the current level of informal prioritisation is considered
454 insufficient.

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7 Tables and Figures

Table 1: Descriptive Statistics

Description	Hip replacement (N=190,103)		Knee replacement (N=203,080)	
	Mean	SD	Mean	SD
Waiting time (in days)	81.7	50.5	86.3	53.6
Pre-operative Oxford Score	17.5	8.2	18.3	7.8
Age	67.7	11.3	69.1	9.3
Gender (0=female, 1=male)	0.41	0.5	0.43	0.5
Proportion of local population receiving unemployment benefits	0.12	0.1	0.13	0.1
Number of emergency admissions in last 365 days	0.11	0.4	0.10	0.5
Number of Elixhauser comorbidities: 0	0.34	0.5	0.26	0.4
Number of Elixhauser comorbidities: 1	0.28	0.5	0.28	0.4
Number of Elixhauser comorbidities: 2	0.19	0.4	0.22	0.4
Number of Elixhauser comorbidities: 3-4	0.13	0.3	0.16	0.4
Number of Elixhauser comorbidities: 5+	0.07	0.2	0.08	0.3
Financial year 2009/10	0.15	0.4	0.16	0.4
Financial year 2010/11	0.19	0.4	0.19	0.4
Financial year 2011/12	0.21	0.4	0.21	0.4
Financial year 2012/13	0.22	0.4	0.22	0.4
Financial year 2013/14	0.23	0.4	0.23	0.4
Treated in private (non-NHS) hospital (0=no, 1=yes)	0.17	0.4	0.16	0.4

Table 2: Comparison of responders and non-responders

Variable	Hip replacement				Knee replacement			
	Responders (N=190,106)		Non-responders (N=107,065)		Responders (N=203,084)		Non-responders (N=122,285)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Waiting time	81.7	50.5	83.7	57.3	86.3	53.6	89.1	60.3
Age	67.7	11.3	68.7	11.7	69.1	9.3	70.0	9.5
Gender (0=female, 1=male)	0.41	0.5	0.40	0.5	0.43	0.5	0.42	0.5
Proportion of local population receiving social security benefits	0.12	0.1	0.13	0.1	0.13	0.1	0.14	0.1
Number of Elixhauser comorbidities	1.59	2.7	1.78	3.7	1.84	2.9	1.96	3.4
Number of emergency admissions in last 365 days	0.11	0.4	0.15	0.5	0.10	0.5	0.13	0.5
Treated in private (non-NHS) hospital (0=no, 1=yes)	0.17	0.4	0.17	0.4	0.16	0.4	0.17	0.4

Table 3: Regression results - hip replacement

Covariate	Pre-operative health only			Pre-operative health and age/sex			Full adjustment		
	Est	SE		Est	SE		Est	SE	
Pre-operative score: 5-8	0.039	0.008	***	0.036	0.008	***	0.037	0.008	***
Pre-operative score: 9-12	0.056	0.007	***	0.054	0.007	***	0.055	0.008	***
Pre-operative score: 13-16	0.077	0.007	***	0.074	0.007	***	0.077	0.007	***
Pre-operative score: 17-20	0.092	0.007	***	0.090	0.007	***	0.094	0.007	***
Pre-operative score: 21-24	0.109	0.008	***	0.107	0.008	***	0.112	0.008	***
Pre-operative score: 25-28	0.132	0.008	***	0.132	0.008	***	0.137	0.008	***
Pre-operative score: 29-32	0.153	0.008	***	0.154	0.008	***	0.160	0.009	***
Pre-operative score: 33-36	0.162	0.010	***	0.162	0.010	***	0.168	0.010	***
Pre-operative score: 37-40	0.193	0.013	***	0.196	0.013	***	0.204	0.013	***
Pre-operative score: 41-48	0.229	0.022	***	0.231	0.022	***	0.239	0.022	***
Age: 45-54				-0.060	0.011	***	-0.063	0.011	***
Age: 55-64				-0.096	0.010	***	-0.100	0.010	***
Age: 65-74				-0.135	0.010	***	-0.141	0.010	***
Age: 75-84				-0.156	0.010	***	-0.163	0.010	***
Age: 85+				-0.161	0.012	***	-0.167	0.012	***
Male				-0.067	0.013	***	-0.067	0.013	***
Number of emergency admissions in last 365 days							-0.019	0.004	***
SES (2nd quintile)							0.005	0.004	
SES (3rd quintile)							0.005	0.004	
SES (4th quintile)							0.014	0.004	***
SES (5th quintile - most deprived)							0.011	0.004	**
Pseudo R2	0.244			0.247			0.248		
N	190,103			190,103			190,103		

Notes: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$. Estimates are semi-elasticities and relative to patient aged <44, female, and pre-operative Oxford score of 0-4. All models include hospital-year fixed effects. Standard errors are robust to over-dispersion. Age-sex interactions, Elixhauser comorbidities and year effects not reported.

Table 4: Regression results - knee replacement

Covariate	Pre-operative health only			Pre-operative health and age/sex			Full adjustment	
	Est	SE		Est	SE		Est	SE
Pre-operative score: 5-8	-0.011	0.009		-0.012	0.009		-0.012	0.009
Pre-operative score: 9-12	0.002	0.009		0.003	0.009		0.005	0.009
Pre-operative score: 13-16	0.005	0.009		0.009	0.009		0.011	0.009
Pre-operative score: 17-20	0.004	0.009		0.010	0.009		0.013	0.009
Pre-operative score: 21-24	0.016	0.009		0.024	0.009	**	0.028	0.009
Pre-operative score: 25-28	0.028	0.009	**	0.038	0.009	***	0.042	0.009
Pre-operative score: 29-32	0.054	0.010	***	0.066	0.010	***	0.070	0.010
Pre-operative score: 33-36	0.058	0.011	***	0.072	0.011	***	0.077	0.011
Pre-operative score: 37-40	0.075	0.015	***	0.090	0.015	***	0.095	0.015
Pre-operative score: 41-48	0.092	0.025	***	0.107	0.025	***	0.111	0.025
Age: 45-54				-0.006	0.020		-0.008	0.020
Age: 55-64				-0.027	0.019		-0.030	0.019
Age: 65-74				-0.068	0.019	***	-0.072	0.019
Age: 75-84				-0.086	0.019	***	-0.090	0.019
Age: 85+				-0.093	0.020	***	-0.095	0.020
Male				-0.012	0.029		-0.010	0.029
Number of emergency admissions in last 365 days							-0.011	0.003
SES (2nd quintile)							0.003	0.004
SES (3rd quintile)							-0.004	0.004
SES (4th quintile)							-0.005	0.004
SES (5th quintile - most deprived)							-0.002	0.004
Pseudo R2	0.230			0.232			0.232	
N	203,080			203,080			203,080	

Notes: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$. Estimates are semi-elasticities and relative to patient aged <44, female, and pre-operative Oxford score of 0-4. All models include hospital-year fixed effects. Standard errors are robust to over-dispersion. Age-sex interactions, Elixhauser comorbidities and year effects not reported.

Table 5: Effect of pain and mobility on waiting time

Covariate	Hip replacement						Knee replacement					
	Pain			Functioning			Pain			Functioning		
	Est	SE		Est	SE		Est	SE		Est	SE	
Pre-operative score: 5-8	0.029	0.004	***	0.013	0.005	**	0.022	0.003	***	0.001	0.005	
Pre-operative score: 9-12	0.053	0.004	***	0.031	0.005	***	0.044	0.004	***	-0.007	0.006	
Pre-operative score: 13-16	0.081	0.006	***	0.042	0.006	***	0.065	0.007	***	0.000	0.006	
Pre-operative score: 17-20	0.099	0.009	***	0.056	0.007	***	0.084	0.020	***	0.012	0.007	
Pre-operative score: 21-24	0.103	0.021	***	0.096	0.013	***				0.031	0.009	***
Pre-operative score: 25-28										0.015	0.019	
Pseudo R2	0.248						0.232					
N	190,103						203,080					

Notes: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$. Estimates are semi-elasticities and relative to pre-operative score of 0-4. All models include hospital-year fixed effects plus a full set of control variables (see text). Standard errors are robust to over-dispersion.

Table 6: Difference in waiting time gradient between short and long wait hospitals

Covariate	Hip replacement					Knee replacement				
	Low waiting time hospitals		High waiting time hospitals			Low waiting time hospitals		High waiting time hospitals		
	Est	SE	Est	SE	***	Est	SE	Est	SE	***
Pre-operative score: 5-8	0.001	0.017	0.044	0.009	***	-0.028	0.023	-0.008	0.010	
Pre-operative score: 9-12	0.027	0.016	0.060	0.008	***	-0.014	0.022	0.009	0.010	
Pre-operative score: 13-16	0.038	0.016	0.086	0.008	***	-0.010	0.022	0.016	0.010	
Pre-operative score: 17-20	0.056	0.016	0.103	0.008	***	0.008	0.022	0.014	0.010	
Pre-operative score: 21-24	0.085	0.017	0.117	0.009	***	0.016	0.022	0.030	0.010	**
Pre-operative score: 25-28	0.117	0.017	0.140	0.009	***	0.046	0.023	0.041	0.010	***
Pre-operative score: 29-32	0.149	0.019	0.161	0.010	***	0.079	0.024	0.067	0.011	***
Pre-operative score: 33-36	0.160	0.022	0.168	0.011	***	0.067	0.028	0.079	0.012	***
Pre-operative score: 37-40	0.198	0.031	0.203	0.015	***	0.108	0.039	0.091	0.016	***
Pre-operative score: 41-48	0.235	0.057	0.237	0.024	***	0.067	0.058	0.122	0.028	***
Pseudo R2	0.235		0.119			0.195		0.117		
N	60,158		129,945			60,639		142,441		

Notes: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$. Estimates are semi-elasticities and relative to pre-operative Oxford score of 0-4. All models include hospital-year fixed effects plus a full set of control variables (see text). Standard errors are robust to over-dispersion.

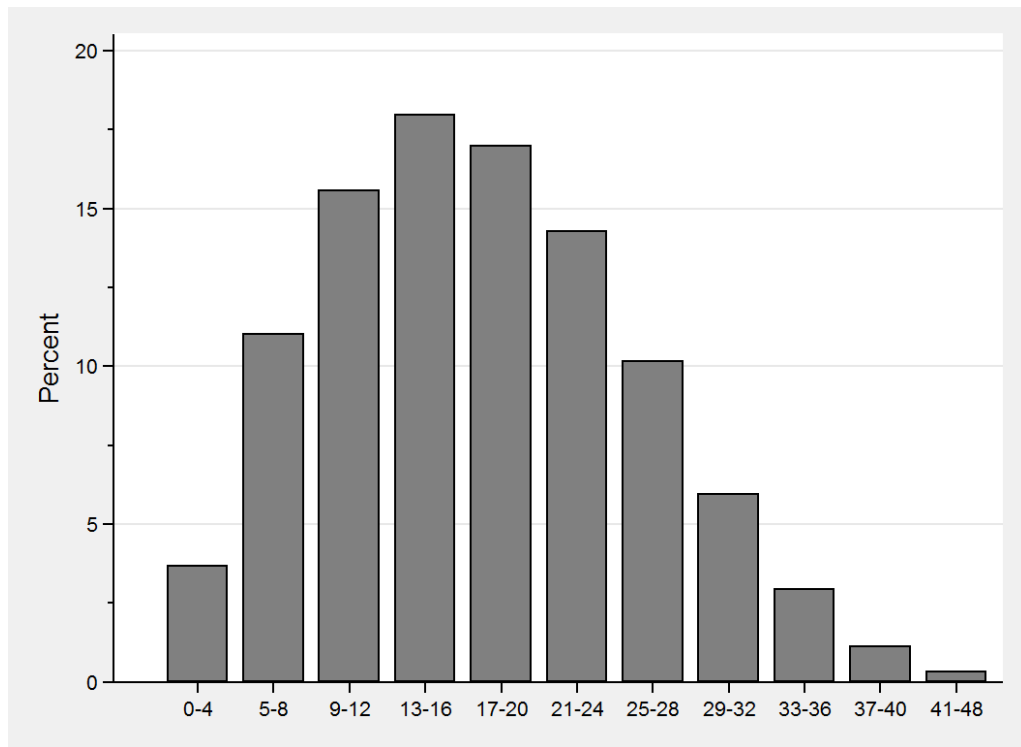
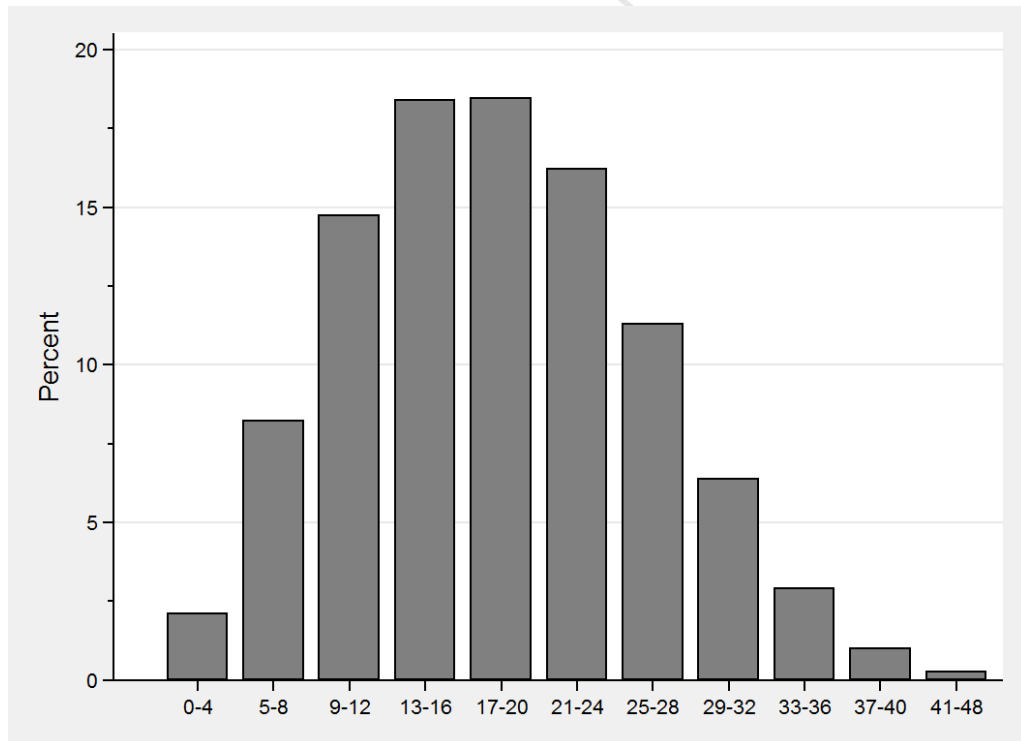
Figure 1: Distribution of pre-operative Oxford Hip Score**Figure 2: Distribution of pre-operative Oxford Knee Score**

Figure 3: Partial effect of severity on waiting time

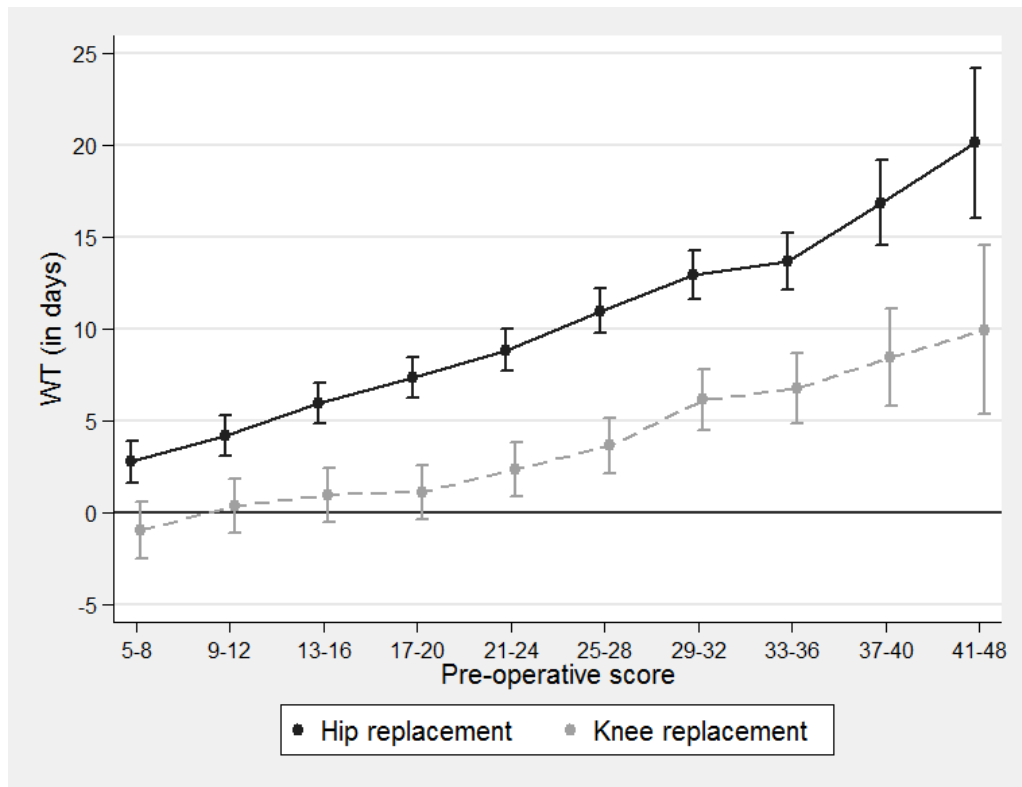


Figure 4: Differential effect of pain and mobility on waiting time

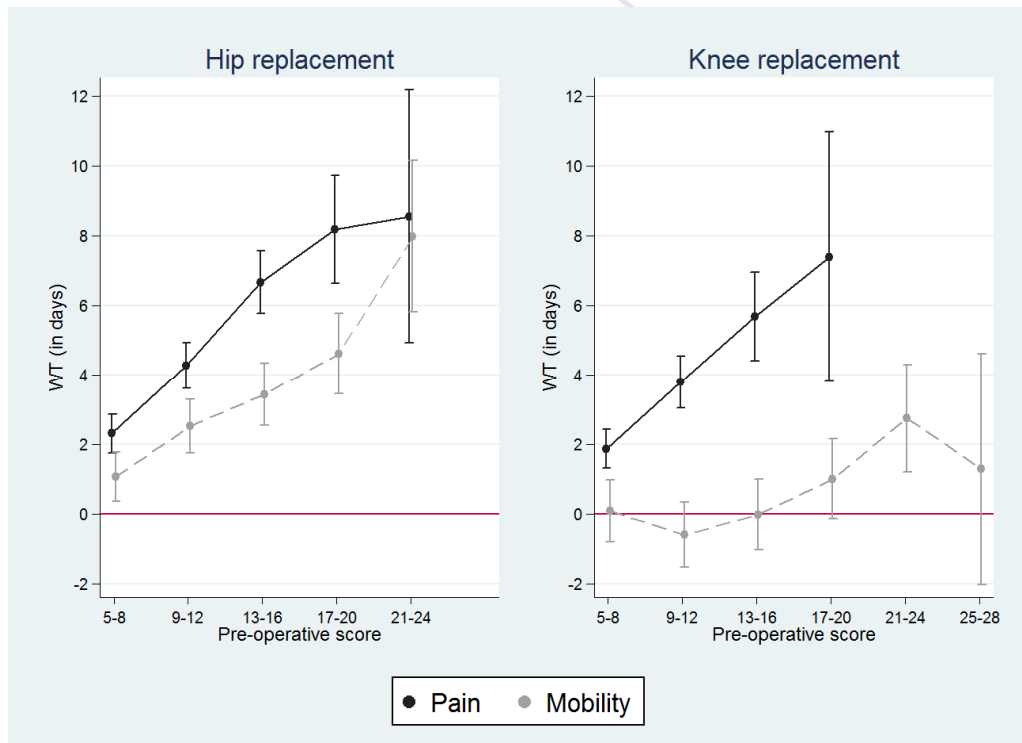


Figure 5: Partial effect of severity on waiting time in short and long wait hospitals - hip replacement surgery

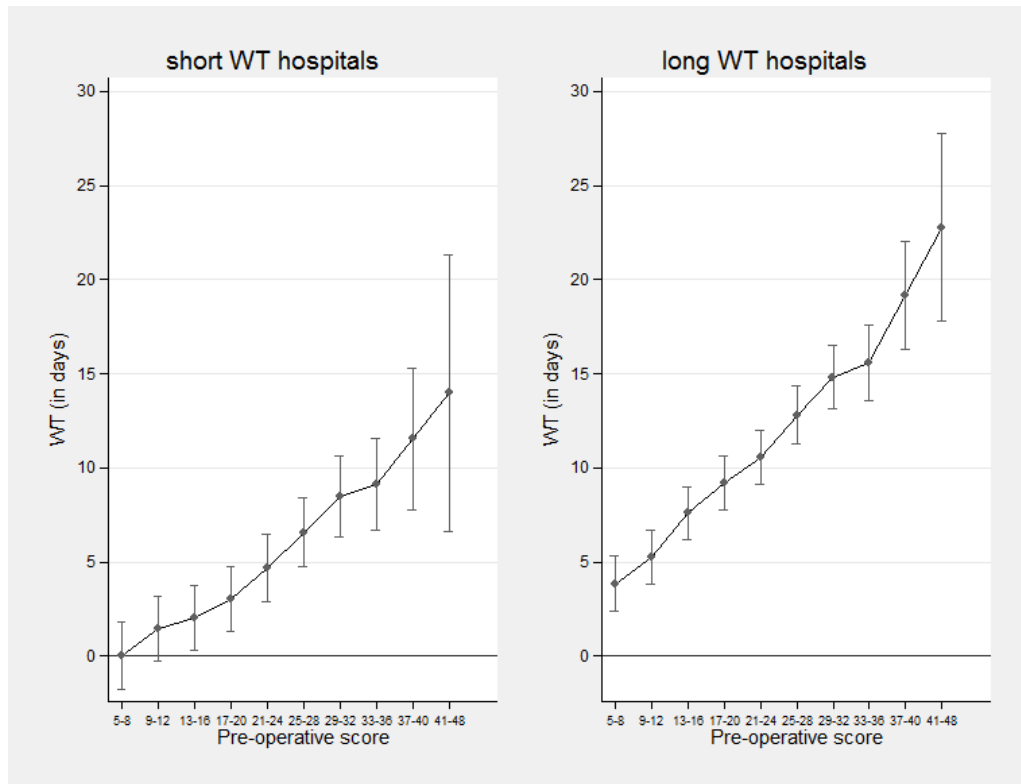
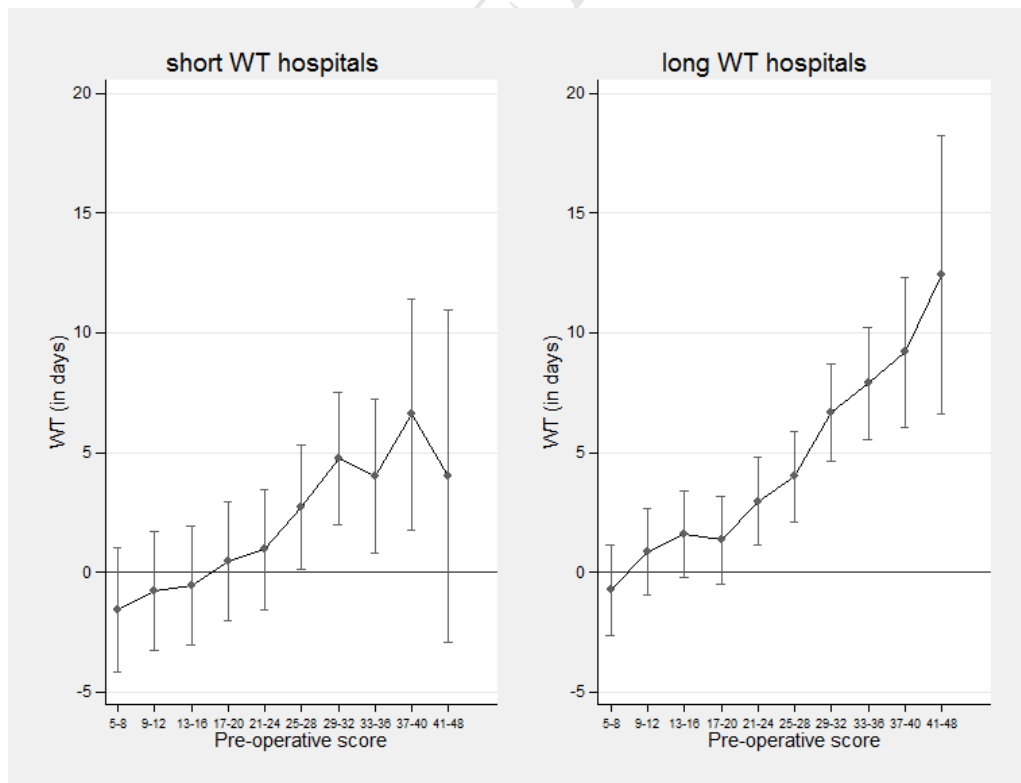


Figure 6: Partial effect of severity on waiting time in short and long wait hospitals - knee replacement surgery



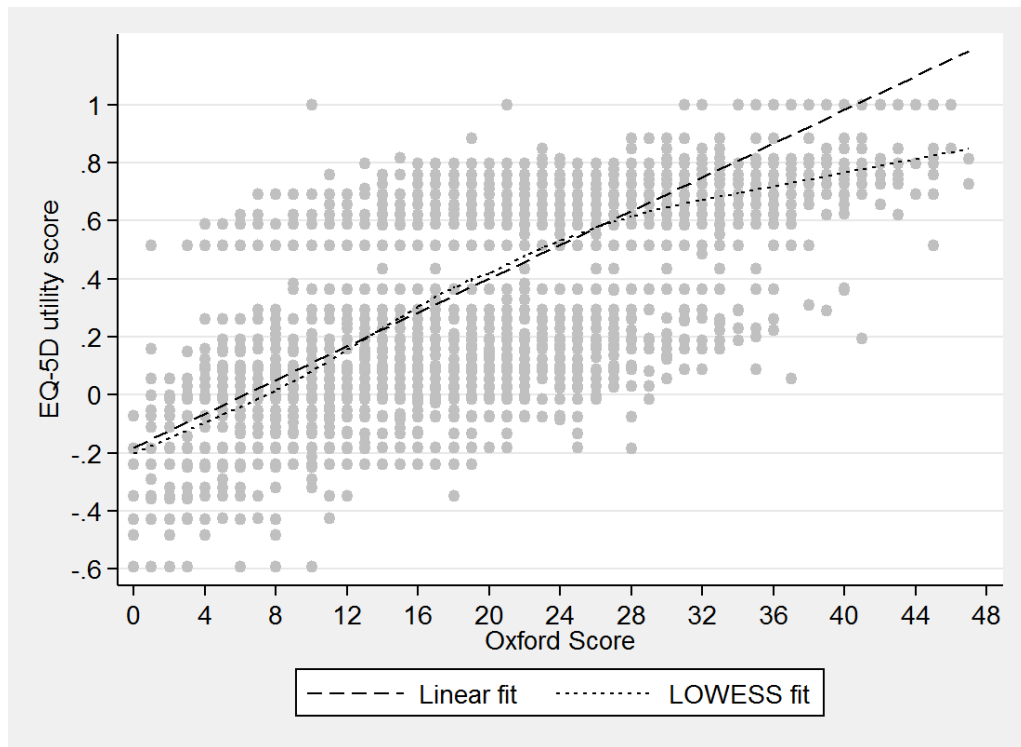
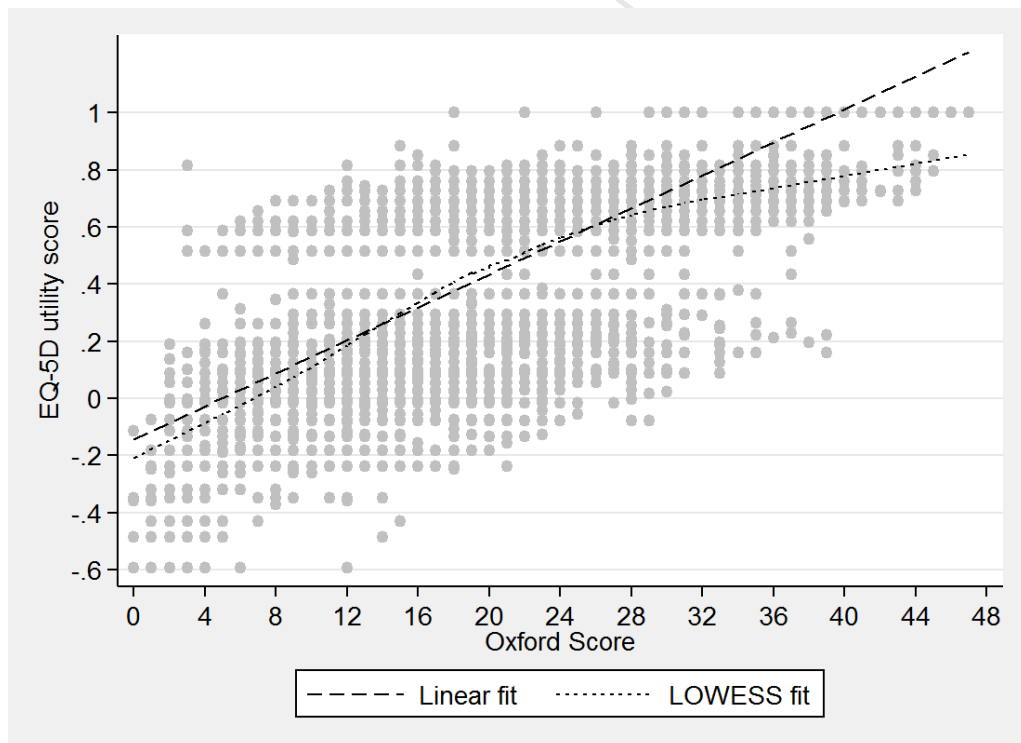
8 Appendix

Appendix 1: Mapping of questions to sub scores - Oxford Hip Score

#	Pain
1	How would you describe the pain you usually had from your hip?
2	Have you had any sudden, severe pain - 'shooting', 'stabbing' or 'spasms' - from the affected hip?
3	Have you been troubled by pain from your hip in bed at night?
4	For how long have you been able to walk before pain from your hip becomes severe? (With or without a stick)
5	After a meal (sat at a table), how painful has it been for you to stand up from a chair because of your hip?
6	How much has pain from your hip interfered with your usual work (including housework)?
#	Mobility
7	Have you had any trouble with washing and drying yourself (all over) because of your hip?
8	Have you had any trouble getting in and out of a car or using public transport because of your hip?
9	Have you been able to put on a pair of socks, stockings or tights?
10	Could you do the household shopping on your own?
11	Have you been able to climb a flight of stairs?
12	Have you been limping when walking, because of your hip?

Appendix 2: Mapping of questions to sub scores - Oxford Knee Score

#	Pain
1	How would you describe the pain you usually have from your knee?
2	Have you been troubled by pain from your knee in bed at night?
3	For how long have you been able to walk before pain from your knee becomes severe? (With or without a stick)
4	After a meal (sat at a table), how painful has it been for you to stand up from a chair because of your knee?
5	How much has pain from your knee interfered with your usual work (including housework)?
#	Mobility
6	Have you had any trouble with washing and drying yourself (all over) because of your knee?
7	Have you had any trouble getting in and out of a car or using public transport because of your knee?
8	Have you been limping when walking, because of your knee?
9	Could you kneel down and get up again afterwards?
10	Have you felt that your knee might suddenly 'give way' or let you down?
11	Could you do the household shopping on your own?
12	Could you walk down one flight of stairs?

Appendix 3: Relationship between Oxford Hip Score and the EQ-5D utility score**Appendix 4: Relationship between Oxford Knee Score and the EQ-5D utility score**

- Patients on waiting list for planned surgery should be prioritised by severity/need
- The English NHS does not implement a formal prioritisation policy
- Empirical analysis shows prioritisation by self-reported pain and immobility
- Pain is more important for prioritisation than mobility
- Hospitals with longer mean waiting time prioritise more

ACCEPTED MANUSCRIPT