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The Effect of Hospital Ownership on Quality of Care: Evidence from England

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Abstract

We investigate whether quality of care differs between public and private hospitals in England with data on 3.8 million publicly-funded patients receiving 133 planned (non-emergency) treatments in 393 public and 190 private hospital sites. Private hospitals treat patients with fewer comorbidities and past hospitalisations. Controlling for observed patient characteristics and treatment type, private hospitals have fewer emergency readmissions. Conversely, after instrumenting the choice of hospital type by the difference in distances from the patient to the nearest public and the nearest private hospital, the effect of ownership is smaller and statistically insignificant. Similar results are obtained with coarsened exact matching. We also find no quality differences between hospitals specialising in planned treatments and other hospitals, nor between for-profit and not-for-profit private hospitals. Our results show the importance of controlling for unobserved patient heterogeneity when comparing quality of public and private hospitals.

Keywords: ownership, hospital, quality, choice, distance, endogeneity.

JEL: C36, H44, I11, L33.

1 Introduction

Countries differ in the mix of public and private providers treating publicly-funded patients (Barros and Siciliani, 2011). For example, in the USA 60% of hospitals are private not-for-profit, 20% are private for-profit, and 20% are public. In France 60% of hospitals are private. In Germany 30% are public, 35% are private not-for-profit and 35% are for-profit hospitals. In the Netherlands, all hospitals are private. In the United Kingdom and in Norway most hospitals are public, but an increasing proportion of publicly-funded patients are treated in private hospitals (Siciliani, Gravelle and Chalkley, 2017).

Whether policy should encourage a particular type of hospital ownership is controversial (Pollock, 2004; Leys and Toft, 2015) and depends, inter alia, on how hospital ownership affects quality of care. There are no clear-cut theoretical predictions about the effect of ownership on quality (Brekke et al, 2014; Glaeser and Shleifer, 2001; Sloan, 2000). Private hospitals have stronger incentives to contain costs and, if this increases their marginal profit from additional patients, they will be more willing to increase quality to attract more patients. But when demand is not responsive to quality or increasing quality has a high cost, private hospitals have a stronger incentive to skimp on quality. Public hospitals may also attract more altruistic workers with a stronger preference for quality (Lakdawalla and Philipson, 2006).

We investigate whether there are differences in quality between public and private hospitals treating publicly-funded patients in England. We use data on 3.8 million publicly-funded patients receiving one of 133 types of planned (non-emergency) treatment in 393 NHS and 190 private hospital sites between April 2013 and February 2014. We measure hospital quality as the probability of an emergency readmission within 28 days of discharge.

A key issue in the comparison of quality between public and private providers of planned care is that there may be unobserved differences in the morbidity of their patients because patients choose their provider and their choices may be affected by their morbidity. We deal with such unobserved heterogeneity in case-mix by using the difference between the distances from the patient's residence to the nearest public and private hospital as an instrument.

We find that private providers treat a less severe observable case-mix with fewer co-morbidities and past emergency hospitalisations. Controlling for case-mix, OLS estimates suggest that private hospitals have an emergency readmission rate which is one third smaller than the 2.3% of NHS hospitals. But instrumental variable estimates show that the choice of provider type is endogenous and, when this is allowed for, there is no difference in quality between public and private hospitals. We obtain similar results when we use OLS and instrumental variables with a sample selected by coarsened exact matching. Our analysis suggests that controlling for a rich set of covariates is not sufficient to adequately account for differences in case-mix between public and private providers.

Private providers can be for-profit or not-for-profit and the resulting differences in incentives might affect quality. We therefore also compare quality in public providers, private not-for-profit and private for-profit providers. Using differential distances between the three types of provider to instrument for the choice of provider type we again find that patient choice of provider type is endogenous. After allowing for endogenous selection there is no difference in quality across the three types of provider.

Some providers, known as treatment centres, specialise in a limited number of planned treatments. Since specialisation could affect quality and most treatment centres are private we therefore also compare quality across four types of provider: public non-treatment centres, public treatment centres, private non-treatment centres and private treatment centres. After instrumenting for choice of provider type with differential distances, we find no difference between public non-treatment centres, private non-treatment centres, and private treatment centres but public treatment centres have higher emergency readmission rates. However, in our sample, there are only six public treatment centres, and their quality is not statistically different from that of private treatment centres.

We also estimate the public versus private models on samples stratified by patient characteristics to examine if patient selection and the effect of ownership varies by type of patient. Stratifying patients by observable morbidity makes no difference to our results: after allowing for endogenous patient selection there is no difference in quality between private and public providers for high and low morbidity patients. When we split the sample by age or by deprivation, we find that there is no endogenous selection in the less deprived or younger samples and quality is higher in private providers. But in the more deprived or older samples there is selection, and private providers have worse quality.

Finally, we estimate separate models for samples defined by type of treatment, rather than pooling all treatments. For non-diagnostic treatments there is endogenous selection and private providers had lower quality. For diagnostic treatments there is no endogenous selection and private providers had higher quality. We find that, in four of the five non-diagnostic procedures (non-trauma knee, cataract, hernia, non-trauma hip) with the highest proportion of private patients, there is evidence of endogenous selection and, once this is accounted for, there is no difference in quality between private and public providers.

We make a number of contributions to the existing literature on the effect of hospital ownership. First, we use data from a period in which public and private hospitals were paid the same prospective price for a given treatment. Our results are therefore not confounded by differences in payment rules, and hence different financial incentives, for different types of hospital.

Second, most previous studies focus on quality of emergency care and use mortality as a measure of quality. We examine quality of planned care, which is as important as emergency care in terms of volume.

Third, given that mortality is negligible for planned care provided by private hospitals in England, as well as in other OECD countries with relatively small private sectors, we use emergency readmissions to measure hospital quality. We use data on 133 different planned treatments, whereas previous studies have usually examined quality differences for a small number of specific treatments. This enables us to examine not only the *overall* effect of ownership on quality, but also whether the effects of ownership differ across types of treatment.

Fourth, in addition to the comparisons of public and private hospitals and public versus private for-profit versus private not-for-profit, we also examine whether public and private ownership has different effects for general hospitals and providers specialising in planned care.

The following sub-sections provide, first, a theoretical model to explain why private hospitals could have higher or lower quality than public hospitals and, second, a short account of the mixed findings in the empirical literature. Section 2 describes the institutional background and the data. Section 3 sets out the estimation strategy and Section 4 reports results. Section 5 concludes.

1.1 Theory

We provide a theory model to illustrate why the effect of ownership on quality is indeterminate. The model is a simplified version of Brekke et al (2012). Since the focus is on ownership we assume that there is a single hospital choosing quality q and facing the demand function $D(q)$ ($D' > 0$).[1] Profit is

$$\pi(q) = [p - c(q)]D(q) - K(q) \tag{1}$$

where p is the fixed tariff paid by the funder, not by the patient. $c(q)$ ($c' > 0$) is the unit cost of treating a patient and $K(q)$ ($K' > 0$) is the fixed cost of quality from investment in information technology, MRI scanners etc. Hospital staff also incur a non-monetary cost of effort $\phi(q)$ ($\phi' > 0$). Hospitals are altruistic and care directly about quality. Altruism is captured by $\alpha b(q)$ where $\alpha > 0$ denotes the degree of altruism and $b(q)$ ($b' > 0$) is patient benefit. The hospital objective function is

$$V(q) = \alpha b(q) - \phi(q) + \delta\pi\,, \tag{2}$$

where δ is the weight that the hospital puts on profit.[2] We expect that not-for-profit private providers, say owned by charities, will place a lower weight on profit than for-profit private providers. Public hospitals subject to a profit constraint, even if just a requirement to break even, will also place a positive but lower weight on profit.

The hospital chooses quality q to satisfy

$$V'(q^*) = \alpha b'(q^*) - \phi'(q^*) + \delta\pi'(q^*) = 0, \tag{3}$$

where

$$\pi'(q^*) = \left[p - c(q^*)\right]D'(q^*) - c'(q^*)D(q^*) - K'(q^*)\,. \tag{4}$$

Quality is chosen so that the marginal monetary and non-monetary benefits, from higher revenues and patients benefits, are equal to the marginal monetary and non-monetary costs. The effect of the profit weight δ on quality is

$$\frac{\partial q^*}{\partial \delta} = -\frac{\pi'(q^*)}{V''(q^*)} = -\frac{\phi'(q^*) - \alpha b'(q^*)}{\delta V''(q^*)} \tag{5}$$

with $V''(q^*) < 0$ from the second order condition.

Thus the effect of a greater weight on profit δ on quality q is in general indeterminate: it will depend on the relative magnitudes of the derivatives of the provider monetary and non-monetary cost function, and patient benefit function with respect to quality. It will also critically depend on the degree of altruism. If altruism is sufficiently high that marginal profit $\pi'(q^*)$ is negative (see (3)), a

[1] The results of the theory model are qualitatively similar if hospitals instead compete on quality (see Brekke et al, 2012).

[2] For example δ could be the weight on profit resulting from internal bargaining within the hospital amongst owners, managers, and medical staff or it could arise because the hospital must earn some minimum profit so that δ is the Lagrange multiplier on profit which is larger the higher is the required minimum profit.

greater weight on profit reduces quality. If altruism is low, the marginal profit is positive (to offset the marginal effort cost) and a greater weight on profit leads the hospital to increase quality.[3]

1.2 Related literature

A systematic review of the US literature reports mixed results: whether for-profit (FP) hospitals provide higher quality, as measured by mortality rates and other adverse events, depends on the region, the data source and the period of analysis (Eggleston et al 2008). For Australia, Jensen et al (2009) control for endogenous selection by employing a sample of patients with their first heart attack (AMI) who are likely to have no or limited choice of provider. They find that private hospitals have lower unplanned readmission and mortality rates. Milcent (2005) investigates differences in AMI mortality rates between public and private hospitals in France when public and private not-for-profit (NFP) hospitals were subject to a global budget and private FP hospitals were paid by fee-for-service. After controlling for differences in severity, public hospitals and private NFP ones have similar outcomes, but private FP hospitals have lower mortality rates. Lien et al, (2008) instrument the choice between Taiwanese NFP and FP hospitals with differential distance. They find that NFP hospitals have better quality and lower mortality for stroke and cardiac treatment. When endogeneity is not taken into account the estimated effect of NFP status is halved.

Picone et al (2002) examine the effects of changes in ownership on quality. This approach allows for unobserved time-invariant provider effects but relies on covariates to control for casemix. Shen (2002) also uses changes in ownership and argues that restricting the analysis to AMI patients reduces endogenous selection problems. Both studies find that hospitals that changed status from NFP to FP had lower quality (higher mortality).

For England, three studies compare public hospitals with private treatment centres during periods in which public and private providers faced different payment regimes. Browne et al (2008) and Chard et al (2011) do not allow for unobserved patient selection but do have condition specific pre and post-procedure health measures for five treatments. Browne et al (2008) find that private treatment centres had greater improvements in functional status and quality of life for hip replacement but smaller improvements for hernia repair. Patients in private treatment centres had fewer post-operative complications for knee replacement, hernia repair and cataracts. Chard et al (2011) report that treatment centres had higher quality for hip and knee and similar quality for varicose vein and hernia surgery. Perotin et al (2013) use a switching regression model to allow for endogenous choice of type of provider by patients having nine types of planned care in 2007. Despite finding heterogeneous effects of ownership on patient satisfaction depending on the treatment specialty, they also find no *overall* difference in patient satisfaction between public hospitals and private treatment centres, once the different effects are summed up.

[3] Notice, by contrast, that the effect of greater altruism, at given weight on profit, is always to increase quality since $\partial V'(q^*)/\partial\alpha = b'(q^*) > 0$.

2 Data

2.1 Institutional background

The English National Health Service (NHS) is tax funded. There is a gatekeeping system: patients register with a general practice and must be referred to hospital for planned care by their general practitioner (GP). Patients do not pay for healthcare other than a small charge for prescriptions. Around 11% of the population have supplementary private healthcare insurance (The King's Fund, 2014).

Since April 2008, NHS patients have been able to choose any public or private hospital provider for planned treatment (Department of Health, 2007). Information on hospital quality and characteristics is publicly available, for example on the NHS Choices website (www.nhs.uk). Hospitals are paid per patient treated with a tariff based on national average costs with an adjustment for local input prices (Department of Health, 2002). The tariff varies by healthcare resource groups (HRGs), the English version of diagnosis related groups (DRGs). Public and private hospitals receive the same HRG payment for treating NHS patients.

NHS patients can be treated in the private sector either in private general hospitals or in Independent Sector Treatment Centres (ISTCs) specialising in a limited set of procedures. There are also NHS treatment centres on NHS hospital sites (Bate et al, 2007). NHS and private treatment centres are paid the same HRG tariff as general hospitals.[4] After the establishment of private sector treatment centres and relaxations of constraints on patient choice of provider there was a rapid increase in the proportion of NHS planned patients treated in private hospitals. For hip replacements, for example, the proportion increased from 3% in 2006 to 18% in 2011 (Arora et al, 2013). Overall, about 10% of NHS-funded planned treatments were carried out in private providers in the financial year 2013/14. Most private providers are for profit.

Both NHS and private sector hospitals treating NHS patients are subject to quality regulation and inspection by the Care Quality Commission which publishes reports and quality ratings. The HRG prospective pricing regime ensures that providers which attract more patients by increasing quality will get more revenue. There are also direct financial incentives for quality (Meacock et al, 2014). In particular, if a hospital's total emergency readmission rate exceeds a benchmark agreed with the local NHS commissioning body they must bear the cost of the emergency readmissions above the threshold[5] and are not paid for the index admissions (Department of Health, 2013).[6]

2.2 Data sources

We use administrative data from Hospital Episodes Statistics (HES) for the financial year April 2013 to March 2014. HES includes information for all publicly-funded inpatient care provided by NHS and private hospitals in England.

We measure hospital quality of planned treatment by whether the patient had an emergency readmission to hospital within 28 days of discharge from the index planned procedure.[7] Emergency readmissions to hospitals are a widely used measure of quality in the clinical and health economics

[4] ISTCs were initially encouraged to enter the market by being offered favourable contracts. The aim was to reduce waiting times in certain planned procedures such as ophthalmology and orthopaedics (House of Commons Health Select Committee, 2006; Cooper et al, 2016).

[5] The above penalizations apply regardless of whether the first hospital of treatment is public or private.

[6] Emergency readmissions for children under 4, maternity, childbirth, cancer and patients discharging against medical advice are excluded from the total readmission rate.

[7] We follow international usage and apply the term "planned" to *all* three of the admission types that HES labels as elective ("where the decision to admit could be separated in time from the actual admission").

literatures (Ashton et al 1997; Weissman et al 1999; Balla et al 2008; Billings et al 2012; Blunt et al 2014) and are also used by as performance indicators by policy makers in the English NHS (Department of Health, 2011, 2012) and in the USA (Rosenthal, 2007). We follow NHS performance indicator methodology (HSCIC, 2013) and define emergency readmissions to exclude readmissions for repeated planned treatments such as cancer, chemotherapy, haemodialysis, but differ in including patients with an index planned day-case admission (82.5% of our sample).

Most NHS and private organisations which provide hospital services are multi-site. We use the HES hospital identifier code to classify hospital sites as belonging to a public (NHS) or private organisation. We also further distinguish in some models between treatment centres and general providers using information provided by the NHS Digital Organisation Data Service.[8,9] We assigned for-profit/not-for-profit status to private providers using the Companies House register and supplementary web searches.

HRGs are assigned to admissions via the Reference Costs Grouper tool.[10] The HRG alphanumeric code has five characters, of which the first four define a given procedure or diagnosis (e.g. the code FZ18 is used for 'Inguinal, Umbilical or Femoral Hernia Procedures'), and the last character is a HRG-specific split used to differentiate further by patient age, or by clinical severity based on complications, or by both. We use the four digit HRG codes without the split, known as *HRG root*, to classify index planned admissions by procedure.[11,12]

We restrict the sample to admissions for NHS funded patients[13] where the index planned treatment (HRG) was carried out at least 30 times in each of four types of provider (NHS non-treatment centre, NHS treatment centre, private non-treatment centre, ISTC) in 2013. (Table A1 shows the distribution of hospital sites and patients by type of hospital).

To control for patient's case-mix and pre-operative severity we include the number of Elixhauser comorbidities (Elixhauser et al 1998), as well as the number of past emergency hospitalisations in the year before the index admission. We also control for the quality of primary care provided by the patient's general practice with a composite quality measure based on the practice's 2012 performance on 42 clinical indicators from the Quality and Outcomes Framework (Doran et al, 2006).

We classify patients as living in a rural or urban area by the Office of National Statistics rurality classification of their Lower Super Output Area (LSOA)[14] of residence. We attribute a measure of LSOA income deprivation based on the 2010 Indices of Multiple Deprivation (McLennan et al 2011) to patients.

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[8] See https://digital.nhs.uk/organisation-data-service/data-downloads/other-nhs for data on NHS hospital sites and https://digital.nhs.uk/organisation-data-service/data-downloads/non-nhs for data on private hospital sites.

[9] Unlike the US, most English private hospitals are owned by for-profit organizations. Out of 25 private organizations in our sample, only 6 are not-for-profit, and they treat just 11% of the private patients in our sample (1.21% of the entire sample). We therefore do not distinguish between for-profit and not-for-profit private providers in our main analysis.

[10] http://content.digital.nhs.uk/article/6226/HRG4-201415-Reference-Cost-Grouper?tabid=3 .

[11] We do not use the 5th character of the HRG code because some of the complications may results from poorer quality hospital care, and hospitals may also upcode patients as the tariff is higher for more complex cases (Doyle et al, 2017). We do not lose any useful information on morbidity contained in the 5th character as we include both age and pre-existing comorbidities in the covariates.

[12] All the HRGs included in the sample have an 'invasive' nature even though the purpose may be diagnostic. Invasive diagnostic procedures may trigger an emergency readmission to hospital in case of incorrect execution or poor pre-, intra- or post-procedural care.

[13] There is no detailed data for privately funded patients in private providers.

[14] There were 32,482 LSOAs in England defined by 2001 Census boundaries. LSOAs have a mean population of 1,500 and are created to be homogeneous with respect to tenure and accommodation type. The rural category includes areas classified as town and fringe, village, hamlet and isolated dwellings, while the urban category consists only of urban areas. See ONS (2004) for details.

Hospital locations are derived from their postcodes. We compute straight-line distances from the centroid of each patient's LSOA of residence to all hospitals providing NHS-funded planned hospital care in 2013/14. The distances are HRG-specific, so that, for example, the distances for hernia surgery patients (HRG root FZ18) are computed only to hospital sites performing hernia surgery.

3 Methods

3.1 Model specification

Our baseline specification for the effect of private ownership on hospital quality for planned care is the linear probability model

$$R_{ij} = \alpha_j + \delta H_i + \mathbf{X}_i'\boldsymbol{\beta} + \varepsilon_i = \alpha_j + \delta H_i + \mathbf{X}_i'\boldsymbol{\beta} + \xi_i + \nu_i , \quad (6)$$

where R_{ij} is an indicator equal to one if patient *i* with a planned admission for treatment *j* is readmitted to any hospital as an emergency within 28 days of the discharge date of the index admission. The emergency readmission is triggered independently on which hospital the patient has been admitted first for the planned treatment. H_i is an indicator equal to 1 if the index hospital is privately-owned; α_j is the fixed effect for HRG *j*. $\mathbf{X}_i$ is a vector of patient characteristics. ζ_i is unobserved severity and v_i is an i.i.d error. We use heteroscedasticity-robust standard errors clustered at HRG root level when estimating (6).

$\mathbf{X}_i$ includes controls for patient age (in 20-year bands), gender, number of Elixhauser co-morbidities, number of emergency hospitalizations in the previous year, whether the patient lives in a rural area, was admitted as a day case, patient LSOA income deprivation, and the patient's GP practice quality score in 2012. $\mathbf{X}_i$ also includes the distance from the centroid of *i*'s LSOA of residence to the nearest A&E department to allow for the possibility that if *i* feels unwell after her discharge from the index planned treatment, her decision to visit an A&E department, and hence possibly to be admitted as an emergency patient, will depend on her distance to the A&E department.

The coefficient of interest is δ: the difference in the probability of an emergency readmission following a planned treatment in a private hospital compared to an NHS hospital. If $\delta < 0$, then there is higher quality of care in private hospitals.

Privately-owned hospitals in England treat NHS patients of lower observed severity for a given condition (Browne et al 2008, Chard et al 2011, Mason et al 2010). Selection on observed severity suggests that there may also be selection on unobserved severity (ζ_i) so that $\text{Cov}(H_i,\zeta_i \mid \alpha_j,\mathbf{X}_i) \neq 0$ and the OLS estimate of δ is biased. Such bias will occur if quality and other hospital characteristics affect patients' choice of provider for planned care (Beckert et al 2012, Gaynor et al 2016, Gutacker et al 2016, Moscelli et al 2016a), patient preferences vary with their unobserved morbidity, and patients believe that quality or other hospital characteristics differ between public and private providers.

To remove this potential bias we instrument for patient choice of provider type and use two stage least squares (2SLS). The first stage linear regression for provider type is

$$H_i = \alpha_j + \theta D_{ij} + \mathbf{X}_i'\boldsymbol{\gamma} + \eta_i , \quad (7)$$

where α_j and X_i are the HRG effects and case-mix adjusters and η_i is a zero mean error term uncorrelated with the explanatories. The instrument D_{ij} is the *difference* between the distance from the centroid of the patient's LSOA to the nearest NHS provider of treatment *j* and the distance to the nearest private provider of treatment *j*. We use robust standard errors clustered on HRG roots for the first and second stage regressions.[15]

[15] The 2SLS models are estimated in Stata 13 using the ivreg2 user written function (Baum et al, 2007).

Differential distance has been used as an instrument in the literature on the effectiveness of healthcare treatments (McClellan et al 1994, Newhouse and McClellan 1998) and the effect of hospital ownership on quality (Sloan et al 2001, Shen 2002, Lien 2008). Results from our first stage model show that it is indeed a strong predictor of the type of hospital at which a patient is treated.

For our IV strategy to work, the instrument should affect the second stage outcome (emergency readmission) only indirectly through hospital type. There are good reasons to believe that this untestable assumption holds. First, differential distances are unlikely to have a direct effect on the probability of an emergency readmission to an NHS hospital. Distances to NHS hospitals may affect the probability that a patient, who is unsure if their symptoms indicate a condition requiring emergency hospital treatment, will make the journey or call an ambulance. We therefore include the distance from the patient's LSOA to the closest NHS site with an A&E department as a covariate in $\mathbf{X}_i$ in both the emergency readmission model (6), whether estimated by OLS or 2SLS, *and* in the first stage selection model (7). The distance to private hospitals, which do not provide emergency care to NHS patients, will not affect the probability of an emergency admission to an NHS general hospital. Thus, conditional on the distance to the nearest NHS A&E department, the *difference* between the distances to the nearest NHS site and to the nearest private site, should not affect the decision to seek emergency care.

Second, it seems implausible that quality of planned care affects patients' decisions about where to live.[16] This would require prospective patients to predict the kind of planned treatments that they would require in the medium-to-long term and the future quality of care at different providers for these different treatments. Aside from the fluctuations in the quality of hospital care over time, the quality of care for different planned treatments is weakly correlated within hospitals (Gravelle et al 2014, Moscelli et al 2016b). Third, even if sicker patients might wish to locate near NHS hospitals with good quality emergency care (though we know of no evidence for this), the qualities of emergency and planned hospital care are also weakly correlated (Gravelle et al 2014, Moscelli et al 2016b). Fourth, we require only that the differential distance instrument is *weakly exogenous*, i.e. uncorrelated with the errors in the second stage readmission model conditional on the rich set of controls and HRG effects (α_j and $\mathbf{X}_i$) included in the readmission model.[17]

Some unobserved selection might not arise from patient choice of provider, but from provider choice of patient. This may be unofficial and uncontracted for or it may be explicit and agreed with local NHS commissioners of care. Some contracts for private treatment centres contain exclusion clauses setting out the grounds on which a referred patient can be refused treatment by the private provider (Cooper et al, 2016; Mason et al 2008).[18] The observed morbidity measures included in $\mathbf{X}_i$ will allow for some provider selection of patients but some unobserved (by the researcher) selection by providers may remain. The greater the degree of cream skimming the weaker will be our differential distance

[16] We do not include patients with conditions like cancer or renal failure who may require many planned hospital admissions and so be more likely to locate near NHS providers. Such patients are also dropped when official emergency readmissions performance indicators for NHS providers are computed: https://indicators.ic.nhs.uk/download/NCHOD/Specification/Spec_33D_533ISP4CPP1_12_V1.pdf

[17] Remarkably, the *weak exogeneity* assumption strengthens the plausibility of the exclusion restriction, as the differential distance IV needs to be uncorrelated with emergency readmissions just for the specific HRG α_j, which the patient is treated for. It is unlikely that a patient will repeatedly change her residence according to the couple of NHS and private hospitals with lowest emergency readmissions rates for a specific treatment, unless in case of repeated planned treatments (e.g. chemotherapy, hemodialysis), which are excluded from our sample.

[18] For example, a tender for treatments by private treatment centres of patients of five Clinical Commissioning Groups in south west England specifies that the provider can exclude patients who had a Body Mass Index of over 40 or who require a general anaesthetic and have a severe systemic disease that is a risk to life, for example unstable angina, or a recent myocardial infarction.
See https://www.bristolccg.nhs.uk/media/medialibrary/2015/10/govbody_28april2015_item10_1.pdf

instrument. If our first stage results show that the instrument is not weak and the Durbin-Wu-Hausman test on the second stage does reject the null of exogeneity of type of provider, then we know that there has been unobserved selection of providers by patients. Comparison of the OLS and 2SLS coefficients on provider type will show whether, as we expect, unobservably sicker patients are more likely to choose public hospitals. The 2SLS estimate of the effect of private ownership may still be biased by unobserved patient selection by provider. However, we know the direction of this bias: provider selection of patients leaves private providers with unobservably healthier patients, and so will lead to an over-estimate of the quality gain from private treatment compared to public treatment. Thus, if our second stage estimates show that private providers are no better than public providers, we can reasonably conclude that public providers have at least as high quality as private providers.

3.2 Matching

Regression adjustment for observable case-mix differences between private and public hospitals may not be adequate in the presence of non-linearities or interaction effects, even if there is no unobserved selection. If private providers treat observably less severe patients, the lack of common support may bias estimates of the effect of ownership (Heckman et al, 1997) even in the absence of unobserved selection.

We therefore use *coarsened exact matching* (CEM) (Blackwell 2009, Iacus, 2012) as a robustness check. We match each patient treated by a private provider to one or more patients treated in public hospitals who have the same gender, age band, number of past year's emergency hospitalizations, number of Elixhauser comorbidities, quintile of the IMD 2010 income score, and the same four digit HRG4 code. We drop observations where the number of past year's emergency hospitalizations and the number of Elixhauser comorbidities exceed 4.[19] We then estimate the OLS and 2SLS models using weights provided by the CEM algorithm.

3.3 Specialisation vs general; for profit vs not for profit

Treatment centres specialise in a small number of HRG treatment types and account for a much larger proportion of NHS patients in private hospitals (46.4%) than in public hospitals (1.4%). Since specialisation in planned care may affect quality we estimate models which distinguish hospitals by whether they are treatment centres as well as by ownership

$$R_{ij} = \alpha_j + \mathbf{H}_i'\boldsymbol{\delta} + \mathbf{X}_i'\boldsymbol{\theta} + \varepsilon_i \ , \tag{8}$$

where $\mathbf{H}_i$ is a vector of three indicators for the patient having an admission to an NHS treatment centre, a private non-treatment centre, or a private treatment centre. The reference type of hospital is an NHS general hospital (non-treatment centre). For the 2SLS specification we estimate three first stage regressions for choice of an NHS treatment centre, private non-treatment centre hospital, and private treatment centre. The instruments in each first stage model are the three differential distances between the closest NHS general hospital and the distances to each of the three other hospital types. The computed distance instruments are HRG-specific since not all hospitals offer the entire spectrum of planned care.

Some of the private hospitals treating NHS patients are for profit and some are not for profit and previous studies in other healthcare systems have found that FP hospitals have lower quality (Sloan et 2001, Picone et al 2002, Shen 2002, Lien et al 2008). We therefore examine whether the FP status of private hospitals affects quality for the NHS patients they treat. We estimate a model similar to (8)

[19] These variables were much more heavily right skewed in NHS hospitals than in private hospitals so that using a category of more than four comorbidities or previous admissions would match private patients to public patients with much higher mean counts. Using finer categories would not result in many matches.

in which public hospitals are the reference category and the alternatives are private NFP and private FP.

3.4 Stratification by patient and procedure

We also estimate models on subsamples defined by patient characteristics. By dichotomising the sample by morbidity, for example, we can investigate whether there is more evidence of unobserved selection for high or low morbidity patients and whether the effect of ownership differs by morbidity. To investigate whether the effect of ownership is procedure specific we estimate separate models for diagnostic and non-diagnostic procedures and procedure specific models for the HRG roots with the largest proportion of patients treated in private providers.

Table 1. Patient descriptive statistics

Panel A. Unmatched sample							
	NHS				Private		
	mean	sd	median		mean	sd	median
28-days Emergency readmission	0.0226	0.15	0		0.0138	0.12	0
Female patient	0.545	0.50	1		0.551	0.50	1
Age	55.96	20.28	59		56.18	16.98	57
Emergency hospitalizations past year	0.25	0.76	0		0.10	0.42	0
Elixhauser comorbidities	0.68	0.97	0		0.67	0.89	0
IMD 2010 income score	0.15	0.11	0.11		0.13	0.10	0.09
GP QOF 2012	79.02	3.69	79.31		79.11	3.63	79.40
Rural patient	0.184	0.39	0		0.214	0.41	0
Daycase patient	0.854	0.35	1		0.697	0.46	1
Distance to closest NHS non-TC hospital site (km)	6.82	6.38	4.65		7.81	6.92	5.54
d_{NHS}: Distance to closest NHS site (non-TC or TC)	6.77	6.32	4.64		7.78	6.90	5.53
d_P: Distance to closest Private site (non-TC or TC)	17.37	21.73	10.22		8.60	7.85	6.31
d_{NHS} - d_P	-10.61	20.72	-3.72		-0.82	7.16	-0.15
N	3,407,820				376,863		
Panel B. Matched sample							
	NHS				Private		
	mean	sd	median		mean	sd	median
28-days Emergency readmission	0.0202	0.14	0		0.0137	0.12	0
Female patient	0.550	0.50	1		0.551	0.50	1
Age	56.39	17.15	57		56.18	16.96	57
Emergency hospitalizations past year	0.10	0.45	0		0.09	0.41	0
Elixhauser comorbidities	0.67	0.89	0		0.67	0.89	0
IMD 2010 income score	0.13	0.10	0.09		0.13	0.10	0.09
GP QOF 2012	79.04	3.64	79.32		79.11	3.63	79.40
Rural patient	0.205	0.4	0		0.214	0.41	0
Daycase patient	0.776	0.42	1		0.697	0.46	1
Distance to closest NHS non-TC hospital site	7.14	6.54	4.95		7.80	6.92	5.54
d_{NHS}: Distance to closest NHS site (non-TC or TC)	7.08	6.49	4.92		7.78	6.89	5.53
d_P: Distance to closest Private site (non-TC or TC)	15.18	18.17	9.64		8.59	7.84	6.30
d_{NHS} - d_P	-8.10	17.08	-2.79		-0.82	7.16	-0.14
N		3,105,647				375,526	

Notes. Patients in matched sample in Panel B are matched using a Coarsened Exact Matching algorithm based on the variables *in italics*, together with the 133 four digit HRG4 codes. Statistics in Panel B are computed using the CEM weights. Number of hospital sites: 148 private non-TC, 42 private TC, 387 NHS non-TC, 6 NHS TC. TC: treatment centre.

4 Results

4.1 Summary statistics

Table 1 has summary statistics by type of chosen hospital (NHS or private). *Panel A* is for the full sample. Although NHS and privately treated patients have similar mean age and gender, NHS treated patients had more emergency hospitalisations (0.25 vs 0.10) in the previous year, come from slightly more income-deprived (mean IMD-income score of 0.15 vs 0.13) and less rural small areas (18% vs 21%), and are more frequently treated as a day-case. They have similar numbers of Elixhauser comorbidities and GP quality scores. NHS treated patients are on average located closer to the nearest NHS hospital site with an A&E department than patients in private hospitals, and are more likely (2.26% vs 1.38%) to undergo an emergency readmission to hospital within 28 days of discharge from the index admission. Notice that for patients in an NHS hospital the distance to the nearest NHS hospital is smaller than the distance to the nearest private provider and vice versa for patients in private providers.

Panel B has descriptive statistics on the matched sample, after reweighting using the CEM algorithm weights.[20] Matching greatly reduces the imbalance in covariates between the two patient groups. There also is a slight reduction in the unconditional probability of emergency readmissions after treatment for NHS patients, most likely because of the exclusion of NHS-treated patients with high severity who could not be matched to private sector patients.

4.2 Estimation results

Table 2 summarises the key results for the unmatched sample from OLS and 2SLS models of the effect on the probability of an emergency readmission of being treated in a private hospital. The full results, reported in the Appendix (Table A2), have plausible effects of the covariates: emergency readmission is more likely for older patients, those with more comorbidities, with more emergency admissions in the previous year, and living in a small area with higher income deprivation. Day-case patients are less likely to have an emergency readmission, suggesting that providers do have better information than is available in the HES data and are more likely to treat a patient as a day-case rather than an overnight stay if they are unobservably (by the researcher) healthier. Patients belonging to practices with higher quality also have lower readmission rates. Patients living further from the nearest general NHS hospital have lower emergency readmission probabilities, whether treated in a private or public provider. Patients in rural areas are also less likely to have an emergency readmission, perhaps reflecting the effects of travel costs, which are not fully captured by the straight line distance to the nearest NHS general hospital.

In Table 2 the OLS estimate of the effect of private ownership after controlling for HRG type but not covariates is −0.0095 (column 1). Controlling for observed case-mix (column 2) reduces the estimated private ownership effect to −0.0070, which implies that patients treated in private providers have a one third lower emergency readmissions risk.

The estimates of the effect of ownership change markedly when we instrument for choice of provider type (column 3). The first stage regression results in the lower part of the table show that the probability of choosing a private provider is higher the greater the difference in distance from the patient to the closest NHS hospital site and to the closest private hospital site. The first stage F-statistic on the instrument is 48.70, which is comfortably larger than the Stock and Yogo (2005) critical value of 16.38 for a type-1 error of 5% and a maximum 10% relative bias with respect to OLS. The Durbin-

[20] Only about 1,300 out of 295,000 patients excluded by the matching algorithm were treated in private hospitals.

Wu-Hausman test (Durbin 1954, Wu 1973, Hausman 1978) rejects the null hypothesis that hospital ownership is exogenous ($p<0.001$).

The second stage estimate of the effect of being treated by a private hospital on the probability of an emergency readmission is positive and statistically insignificant, whereas the OLS estimate was negative and statistically significant. Moreover, the 99% confidence interval around the 2SLS estimate of δ is [-0.0028; 0.0085], which does not include the OLS estimate.

We obtain similar 2SLS results when the instruments are the distances to the nearest NHS and nearest private hospital (column 4), the proportional differential distance (column 5), and the proportional distances to the nearest NHS and nearest private hospital (column 6).[21] The 2SLS estimates of the effect of private ownership on probability of emergency admission range from 0.0028 to 0.0044 and are all statistically insignificant.

Table 2. Effect of ownership on emergency readmissions

	Emergency readmission	Emergency readmission	Emergency readmission	Emergency readmission	Emergency readmission	Emergency readmission
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS with HRGs only	OLS	2SLS	2SLS	2SLS	2SLS
Private	-0.0095***	-0.0070***	0.0028	0.0028	0.0044	0.0030
	(-8.9607)	(-7.3660)	(1.2956)	(1.2935)	(0.8286)	(0.6589)
R^2	0.0129	0.0303	0.0299	0.0299	0.0298	0.0299
IV 1st stage choice of provider						
			Private	Private	Private	Private
			(3)	(4)	(5)	(6)
$d_{NHS} - d_P$			0.0021***			
			(6.9783)			
d_{NHS}				0.0060***		
				(5.6921)		
d_P				-0.0021***		
				(-6.9979)		
$(d_{NHS} - d_P)/\min\{d_{NHS},d_P\}$					0.0009***	
					(7.3771)	
$d_{NHS}/ \min\{d_{NHS},d_P\}$						0.0029***
						(9.6772)
$d_P/ \min\{d_{NHS},d_P\}$						-0.0008***
						(-7.2841)
1st stage F-stat			48.70	29.50	54.42	61.21
Endogeneity Test Chi²			10.95	10.96	3.84	4.07
Endogeneity Test p-value			0.0009	0.0009	0.0501	0.0436
Sargan-Hansen Overidentif. Test Chi²				0.0058		0.2936
Sargan-Hansen Test p-value				0.9392		0.5879
Patients			3,784,683	3,784,683	3,784,683	3,784,683
HRGs			133	133	133	133

Notes. All models include 133 HRG effects and all except model (1) include age in bands (0-20/21-40/41-60/61-80/over 80), gender, number of Elixhauser comorbidities, number of emergency hospital admissions in the previous year, quality of patient's GP in 2012, rurality and IMD income deprivation score of LSOA of patient's residence, indicator for day-case patients, distance from the centroid of patient's residence LSOA to the closest general NHS hospital. d_{NHS}: patient distance to nearest NHS hospital, d_P: patient distance to nearest private hospital. Distances procedure specific. t-stats in parenthesis based on cluster-robust standard errors at HRG level; * p<0.10, ** p<0.05, *** p<0.01.

[21] With two distance-based instruments, either absolute (column (4)) or proportionate (column (6)), the Sargan-Hansen (Sargan 1988; Hansen 1982) over-identification test fails to reject the validity of the IVs.

The results in **Table 3** are from models estimated on the matched sample. OLS and 2SLS results are very similar to those estimated on the unmatched sample: the OLS estimates suggest a large and statistically significant reduction in readmission risk for patients in private providers but the 2SLS estimates indicate a higher, though statistically significant, risk for patients in private providers. The first stage F-statistic on the excluded instrument (differential distance) is very large (240). The Durbin-Wu-Hausman test rejects the null of the exogeneity of hospital type (p = 0.004) and the OLS estimated effect is outside the 2SLS 99% confidence interval [–0.0038, 0.0092].

Table 3. Effect of ownership on quality, matched sample

	Emergency readmission	Emergency readmission	Emergency readmission
	(1)	(2)	(3)
	OLS with HRGs & no case-mix controls	OLS with HRGs & case-mix controls	2SLS with HRGs & case-mix controls
Private	-0.0066***	-0.0072***	0.0027
	(-6.8278)	(-7.6404)	(1.0739)
R^2	0.0120	0.0197	0.0192
IV 1st stage choice of provider			
			Private
$d_{NHS} - d_P$			0.0030***
1st stage F-stat			239.9045
Endogeneity Test Chi^2			8.2524
Endogeneity Test p-value			0.0041
Patients	3,481,173	3,481,173	3,481,173
Number of HRGs	133	133	133

Notes. Sample selected by Coarsened Exact Matching. d_{NHS} patient distance to nearest NHS hospital. d_P distance to nearest private hospital. Controls and HRG effects as for Table 2 columns (2) and (3). t-stats in parenthesis based on cluster-robust standard errors at HRG level; * p<0.10, ** p<0.05, *** p<0.01.

Table 4 compares private non-treatment centres, private treatment centres, and NHS treatment centres against NHS non-treatment centres. The OLS model suggests that quality is higher for patients by both types of private providers compared with NHS non-treatment centres. There is also a small reduction in readmission probability (−0.0014) in NHS treatment centres, though the coefficient is statistically significant only at 10%. The Durbin-Wu-Hausman test rejects the null of exogeneity of the hospital types at 5%.

Compared to OLS, the 2SLS coefficient on private non-treatment centre is greatly reduced (to −0.0005) and statistically insignificant. The coefficient on private treatment centre type changes sign to positive and is also statistically insignificant. The coefficient on the NHS treatment centre indicator also changes sign and suggests an increase in the emergency readmission probability of 0.018 compared with NHS non-treatment centres. Since the overall NHS mean readmission probability of 0.026, the effect of NHS non-treatment centres seems very large. However, we cannot reject at the 5% level the null hypothesis that the 2SLS estimates of the effects of NHS treatment centres and private treatment centres on readmissions are equal. Nor can we reject the null that the effects of private providers (both private ISTC and private non-TC) and NHS treatment centres are equal to zero.

Table 4. Effect of ownership and specialization on emergency readmission probability

	Emergency readmission	Emergency readmission			
	(1)	(2)			
	OLS	2SLS			
Private non-TC	-0.0091***	-0.0005			
	(-8.2160)	(-0.1100)			
Private TC	-0.0048***	0.0042			
	(-5.8462)	(1.5860)			
NHS TC	-0.0014*	0.0184**			
	(-1.8482)	(2.4730)			
1st stage choice of provider type					
			Private non-TC	Private TC	NHS TC
$d_{NHSnonTC} - d_{PnonTC}$			0.0011***	-0.0007***	-0.0001***
			(7.1424)	(-4.5836)	(-3.2424)
$d_{NHSnonTC} - d_{ISTC}$			-0.0002*	0.0018***	-0.0001
			(-1.9736)	(8.5846)	(-1.2166)
$d_{NHSnonTC} - d_{NHS\ TC}$			-0.0001***	-0.0002***	0.0003***
			(-6.1326)	(-4.9433)	(11.3331)
R^2	0.0303	0.0175	0.0387	0.0535	0.0300
1st stage F-stat - private non-TC			20.77		
1st stage F-stat – private TC				35.73	
1st stage F-stat - NHS TC					85.66
Endogeneity Test Chi² stat.		8.74			
Endogeneity Test p-value		0.0330			
Wald Test p-value: private non-TC = private TC	0.0000	0.2950			
Wald Test p-value: private non-TC = NHSTC	0.0000	0.0207			
Wald Test p-value: private TC = NHS TC	0.0000	0.0526			
Wald Test p-value: private non-TC=ISTC=NHSTC=0	0.0000	0.0516			

Notes. Covariates, HRG effects, and sample size as in Table 2, columns (2) and (3). $d_{NHSnonTC}$ patient distance to nearest NHS non TC, d_{PnonTC} patient distance to nearest private non TC, d_{NHSTC} patient distance to nearest NHS TC. t-stats in parenthesis based on cluster-robust standard errors at HRGs level. * p<0.10, ** p<0.05, *** p<0.01.

As there are only 6 NHS TCs and they may not be properly captured in Hospital Episode Statistics, we re-ran the models after combining NHS TCs and NHS non-TCs into a single NHS type. The OLS and 2SLS results (Appendix Table A3) for private non-TCs are similar to those in Table 4. For the private TCs, the 2SLS results indicate a lower quality than NHS hospitals at 5% level. However, we cannot reject at the 5% level the null that the quality of private treatment centres and private non-treatment centres are equal to each other and to the baseline NHS type.

Table 5 compares FP and NFP private providers with NHS providers.[22] The OLS estimates suggest that both types of private hospitals have higher quality than NHS providers. However, in the 2SLS model the Durbin-Wu-Hausman test rejects the null of the exogeneity of private hospital types (p = 0.0073) and the instruments are not weak according to the Stock and Yogo (2005) test based on a desired 2SLS maximal size set at 10% (the critical value with two endogenous regressors is 7.03). The 2SLS estimates of the effect of private FP and private FP status relative to public providers are not statistically significant. Both OLS and 2SLS models reject the null hypothesis that private FP and private NFP hospitals have the same quality.

[22] We exclude HRG root BZ04 (‘Lens Capsulotomy’) from this analysis as it was not offered in any private NFP site. In year 2013/14 there were 25 ISP organisations in total (19 FP, 6 NFP), treating planned NHS-funded patients. The private NFP and FP organisations owned 32 and 157 hospital sites respectively.

Table 5. Effect of ownership and for-profit status on emergency readmission probability

	Emergency readmission	Emergency readmission			
	(1)	(2)			
	OLS	2SLS			
Private Not For Profit	-0.0083***	-0.0004			
	(-4.3489)	(-0.0399)			
Private For Profit	-0.0069***	0.0034			
	(-7.7823)	(1.3862)			
1st stage choice of provider type					
			Private NFP		Private FP
$d_{NHS} - d_{P\_NFP}$			0.0002***		-0.0002***
			(5.1968)		(-3.6787)
$d_{NHS} - d_{P\_FP}$			-0.0002***		0.0021***
			(-4.0715)		(7.2403)
Patients	3,773,129	3,773,129	3,773,129		3,773,129
Number of HRGs	132	132	132		132
R^2	0.0303	0.0176	0.0752		0.0224
1st stage F-stat – private NFP			14.29		
1st stage F-stat – private FP					26.22
Endogeneity Test Chi² stat.		9.84			
Endogeneity Test p-value		0.0073			
FP=NFP F-test p-value	0.3031	0.7168			

Notes. Models include 132 HRG effects. Covariates as in Table 2 columns (2) and (3). d_{NHS} = patient distance to nearest NHS hospital site, d_{P_NFP} patient distance to nearest not-for-profit ISP hospital site, d_{P_FP} patient distance to nearest private for-profit hospital site. t-stats in parenthesis based on cluster-robust standard errors at HRG level. * p<0.10, ** p<0.05, *** p<0.01.

Table 6. Effect of ownership on quality, controlling for competition

	Emergency readmission	Emergency readmission
	(1)	(2)
	OLS	2SLS
Private provider	-0.0070***	0.0026
	(-7.4502)	(1.4589)
Number of rival hospital sites within 30km	-0.0000	0.0000
	(-0.7344)	(0.2297)
1st stage choice of provider type		
$d_{NHS} - d_P$		0.0024***
		(7.2000)
Number of rival hospital sites within 30km		-0.0010***
		(-13.6974)
Patients	3,784,683	3,784,683
Number of HRGs	133	133
R^2	0.0303	0.0299
1st stage F-stat		51.84
Endogeneity Test Chi² stat.		15.65
Endogeneity Test Chi² stat. p-value		0.0001

Notes. Same sample, other controls and HRG effects as in columns (2) and (3) of Table 2. In 2013/14, NHS and private hospitals had mean (sd) numbers of rival sites within 30km of 31 (30.5) and 23.6 (22.9). t-stats in parenthesis based on cluster-robust standard errors at HRG level; * p<0.10, ** p<0.05, *** p<0.01.

In **Table 6** we report results from a robustness check in which we include a measure of market structure as a covariate to pick up any potential effects of competition on quality. Including the market structure measure has little effect: the direct effect of competition on quality is statistically significant in both the OLS and 2SLS models, and the OLS and 2SLS estimates of the effect of ownership are very similar to those in the preferred model in column (3) of Table 2.

Table 7 reports results from five pairs of models estimated on dichotomous sub-samples defined by patient characteristics. The left hand model in each panel is estimated on the sub-sample which we would expect to have a lower risk of emergency readmission and the right hand part on patients likely to have higher risk. We see that dichotomising the sample by low versus high morbidity (no versus some previous emergency admissions in *panel a*, no versus some comorbidities in *panel b*), does not change the results reported in Table 2. The OLS estimates of the effect of ownership are biased in favour of private providers but the 2SLS estimates show no significant effect.

In *panel c* the subsamples are defined by the income deprivation quintile of the patient's small area of residence (least deprived quintile versus four most deprived quintiles). For patients in the least deprived quintile we can no longer reject the null hypothesis that provider type is exogenous and so the OLS estimate is preferred. For patients in the more deprived quintiles the 2SLS model is preferred. Panel *d* implies that private providers have better quality relative to public providers for the least deprived patients and possibly worse quality for the most deprived. We get qualitatively similar results in panel *d* where the sample is dichotomised by age: we cannot reject endogeneity of hospital type for younger patients. The OLS estimates for younger patients and the 2SLS estimates for older patients indicate that treatment in a private provider is better for younger patients and worse for older patients. Panel *e* dichotomises by type of HRG (diagnostic with a mean readmission rate of 1.88% vs non-diagnostic with a mean readmission rate of 2.17%). Again, like panels c and d, we cannot reject the null of exogeneity for the patients with a lower average readmission rate and private providers are better for the patients with diagnostic HRGs and worse for those with non-diagnostic HRGs.

Notice that in all five dichotomisations the F statistic on the differential distance instrument is considerable smaller, though always statistically significant, in the models estimated on the right hand subsamples which have higher emergency readmission rates, suggesting that unobserved selection by providers is greater for these patients.

Table 7. Heterogeneity of ownership effect of based on observable patient's characteristics

	Emergency readmission	Emergency readmission	Emergency readmission	Emergency readmission
	(1)	(2)	(3)	(4)
	OLS	2SLS	OLS	2SLS
a. Effect of ownership by severity proxy (past emergency in the previous year)				
	Past emergency admission = 0		Past emergency admission > 0	
Private provider	-0.0070***	0.0013	-0.0090***	0.0205
	(-7.23)	(0.64)	(-6.30)	(1.44)
IV 1^{st} stage choice of provider				
$d_{NHS} - d_{ISP}$		0.0022***		0.0012***
		(7.03)		(6.22)
Patients	3,202,451	3,202,451	582,232	582,232
1st stage F-stat		49.44		38.67
Endogeneity Test p-value		0.0021		0.0341
b. Effect of ownership by comorbidies included in the Elixhauser index.				
	Elixhauser comorbidities = 0		Elixhauser comorbidities > 0	
Private provider	-0.0055***	0.0014	-0.0087***	0.0044
	(-6.94)	(0.69)	(-7.01)	(1.35)
IV 1^{st} stage choice of provider				
$d_{NHS} - d_{ISP}$		0.0021***		0.0020***
		(8.84)		(4.72)
Patients	2,161,662	2,161,662	1,623,021	1,623,021
1st stage F-stat		78.07		22.23
Endogeneity Test p-value		0.0035		0.0050
c. Effect of ownership by Income Deprivation Quintiles				
	Least deprived quintile		4 most deprived quintiles	
Private provider	-0.0065***	-0.0027	-0.0072***	0.0043*
	(-7.24)	(-0.72)	(-7.19)	(1.80)
IV 1^{st} stage choice of provider				
$d_{NHS} - d_{ISP}$		0.0030***		0.0019***
		(7.47)		(6.77)
Patients	722,061	722,061	3,062,622	3,062,622
1st stage F-stat		55.79		45.90
Endogeneity Test p-value		0.3480		0.0004
d Effect of ownership by Age				
	Age <= median age (59 years)		Age > median age (59 years)	
Private provider	-0.0073***	-0.0034	-0.0068***	0.0095***
	(-7.96)	(-1.24)	(-5.28)	(3.08)
IV 1^{st} stage choice of provider				
$d_{NHS} - d_{ISP}$		0.0021***		0.0020***
		(8.22)		(4.36)
Patients	1,876,280	1,876,280	1,908,403	1,908,403
1st stage F-stat		67.50		18.98
Endogeneity Test p-value		0.1827		0.0009
e. Effect of ownership – by HRG type (non-diagnostic vs diagnostic)				
	Diagnostic HRGs		Non-diagnostic HRGs	
Private provider	-0.0030***	-0.0044	-0.0079***	0.0044**
	(-4.03)	(-0.71)	(-7.08)	(2.01)
IV 1^{st} stage choice of provider				
$d_{NHS} - d_{ISP}$		0.0022***		0.0020***
		(14.15)		(5.89)
Patients	1,127,586	1,127,586	2,657,097	2,657,097
1st stage F-stat		200.11		34.66
Endogeneity Test p-value		0.8115		0.0003

Notes. Controls for confounding as in Table 2. Number of HRGs is 133 for panels *a* to *d*, and in panel *e* 14 HRGs are diagnostic and 119 are non-diagnostic. t-stats in parenthesis based on cluster-robust standard errors at HRGs level; *p<0.10, ** p<0.05, *** p<0.01.

Table 8 reports results from a more detailed investigation of how the effect of ownership on quality differs by treatment type. We estimated separate models for the 15 HRGs with the largest number of patients treated in private hospitals.[23] The 15 HRGs are for 2,123,479 patients, more than half of the full sample. The results fall into three groups:

(*i*) Five HRGs (Major & Intermediate Knee Procedures for Non-Trauma, Phacoemulsification Cataract Extraction and Lens Implant, Inguinal, Umbilical or Femoral Hernia Procedures, Major & intermediate Hip Procedures for Non-Trauma and Minor Anal Procedures for 688,872 patients) have results similar to those for all procedures in **Tables 2** and **3.** They have negative and statistically significant OLS coefficients for treatment in a private hospital but the 2SLS coefficients on hospital type are smaller and are not statistically significant. The Durbin-Wu-Hausman tests reject the null of exogenous hospital and the first stage F-statistics on the differential distance instrument are very large.

(*ii*) Four HRGs (Diagnostic Colonoscopy, Major Pain Procedures, Pain Radiofrequency Treatments, Diagnostic Flexible Cystoscopy) covering 525,297 patients have statistically insignificant effects of ownership in both OLS and 2SLS specifications, and the Durbin-Wu-Hausman tests do not reject the null of exogenous hospital type.

(*iii*) Six HRGs (Diagnostic Endoscopic Upper Gastrointestinal Tract Procedures, Minor Hand Procedures for Non-Trauma, Major & Intermediate Shoulder or Upper Arm Procedures for Non-Trauma, Diagnostic Flexible Sigmoidoscopy, Minor Skin Procedures, Intermediate Foot Procedures for Non-Trauma) covering 909,310 patients have negative and statistically significant effects of private ownership with OLS but statistically insignificant effects with 2SLS. The Durbin-Wu-Hausman test does not reject the exogeneity of hospital ownership. Hence the OLS estimates are valid and for this set of HRGs patients treated in private hospitals have a lower probability of emergency readmissions.

[23] Some HRGs for similar procedures (e.g. 'Major & Intermediate Knee Procedures for Non-Trauma' or 'Phacoemulsification Cataract Extraction and Lens Implant') are bundled together.

Table 8. Effect of ownership on quality by procedure

		Private providers		NHS providers		Effect of private ownership			First stage	
Procedures	HRG root codes	Patients	28-day emergency readmission rate	Patients	28-day emergency readmission rate	OLS estimate (t-stat)	2SLS estimate (t-stat)	Endogeneity test (p-value)	1st Stage F-stat	Effect of IV on choice of private hospital
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(a) Major & Intermediate Knee Procedures for Non-Trauma	HB21, HB22, HB23	48,095	1.534%	144,892	2.989%	-0.0127*** (-17.67)	0.0043 (0.74)	8.6373*** (0.00)	6383.1	0.0065*** (79.89)
(b) Phacoemulsification Cataract Extraction and Lens Implant	BZ02, BZ03	38,862	0.952%	274,157	1.482%	-0.0033*** (-5.55)	0.0051* (1.72)	8.2047*** (0.00)	21584.6	0.0047*** (146.92)
(c) Diagnostic Endoscopic Upper Gastrointestinal Tract Procedures	FZ61, FZ60	25,476	0.993%	418,758	2.127%	-0.0041*** (-6.11)	-0.0141* (-1.87)	1.7909 (0.18)	11912.7	0.0023*** (109.15)
(d) Inguinal, Umbilical or Femoral Hernia Procedures	FZ18	17,030	1.491%	66,286	3.581%	-0.0174*** (-14.63)	0.0084 (1.10)	11.4934*** (0.00)	4856.1	0.0065*** (69.69)
(e) Diagnostic Colonoscopy	FZ51, FZ52	16,871	0.984%	266,114	1.385%	-0.0008 (-1.03)	0.0033 (0.40)	0.2529 (0.62)	6572.8	0.0024*** (81.07)
(f) Major & Intermediate Hip Procedures for Non-Trauma	HB11, HB12, HB13	16,227	3.186%	54,097	4.475%	-0.0077*** (-4.62)	0.0154 (1.42)	4.6099*** (0.03)	2521.1	0.0061*** (50.21)
(g) Minor Hand Procedures for Non-Trauma	HB55, HB56	12,988	0.554%	60,978	0.987%	-0.0035*** (-4.31)	-0.0034 (-0.66)	0.0008 (0.98)	3957.4	0.0058*** (62.91)
(h) Major Pain Procedures	AB04	12,675	1.262%	87,246	1.474%	-0.0007 (-0.62)	0.0004 (0.04)	0.0138 (0.91)	1677.2	0.0029*** (40.95)
(i) Major & Intermediate Shoulder or Upper Arm Procedures for Non-Trauma	HB61, HB62	11,160	0.824%	45,092	1.333%	-0.0043*** (-4.15)	-0.0068 (-0.79)	0.0820 (0.77)	2015.3	0.0060*** (44.89)
(j) Diagnostic Flexible Sigmoidoscopy	FZ54, FZ55	10,007	1.009%	158,579	1.764%	-0.0031*** (-2.75)	-0.0025 (-0.21)	0.0027 (0.96)	5008.4	0.0020*** (70.77)
(k) Minor Skin Procedures	JC43	9,596	0.573%	116,668	1.146%	-0.0045*** (-4.82)	0.0064 (0.61)	1.0772 (0.30)	3262.0	0.0023*** (57.11)
(l) Intermediate Foot Procedures for Non-Trauma	HB33, HB32	8,133	0.898%	31,875	1.785%	-0.0057*** (-4.50)	-0.0144 (-1.42)	0.7416 (0.39)	2300.1	0.0053*** (47.96)
(m) Pain Radiofrequency Treatments	AB08	6,007	1.415%	13,290	1.467%	-0.0006 (-0.30)	-0.0045 (-0.22)	0.0366 (0.85)	169.0	0.0029*** (13.00)
(n) Diagnostic Flexible Cystoscopy	LB72	5,699	1.509%	117,395	2.141%	-0.0012 (-0.72)	0.0153 (0.97)	1.1217 (0.29)	3551.2	0.0017*** (59.59)
(o) Minor Anal Procedures	FZ23	5,455	1.155%	23,771	2.238%	-0.0094*** (-5.12)	0.0187* (1.92)	8.3899*** (0.00)	1766.5	0.0071*** (42.03)

Notes. Controls for confounding as in Table 1 (excluding HRG dummies). t-stats based on heteroscedasticity-robust standard errors; IV: patient distance to nearest NHS provider minus patient distance to nearest private provider. * p<0.10, ** p<0.05, *** p<0.01.

5 Conclusions

In the English NHS publicly funded patients have historically been treated almost entirely in public hospitals. More recently private providers have been allowed to enter the market and to treat NHS patients, with the primary aim of reducing waiting times for planned treatments by increasing capacity (Cooper et al, 2016).

We have investigated the effect of being treated in private and public hospitals on one important aspect of the quality of care for publicly funded patients undergoing planned treatment – whether the patient subsequently had an emergency readmission within 28 days of discharge from their initial treatment. We use data on 133 different planned treatments undergone by 3.8 million publicly-funded patients in England between April 2013 and February 2014. We find that, on average over all treatments studied, private hospitals and public hospitals provide similar quality of care once case-mix and patient self-selection into hospital types is adequately controlled for via instrumental variable regression. Simple case-mix adjustment based on observed patient characteristics alone provides biased estimates of quality differences that suggest that private providers have higher quality for publicly funded patients. We also find no quality differences between public and private specialised and non-specialised providers. Nor does quality in private providers depend on whether they are for profit or not profit. There are however statistically and economically significant differences in quality between public and private providers for specific types of care. For example, public providers have higher quality overall for non-diagnostic treatments whilst private providers do better overall for diagnostic treatments. We find no difference in quality between public and private providers for four of the five non-diagnostic treatments with the largest proportion of patients in private providers.

Evaluating the opening of the market to private hospitals requires consideration of the effects on the quality of care for NHS patients as well as on waiting times and the cost to taxpayers who fund the NHS. We have not considered the effect on waiting times, nor have we investigated whether the costs of subsequent emergency readmissions differ for patients first treated in the private and public sectors. Our estimate of the quality effects of public versus private hospitals are based on data from a period in which private treatment of NHS patients is relevant but still limited. If private providers gain market share their incentives may change and they may engage in more rent extraction at the expense of quality. We have demonstrated in this paper how it will be possible to monitor quality even in the absence of complete information to adjust for casemix differences between public and private providers.

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Appendix

Table A1. Numbers of sites and patients by hospital type

	Sites	Patients
NHS providers	393	3,407,820
NHS non-treatment centres	387	3,359,963
NHS treatment centres	6	47,857
Private providers	190	376,863
Private non-treatment centres	148	202,152
Private treatment centres	42	174,711
Private for profit	157	335,132
Private not for profit	32	41,731

Notes. Providers are hospital sites. Ownership and for profit status is attached to the organisation that owns the sites. Numbers are from the estimation samples. One HRG was dropped from the model with FP and NFP providers as it was not carried out in any NFP provider.

Table A2. Effect of ownership on emergency readmission probability: full results

	OLS	IV First Stage	2SLS
	(1)	(2)	(3)
	Emergency readmission	Private provider	Emergency readmission
Private provider	-0.0070***		0.0028
	(-7.3660)		(1.2956)
$d_{NHS} - d_P$		0.0021***	
		(6.9783)	
$d_{NHSnonTC}$	-0.0001***	0.0011***	-0.0001***
	(-3.1627)	(5.4195)	(-3.7077)
GP QOF quality	-0.0001***	0.0004***	-0.0001***
	(-3.0940)	(3.3683)	(-3.2361)
Patient living in rural area (LSOA)	-0.0005**	0.0061***	-0.0004**
	(-2.2877)	(2.6520)	(-2.0341)
Daycase patient	-0.0102***	-0.0896***	-0.0093***
	(-9.9675)	(-5.5145)	(-8.7418)
Female patient	-0.0013***	0.0030**	-0.0013***
	(-3.3644)	(2.0061)	(-3.4212)
Patient aged 0-19 years	-0.0025	-0.0882***	-0.0017
	(-0.8906)	(-7.8309)	(-0.5977)
Patient aged 20-39 years	0.0027**	0.0214***	0.0024**
	(2.3042)	(3.2166)	(2.1408)
Patient aged 40-59 years	-0.0011**	0.0186***	-0.0012***
	(-2.3590)	(5.7898)	(-2.9206)
Patient aged over 80 years	0.0103***	-0.0186***	0.0105***
	(7.1923)	(-6.0605)	(7.2460)
N. past year emergency admissions	0.0242***	-0.0156***	0.0243***
	(35.7515)	(-10.7951)	(36.5689)
Number of Elixhauser co-morbidities	0.0042***	-0.0039	0.0043***
	(16.2827)	(-1.4704)	(16.7363)
IMD income deprivation score	0.0109***	-0.1325***	0.0122***
	(9.2000)	(-12.4959)	(9.3523)
Constant	0.0375***	0.1063***	0.0368***
	(21.5176)	(4.6885)	(22.0259)
HRGs fixed effects	YES	YES	YES
Statistics			
Patients	3784683	3784683	3784683
HRGs	133	133	133
R^2	0.0303	0.0819	0.0299
1st stage F-stat			48.6961
1st stage F-stat p-value			0.0000
Durbin-Wu-Hausman Endogeneity Test Chi^2			10.9500
Durbin-Wu-Hausman Endogeneity Test p-value			0.0009

Notes. All models include 133 HRGs and; $d_{NHSnonTC}$: distance from the centroid of patient's residence LSOA to the closest general NHS hospital. d_{NHS}: patient distance to nearest NHS hospital. d_P: patient distance to nearest private provider. Distances computed to generate the instrumental variables are procedure specific. t-stats in parenthesis based on cluster-robust standard errors at HRG level; * p<0.10, ** p<0.05, *** p<0.01.

Table A3. Effect of ownership and specialization on emergency readmission probability

	Emergency readmission	Emergency readmission		
	(1)	(2)		
	OLS	2SLS		
Private non-TC	-0.0091***	0.0022		
	(-8.2411)	(0.4928)		
Private TC	-0.0047***	0.0058**		
	(-5.8639)	(2.1076)		
1st stage choice of provider type				
			Private non-TC	Private TC
$d_{NHS} - d_{PnonTC}$			0.0010***	-0.0008***
			(6.7730)	(-5.2629)
$d_{NHS} - d_{ISTC}$			-0.0002***	0.0017***
			(-2.6916)	(8.8357)
Patients	3784683	3784683	3784683	3784683
Number of HRGs	133	133	133	133
R^2	0.0303	0.0374	0.0507	0.0175
1st stage F-stat – Private non-TC			30.3505	
1st stage F-stat – ISTC				53.7565
Endogeneity test Chi^2 stat.				8.6401
Endogeneity test p-value				0.0133
Wald test p-value: Private non-TC = ISTC	0.0000	0.3996		
Wald test p-value: Private non-TC = ISTC = 0	0.0000	0.0991		

Notes. Controls for confounding as in Table 4. TC: treatment centre. d_{NHS} = patient distance to nearest NHS hospital site, d_{PnonTC} = patient distance to nearest private non TC, d_{ISTC} = patient distance to nearest private TC hospital site. t-stats in parenthesis based on cluster-robust standard errors at HRG level. * p<0.10, ** p<0.05, *** p<0.01.