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Does Hospital Competition Harm Equity? Evidence from the English National Health Service

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Does hospital competition harm equity? Evidence from the English National Health Service

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Abstract

Increasing evidence shows that hospital competition under fixed prices can improve quality and reduce cost. Concerns remain, however, that competition may undermine socio-economic equity in the utilisation of care. We test this hypothesis in the context of the pro-competition reforms of the English National Health Service progressively introduced from 2004 to 2006. We use a panel of 32,482 English small areas followed from 2003 to 2008 and a difference in differences approach. The effect of competition on equity is identified by the interaction between market structure, small area income deprivation and year. We find a negative association between market dispersion and elective admissions in deprived areas. The effect of pro-competition reform was to reduce this negative association slightly, suggesting that competition did not undermine equity.

1. Introduction

There is a substantial body of economic theory and evidence about the effects of competition on the cost and quality of hospital care (Gaynor, 2006). It is known, for instance, that competition can improve quality (Kessler and McClellan, 2000) though not if buyers have poor information about quality (Propper et al., 2008). Less is known, however, about the effects of competition on socio-economic inequality in hospital care (Cookson et al., 2010). We aim to provide some evidence in the context of important pro-competition reforms of the universal and comprehensive English National Health Service (NHS) between 2003 and 2008.

The reforms were introduced by a Labour administration led by Prime Minister Tony Blair and his Chancellor Gordon Brown, who subsequently became Prime Minister from 2007-10. These "Blair/Brown" reforms fostered competition in two main ways. First, on the supply side, independent sector (IS) hospitals were encouraged gradually to enter the market for NHS funded patients: we estimate that IS activity made up 0.03% of NHS non-emergency inpatient activity in 2003/4 rising to 2.17% by 2008/9. Second, on the demand side, patients were offered a choice of hospital from December 2005 and case based hospital payment was gradually phased in from 2003/4 to 2008/9 so that money would follow the patient's choice (Department of Health, 2003). Prime Minister Blair predicted his reforms would enhance equity for poorer patients, by increasing hospital capacity and patient choice (Blair, 2003). By contrast, critics predicted that choice and independent sector provision would undermine socio-economic equity (Appleby et al., 2003; Barr et al., 2008; Oliver and Evans, 2005; Tudor-Hart, 2006). Evidence on the equity effects of competition is timely, as at the time of writing the English NHS is about to embark upon a potentially even more ambitious programme of pro-competition reform under the coalition administration of Conservative Prime Minister David Cameron and Liberal Democrat Deputy Prime Minister Nick Clegg (Department of Health, 2010).

In providing evidence of this kind, one key challenge lies in disentangling the effects of hospital competition on socio-economic equity from the effects of other contemporaneous changes in the health system and the wider social and economic environment. For example, the rapid growth in NHS spending and capacity during the 2000s may have tended to improve socio-economic equity in hospital care, if activity was able to grow faster in deprived areas with greater unmet need. Changes in the wider socio-economic environment may also have played a role, for example improved access to web-based information and the ageing of the consumerist "baby boomer" generation. Our research design aims to disentangle the specific effects of competition from these broader influences on socio-economic equity in hospital care.

We identify the effect of competition on utilisation of hospital services by exploiting geographical variation in hospital market concentration and time variation in the "dose" of competition generated by the introduction of the pro-competition reforms. Indices of local market concentration are constructed by computing hospital level indices based on both observed and predicted patient flows, and then attributing these to small areas using distance-weighted averages. As one would expect, the pro-competition Blair/Brown reforms were accompanied by a general fall in hospital market concentration throughout the period as competition set in. However, local market concentration varies by different amounts in different parts of the country and over different points in time. Towards the beginning of the reform period, variation in local market concentration reflects variation in local demand and supply factors. As the pro-competition reforms are gradually phased in, however, falls in local market concentration are likely to reflect increases in competitive pressure. We can therefore identify the effect of competition by the variation in market concentration before and during the introduction of pro-competition reforms using a difference in differences (DID) approach.

The second key challenge lies in measuring change in socio-economic equity in hospital care, and doing so in a way that can be linked to change in local hospital market concentration. Conventional individual level survey data approaches are unable to include adequately large samples of individuals using hospital care each year in all local hospital markets in England. We therefore use administrative data on all individuals aged 18 and over who used hospital care in the English NHS from 2003 to 2008, comprising a total of 37.7 million elective inpatient hospital admissions. Unfortunately, this data cannot be linked to individual level data on socio-economic status in England. Therefore, we aggregate to the level of 32,482 English small areas with average population of 1,500 and use available indices of small area socioeconomic deprivation.

The concept of equity we examine is small area socio-economic equality in health care utilisation for equal need. We estimate fixed effect linear panel data models of small area hospital utilisation as a function of population need, deprivation and market structure. The competition effects on equity are identified by examining how the interaction between market structure and deprivation changes over time. Variations in equity over time can be more robustly identified than levels of equity at a given point in time. Levels of equity are hard to quantify in cross sectional analysis because one has to assume that observed utilisation inequalities relative to need are not biased by unobserved heterogeneity in population need. By contrast, our identification of equity effects rests on the more reasonable assumption that unobserved heterogeneity in population need between more and less deprived areas remains stable from one year to the next.

We assume throughout that there was pre-existing inequity in hospital utilisation favouring socio-economically advantaged individuals and areas prior to the reform period. This consideration is largely shared by both critics and proponents of pro-competition reform and supported by cross sectional evidence from a range of survey and administrative studies (Dixon et al., 2007). We therefore interpret a relative increase in hospital utilisation in deprived areas as a beneficial improvement in socio-economic equity, and a relative decrease as a harmful deterioration in socio-economic equity.

2. Background

2.1 Pro-competition reform of universal and comprehensive health systems

Pro-competition reform is a perennial policy prescription in debates about how to improve health care efficiency (Cookson and Dawson, 2006; Cutler, 2002; Federal Trade Commission and Department of Justice, 2004). A number of high income countries have experimented with pro-competition reform designed to improve efficiency in the context of "equity-oriented" health systems designed to ensure that all citizens have access to a comprehensive package of health care (Cutler, 2002). Two distinct types of reform have emerged. First, "quasi market" reforms introduced in the context of single payer "Beveridge" style health systems like the English NHS (Le Grand et al., 1998). Other countries that experimented with "quasi market" reforms in the 1990s include Italy (France and Taroni, 2005), Sweden (Harrison and Calltorp, 2000) and New Zealand (Ashton et al., 2005). Second, "managed competition" reforms introduced in the context of "Bismark" style health systems funded by multiple social insurance plans (sometimes known as "sickness funds"). Countries that have experimented with "managed competition" reform in the 1990s and 2000s include Germany (Brown and Amelung, 1999), the Netherlands (Schut and van de Ven, 2011) and Switzerland (Reinhardt, 2004).

The fundamental difference is that "managed competition" involves competition between third party payers for enrolees as well as competition between hospitals for patients. In theory, "managed competition" gives payers an incentive to contract selectively and aggressively with hospitals to lower prices and raise quality. The "management" of competition has various elements, including:

1. Government provision of comparative information on health plan quality, to ensure that enrolees are well informed consumers and not duped by misleading advertising
2. Regulation of revenues, via a cross subsidisation formula that compensates plans that enrol relatively elderly and unhealthy individuals likely to cost more, to ensure that plans do not compete by "cream-skimming" young and healthy enrolees who cost less
3. Regulation of the minimum benefit package, to ensure all citizens have access to a fairly comprehensive package of care and are protected from catastrophic financial risk of having to pay out of pocket for uncovered services
4. Regulation of health plan premiums for the minimum benefit package, via "community rating" as a fixed percentage of income with means-tested subsidies.

By contrast, "quasi markets" operate within a "single payer" system with a single comprehensive benefit package for all citizens funded via a single taxation and/or a social insurance system. Competition between third party payers for enrollees is prohibited. Instead, competition between hospitals for patients is introduced by one or both of the following two demand side reforms. First, "payer-driven competition" involving selective contracting with hospitals by geographically defined third party payers. Second, "patient-driven competition" involving patient choice of hospital with money following the patient in the form of a fixed price hospital payment. There is an obvous tension between "patient-driven" and "payer-driven" competition, since the ability of a payer to switch activity from one hospital to another is diluted if patients can choose either hospital. "Quasi market" reforms also often include supply side reforms designed to encourage hospitals to behave in a competitive manner – for example, deregulation of publicly owned hospitals (e.g. relaxing central controls over recruitment, disposal of assets and retention of surplus) and/or facilitated entry of independent sector hospitals (both for-profit and not-for-profit) into the quasi market for publicly funded patients.

Both types of pro-competition reform are heavily constrained by rules designed to ensure equity in the delivery and financing of health care, and by political barriers to exit – politicians always face strong opposition from local constituents when public hospitals are threatened with closure (Le Grand, 2002). Nevertheless, there is robust evidence from studies of "quasi market" reforms of the English NHS in the 1990s that pro-competition reform can introduce some limited forms of competitive pressure and that this competitive pressure can have some limited effects on efficiency and quality (Propper et al., 2008; Propper and Soderlund, 1998). Unfortunately, pro-competition reforms in other countries have not yet been subject to rigorous evaluation and so evidence on their effects is limited.

2.2 The Blair/Brown pro-competition reforms of the English NHS

The Blair/Brown reforms involved both supply side and demand side mechanisms for introducing hospital competition. On the supply side, independent sector (IS) providers were encouraged to enter the market for publicly funded NHS patients, initially through the "Independent Sector Treatment Centre" programme of nationally agreed contracts with generous terms (Mason et al., 2010). This reform was introduced in 2003/4, but IS providers only started to provide more than 1% of NHS activity from 2006/7 - we estimate that IS activity made up 0.03% of NHS non-emergency inpatient activity in 2003/4, rising to 0.08% in 2004/5, 0.31% in 2005/6, 1.12% in 2006/7, 1.42% in 2007/8 and 2.17% in 2008/9.[1] Prior to this reform, IS provision of NHS funded services was mostly sub-contracted on an *ad hoc* basis by publicly funded NHS hospitals at times of capacity shortage, for example to perform "waiting list initiatives" to clear patient backlogs, rather than routinely offered on a competitive basis.

On the demand side, patient choice of hospital at the point of GP referral was phased in nationally from December 2005. The policy was that from December 2005 all patients should be offered a choice of four or five hospitals including one independent sector provider, leading up to "free choice" of any public or independent hospital in the NHS national directory from April 2008 (Dixon et al., 2010). This was coupled with a national system of fixed price case based hospital payment based on a local variant of DRGs ("Healthcare Resource Groups"), which was gradually phased in nationally from 2003/4 for a small basket of elective inpatient services and progressively expanded to include all elective services in 2005/6. The financial impact of this policy on hospital revenue was also gradual with a four year transition path which came to an end in 2008/9. Prior to these reforms, NHS patients largely had to accept whatever referral their GP made for them and hospitals were largely paid on the basis of block contracts negotiated with local public agencies ("Primary Care Trusts") responsible for purchasing health care on behalf of the local population.

All of these reforms were introduced alongside substantial growth in NHS expenditure. From 1999 to 2010, real annual NHS spending growth averaged 6.56% compared with 3.48% from 1950/51 to 1999 (Appleby et al., 2009). Between 2003 and 2008, real net expenditure on the NHS in England grew by 30.1% from 72.7 to 92.5 billion in GBP sterling at 2008 prices, with real annual spending growth of 9.4% in 2003, 4.7% in 2004, 7.8% in 2005, 3.2% in 2006, 7.8% in 2007 and 3.6% in 2008 (House of Commons Health Committee, 2010). The reforms were also introduced alongside a strong target-based performance management regime for hospitals involving publication of data on performance against target and associated rewards and sanctions for hospital managers. In particular, hospital managers were strongly incentivised to meet an aggressive sequence of maximum waiting time targets for elective inpatient treatment: 18 months from outpatient consultation to inpatient treatment by March 2001, falling by three months a year to 12 months by March 2003, 9 months by March 2004, then 6 months by December 2005 and ultimately to 18 weeks from GP referral to inpatient treatment by December 2008 (Department of Health, 2000, 2004). There is evidence that these reforms increased hospital competition and that this competition improved hospital quality (Cooper et al., 2010; Gaynor et al., 2010). However, there is no evidence about the effects of hospital competition during the Blair/Brown reform period on socio-economic equity.

2.3 A theoretical story about why the Blair/Brown reforms might undermine socio-economic equity in hospital care

Unfortunately, economic theory offers no theoretical predictions about the effects of competition on socio-economic inequality in hospital care. We therefore focus attention in this section on the empirical hypothesis commonly raised by critics of hospital competition: that competition will undermine socio-economic equity in hospital care. Critics rarely spell out the causal mechanisms through which competition might be expected to influence socio-economic inequality in hospital care (Dixon and Le Grand, 2006). However, we attempt to spell out one possible causal mechanism below, based on the idea that competition may reduce the "pro-social motivation" of NHS managers and clinicians of NHS managers and clinicians to treat patients on the basis of clinical need, regardless of financial and non-financial incentives to do otherwise.

In economics, the term "pro-social motivation" refers to the general idea that an individual may be motivated by concerns for the welfare of other people in society (Bénabou and Tirole, 2006). Pro-social motivation may involve a mixture of (i) "extrinsic" motivations such as direct financial or non-financial rewards, (ii) "intrinsic" motivations such as ethical beliefs about duty or the "warm glow" of satisfaction from helping others, and (iii) "reputational" motivations such as concern for future

[1] Source: the Hospital Episodes Statistics.

employment and promotion prospects. Evidence to support the claim that “pro-social motivation” can influence the behaviour of public sector workers, compared with private sector workers, includes large-scale US and UK survey findings that public sector workers are more likely than private sector workers to do voluntary work (Houston, 2006) and unpaid overtime (Gregg et al., 2011).

In the case of health care, professional medical associations clearly have an important influence on the pro-social motivation of medical practitioners, through their involvement in medical training, accreditation and regulation and in setting general professional norms of medical ethics. However, individual hospitals may also be able to influence pro-social motivation by setting their “mission” or “ethos” and tailoring recruitment, remuneration and promotion practices accordingly. A hospital’s ability to influence “intrinsic” motivation may be partly a selection effect, in attracting certain types of people to work in the hospital, and partly an effect of organisational ethos in helping to re-shape employee preferences. Through these mechanisms, NHS hospital managers and clinicians may be powerfully motivated to provide high quality care to all patients on the basis of clinical need, irrespective of personal incentives such as pay and working conditions and corporate incentives such as financial and waiting time targets.

According to the behavioural economic theory of “motivational crowding out” (Frey and Oberholzer-Gee, 1997), the introduction of incentive mechanisms with “extrinsic” rewards and punishments – such as competition – may cause pro-social motivations to be reduced or “crowded out” by self-interested motivations. To put it in Le Grand’s colourful terminology, competition may encourage health professionals to behave more like self-interested “knaves” than pro-social “knights” (Le Grand, 2003). Faced with competitive incentives, hospital decision makers may focus on self-interested goals such as maintaining financial stability and meeting waiting time targets, rather than pro-social goals such as providing high quality care to all patients on the basis of clinical need.

The waiting time targets and case based hospital payment mechanisms introduced into the English NHS in the 2000s may have given hospital managers and clinicians an incentive to alter specialist referral and admission thresholds in order to select against patients who cost more to treat and stay longer in hospital thus making it harder to clear patient backlogs. There is a standard body of economic theory about hospital incentives to focus on treating fit, low cost, short staying patients (“creaming”) and to avoid treating unfit, high cost, long staying patients (“dumping”) (Ellis, 1998). There is also some evidence that socio-economically disadvantaged patients tend to suffer from greater co-morbidity and to consume more hospital resources including more complications and longer lengths of stay (Epstein et al., 1990). The NHS environment in the 2000s may therefore have given hospitals an incentive to under-admit disadvantaged patients and over-admit advantaged patients. Prior to the introduction of competition, these incentives may be held in check by pro-social motivation among staff. However, if competition leads to a reduction in pro-social motivation, hospital decision makers may start to respond to these pre-existing incentives to “cream” advantaged patients and “dump” disadvantaged patients – thus increasing socio-economic inequality in the use of hospital care.

Different theoretical stories could be constructed about why competition might lead to socio-economic inequality in the quality of hospital care used – for instance, the idea that advantaged individuals tend to be more active and better informed consumers in a competitive marketplace, and therefore better able to avoid low quality hospitals. However, our focus in this paper is on socio-economic inequality in the volume of hospital care used.

3. Data

Table 1 presents global descriptive statistics for the main small area level variables, pooled from 2003 to 2008, and table 2 presents year-by-year means. The unit of analysis is the Lower Super Output Area (LSOA). There are 32,482 LSOAs in England with a mean population of about 1,500 individuals and a minimum of 1,000.

Table 1: Descriptive statistics for key small area variables, pooled from 2003 to 2008

Variable	N	Mean	Std. Dev.	Min	Max
Outcome variable					
All elective inpatient admissions	194,700	194	87	1	1,225
Other variables of interest					
Observed HHI (*)	194,700	5,747	1,149	3,184	9,095
Predicted HHI (**)	64,900	4,054	2,331	5,561	9,625
Independent sector hospitals within 60km	194,700	3.923	4.970	0	29
Public hospitals within 60km	194,700	21.974	15.334	1	51
Deprivation (IMD 2007 income domain)	194,700	15.626	12.182	0.130	83.017
Supply variables					
GPs per 1,000 population	194,688	5.153	2.181	0.004	22.820
Need variables					
Atrial fibrillation	194,688	1.313	0.432	0.002	3.862
Cancer	194,688	0.837	0.376	0.000	3.158
Chronic kidney disease	194,688	2.632	1.224	0.004	11.722
Chronic obstructive pulmonary disease	194,688	1.429	0.581	0.000	4.720
Coronary heart disease	194,688	3.559	1.031	0.002	11.371
Diabetes	194,688	3.618	0.764	0.002	9.961
Epilepsy	194,688	0.599	0.140	0.000	2.303
Heart failure	194,688	0.774	0.259	0.001	3.972
Hypertension	194,688	12.182	2.511	0.006	26.771
Hypothyroidism	194,688	2.484	0.708	0.001	6.427
Obesity	194,688	7.563	1.965	0.011	22.327
Stroke and transient ischaemic attack	194,688	1.580	0.502	0.001	10.106
Total population aged 20 or over	194,700	1178	210	307	7,849

Notes to table 1:

1. Observations on the 32,480 Lower Layer Super Output Areas (LSOAs) in England are pooled across all seven years from 2003 to 2008.
2. Population size variables by 5 year age-sex bands not reported for reasons of space.

(*)Herfindahl-Hirschman Index of market concentration; range from 0 (max dispersion) to 10,000 (max concentration). Calculation described in Appendix 1.
(**)Predicted HHI is calculated for 2003 and 2008 only. Calculation described in Appendix 2.

3.1 Hospital utilisation

Our hospital utilisation variable is based on data from the national Hospital Episode Statistics (HES) inpatient database, which covers all hospital patients admitted to hospital in the English NHS. All elective (non-emergency) inpatient admissions were extracted for individuals aged 18 and over in financial years 2003/4 through 2008/9. We focus on acute hospital elective admissions excluding admissions to Primary Care Trusts (PCTs) and mental health care trusts. Anonymous records were extracted by financial year and summed to the patient's small area of residence. Observations were excluded if there were missing data fields for small area or age, which occurred in a very small proportion of cases (fewer than 0.1%), or if there were duplicate records or other forms of multiple counting of episodes for the same admission. Records were linked in the form of Continuous

Inpatient Spells that include transfers between consultant and hospital within same admission spell (Castelli et al., 2008). We included all relevant providers of NHS hospital care, including Independent Sector Treatment Centres (ISTCs) under national contracts and Independent Sector providers under local contracts. As discussed later, ISTC activity reporting is incomplete, especially from 2003/4 to 2006/7.

Year by year utilisation rates per 100,000 population for each of these hospital utilisation indicators are reported in Table 2, based on mid-year population estimates from the Office for National Statistics (ONS).

Table 2: Descriptive statistics by year (small area mean values)

	2003	2004	2005	2006	2007	2008
Total population aged 20 or over	1,155	1,161	1,173	1,183	1,193	1,203
All elective inpatient admissions per 100,000	15,129	15,137	16,055	16,851	16,960	19,039
Observed HHI (*)	5,903	5,885	5,814	5,715	5,676	5,487
Predicted HHI (*) (**)	4,096	n/a	n/a	n/a	n/a	4,013
Independent sector hospitals within 60km	0.077	0.298	3.081	3.217	5.888	10.978
Public hospitals within 60km	22.194	22.194	22.194	21.929	21.665	21.665

Notes to table 2:

1. Observations on the 32,480 Lower Layer Super Output Areas (LSOAs) in England are pooled across all seven years from 2003 to 2008.
2. Population size variables by 5 year age-sex bands not reported for reasons of space.

(*) Herfindahl-Hirschman Index of market concentration; range from 0 (max dispersion) to 10,000 (max concentration). Calculation described in Appendix 1.

(**) Predicted HHI is calculated for 2003 and 2008 only. Calculation described in Appendix 2.

3.2 Indices of hospital market structure

We measure market structure using a Herfindahl-Hirschman Index (HHI) of hospital market concentration. The index is defined as the sum of the squared market shares of all hospitals in the market, and normally ranges from 0 (max market dispersion) to 10,000 (max market concentration).

In our analysis, a "hospital" is defined as either an NHS Trust (a group of local public hospital sites funded and managed under the same organisational umbrella) or an independent sector provider site. Our data on market shares include patient flows to both NHS Trusts and IS sites, though in sensitivity analysis we also construct indices based on NHS Trusts only.

We calculate two versions of the HHI using two different approaches. The first is based on observed patient flows from their GP practice[2] to the hospital, and is calculated separately for each year from 2003 to 2008 as described in Appendix 1. The "observed HHI" assumes the GP practice is the relevant market unit since in the English hospital market patients access elective care through their GP referrals. Also, a number of surveys conducted by the Department of Health show that the patient's GP is the most important source of information when patients choose the hospital for their treatment[3]. In sensitivity analysis we also calculate an alternative version of this index using the patient small area of residence (i.e. the LSOA) as the initial market unit in place of the GP practices. We find a 90% correlation between these two versions of the observed concentration index. This is not surprising given that patients typically live close to their GP practice to minimize travel costs.

The second version of the HHI is based on predicted probabilities of patients being admitted to any hospital. Estimated probabilities are based on the interaction between exogenous patient and hospital characteristics that are likely to influence the patient's choice of hospital. Therefore, the "predicted HHI" is purged of potential bias from unobservable patient and hospital characteristics, such as

[2] This is the medical practice where the patient is registered for accessing primary care.
[3] Reports on the National Patient Choice Survey, July, December, January 2008.

hospital quality or patient health status. This index is based on the works of Kessler and McClellan (2000) and Gowrisankaran and Town (2003) and is described in Appendix 2. We construct the predicted HHI using observations in 2003 and 2008 only, since its calculation requires a considerable amount of data and computer resources.

Finally, we compute a time varying index of independent sector penetration, in order to test the hypothesis that apparent effects of competition are an artefact of increases in local hospital capacity rather than a real increase in competition. This index simply counts the number of independent sector providers within a 60km fixed radius distance from the LSOA demographic centroid.[4] In sensitivity analysis we construct alternative specifications of such an index by varying the radius (30Km and 45Km) and the size of the independent sector hospital included (>500 or >1,000 admissions).

3.3 Area deprivation

Small area socio-economic status is measured using the income deprivation domain of the English Indices of Deprivation 2007 (Noble et al., 2008). This index indicates the proportion of individuals resident in the LSOA in the year 2004 who were living in low income households. Low income households are defined as those either receiving means-tested low income out-of-work benefits (including income support, income-based job seeker's allowance, pension credit guarantee, and subsistence or accommodation support from the national asylum support service) or receiving means-tested low income in-work benefits (including working families tax credit and child tax credit) and whose equivalised income is below 60% of the median before housing costs. The index was produced by the Social Disadvantage Research Centre at the University of Oxford for the Department of Communities and Local Government.

We use this index because it is easy to interpret on a cardinal scale suitable for regression analysis and does not include any health related variables that might introduce circularity into the modelling. For most of the analysis, we treat this index as a cardinal variable. This allows us to take account of the full socio-economic distribution and avoids the potential selection biases associated with focusing on ratios or gaps between arbitrarily defined extreme groups. In one illustrative graph, however, we use this index to categorise small areas as "deprived" or "non-deprived" in terms of the absolute proportion of individuals living in low income households: (1) 0-20% ("low deprivation") and (2) 20% or more ("high deprivation"). This generates two unequally sized groups comprising 72.2% and 27.8% of small areas respectively. We also conduct sensitivity analysis using the Economic Deprivation Index (Noble et al., 2009). This index measures income deprivation among individuals aged under 60 and is time-varying for the first three years of our period from 2003 to 2005 but frozen thereafter for the next three years.

3.4 Need and GP supply variables

We control for a range of time varying small area need variables including population size, age-sex structure, and disease prevalence. We use ONS mid-year population estimates in 5 year age-sex bands (from 15-19 to 85 plus). Estimates of disease prevalence at GP practice level are obtained from data collected in the process of administering the pay for performance scheme for GPs in the NHS introduced in 2004/5, known as the "Quality and Outcomes Framework" (QOF). The data cover nearly all GP practices in England, and are extracted from disease registers submitted to the national Quality Management and Analysis System (QMAS). The data show the proportion of individuals registered to the GP practice who are recorded as having the disease in question. We attribute this to small area level using the Attribution Dataset of patient registration addresses within GP practices. The attribution process assumes that prevalence for a particular small area is a weighted sum of the prevalence in each GP practice serving that small area, with weights proportional to the number of small area residents registered with each GP practice. Both the QOF data and practice to small area attribution data were obtained from the NHS Information Centre. Eight of the twelve variables we use are available from 2004/5, though four of them (atrial fibrillation, chronic kidney disease, heart failure and obesity) are only available from 2006/7 following a revision to the QOF scheme. All of the disease prevalence variables use all age practice list size as the population denominator. However,

[4] We also conduct sensitivity analysis using 15km, 30km and 45km fix radius and including IS providers with at least 1,000 NHS patient admissions only. We find that the largest impact on elective admissions is obtained using 60Km fix radius and including all IS providers with at least 100 NHS patient admissions that we use in this study. Unfortunately, we are not able to produce an indicator of IS penetration based on the number of beds due to lack of data on IS providers.

diabetes prevalence is based on patients aged 17 and over; epilepsy and chronic kidney disease is based on patients aged 18 and over; and obesity prevalence is based on patients aged 16 and over.

We also control for time varying GP supply, by computing GPs per 10,000 population. This variable is based on GP practice level administrative data on whole time equivalent GPs per registered patient, from the General Medical Services database. This GP practice level variable is then attributed to LSOA level using the same procedure described above, as a weighted average based on the share of GP practice registered patients resident in the LSOA.

4. Methods

We model small area utilisation as a function of local market structure, time policy trend and population demographic and need variables. We use small area level fixed effects to allow for unobserved heterogeneity between small areas in local supply and demand factors that did not change between 2003 and 2008. The effect of each explanatory variable is therefore identified using within-area variation over time rather than between-area variation in global mean levels of the variables across all periods. We use a fixed effects specification as opposed to a random effects specification in order to control for unobserved heterogeneity between small areas in time invariant characteristics likely to be correlated with local market structure, such as historical supply and demand factors that generate between-area variations in global mean utilisation, market structure and need.

Our small area level regression equation can be written:

$$y_{it} = \delta HHI_{it} + \omega IMD_i * HHI_{it} + (\tau + \gamma HHI_{it} + \varphi IMD_i + \theta IMD_i * HHI_{it}) * I(t) + + \boldsymbol{\beta}'\mathbf{x}_{it} + \mu_i + \varepsilon_{it} \quad (1)$$

Where:

y_{it} is the utilisation count in small area *i* in year *t.*

HHI_{it} is the index measuring of market competition.

IMD_{it} is the time invariant index of income deprivation.

$I(t)$ is an indicator function of the post reform period that takes value equals 1 in the financial year 2008 and zero otherwise.

$\mathbf{x}_{it}$ is a vector of time varying control variables, including need variables: small area population size and demographic characteristics, prevalence of diseases; and supply variables: number of independent sector hospitals within 60km and whole time equivalent GP numbers.

μ_i is the small area fixed effect.

We use a linear model specification since inpatient admissions are approximately normally distributed at small area level. We estimate the effect of competition on equity using two model specifications based on equation (1). The first model uses the observed HHI and estimates the year by year impact of competition as the reform is gradually phased in from 2003 to 2008. The second model uses the predicted HHI and is estimated using observations before (2003) and during the reform implementation (2008) only. The predicted HHI allows for a more accurate identification of the competition effect, although this index requires intensive calculations and thus we limit the analysis to two years only.

In all regression models, we multiply the HHI concentration index by a constant term (-1/100) so that the index measures increasing market dispersion rather than concentration and range from -100 (minimum market dispersion, i.e. monopoly) to 0 (maximum market dispersion). This facilitates the interpretation of the model coefficients $\delta, \omega, \gamma,$ and θ in terms of marginal effects of increasing market dispersion rather than increasing concentration. Also, we treat income deprivation as a continuous variable on a scale of 0 to 100.

The effect of competition on socio-economic equity is identified using a three-way interaction term between the indicator of local market dispersion (i.e. the re-scaled HHI), the indicator of small area deprivation, and a year dummy variable capturing the gradual introduction of competition over time. The estimated coefficient on this three-way interaction term can be interpreted as the year by year change, as competition is introduced, in the effect of local market dispersion on utilisation by increasing levels of deprivation. (Or, equivalently, the year by year change in the effect of deprivation on utilisation by increasing levels of local market dispersion).

The baseline effect of deprivation on utilisation is not identified by our fixed effect model since our indicator of deprivation is not time varying. However, we can identify change over time in the effect of deprivation, based on within-area change over time in utilisation. The coefficient φ on the $IMD_i * I(t)$ term can be interpreted as the difference in the effect of income deprivation on utilisation between

2008 and 2003 (the baseline year) for small areas with highly dispersed markets (the baseline market structure). A negative coefficient would indicate a relative decrease in utilisation among deprived areas in dispersed markets since 2003 – which can be interpreted as a harmful decline in socio-economic equity – and *vice versa.*

The coefficient ω on the $IMD_i * HHI_{it}$ term identifies the effect of local market dispersion on socio-economic equity in 2003 (the baseline year). This coefficient shows how dispersion modifies the effect of deprivation in 2003. A negative coefficient would indicate a negative modification effect, suggesting that increasing level of market dispersion reduces utilisation in deprived areas in 2003.[5] Such an effect cannot be attributed to competition, however, since in 2003 there is no hospital competition. Instead, it can be attributed to other local supply and demand factors that influence the degree of market dispersion in 2003 – such as hospital re-configurations and changes in GP referral patterns for reasons unconnected with competition, such as waiting time targets.

Over time, however, change in dispersion starts to be more closely related to competitive pressure, as competition is introduced and starts to influence local market dispersion. The effect of competition on socio-economic equity can therefore be identified by the coefficient θ on the $IMD_i * HHI_{it} * I(t)$ term. This coefficient identifies the change in how dispersion modifies the effect of deprivation on utilisation before and after the introduction of the competition reform. A positive coefficient indicates that competition increases utilisation by increasing level of deprivation. This can be interpreted as competition having a positive effect on equity since other studies have shown that deprived areas use less heath care service than needed (Dixon et al., 2007). In contrast, a negative coefficient indicates that competition reduces utilisation in more deprived areas and thus has a negative effect on equity. In sensitivity analysis, we calculate the interaction effect in each of the 2003-2008 years and so the estimated coefficients show the full pattern of changes over time in the relationship between market dispersion and deprivation.

Other coefficients of interest include the baseline dispersion coefficient, which indicates the marginal effect of market dispersion on utilisation in 2003 for small areas with no income deprivation (i.e. at the baseline), and the dispersion-year coefficients which indicate the change in this marginal effect over time.

Our identification strategy assumes the absence of unobservable time variant confounders correlated both with local market structure and deprivation. This assumption is slightly different than the standard identification hypothesis of DID models. Time variant policy confounders are allowed to be correlated with competition or deprivation as long as they are not correlated with both. For instance, assume the implementation of the competition reform is accompanied by increasing extra health care resources in areas with highly dispersed markets, hence the identification of the effect of competition on utilisation (i.e. coefficients δ and γ) will be biased. However, the effect of competition on equity is still identified (i.e. coefficient θ) provided that the extra funding is randomly allocated between deprived and non-deprived areas. The identification of the effect of competition on equity is achieved by subtracting the effect of market dispersion from the effect of deprivation pre and post the introduction of the reform. Therefore, the coefficient θ is still identified even when the coefficients δ and γ are not, provided that the bias affects deprived and non-deprived areas equally.[6]

One of the confounders potentially capable of influencing the relationship between deprivation, competition and utilisation could be the entry of independent sector providers into NHS market during this period. Independent sector providers were authorised and incentivised to enter hospital markets with lack of supply, which were often characterised by high market concentration and located in income deprived areas. We control for such a potential confounding effect by including in the regression analysis a time varying indicator of independent sector penetration in the local hospital markets. The indicator counts the number of independent sector providers within 60Km fix radius distance from the small area.

Regression models were estimated using the statistical package Stata 11 and using robust standard errors clustered around small areas.

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[5] An equivalent interpretation is that an increasing level of deprivation reduces utilisation in areas having highly dispersed hospital markets.
[6] Equivalently, if a flow of extra funding is injected in income deprived areas over time, then the identification of the effect of deprivation on utilisation will be biased (i.e. coefficient φ), but the effect of competition on equity can be still identified.

5. Results

5.1 Change in hospital market structure between 2003 and 2008

Figure 1 presents kernel density plots of the distribution of the HHI of hospital market concentration across small areas of England, comparing 2003 with 2008. The index ranges from 0, indicating infinite market dispersion, to 10,000 indicating maximum market concentration (i.e. monopoly). There is a clear leftward shift between 2003 and 2008, showing that market concentration fell as the pro-competition reforms were introduced. Figure 2 presents the geographical distribution of the HHI on a "heat map" of England, again comparing 2003 with 2008. These maps also show a pattern of reduced market concentration between 2003 and 2008. These figures confirm the pattern in Table 2, which shows the mean concentration index decreasing from 5,900 in 2003 to 5,490 in 2008. The HHI is calculated using observed patients flows from GP practice to hospitals as described in Appendix 1.

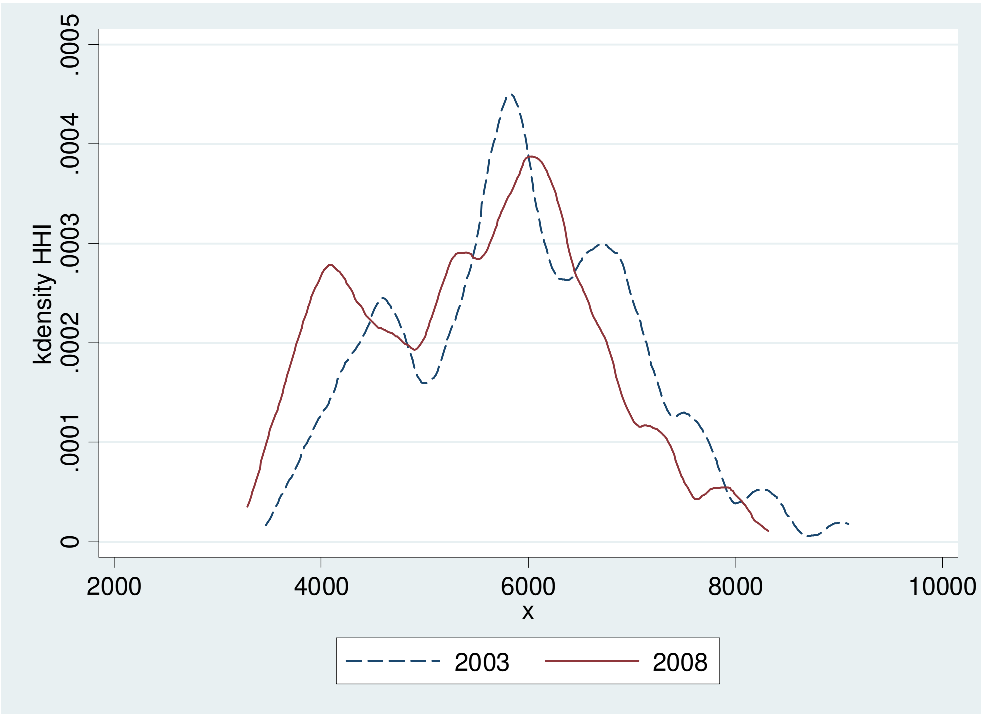

Figure 1: HHI of hospital market concentration for among English small areas, comparing 2003 and 2008 (kernel density plot)

Note to figure 1:
Herfindahl-Hirschman Index of market concentration based on observed patient flows; range from 0 (max market dispersion) to 10,000 (max market concentration). Calculation described in Appendix 2.

5.2 Equity effects on all elective inpatient hospital utilisation

Figure 3 shows crude annual utilisation trends in all elective inpatient admissions broken down by two dispersion groups ("low dispersion" and "high dispersion") and two deprivation groups ("low deprivation" and "high deprivation").

In 2003, "low dispersion" areas have substantially higher hospital utilisation than "high dispersion" areas. Furthermore, within both dispersion groups, "high deprivation" areas have higher utilisation than "low deprivation" areas in 2003. Utilisation then grows over time in all four groups, though more rapidly in "high dispersion" than "low dispersion" areas. Within the "low dispersion" group, utilisation grows faster in the "low deprivation" areas. By contrast, within the "high dispersion" group, utilisation grows slightly faster in the "high deprivation" areas. Growth of utilisation in deprived areas was thus faster within the "high dispersion" group of areas than the "low dispersion" group. By 2008, the "dispersed, deprived" group had caught up with the "non-dispersed, deprived group", whereas the

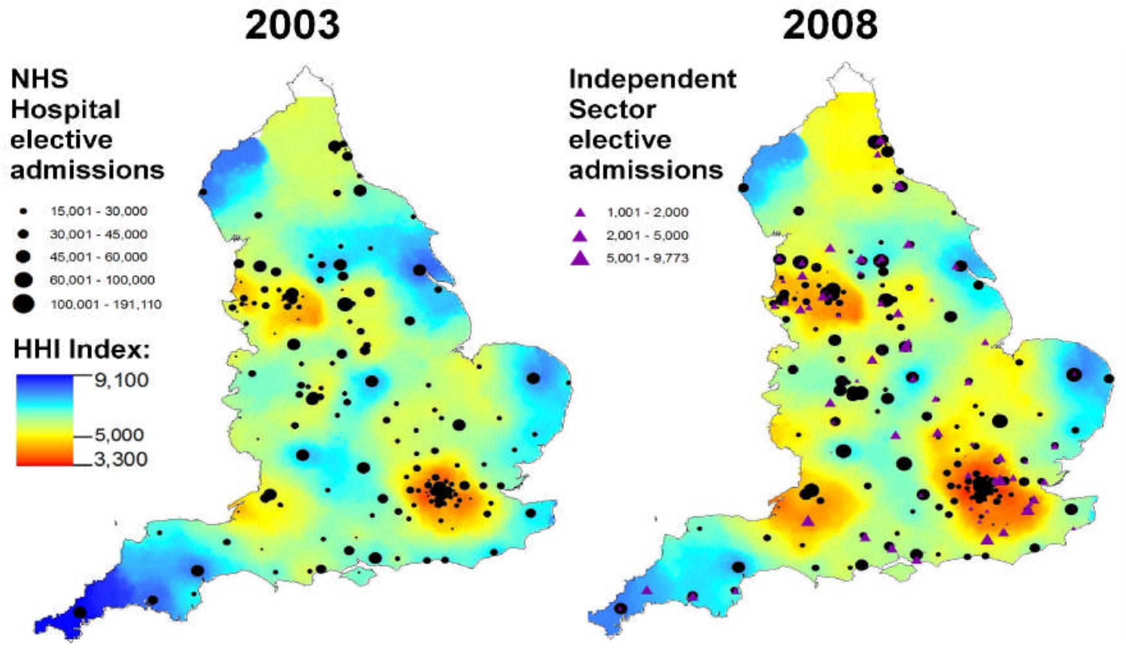

Figure 2: Hospital market concentration in the English NHS, comparing 2003 and 2008

Note to figure 2: Herfindahl-Hirschman Index of market concentration based on observed patient flows; range from 0 (max market dispersion) to 10,000 (max market concentration). Calculation described in Appendix 2.

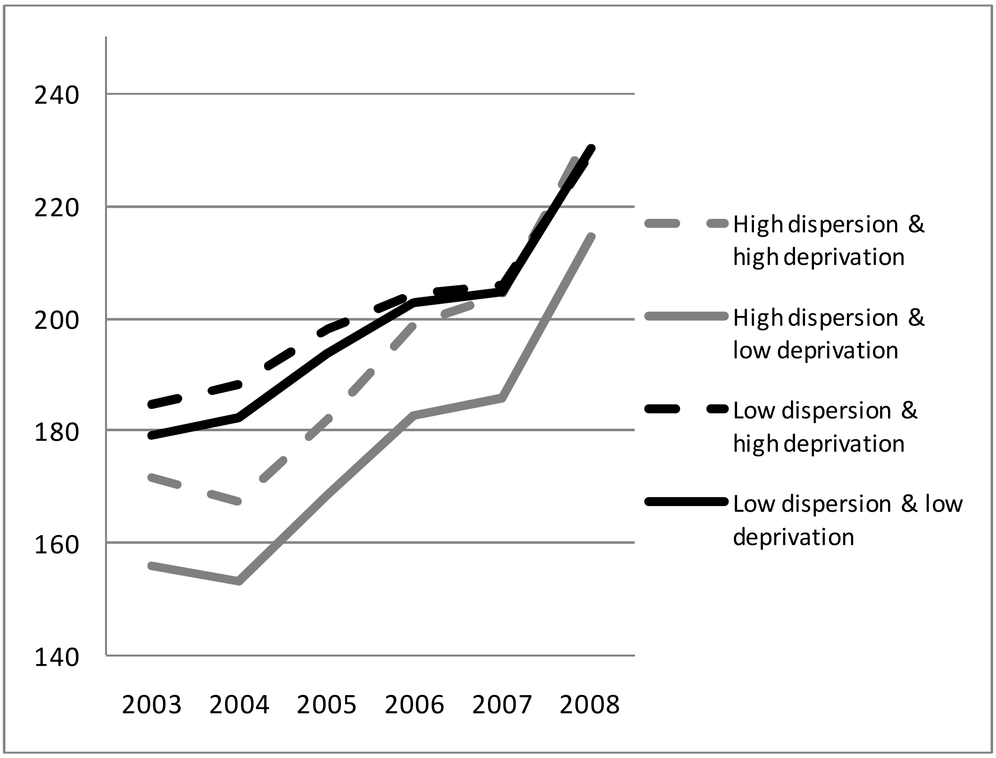

Figure3: Elective inpatient hospital utilisation by deprivation and dispersion (observed rates per 1000,000 population)

Notes to figure 3:

1. “High dispersion” refers to areas with HHI in 2003 < 5,000 (34.3% of areas) and “low dispersion” to other areas (65.7% of areas).
2. “High deprivation” refers to areas with IMD 2007 income deprivation score > 20% (27.8% of areas) and “low deprivation” refers to all other areas (72.5% of areas).

"dispersed, non-deprived" group still lagged behind the "non-dispersed, non-deprived" group. Insofar as the "high dispersion" group is likely to face a larger increase in competitive pressure during the period, this is suggestive evidence that competition may have helped to facilitate growth in elective hospital admissions in deprived areas and thus to improve socio-economic equity.

We now turn to the regression results, to examine competition effects on equity using statistical methods that control for confounding factors and are less sensitive to arbitrary definition of dispersion groups and deprivation groups than the graphical methods.

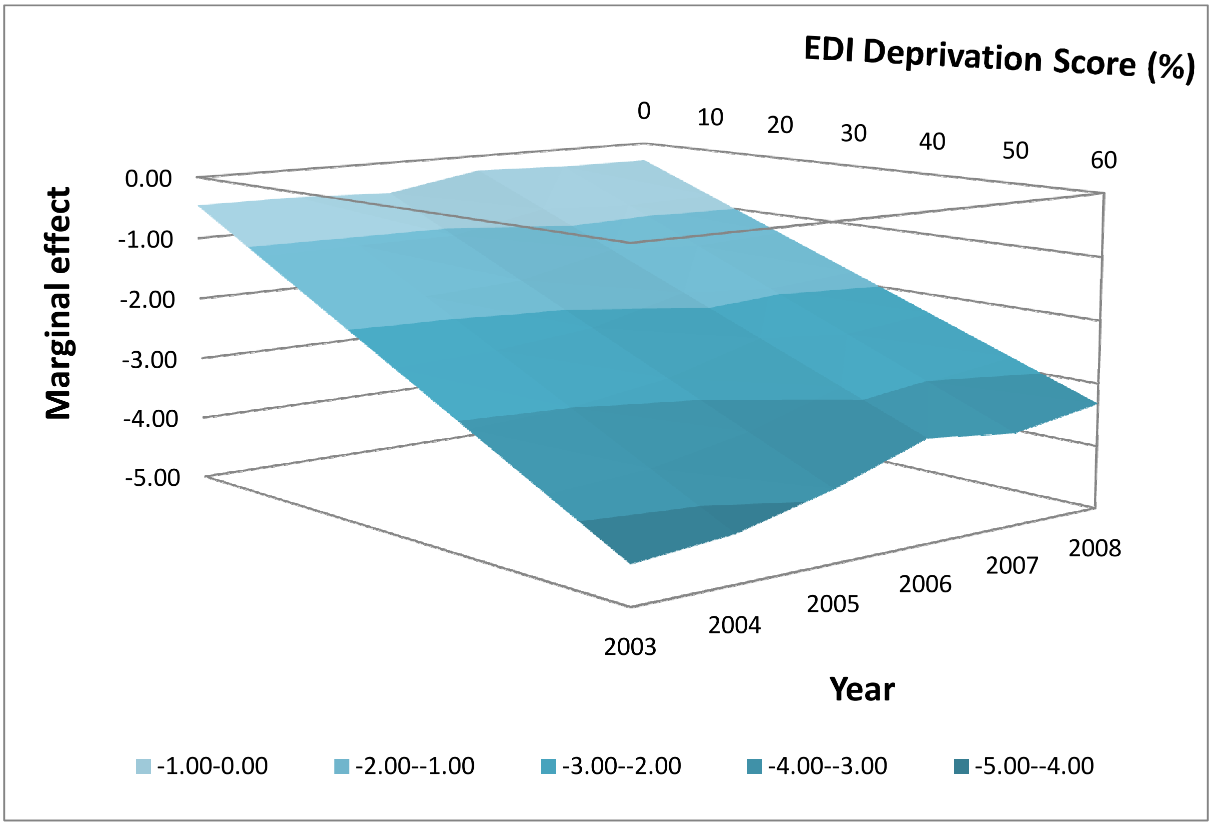

Figure 4: Marginal effect of hospital market dispersion on all elective inpatient admissions

Note to figure 4: The figures plots the estimated marginal effects reported in table 3 using model 1.

Our regression results are perhaps easiest to understand in graphical form, since the interaction terms can be hard to interpret. Figure 4 shows how the marginal effect of local market dispersion on utilisation varies by deprivation and over time. The graph is obtained by plotting the coefficients estimated using model 1 (Table 3) and show the variation in total elective admissions generated by one unit variation in market dispersion by deprivation and year. In each year, the marginal effect of dispersion is negative. This negative effect is modified by deprivation to become even more negative in more deprived areas. Over time, however, this negative modification effect of deprivation is gradually attenuated, as shown by the upward slope of the marginal effect contour on the year axis from 2003 to 2008. The effect of dispersion on utilisation in deprived areas is still negative in 2008 – but less so than in 2003. So competition has slightly attenuated this effect and thus slightly increased utilisation in deprived areas. Since we assume there was pre-existing socio-economic inequity favouring advantaged areas in 2003, we can interpret this result as showing that competition slightly improved socio-economic equity. We now turn to the full results, for completeness.

Table 3 shows the results of two linear fixed effect models of all elective inpatient admissions. Model 1 uses the observed competition index (described in appendix 1) and model 2 uses the predicted competition index (described in appendix 2).

The deprivation*year interactions show a pattern of significant and increasingly positive coefficients, rising to 1.339 by 2008 in model 1. This suggest that, in the reference category areas with high

Table 3: Competition effects on equity in utilisation of elective hospital services across small areas.

Variables	Model 1 (Observed competition index)		Model 2 (Predicted competition index)	
	Coefficients	se	Coefficients	se
Dispersion * Deprivation * 2008	0.0155**	(0.00362)	0.0141**	(0.00205)
Dispersion * Deprivation * 2007	0.0116**	(0.00319)	n/a	n/a
Dispersion * Deprivation * 2006	0.0135**	(0.00299)	n/a	n/a
Dispersion * Deprivation * 2005	0.00956**	(0.00247)	n/a	n/a
Dispersion * Deprivation * 2004	0.00229	(0.00183)	n/a	n/a
Dispersion * 2008	0.144*	(0.0733)	-0.0659	(0.0444)
Dispersion * 2007	0.149*	(0.0630)	n/a	n/a
Dispersion * 2006	0.202**	(0.0594)	n/a	n/a
Dispersion * 2005	-0.0661	(0.0503)	n/a	n/a
Dispersion * 2004	-0.00485	(0.0377)	n/a	n/a
Deprivation * 2008	1.339**	(0.216)	0.740**	(0.0964)
Deprivation * 2007	1.019**	(0.193)	n/a	n/a
Deprivation * 2006	0.980**	(0.183)	n/a	n/a
Deprivation * 2005	0.722**	(0.151)	n/a	n/a
Deprivation * 2004	0.225*	(0.110)	n/a	n/a
Dispersion * Deprivation	-0.0656**	(0.00842)	-0.0150	(0.00871)
Dispersion	-0.461**	(0.135)	-0.146	(0.145)
Independent sector hospitals within 60km	0.466**	(0.0792)	0.434**	(0.120)
year2008	27.25**	(4.818)	10.33**	(3.565)
year2007	9.380*	(4.035)	n/a	n/a
year2006	19.09**	(3.727)	n/a	n/a
year2005	-1.300	(3.129)	n/a	n/a
year2004	-1.867	(2.272)	n/a	n/a

Notes to table 3:

1. Results from liner panel data models with fixed effects
2. Dependent variables: all elective hospital admissions
3. Unit of analysis: small areas (LSOAs)
4. Both models include controls for: GPs per 10,000 population, population size, age-sex fractions and prevalence of diseases described in Table 1(coefficients not shown).
5. Baseline: zero deprivation and zero competition areas in 2003.
6. Dispersion is measured by using the HHI indices of market concentration described in Appendix 1 and 2. Both indices are re-scaled from -100 (min market dispersion) to 0 (max market dispersion) to facilitate the interpretation of the regression results.
7. Deprivation is measured by using the income domain of the Indices of Multiple Deprivation 2007. Scale from 0 to 100, with 100 representing 100% of individuals from households on low income benefits. Deprivation is fixed over time, so its effect cannot be separately identified from the fixed effects in both models.
8. Standard errors clustered by small areas in parentheses.
9. ** p<0.01, * p<0.05

market dispersion, the effect on admissions of a one unit change in the percentage of individuals living in households on low income benefits was 1.339 higher in 2008 than 2003. This is a relatively small effect in the context of a global mean small area admission count of 193. Moreover, this effect is substantially smaller (0.740) in model 2 using the predicted competition index.

The dispersion*deprivation coefficient of -0.0656 in model 1 is also significant though very small. There are two logically equivalent ways of interpreting this coefficient. First, in terms of the effect of deprivation on utilisation, and how this is modified by dispersion. Second, in terms of the effect of dispersion on utilisation, and how this is modified by deprivation. In the former interpretation, this coefficient suggests that in 2003 (the baseline) a one percentage point increase in local hospital market dispersion modified the effect of deprivation on utilisation by -0.0656 of one admission. Equivalently, in the latter interpretation, this coefficient suggests that a one percentage point increase in deprivation modified the effect of local hospital dispersion by -0.0656 of one admission. However, this effect is much smaller (-0.0150) and no longer significant in model 2.

The dispersion*deprivation*year terms show a pattern of significant and increasingly positive coefficients (model 1). This again can be interpreted in two different though logically equivalent ways. First, it suggests that competition slightly attenuated the negative modification effect of dispersion on the effect of deprivation on utilisation. Second, it suggests that competition slightly attenuated the negative modification effect of deprivation on the effect of dispersion on utilisation. Either way, the coefficient suggests that competition slightly increased utilisation in deprived areas and therefore slightly improved socio-economic equity. These coefficients are very small, however: by 2008, the modification effect is attenuated by only 0.0155 of one admission. Model 2 provides a very similar estimate of the same coefficient (0.0144) suggesting that the effect of competition on equity is robust to the use of either the observed or the predicted competition index.

Table 4 reports the results of our sensitivity analyses using a time varying index of income deprivation (i.e. the income domain of EDI index) and the predicted competition index. We obtain precisely the same pattern of results produced by model 2.

Table 4 Competition effects on equity in utilisation of elective hospital services across small areas. Sensitivity analysis using time-varying income deprivation index

Variables	**Model 3 (Predicted competition index & time varying deprivation index)**	
	all elective	se
Dispersion * Deprivation * 2008	0.0174**	(0.00238)
Dispersion * 2008	-0.0473	(0.0412)
Deprivation * 2008	0.887**	(0.108)
Dispersion * Deprivation	-0.0122	(0.00783)
Dispersion	-0.225	(0.117)
Deprivation	-0.406	(0.438)
Independent sector hospitals within 60km	0.426**	(0.120)
year2008	12.44**	(3.473)

Notes to table 4:

1. Results from liner panel data models with fixed effects
2. Dependent variables: all elective hospital admissions
3. Unit of analysis: small areas (LSOA)
4. Model includes controls for: GPs per 10,000 population, population size, age-sex fractions and prevalence of diseases described in Table 1(coefficients not shown).
5. Baseline: zero deprivation and zero competition areas in 2003.
6. Dispersion is measured by using the HHI indices of market concentration described in Appendix 1 and 2. Both indices are re-scaled from -100 (min market dispersion) to 0 (max market dispersion) to facilitate the interpretation of the regression results.
7. Deprivation is measured using the income domain of the Economic Deprivation Index 2008. Scale from 0 to 100, with 100 representing 100% of individuals aged under 60 from households on low income benefits. Time-varying values are only available from 2003 to 2005; we use fixed 2005 values as measure of deprivation in 2008.
8. Standard errors clustered by small areas in parentheses.
9. ** $p<0.01$, * $p<0.05$

6. Discussion

6.1 Main findings

We find no evidence that increased competition in the English NHS from 2003 to 2008 had any harmful effect on socio-economic equity in hospital care. If anything, we find that competition may have very slightly improved socio-economic equity, by helping to facilitate the slightly more rapid growth of elective inpatient admissions over time in deprived areas. Our findings do not support the hypothesis that competition undermines socio-economic equity in health care, or the theoretical story that competition reduces the pro-social motivation of hospitals to treat deprived patients.

However, the increase in hospital competition between 2003 and 2008 was not large. One indication of this is that hospital market concentration fell by just under 500 points in the HHI between 2003 and 2008, from 5,900 to 5,490. So it remains possible that larger doses of competition could have important effects on socio-economic equity.

A number of possible speculations can explain why competition very slightly increased elective inpatient admissions in deprived areas. One is that patient choice was particularly beneficial to deprived patients living in "high choice" areas with dispersed hospital markets, in helping them choose hospitals with lower waiting times. In turn, this may have increased utilisation in those deprived areas by reducing local waiting list backlogs and allowed local clinicians to lower referral and treatment thresholds. Another possible speculation is that competitive pressure may have generated market incentives for hospitals to seek out profitable new business among patients with previously unmet needs, who may disproportionately reside in deprived areas. However, the effect is so small as to be negligible from a national policy perspective.

Figure 3 illustrates the importance of using a fixed effect specification. Elective inpatient admission rates in 2003 are substantially higher in areas with more concentrated hospital markets. Since competition was only gradually introduced after 2003, this between-area association cannot be attributed to competition in 2003 but must instead be the result of unobserved historical factors. One possible speculation is that the association may be due to population growth in some metropolitan areas during the 1980s and 1990s outstripping growth in hospital capacity in those areas. Those areas may therefore tend to have both low utilisation rates per head of population and relatively dispersed hospital markets compared with rural areas with low population density and few local hospitals. Our fixed effect specification purges the effect of this historical between-area association from our estimates.

The predicted HHI provides substantially smaller estimates of the effect of competition on elective admissions than the observed HHI. The former is calculated excluding potentially endogenous factors, such as hospital quality and waiting times. In particular, hospitals increasing their capacity are likely to expand their market share by lowering their waiting times and hence becoming more appealing to patients. This might explain the difference in the estimated effect of competition when using the observed HHI as compared with the estimated HHI. However, both indices provide similar predictions of the effect of competition by deprivation and year. This suggests that the bias might equally affect deprived and non-deprived areas and thus it cancels out in the DID setting.

Finally, we find that the incorporation of IS penetration generally reduces the effect of market dispersion as expected, but does not affect the key coefficient on the three way interaction terms between market dispersion*deprivation*time under all model specifications.

6.2 Methodological strengths and limitations

One strength of our study is the use of panel data methods to identify effects of competition. We exploit both change in local market dispersion within small areas and change in policy regime to identify effects of competition. This is more powerful than relying on cross sectional variation in market dispersion between small areas, which may be correlated with unobservable historical and geographical determinants of hospital utilisation that have nothing to do with competition.

Also, our study uses a measure of competition based on predicted HHI as opposed to the observed HHI. This allows for potentially endogenous factors influencing the patient choice of hospitals such us hospital quality and patient health status.

A third strength is that our study covers all patients in the English NHS. This is an important advantage of administrative data over survey data for our purposes. Our study is representative of all sections of the community including the most socio-economically deprived individuals who are sometimes hard to include in sample surveys. Moreover, we have a sufficient number of observations to detect statistically significant changes in equity trends associated with changes in competition.

This study has several limitations. First, we only observe socio-economic status at the level of small areas – with mean population 1,500 – and not at the level of individuals. This means that we can only draw conclusions about people living in low income areas, since not all individuals living in low income areas have low socio-economic status. Nevertheless, living in a low income area is a reasonable proxy for low socio-economic status, since housing in England is highly segregated by socio-economic status and LSOA boundaries were designed by ONS to delineate relatively homogenous small areas in terms of socio-economic status and other social factors. Second, we focus on hospital care and do not specifically examine equity in primary care. However, all of our hospital utilisation indicators potentially capture inequities arising at the primary care stage in the patient pathway. Finally, like all administrative datasets, HES contains coding and measurement errors. One possible source of bias is missing data for Independent Sector (IS) providers. If IS patients are less likely to be drawn from deprived communities, the missing data could in theory obscure disproportionate rises in IS activity in affluent areas. However, mean area deprivation is not much lower among IS patients than among patients treated by NHS Trusts: only 1.56 percentage points lower in a recent study of 2007/8 data covering 78% of procedures coded in IS activity (Mason et al. 2010). Furthermore, IS activity makes up a relatively small proportion of NHS activity in the early years of the ISTC programme when coding was particularly poor – less than 1% until 2006/7 – and activity coding has improved since then (NHS Information Centre 2009). Missing data on IS activity is thus unlikely to be sufficiently large proportion of total activity to bias our results. A final limitation is that we only examine inequality in the volume of hospital care, as opposed to the quality and outcomes of hospital care. We therefore cannot test hypotheses about effects of competition on quality of care or theoretical stories about deprived patients being less able than affluent patients to avoid low quality hospitals due to poor information and reluctance to travel long distances.

6.3 Comparison with other studies

Our main finding that hospital competition had no substantial effect on socio-economic equity during the Blair/Brown reforms is consistent with previous findings about the effects of hospital competition during the Thatcher/Major "internal market" reforms of the NHS in the 1990s. A small area study of NHS hospital episode statistics from 1991 to 2001 found that the NHS "internal market" reforms had no impact on socio-economic inequalities in hip replacement and revascularisation (Cookson et al., 2010). Like the Blair/Brown reforms, however, the "internal market" reforms of the 1990s involved a relatively small dose of hospital competition.

Our findings are also consistent with studies of overall trends in small area socio-economic equity during the 2000s, which have generally shown no change during the period – including small area socio-economic equity in waiting times for hip replacement, knee replacement and cataract surgery from 1999 to 2007 (Cooper et al., 2009), rates of preferred surgery for colorectal, breast and lung cancer between 1999 and 2006 (Raine et al., 2010) and rates of all elective inpatient admissions, all outpatient visits, hip replacement, cataract surgery, gastroscopy and coronary revascularisation (Cookson et al, 2010.).

Taken together with the results of other studies, our results suggest that socio-economic patterns of health care utilisation are deeply ingrained, and that small doses of "quasi market" competition have little or no effect on socio-economic equity in health care in the context of universal and comprehensive health systems.

Appendix 1

The observed competition index is calculated following a three step procedure. We first calculate HHI concentration indices at GP practice level, based on observed shares of patients referred by the GP practice to any hospital. This index measures the degree of concentration of GP practice referrals for elective admissions for each GP practice in England.

In the second step, we calculate HHI indices at hospital level as a weighted average of the HHI scores of all GP practices referring patients to that hospital. The weights are calculated using the number of hospital admissions coming from each GP practice.

Finally, we attribute the hospital level HHI indices to each LSOA as weighted average of public hospitals located within a 60 km fixed radius distance from the LSOA demographic centroid. The weights are inversely proportional to the hospital distance from the LSOA to reflect patient willingness to travel: hospitals closer to the LSOA population are given greater weight. All hospital within 5 km distance from the LSAO are given same weight. Propper et al. (2007) find that 90% of patients for elective admissions travel no further than 60km. Almost all LSOAs in England have at least one hospital within 60 km. The few (about 30) LSOAs with no hospitals within 60 km are on the border with Scotland, and most probably seek care in Scottish hospitals, so we exclude them from our study. All hospitals that are very close to the LSOA centroid are given same weight, since LSOA residents do not all live in the population centroid but are dispersed within this area. In sensitivity analysis, we use alternative fix radius (30Km and 45Km) and find the completion indices are highly correlated and produce very similar results.

Appendix 2

The identification of the effect of competition on equity in utilisation is potentially exposed to endogeneity bias when using an index of competition based on observed patient flows to hospitals. For example, a hospital investing in extra capacity might attract larger patient flows by lowering its waiting time, thus influencing both market structure and absolute utilisation volume. Moreover, the relationship between patient volumes and patient shares might vary by the socioeconomic characteristics of patients. Patients from lower socioeconomic back grounds might not be willing to travel long distances and choose a different provider from their local hospital (Propper et al., 2006). Finally, patient flows might be affected by unobservable characteristics of patient health status, which are potentially correlated with their socioeconomic background.

To overcome potential problems of endogeneity, we follow the approach described in Kessler and McClelland (2000) and Gowrisankaran and Town (2003) and measure competition using patient travel distances that are exogenous to unobserved characteristics of patients and hospitals. The predicted competition index at small area level is obtained following a three steps procedure.

In the first step, we specify a model of hospital choice at patient level as a function of exogenous determinants of the patient admission using the following specification of the patient indirect utility function (Kessler and McClellan, 2000):

$$U_{ij} = \sum_{h=1}^{3}\left\{DD_{ij}^{h+} \times \left[\theta_1^h Z_j^h + \theta_2^h\left(1 - Z_j^h\right)\right] + DD_{ij}^{h-} \times \left[\theta_3^h Z_j^h + \theta_4^h\left(1 - Z_j^h\right)\right]\right\} +$$

$$+ \textstyle\sum_{h=1}^{3}\left\{X_i Z_j^h \lambda^h\right\} + \epsilon_{ij} \qquad (2)$$

The utility of patient i from choosing the hospital j depends on: the relative distance of hospitals of a similar h type to hospital j - captured by the vector DD_{ij}^{h+} in the first term of equation 2; the relative distance of hospitals of different type - captured by the vector DD_{ij}^{h-} in the second term of equation 2; and the interaction between individual i characteristics, X_i , and hospital j characteristics - the latter are captured by a binary indicator Z_j^h in the last term of equation 2, $Z_j^h = 1$ if hospital j is of the type h and zero otherwise.

We allow for three different types of hospitals in our model – large public hospitals, teaching hospitals, independent sector hospitals. Also, we allow for individual characteristics such as patient severity (i.e. patient admitted with just one diagnosis, 2-3 co-diagnoses and more than three), patient age (i.e. patients aged from 18-50 and more than 50), patient socioeconomic status (i.e. patients from the most income deprived 20% of small areas). We restrict the choice set to all hospitals within 100km fix radius conditional of having at least one hospital of each type in the choice set.

The model described in equation 2 is used to predict the probability of each patient admission:

$$\Pi_{ij} = \Pr\left(Y_{ij} = 1\right) = \frac{\exp(U_{ij})}{\sum_{j=1}^{J_i} \exp(U_{ij})} \qquad (3)$$

Where J_i are the hospitals in the choice set of individual i. Equation 3 is solved by maximising the following log-likelihood function:

$$\log L = \textstyle\sum_{i=1}^{n} \sum_{j=1}^{J} \log\left(\Pi_{ij}\right) \qquad (4)$$

We estimate equation 4 using a conditional logit separately for 2003 and 2008.

In the second step, we can calculate the hospital level HHI following Gowrisankaran and Town (2003):

$$H\widehat{H}I_j = \frac{1}{\widehat{n}_j} \textstyle\sum_{j=1}^{J_i} \widehat{\pi}_{ij} \times H\widehat{H}I_i \qquad (5)$$

With:

$$\hat{n}_j = \sum_{i=1}^{n} \widehat{\Pi}_{ij} \quad \text{and} \quad H\widehat{H}I_i = \sum_{j=1}^{J_i} \widehat{\Pi}_{ij}$$

Following Kessler and Mclellan (2000) and Gowrisankaran and Town (2003), we exclude patient level and hospital level characteristics from the main effects entering equation 2 and obtain an index of competition based on exogenous determinants of patient flows rather than potentially endogenous factors.

In the third step, we attribute the hospital level competition index obtained from equation 5 to small areas using a weighted average of public hospital HHI. We weight the hospitals' HHI by the inverse of their distance to the demographic centroid of the LSOA:

$$H\widehat{H}I_l = \frac{1}{w_l} \sum_{j=1}^{J} w_{jl} \times H\widehat{H}I_j \qquad (6)$$

We restrict the number of hospitals to be directly included in the LSOA market to those falling within a radius of 60km from the small area demographic centroid and attribute an equal distance to hospitals located within a radius of 5Km. Fixing the LSOA market radius at 60Km prevents to artificially inflate the competition of those LSOAs having few hospitals in their closest neighbourhood. The contribution of distant hospitals is indirectly included in the LSOA market through their competition interactions with local hospitals as described in equation 5. In sensitivity analysis, we use alternative fix radius (30Km and 45Km) and find the completion indices are highly correlated and produce very similar results.

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