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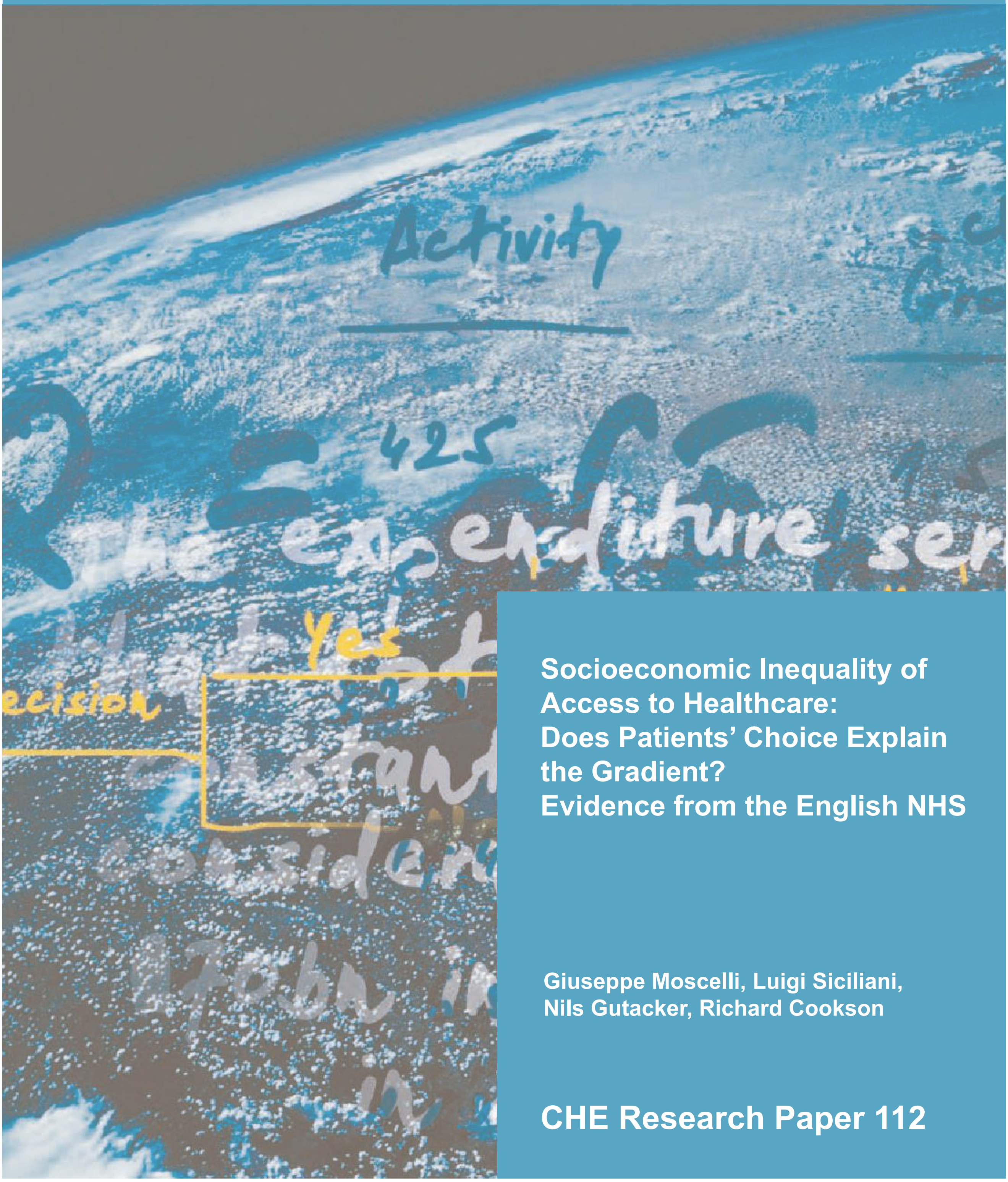

Socioeconomic Inequality of Access to Healthcare: Does Patients' Choice Explain the Gradient? Evidence from the English NHS

Giuseppe Moscelli, Luigi Siciliani,
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Giuseppe Moscelli[1]
Luigi Siciliani[1,2]
Nils Gutacker[1]
Richard Cookson[1]

[1]Centre for Health Economics, University of York, UK
[2]Department of Economics and Related Studies, University of York, UK

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Background to series

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Abstract

Equity of access is a key policy objective in publicly-funded healthcare systems. Using data on patients undergoing non-emergency heart revascularization procedures in the English National Health Service, we find evidence of significant differences in waiting times within public hospitals between patients with different socioeconomic status (up to 35% difference between the most and least deprived population quintiles). We employ selection models to test whether such differences are explained by patients exercising choice over hospital or type of treatment. Selection bias due to choice has a limited effect on the gradient suggesting the presence of substantial inequities within the public system.

Keywords: waiting times, inequalities, socioeconomic status, selection bias, choice.

JEL codes: I14, I11, I18, C34.

1. Introduction

Equity in access to healthcare is an important policy concern, especially in countries with a publicly funded health system. A substantial body of literature has provided empirical evidence about inequalities in the utilization of healthcare associated with socioeconomic status (SES), typically favouring richer patients (Van Doorslaer et al., 2000, Van Doorslaer et al., 2004). A more recent empirical literature suggests that pro-rich inequalities extend to timely access to planned (i.e. non-emergency) healthcare.

Many OECD countries provide universal access to healthcare irrespective of patients' ability to pay. In these healthcare systems, access to publicly-funded services is not means tested and waiting times act as a rationing mechanism to clear supply and demand for planned healthcare (Martin and Smith, 1999). Patients demanding treatment are added to a waiting list and must wait before receiving treatment. Waiting times differ markedly across procedures and reach several months for common procedures like hip replacement or cataract surgery (Siciliani et al., 2013). Considerable attention is paid to waiting times in public sector management, as these are seen as benchmark indicators for both efficiency (Smith, 2002, Oliver, 2005) and satisfaction with public services (Cutler, 2002).

Rationing by waiting times may generate discontent amongst patients (Lindsay and Feigenbaum, 1984, Propper, 1995, Siciliani and Hurst, 2005), as treatment benefits get postponed, suffering and uncertainty are prolonged, and the patients' health status may deteriorate while waiting (Appleby et al., 2005, Oudhoff et al., 2007). On the other hand, using waiting times instead of user fees to limit demand provides an advantage from an equity perspective as it grants access to healthcare services independently of ability to pay.

Patients are commonly prioritized according to their medical need: more severely ill patients wait less, both for a given procedure and across procedures with different degrees of severity (Gravelle and Siciliani, 2008). However, patients with the same level of need are supposed to wait their turn on a "first-come, first-served" basis, irrespective of their income or social position. This is meant to guarantee equity of access to treatment.

Despite this strong equity notion, a recent empirical literature suggests that individuals with lower SES tend to wait longer within publicly-funded hospitals than those with higher SES in a range of OECD countries (reviewed in detail below). Inequalities within the same hospital occur for several reasons. It may be the result of patient selection, if individuals with different SES have different preferences regarding choice of hospital and medical treatment. Individuals with higher SES may be more active and better organized in engaging with the health system, and more effective in expressing their needs. They could exploit their social networks to gain priority or be less likely to miss scheduled pre-treatment appointments with specialist doctors. Finally, inequalities may be due to unconscious bias and "statistical discrimination" by doctors (Van Ryn and Burke, 2000, Balsa and McGuire, 2001).[1]

In this study we aim to shed some light on the causal mechanisms behind the SES differential in waiting times, by focusing on the first of these potential explanations. We estimate waiting time inequalities by SES arising within publicly-funded hospitals in England for patients in need of cardiac revascularization over the period 2002-2010.We then test whether part of the gradient can be

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[1] We focus on inequalities *within* hospitals. Income-related inequalities can arise also *across* hospitals which may be due to differences in the volume of supply across areas with different socioeconomic composition, or differences in the quality of supply (Propper and Van Reenen, 2010).

explained by differences in patient choice and preferences with regard to the hospital of treatment and/or the type of medical procedure, and whether this has changed over time.

The introduction or enhancement of patient choice in the healthcare sector has been undertaken by administrations in several industrialized countries, including Denmark, the Netherlands, Germany, Sweden and the USA (Thomson and Dixon, 2006), based on economic theory suggesting that freedom of choice in public services can motivate suppliers to increase service quality and prevent mismatch amongst consumers and suppliers (Hoxby, 2000, Le Grand, 2006).

However, preferences driving healthcare choices are likely to be heterogeneous for patients belonging to different SES groups. More income-deprived patients might be less willing, or able to afford, to travel for planned care than less deprived patients. Moreover, prospective patients with different SES might have different risk and/or time preferences and face different constraints. Within cardiac revascularization interventions, angioplasty has both a lower perioperative mortality risk and shorter post-operative inpatient length of stay than coronary bypass surgery, but also a higher risk of subsequent cardiac or cerebrovascular events and need for revascularisation (Brener et al., 2004, Hannan et al., 2005, Griffin et al., 2007, Taggart, 2007). While for the majority of patients the type of treatment will be determined by their medical profile, for some patients there is uncertainty about the optimal treatment and different risk and time preferences may therefore motivate some patients to “switch” between procedures.

We include patient choice in our models allowing for a self-selection mechanism modelled with switching regimes. If individual preferences and constraints (e.g. ability to pay for transportation to hospitals located further away) do not play an important role in explaining the income-inequality gap in access to healthcare, then the gradient is more likely to represent *unfair* inequalities that are not justifiable. Such findings are important in the context of the English NHS, which has expended substantial monetary and non-monetary efforts during the period considered in our study to improve timely access to planned care (Department of Health, 2000).

Our key findings are as follows. Patients living in more income-deprived (poorer) areas wait longer within a hospital for two common elective heart revascularization procedures, coronary artery bypass grafting (CABG) surgery and angioplasty (PCI, i.e. percutaneous coronary intervention). The estimated income-inequality gaps in waiting times are large. We find that in 2002 patients in need of CABG surgery in the least deprived quintile waited 35% less compared to the most deprived ones. The gradient gradually falls to 10% and 15% in 2010, respectively, following the general reductions in waiting times at system level. Most importantly we find that the gradient is not substantially altered once patients’ choice over hospital or treatment is taken into account. These findings are important for publicly-funded systems like the English NHS, which aims to prioritise access according to medical need regardless of economic status.

The presence of waiting time inequality is consistent with previous studies. 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. Laudicella et al. (2012) focus on variations in waiting times within hospitals for hip replacement in 2001 in England, and find that patients living in areas with a higher proportion of educated individuals or more affluent were favoured in their waits. Both studies, like ours, rely on administrative NHS data that do not cover treatment of privately funded patients who are more likely to live in the most affluent areas.

There is also evidence of inequalities from other countries with publicly-funded healthcare systems. Using administrative data from Norway, Monstad et al. (2014) find that richer men and more educated women tend to wait less for hip replacement within the same hospital. Kaarboe and

Carlsen (2014) find evidence of inequalities when waiting times are pooled across all surgical procedures. Sharma et al. (2013) find that patients living in areas with high SES wait on average 13% less for elective surgery than patients in areas associated with low SES, using data from the State of Victoria (Australia). Johar et al. (2013) find that patients with low SES wait on average 16 to 24% longer than people with high SES in New South Wales (Australia), after controlling for supply factors. Without controlling for hospital fixed effects, Alter et al. (1999) find that patients undergoing cardiac revascularisation in the highest income quintile group in Canada wait 45% less compared to patients in the lowest income quintile group, which could be explained by different availability of resources across hospitals.[2]

We make a number of contributions to the existing literature. First, and most importantly, we explicitly allow for patients' choices, thereby addressing possible self-selection bias in the gradient that could be due to bypassing the local hospital and/or choice of revascularization procedure. Arguably, inequalities in waiting times due to choice factors within the control of the patient are not "unfair" and reflect personal preferences. We use a Roy model (Heckman, 2010) and present distinct models for two self-selection choices of bypassing the closest hospital and of choosing the procedure.

Second, we focus on cardiac revascularization treatments where the risk of mortality, both while waiting and during the intervention, is not negligible. For this reason, inequalities in access to these procedures have been a key concern for English health policy-makers. This contrasts to previous studies that focus on procedures where mortality risk is negligible (such as cataract or hip replacement).[3] Whether we should expect a larger gradient for revascularization is *a priori* ambiguous. On one hand, the management of the list may be more rigorous. On the other hand, patients may be more impatient to undergo treatment and willing to invest more effort to "play the system" to obtain a shorter wait.

Third, we investigate how inequalities have evolved over time. Among other things, we investigate whether income-related waiting time inequalities are more pronounced when waits are long.[4] Given the current economic climate, this is of policy interest since waiting times have risen and are expected to further increase (Dorning and Blunt, 2015).

The study is organised as follows. Section 2 introduces the institutional background. Section 3 presents the econometric methods. Sections 4 and 5 describe respectively data and results. Section 6 concludes.

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[2] Of all these studies, only Monstad et al. (2014) use income information at individual patient level, while all the others use income measured at small area level as a proxy of SES.

[3] An exception is Alter et al. (1999), who lump together the two procedures and focuses on inequalities across hospitals.

[4] This goal is achieved in two ways. We report the evolution of the waiting time gradient in all the years of the sample, and so we measure the reduction in the gradient that is likely due to the waiting times policy enacted in 2003. We also employ yearly quantile regressions to assess the size of the gradient along the conditional distribution of hospital waiting times.

2. Institutional Setting

During the years 2002 to 2010, the English NHS underwent a period of accelerated expenditure growth and substantial health system reforms. This was the result of a perception that the NHS had been “under-funded” during the previous two decades, and quality was suffering as a result (Moran, 1999). A large investment plan was designed and implemented, leading to a 50% increase in the allocated budget and around a third increase in capacity over a five year period. This included funding for additional beds in existing hospitals, building of new hospitals and care centres, employment of additional doctors, nurses and supporting staff. However, this was also accompanied by a major programme of reforms.

One of the most effective reforms was the implementation of centrally imposed waiting time targets with associated penalties for failure. This policy regime was explicitly aimed at reducing excessive waiting times for planned operations. The maximum waiting time for planned procedures was gradually reduced from 18 months to 12 months in 2003, 9 months in 2004 and 6 months in 2005. The maximum waiting time was further reduced in 2010 to 18 weeks from referral to treatment (NHS England, 2013). The waiting time policy was a core part of a performance management strategy that required hospitals to meet targets to avoid the risk of either a senior-management change or take-over by a better performing hospital. These strong policy incentives contributed to the decline of waiting times for planned surgeries without measurable detriment to quality (Propper et al., 2008, 2010).

In approximately the same period, a policy allowing patients to choose the hospital for planned treatment was introduced in the English NHS, with the aim of providing a competitive incentive for hospitals to improve quality and responsiveness to citizens’ needs. This policy was part of a broader attempt to modernize the public sector by enhancing consumers’ choice, both in UK and other countries (Besley and Ghatak, 2003, Pawson et al., 2006, Musset, 2012, Vrangbaek et al., 2012).

The hospital choice policy was rolled out in phases between 2006 and 2008. However, for life-threatening conditions, including those requiring revascularisation procedures such as CABG surgery and angioplasty (Department of Health, 2002), hospital choice was offered from July 2002. From that date, patients who had been waiting for more than six months were given the option to choose from a range of alternative providers.

3. Methods

3.1 Baseline model without accounting for patient's choices

We are interested in quantifying the extent of socioeconomic inequality in waiting time for NHS-funded elective surgery within English NHS hospitals, and its evolution over time. Our data are repeated cross-sections of individuals receiving a given revascularization procedure, i.e. either CABG surgery or PCI. Our first econometric strategy uses a linear model with hospital fixed effects, estimated separately for each financial year and revascularization procedure.

Define W as the waiting time between the time the patient is added to the waiting list, after specialist assessment, and the time the patient is admitted to a hospital for treatment. The model is specified as:

$$w_{ij} = h_j + \beta_1' y_{ij} + \beta_2' s_{ij} + \beta_3' x_{ij} + \varepsilon_{ij} \tag{1}$$

where $w_{ij} = \ln\left(W_{ij}\right)$ and W_{ij} is the waiting time of patient *i* in hospital *j* receiving the procedure in a given financial year. y_{ij} is a vector of dummy variables capturing socioeconomic status as measured by income deprivation of the area where the patients resides. We split the income deprivation distribution into five quintiles, with the highest indicating the least deprived areas (our reference category). β_1 is the vector of coefficients of interest. Income-related inequalities favouring the rich arise if the elements of β_1 are positive.

The vector s_{ij} contains severity controls: age, gender, number of secondary diagnoses, number of hospital emergency admissions in the year preceding the procedure, and dummies for Charlson co-morbidities (Charlson et al., 1987). These proxies control for patients' latent health status, which is unknown to the econometrician but known to the doctor and/or the patient herself. Controlling for severity and comorbidity is important because these are legitimate reasons for higher priority on the waiting list which are also (negatively) correlated with income (Marmot et al., 1991, Smith, 1999, Wagstaff and Van Doorslaer, 2000). Omitting severity might result in a positive association between waiting times and SES, which disappears once severity is controlled for. Vector x_{ij} includes non-severity variables such as month of admission.

h_j is a vector of hospital fixed effects. It controls for differences in waiting times across hospitals which may arise from: unobserved supply and demand factors, such as the number of beds, nurses, doctors, infrastructure, management and organization, and quality. This implies β_1 should be interpreted as waiting time inequalities arising *within* a hospital, as opposed to *across* hospitals.

ε_{ij} is the idiosyncratic error. We estimate Equation (1) through OLS with Huber-White standard errors robust to unknown heteroscedasticity. We use the logarithmic transformation of the dependent variable, w_{ij}, instead of its natural level W_{ij}, to reduce the skewness of the waiting times distribution. We also provide estimates of the waiting time inequalities in the natural scale by employing a Duan smearing adjustment (Duan, 1983).

Despite the hospital fixed effects and the extensive controls on severity, OLS estimation of Equation (1) may still potentially provide biased estimates of the income gradient β_1 in the presence of selection bias due to patient choice (Heckman, 1979).

We do not have information regarding insured patients opting out of the NHS who are treated by private sector hospitals. The private sector accounted for about 2.1% (6.8%) of planned CABG (PCI) interventions during the years 2008/2011 in England (Ludman, 2012, NICOR, 2012). However, we can assume that private treatments will be sought mainly by the wealthiest patients, living in the least income deprived areas. In this case, our estimates of the income-deprivation gradient on waiting times would be potentially downward biased.

Our analysis controls for two sources of self-selection bias that are due to choice: hospital choice, i.e. patients may differ in the willingness to bypass the local hospital, and procedure choice, i.e. selecting into treatment (bypass versus angioplasty). We may expect more income-deprived individuals to be less willing to travel than less deprived ones, and therefore more likely to seek care in the closest hospital. These costs may increase non-linearly if more income-deprived patients are also unobservably sicker than less deprived ones. The reverse holds for less deprived patients, so there might be an upward bias in $\hat{\beta}_1$ for low-income, less-mobile patients; and a downward bias in $\hat{\beta}_1$ for high-income, more mobile patients.

Revascularization procedures have different risk profiles: both are effective, and while CABG carries a higher risk of short-term mortality it also exhibits better long-term survival rates and quality of life than PCI for patients older than 65 or with certain co-morbidities (The BARI investigators, 1996, 2007, Hlatky et al., 2009, Taggart, 2009). We have proxies of patient health status and severity as control variables but cannot observe the exact patient pathology. Even if we knew the pathology, PCI and CABG might still be substitutes for prospective patients. Patient risk preferences might influence the choice of treatment, as might time preferences. The two procedures have different in-hospital lengths of stay (two days for PCI as opposed to nine days for CABG), which implies different opportunity costs. If high-income patients are both less sick and have lower rates of time preference, they are more likely to undergo a CABG procedure, which may be perceived as imposing greater short-term risk, inconvenience and loss of time, but delivering greater long-run benefits to health and longevity. The opposite is true for low-income individuals, who may prefer PCI to minimize short-term risks and opportunity costs.

Both sources of selection bias might be interpreted as “fair” sources of inequalities among patients, insofar as choice of treatment and hospital is considered a matter of individual responsibility rather than a barrier to access for which healthcare policy makers should be held to account.

3.2 Endogenous switching regression models (Roy model)

The choices of hospital bypassing and procedure can be addressed using self-selection models that isolate the “unfair” inequality gradient due to income deprivation. We estimate Roy models to deal with endogenous switching regimes (Roy, 1951, Heckman and Honore, 1990, Heckman, 2010) due to either hospital bypassing or choice of procedure. We model and estimate the two choices separately as we are interested in the marginal effect of each self-selection mechanism on the waiting time gradient.[5]

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[5] We provide estimates of a joint self-selection model for procedures and hospital location in Appendix C.

In the selection equation for hospital bypassing, we model self-selection of patients into closest versus not-closest hospitals (based on their area of residence). Define n_{ij} as a dummy equal to 1 if the patient bypasses the closest hospital and 0 otherwise. The Roy model for bypassing the closing hospital is defined by:

$$\begin{cases} n_{ij} = I\left(\gamma_0' z_{ij} + \gamma_1' y_{ij} + \gamma_2' s_{ij} + \gamma_3' x_{ij} + \nu_{ij} > 0\right),\ n_{ij} = \{0,1\}, \\ w_{ijn}^* = w_{ij1} = h_j + \beta_{1,1}' y_{ij1} + \beta_{2,1}' s_{ij1} + \beta_{3,1}' x_{ij1} + \varepsilon_{ij1},\ \text{if } n_{ij} = 1, \\ w_{ijn}^* = w_{ij0} = h_j + \beta_{1,0}' y_{ij0} + \beta_{2,0}' s_{ij0} + \beta_{3,0}' x_{ij0} + \varepsilon_{ij0},\ \text{if } n_{ij} = 0 \end{cases} \tag{2}$$

where w_{ij1} and w_{ij0} represent the observed log waiting times for patients selecting respectively into a further away hospital or into the closest one.

The estimating equations of the Roy model accounting for self-selection into closest vs. not closest hospital for each procedure are:

$$n_{ij} = I\left(\gamma_0' z_{ij} + \gamma_1' y_{ij} + \gamma_2' s_{ij} + \gamma_3' x_{ij} + \nu_{ij} > 0\right),\ n_{ij} = \{0,1\} \tag{3}$$

$$E\left\{w_{ij1} \mid h_j, y_{ij1}, s_{ij1}, x_{ij1}, \hat{p}_z\right\} = h_j + \beta_{1,1}' y_{ij1} + \beta_{2,1}' s_{ij1} + \beta_{3,1}' x_{ij1} + \rho_1 \lambda_{ij1}(\hat{p}_z) \tag{4}$$

$$E\left\{w_{ij0} \mid h_j, y_{ij0}, s_{ij0}, x_{ij0}, \hat{p}_z\right\} = h_j + \beta_{1,0}' y_{ij0} + \beta_{2,0}' s_{ij0} + \beta_{3,0}' x_{ij0} + \rho_0 \lambda_{ij0}(\hat{p}_z) \tag{5}$$

The unobserved error terms $\nu, \varepsilon_0, \varepsilon_1$ follow a degenerate trivariate Gaussian distribution, i.e.

$\left(\nu, \varepsilon_0, \varepsilon_1\right) \sim TN\left(0, \Omega_n\right)$, with mean zero and covariance matrix Ω$_n$, where $\Omega_n = \begin{bmatrix} \sigma_\nu^2 & \sigma_{\varepsilon 0} & \sigma_{\varepsilon 1} \\ \sigma_{\varepsilon 0} & \sigma_{\varepsilon 0}^2 & \cdot \\ \sigma_{\varepsilon 1} & \cdot & \sigma_{\varepsilon 1}^2 \end{bmatrix}$.

The covariance between ε_1 and ε_0 is not defined, as w_1 and w_0 are never observed simultaneously.

The patient self-selects into a given hospital, based on her utility, according to the selection Eq. (3). Patient's choice of the hospital is potentially driven by all factors affecting waiting times, i.e. severity, co-morbidities, other patient characteristics and income deprivation. We observe Eq. (4) when patients bypass the closest hospital and Eq. (5) when they opt for the closest hospital.

The model can be identified through nonlinearities, but it is good practice to include at least one exclusion restriction variable (instrument) in the selection equation to avoid collinearity problems in the outcome equation (Newey, 1999). We follow McClellan et al. (1994) in the choice of the instrument z_{ij}, which measures the difference in the distances between the first and second provider of care for a given procedure from the patient's area of residence. The patient is expected to be more likely to choose the closest hospital if the alternative hospital is further away from her location. The differential distance between the first and second provider is a measure of the relative opportunity cost between hospital locations for a given procedure, hence it is a proper instrument for selection into the closest hospital. Patients with two hospitals at approximately the same distance from home will be marginally indifferent on travelling to one provider or another. It is unlikely that z_{ij} is endogenous for waiting times, or correlated with ε_1 or ε_0, as we can assume hospital location to be independent from the patient's area of residence, conditional on controls for y_{ij}, s_{ij} and x_{ij}.[6]

We estimate model (2) in two steps (Brave and Walstrum, 2014). In the first step, we retrieve the propensity score p (Rosenbaum and Rubin, 1983) from the estimation of a probit model for the selection equation. Based on the estimated propensity score ($\hat{p}$), the selection correction terms for the two outcome equations are computed as $\lambda_1(\hat{p}_z) = \phi\left[\Phi^{-1}(\hat{p}_z)\right] / \left[1-\hat{p}_z\right]$ and $\lambda_0(\hat{p}_z) = -\phi\left[\Phi^{-1}(\hat{p}_z)\right] / \left[\hat{p}_z\right]$. In the second step, two separate equations for the waiting time outcomes are estimated, one for each regime of hospital choice (closest/not closest). Selection correction for the two conditional means is addressed by the terms $\lambda_1(\hat{p})$ and $\lambda_0(\hat{p})$: there is a potential self-selection bias in the estimates when ρ_1 and ρ_0 are significantly different from zero. Estimation is performed by OLS on the original covariates plus the selection correction term. Standard errors are bootstrapped to account for the two-step estimation process (Murphy and Topel, 2002).

Including hospital fixed-effects h_j in the waiting times equations of the Roy model is critical. Hospital effects must be equal in the two regimes, because they represent supply or quality shifters that are valid for the same hospital, independently on the choice of the patient. Otherwise, we would be assuming different waiting time production functions for the same hospital, one for each regime of hospital bypassing. Hence we constrain the hospital level effects to be the same as those estimated by OLS in Eq. (1).[7]

We estimate a similar Roy model for the choice between CABG surgery and PCI, with analogous specifications and distributional assumptions of the error terms. Here we use the difference between the average distance to the first three CABG hospitals and the average distance to first three PCI hospitals from the patient's area of residence as an exclusion restriction (variable c_{ij}). Let k_{ij} be the indicator variable with value 1 if the patient undergoes a CABG surgery, and 0 if she opts for a PCI procedure. The estimating equations are

$$k_{ij} = I\left(m_0'c_{ij} + m_1'y_{ij} + m_2's_{ij} + m_3'x_{ij} + \varsigma_{ij} > 0\right),\ k_{ij} = \{0,1\}, \tag{6}$$

$$E\left\{w_{ij1} \mid h_{j1}, y_{ij1}, s_{ij1}, x_{ij1}, \hat{p}_c\right\} = h_{j1} + \delta_{1,1}'y_{ij1} + \delta_{2,1}'s_{ij1} + \delta_{3,1}'x_{ij1} + \rho_1\lambda_{ij1}(\hat{p}_c) \tag{7}$$

$$E\left\{w_{ij0} \mid h_{j0}, y_{ij0}, s_{ij0}, x_{ij0}, \hat{p}_c\right\} = h_{j0} + \delta_{1,0}'y_{ij0} + \delta_{2,0}'s_{ij0} + \delta_{3,0}'x_{ij0} + \rho_0\lambda_{ij0}(\hat{p}_c) \tag{8}$$

with selection correction terms $\lambda_1(\hat{p}_c) = \phi\left[\Phi^{-1}(\hat{p}_c)\right] / \left[1-\hat{p}\right]_c$ and $\lambda_0(\hat{p}_c) = -\phi\left[\Phi^{-1}(\hat{p}_c)\right] / \left[\hat{p}_c\right]$.

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[6] The differential distance could be endogenous if patients' choose their location on the basis of hospital locations. Although this hypothesis cannot be ruled out a priori, it is unlikely to be the case for most of the population in England. Moreover, in our case residential sorting requires *ex ante* knowledge of the patients about the probability of needing cardiac revascularization treatment in the near future.

[7] Hospital fixed effects are estimated from Eq. (1) and included in the estimation of Equations (4) and (5). To address any concern of estimation bias, we ran an exploratory model where the hospital effects were constrained to be proportional to those obtained through OLS, but equal in the two arms of the selection model. Then we run a t-test on the fixed-effects coefficients in each year, testing if the estimated fixed effects coefficient shifter is equal to 1. The test is never rejected, suggesting that the constrained fixed-effects in the Roy model are statistically equivalent to the OLS fixed effects from Eq. (1).

Ceteris paribus, the patient is assumed to select the procedure with the "highest availability" in her location. If hospitals providing CABG surgery are far away and PCI providers are on average closer to the patient, the patient is more likely to choose PCI to minimize her opportunity cost of travel. The set of English hospitals providing elective CABG surgery is substantially smaller compared to PCIs. While in 2002 the number of hospitals was similar (32 for CABG and 37 for PCI), by 2010 the number of hospitals offering PCIs had more than doubled (32 for CABG and 83 for PCI). For only about 30% of the patients in our sample the nearest three hospitals offer both PCI and CABG surgery, so there is substantial variation in our exclusion restriction variable. We allow for different hospital fixed-effects in the waiting time equations, h_{j1} and h_{j0} .

3.3 Fixed effects quantile regressions

We also provide estimates of a quantile regression model accounting for hospital fixed effects. Quantile regressions are useful to test how the gradient differs at different points of the waiting time distribution. Hospital fixed effects are introduced following the method proposed by Canay (2011). Provided that h_{jk} is a pure location shift of the conditional quantile function, the parameters of interest can be consistently identified by running a quantile regression of the difference between the individual outcome and the fixed effects ($\overline{w}_{ijn} = w_{ijn} - h_j$) on the usual covariate set. The outcome Equation for the $\tau\mathrm{th}$ conditional quantile (Q_τ) is given by

$$Q_\tau\left(\overline{w}_{ij1} \mid y_{ij1}, s_{ij1}, x_{ij1}\right) = \beta_{1,1}{}'(\tau) y_{ij1} + \beta_{2,1}{}'(\tau) s_{ij1} + \beta_{3,1}{}'(\tau) x_{ij1} + Q_\tau\left(\varepsilon_{ij1}(\tau)\right) \tag{9}$$

4. Data

We use data from the Hospital Episode Statistics (HES) for the nine financial years (April to March) 2002/03 to 2010/11.[8] HES is an administrative dataset containing records of all NHS-funded hospital admissions in England. The sample includes all elective patients admitted for CABG surgery or PCI. We exclude duplicates, incomplete admission records, or records with missing information on important covariates. Elective inpatient waiting time measures the total wait of the patient from the time she is added to the waiting list to when she is admitted to hospital to receive treatment. We extract information on patients' age, gender, month of admission, and severity controls such as number of secondary diagnoses, Charlson comorbidities and the number of past emergency admissions to hospitals in the year preceding the surgery.

As a measure of income deprivation we use the income domain of the Economic Deprivation Index (EDI) (Gill, 2012). This index tracks levels of economic deprivation from 1999 to 2009 in small areas in England, called Lower-layer Super Output Areas (LSOAs). In the period 2002-2011, there were 32,482 LSOAs, with an average population of around 1500 residents. EDI measures the proportion of people aged under 60 in an area who are living in low income households (more specifically, benefit units) that are claiming certain out-of-work means-tested social security benefits.[9] It is also referred to as the income deprivation rate. EDI is comparable over the period considered since it takes account of changes to the tax and benefit systems over time. For this reason, using EDI to proxy income deprivation is preferable to the more commonly used Index of Multiple Deprivation. LSOAs are ranked according to the level of economic deprivation in each year. Our main regressors of interest are a set of dummy variables, corresponding to the five quintiles of the income deprivation distribution at LSOA level in each year of the sample. The first and fifth quintiles represent respectively the most and least income deprived LSOAs.[10]

Straight-line distances between the patient LSOA of residence and all relevant hospitals in a given year are computed by matching HES data with hospital postcode information and geographic coordinates. The hospital choice sets for patients are computed separately by procedures, and then merged. We construct a binary indicator for bypassing the closest hospital, based on the actual procedure chosen.

Table 1 provides descriptive statistics on treated patients and average waiting times. Over the period considered, there have been more than 320,000 elective publicly-funded revascularization procedures. The number of PCIs was almost twice that of CABG surgeries at the end of the period, despite the level being quite similar in 2002. The drop in CABG procedures and the increase in PCIs indicate a plausible substitution effect over time.

For both procedures waiting times have declined sharply in the last decade starting at 153 (90) days for CABG (PCI) in 2002 and falling to 50 (40) in 2010. Figure 1(a) and Figure 1(b) show the trend in the average waiting times for the two revascularization procedures between 2002 and 2010, i.e. the unconditional waiting times means by income deprivation category. Unconditional waiting times for CABG (PCI) fell sharply after 2003 (2004). For both procedures, in the starting years of the sample patients living in the most deprived LSOAs (Q1) waited longer than those patients living in the least deprived areas (Q5). While this is true for PCI patients in all the years of the sample, most income-

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[9] In particular, the means-tested benefits are Income Support (IS) or income-based Jobseeker's Allowance (JSA-IB). For further details on the procedure and the index calculation, see McLennan et al. (2011).

[10] In the regression analysis we consider the least income deprived quintile as the reference category. We estimate each model with a constant, hence the reference category gets omitted from the specifications.

deprived CABG patients seemed to receive a faster treatment than their least deprived counterparts from 2008 onwards.

Table 1: Treated patients and average waiting times by year and procedure.

Revascularization Procedures	PCI (coronary angioplasty)		CABG (coronary bypass)	
Years	Patients Treated	Average Wait (days)	Patients Treated	Average Wait (days)
Whole sample	*211,589*	*57.57*	*109,487*	*83.17*
2002	16,099	89.76	14,661	153.48
2003	20,144	93.03	14,219	106.12
2004	24,358	83.73	14,074	98.33
2005	25,632	56.47	12,060	65.36
2006	26,775	52.54	11,536	65.93
2007	25,553	44.30	12,218	64.43
2008	25,404	37.35	11,831	57.82
2009	23,862	40.03	10,000	49.54
2010	23,762	39.23	8,888	50.39

Table 2 reports descriptive statistics of the patient sample. Both PCI and CABG patients are on average 64-65 years old. PCI patients have fewer comorbidities and more past emergency utilizations in the year preceding the intervention than CABG patients. Both procedures are spread similarly in terms of LSOA income deprivation and months of admission. 82% (74%) of CABG (PCI) patients are male. The average distance travelled to the chosen hospital is 32 (26) km for CABG (PCI) patients, being higher for CABG patients since fewer hospitals offer this procedure. More than 35% of patients bypass the local hospital.

The exclusion restriction variables are based on distances and are reported at the bottom of the table. For patients who underwent CABG surgery, the average difference between the closest and second-closest hospital is 22km, although for a quarter of patients this distance exceeds 42.5km. Similarly, the mean differential distance for PCI patients is 16km and for 25% of patients it exceeds 33km. Hospitals that provide CABG surgery are on average further away than those providing PCI services for all patients in our sample, although this difference is less pronounced for patients that underwent CABG surgery (11km vs 13km), i.e. CABG surgery was relatively more available to them.

Table 2: Sample descriptive statistics by procedure.

	Mean PCI	Mean CABG
Waiting Times (in days)	57.57	83.17
EDI Income - 1st Quintile (most deprived)	18.66%	19.13%
EDI Income - 2nd Quintile	19.70%	20.09%
EDI Income - 3rd Quintile	20.89%	20.89%
EDI Income - 4th Quintile	20.92%	20.82%
EDI Income - 5th Quintile	19.82%	19.07%
Patient bypasses the closest hospital	38.61%	35.96%
Number of diagnosis	4.37	5.72
Past emergency utilization past 365 days	0.37	0.28
Patient age	64.09	65.33
Patient is female	25.85%	18.09%
Distance between patient's LSOA to chosen hospital (km)	24.53	32.41
Congestive Heart Failure	2.45%	7.09%
Peripheral Vascular Disease	4.16%	7.36%
Cerebrovascular Disease	0.63%	2.74%
Chronic Obstructive Pulmonary Disease	7.01%	8.55%
Rheumatoid Disease	0.86%	0.99%
Peptic Ulcer Disease	0.17%	0.43%
Mild Liver Disease	0.16%	0.19%
Diabetes	16.76%	20.76%
Diabetes & Complications	0.59%	0.98%
Renal Disease	2.52%	3.48%
Cancer	0.73%	0.82%
Admission Month: January	8.31%	8.53%
Admission Month: February	8.48%	8.06%
Admission Month: March	9.19%	8.62%
Admission Month: April	7.79%	8.14%
Admission Month: May	7.76%	8.26%
Admission Month: June	8.74%	8.92%
Admission Month: July	8.80%	8.79%
Admission Month: August	7.96%	8.50%
Admission Month: September	8.54%	8.72%
Admission Month: October	8.67%	8.72%
Admission Month: November	9.01%	8.52%
Admission Month: December	6.75%	6.23%
Distance difference: 2nd minus 1st closest hospital (CABG)		22.15
Distance difference : 2nd minus 1st closest hospital (PCI)	16.07	
Difference in mean hospitals distances: 3 closest CABG minus 3 closest PCI	12.92	10.80

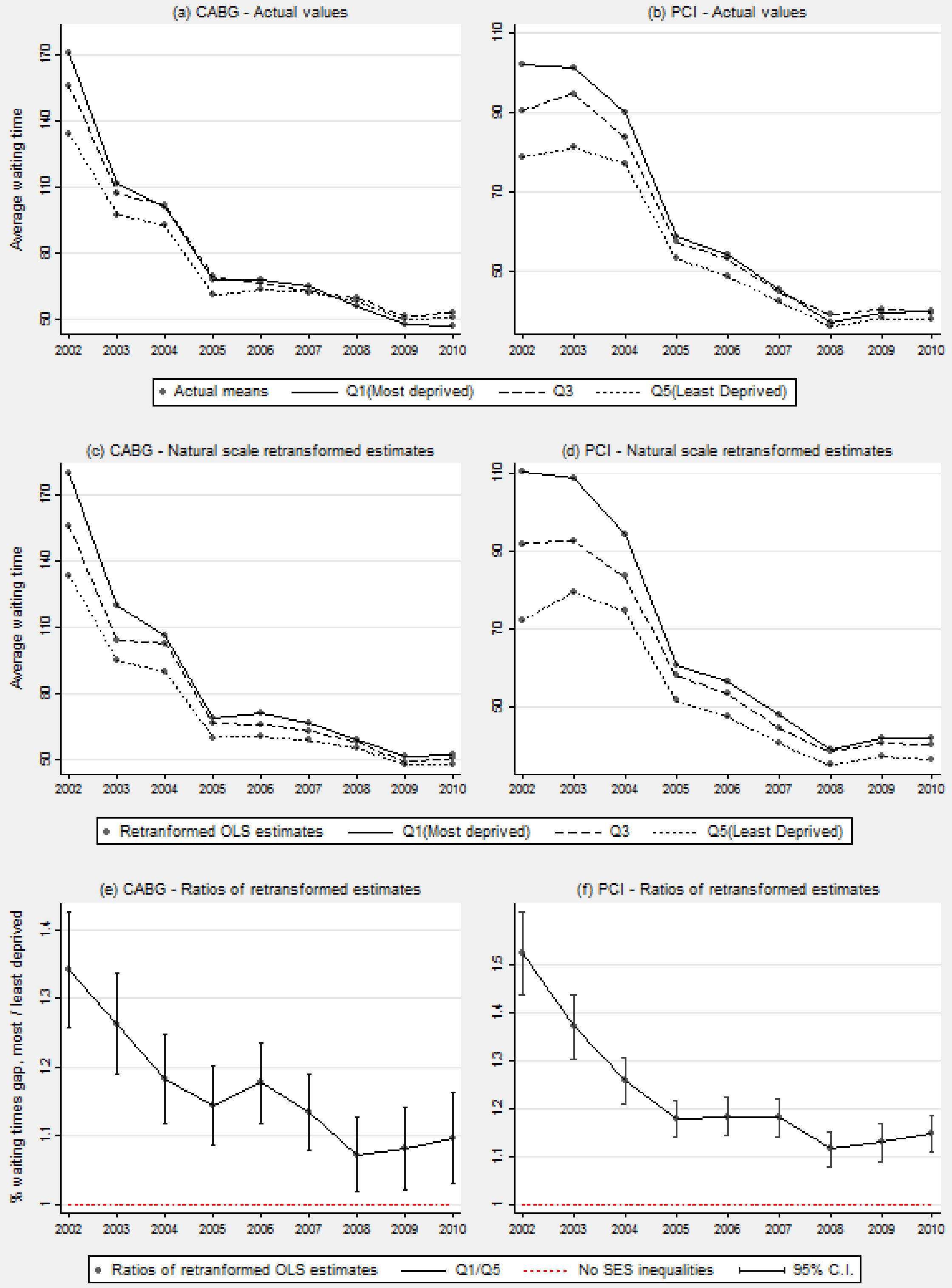

Figure 1: Actual and estimated absolute and percentage income-related inequalities in waiting times over years 2002/2010.

5. Results

5.1 OLS with Hospital Fixed Effects

Table 3 and Table 4 show the effect of income deprivation on waiting time for CABG and PCI patients respectively. The inequality gradient is statistically significant at 1% level for the two most deprived income quintiles in each year for PCI and for most years for CABG.

We plot the conditional waiting time in days, after applying a Duan smearing adjustment, in Figure 1 (c) and Figure 2 (d). The figures show that in 2002, CABG patients who were most income deprived waited 35% longer than least income deprived ones, as measured on the natural scale (see Figure 1 (e)). The effect reduced over time, but remained between 18% and 8% in all years after 2005. The quantitative effect is larger for patients who underwent PCI. In 2002, patients who were most income deprived waited 52% longer than the least income-deprived patients (see Figure 1 (f)). The gap remains above 18% in all years up to 2007 and above 10% after 2007.

Controlling for other variables, the difference in waiting times between the most and least deprived patients was 43 days for CABG and 24 days for PCI in 2002. By 2010, it was five days for both procedures.

All case-mix variables showed the expected sign and were statistically significant in most specifications. For example, the effect of past emergency utilizations on waiting time is negative and significant at 1%, which is consistent with patient prioritisation on the basis of health status.

5.2 Switching regression with choice of bypassing the closest hospital

Tables 5 and 6 show the effect of income deprivation on waiting times accounting for self-selection due to bypassing the closest hospital.[11] CABG and PCI patients are analysed separately. In almost every year, the selection correction term is statistically significant, providing evidence of self-selection. In both procedure sub-samples, the first stage probit suggests that least income-deprived patients are more mobile and incline to travel farther, bypassing the closest hospitals, while the opposite is true for the patients in most income-deprived areas.

Until 2006/7, the income inequality gradient for patients bypassing local hospitals is less pronounced than for those treated at the closest hospital for both procedures. The most income deprived CABG (PCI) patients admitted to the closest hospital waited around 37% (43%) in 2002 and 17% (18%) in 2010 longer compared to the least income deprived ones. The most deprived patients CABG (PCI) patients bypassing the closest hospital waited instead 17% (40%) in 2002 and 14% (14%) in 2010 longer compared to the least income deprived ones. From 2008/9 onwards the gradient tends to fade away in size and is not always statistically significant for CABG patients, while it remains statistically significant for PCI patients.

The first stage regression shows that a higher differential distance between the closest and second closest provider (our exclusion restriction) implies a lower probability of bypassing the local hospital and it is always statistically significant at the 1% level for both procedures.

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[11] We also formally test for the hypothesis of switching regimes by revascularization procedure and by choice of closest hospital bypassing, through a Chow test (Chow, 1960); and for the common support of the propensity score across self-selection arms, via histograms. Results are reported in Appendices A and B and confirm both the switching regimes hypothesis and the presence of a substantial common support for the propensity score.

Table 3: Effect of income deprivation (quintiles of yearly income deprivation distribution) on CABG waiting times.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	2002	2003	2004	2005	2006	2007	2008	2009	2010
EDI income 1st quintile (most deprived)	0.2942***	0.2333***	0.1681***	0.1346***	0.1627***	0.1260***	0.0702**	0.0779***	0.0921**
EDI income 2nd quintile	0.2092***	0.1871***	0.1013***	0.1150***	0.1451***	0.1623***	0.0656**	0.0819***	0.0935**
EDI income 3rd quintile	0.1529***	0.0903**	0.1341***	0.0983***	0.0834**	0.0724***	0.0485*	0.0270	0.0648*
EDI income 4th quintile	0.0221	0.0582*	0.0528**	0.0628**	0.0343	0.0947***	0.0279	0.0081	0.0326
Constant	4.2215***	4.0960***	4.0651***	3.6726***	3.7363***	3.6791***	3.6018***	3.4662***	3.4424***
Patients	14654	14213	14074	12060	11536	12218	11829	10000	8888
Hospital Sites	32	35	34	32	32	33	34	32	32
R^2	0.19	0.19	0.12	0.13	0.17	0.22	0.17	0.17	0.15

Notes. Controls: Age, age bands dummies, admission month, Charlson comorbidities dummies, gender, number of secondary diagnoses, past emergency utilization, hospital fixed effects. * p<0.10, ** p<0.05, *** p<0.01

Table 4: Effect of income deprivation (quintiles of yearly income deprivation distribution) on PCI waiting times.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	2002	2003	2004	2005	2006	2007	2008	2009	2010
EDI income 1st quintile (most deprived)	0.4231***	0.3164***	0.2306***	0.1637***	0.1688***	0.1667***	0.1098***	0.1217***	0.1381***
EDI income 2nd quintile	0.3402***	0.2654***	0.1980***	0.1581***	0.1638***	0.1204***	0.0954***	0.1186***	0.1193***
EDI income 3rd quintile	0.2402***	0.1569***	0.1102***	0.1164***	0.1171***	0.0924***	0.0986***	0.0887***	0.0966***
EDI income 4th quintile	0.1078***	0.0931***	0.0487**	0.0361*	0.0667***	0.0667***	0.0520***	0.0539**	0.0490**
Constant	3.7968***	3.9128***	3.9489***	3.5820***	3.5585***	3.2195***	3.2286***	3.1844***	3.2231***
Patients	16095	20140	24355	25632	26772	25545	25399	23861	23759
Hospital Sites	37	42	44	52	60	66	73	76	83
R^2	0.13	0.14	0.13	0.12	0.10	0.15	0.16	0.18	0.16

Notes. Controls: Age, age bands dummies, admission month, Charlson comorbidities dummies, gender, number of secondary diagnoses, past emergency utilization, hospital fixed effects. * p<0.10, ** p<0.05, *** p<0.01

Table 5: Roy model: Income inequalities in CABG waiting times, accounting for selection of hospital distance.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	2002	2003	2004	2005	2006	2007	2008	2009	2010
Patients not choosing the closest CABG hospital site – Equation (4)									
EDI income 1st quintile	0.1671***	0.2229***	0.2274***	0.0818*	0.1429***	0.1636***	0.0153	0.0976**	0.0660
EDI income 2nd quintile	0.1086**	0.1947***	0.0856*	0.0797*	0.1353***	0.1760***	0.0150	0.1095**	0.1583***
EDI income 3rd quintile	0.0474	0.0807*	0.1564***	0.0716*	0.0690	0.1062***	0.0421	0.0724	0.0227
EDI income 4th quintile	-0.0035	0.0691	0.0381	0.0272	0.0104	0.1395***	0.0076	0.0265	0.0484
IMR1 - Not closest	0.1277**	0.1970***	0.2664***	0.0086	-0.0465	0.0187	0.1122**	0.0505	-0.0653
Constant	4.3941***	4.1392***	4.3827***	3.7694***	3.7312***	3.6206***	3.6255***	3.6014***	3.3693***
Patients choosing the closest CABG hospital site – Equation (5)									
EDI income 1st quintile	0.3666***	0.2527***	0.1469***	0.1687***	0.1762***	0.1089***	0.1114***	0.0692**	0.1020***
EDI income 2nd quintile	0.2711***	0.1846***	0.1166***	0.1405***	0.1523***	0.1535***	0.0985***	0.0708**	0.0608*
EDI income 3rd quintile	0.2172***	0.1045***	0.1287***	0.1172***	0.0933***	0.0514*	0.0689**	0.0057	0.0847**
EDI income 4th quintile	0.0427	0.0577	0.0690**	0.0883***	0.0513	0.0693**	0.0433	-0.0009	0.0265
IMR0 - Closest	-0.0174	-0.0091	-0.0988**	-0.0172	0.0281	-0.0234	0.0522	0.0014	0.0719**
Constant	4.1892***	4.1937***	4.0696***	3.6239***	3.7021***	3.7343***	3.6118***	3.4253***	3.4176***
1st Stage Probit for Choice of provider by distance: CLOSEST vs NOT CLOSEST hospital - only CABG – Equation (3)									
Distance difference 2nd - 1st provider	-0.0339***	-0.0184***	-0.0182***	-0.0316***	-0.0366***	-0.0282***	-0.0318***	-0.0329***	-0.0380***
EDI income 1st quintile	-0.1832***	-0.2132***	-0.2065***	-0.2825***	-0.3233***	-0.2321***	-0.2405***	-0.1738***	-0.1348***
EDI income 2nd quintile	-0.0185	-0.0361	-0.0186	-0.0800**	-0.0185	-0.0854**	-0.0165	-0.0561	-0.0017
EDI income 3rd quintile	-0.0233	-0.0503	-0.0229	-0.0110	-0.0868**	-0.0273	-0.0725*	0.0130	0.0187
EDI income 4th quintile	-0.0265	-0.0171	-0.0426	-0.0313	-0.0706*	-0.0546	0.0397	0.0268	0.0591
Constant	0.2726***	0.1231**	0.0626	0.2071***	0.2775***	0.1454**	0.1883***	0.1853***	0.2735***
Patients	14654	14213	14074	12060	11536	12218	11829	10000	8888
Chi-squared p-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudo R^2	0.14	0.08	0.09	0.15	0.18	0.13	0.15	0.14	0.18

Notes. Roy model on CABG sample based on Model (2). Exclusion restriction in the 1st stage regression: differential distance between second and first CABG hospital site. Controls: Age, age bands dummies, admission month, Charlson comorbidities dummies, Gender, Number of diagnosis, Emergency Past utilization previous year, hospital fixed effects (except for 1st stage probit choice). IMR = Parametric selection correction (Inverse Mills Ratio). * p<0.10, ** p<0.05, *** p<0.01

Table 6: Roy model: Income inequalities in PCI waiting times, accounting for selection of hospital distance.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	2002	2003	2004	2005	2006	2007	2008	2009	2010
Patients not choosing the closest PCI hospital site – Equation (4)									
EDI income 1st quintile	0.4043***	0.2845***	0.1846***	0.1478***	0.1422***	0.2120***	0.1269***	0.1496***	0.1425***
EDI income 2nd quintile	0.3251***	0.2956***	0.1930***	0.1516***	0.1340***	0.1537***	0.1314***	0.1612***	0.1119***
EDI income 3rd quintile	0.2375***	0.1595***	0.0912***	0.1169***	0.0881***	0.1424***	0.1174***	0.1277***	0.0824***
EDI income 4th quintile	0.0710	0.0890**	0.0013	0.0474*	0.0645**	0.1115***	0.0717***	0.0980***	0.0771***
IMR1 - Not Closest	-0.1001**	-0.0272	-0.0386	-0.0018	-0.0648**	-0.0106	-0.0575**	0.0263	-0.0054
Constant	3.5600***	3.8989***	3.8665***	3.5116***	3.4935***	3.1513***	3.1757***	3.2392***	3.2156***
Patients choosing the closest PCI hospital site – Equation (5)									
EDI income 1st quintile	0.4344***	0.3219***	0.2493***	0.1747***	0.1841***	0.1363***	0.1004***	0.1090***	0.1374***
EDI income 2nd quintile	0.3447***	0.2394***	0.1992***	0.1634***	0.1868***	0.0966***	0.0735***	0.0946***	0.1228***
EDI income 3rd quintile	0.2412***	0.1471***	0.1204***	0.1171***	0.1362***	0.0537**	0.0855***	0.0689***	0.1061***
EDI income 4th quintile	0.1292***	0.0909***	0.0735***	0.0292	0.0654***	0.0333	0.0400*	0.0301	0.0336
IMR0 - Closest	0.1104***	0.0279	-0.0073	-0.0035	-0.0267	-0.0093	-0.0102	0.0286	0.0037
Constant	3.8188***	3.9022***	3.9710***	3.6293***	3.5824***	3.2653***	3.2319***	3.1540***	3.2218***
1^{st} Stage Probit for Choice of provider by distance: CLOSEST vs NOT CLOSEST hospital - only PCI – Equation (3)									
Distance difference 2nd - 1st provider	-0.0342***	-0.0419***	-0.0385***	-0.0408***	-0.0174***	-0.0224***	-0.0302***	-0.0422***	-0.0423***
EDI income 1st quintile	-0.3843***	-0.3981***	-0.3217***	-0.2464***	-0.1281***	-0.0521**	-0.0282	-0.1350***	-0.1433***
EDI income 2nd quintile	-0.1111***	-0.1223***	-0.0101	-0.0190	-0.0220	0.0588**	0.0614**	-0.0193	-0.0569**
EDI income 3rd quintile	-0.0792**	-0.0775**	-0.0409	-0.0400	0.0102	0.0317	0.0642**	0.0313	0.0308
EDI income 4th quintile	-0.0871***	-0.0644**	-0.0442	-0.0030	-0.0008	-0.0036	0.1045***	0.0278	0.0270
Constant	0.2822***	0.3393***	0.2140***	0.3757***	0.0823**	0.1052***	0.0909**	0.0974**	0.1691***
Patients	16095	20140	24355	25632	26772	25545	25399	23861	23759
Chi-squared p-value	0	0	0	0	0	0	0	0	0
Pseudo R^2	0.14	0.18	0.16	0.16	0.05	0.07	0.08	0.1	0.09

Notes. Roy model on PCI sample based on Model (2). Exclusion restriction in the 1^{st} stage regression: differential distance between second and first PCI hospital site. Controls: Age, age bands dummies, admission month, Charlson comorbidities dummies, Gender, Number of diagnosis, Emergency Past utilization previous year, hospital fixed effects (except for 1^{st} stage probit choice). IMR = Parametric selection correction (Inverse Mills Ratio). * p<0.10, ** p<0.05, *** p<0.01

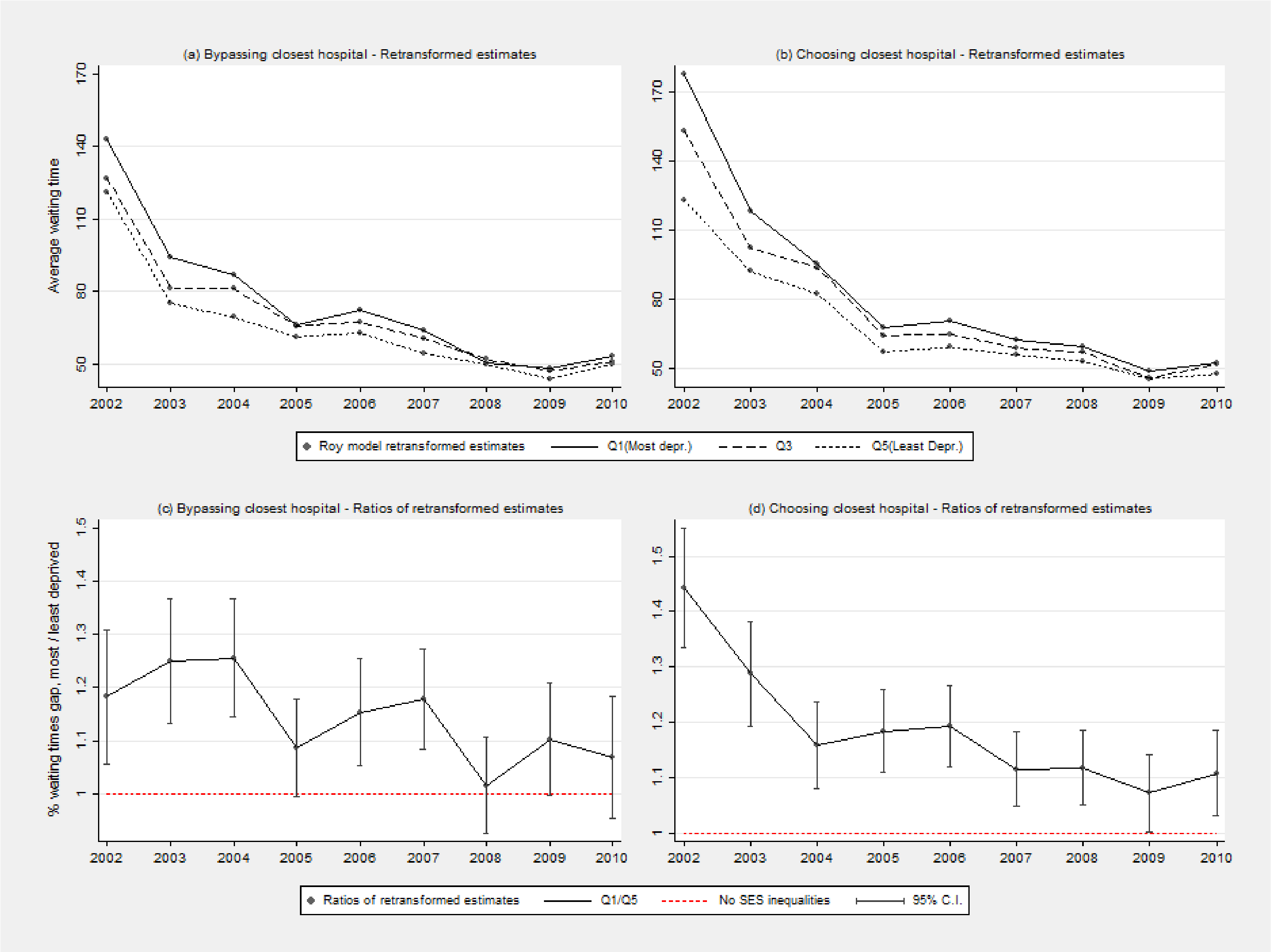

Figure 2: Estimated CABG waiting times by chosen hospital location and deprivation quintile

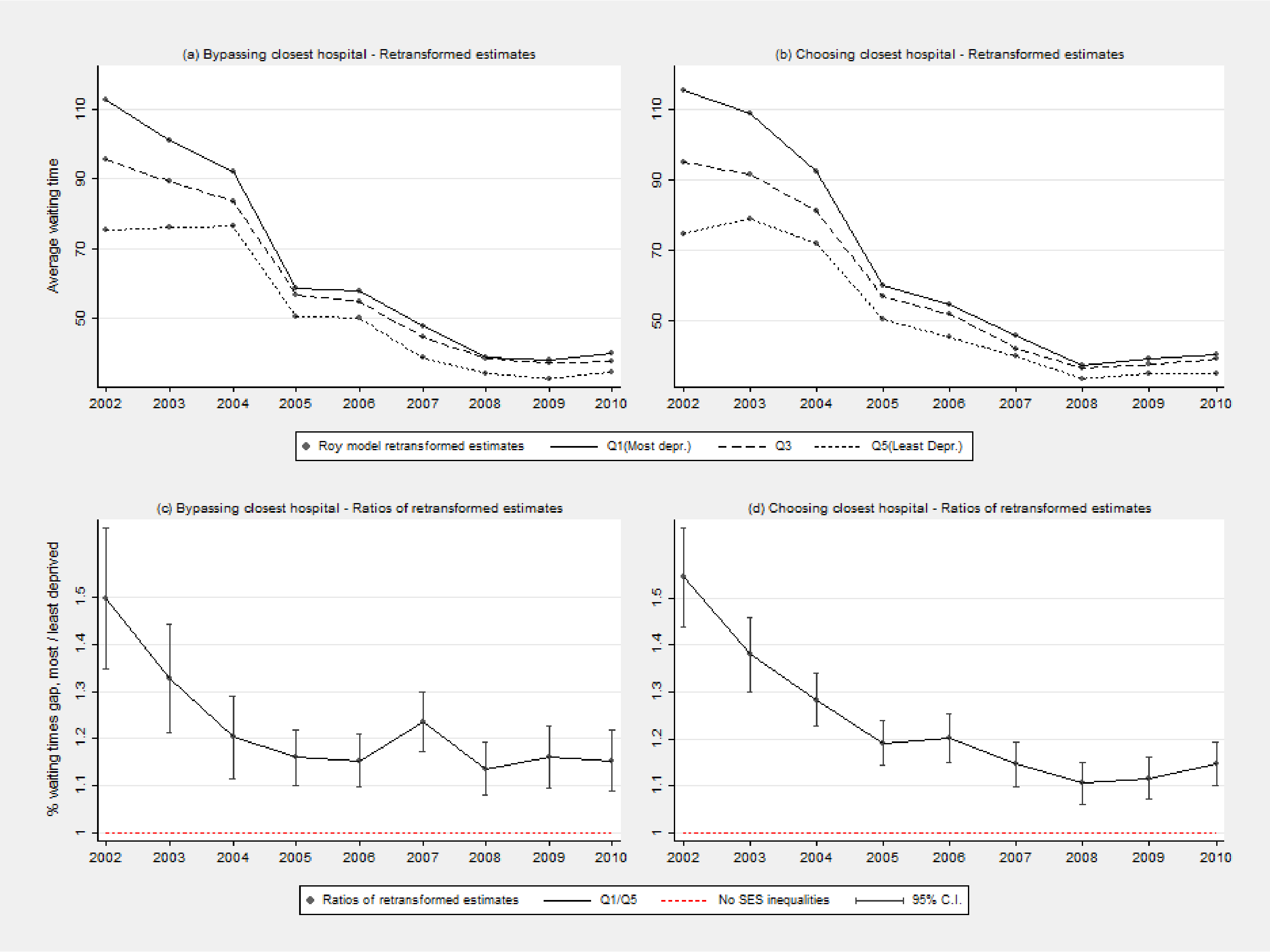

Figure 3: Estimated PCI waiting times by chosen hospital location and deprivation quintile

Overall, the second stage regressions confirm the presence of a significant (both quantitatively and statistically) socioeconomic gradient in waiting times. Not surprisingly, the magnitude of the OLS gradient is an average of the estimated gradients of the switching regression model.

Figure 2 and Figure 3 show the plots of the conditional estimates from the Roy model with choice of bypassing the closest hospital after being retransformed on the raw scale with a Duan smearing adjustment.

The estimates plotted in the graphs confirm the OLS results on the presence of the gradient. Substantial income-related inequalities in waiting times between patients living in the most and the least deprived areas persist even allowing for choice. However, the decision to bypass the closest hospital pays off, for patients of both procedures in each year. The inequality gap is smaller for CABG patients who travel farther. In 2002/03 (2010/11) the gap for most deprived CABG patients bypassing the closest hospital was equal to 18% (7%), and 44% (11%) for patients treated at the closest provider. Not only did inequalities decline together with average waiting times, but choice might have been beneficial, at least in partially reducing the gap in healthcare access between the most and least deprived. This is especially true for CABG patients, having a very limited number of providers to be treated at.

Bypassing the closest provider was beneficial only in the early years for PCI most deprived patients. In 2002/03 (2010/11) the percentage gap for PCI most deprived patients bypassing the closest hospital was equal to 50% (15%), compared to 54% (15%) for patients treated at the closest provider. The different dynamics for the gap of PCI patients might be due to the large increase in the number of PCI providers, which almost doubled during the period. The increase in PCI suppliers and supply has likely reduced the number of patients bypassing the closest hospital in search of more favourable waiting times.

5.3 Switching regressions with choice of procedure

Table 7 shows the effect of income deprivation on waiting times accounting for self-selection into procedure. The first stage probit suggests that no significant preference in the choice of revascularization procedure is due to the income deprivation status. This is reassuring, as in an equitable healthcare system the choice between procedures is granted fairly to patients of any socioeconomic background. The selection correction terms are significant at 5% levels in just five of the nine years. In line with simpler OLS models, results indicate larger income-related inequalities in waiting times for PCI than for CABG surgery. Compared to the OLS results, the quantitative effect of the gradient is generally unchanged when self-selection into treatment is taken into account, with the exception of the estimates for 2002.

The coefficient of the exclusion restriction variable is negative and significant at 1% level in five of the nine years analysed. As expected, a larger differential distance to CABG provider reduces the probability of choosing CABG surgery.

Table 7: Roy model. Income inequalities in waiting times on CABG and PCI samples, accounting for selection of procedure.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	2002	2003	2004	2005	2006	2007	2008	2009	2010
Patients choosing CABG – Equation (7)									
EDI income 1st quintile	0.3605***	0.2238***	0.1614***	0.1319***	0.1544***	0.1260***	0.0695***	0.0783***	0.0927***
EDI income 2nd quintile	0.2557***	0.1711***	0.1028***	0.1107***	0.1425***	0.1623***	0.0708***	0.0809***	0.0925***
EDI income 3rd quintile	0.1868***	0.0894***	0.1423***	0.0959***	0.0878***	0.0724***	0.0481*	0.0267	0.0679**
EDI income 4th quintile	0.0450	0.0685**	0.0602**	0.0578**	0.0336	0.0947***	0.0225	0.0080	0.0300
IMR1 - CABG	-0.5930**	0.7736**	0.5971**	0.1162	0.3761	-0.0025	-0.2828	0.1087	0.1413
Constant	3.9205***	4.7000***	4.2609***	3.8637***	4.2500***	3.9414***	3.0829***	3.2087***	3.3728***
Patients choosing PCI – Equation (8)									
EDI income 1st quintile	0.5063***	0.3105***	0.2323***	0.1661***	0.1688***	0.1670***	0.1093***	0.1189***	0.1364***
EDI income 2nd quintile	0.3974***	0.2556***	0.1977***	0.1622***	0.1638***	0.1193***	0.0988***	0.1215***	0.1214***
EDI income 3rd quintile	0.2819***	0.1568***	0.1083***	0.1189***	0.1171***	0.0903***	0.0985***	0.0898***	0.0906***
EDI income 4th quintile	0.1365***	0.0998***	0.0469**	0.0406**	0.0667***	0.0672***	0.0486***	0.0547***	0.0541***
IMR0 - PCI	-0.7795*	0.5696	-0.1959	-0.1536	0.0035	0.1766	-0.2522	-0.5481***	-0.4976***
Constant	4.2005***	3.5923***	4.1968***	3.6976***	3.5055***	3.0236***	3.5466***	3.4960***	3.4379***
1st Stage Probit for Choice of procedure: CABG vs PCI – Equation (6)									
Differential distance of first 3 hospitals by procedure	-0.0016***	0.0001	-0.0013***	-0.0008**	-0.0004	0.0009***	-0.0003	-0.0008**	-0.0020***
EDI income 1st quintile	0.1810***	0.0191	0.0173	0.0338	0.0295	-0.0008	-0.0030	-0.0087	-0.0053
EDI income 2nd quintile	0.1254***	0.0314	-0.0024	0.0543**	0.0077	0.0148	0.0281	0.0139	0.0104
EDI income 3rd quintile	0.0909***	0.0016	-0.0176	0.0314	-0.0171	0.0252	-0.0014	0.0039	-0.0300
EDI income 4th quintile	0.0636***	-0.0210	-0.0177	0.0612***	0.0017	-0.0050	-0.0284	0.0013	0.0282
Constant	-0.0714**	-0.1671***	-0.3132***	-0.4841***	-0.4246***	-0.2987***	-0.3746***	-0.4634***	-0.5697***
Patients	30749	34353	38429	37692	38308	37763	37228	33861	32647
Chi2_pval	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudo R^2	0.07	0.07	0.07	0.07	0.08	0.08	0.10	0.10	0.13

Notes. Roy model on joint CABG and PCI samples. Exclusion restriction in the 1st stage regression: (average) distance between the first three hospitals providing CABG and the first three ones providing PCI. Controls: Age, age bands dummies, admission month, Charlson comorbidities dummies, Gender, Number of diagnosis, Emergency Past utilization previous year, hospital fixed effects (except for 1st stage probit choice). IMR = Parametric selection correction (Inverse Mills Ratio). * p<0.10, ** p<0.05, *** p<0.01

5.4 Quantile regressions with hospital fixed effects

Table 8 and Table 9 report the effect of income deprivation on waiting times at different quantiles (10th, 25th, 50th, 75th and 90th) of the conditional waiting time distribution. Income-related inequalities affected the entire waiting time distribution and were not confined to hospital with either relatively short or long waiting times.

We plot the conditional waiting time in days, after applying a Duan smearing adjustment, in Figure 1 (b) and Figure 1 (e). The figures show that in 2002, CABG patients who were most income deprived waited 35% longer than least income deprived ones, as measured on the natural scale (see Figure 1 (c)). The effect reduced over time, but remained between 18% and 8% in all years after 2005. The quantitative effect is larger for patients who underwent PCI. In 2002, patients who were most income deprived waited 52% longer than the least income-deprived patients (see Figure 1 (f)). The gap remains above 18% in all years up to 2007 and above 10% after 2007.

In the PCI sample, the dynamics are somewhat different. The gradient is still decreasing in time and it reduces as the conditional waiting time increases. But the gradient remains significant at shorter waits, and it completely fades away at longer waits. This could be evidence of a “selection into treatment” effect: wealthier patients might choose PCI instead of CABG as long as they are treated promptly. When they are not given sufficiently short waiting times (below 90th quantile), they have weaker incentives to insist on shorter wait and might switch to CABG, which offers longer-lasting health benefits.

Table 8: Quantile Regression with hospital fixed effects (Equation (9)). Income inequalities in waiting times. CABG patients.

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		2002	2003	2004	2005	2006	2007	2008	2009	2010
Q10	EDI income 1st quintile	0.4781***	0.3623***	0.1852**	0.2308***	0.1857**	0.2108**	0.1797**	0.1173*	0.1224
	EDI income 2nd quintile	0.3441***	0.2063**	0.1333	0.3140***	0.2455**	0.3423***	0.1507*	0.1380*	0.0968
	EDI income 3rd quintile	0.1438	0.1042	0.3044***	0.2311***	0.1746*	0.2012**	0.1857**	0.0525	0.0831
	EDI income 4th quintile	0.0392	0.0204	0.0742	0.1675**	0.0227	0.2250***	0.1355*	0.1347**	0.0665
	Constant	2.6351***	2.7324***	2.4530***	2.2791***	2.4700***	2.5190***	2.5164***	2.2392***	2.1420***
Q25	EDI income 1st quintile	0.4076***	0.2912***	0.2459***	0.1217***	0.1500***	0.1073**	0.1029**	0.0274	0.0860*
	EDI income 2nd quintile	0.2803***	0.2719***	0.1611***	0.1403***	0.1658***	0.2006***	0.0201	0.0964**	0.0801*
	EDI income 3rd quintile	0.2522***	0.1281**	0.2197***	0.1473***	0.1407***	0.0958**	0.0925**	0.0676	0.1162***
	EDI income 4th quintile	0.0645	0.1213**	0.1196**	0.1193**	0.0463	0.1552***	0.0445	0.0054	0.0747*
	Constant	3.6949***	3.6300***	3.6097***	3.3185***	3.4895***	3.4133***	3.2577***	3.0262***	2.9401***
Q50	EDI income 1st quintile	0.3345***	0.1708***	0.1266***	0.0981***	0.0909***	0.0547***	0.0417*	0.0500*	0.0348
	EDI income 2nd quintile	0.2652***	0.1521***	0.0754**	0.0649***	0.0902***	0.0586***	0.0473**	0.0400	0.0556*
	EDI income 3rd quintile	0.1997***	0.0900***	0.0758***	0.0503***	0.0537***	0.0145	0.0157	0.0177	0.0717**
	EDI income 4th quintile	0.0776**	0.0831***	0.0688***	0.0220	0.0123	0.0097	0.0121	-0.0058	0.0449
	Constant	4.4834***	4.2945***	4.3179***	3.9716***	3.9942***	3.8896***	3.7613***	3.6483***	3.6208***
Q75	EDI income 1st quintile	0.1666***	0.1572***	0.1038***	0.1110***	0.0733***	0.0914***	0.0478**	0.0699***	0.0611**
	EDI income 2nd quintile	0.1154***	0.1267***	0.0583***	0.0722***	0.0678***	0.0676***	0.0580***	0.0713***	0.0764***
	EDI income 3rd quintile	0.0943***	0.0758***	0.0417**	0.0536***	0.0123	0.0025	-0.0035	-0.0064	0.0165
	EDI income 4th quintile	0.0158	0.0513**	0.0130	0.0115	0.0007	0.0188	0.0009	-0.0169	0.0206
	Constant	5.0263***	4.7974***	4.8169***	4.2386***	4.2504***	4.2022***	4.1475***	4.1075***	4.0677***
Q90	EDI income 1st quintile	0.1246***	0.1572***	0.1269***	0.2071***	0.1492***	0.1270***	0.0634**	0.1068***	0.0931**
	EDI income 2nd quintile	0.0673**	0.0826***	0.0832***	0.0963***	0.0672**	0.1195***	0.0547**	0.0808***	0.0730**
	EDI income 3rd quintile	0.0729***	0.0235	0.0261	0.1418***	0.0097	0.0181	-0.0061	0.0186	-0.0086
	EDI income 4th quintile	-0.0398	0.0064	0.0114	0.0423	0.0064	0.0492*	-0.0252	-0.0341	-0.0359
	Constant	5.4508***	5.2016***	5.1144***	4.4868***	4.5393***	4.5039***	4.4267***	4.3707***	4.4607***
	Patients	14654	14213	14074	12060	11536	12218	11829	10000	8888

Notes. Sample: CABG patients only. Controls: Age, age bands dummies, Charlson comorbidities dummies, Gender, Number of diagnosis, Emergency Past utilization previous year, hospital fixed effects. * p<0.10, ** p<0.05, *** p<0.01

Table 9: Quantile Regression with hospital fixed effects (Equation (9)). Income inequalities in waiting times. PCI patients.

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		2002	2003	2004	2005	2006	2007	2008	2009	2010
Q10	EDI income 1st quintile	0.5347***	0.6444***	0.4813***	0.3905***	0.4859***	0.4600***	0.2968***	0.3182***	0.3839***
	EDI income 2nd quintile	0.4944***	0.5205***	0.4590***	0.4294***	0.4193***	0.3107***	0.2569***	0.2808***	0.3241***
	EDI income 3rd quintile	0.3526***	0.2711***	0.2661***	0.2765***	0.3062***	0.2480***	0.2604***	0.2150***	0.2933***
	EDI income 4th quintile	0.1697***	0.1847***	0.1071*	0.0948*	0.1548***	0.1789***	0.1513***	0.1225**	0.1468***
	Constant	2.2762***	2.1458***	2.6752***	2.4491***	2.3963***	1.9818***	2.1178***	2.0808***	2.0726***
Q25	EDI income 1st quintile	0.5478***	0.4538***	0.3173***	0.2200***	0.2393***	0.1999***	0.1251***	0.1640***	0.1394***
	EDI income 2nd quintile	0.4572***	0.3758***	0.2781***	0.1969***	0.2126***	0.1406***	0.1156***	0.1771***	0.1437***
	EDI income 3rd quintile	0.2863***	0.2468***	0.1435***	0.1612***	0.1671***	0.1349***	0.1197***	0.1322***	0.1216***
	EDI income 4th quintile	0.0950*	0.1418***	0.1018***	0.0475	0.0994***	0.1159***	0.0722***	0.0731***	0.0756***
	Constant	3.1844***	3.3229***	3.5771***	3.2415***	3.2364***	2.8132***	2.8449***	2.8313***	2.8654***
Q50	EDI income 1st quintile	0.4000***	0.2463***	0.1590***	0.0902***	0.0993***	0.0637***	0.0575***	0.0667***	0.0762***
	EDI income 2nd quintile	0.3139***	0.2306***	0.1374***	0.0882***	0.0977***	0.0580***	0.0590***	0.0527***	0.0706***
	EDI income 3rd quintile	0.1906***	0.1495***	0.0633***	0.0762***	0.0585***	0.0616***	0.0710***	0.0507***	0.0624***
	EDI income 4th quintile	0.0580*	0.1045***	0.0477**	0.0155	0.0382***	0.0446***	0.0367**	0.0239	0.0427***
	Constant	4.0244***	4.2324***	4.1930***	3.8407***	3.7552***	3.4175***	3.3684***	3.3757***	3.3635***
Q75	EDI income 1st quintile	0.2892***	0.1276***	0.0786***	0.0560***	0.0475***	0.0433***	0.0336**	0.0429***	0.0331**
	EDI income 2nd quintile	0.2042***	0.1341***	0.0629***	0.0592***	0.0642***	0.0433***	0.0300**	0.0398***	0.0444***
	EDI income 3rd quintile	0.1620***	0.0748***	0.0238	0.0477***	0.0346***	0.0194	0.0302**	0.0313**	0.0353***
	EDI income 4th quintile	0.0418	0.0504***	-0.0057	0.0095	0.0180	0.0181	0.0139	0.0192	0.0136
	Constant	4.6330***	4.7744***	4.6121***	4.1564***	4.1107***	3.8019***	3.7545***	3.7348***	3.7794***
Q90	EDI income 1st quintile	0.2444***	0.1234***	0.0630***	0.0330**	0.0417***	0.0212	0.0190	0.0263	0.0100
	EDI income 2nd quintile	0.1551***	0.0939***	0.0611***	0.0401***	0.0645***	0.0211	0.0277	0.0313*	0.0300
	EDI income 3rd quintile	0.1178***	0.0352	0.0184	0.0106	0.0480***	-0.0083	0.0167	0.0252	0.0116
	EDI income 4th quintile	0.0346	0.0021	-0.0075	-0.0168	0.0272**	-0.0109	0.0029	0.0107	-0.0163
	Constant	5.0896***	5.1053***	4.9312***	4.3945***	4.3773***	4.1261***	4.0557***	4.0240***	4.0714***
	Patients	16095	20140	24355	25632	26772	25545	25399	23861	23759

Notes. Sample: PCI patients only. Controls: Age, age bands dummies, Charlson comorbidities dummies, Gender, Number of diagnosis, Emergency Past utilization previous year, hospital fixed effects. * p<0.10, ** p<0.05, *** p<0.01

6. Conclusions

This study provides evidence of income-related inequalities in waiting times for cardiac revascularization procedures in the English NHS. Given our econometric framework with hospital fixed effects, the estimated inequalities can be interpreted as arising *within hospitals* rather than across hospitals. The quantitative effect tends to be large, with relative gaps between patients living in the most and least deprived fifths of small areas of 35% for CABG and 50% for PCI in 2002, falling to 10% and 15% respectively in 2011. The gap is also large compared to the gradient identified in other studies for non-life-threatening treatments such as hip replacement (Cooper et al., 2009, Laudicella et al., 2012). This suggests that inequalities in waiting times may be exacerbated when patients seek care for potentially life-threatening diseases.

The analysis also shows that such socio-economic inequalities in waiting time cannot be explained by choice of hospital or treatment. Choice of hospital and treatment makes a statistically significant but relatively small contribution to socio-economic inequality in waiting times. Self-selection due to choice did not increase much after 2006 when the English NHS choice reforms were introduced. The level of pro-rich inequality in waiting time depends more on average waiting times than on the extent of patient choice. Inequalities reduced but did not disappear during a period of sustained expenditure growth in the English NHS in the 2000s. The substantial fall in pro-rich inequality began in 2002 when average waiting times started to fall, and had largely finished by 2006 when choice began to increase. Quantile regressions show that inequalities are pervasive and present both in low as well as high waiting time hospitals.

Several mechanisms may explain the presence of a gradient in waiting times after controlling for selection due to patients' choice. One plausible mechanism is what we might call *elbowing behaviour* by less deprived patients. More socioeconomically advantaged patients are likely better endowed with information, networking skills, contacts and consciousness of their rights, enabling them to exercise more effective pressure to get prioritized for treatment. Moreover, the practice of *defensive medicine* by medical staff and hospital management may imply that richer patients are riskier to disappoint if the health of the patient deteriorates while waiting, since they (or their families) are more likely to promote legal actions for medical malpractice against the treating hospital. Finally, the phenomenon of *unconscious bias* can occur if doctors are better able to understand and interpret the health symptoms of patients who are closer to them in terms of socioeconomic status. Similarly, for unconscious psycho-social reasons they may under-estimate the need in socially disadvantaged patients. Future research could explore in greater detail which of these mechanisms is at work.

Our main insight for policy is that publicly-funded health systems are prone to substantial pro-rich inequalities in hospital waiting times, even in countries like England with well-funded and mature systems of universal health coverage. We have shown that substantial socioeconomic inequalities can occur within the same hospital, for patients waiting for effective treatment for a serious heart condition, and that these inequalities are not primarily due to differences in patient choice of hospital or procedure. Policy makers may see inequality in waiting time as a particularly concerning source of inequality in access to care, since waiting times appear to be directly under the control of healthcare providers. Policy makers in Europe and other countries have explicit policy goals to ensure equality of access based on need, not ability to pay, so inequalities of this kind are cause for concern and need to be addressed.

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Appendix A: Chow F-test for switching regimes

Table A 1: Chow F-test for switching regimes.

CHOW test on Procedures (a)

Years	2002	2003	2004	2005	2006	2007	2008	2009	2010
Chow F-stat value	34.557	19.704	14.357	14.584	16.588	27.703	27.063	12.416	11.108
F-stat 90% C.L.	1.216	1.205	1.205	1.198	1.189	1.183	1.176	1.174	1.170
F-stat 95% C.L.	1.285	1.270	1.270	1.261	1.249	1.240	1.231	1.229	1.223
F-stat 99% C.L.	1.422	1.399	1.399	1.384	1.367	1.353	1.339	1.336	1.327

CHOW test on Closest Hospital Bypassing - CABG sample (b)

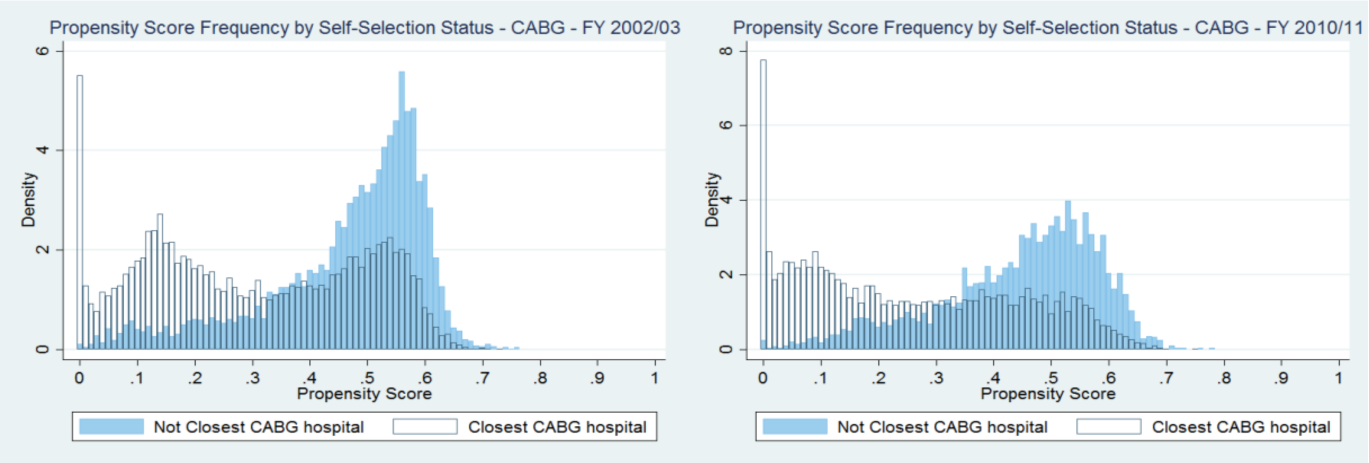
Years	2002	2003	2004	2005	2006	2007	2008	2009	2010
Chow F-stat value	3.432	2.339	2.326	1.278	1.756	1.668	1.466	1.385	1.197
F-stat 90% C.L.	1.228	1.223	1.224	1.228	1.228	1.226	1.224	1.228	1.228
F-stat 95% C.L.	1.301	1.294	1.297	1.301	1.301	1.299	1.297	1.302	1.302
F-stat 99% C.L.	1.447	1.436	1.440	1.447	1.447	1.444	1.440	1.448	1.448

CHOW test on Closest Hospital Bypassing - PCI sample (c)

Years	2002	2003	2004	2005	2006	2007	2008	2009	2010
Chow F-stat value	3.237	3.776	2.754	3.252	2.403	3.115	2.457	2.545	1.703
F-stat 90% C.L.	1.219	1.212	1.209	1.199	1.190	1.185	1.178	1.176	1.171
F-stat 95% C.L.	1.290	1.280	1.276	1.262	1.251	1.243	1.235	1.231	1.224
F-stat 99% C.L.	1.430	1.414	1.408	1.387	1.369	1.357	1.345	1.340	1.329

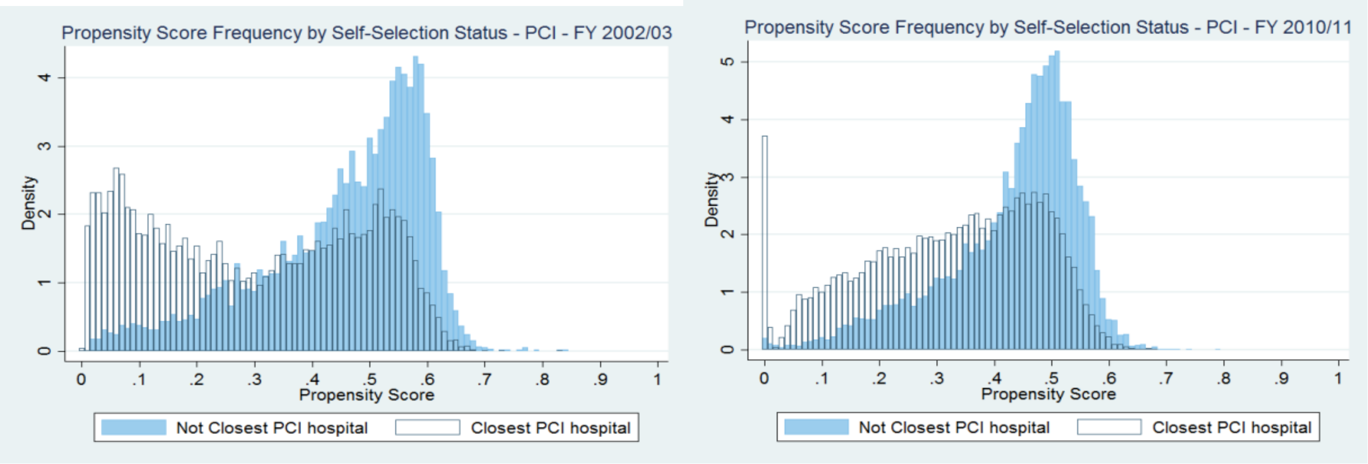
In each year, the Chow F-test rejects the hypothesis of the conditional waiting times for the two revascularization procedures coming from the same data generating process at 99% confidence level. The test also rejects the hypothesis of conditional waiting times for each procedure coming from the exact same process for people treated or not at their closest hospital site, at 99% confidence level for PCI and at least 95% confidence level for CABG (excluding the last year of the sample). These results support the use of switching regression models as the correct empirical specification for our analysis.

Appendix B: Propensity score by self-selection status



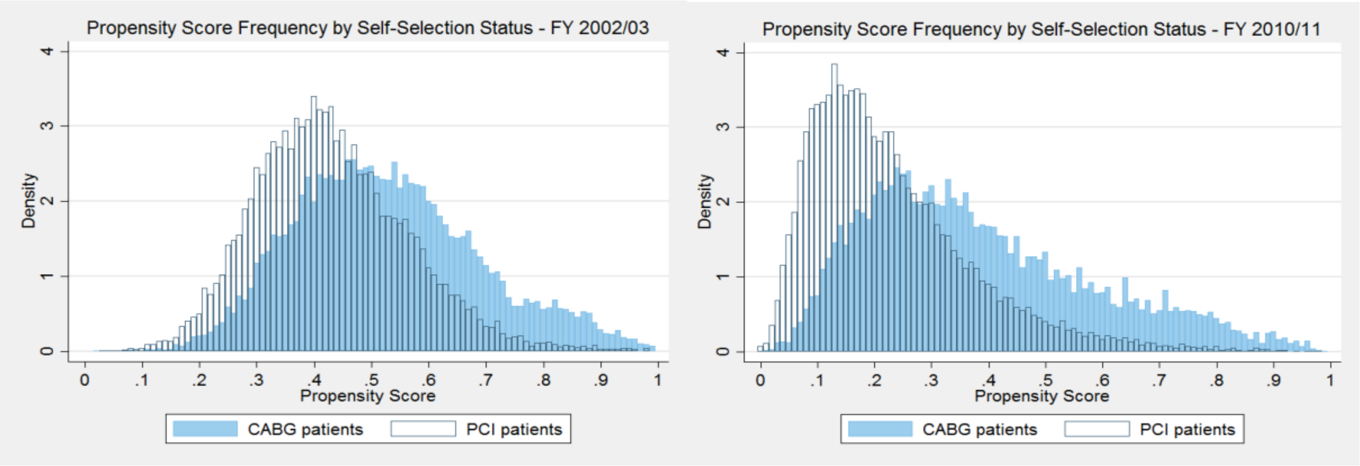
(a) CABG patients - Year 2002/03 - Hospital bypassing

(b) CABG patients - Year 2010/11 - Hospital bypassing



(c) PCI patients - Year 2002/03 - Hospital bypassing

(d) PCI patients - Year 2010/11 - Hospital bypassing



(e) All patients - Year 2002/03 - procedure choice

(f) All patients - Year 2010/11 - procedure choice

Figure B1: Propensity score by self-selection status

In Figure B1 we plot a graphical representation of the estimated parametric propensity score computed in financial years 2002/03 and 2010/11, based on the observable covariates included in the model. The top two graphs in Figure B1 show the propensity score frequency in the CABG sample based on the estimates of Eq. (3), the middle ones show the propensity score frequency in the PCI sample based on the estimates of Eq. (3) and the bottom ones the propensity score frequency in the pooled CABG and PCI patients’ sample based on the estimates of Eq. (6).

The plots show the validity of the common support assumption in our models. If patients in the different selection regimes were so different to the point of not being comparable, then the plots in Figure B1 would show a complete lack of overlap of the frequencies of the estimated propensity score by bandwidth (vertical axis). The overlap of the distributions instead is quite evident. The specification of the first stage probit seems to be adequately capturing the common underlying risk factors behind the self-selection choices and the estimated propensity score for the two treatment subgroups in each plots lies roughly in the same domain (horizontal axis). Hence, the sub-populations of treated patients are still comparable and not too heterogeneous on their observable health risk profiles, when they are split by self-selection regime.

Appendix C: Self-selection model with joint choice of procedure and closest hospital bypassing

In Table C 1 we show the results for a Roy model for the joint choice of selection into procedure and selection of bypassing the closest hospital. The selection correction is computed parametrically and based on the modification of the Dubin and McFadden (1984) multinomial logit selection correction proposed by Bourguignon et al. (2007). With this method, there are as many selection correction terms as the switching regimes, which are four in our case: two for the choice of closest hospital bypassing and two for choice of procedure. Both exclusion restrictions based on distance are used in the first step multinomial logit regression.

Results. The estimation of the joint model for selection of hospital bypassing and procedure suggests very similar results to those in Table 5 and Table 6. A positive and strongly significant socio-economic gradient is found in each year for CABG patients choosing the closest hospital, as well as for both categories of PCI patients. The estimates of the gradient for CABG patients bypassing the closest hospital show a more erratic behaviour, and are significant for most but not all the years. It is not unlikely that in this case the estimation is fuzzier, as this is also the category with the smallest sample size. However, the results for the remaining three categories clearly show a strongly significant but decreasing socio-economic gradient in waiting time due to income deprivation. The estimated coefficients are larger and always significant in the most income deprived group, for both CABG and PCI patients choosing the closest hospitals. Hence, this confirms that most of the more income-deprived patients needing cardiac revascularization have been subject to waiting time inequalities due to SES in the English NHS between 2002 and 2010.

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Table C 1: Generalized selection model with joint correction for choice of bypassing the closest hospital and procedure

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	2002	2003	2004	2005	2006	2007	2008	2009	2010
					CABG patients – bypassing the closest hospital				
EDI income 1st quintile	0.1299*	0.2387***	0.2063***	0.0622	0.1413***	0.1615***	0.0655	0.0795	0.0353
EDI income 2nd quintile	0.0790	0.1950***	0.0831*	0.0668*	0.1379***	0.1755***	0.0261	0.1040**	0.1417**
EDI income 3rd quintile	0.0168	0.0845*	0.1577***	0.0674	0.0673	0.1057***	0.1113**	0.0703	0.0235
EDI income 4th quintile	-0.0239	0.0759	0.0348	0.0133	0.0092	0.1384***	0.0815	0.0235	0.0467
Selection correction 1	0.1435	-0.1877*	-0.5304***	-0.1159	0.0304	-0.0157	-0.9992***	-0.1767	-0.1528
Selection correction 2	1.4671**	-0.2402	-1.6556***	-0.9507**	-0.3961	0.0602	-1.3930***	-0.5345	-0.2145
Selection correction 3	1.5134**	0.0629	-0.8693	-0.2172	-0.3878	-0.0589	1.4203**	-0.3329	0.1872
Selection correction 4	1.3843	0.4407	-0.6518	-0.0103	-0.0606	-0.1390	-0.7395	-0.7689	-1.2848**
Constant	5.6196***	4.3065***	3.7506***	3.5749***	3.4398***	3.5693***	4.7056***	3.1947***	3.1095***
					CABG patients – choosing the closest hospital				
EDI income 1st quintile	0.3231***	0.2423***	0.1447***	0.1553***	0.1559***	0.1116***	0.1216***	0.0673**	0.0915**
EDI income 2nd quintile	0.2398***	0.1653***	0.1143***	0.1242***	0.1524***	0.1448***	0.1099***	0.0716**	0.0556
EDI income 3rd quintile	0.1948***	0.0994**	0.1401***	0.1094***	0.0894***	0.0405	0.0789**	0.0040	0.0718**
EDI income 4th quintile	0.0269	0.0683*	0.0763**	0.0746**	0.0435	0.0693**	0.0419	-0.0025	0.0290
Selection correction 1	0.4425**	-0.1876	0.2403	0.3175	-0.2225	-0.3966	0.0094	-0.2023	-0.0819
Selection correction 2	0.2123	-0.3353*	-0.2835	-0.1094	-0.2841*	-0.2369**	0.3056*	0.0511	0.1948*
Selection correction 3	0.9843**	0.5516	0.6292	0.3296	-0.0895	0.4122	-0.0133	-0.0504	-0.2675
Selection correction 4	1.2962**	1.0995*	1.4148**	0.7802	0.2199	0.6098**	-0.4410	-0.2979	-0.5977*
Constant	4.8880***	5.1171***	5.2154***	4.2758***	4.0679***	4.2878***	3.1040***	3.1771***	2.8286***

PCI patients – bypassing the closest hospital

EDI income 1st quintile	0.3005***	0.2947***	0.1851***	0.1409***	0.1219***	0.2022***	0.1729***	0.1434***	0.1411***
EDI income 2nd quintile	0.2632***	0.2754***	0.1866***	0.1502***	0.1337***	0.1551***	0.1327***	0.1631***	0.1055***
EDI income 3rd quintile	0.1904***	0.1731***	0.0875**	0.1173***	0.0938***	0.1491***	0.1468***	0.1309***	0.0780***
EDI income 4th quintile	0.0366	0.1146**	-0.0051	0.0474	0.0633**	0.1074***	0.0885***	0.0990***	0.0706**
Selection correction 1	-0.4432	-1.7725**	0.7086	0.7006	-0.9006	0.8850	-1.6384***	-0.6523	-0.6232
Selection correction 2	-1.4632	-1.0162	-0.6435	-0.0597	-1.2222**	0.4955	0.0408	-0.1519	0.1458
Selection correction 3	0.1203	0.4246***	-0.1077	0.0043	-0.0671	-0.0993	0.1486**	-0.2483***	-0.0698
Selection correction 4	0.5363	1.4040**	0.1466	0.2880	-0.6262*	-0.1983	-0.3049	-1.0517***	-0.3934
Constant	3.0727***	3.1742***	4.0644***	3.7554***	2.8033***	3.5259***	2.6148***	2.8115***	3.0442***

PCI patients – choosing the closest hospital

EDI income 1st quintile	0.3513***	0.3094***	0.2421***	0.1750***	0.1948***	0.1462***	0.0876***	0.1052***	0.1327***
EDI income 2nd quintile	0.2932***	0.2199***	0.1972***	0.1600***	0.1837***	0.0923***	0.0654***	0.0943***	0.1175***
EDI income 3rd quintile	0.2038***	0.1413***	0.1276***	0.1155***	0.1428***	0.0436*	0.0789***	0.0712***	0.1030***
EDI income 4th quintile	0.1021**	0.1034***	0.0769***	0.0233	0.0711***	0.0360	0.0423**	0.0329	0.0343
Selection correction 1	-0.1947	-0.2666	-0.3714	-0.4835**	-0.4667	-0.9468**	-0.1649	-0.0197	-0.4650*
Selection correction 2	-0.6268	-1.2616***	-1.3795***	-0.3843	0.1909	-0.6834*	-0.8073**	-0.4645	0.0988
Selection correction 3	0.4207	0.4263	-0.1828	-0.1140	0.1630	0.4140**	-0.1878	-0.3433**	-0.3266**
Selection correction 4	0.4816	0.4529**	0.0691	-0.1169	-0.1133	0.1804	-0.0244	-0.1742	-0.3293***
Constant	3.2925***	3.1745***	3.3433***	3.4709***	3.6752***	2.8312***	2.8950***	3.0352***	3.2928***

Notes. Roy model on joint cardiac revascularization procedures (CABG and PCI) sample based on multinomial logit selection correction. Exclusion restrictions in the 1st stage regression: a) differential distance between second and first hospital site (by procedure); b) (average) distance between the first three hospitals providing CABG and the first three ones providing PCI. Controls: Age, age bands dummies, admission month, Charlson comorbidities dummies, Gender, Number of diagnosis, Emergency Past utilization previous year, hospital fixed effects (except for 1st stage multinomial logit regression). * p<0.10, ** p<0.05, *** p<0.01