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Waiting Time Prioritisation: Evidence from England

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Abstract

Waiting time prioritisation policies are increasingly common amongst OECD countries. The key idea is that patients with higher severity and higher marginal disutility of waiting should be prioritised on the list and therefore wait less. There is however very little empirical evidence on the extent to which doctors prioritise patients on the list. This paper fills this gap in knowledge. We use administrative data on all hip and knee replacements patients waiting in England over the years 2009-12 and link those to data from the national patient-reported outcome measures survey in England. These data provide a unique opportunity to measure patients' severity before surgery accurately and explore the relationship between severity and waiting times. Our regression results show that patients with higher severity tend to wait less, as expected, but the degree of prioritisation is surprisingly low. We also test whether the degree of prioritisation differs between hospitals with long and short waiting times. We find that the gradient is steeper in hospitals with longer waiting times. The finding has implications for countries which have been hit by the financial crisis leading to fewer resources for their health systems and longer waiting times for elective patients.

Keywords: Waiting times; severity; prioritisation
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1 Introduction

Waiting times are a major health policy concern in several OECD countries (Siciliani et al., 2013). For many common elective procedures, such as cataract surgery and hip and knee replacements, patients have to wait weeks or months. For example, in 2012 mean waiting times for hip replacement were above 80 days in several OECD countries with considerable variations, e.g. above 150 days in Spain and about 50 days in the Netherlands (Siciliani et al., 2014). Waiting times may generate discontent amongst patients as benefits from treatment get postponed and suffering and uncertainty are prolonged (Lindsay and Feigenbaum, 1984).

In the presence of constraints on capacity combined with public health insurance and limited or zero 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 have to 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 (Martin and Smith, 1999, Martin and Smith, 2003, Iversen and Siciliani, 2011).

A number of countries have experimented with policies to reduce waiting times, either by increasing the capacity of the healthcare system, e.g. by allowing privately operated providers to treat publicly-funded patients (Naylor and Gregory, 2009), incentivising healthcare providers through maximum waiting time targets or guarantees (Propper et al., 2008b), or by managing demand more actively. These policies have shown varying degree of success (Siciliani and Hurst, 2005, Siciliani et al., 2013).

The global economic crisis has led to increasing pressure on the healthcare budgets of many OECD countries (van Gool and Pearson, 2014). With budgets either being cut or set at zero nominal growth and demand increasing due to an aging population, the shortfall of supply relative to demand is likely to increase, leading to longer waiting times. It is therefore important that the available supply of services is managed in the most appropriate way in order to maximise the welfare of the patient population requiring treatment.

Waiting time prioritisation policies are intended to improve the management of the waiting list and are common across OECD countries (Siciliani et al., 2013). The key idea is simple. Given that waiting times are an unavoidable evil, at least patients should be prioritised on the list based on their severity. Patients with higher severity have a higher marginal disutility of waiting (e.g. higher suffering), and should therefore wait less compared to patients with lower marginal disutility of waiting. From a theoretical perspective, it has been shown that such policies are generally welfare improving even in settings where severity is only partially observable since prioritisation reduces the overall deadweight loss from waiting (Gravelle and Siciliani, 2008, Gravelle and Siciliani, 2009, see also Siciliani and Iversen, 2012 for a simpler model).

Countries tend to 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 (such as Australia and Italy, which recommend different maximum waiting times based on three or four groups of patients). For example, as part of the Western Canada Waiting List project, scoring tools have been developed that integrating 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).[1] 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 detailed description of prioritization policies).[2]

Despite the great policy interest in waiting-time prioritisation, there is very limited evidence within the economics literature which investigates empirically 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, and c) whether waits reduce linearly or non-linearly with severity. Without this information it is difficult for policymakers to decide whether more efforts should be devoted

[1] As an example, patients affected by "Lens-induced glaucoma" should be treated within four weeks (urgent, 71–90 points); patients categorised as "Cataract extraction required in order to treat posterior segment disease" within 12 weeks (semi-urgent, 51–70 points); all other cataracts: (1–50 points) according to visual acuity score (max 5 points), clinical modifiers (max 5 points), severity of visual impairment (max 10 points), ability to work, give care, live independently (max 5 points), other disability (max 5 points). If patients score 21–50 they are considered "routine" and should be treated within six months. Patients scoring less than 20 are "deferrable" (Siciliani and Hurst, 2005).

[2] They were developed in co-operation between Directorate of Health and Regional Health Authorities and cover conditions within 32 main "medical chapters". These describe a selection of medical conditions, a typical patient, and a *recommendation* on maximum waiting time. It is physicians at hospitals who ultimately decide and the actual wait may therefore vary over recommendations, e.g. due to patient's age, treatment efficacy, or co-morbidities.

to further encourage prioritisation of patients on the waiting list. We aim at filling this gap in knowledge.

Most of the existing evidence is within the medical literature which relies on selected samples and generally small-scale studies. The most likely reason is that large-scale administrative databases do not contain accurate measures of severity, and comorbidity burden is only a poor proxy for general health status (Gutacker et al., 2015b). In this study, we take advantage of a new dataset containing detailed measures of patient self-reported health status collected alongside routine surgery. 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 test the extent to which more severely ill patients (as measured by the Oxford Hip and Knee Scores (OHS/OKS) which captures patients' joint-related pain and degree of mobility and autonomy) wait less. We also explore the differential role of pain and mobility on waiting time by splitting the Oxford scores into sub-components. We estimate Poisson model to allow for the discrete measure of inpatient waits (in days) and the skewed distribution of waiting times. Critically, we control for hospital fixed effects. Therefore, differences in waits across patients with different severity arise *within* the hospital rather than *across* hospitals.

Our key result is that patients with higher severity tend to wait less but the effect appears to be modest. Hip replacement patients in the top severity group (0-4 points) wait approximately 11% less than those with average severity (17-20 points), and patients with low severity (>37 points) wait at least 19% longer than those of average severity. There is heterogeneity across treatments: the gradient for patients in need of knee replacement is substantially flatter. Moreover, while both mobility and pain affect patients' wait for hip replacement patients, only pain matters for knee replacement. We also find evidence of pro-elderly inequalities, with patients over 65 years old waiting about 10% less than other patients, conditional on observed severity.

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 in the attempt to reduce the overall disutility from waiting. However, 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 in the health sector. A key focus in this literature has been the estimation of demand and supply elasticities to waiting times. These studies typically find that demand is inelastic to waiting times (with an elasticity of about -0.1) while supply elasticity estimates vary depending on study design (Martin and Smith, 1999, Martin and Smith, 2003, Martin et al., 2007, see

Iversen and Siciliani, 2011 for a review). Some studies focus on specific policy interventions such as the introduction of maximum waiting-time guarantees combined with penalties for non-compliance (e.g. Propper et al., 2008b, Dimakou et al., 2009) or the effect of competition (Siciliani and Martin, 2007, Propper et al., 2008a). Other studies focus on waiting-time inequalities by socioeconomic status. Cooper et al. (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 et al., 2012, who focus on variations in waiting times within hospitals). Similarly, Monstad et al. (2014) find that in Norway richer men and more educated women tend to wait less for hip replacement (see also Kaarboe and Carlsen, 2014). Similar evidence for Australia is provided by Sharma et al. (2013) and Johar et al. (2013).

Some recent studies from Norway focus on prioritisation. Askildsen et al. (2011) compare recommended max waiting time by medical guidelines with actual waiting times. These guidelines recommend a differential waiting time across different conditions rather than within a given condition (the focus being therefore quite different from prioritisation within a condition as we pursue in this study). They find that most severe conditions receive too low priority compared to the recommendations. The related study by Januleviciute et al. (2013) also suggests that the introduction of such guidelines had no effect on improving wait prioritisation across four major severity groups (see also Askildsen et al., 2010).

2 Methods

We estimate fixed effects Poisson regression models to relate the number of days on the waiting list w_{ij} for patient $i = 1, \dots, N$ in hospital $j = 1, \dots, J$ to observed patient characteristics and the provider of care (Cameron and Trivedi, 1998).[3] The model is specified as

$$w_{ij} = \exp(\beta_1' s_{ij} + \beta_2' x_{ij} + h_j)$$

and does not include an exposure term. Coefficient estimates are semi-elasticities. We also report average partial effects (APEs) on the untransformed scale.[4] We obtained cluster-robust Huber-White standard errors to account for potential over-dispersion (Cameron and Trivedi, 1998).

The variable s_{ij} is our key variable of interest. It measures severity in terms of patients' pain at rest or in movement, and their ability to walk. 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. We allow for the gradient to be non-linear by splitting severity into twelve bands.

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_{ij} includes the patient's age (coded as 0-44, 45-54, 55-64, 65-74, 75-84 and 85+), sex and age-

[3] 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 (Manning, 1998, Gould, 2011).

[4] The non-linear nature of the model requires evaluating APEs at the observed level of all covariates, including the overall intercept. The fixed effect (FE) Poisson estimator in Stata 13 does not include an overall intercept in the model. Instead it specifies the hospital FEs as the sum of the intercept plus the hospital-specific deviations from it. All FEs are conditioned out of the likelihood prior to estimation. In order to recover the overall intercept, we follow Cameron and Trivedi (1998, p. 281) and first calculate the hospital FEs as $\widehat{h_j} = \frac{\sum_i w_{ij}}{\sum_i \exp(\widehat{\beta_1'} s_{ij} + \widehat{\beta_2'} x_{ij})}$ and then take the average across all j, i.e. $\sum_j \widehat{h_j}$. We then use this overall intercept in the calculation of the APEs.

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 fixed effects h_j to control for differences in waiting times across hospitals which may arise from unobserved supply factors (e.g. availability of beds, nurses, doctors, infrastructure, management and organization, and quality) and unobserved regional demand factors such as overall health of the population. Hence, the coefficients on severity and other control variables are estimated from within-provider variation only.

All analyses were conducted in Stata version 13.

3 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 2012 in NHS or private providers.[5] HES contains rich information on patients' demographic and medical characteristics, small

[5] See Department of Health (2008) for procedure codes. Patients having revision surgery are likely to differ from those receiving primary surgery and are more likely to return to the hospital providing their initial surgery.

area of residence and on the hospital stay. Privately-funded patients treated in the private sector are not included in HES and are excluded from our analysis.[6]

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 et al., 1998, Gutacker et al., 2015a). 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), which we interpret as a proxy of income deprivation.[7]

We link these data to information obtained as part of the national patient-reported outcome measures (PROM) survey (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 a central agency. Participation in the PROM survey is compulsory for providers

[6] Around 11% of the English population have supplementary private insurance and 16% of hip replacement surgeries are funded privately (Commission on the Future of Health and Social Care, 2014).
[7] LSOAs have an average population of 1,500 inhabitants and are intended to be homogeneous with respect to housing tenure and accommodation type.

but optional for patients. Complete pre- and post-operative questionnaires can be linked to HES records for about 60% of patients.

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 et al., 1996, Dawson et al., 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 twelve equally sized groups of four points each (coded as 0-4, 5-8, 9-12, 13-16, 17-20, 21-24, 25-28, 29-32, 33-36, 37-40, 41-44, 45-48). 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). 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 = 0.70 for OKS and EQ-5D utility score.

4 Results

4.1 Descriptive statistics

Over the three-year period considered there have been about 104,000 publicly-funded hip replacement procedures and about 111,000 knee replacement procedures. Descriptive statistics are provided in Table 1.

For hip replacement patients, the average observed waiting time (our dependent variable) is 83 days. Patients are on average 68 years old and nearly 60% of patients are female. The average pre-operative OHS is 17.6 points. Patients had an average of 0.1 emergency admissions in the year proceeding hospital admission for an elective hip replacement. Only 65% of patients had at least one comorbid condition with only 6% reporting more than five. The average waiting time for knee replacement surgery is slightly higher than for hip replacement surgery (87 vs 83 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 one day for hip replacement patients and two 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 size and unlikely to induce bias.

[Table 2 here]

4.2 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 and year fixed effects (not reported). Differences in waiting times across patients with different severity can be interpreted as *within* the hospital, rather than *across* hospitals. 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 8 days) longer. Patients with highest severity (with a score above 37 points) wait at least 20% (16 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 over 65 years old wait about 11-14% less than patients below 45 years (and about 8-10% less than patients aged 45-54). Male patients wait 5% 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 neighbourhoods wait approximately 1.5% longer than those in the least deprived neighbourhoods.

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 25 OKS points do not differ significantly in waiting times. Patients with scores in the range of 25 to 44 wait about 4-10% longer compared to patients with a score below 25. 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, ignoring the top two groups which include very few observations and are estimated with large confidence intervals. Patients older than 75 years wait about 7% less than younger patients. There is no statistically significant difference across genders or socio-economic groups.

[Table 4 here]

4.3 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 effects of pain on prioritisation is somewhat 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]

4.4 Hospitals with long and short waiting times

We also test whether prioritisation is more pronounced when waiting times are generally longer. To do so we split the sample into two groups, hospitals with an average wait above the median and hospitals below the median.[8]

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

[8] The median hospital level waiting time is 78 days for hip replacement surgery and 80 days for knee replacement surgery.

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. Excluding the two top groups (i.e. low-severity patients with infrequent observations) less severe patients can wait up to 19 days longer than severe patients in high-wait hospitals. Conversely, less severe patients in low-wait hospitals wait only up to 10 days longer. Therefore waiting time prioritisation is more pronounced 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 10 days longer.

[Table 6 here]

[Figure 5 and Figure 6 here]

5 Discussion

The global economic crisis has had profound effects on public finances and public services. Many OECD countries are either faced with cuts to their healthcare budgets or zero nominal growth. This is likely to affect the supply of care, which can no longer keep up with the increasing demand for care. 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 small severity gradient in waiting time. For every four points on the OHS (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 OKS for patients with pre-operative scores above 24. There is no discernible gradient among more severe patients. The gradient for hip replacement surgery does not differ according to whether the patient indicates problems of mobility or pain. For knee replacement surgery pain seems to be more important than mobility.

The overall severity gradient in waiting time seems small in absolute terms. This may be because the English NHS has not adopted a formal model of prioritisation for hip and knee replacement surgery, or because average waiting times are now at a historic low so that prioritisation is considered less important by hospital specialists.

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 than hospitals with below median waiting times. 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, we cannot rule out that our measure of severity is imperfect and that these variables capture some unobserved component of severity.

6 Conclusions

There is modest prioritisation for elective hip and knee replacement according to patients' severity in the English NHS. The size of the gradient implies that clinicians managing the waiting list either believe that the marginal disutility of waiting for surgery does not vary significantly 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 severe patients wait less. Following initiatives in other OECD countries, the English NHS and other healthcare systems faced with increasing excess demand for elective surgery should put more emphasis in encouraging further prioritisation on the list.

We conclude with some 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 review of the medical literature found no evidence of deterioration during reasonable long waiting-time periods (up to six months; see Hoogeboom et al. (2009)). Therefore, we do not expect this to be a serious concern. Second, not all patients respond to the PROM questionnaire, which may give rise to selection bias. However, such bias is likely to be small as we find only very small difference in the average waiting time for responders and non-responders.

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8 Tables and Figures

Table 1: Descriptive Statistics

	Hip replacement (N=103,518)		Knee replacement (N=110,844)	
Description	Mean	SD	Mean	SD
Waiting time (in days)	83.1	49.6	87.1	52.6
Pre-operative Oxford Score	17.6	8.3	18.4	7.8
Age	67.6	11.2	69.2	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	0.5	0.10	0.5
Number of Elixhauser comorbidities: 0	0.35	0.5	0.28	0.4
Number of Elixhauser comorbidities: 1	0.29	0.5	0.28	0.4
Number of Elixhauser comorbidities: 2	0.18	0.4	0.21	0.4
Number of Elixhauser comorbidities: 3-4	0.12	0.3	0.15	0.4
Number of Elixhauser comorbidities: 5+	0.06	0.2	0.08	0.3
FY 2009/10	0.28	0.4	0.29	0.5
FY 2010/11	0.35	0.5	0.34	0.5
FY 2011/12	0.37	0.5	0.37	0.5

Table 2: Comparison of responders and non-responders

	Hip replacement				Knee replacement			
	Responders (N=103,518)		Non-responders (N=72,339)		Responders (N=110,844)		Non-responders (N=83,275)	
Variable	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Waiting time	83.11	49.6	84.19	54.7	87.14	52.6	89.13	57.8
Age	67.59	11.2	68.67	11.7	69.16	9.3	70.12	9.5
Gender (0=female, 1=male)	0.41	0.5	0.39	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	1.55	3.0	1.76	3.6	1.79	3.2	1.95	4.1
Number of emergency admissions in last 365 days	0.11	0.5	0.15	0.5	0.10	0.5	0.13	0.5

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	0.050	0.011	***	0.047	0.011	***	0.047	0.011	***
Pre-operative score: 9-12	0.068	0.010	***	0.065	0.010	***	0.065	0.010	***
Pre-operative score: 13-16	0.084	0.011	***	0.080	0.011	***	0.081	0.011	***
Pre-operative score: 17-20	0.095	0.012	***	0.092	0.011	***	0.095	0.011	***
Pre-operative score: 21-24	0.112	0.012	***	0.109	0.012	***	0.111	0.012	***
Pre-operative score: 25-28	0.139	0.012	***	0.136	0.012	***	0.139	0.012	***
Pre-operative score: 29-32	0.161	0.013	***	0.161	0.013	***	0.165	0.013	***
Pre-operative score: 33-36	0.170	0.015	***	0.168	0.014	***	0.172	0.015	***
Pre-operative score: 37-40	0.192	0.017	***	0.191	0.017	***	0.197	0.017	***
Pre-operative score: 41-44	0.213	0.033	***	0.212	0.033	***	0.217	0.033	***
Pre-operative score: 45-48	0.273	0.084	**	0.276	0.084	**	0.285	0.084	***
Age: 45-54				-0.032	0.016	*	-0.034	0.016	*
Age: 55-64				-0.078	0.016	***	-0.080	0.016	***
Age: 65-74				-0.110	0.016	***	-0.114	0.016	***
Age: 75-84				-0.133	0.017	***	-0.138	0.017	***
Age: 85+				-0.137	0.019	***	-0.141	0.019	***
Male				-0.045	0.019	*	-0.047	0.019	*
Number of emergency admissions in last 365 days							-0.017	0.006	**
SES (2nd quintile)							0.000	0.005	
SES (3rd quintile)							0.007	0.006	
SES (4th quintile)							0.015	0.006	*
SES (5th quintile - most deprived)							0.015	0.006	*
N	103,518			103,518			103,518		

Note: Estimates are semi-elasticities and relative to patient aged <44, female, and pre-operative Oxford score of 0-4. All models include hospital and 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	-0.015	0.014		-0.015	0.014		-0.014	0.014	
Pre-operative score: 9-12	-0.004	0.014		-0.002	0.014		-0.002	0.014	
Pre-operative score: 13-16	-0.003	0.015		0.001	0.015		0.003	0.015	
Pre-operative score: 17-20	-0.001	0.014		0.005	0.014		0.007	0.014	
Pre-operative score: 21-24	0.011	0.015		0.019	0.015		0.022	0.015	
Pre-operative score: 25-28	0.026	0.015		0.037	0.015	*	0.040	0.016	**
Pre-operative score: 29-32	0.045	0.015	**	0.057	0.015	***	0.061	0.015	***
Pre-operative score: 33-36	0.053	0.018	**	0.068	0.019	***	0.072	0.019	***
Pre-operative score: 37-40	0.081	0.023	***	0.098	0.023	***	0.101	0.023	***
Pre-operative score: 41-44	0.072	0.033	*	0.088	0.034	**	0.091	0.034	**
Pre-operative score: 45-48	0.073	0.069		0.089	0.070		0.088	0.070	
Age: 45-54				0.003	0.028		-0.001	0.028	
Age: 55-64				-0.004	0.028		-0.009	0.028	
Age: 65-74				-0.048	0.028		-0.054	0.028	
Age: 75-84				-0.068	0.029	*	-0.075	0.029	**
Age: 85+				-0.065	0.029	*	-0.070	0.029	*
Male				-0.005	0.041		-0.004	0.041	
Number of emergency admissions in last 365 days							-0.013	0.004	***
SES (2nd quintile)							-0.001	0.005	
SES (3rd quintile)							-0.006	0.005	
SES (4th quintile)							-0.007	0.006	
SES (5th quintile - most deprived)							0.000	0.006	
N	110,844			110,844			110,844		

Note: Estimates are semi-elasticities and relative to patient aged <44, female, and pre-operative Oxford score of 0-4. All models include hospital and 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			Mobility			Pain			Mobility		
Covariate	Est	SE		Est	SE		Est	SE		Est	SE	
Pre-operative score: 5-8	0.027	0.005	***	0.019	0.006	**	0.015	0.004	***	-0.003	0.008	
Pre-operative score: 9-12	0.050	0.006	***	0.031	0.007	***	0.037	0.007	***	-0.011	0.009	
Pre-operative score: 13-16	0.082	0.008	***	0.039	0.008	***	0.059	0.011	***	0.005	0.010	
Pre-operative score: 17-20	0.097	0.012	***	0.059	0.011	***	0.119	0.029	***	0.014	0.011	
Pre-operative score: 21-24	0.083	0.025	***	0.078	0.018	***				0.029	0.013	*
Pre-operative score: 25-28										-0.003	0.029	
N	103,518						110,844					

Note: Estimates are semi-elasticities and relative to pre-operative score of 0-4. All models include hospital and 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	0.042	0.025		0.048	0.012	***	-0.043	0.030		-0.008	0.016	
Pre-operative score: 9-12	0.056	0.021	**	0.068	0.011	***	-0.033	0.033		0.005	0.015	
Pre-operative score: 13-16	0.073	0.021	***	0.083	0.012	***	-0.051	0.032		0.016	0.017	
Pre-operative score: 17-20	0.096	0.023	***	0.094	0.013	***	-0.031	0.030		0.016	0.016	
Pre-operative score: 21-24	0.127	0.024	***	0.107	0.013	***	-0.013	0.030		0.030	0.017	
Pre-operative score: 25-28	0.153	0.026	***	0.136	0.013	***	0.030	0.034		0.041	0.017	*
Pre-operative score: 29-32	0.199	0.031	***	0.157	0.014	***	0.033	0.035		0.066	0.016	***
Pre-operative score: 33-36	0.193	0.038	***	0.168	0.016	***	0.057	0.040		0.073	0.021	***
Pre-operative score: 37-40	0.161	0.047	***	0.203	0.018	***	0.101	0.044	*	0.099	0.027	***
Pre-operative score: 41-44	0.314	0.126	*	0.202	0.031	***	0.069	0.091		0.093	0.035	**
Pre-operative score: 45-48	0.808	0.448		0.226	0.067	***	-0.251	0.214		0.129	0.074	
N	30,373			73,145			35,151			75,693		

Note: Estimates are semi-elasticities and relative to pre-operative Oxford score of 0-4. All models include hospital and 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

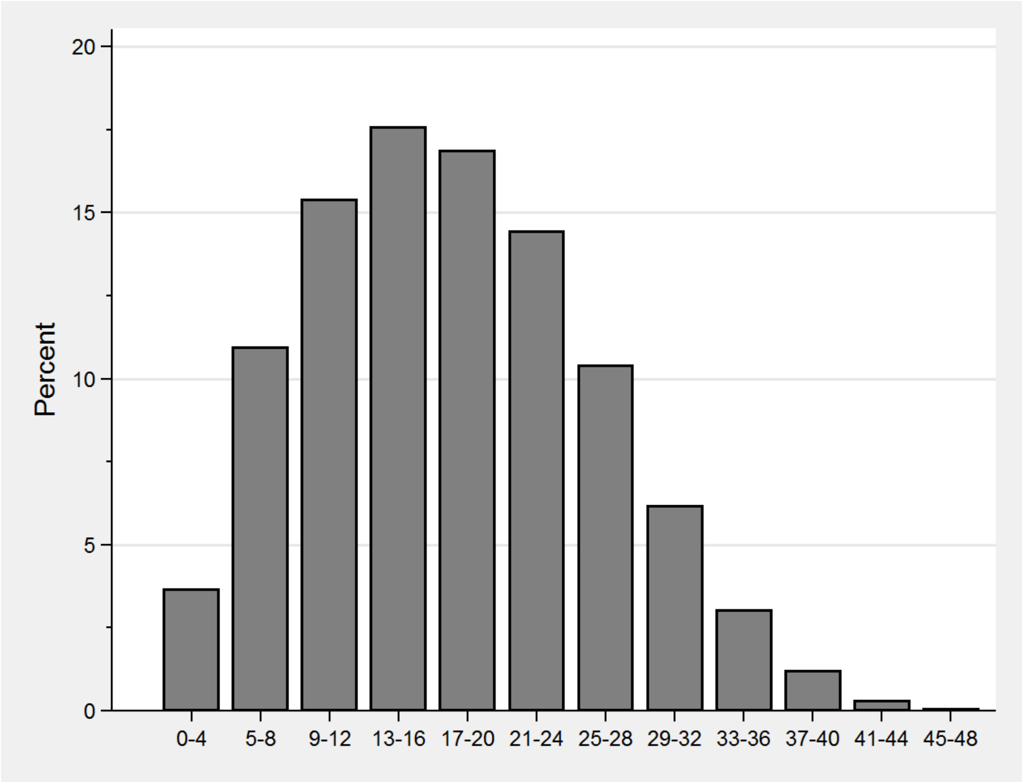


Figure 2: Distribution of pre-operative Oxford Knee Score

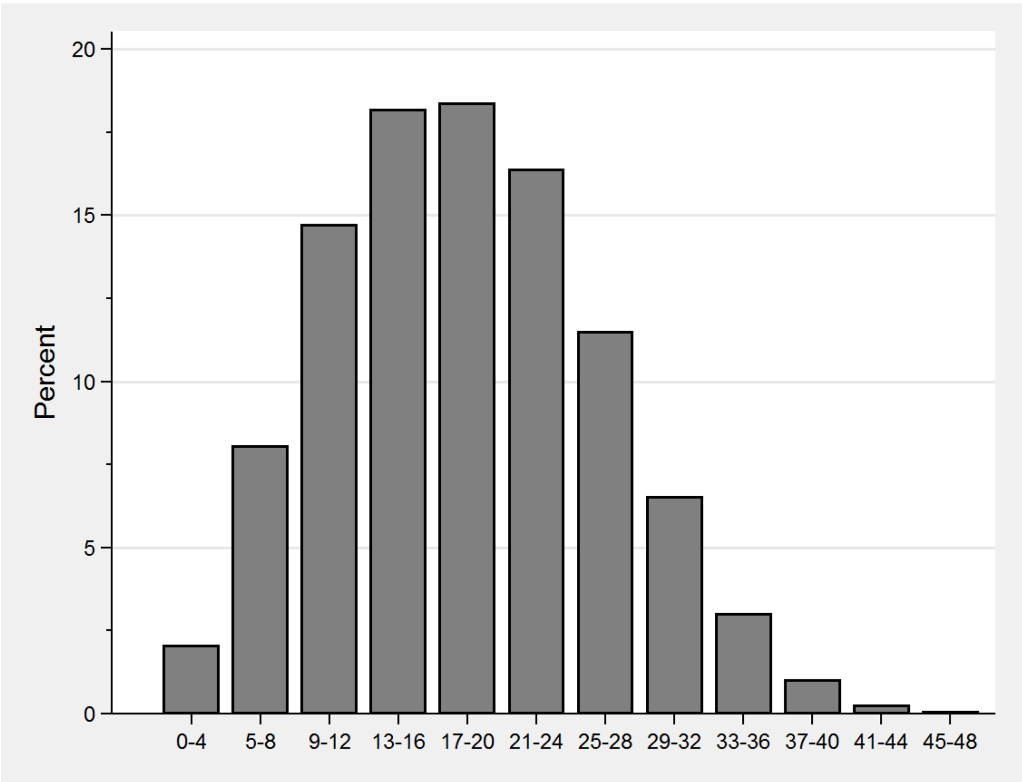


Figure 3: Partial effect of severity on waiting time

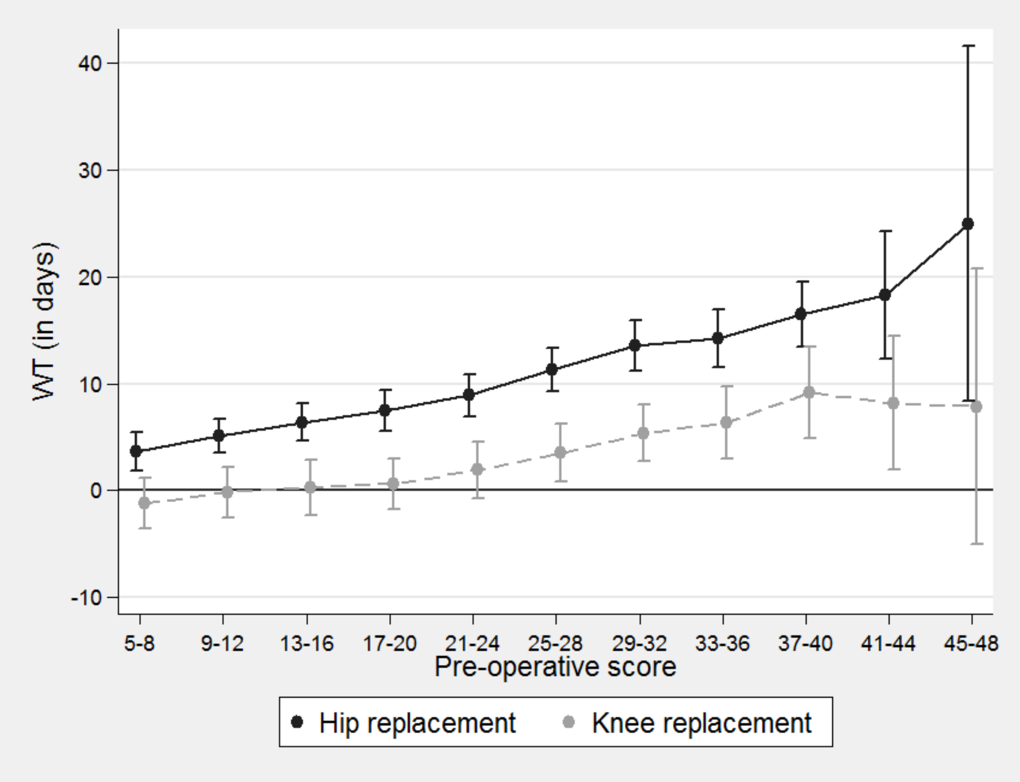


Figure 4: Differential effect of pain and mobility on waiting time

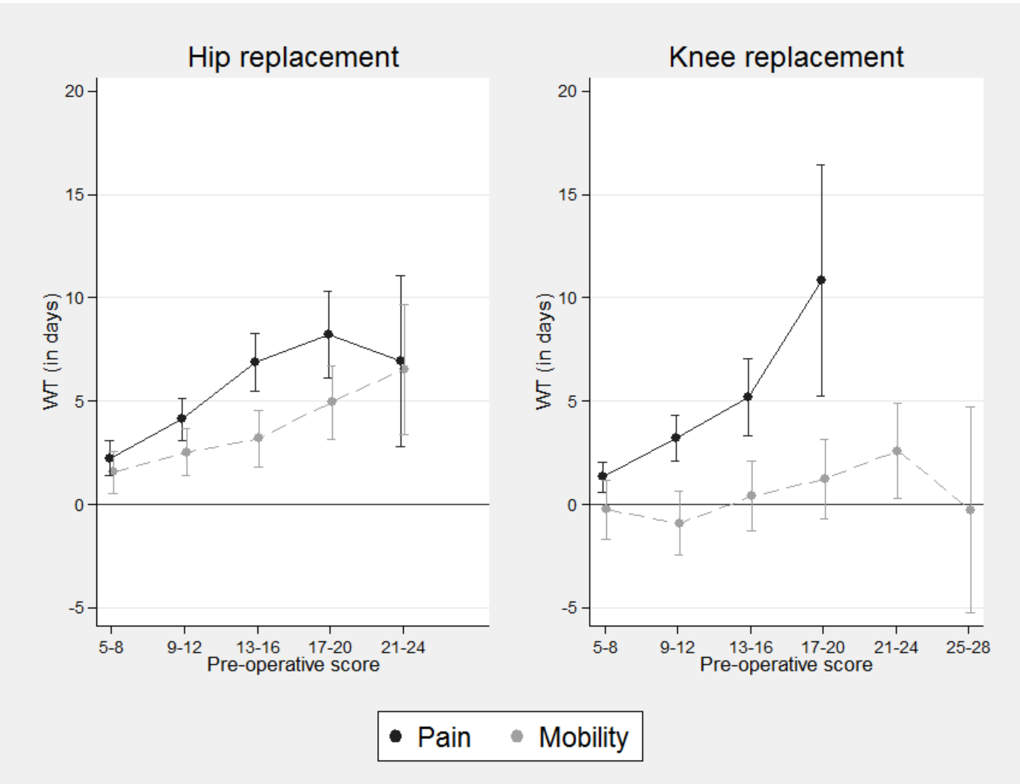


Figure 5: Partial effect of severity on waiting time in short and long wait hospitals - hip replacement surgery

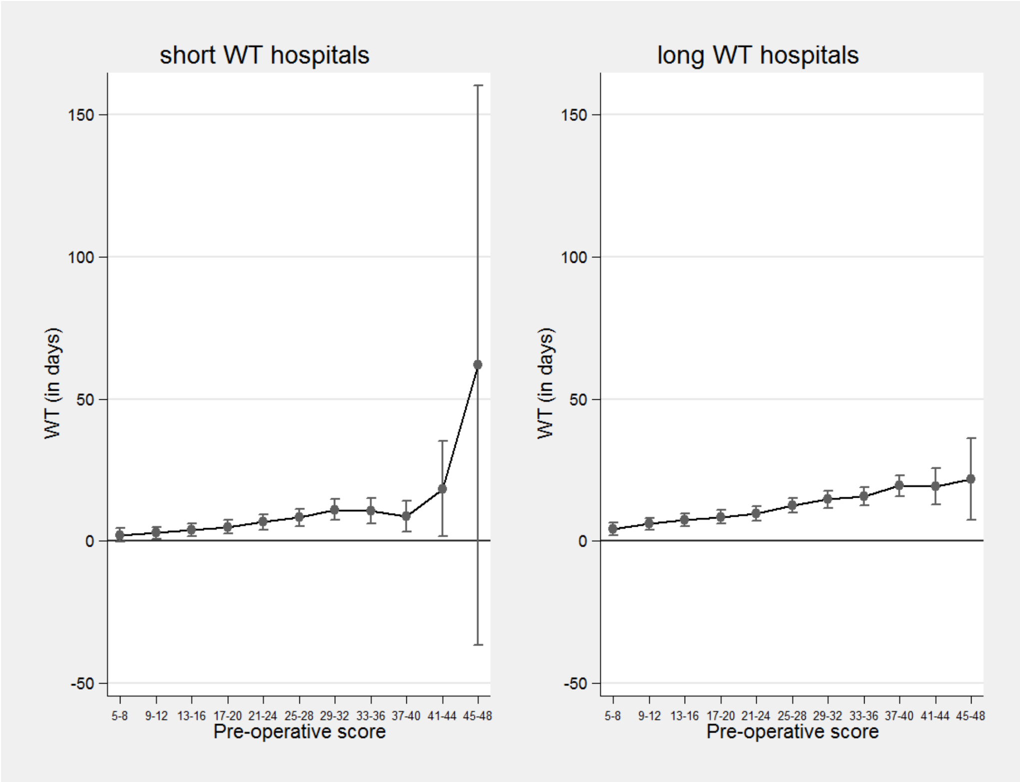
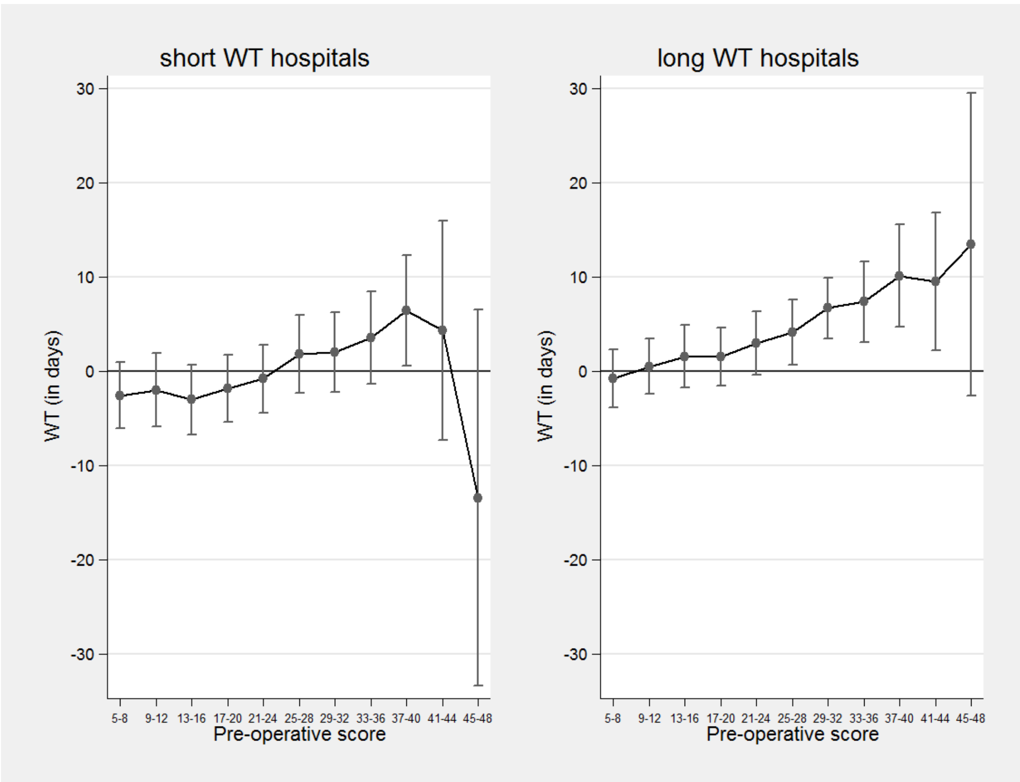


Figure 6: Partial effect of severity on waiting time in short and long wait hospitals - knee replacement surgery



9 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?