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Does waiting time influence the effectiveness of surgery? Evidence from the national PROMs dataset

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Reducing waiting times for treatment has been a major focus of the NHS over the last ten years. Little is known about the effects on health prior to surgery and on the effectiveness of surgical intervention. The collection of data on Patient Reported Outcome Measures for all patients undergoing four procedures facilitates analysis of the impact of waiting times on patient outcomes on a large and representative sample of patients. The availability of PROMs before and after surgery allows us to estimate the impact of waiting times on the effectiveness of treatment, conditioning on the effect of waiting time on health deterioration prior to surgery and the endogeneity of waiting times caused by prioritisation with respect to pre-intervention health. We estimate the effect of waiting times on the effectiveness of hip replacement and varicose vein surgery. After controlling for a broad set of observed patient characteristics and hospital effects, we find that waiting times for hip replacement have negative and statistically significant effects on the health gain. This impact is also seen in patients' changes in self-assessed health and perceptions of the effectiveness of treatment. For two generic and one condition-specific outcome measures, the average magnitude of this effect at patient level is a small (0.1% of the outcome measure range) decline in health gain for an additional one-week wait. However, since patients waited one week longer on average in 2010 than in 2009, this deterioration in NHS performance has a population health impact.

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Background

Waiting times are a significant source of dissatisfaction of the UK population with the NHS. Reducing the maximum waiting time was a policy priority for the New Labour government in the early-2000s. Through a "targets and terror" regime, the government reduced the length of time waited by the longest waiters throughout the last decade. Maximum waiting times were reduced from over 18 months to 18 weeks with little evidence of negative side-effects (Propper et al, 2010).

Propper (1995) estimated the disutility of time spent on a waiting list to be £50 per patient per month at 1991 prices. Waiting for treatment can be associated with a loss of social welfare for three reasons (Cullis *et al.* 2000; Koopmanschap *et al.* 2005). First, because of time preference, benefits received now are worth more than those received later. Second, individuals on a waiting list can be expected to be in less good health whilst on the waiting list than after treatment. Third, waiting for treatment can affect the effectiveness or health gain of an intervention such as surgery.

There may be cases in which potential benefits of treatment quickly fall to zero during a waiting period if the health status is acute and the body is able to recover spontaneously. In other situations when spontaneous recovery will not occur or health does not remain stable, the benefit may be expected to fall as treatment is delayed, representing the discounted benefits of treatment (Cullis *et al.* 2000). In the interim period of waiting, the health-related quality of life (HRQoL) of the individual may remain stable (or the disease stabilised) or HRQoL may deteriorate, and any effect of waiting may be reversible or irreversible and/or prolong post-intervention recovery (Koopmanschap *et al.* 2005).

The impact of these different scenarios on the effectiveness of treatment varies. Where HRQoL is stable, or deterioration in HRQoL is reversible (for example: top left, figure 1) waiting for treatment is associated with some loss in HRQoL (extended time in temporary sub-optimal health state) and potentially extended time incurring higher costs, therefore the longer the wait, the lower the cost-effectiveness of the treatment. If the wait also prolongs the recovery and rehabilitation time (for example: top right, figure 1) then this impact on cost-effectiveness is compounded. Where the reduction in HRQoL whilst on a waiting list is fully or partly irreversible (for example: bottom panels of figure 1), the reduction in HRQoL (and potentially higher costs) will be maintained, reducing the effectiveness of the intervention (Koopmanschap *et al.* 2005).

Since 2009, providers of elective surgery funded by the NHS in England have been required to collect and submit Patient Reported Outcome Measures (PROMs) for patients undergoing four large-volume procedures, hip replacement, knee replacement, inguinal hernia, and varicose veins. This large and rich dataset has the potential to provide new evidence on how waiting times affect outcomes. In this

paper we consider the effects of waiting on health gain for two large-volume surgical procedures, hip replacement and varicose vein surgery.

The existing evidence of the impact of waiting time on health outcomes is mixed for these two procedures. Studies have considered different waiting times and different effects of waiting times on pre-surgery or post-surgery health. Health can be measured when patients are placed on the waiting list, at admission, or following surgery. Waiting times can be measured between GP referral and specialist assessment and/or between specialist decision to treat and receipt of treatment.

Evidence from randomised controlled trials suggests that longer waiting times are not associated with either poorer health status at admission or poorer post-operative outcomes. An early trial in rheumatology assessed the impact of randomisation to a fast-track appointment compared with usual waiting time for non-urgent appointments (Hurst *et al.* 2000). The results of the trial suggested that longer waiting times were not associated with poorer patient-reported pain (VAS), depression (HAD), or health-related quality of life (SF-12 PCS/MCS, EQ-5D) at the time of intervention. However, although outcomes were similar, equal outcomes at follow ups scheduled for one month post appointment suggest that it is possible that the patients randomised to fast-track appointments may receive earlier benefit. No difference between trial arms was seen at 15 months post referral, and patients in both arms experienced significant and similar improvement. The authors conclude that rationing by delay did not lead to poorer mental or physical health outcomes. The authors at this stage believed that this study was the only randomized controlled trial to have explicitly tested the impact of waiting on health.

A subsequent randomised controlled trial of 395 people with osteoarthritis from 3 hospitals in Finland awaiting hip replacement patients found no difference in health status at admission between patients randomised to a waiting list of <3 months compared with those on a non-fixed waiting time list (28% waited 3-6 months, 57% waited >6 months) (Hirvonen *et al.* 2009). Patients completed outcome measures at the time of placing on the waiting list and at hospital admission and neither generic nor disease-specific measures indicated that a longer waiting time was associated with poorer health status at admission. There were a number of methodological weaknesses with this trial. Firstly 108 (21%) of eligible participants were excluded from the trial for refusing consent, limiting the generalizability of results. 53 participants had waiting times which exceeded 3 months although intention-to-treat and per-protocol analyses found consistent results. Conversely, 15% of participants in the standard waiting list group waited less than 3 months which would reduce the difference between the two groups. A similar randomised controlled trial in the same setting by the same group using people with osteoarthritis awaiting knee replacement also found no difference in health status at admission date between those with a short wait (mean 95 days, s.d. 81) and those with a longer wait (mean 239 days, s.d. 135) (Tuominen *et al.* 2010). Interestingly, those in the longer waiting arm experienced a

significantly greater gain in 15-D score from surgery one year post-operatively. This trial was subject to similar limitations as its total hip replacement predecessor.

Observational studies suggest negative effects of waiting on patient outcomes, particularly for long waits of 6 months or more, in joint replacement in terms of health status at admission. In turn, poorer health status at admission is associated with poorer post-operative health status. Although some studies find that the health gain is similar or greater in those with poorer health status, it appears that these health gains do not equate to comparable post-operative health status and therefore may represent an irreversible deficit. A review of nine studies by the Western Canada Waiting List Investigators reported that some evidence links waiting for more than 6 months with deterioration in functional health status pre-treatment and that poorer pre-operative functional health status is predictive of poorer post-operative health status (Noseworthy *et al.* 2005). These investigators also reported that very long waits (longer than 12 months) were associated with poorer post-operative outcomes. One of the studies reviewed, Hajat et al., used an observational study to explore the outcomes of over 5000 patients undergoing total hip replacement in the UK (Hajat *et al.* 2002). The study used self-reported waiting time for the operation and found that 3- and 12 month post-operative outcomes indicated that those that started with a poorer OHS (Oxford Hip Score) had larger improvements but the level of OHS remained poorer. Pre-operative OHS scores deteriorated with the length of outpatient wait. Outpatient waiting time had a significant and independent (of age, gender, ASA score, housing status, grade of surgeon, inpatient wait) association with poorer outcome; this appeared to be clinically significant for waits of 12 months or more. The results of the review by the Western Canada Waiting List Investigators in joint replacement were supported by similar findings by a group reviewing the effects of waiting times on outcomes for the treatment of chronic pain (Lynch *et al.* 2008).

Since the Western Canada Waiting List Investigators reported the results of their review, further evidence consistent with their findings has emerged. A prospective study of 201 patients undergoing total hip replacement in a single Vancouver hospital reported decreases in the odds of a better than expected outcome (based on analysis of the expected outcome for a given individual preoperative WOMAC function score) of 8% per month and 50% for waits of 6 months or more (Garbuz *et al.* 2006). All post-operative WOMAC outcome scales were strongly associated with pre-operative scores. No association was found between waiting and pain or stiffness outcomes. Escobar and colleagues, however, in a study of 983 consecutive patients at a single centre in Spain, found no difference in health gains (WOMAC) at 6 months according to waiting time (Escobar *et al.* 2009).

The evidence of the impact on waiting times on pre- and post-operative health status in elective general surgery settings such as varicose veins is sparse. Reports from observational studies suggest that objective measurements of severity and anxiety increase with waiting times (again these are long

waits), however self-reported HRQoL did not appear to deteriorate. Epidemiological evidence suggests that statistically significant deterioration, measured by objective clinical assessment tools such as ultrasound scanning, occurred in patients who had waited for a median of 20 months for surgery (Sarin *et al.* 1993). However, this study did not collect any patient reported outcomes; therefore it is not clear whether this clinical deterioration impacted on health status or health-related quality of life. A subsequent study explored the impact of waiting for elective surgery on general health perception questionnaire (GHPQ), HRQoL (EQ-5D), emotional and anxiety outcomes (State-Trait Anxiety Inventory), and post-operative outcomes using varicose veins, inguinal hernia, and gallstones as exemplars (Oudhoff *et al.* 2007). The study used a cross-sectional design of 505 patients from 27 hospitals in the Netherlands to assess pre-operative health status and 90 day post-operative outcomes. The study found no association between the length of waiting time (median wait: 170 days for varicose veins, 115 for inguinal hernia, 111 for gallstones) and general health perception or HRQoL outcomes, although anxiety was higher in those who had waited longer for inguinal hernia surgery. All three types of surgery were associated with gains in general health perception, the largest for those undergoing gallstone surgeries. The findings suggest that waiting prolongs the time spent in sub-optimal health but no strong effect of waiting on outcomes post-treatment.

By using a large database on all elective hip replacement procedures and varicose veins in England, our analysis improves upon the previous literature by allowing us to control for a broad set of covariates which may affect waiting times and/or health outcomes. We focus our interest on the two generic measures of health, the EQ-5D index and EQ-VAS, and one disease-specific metric: the Oxford Hip Score for hip replacement and Aberdeen Varicose Vein for varicose veins surgery. We also examine reported satisfaction with the procedure post-surgery, patient perceptions of the success of the intervention, and self-assessed general health.

Data and preliminary evidence

This paper analyses Patient Reported Outcomes Measures (PROMs) data from the Hospital Episode Statistics (HES) database, which contains standardized information from all hospital admissions in the English NHS. The Patient Reported Outcome Measures (PROMs) are patient-level data collected from all providers of NHS-funded care for four large-volume procedures: hip replacement, knee replacement, hernia repair, and varicose veins. The data have been collected since the 1st April 2009. Patients are surveyed before and after surgery, using paper-based self-completion questionnaires. The pre- and post-surgery questionnaires collect information on generic health measures (EQ5D-3L (referred to hereafter as EQ-5D), EQ-VAS, self-assessed health) and disease specific measures (the Oxford Hip Score (OHS) or Aberdeen Varicose Vein Questionnaire (AVQQ)). The post-surgery

questionnaire also collects information on patient satisfaction with the procedure and their perception of success of the intervention.

The EQ-5D questionnaire asks patients to classify themselves as having one of three levels of health in each of five dimensions of health – mobility, self-care, usual activities (all three scored as no problems/some problems/unable), pain/discomfort and anxiety/depression (both scored as no/moderate/extreme). This results in an EQ-5D health profile for a patient. A preference-based societal utility estimate can also be assigned to the EQ5D profile (Dolan, 1997), known as the EQ-5D index. The PROMs initiative also collects information on the visual analogue scale, the EQ-VAS, which records each patient's overall assessment of their health on a scale from 100 (best imaginable health) to 0 (worst imaginable health) and patient's self-assessed health: "In general would you say your health is...", with response categories from "Poor" to "Excellent".

The PROMs database offers a very large sample size of patients containing information on health (frequency and duration of symptoms; previous surgery, disability, pre-existing conditions, disease-specific and generic measures of self-reported health) and socio-demographic characteristics (age, sex, and income and educational deprivation based on the respondent's postcode).

The sample we analyse contains patients admitted for treatment between April 1, 2009 and November 1, 2010. We keep only observations for which the status of the post-surgery instrument is complete[1] (40% of all hip replacement and 55% of all varicose veins records). We further eliminate a small number of observations with duplicate episode identifiers (63 hip replacement observations and 9 varicose veins) and 1.5% of the sample with waiting times longer than 30 weeks. While the delay between date of admission to hospital and surgery date is not always trivial (median – 0 days, mean - 3 days), we choose to focus on the relationship between the wait that elapses between hospital consultant's decision to treat and the date of admission. We augment the database by adding two continuous measures of income and education/skills from the Index of Multiple Deprivation. These are measured for lower-level super output areas (LSOAs) and are attached to patients on the basis of their area of residence. The income deprivation measure represents the proportion of the population receiving State benefits on the grounds of low income. The education measure is a composite of educational attainment from Key Stage 2 to higher education in children and young people and the prevalence of formal educational qualifications in the working-age population.

The restrictions yielded a sample of 24,580 observations. The summary statistics of our analytical samples are shown in table 1. Of all patients admitted to hospital for elective hip replacement, 9% had previously had hip replacement surgery. The average age of patients undergoing hip-replacement surgery was 68.5 years and most were female (61%). Two-thirds of patients had had problems with

[1] The status of the record is complete if both questionnaires 1 and 2 have been completed.

the hip on which they are having the surgery for 1-5 years. 71% of all patients have arthritis and 39% have some type of disability. The two most prevalent health problems were high blood pressure (40% of the patients) followed by heart disease (10%). The majority of patients in the sample reported no problems or some problems with self-care (99%) and no or moderate anxiety/depression (95%). However, 93% of the patients had some problems with mobility, 75% had some problems performing their usual activities, 19% were unable to perform their usual activities, and 99% reported moderate or extreme pain. Most patients were living with a significant other, friends, or family (73%). The average patient lives in an area in which 12% of the population receives state benefits on the grounds of low income.

On average, patients completed the pre-operative questionnaire 27 days (3.8 weeks) before surgery and completed the post-operative questionnaire within 200 days (28 weeks)[2]. Patients, on average, waited 80 days (11.26 weeks) for treatment. Figure 2 shows the distributions of waiting times in 2009 and 2010. In 2009, 86% of the patients receive hip replacement surgery within 18 weeks. This had fallen to 81% by 2010. The mean waiting time in 2009 was also lower than the mean waiting time in 2010 (76.6 days versus 83.8 days).

The satisfaction and health perception outcome measures point to improvement in patient reported health. Approximately 95% of the patients thought that their hip problems were better following the surgery. Approximately 90% assessed the results of the surgery as "good", "very good", or "excellent". In the pre-surgery period 34% of patients ranked their health as excellent or very good, post-surgery the share of these patients increased to 50%.

Figure 3 shows mean pre-surgery and post-surgery Oxford Hip Scores as a function of the time spent on the waiting list in weeks. Patients that had waited longer were in better pre-surgery health and report smaller changes in health. The patterns for the EQ-5D index and EQ-VAS measures are similar (figures available upon request). Figure 4 plots the 10^{th}, 25^{th}, 50^{th}, 75^{th}, and 90^{th} percentiles of the pre-surgery Oxford Hip Score and the change as a function of the time spent waiting for surgery.

The descriptive evidence in Figures 3 and 4 does not control for any potentially confounding covariates, such as frequency and duration of symptoms, previous surgery, pre-existing health conditions, or characteristics of the hospital in which the patient was admitted. Thus they do not control for the potential effect of patient characteristics and/or provider effects on both health outcomes and waiting times.

The varicose vein surgery sample consisted of 6,499 observations. 39% of patients admitted for varicose vein surgery had previously had surgical treatment of their varicose veins, and the majority (56%) reported having had problems with varicose veins for 10 years or more. 91% reported having a

[2] The post-surgery questionnaires are mailed after 6 months, i.e. 26 weeks.

disability, although reports of specific comorbid conditions were lower than those scheduled for hip replacement surgery except for circulatory problems (15%). Responses to the EQ-5D questionnaire suggested that pain/discomfort was the domain in which patients were most affected, with 67% reporting moderate problems. Around 20% reported moderate anxiety/depression and problems with usual activities.

Individuals scheduled for varicose vein surgery had an average age of 53 years. The income and education profile was comparable with those scheduled for hip replacement surgery. On average, the pre-operative PROMs questionnaire was completed 20 days (3.8 weeks) before surgery and the post-operative questionnaire within 134 days (19 weeks)[3]. The average wait for treatment was 76 days (11 weeks). Figure 5 shows the distribution of waiting times for varicose vein surgery in 2009 and 2010. Mean waiting times increased from 69 days in 2009 to 73 days in 2010.

91% of patients thought that their varicose vein related problems were better following the surgery, and satisfaction with the operation appeared high with 86% assessing results of the surgery as "good", "very good", or "excellent". The proportion of patients reporting excellent health increased from 10% to 14%.

Econometric framework

The timing of the health measures is the most important consideration when modelling the impact of waiting times on patient reported outcome measures. Patient health information is first observed by the researcher from the pre-surgery questionnaire, which is completed some time after the consultant has put the patient on the waiting list and some time before they receive treatment. We then observe health status again with the post-surgery questionnaire. Thus, there are three different waiting periods that take place along the time interval which starts with consultant's decision to admit and ends with the completion of the post-surgery questionnaire. The first waiting period is the time that passes from consultant's decision to admit to the date of the pre-surgery questionnaire. All of our pre-surgery health measures are taken on the date this questionnaire is completed. However, some of the variables are time-invariant (e.g. gender, certain health conditions) or time-defined (age, length of symptoms), so we can construct a set of determinants of health as of the date of consultant's decision to admit. The second time period is between the completion of the pre-surgery questionnaire and the surgery date. This is not a particularly long period. The final period covers the time from the surgery date to the date of completion of the post-surgery questionnaire and captures the length of the recovery period. The post-surgery questionnaires are sent out after 6 months of the surgery date in the case of hip replacement and after 3 months for varicose vein surgery.

[3] The post-surgery questionnaires are mailed after 3 months, i.e. 13 weeks.

The analysis needs to account for the fact that there are likely to be observable and unobservable (to the researcher) factors that impact both waiting times and patient outcomes. For example, for patients with arthritis, being physically active is one of the most important things they can do to control this condition, and longer waits may lead to worsened health, ceteris paribus. We benefit from the rich health information in the PROMs database to control for the potential endogeneity of waiting time. We introduce a broad set of health measures and personal characteristics recorded at the date of the pre-surgery questionnaire. We also introduce a full set of provider effects to control for heterogeneity across hospitals that affects their management of waiting lists and quality of care.

We begin by analysing how time-invariant patient characteristics correlate with waiting times using OLS regression. We then utilise OLS, quantile regression, and ordered probit regression models to analyse post-surgery health outcomes as a function of waiting times for surgery. After controlling for a broad set of baseline health characteristics, patient demographic characteristics, and provider effects we test whether longer waits lead to worse post-surgery health outcomes as measured by the EQ-5D index, EQ-VAS, OHS, AVV and self-assessed health measures. Finally, we analyse two post-surgery assessments of the impact of surgery.

Assume y_{ij} corresponds to the health outcome variable in the i-th patient, *i*=1,.., N, who received hip-replacement at hospital j, $j = 1, \dots, M$.

$$y_{ijt=2} = \propto y_{ijt=1} + \beta X_{ij} + Z_j u_j + \varepsilon_{ij} \qquad (1)$$

There are M unobservable hospital-level effects u_j, X_{ij} observable characteristics and ε_{ij} is the random component. Three waiting times variables $w1_{ij}, w2_{ij}, w3_{ij}$ are included in vector X_{ij}. These waits are, respectively, from the decision to admit to pre-surgery questionnaire, from the date of the pre-surgery questionnaire to the date of the surgery, and from the surgery date to the date of post-surgery questionnaire.

We employ a quantile regression approach to explore whether waiting times influence the health gain differentially across points in the post-surgery health distribution. Unlike OLS, which relates the mean response to the covariates, the quantile regression approach estimates the functional relationship by minimizing a weighted sum of absolute values of residuals. We specify:

$$\min_{\beta_\tau} \sum_{i:y_{ij} \geq \beta X_{ij} + Z_j u_j}^{N} \tau \left| y_{ij} - \beta_\tau X_{ij} - Z_{j_\tau} u_j \right| + \sum_{i:y_{ij} < \beta X_{ij} + Z_j u_j}^{N} (1-\tau) \left| y_{ij} - \beta_\tau X_{ij} - Z_{j_\tau} u_j \right|$$

where $0 < \tau < 1$ is the quantile of interest, and β_τ and Z_{j_τ} are contingent on the value of τ. By using different measures of central tendency and statistical dispersion we obtain a more comprehensive

analysis of the relationship between health outcomes and waiting times. The minimization procedure ensures the estimation is more robust with respect to outliers.

Another method is ordered probit analysis, which we apply when our dependent variables are satisfaction from surgery, success of the procedure, and general health. The underlying relationship is characterized by a latent variable model

$$y_{ij}^{*} = \beta X_{ij} + Z_j u_j + \varepsilon_{ij}$$

We do not observe y^{*} directly, but observe ordered categories of response:

$$y_{ij} = \begin{cases} 0, & -\infty < y_{ij}^{*} \leq \alpha_0 \\ 1, & \alpha_0 < y_{ij}^{*} \leq \alpha_1 \\ 2, & \alpha_1 < y_{ij}^{*} \leq \alpha_2 \\ 3, & \alpha_2 < y_{ij}^{*} \leq \alpha_3 \\ 4, & \alpha_3 < y_{ij}^{*} \leq \alpha_4 \end{cases}$$

The parameters β, Z and α are estimated by maximum likelihood.

Results

Table 2 reports the results from OLS regression of the waiting time on time-invariant and time-defined variables. We find that older patients wait longer for surgery, but the effect is non-linear. Patients who have had the symptoms for a longer period of time are also observed to wait longer for surgery. Patients who do not have disability or have previously had hip surgery are assigned longer waits. None of the specific chronic health conditions is found to correlate with waiting times. In the varicose vein surgery sample, only the baseline patient characteristics living alone and previous varicose vein surgery were statistically significantly correlated with waiting time, both showing a positive relationship of greater waiting time with higher levels.

Table 3 reports the estimated coefficients on the waiting times variables from the OLS regressions of the post-surgery PROMs. To obtain coefficients on similar scales across measures, we have multiplied the EQ-5D index scores by 100 and rescaled the disease-specific scores to run from zero (worst state) to 100 (best state). The waiting time between the decision to admit and completion of the pre-surgery questionnaire has a negative and statistically significant effect on the post-surgery scores for hip replacement. An additional week of waiting reduces the EQ-VAS, EQ-5D index, and OHS scores by 0.09%, 0.08%, and 0.1% of their full potential range, respectively. The additional wait that accrues between the completion of the pre-surgery questionnaire and surgery date does not have a statistically

significant effect on the generic health scores, but impacts negatively and significantly on the OHS. The coefficients on the two pre-surgery waiting periods are of similar magnitude.

The effects of waiting time on outcomes for varicose vein surgery do not reach statistical significance and are much smaller. The effect of an additional week's wait range from a very small increase of 0.02% in post-surgery EQ-5D index scores to a very small decrease of -0.02% in post-surgery EQ-VAS and AVV scores. The additional wait between the completion of the pre-surgery questionnaire and surgery has non-significant effects of a similar magnitude and direction on outcomes.

Table 4 shows the estimates for the remaining patient specific covariates. They include patient gender and age, and age polynomials of second and third degree. We control for pre-surgery health scores, generic health measures for the pre-surgery period. The coefficient estimates on the variables "General health", "self-care", "mobility", "activity", "pain/discomfort", "anxiety" should be interpreted relative to the excluded category. Similar interpretation should be applied to "living arrangements" and "length of symptoms" variables. We have also controlled for different pre-existing health conditions. Patients with higher health scores at the date of completion of the pre-surgery questionnaire have higher post-surgery scores. Two dimensions of the EQ5D index, patient ability to take care of themselves and their anxiety level, have negative and significant impact on their post-surgery scores. Several pre-existing health problems are found to be negatively and significantly associated with post-surgery scores for all three outcomes. These conditions are problems with circulation, diabetes, liver disease, depression, and arthritis. Patients who had previously hip surgery report large, negative, and statistically significant decline post-surgery health state. Patients who have had hip problems for longer period prior to the surgery also report worse post-surgery outcomes. Patients from income-deprived areas report lower EQ-VAS and Oxford Hip scores. Higher levels of education/skills/training deprivation has a negative and statistically significant association with Oxford Hip Score results.

The coefficients on the covariates in the varicose veins model show a similar pattern to those in the hip replacement surgery models. Briefly, patients with higher pre-operative surgery PROMs scores have higher post-surgery scores, whilst those with poorer self-reported general health, residing in a nursing home, reporting arthritis as a pre-existing health problem, or having had previous varicose vein surgery have poorer post-surgery scores. In addition, female gender, reporting EQ-5D anxiety and depression, pre-existing circulation problems, and having a longer period with varicose veins report poorer EQ-5D and Aberdeen Varicose Vein outcomes, poorer EQ-5D self care scores were associated with poorer EQ-5D and EQ-5D scores, and depression (either reported as a pre-existing condition or on the EQ-5D anxiety/depression domain) was associated with poorer post-operative EQ-5D scores.

Table 5 presents the parameter estimates for the different waiting time variables in quantile regressions for hip replacement patients. The results point to a negative impact of the wait between decision to admit and the completion of the pre-surgery questionnaire for patients whose health scores are lower than the median with those in the lowest quantile reporting the largest decline in health. We do not find any consistent evidence of health deterioration as a result of the wait between the pre-surgery questionnaire and surgery date. The length of the period between the surgery date to the date of the post-surgery questionnaire is not correlated with patient-reported health outcome scores.

Table 6 presents the waiting time estimates associated with the probability of being in each category for the three categorical variables that we study. We find that longer waits decrease the probability that patients assess the state of their post-surgery hip problems as much better compared to before. The probabilities associated with the remaining categories – "a little better", "about the same", "a little worse", "much worse" - increase. Similarly, longer waits decrease the probability of reporting excellent results from surgery or self-reporting health status as excellent and increase the probability of perceiving the outcomes as "very good", "good"," fair", or "poor". We also find that longer waits between the pre-surgery questionnaire and surgery date decrease the probability of patients reporting excellent results from surgery. They also impact negatively the probability that patients rank their health as excellent or very good. This wait is associated with higher probability of perceiving the post-surgery outcomes as "very good", "good"," fair", or "poor" and higher probability of self-reporting health as "good"," fair", or "poor". The ordered probit models are currently estimated without provider effects. These will be incorporated in later work.

Concluding remarks

Our initial descriptive evidence suggested that longer waiting times for elective surgery could have a negative effect on post-surgery outcomes. The regression results, which control for a wide range of covariates, rich information on the patient's pre-surgery health state, health-reporting heterogeneity and endogeneity caused by prioritisation according to need, point to statistically significant decrements in post-surgery scores as a result of longer waits for surgery. This finding is consistent across health measures for hip replacement surgery but does not apply to varicose vein surgery.

At patient level, the magnitude of the effect appears to be small, being a reduction in outcome of 0.1% of the range for each additional week of waiting. However, between 2009 and 2010, the average amount of time that patients in our sample waited for hip replacement surgery increased by one week. Applied to an annual patient population of 68,500 in 2010/11, such a deterioration in NHS performance has a more substantial health impact, particularly if this reduction in HRQoL is sustained over time.

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Table 1: Summary Statistics

	Hip replacement				Varicose vein			
Variable	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
Dependent variables								
EQ-VAS (Q1)	66.39	20.919	0	100	80.23	15.665	0	100
EQ-VAS (Q2)	75.63	18.029	0	100	79.74	16.201	0	100
EQ-5D index (Q1)	0.35	0.321	-0.594	1	0.80	0.211	-0.349	1
EQ-5D index (Q2)	0.76	0.254	-0.594	1	0.86	0.203	-0.594	1
Oxford Hip Score (Q1)	18.21	8.318	0	48				
Oxford Hip Score (Q2)	38.09	9.342	0	48				
Aberdeen V.V. Score (Q1)					18.88	10.146	0	91.63
Aberdeen V.V. Score (Q2)					10.95	9.923	0	86.64
General Health (Q1)								
Excellent	0.05				0.10			
very good	0.29				0.41			
Good	0.44				0.39			
Fair	0.19				0.09			
Poor	0.03				0.01			
General Health (Q2)								
Excellent	0.08				0.14			
very good	0.34				0.41			
Good	0.39				0.35			
Fair	0.16				0.08			
Poor	0.02				0.01			
Overall, how are your hip problems now, compared to before your operation?								
much better	0.85				0.72			
a little better	0.10				0.19			
about the same	0.03				0.06			
a little worse	0.01				0.02			
much worse	0.01				0.01			
How would you describe the results of your operation?								
Excellent	0.38				0.21			
very good	0.35				0.38			
Good	0.19				0.27			
Fair	0.06				0.10			
Poor	0.02				0.04			
Waiting time variables								
Delay b/n dcsn to admit and date of q1 (weeks)	8.39	6.011	0	30	8.15	6.253	0	30
Delay b/n date of q1 and date of surgery (weeks)	3.26	3.429	0	26	2.78	4.763	0	54
Delay b/n date of surgery and date of q2 (weeks)	28.77	9.930	0	556	19.15	8.855	0	536

Patient Characteristics	Hip replacement				Varicose veins			
Income deprivation	0.12	0.089	0.01	0.77	0.13	0.098	0.01	0.58
Education deprivation	18.50	16.382	0.01	99.34	19.94	17.24	0.01	98.84
Age (years)	68.55	10.325	15	96	53.28	14.176	17	94
Female	0.61	0.488			0.66	0.474		
Living arrangements								
Spouse/family/friends	0.73				0.85			
Alone	0.26				0.15			
nursing home, hospital	0.00				0.00			
Other	0.00				0.00			

Health History	Hip Replacement	Varicose veins
Previous surgery	0.09	0.39
Heart disease	0.10	0.04
High blood pressure	0.40	0.19
Stroke	0.01	0.01
Circulation	0.07	0.15
Lung disease	0.06	0.04
Diabetes	0.08	0.03
Kidney disease	0.02	0.01
Nervous system	0.01	0.00
Liver disease	0.00	0.00
Cancer	0.04	0.02
Depression	0.06	0.06
Arthritis	0.71	0.18
Disability	0.39	0.91

	Hip replacement	Varicose vein
Length of symptoms		
<1 year	0.15	0.02
1–5 years	0.66	0.21
6-10 years	0.11	0.21
>10 years	0.08	0.56
Dimensions of the EQ-5D		
Self-care		
no problems	0.45	0.97
some problems	0.54	0.03
unable	0.01	0.00
Mobility		
no problems	0.06	0.79
some problems	0.93	0.21
unable	0.01	0.00
Pain/Discomfort		
no	0.01	0.32
moderate	0.58	0.67
extreme	0.41	0.01
Anxiety		
no	0.57	0.80
moderate	0.38	0.19
extreme	0.05	0.01
Usual activity		
no problems	0.06	0.77
some problems	0.75	0.22
unable	0.19	0.01

Table 2: Regression of waiting times on time-invariant and time-defined variables

Variable	Hip replacement	Varicose veins
Female	0.0736	0.1409
Age	0.3056*	-0.1921
Age2	-0.0055**	0.0042
Age3	0.0000**	0.0000
Living arrangements		
Alone	0.0720	0.5717**
Nursing home, hospital	0.9410	1.0998
Other	-0.2073	0.3916
Length of hip symptoms		
1–5 years	0.9989***	0.4620
6-10 years	1.1129***	0.2471
>10 years	1.6405***	0.2501
Previous surgery	0.4529**	0.4311**
Heart disease	0.1312	-0.0969
High blood pressure	0.0180	0.0338
Stroke	0.0743	0.2194
Circulation	0.0518	0.1755
Lung disease	0.2514	-0.2421
Diabetes	0.0652	1.0416
Kidney disease	0.1470	-0.7323
Nervous system	-0.4079	0.0727
Liver disease	1.2606	0.0150
Cancer	-0.0265	-0.3228
Arthritis	0.1306	0.1755
No disability	0.2306**	0.1965
Income deprivation	0.6616	-0.7055
Education	-0.0026	-0.0061
N	18988	6039
Adjusted R2	0.2480	0.1684

Table 3: Coefficients on waiting times variables from the OLS regression of post-surgery health outcomes[4]

	Wait between decision to admit and Q1	Wait between Q1 and surgery date	Time between surgery date and Q2
Hip Replacement			
EQ-VAS	-0.086**	-0.047	0.004
EQ-5D index	-0.079***	-0.049	0.011
HR Score	-0.101***	-0.109*	0.016
Varicose veins			
EQ-VAS	-0.018	-0.037	-0.012
EQ-5D index	0.015	0.019	-0.026
AVV Score	-0.024	-0.039	0.005

legend: * p<0.05; ** p<0.01; *** p<0.001

[4] To obtain coefficients on similar scales across measures, we have multiplied the EQ-5D index scores by 100 and rescaled the disease-specific scores to run from zero (worst state) to 100 (best state).

Table 4: Coefficients on other covariates from the OLS regression of post-surgery health outcomes[5]

	Hip Replacement			Varicose veins		
Variable	EQ-VAS	EQ-5D index	OHS	EQ-VAS	EQ-5D index	AVV
Female	-0.1655	-0.9364***	-1.3815***	-0.0861	-1.0360***	-1.3767***
Age	-0.4021	-0.6697	-0.0947	0.0547	-0.1112	0.1527
Age^2	0.0088	0.0153*	0.006	-0.0001	0.0035	-0.0026
Age^3	-0.0001	-0.0001**	-0.0001	-0.0000	-0.0000	0.0000
EQ-VAS (q1)	0.0900***			0.2308***		
Oxford Hip Score (q1)			0.1828***			
Aberdeen VV score (q1)						0.4606***
General health (q1)						
very good	-4.1977***	-1.4960***	-1.7780**	-4.3399***	-0.5277	-0.6188
good	-8.9506***	-3.6358***	-4.6106***	-10.3243***	-2.5164***	-1.2745***
fair	-16.5058***	-7.8592***	-9.5071***	-17.9313***	-5.1253***	-2.9565***
poor	-20.5620***	-12.2304***	-11.8183***	-29.5486***	-9.5732***	-4.4606**
Self –care						
some problems	-1.1755***	-2.6589***	-1.9490***	-5.7591**	-11.0400***	-1.6697
unable	-4.9515**	-10.2373***	-6.1051***	5.5065	-17.7479	3.6442
Mobility						
some problems	-0.4931	-0.1208	1.4968**	-2.1502***	-3.1511***	0.1516
unable	1.3968	-0.7901	0.5607	4.4735	8.6607*	-0.7094
Pain/discomfort						
moderate	0.8971	-0.3187	0.4098	-0.0983	-2.6019***	0.1327
extreme	-0.5951	-2.2393*	-0.0651	-0.2117	-10.3822***	-2.4011***
Anxiety/depression						
moderate	-1.3273***	-2.0893***	-1.3847***	-1.3506*	-2.3721***	-0.3534
extreme	-2.5935**	-5.9715***	-4.2768***	-3.7147	-7.9725***	-0.5854
Usual activity						
some	0.3886	-0.2882	1.5314**	0.0681	-1.1613*	0.3597
unable	-1.2112	-3.4514***	-0.1718	0.3137	-2.5223	0.9404
No disability (q1)	3.2764***	3.4825***	3.7123***	3.9793***	7.0003***	1.2354*
Living arrangements						
alone	0.025	0.2125	-0.211	-0.7877	-1.0157*	-0.8831**
nursing home, hospital	-6.0307	-0.4796	-0.1463	-8.5601***	-5.2275*	-4.9099*
other	-0.0339	-0.5756	-0.4266	-4.1507	0.0870	-0.9574
Length of symptoms						
1–5 years	-0.2504	-0.8609**	-1.3225***	0.6877	-1.3675	-0.8021
6-10 years	-0.4293	-1.2419**	-2.1019***	0.4315	-1.5639	-0.8638
>10 years	-0.412	-2.1806***	-3.2052***	-0.1305	-2.3361**	-1.4365*
Previous surgery	-3.4533***	-4.8706***	-8.7315***	-0.1435	-1.2897***	-2.1385***
Heart disease	-1.9947***	-0.8806*	-0.5071	0.7620	-0.5808	-0.5814
High blood pressure	0.1232	0.5795*	0.7815**	-0.6792	-0.5156	-0.1354
Stroke	-1.6454	-1.5145	-1.9508	-1.2628	-6.7554*	-0.4790
Circulation	-2.3355***	-2.6102***	-4.5136***	-0.5045	-1.5074**	-1.3683***
Lung disease	-2.6922***	-0.1318	-0.0137	-2.0044	1.2908	0.1345
Diabetes	-1.9190***	-0.8978*	-1.3853**	1.5455	0.5521	0.1260
Kidney disease	-0.9064	0.003	0.9834	-4.4848	-2.9645	0.2499
Nervous system	-5.0685**	-2.6735*	-2.4926	0.5544	5.0815*	0.6443
Liver disease	-7.2311**	-6.6196**	-6.8206**	5.0490	5.9981**	-0.5391
Cancer	-1.4398*	-0.3182	0.6142	-1.8812	-1.6378	-1.4505
Depression	-4.6246***	-6.7702***	-4.3733***	-0.3714	-3.4469***	-0.6349
Arthritis	-1.5717***	-1.3970***	-0.8915**	-1.4583**	-1.5405***	0.8683**
Income deprivation	-5.1913	-6.5923*	-10.0374**	-3.0323	-2.9548	-3.3886
Education deprivation	-0.0049	-0.0224	-0.0332*	-0.0013	-0.0095	0.0159
N	14,650	15,642	16,306	4949	5283	5363
Adjusted R2	0.2706	0.2383	0.2386	0.4086	0.3773	0.3668

legend: * p<0.05; ** p<0.01; *** p<0.001

[5] To obtain coefficients on similar scales across measures, we have multiplied the EQ-5D index scores by 100 and rescaled the disease-specific scores to run from zero (worst state) to 100 (best state).

Table 5: Coefficients on waiting times variables from quantile regression of post-surgery health outcomes[6]

	Wait between decision to admit and Q1	Wait between Q1 and surgery date	Time between surgery date and Q2
p10			
EQ-VAS	-0.1917**	-0.1517	-0.0356
EQ-5D index	-0.1414*	-0.0091	0.0081
HR Score	-0.2462***	-0.1904	0.0004
p25			
EQ-VAS	-0.0974**	0.0258	-0.0520*
EQ-5D index	-0.0685	-0.0094	0.0081
HR Score	-0.1081*	-0.0811	0.0028
p50			
EQ-VAS	-0.0615*	-0.0631	0.0174
EQ-5D index	-0.0487	-0.0476	0.0150
HR Score	-0.0876**	-0.0662	0.0128
p75			
EQ-VAS	-0.0543*	-0.0619	0.0086
EQ-5D index	n/a	n/a	n/a
HR Score	-0.0173	-0.0416	0.0008
p90			
EQ-VAS	-0.0083	-0.0212	-0.0008
EQ-5D index	n/a	n/a	n/a
HR Score	-0.0182	-0.0046	-0.0047

legend: * p<0.05; ** p<0.01; *** p<0.001

Table 6 Marginal effects for waiting times variables from ordered probit regressions

	Wait between decision to admit and Q1	Wait between Q1 and surgery date	Time between surgery date and Q2
Overall, how are your hip problems now, compared to before your operation?			
Much better	-0.0016**	-0.001	0.0000
A little better	0.0009**	0.0001	0.0000
About the same	0.0003**	0.0002	0.0000
A little worse	0.0002**	0.0001	0.0000
Much worse	0.0002**	0.0001	0.0000
How would you describe the results of your operation?			
Excellent	-0.0019**	-0.0030**	-0.0005
Very good	0.0003**	0.0004**	0.0001
Good	0.0009**	0.0014**	0.0002
Fair	0.0005**	0.0008**	0.0001
Poor	0.0002**	0.0003**	0.0001
In general would you say your health is...?			
Excellent	-0.0003*	-0.0005*	-0.0002*
Very good	-0.0012*	-0.0017	-0.0006*
Good	0.0007*	0.0011*	0.0003*
Fair	0.0007*	0.0011*	0.0003*
Poor	0.0001*	0.0001*	0.0000*

legend: * p<0.05; ** p<0.01; *** p<0.001

[6] To obtain coefficients on similar scales across measures, we have multiplied the EQ-5D index scores by 100 and rescaled the disease-specific scores to run from zero (worst state) to 100 (best state).

Figure 1: Potential impacts of waiting for treatment on HRQoL. Source: Koopmanschap *et al.* 2005

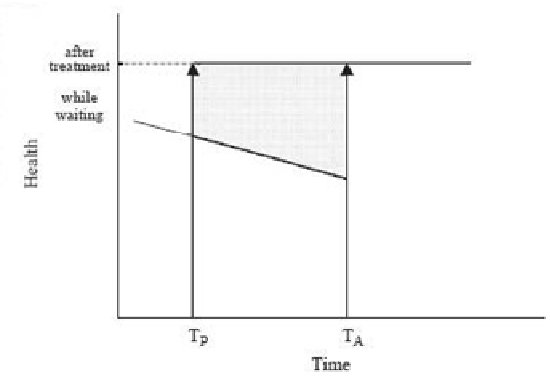

Fig. 2. Scenario: deteriorating health, reversible effect.

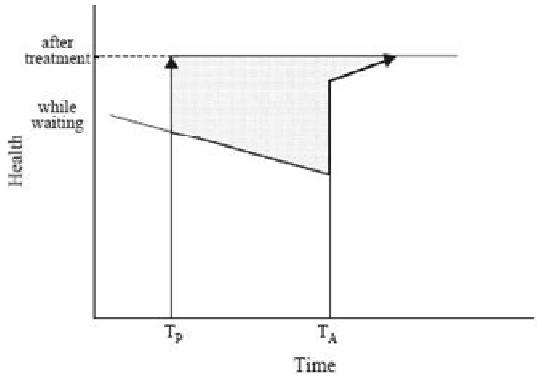

Fig. 3. Scenario: deteriorating health, reversible effect, prolonged rehabilitation.

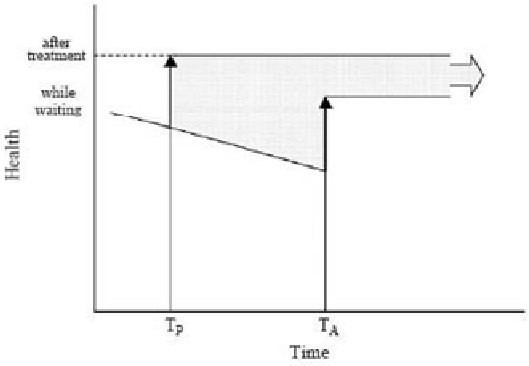

Fig. 4. Scenario: deteriorating health, partly reversible effect.

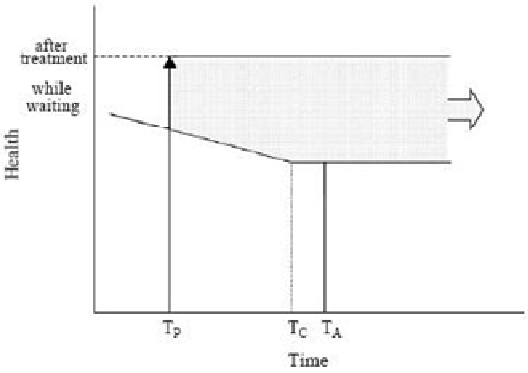

Fig. 5. Scenario: deteriorating health, irreversible effect.

Figure 2: Distribution of waiting times for hip replacement surgery

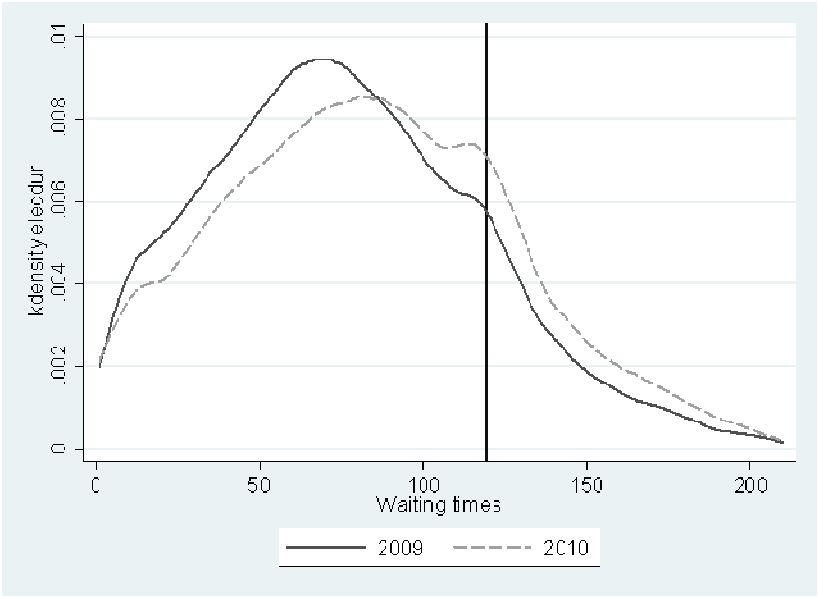

Figure 3: Relationship between waiting times and Oxford Hip Score

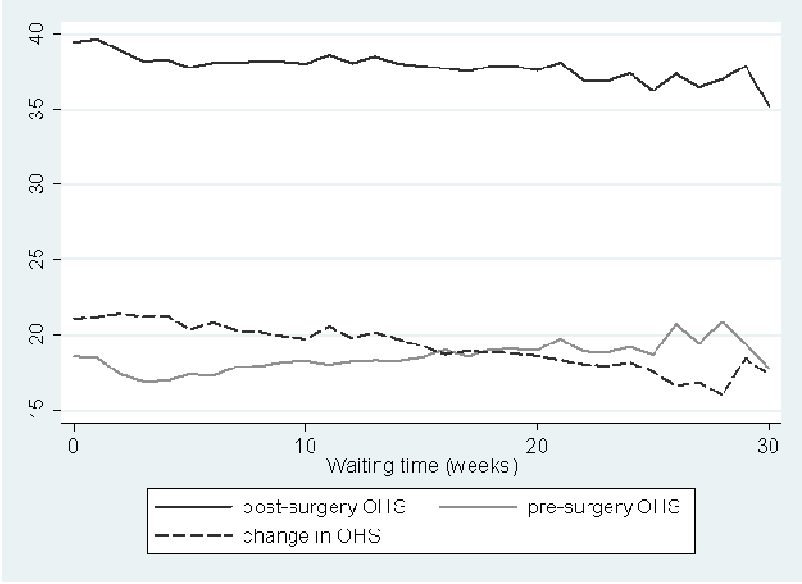

Figure 4: Relationship between waiting times and Oxford Hip Score: by quantile

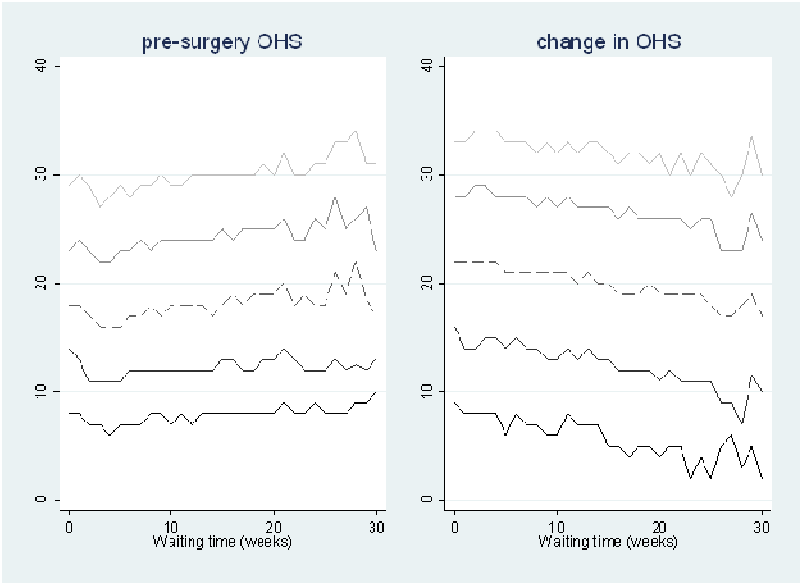

Figure 5: Distribution of waiting times for varicose vein surgery