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Waiting time prioritisation: Evidence from England

Nils Gutacker, Luigi Siciliani, Richard Cookson

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Authors:
1. Nils Gutacker
   Centre for Health Economics
   University of York

2. Luigi Siciliani
   Department of Economics and Related Studies
   University of York

3. Richard Cookson
   Centre for Health Economics
   University of York

***Corresponding author*:** Nils Gutacker, Centre for Health Economics, Alcuin A Block, University of York, Heslington, YO10 5DD. Email: nils.gutacker@york.ac.uk, Tel. +44 1904 321443, Fax +44 1904 321454

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Waiting time prioritisation - Evidence from England

Abstract

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

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

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

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

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

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

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

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

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

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

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

2 Methods

2.1 Data

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

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

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

Each PROM questionnaire includes a condition-specific and a generic instrument. The Oxford Hip or Knee Scores (OHS/OKS) are condition-specific instruments with 12 questions on joint-related functioning and pain (Dawson, Fitzpatrick, Carr, & Murray, 1996; Dawson, Fitzpatrick, Murray, & Carr, 1998). Each item is scored on a five-point scale, ranging from four (no problems) to zero (severe problems). The overall score ranges from zero (worst) to 48 (best) and is calculated by simple summation across items. For our main analysis we split this score into eleven groups, composed of twelve equally sized groups of four points each with the top two groups merged due to low numbers of patients (coded as 0-4, 5-8, 9-12, 13-16, 17-20, 21-24, 25-28, 29-32, 33-36, 37-40, 41-48). This allows for a flexible estimation of a (potentially) non-linear relationship between severity and waiting times. In further analysis we also use two sub-scores based on items relating to mobility and pain (see Appendix for how items are matched to sub-scores); again coded as groups of four points. The PROM questionnaire also includes the EQ-5D, a generic measure of HRQoL that can be applied to different health conditions (Brooks, 1996) and can be converted into utility scores using the UK general population tariff with one indicating full health and zero indicating a health state equivalent to being dead (Dolan, 1997). We focus on the Oxford scores throughout this paper because i) we expect them to be more sensitive to differences in severity as considered by the consultant than the EQ-5D, ii) we do not wish to make comparisons across conditions, and iii) their focus on pain and mobility mirrors the criteria used for prioritisation of hip replacement patients in the Canadian context (see Introduction). The correlation between the condition-specific and generic measures is high, with rho = 0.74 for OHS and the EQ-5D utility score and rho = 0.71 for OKS and EQ-5D utility score. We estimate that, on average, a 4 point increase on the pre-operative Oxford scores is associated with a utility increase of 0.114 (SE=0.0005) for both hip and knee replacement patients, adjusted for case-mix (see Appendix). To put this into context, based on the current NICE cost-effectiveness thresholds value of around £30,000 per quality-adjusted life year the NHS in England would be willing to spend up to £3,420 to allow one patient to spend a year in a 0.114 utility points (=4 OHS points) better health state (NICE, 2008).

No ethical approval was required for secondary data analysis.

2.2 Empirical analysis

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

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

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

The variable s_{ijt} is our key variable of interest. It measures severity in terms of patients' pain at rest or in movement, and their ability to move about. This information is available from a national census of all patients undergoing elective hip or knee replacement (more details are provided in the data section). The vector β_1 thus provides an estimate of the degree of waiting-time prioritisation on the list according to severity as measured by pain and immobility. We allow for the relationship between severity and waiting time to be non-linear by splitting severity into eleven bands, thus allowing for a potentially non-linear 'severity gradient' in waiting time.

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

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

All analyses were conducted in Stata version 13.

3 Results

3.1 Descriptive statistics

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

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

[Table 1 here]

[Figure 1 and Figure 2 here]

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

[Table 2 here]

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

3.2 Estimates of the severity gradient in waiting time

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

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

[Table 3 here]

[Figure 3 here]

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

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

[Table 4 here]

3.3 Different dimensions of severity: pain or mobility

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

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

[Table 5 here]

[Figure 4 here]

3.4 Hospitals with long and short waiting times

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

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

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

A similar picture arises when looking at knee replacement patients (Figure 6). Prioritisation is more pronounced in long-wait hospitals. In short-wait hospitals there are very little discernible differences between different severity groups. In high-wait hospitals, prioritisation tends to be linear and patients with lower severity wait up to about 12 days longer.

[Table 6 here]

[Figure 5 and Figure 6 here]

4 Discussion

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

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

Using data on waiting time and self-reported pre-operative health status for over 200,000 patients undergoing elective hip and knee replacement in the English NHS, we demonstrate a statistically significant, albeit modest severity gradient in waiting time. For every four points on the Oxford Hip Score (ranging from 0 (worst) to 48 (best)) we see an increase in waiting time of approximately two days. This applies across the entire range of severity. Conversely, waiting times increase by approximately 1-2 days for every four points increase on the Oxford Knee Score for knee replacement patients with pre-operative scores above 20. There is no discernible gradient among more severe patients. Prioritisation for hip and knee replacement surgery is driven primarily by the amount of pain patients receive from their joint, with less importance given to mobility.

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

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

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

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

5 Conclusions

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

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7 Tables and Figures

Table 1: Descriptive Statistics

	Hip replacement (N=190,103)		Knee replacement (N=203,080)	
Description	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

	Pre-operative health only			Pre-operative health and age/sex			Full adjustment		
Covariate	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

	Pre-operative health only			Pre-operative health and age/sex			Full adjustment		
Covariate	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.*

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

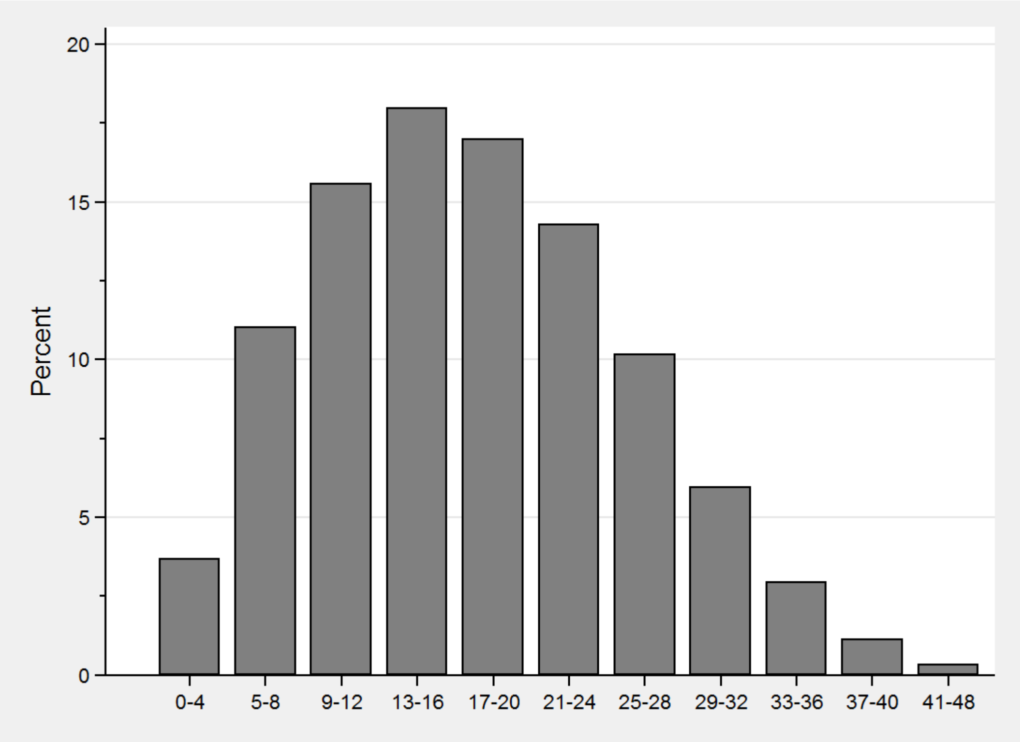


Figure 2: Distribution of pre-operative Oxford Knee Score

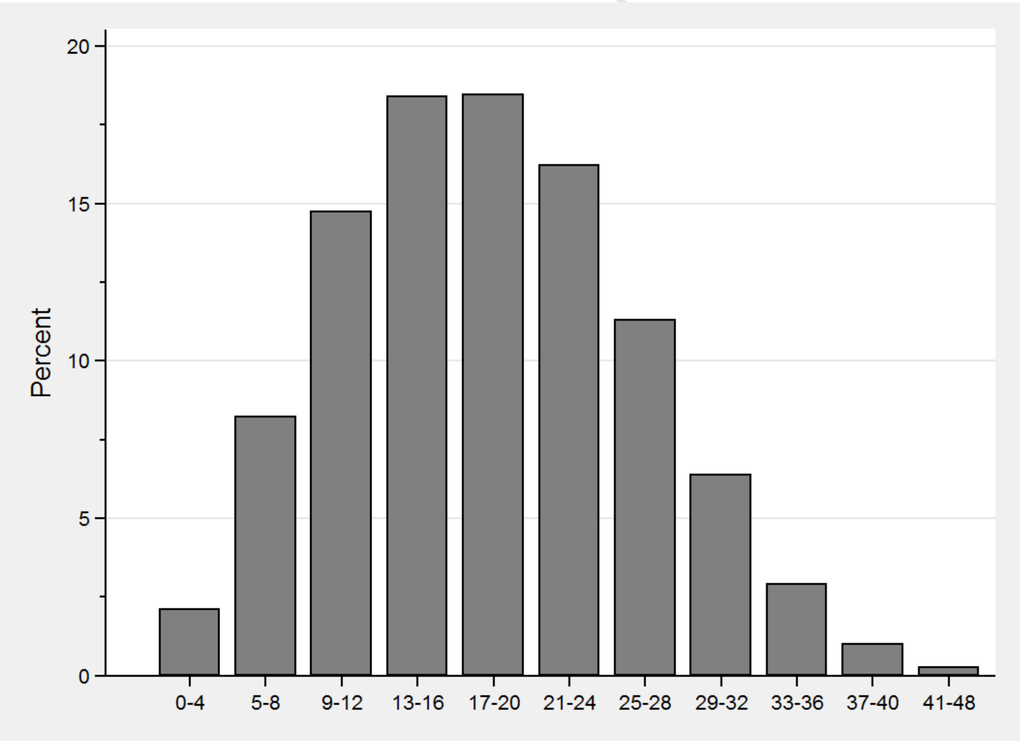


Figure 3: Partial effect of severity on waiting time

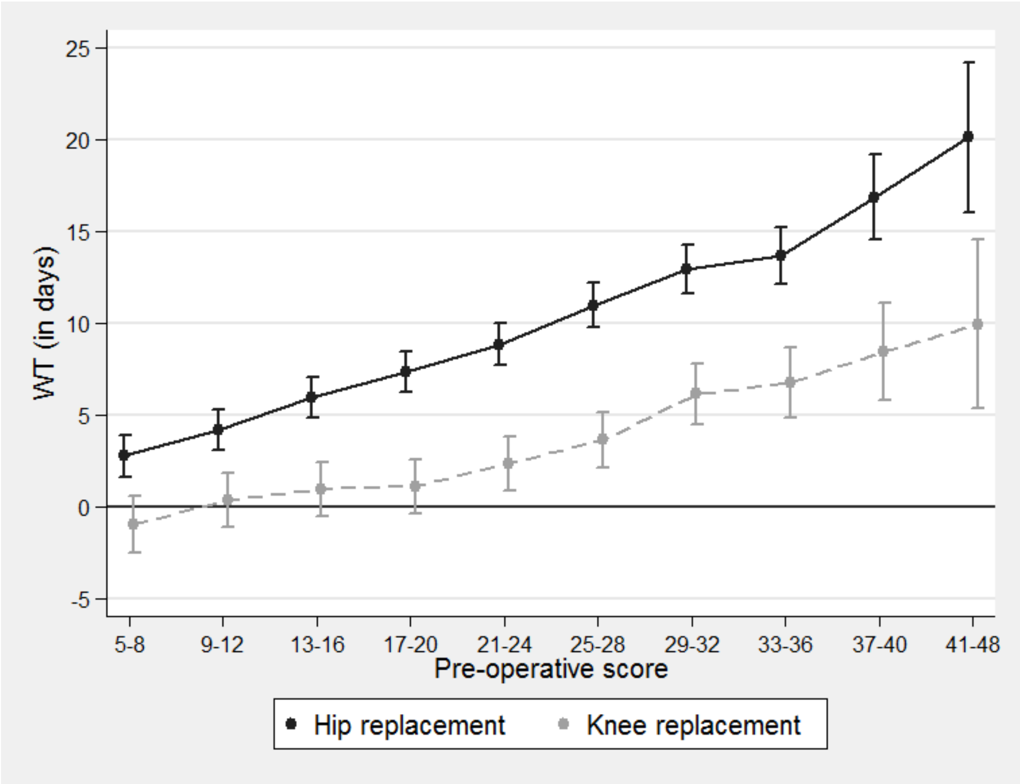


Figure 4: Differential effect of pain and mobility on waiting time

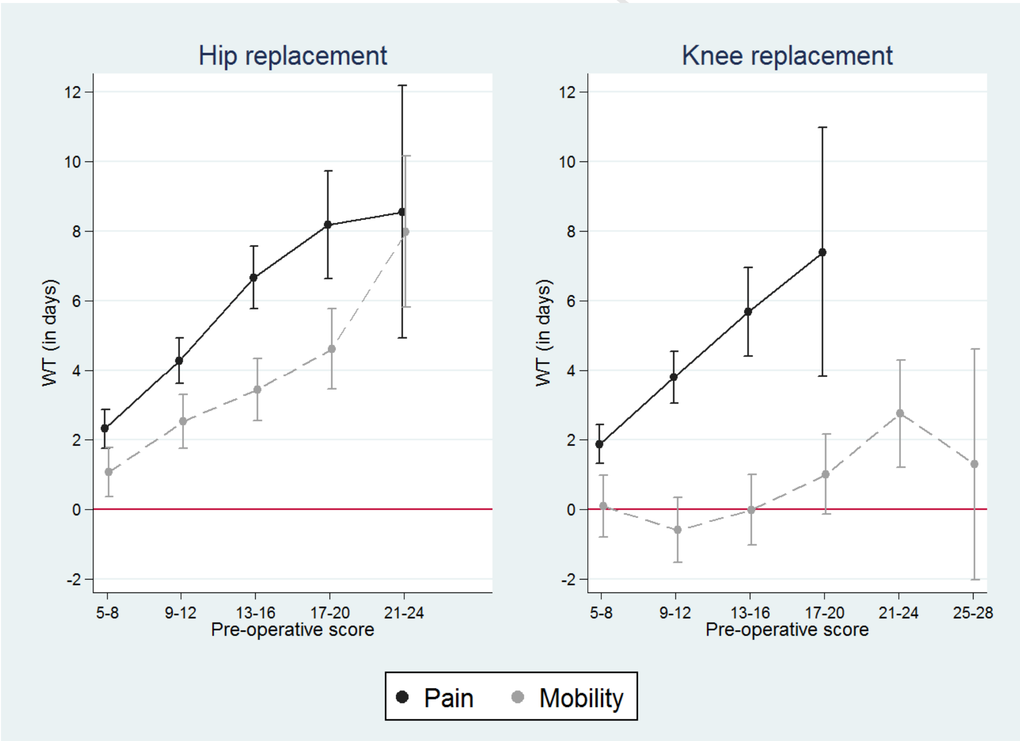


Figure 5: Partial effect of severity on waiting time in short and long wait hospitals - hip replacement surgery

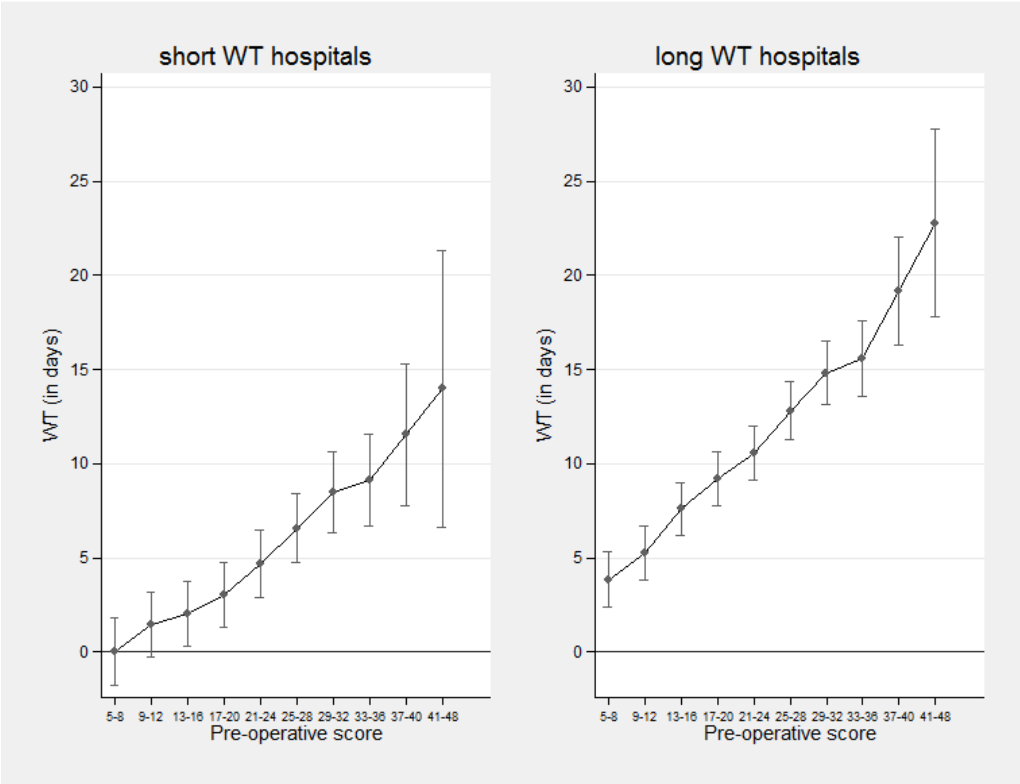
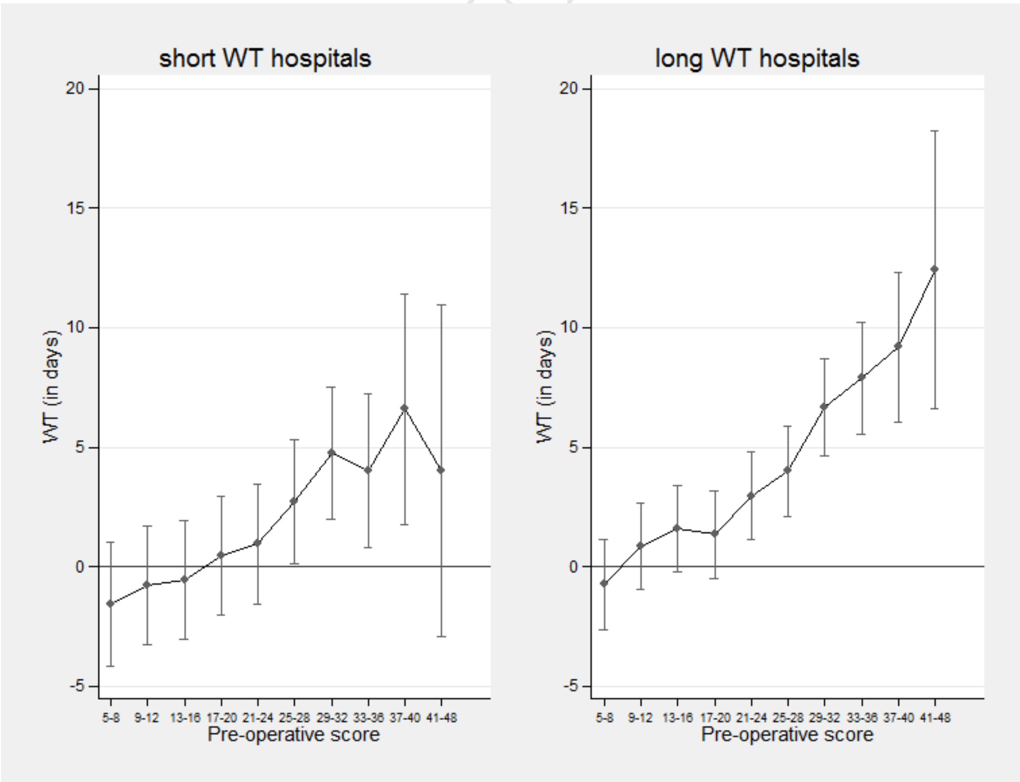


Figure 6: Partial effect of severity on waiting time in short and long wait hospitals - knee replacement surgery



8 Appendix

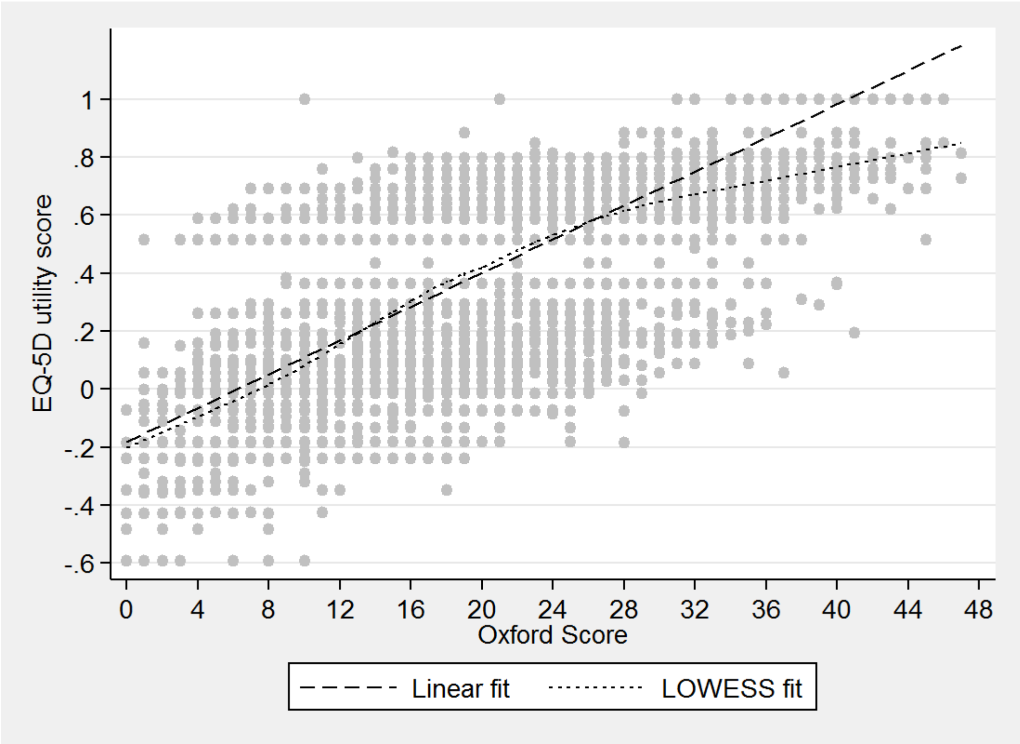
Appendix 1: Mapping of questions to sub scores - Oxford Hip Score

#	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?

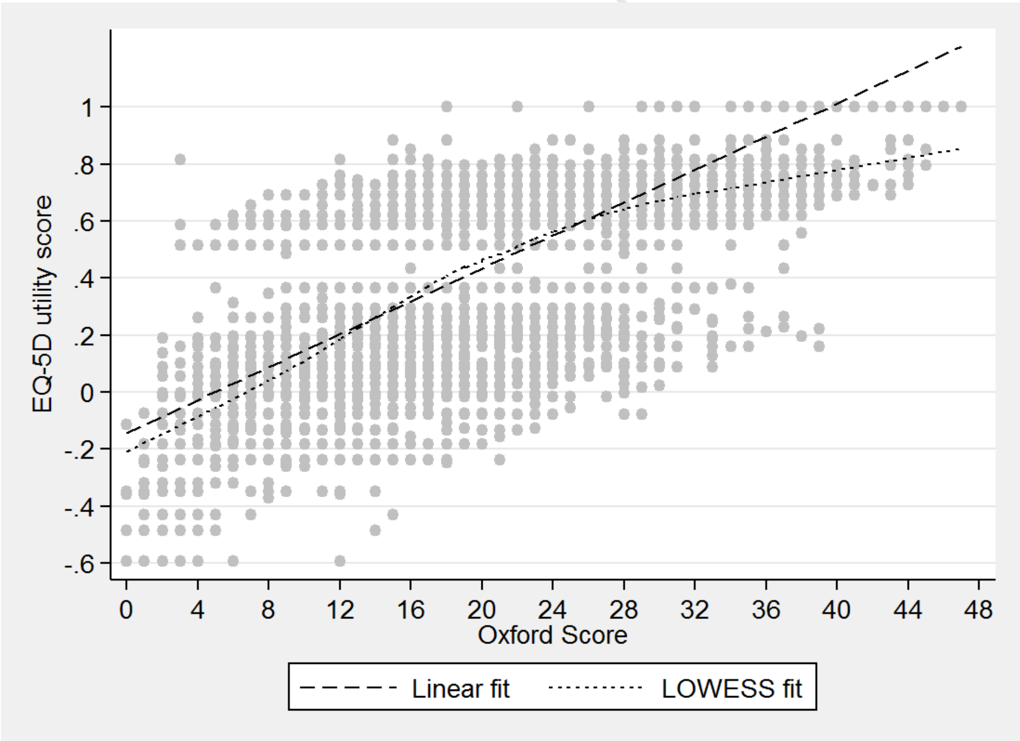
Appendix 2: Mapping of questions to sub scores - Oxford Knee Score

#	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