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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.

1 Introduction

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

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

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

Waiting time prioritisation policies are intended to improve the management of the waiting 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.

1.1 Related literature

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

8

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.

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

11

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.

12

268   All analyses were conducted in Stata version 13.

3   Results

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

14

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

15

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).

16

354   [Table 5 here]

355   [Figure 4 here]

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]

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 Hoogeboom 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

	Hip replacement				Knee replacement			
	Responders (N=190,106)		Non-responders (N=107,065)		Responders (N=203,084)		Non-responders (N=122,285)	
Variable	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

	Hip replacement						Knee replacement					
	Pain			Functioning			Pain			Functioning		
Covariate	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.

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

	Hip replacement						Knee replacement					
	Low waiting time hospitals			High waiting time hospitals			Low waiting time hospitals			High waiting time hospitals		
Covariate	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.
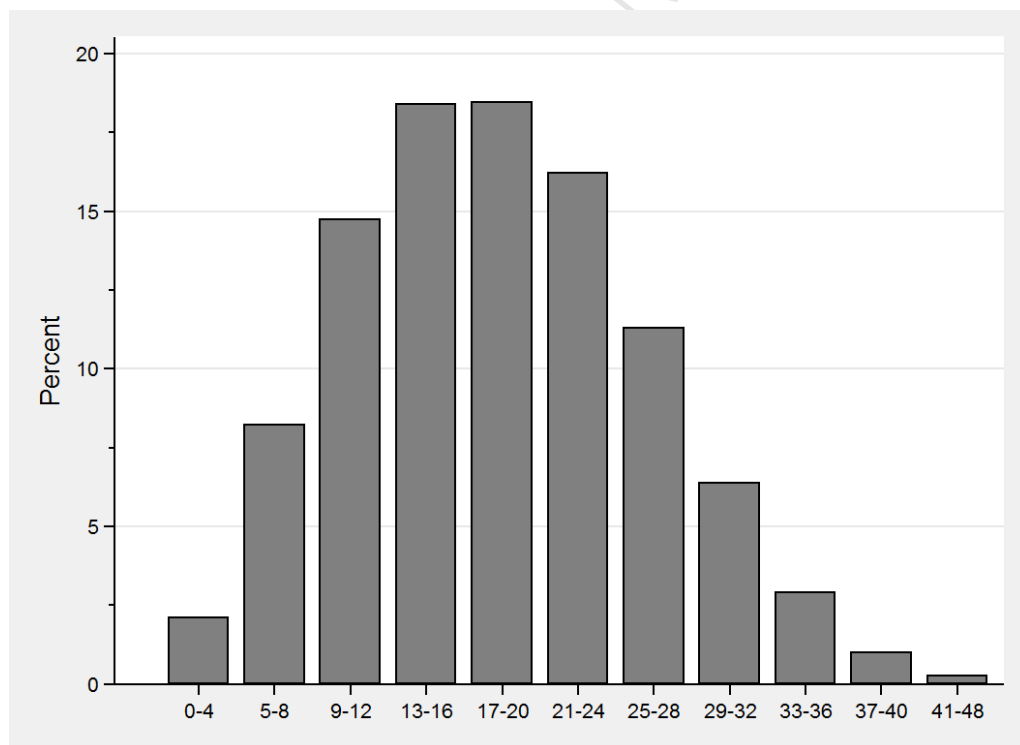
Figure 1: Distribution of pre-operative Oxford Hip Score
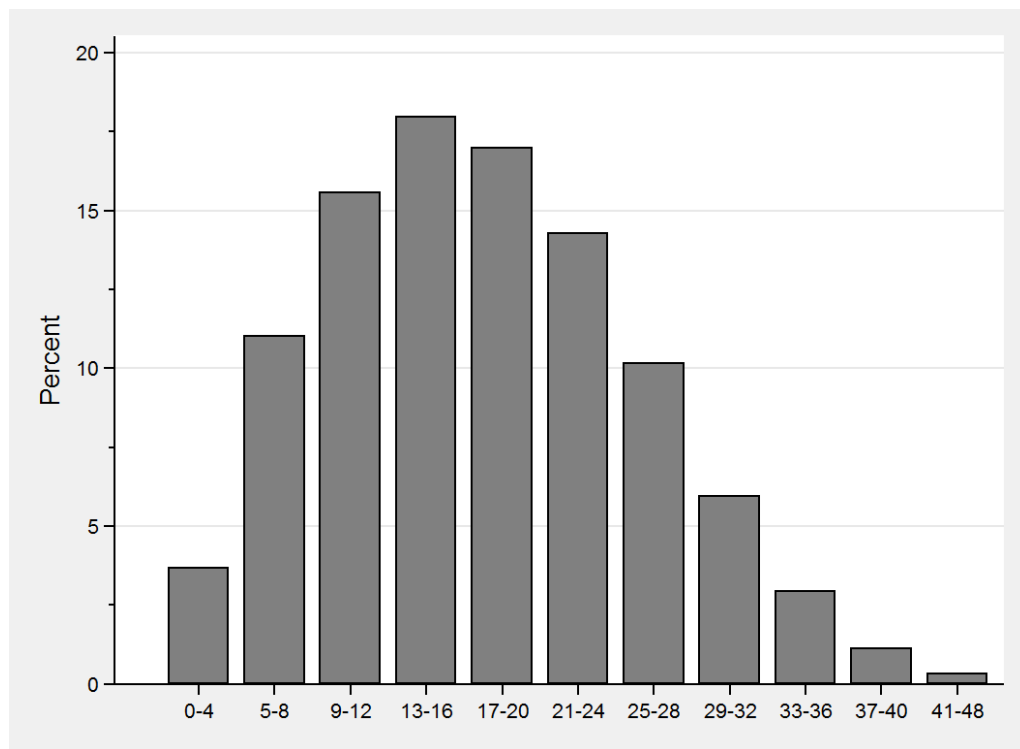
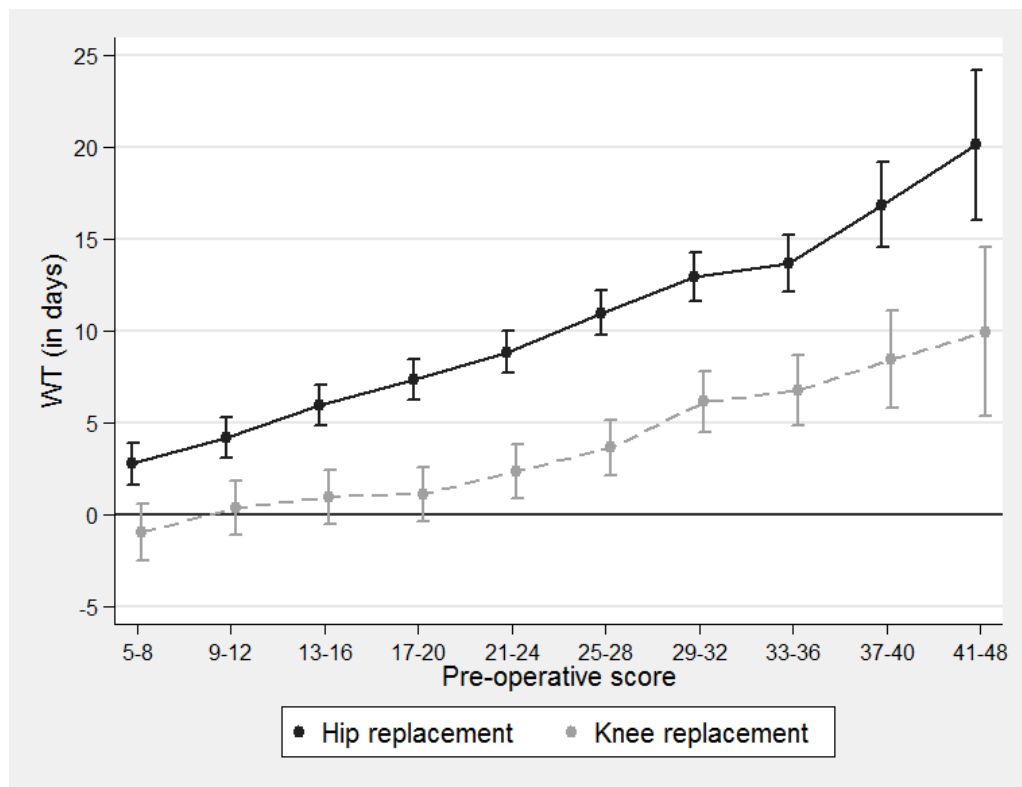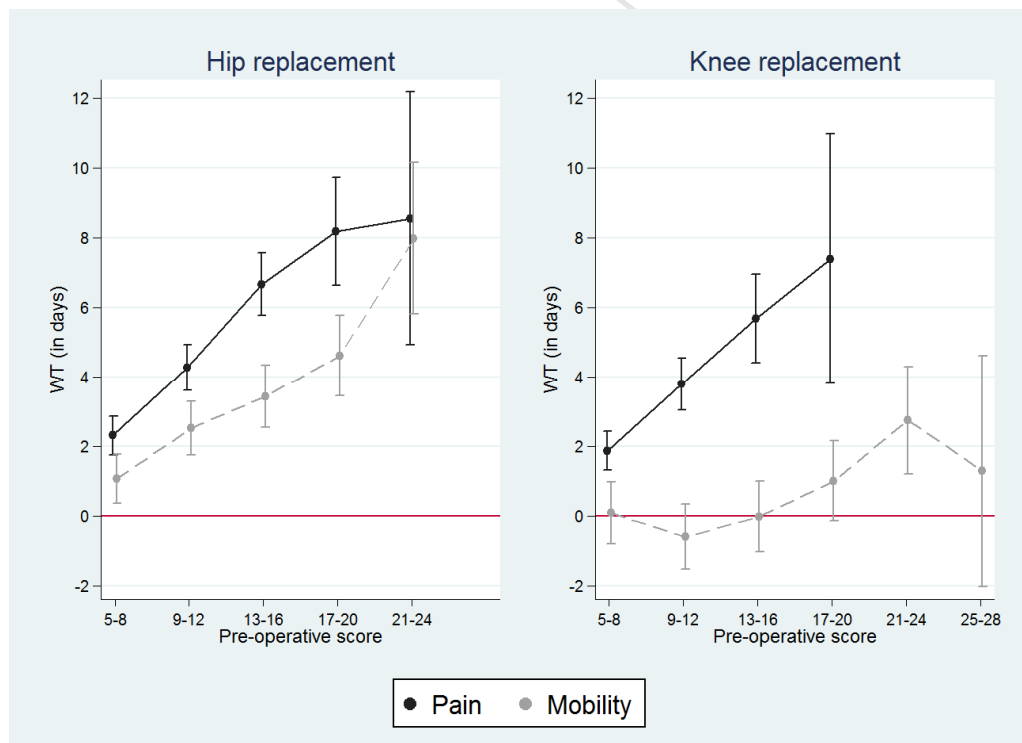**Figure 2: Distribution of pre-operative Oxford Knee Score**

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
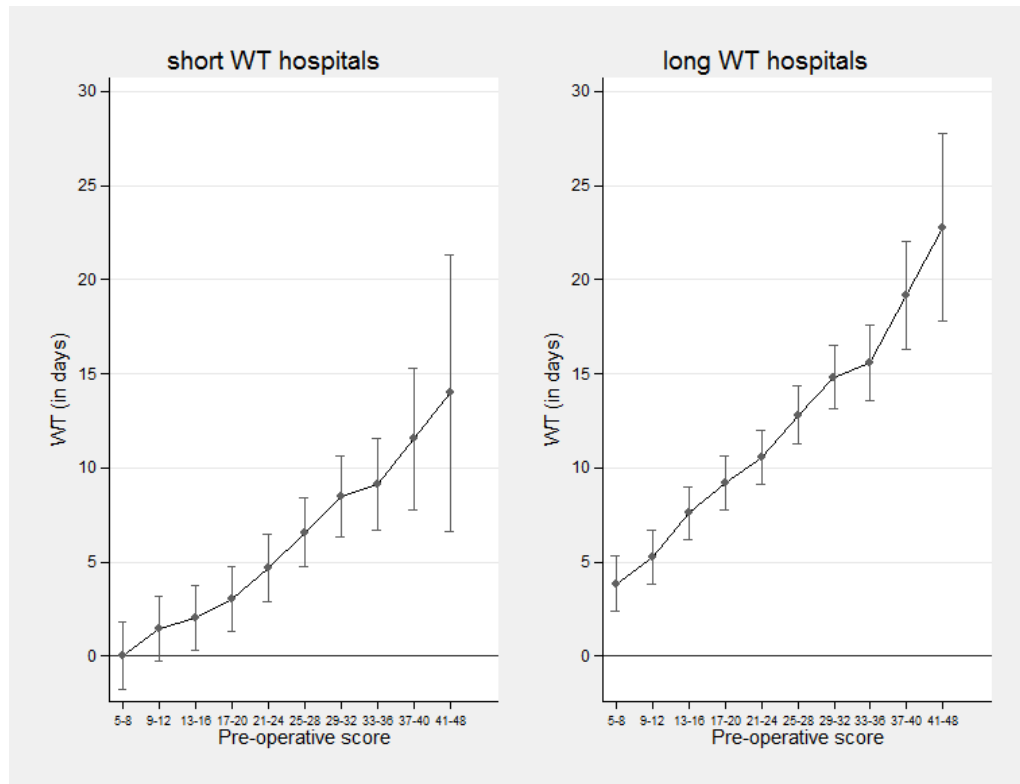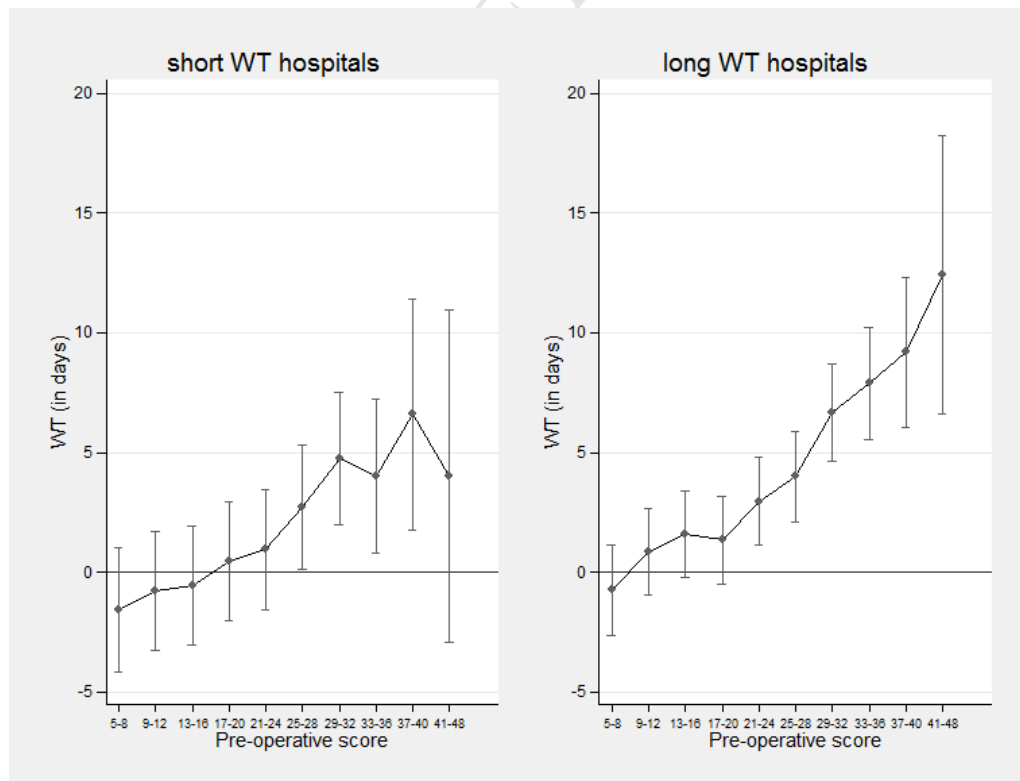

Figure 6: Partial effect of severity on waiting time in short and long wait hospitals - knee replacement surgery
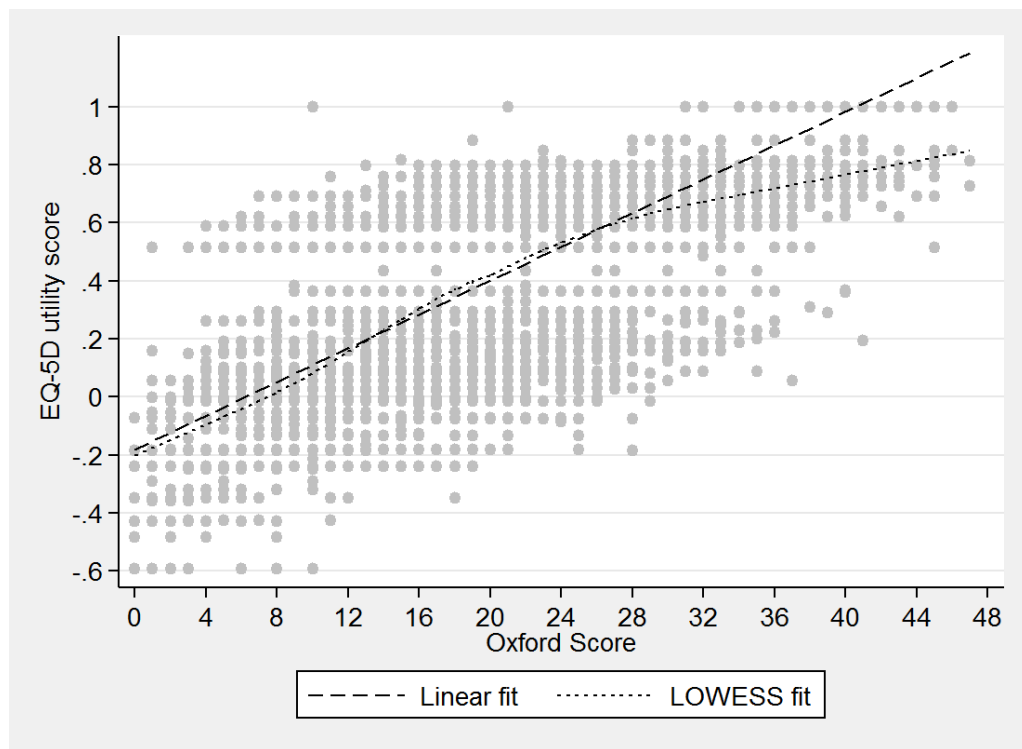
8 Appendix

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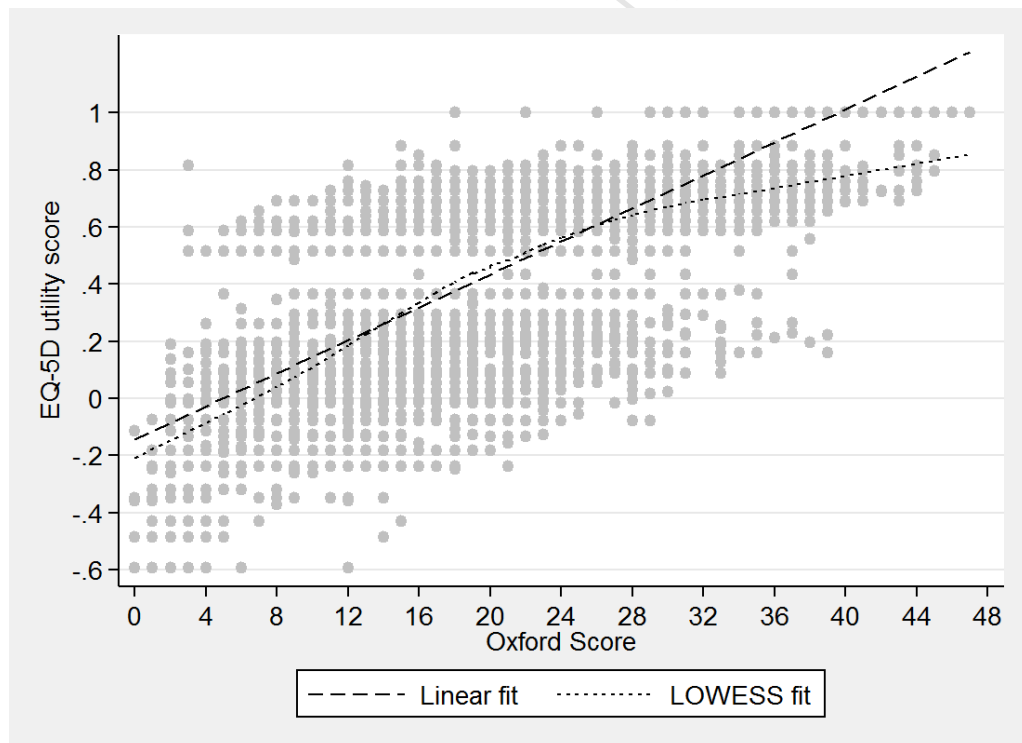
- Patients on waiting list for planned surgery should be prioritised by severity/need
- The English NHS does not implement a formal prioritisation policy
- Empirical analysis shows prioritisation by self-reported pain and immobility
- Pain is more important for prioritisation than mobility
- Hospitals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