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THE LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCE

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**Abstract:**

This paper examines whether or not hospital competition in a market with fixed reimbursement prices can prompt improvements in clinical quality. In January 2006, the British Government introduced a major extension of their market-based reforms to the English National Health Service. From January 2006 onwards, every patient in England could choose their hospital for secondary care and hospitals had to compete with each other to attract patients to secure their revenue. One of the central aims of this policy was to create financial incentives for providers to improve their clinical performance. This paper assesses whether this aim has been achieved and competition led to improvements in quality. For our estimation, we exploit the fact that choice-based reforms will create sharper financial incentives for hospitals in markets where choice is geographically feasible and that prior to 2006, in the absence of patient choice, hospitals had no direct financial incentive to improve performance in order to attract more patients. We use a modified difference-in-difference estimator to analyze whether quality improved more quickly in more competitive markets after the government introduced its new wave of market-based reforms. Using AMI mortality as a quality indicator, we find that mortality fell more quickly (i.e. quality improved) for patients living in more competitive markets after the introduction of hospital competition in January 2006. Our results suggest that hospital competition in markets with fixed prices can lead to improvements in clinical quality.

Keywords: Health Care, Quality, Competition, Choice, Incentives, Reimbursement
JEL codes: I1, L1, R0

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## 1. Introduction

Increasingly, policy-makers across the world are embracing hospital competition in order to create financial incentives for health care providers to improve quality and efficiency. England has not been an exception to this trend. Over the last two decades, successive governments in England have introduced two waves of market-based reforms, each of which was centered on increasing hospital competition in the state-funded National Health Service (NHS). The latest wave of reforms, which came into force in January 2006, gave every NHS patient a choice of their secondary care provider and allowed hospitals to compete with each other to attract patients. However, in spite of significant interest in creating sharper financial incentives in the health care sector, there is not a consensus on how health care markets should be structured or on the impact of hospital competition on clinical quality (Dranove and Satterthwaite, 1992, Dranove and Satterthwaite, 2000, Gaynor, 2004, Gaynor and Haas-Wilson, 1999). This ambiguity about the theoretical impact of competition on clinical quality together with ideological opposition to introducing competition into the NHS has made the most recent wave of English NHS reforms, commonly referred to as the 'patient choice' reforms, remarkably controversial (Dixon, 2009).

The crucial difference between the first wave of NHS reforms in the mid-1990s and the post-2006 patient choice reforms was the extent to which hospitals could compete on both price and quality. During the 1990s NHS internal market, hospitals could set their own prices and they competed for annual contracts on the basis of their price and quality. A decade later, in the most recent way of market-based reforms, prices were set centrally by the UK Department of Health and hospitals could only compete for market-share on the basis of their quality. Gaynor (2004) has hypothesized that hospital competition in markets with fixed reimbursement prices may improve clinical quality, whereas hospital competition in markets where firms can set their own prices may reduce clinical quality. Consistent with this hypothesis, Propper et al. (2004) and Propper et al. (2008) found that higher hospital competition in the 1990s NHS internal market, when reimbursement prices were variable, was associated with an increase in hospital mortality.

This paper examines whether hospital competition during the latest wave of NHS reforms led to improvements in clinical quality. We hypothesize that as hospitals were exposed to financial incentives to compete for patients on published quality measures like standardized hospital mortality, surgical volume and infection rates in a market with fixed prices, hospitals likely took steps to improve their clinical performance. We use the January 2006 formal introduction of hospital competition across England to create a quasi-natural experiment to estimate the impact of hospital competition on clinical quality, which we measure using 30-day in hospital mortality from acute myocardial infarction (AMI). For our estimation, we exploit the fact that choice-based reforms will create sharper financial incentives for hospitals in markets where choice is geographically feasible and that prior to 2006, in the absence of patient choice, hospitals had no direct financial incentive to improve performance in order to attract more patients. Specifically, we use a modified difference-in-difference (DiD) estimator to test whether patient outcomes in high-choice areas have improved at a significantly faster rate post-reform than in low-choice areas after all patients in England were formally given the ability to select their hospital in January 2006.

Ultimately, we find that after the formal introduction of patient choice in January, AMI mortality decreased more quickly for patients living in areas with more competitive spatial hospital markets. In the three-year period after the reforms were introduced in 2006, one standard deviation more hospital competition was associated with approximately a 1% decrease in AMI mortality. In short, higher hospital competition was associated with faster rate of decrease in AMI mortality. There is significant evidence in England that in-hospital time to thrombolysis and the availability of angioplasty vary significantly across NHS hospitals (Walker et al., 2009). Given that both factors are strongly associated with AMI mortality, one explanation for our results is that increased competition led to faster uptake of angioplasty and/or an increase in the speed at which patients receive thrombolysis, although our data do not allow us to ascertain whether or not that was the case (Fibrinolytic Therapy Trialists' (FTT) Collaborative Group, 1994, Gale et al., 2008, GUSTO investigators, 1993, Zijlstra et al., 1999). Our results support the hypothesis that in markets with fixed prices, hospital competition can improve patient outcomes.

Our work makes additional contributions to the empirical literature on spatial hospital competition by carefully addressing the potential endogeneity of spatial competition measures to hospital quality. In this respect, to bolster our DiD strategy we: a) base market structure on patients' residential location rather than hospital location; b) measure competition from patient choices over elective procedures, but measure health service quality using an emergency procedure (AMI) that is a marker for overall clinical quality; c) devise an instrumental variable (IV) strategy that exploits the variance in distances between where people live and their four nearest hospitals as a source of exogenous variation in hospital market power; and d) present various tests that indicate that our estimates arise, post-reform, from market structure in the health service, and not from spurious aspects of urban-density.

This paper is structured as follows. Section 2 outlines the recent NHS market-based reforms and contrasts them to the internal market reforms of the 1990s. Section 3 examines the existing literature on the impact of hospital competition on quality. Section 4 presents our data, outlines our various measures of competition and our empirical model. Section 5 contains our results. Section 6 includes an analysis of our results and our conclusions.

## 2. Competition in the English NHS

The pre-1990 English National Health Service (NHS) was driven by central government control and had few financial incentives for quality or efficiency (Cutler, 2002). In the four decades after the NHS was founded, successive governments were able to control costs using supply-side regulation and prospective hospital budgeting. The high degree of centralization allowed spending in the UK to grow more slowly than spending in almost every other developed country (Cutler, 2002). On the other hand, the heavy centralization in the UK likely gave rise to inefficiency and delayed the uptake of new technology (McClellan et al., 1999).

The most notable feature of the internal market was that it separated the providers of health care from the purchasers of health care (Propper et al., 2004). Newly formed local bodies would consider the needs of their patient population and establish annual contracts to purchase a fixed number of surgical interventions from local hospitals (Le Grand et al., 1998). The hope was these new purchasers would purchase wisely and maximize quality for the lowest price, since both the price and quality of the services being purchased was variable. The internal market remained in operation until 1997, when the newly elected Labour party dismantled most elements of it, but retained the separation between purchasers and providers.

Traditional microeconomic theory predicts that competition will lead to more efficient welfare outcomes. However, there is a growing literature noting the potential for price and quality competition to have a deleterious impact on quality in health care markets, if hospitals have the freedom to set both the price and the quality of service delivery (Chalkley and Malcomson, 1998, Gaynor, 2004). Ultimately, the outcome of simultaneous price and quality competition is dependent on whether or not purchasers are equally sensitive to both price and quality (Gaynor and Haas-Wilson, 1999, Propper et al., 2004, Propper et al., 2006). In competitive health care markets, where quality is noisy and often difficult to measure, purchasers may well be significantly elastic to price and as a result, quality may suffer (Chalkley and Malcomson, 1998, Gaynor, 2004, Kranton, 2003, Volpp et al., 2003). Conversely, Gaynor (2004) draws on a well established body of literature to show that in fixed price competitive hospital markets, as long as the reimbursement rate per procedure is greater than the hospitals' marginal costs per episode of care, the quality of care provision should rise (Gaynor, 2004).

The most recent wave of market-based reforms to the NHS had four key elements, all implemented between 2003 and 2008, which created financial incentives for hospitals to attract patients and introduced hospital competition. Figure 1 is a timeline of the key elements of the reforms. Prior to 2006, the government introduced several policy elements necessary to support hospital competition and on January 1, 2006, the incentives from hospital competition came into force. We regard January 1, 2006 as our 'policy on' date, and the first point when hospitals were significantly exposed to financial incentives from competition.

In an effort to create an environment that would support competition, beginning in 2002, the health service increasingly began paying for NHS patients to receive care in private sector facilities and attempted to increase and diversify the hospital sector in England (Department of Health, 2002). The NHS helped coordinate and fund the development of Independent Sector Treatment Centers (ISTCs) which were to provide elective surgery and diagnostic services. Between 2002 and 2008, 42 ISTCs opened across England and they are projected to eventually provide up to 15% of elective care (Propper et al., 2006). The government encouraged private sector hospitals to enter the market so that patients would have additional choice for elective care and NHS hospitals would face increased competition to attract patients. At the same time, in an effort to encourage local innovation, the government gave high performing hospitals additional fiscal, clinical and managerial autonomy. Hospitals that earned additional autonomy were referred to as 'foundation trusts'.

In 2005, the government implemented a new fixed-price funding mechanism called 'Payment By Results' (PBR), which was largely a case-based payment system modeled on the diagnosis-related group (DRG) payment system in the US (Department of Health, 2009a). Previously, hospitals were paid via annual budgets and bulk-purchasing contracts from local purchasing organizations with little attention to clinical quality (Chalkley and Malcomson, 1998). The key feature of the PBR system in relation to the market-based reforms was that the money in the health system would eventually follow the patients' choices so that hospitals were only paid if they were able to attract patients (Le Grand, 2007, Dixon, 2004). The Department of Health created service-related tariffs and adjusted them according to several factors such as whether a hospital was an academic center, patient severity and local wage rates (Department of Health, 2009a).

After diversifying the hospital sector, adding additional capacity to the health system and introducing a reimbursement scheme that rewarded hospitals for attracting patients, the government was in a position to tie hospitals' financial success with their ability to attract patients. From January 2006 onwards, the major plank of the government's market reforms came into force and patients were given the ability to choose between four or more providers for secondary care (Department of Health, 2002, Department of Health, 2003, Department of Health, 2004, Department of Health, 2009b).[1] By giving patients the ability to choose their hospital and allowing money to follow patients through the health system, hospitals had financial incentives to attract patients. In April 2008, patients were given the ability to choose from any provider in England, as long as the provider met NHS standards, and were paid using the traditional NHS tariff (Department of Health, 2007, Department of Health, 2009b).

Along with giving patients a formal choice of where they could receive secondary care, the government also introduced a new information system that enabled paperless referrals and appointment bookings and provided information on quality to help patients make more informed choices (Department of Health, 2009a). The paperless referral and appointment system, known as 'Choose and Book', allowed patients to book hospital appointments online, with their general practitioner (GP) or, if they preferred, by telephone (Department of Health, 2009d). The booking interface gave the person booking the appointment the ability to search for hospitals based on geographic distance and see estimates of each hospitals' waiting times that were based on the last 20 appointments at each hospital. The 'Choose and Book' system was rolled out as patients in the NHS were given a choice of their secondary care provider.

In 2007, the government also created a website designed to provide additional quality information to inform patients' choices. The hope was that providing additional quality

[1] From 2003 – 2005, certain patients living in London and Manchester who were waiting for long periods of time were allowed to choose receive care at an alternative that had a shorter waiting time .

information to inform patients' choice would create an environment where hospitals competed on quality, not price. The website currently includes information collected by the national hospital accreditation bodies, including risk-adjusted mortality rates, and detailed information on waiting times, infection rates and hospital activity rates for particular procedures (Department of Health, 2009c). The website also includes patient comments and more detailed information on hospital accessibility, general visiting hours and parking arrangements.

In the previous internal market, with price and quality competition, hospitals faced a downward sloping demand curve. Crucially, hospitals faced a tradeoff between price, quality and volume. Higher fees might have meant that hospitals could generate more revenue per patient, but higher prices might have also led to lower demand for their services. In the current market in the NHS, hospitals have to maximize the difference between their revenues and costs with no consideration of the impact price will make on the volume of care they deliver because prices are fixed. In contrast with the internal market, purchasing decisions during this latter wave of market-based reforms could not be driven by the price of services. Instead, hospitals can only differentiate themselves based on their location, and on their real and perceived quality.

We hypothesize that the incentives for clinical quality created in the second wave of market-based reforms are sharper than the incentives for quality created during the internal market period. There may be particularly significant incentives for quality during the second wave of reforms because in the NHS, a key component of a GP's role is to serve explicitly as an agent choosing secondary care for their patients. Elsewhere, Allen (1984), Klein and Leffler (1981) and Shapiro (1983) have found that even in markets with imperfect information, there is likely to be an equilibrium with optimal quality if consumers can perceive quality *ex post* and providers have an interest in attracting repeat business. Since GPs serve as agents for different patients for the same set of conditions on an ongoing basis, they are well positioned to observe quality *ex post* and use that information to advise future patients. In effect, despite the fact that patients seldom attend hospitals for the same procedures twice, the fact that GPs are often involved in the same referral decisions countless times means that they are able to significantly inform patient choices through information on *ex post* quality. As a result, we expect that after 2005, clinical quality should rise in more competitive hospital markets in England, unlike the positive relationship between competition and mortality that Propper et al. (2004) and Propper et al. (2008) observed during the initial internal market reforms. The dominant focus of the paper is testing this hypothesis.

One important point before we proceed. In both the internal market and the current wave of market-based reforms in England, the state is still responsible for funding health care. In both incarnations, the markets that were created can be characterized as 'quasi-markets' (Le Grand and Bartlett, 1993). The general idea behind 'quasi-markets' is that the state no longer combines the funding and provision of services, but rather confines its role to paying for and purchasing care from a variety of providers. On the demand side, there may be decentralized purchasing, but in most cases, most of the funds start from central government. On the supply side, there is competition between providers, which may themselves be state-run, private, or non-profit. In the current wave of reforms, private hospitals distribute their profits to shareholders and traditional NHS facilities which dominate the market re-invest their profits and may distribute them in the form of higher pay for staff and management.

## 3. Evidence on The Relationship Between Hospital Competition and Clinical Quality

The bulk of the literature assessing the relationship between hospital competition and quality comes from the US (Dranove and White, 1994, Kessler and McClellan, 2000, Propper et al., 2006). At present, there is very little evidence on the impact of competition on quality in the UK and almost no empirical evidence on the impact of the latest wave of market-based NHS reforms on clinical quality. Given the emphasis we place on differentiating between the incentives in fixed price and variable price hospital markets, we discuss whether the studies below occurred in fixed price or variable price settings.

*3.1 US evidence on the impact of hospital competition on clinical quality*

Historically, the bulk of the existing competition literature from the US investigates the relationship between competition, prices and capacity (Dranove and Satterthwaite, 1992, Hughes and Luft, 1991, Joskow, 1980, Noether, 1988, Robinson and Luft, 1985a, Robinson et al., 1987, Robinson and Luft, 1985b, Wolley, 1989, Zwanziger and Melnick, 1988, Gruber, 1994). However, there is a growing literature in the US that looks at the impact of hospital competition on clinical performance (Gowrisankaran and Town, 2003, Ho and Hamilton, 2000, Kessler and Geppert, 2005, Kessler and McClellan, 2000, Mukamel et al., 2002, Propper et al., 2004, Sari, 2002). The trend emerging from the more recent work on competition and quality is that under fixed-priced competition, higher levels of competition generally lead to improvements in clinical performance, so long as the reimbursement price covers the marginal cost (Gaynor, 2004).

Kessler and McClellan (2000) examined the impact of hospital competition on AMI mortality for Medicare beneficiaries from 1985 to 1994 in a market with fixed prices. They simulate demand in order to create measures of competition that are not based on actual patient flows. They find that in the 1980s, the impact of competition was ambiguous, but in the 1990s, they find that higher competition led to lower prices and lower mortality. Using similar methodology, Kessler and Geppert (2005) found that competition was not only associated with improved outcomes in their Medicare population, but it also led to more intensive treatment for sicker patients, and less intense treatment for healthier patients who needed less care. Gowriskaran and Town (2003) also simulate demand in order to measure competition and examine the impact of competition in a fixed price Medicare market and in a variable priced market for HMO patients. They find that in the fixed price market, higher competition led to an increase in mortality (Gowrisankaran and Town, 2003). However, they hypothesize that their results stem from the fact that hospitals in California were underpaid for Medicare patients with AMI, rather than from competition. This is consistent with research, which found that lower Medicare reimbursement rates led to increases in mortality, particularly in competitive markets (Shen, 2003).

In a variable price setting, Gowriskaran and Town (2003) found that higher competition led to lower mortality. Likewise, Sari (2002) found that higher hospital concentration in a variable priced market led to a significant reduction in clinical quality. Whereas most research relies on 30-day AMI mortality as the dominant measure of quality, Sari measured quality via obstetric complications, iatrogenic complications, wound infections and the provision of inappropriate services. Hamilton and Ho (1998) looked at competition by examining hospital mergers and found that there was no significant relationship between competition and mortality. Volpp et al. (2003) exploit the fact that from 1991 through 1996, New Jersey introduced price competition and smaller subsidies for the uninsured, whereas New York State did not. Using a DiD framework, Volpp et al. (2003) found that price deregulation and a decrease in subsidies for the uninsured was associated with a significant increase in AMI mortality.

### *3.2 English evidence on the impact of hospital competition in the NHS*

Nearly all of the English literature on hospital competition is based on the initial NHS internal market reforms. To our knowledge, there has been no evidence published thus far on the impact of hospital competition on clinical quality during the newly created market.

In general, there is a near uniform consensus that the internal market never created sharp incentives for hospitals or a significant degree of competition (Klein, 1999, Le Grand, 1999, Le Grand et al., 1998). There is some evidence that prices fell during the internal market (Propper, 1996, Propper et al., 1998, Soderlund et al., 1997); however, Soderlund et al (1997) found that higher competition was not associated with lower quality.

Hamilton and Bramley-Harker (1999) examined the impact of the NHS internal market on patient waiting times and length of stay for hip replacement from 1991 through 1994/5. Using survival analysis to look at hospital level data during the internal market reform period, they found that waiting times for hip replacements fell and so too did patients' average length of stay (Hamilton and Bramley-Harker, 1999). In addition, their results suggest that after the internal market was introduced, patients were more likely to be transferred to another facility, rather than remaining in the hospital where they had the surgery until they were ready to be discharged home.

The strongest evidence on the impact of hospital competition on patient quality in the NHS comes from Propper et al (2004) and Propper et al. (2008), which considers this impact under a variable price market regime. Propper et al. (2004) measure competition using hospital counts within markets defined using a 30-minute drive time from ward centers. Using hospital level data and controlling for hospital and local area characteristics, they find that higher competition led to a statistically significant increase in 30-day AMI mortality that was larger than the mortality decline attributed to technological innovation during the same period (Propper et al., 2004). Propper et al (2004) estimate that a shift from the 25$^{th}$ to the 75$^{th}$ decile in the competition distribution resulted in a 0.01 reduction in the mortality rate, which was approximately 20% of the standard error. A further 2008 study by Propper et al. uses hospital panel data and a DiD estimation over a longer time period to see whether more competitive areas had higher or lower AMI mortality. Similar to their findings from previous work, Propper et al. (2008) found that higher competition during periods of competition was associated with higher AMI mortality.

### *3.3 Empirical Challenges Measuring Competition*

One of the major challenges for researchers analyzing the impact of hospital competition on clinical quality is developing accurate measures of hospital spatial competition (Baker, 2001). There are two important issues in this respect: first, how to define the appropriate market area; and second what index of competition to use to quantify competition within the defined market.

There is general agreement that administrative boundaries make for poor definitions of hospital markets (unless patients are constrained to providers within those boundaries). In order to create more accurate market definitions, investigators typically calculate market size in one of three ways. One option is to create a fixed radius, defined by a largely arbitrary distance that creates a circular market of radius *r*. Investigators then calculate the degree of competition inside that circular market. A second option is to create a variable radius market where the radius *r* that dictates the size of the market varies according to pre-existing referral patterns, actual patient flows, or hospital catchment areas. For instance, a variable radius *r* could be set at a length that captures the home addresses of 75% of patients that attended a particular hospital. A third option is create a radius that varies according to travel distance. An example of a travel-based radius would be to define radius *r* as the distance that captures the hospitals within a thirty-minute travel time from a particular patient's home address.

Each market definition has its respective strengths and weaknesses. Fixed radius measures may over- or under-estimate the actual size of the market, and in ways that are correlated with urban density. These shortcomings of fixed-radius based measures stem from the fact that they do not factor in the typical preferences and travel patterns of patients when they estimate the size of the market. For example, a 30km radius encompasses nearly all of a major metropolitan area like London, but London-based patients are unlikely, in practice, to consider every hospital in London in their choice set. Conversely, a rural resident may have only one hospital within 30km but be quite prepared to consider other choices further a-field for a one-off elective hospital procedure. As a result, the fixed radius measures may suffer from an urban bias in which effects caused by differences in (unobserved) characteristics of urban patients, labor markets for health professionals and other aspects of urban health provision are falsely attributed to hospital competition. Conversely, the advantage of this type of fixed radius market definition is that the market size is not dependent on unobserved dimensions of hospital quality.

Variable radius measures infer market areas from de-facto patient travel patterns, which take into account the actual travel behavior of rural versus urban residents. However, this strength is also a drawback in that the market areas revealed by the data may be in part determined by the quality and popularity of hospitals and as a result, be endogenous to quality (Kessler and McClellan, 2000). For example, a relatively high performing hospital may have a larger catchment area encompassing more competitors than does a lower quality competitor. It is therefore possible to mistakenly infer a causal link between competition and quality, when the correlation is caused by differences in hospital quality affecting catchment area size.

Rather than using actual patient flows, Kessler and McClellan (2000) predict flows from patient demographics and patient-hospital distances and use the predicted flows to calculate competition. While this measure of competition has clear strengths, the drawback of their work is that the measure of competition is only as good as their underlying model of patient flows. The idea that patient demographics are exogenous to patient health outcomes is also debatable.

Propper et al. (2004) use travel time limits along road networks to define market size, based on the assumption that it is road travel time rather than straight-line distance that is relevant. They argue that this definition of market size ameliorates some of the concerns raised by Kessler and McClellan (2000). They rightly suggest that markets defined by road travel time limits are, like fixed distance markets, not determined by hospital quality. The authors also suggest that this method improves on fixed distances because 30-minute time limit zones will be smaller in congested urban locations than in rural locations due to lower travel speeds. In practice, however, we will see below that markets defined using radii derived from travel distances tend to be highly correlated with fixed radius markets, so the advantages of time over distance may be hypothetical.

Once investigators determine the size of hospital markets, the next challenge is selecting an appropriate index of competition. According to the industrial organization literature, a standard measure of competition is the Hirschman-Herfindahl index of market concentration. However, this index was designed for use in aggregate analyses, in which the market-specific HHI applies to the market as a whole and to every firm or service provider within that market and not to estimate competition for single firms. When HHIs are calculated for individual firms, they are subject to extensive bias because the observed concentration is often the result of each firm's quality. For example, a highly rated hospital that attracts patients away from its neighbors will appear to operate in a concentrated market because the concentration is an outcome of its quality. An alternative strategy is simply to consider one component of the HHI - the number of competitors in the market. This solution is the one adopted by Propper et al. (2004) and Propper et al. (2008). The disadvantage with this strategy is that it disregards inequality in the shares in the marker, which may be an important indicator of competitive forces and the underlying market dynamics.

On balance, therefore, there are no perfect measures of market size or competition. Each measure has respective strengths and weaknesses. In our empirical work we will use variable radius market areas, which we argue are better in principle than fixed distance-based or time-based markets at eliminating urban biases. However, we take a number of steps to overcome the potential endogeneity of indices based on patient flows. These are described in detail in our methods section below. We also show that our results are similar using four different types of market definitions: a fixed radius measure, two variable radius-based measures and a variable time travel measure.

## 4. Data Sources, Measures of Competition, and Estimation Methods

### *4.1 Data sources and setup*

Our paper relies on patient-level data from 2002 through 2008 that are derived from the NHS Wide Clearing Service. The data are drawn from a large administrative dataset, which records nearly every inpatient spell in the NHS and provides a wide range of information on patients and their treatment. Each observation in this dataset is a separate hospital admission. Our analysis also makes use of data on admissions for elective procedures (hip replacement, knee replacement, knee arthroscopy, cataract repair and hernia) in the construction of competition variables.

Our indicator of health service quality is whether or not a patient admitted for an acute myocardial infarction (AMI) died within the hospital within 30 days of admission. Risk-adjusted 30-day AMI mortality is a commonly used measure of clinical performance that is frequently used in the literature assessing the relationship between competition and quality, for example in Volpp et al. (2003), Propper et al. (2004) and Propper et al. (2008). In our analysis, we include every patient who had a main International Classification of Disease (ICD) 10 code of I21 or I22 and only include emergency AMI admissions and admissions where the patients' length of stay was three days or more (unless the patient died within the first three days of being admitted) (World Health Organization, 2009).[2]

There is a large literature on the role, usefulness and drawbacks of hospital mortality as a measure of clinical quality (Thomas and Hofer, 1998, McClellan and Staiger, 1999). While 30-day AMI mortality is a frequently used measure of clinical quality, there are several issues with its use. First, as with all quality measures, there is a question of whether or not a single measure can capture the multidimensional nature of health care quality (McClellan and Staiger, 1999). However, to that end, numerous studies have found that risk-adjusted 30-day mortality for AMI is highly correlated with other aspects of hospital quality and various process measures of quality (Allison et al., 2000, Chen et al., 1999, Dubois et al., 1987, Meehan et al., 1996). Likely, this is because the same elements that lead to high quality AMI treatment are common for treatments for other conditions, such as care coordination, the speed of treatment and timely access to surgical interventions. In the context of this paper, mortality from AMI is meant to serve as the quality 'canary in the mineshaft' for general aspects of clinical performance.

A second issue with 30-day mortality is the noise inherent with this type of measure. Because hospitals treat relatively few AMI patients per year, hospital level mortality may

[2] We choose to ignore patients with a length of stay of less than three days in order to avoid possible up-coding, whereby patients with other conditions were coded as having an AMI in order to generate larger reimbursements.

vary significantly between years, depending on the patient population a hospital attracts in a given year. This problem is particularly acute when using hospital level data, like Propper et al. (2008), where it is difficult to suitably risk adjust and where the analysis focuses on average, annual hospital-level performance. To help attenuate this problem in our research, consistent with NHS data cleaning rules, we limit observations to patients who were treated at hospitals that saw, at a minimum, 25 AMI patients per year (National Health Service Choices, 2009). Further, because we were using patient-level data with risk-adjustments for patients' age, socio-economic status and co-morbidities and were not looking at aggregate level hospital performance, we believe our use of 30-day mortality is less subject to bias than research looking at performance at a hospital level.

Elsewhere, McClellan and Staiger (1999) have reported that while 7-day and 30-day are highly correlated, 30-day AMI mortality has higher statistical variation than 7-day mortality. As Propper et al. (2008) note, this is seemingly because hospital performance has the most direct effect on outcomes during the first 7 days of clinical care. Nevertheless, the English government still uses 30-day in hospital mortality as one of their preferred measures of quality, rather than 7-day mortality. Their use of 30-day mortality as a quality indicator is consistent with published work from the OECD which recommends use of 30-day AMI mortality as one of its key indicators of clinical performance (Mattke et al., 2006).

Our patient level data allow us to effectively risk-adjust for clinical severity by controlling for patient characteristics in our estimates. These patient characteristics include gender, ethnicity, age and Charlson comorbidity score (Charlson et al., 1978). The data suppliers use the patients' home address to link to residential area characteristics like urban density and socio-economic status. Socio-economic status is measured at the 2001 GB Census Output Area Level using the income vector of the 2004 Index of Multiple Deprivation (Communities and Local Government Department, 2009). For confidentiality reasons, the patient home addresses are not available for use in our analysis. However, we do have access to codes that identify the patient's GP and GP postcode. There are around 7600-7700 GP postcodes in each year in our data. Patients can usually (at the time relevant for our study) only register at a GP practice if they live in the catchment area of that GP.

At the hospital level, we know hospital site postcodes, the NHS Trust to which the site belongs and we have indicators of the hospital type (teaching hospitals, Foundation trust status) and hospital size.[3] Most existing research on the NHS is at the hospital Trust level and typically uses the address of the Trust headquarters to define the location where patients received care. This is a very approximate basis for locating hospitals and constructing spatial competition variables. In practice, NHS trusts are usually composed of multiple smaller sites, which are sometimes separated by distances of up to 50km, and Trust headquarters are often not located where the Trust actually performs clinical care. Trust-based competition indices thus miss out on important dimensions of inter-site competition both between and within Trusts.

We are able to improve on this by using postcodes of the hospital site where the patient receives their treatment. Site postcodes are missing in our data for up to 15% of the patient observations, but most of these cases with missing site codes come from patients treated at trusts that only actually had one site. For observations where the site postcode was missing and the Trust only had one site, we replace the missing site postcode with the Trust postcode. For the fewer than 2% of observations where there was a missing site postcode for a patient treated at a Trust with more than one site, we randomly assigned patients to sites within that Trust.

Using geographical coordinates of the GP postcode and hospital site postcode, we calculate distances between a patient's GP and the hospital where their secondary care was delivered. This distance is an important component in our analysis and is used as an input into our competition measures. For our main analysis, we use matrices of straight-

[3] Beginning in 2004, high performing NHS Trusts were given ‘Foundation Trust’ status. As a result, rather than being than being owned by the NHS, they can be viewed as not for profit corporations that are only accountable to their local communities, not the central government. Foundation Trusts have more flexibility than ordinary trusts over their management practice, pay scale, and capital investment strategies.

line distances. For some of our supplementary results, we calculate origin-destination matrices from minimum road travel times along the primary road network. This generalized network was provided by the Department of Transport and is populated with road link-specific travel speeds derived from their National Transport Model for 2003. We generated the GP-hospital origin-destination matrix using the Network Analysis tools of ESRI ArcGIS.

### *4.2 Market Definition and Measures of Competition*

As discussed in the literature review, no spatial measure of competition is free from problems. Our preferred method of defining market areas is based on a variable radius derived from patient flows from GPs to hospitals. Within this market area, to measure the degree of market concentration, we calculate the negative natural logarithm of an HHI based on hospitals' patient shares. This negative log transformation of the HHI is convenient because it increases with competition, with zero corresponding to monopoly and infinity to perfect competition. For given market area j, our competition index is:

(1) $$nlhhi_j = -\ln\sum_{k=1}^{N}\left(\frac{n_k}{N_j}\right)^2 .$$

Here, nk is the number of procedures carried out at hospital site k within market area j and Nj is the total number of procedures carried out in market area j.

Both market size and HHI are potentially determined by hospital quality. As a first step to mitigate these endogeneity issues, we center market areas on patients' GPs, not the hospital at which they received treatment for AMI. In addition, we base both the market radius and the HHIs on the *elective* procedures carried out by hospitals, not on the share of AMIs carried out by hospitals.

Details of the method of market construction are as follows. Consider an elective procedure, e.g. hip replacements, in one year, e.g. 2002. We first use matrices of patient flows from GPs to hospitals for hip replacement in 2002, to deduce GP centered market areas. Specifically, we find the radius that represents the 95$^{th}$ percentile of distance traveled from a GP to hospitals for hip replacements in 2002. This radius defines the limit of the *feasible* choice set for patients at this GP in 2002. Note, only one patient needs to attend a hospital site for that site to modify the GP-centered market radius. We then compute the HHI based on *all* hospitals providing hip replacements within this GP's market area, regardless of whether this GP actually refers patients to all of these hospitals. This process is repeated for all GPs, all years 2002-2008 and all five elective procedures. A single elective HHI is calculated for each GP and year as a weighted average of the procedure-specific HHIs, where the weights are proportional to the volume of patients in each procedure category. The final composite elective procedure-based HHI thus varies by GP and by year, because both the GP market radius and the distribution of patients across hospitals vary by GP and year. We also compute a time-constant GP-specific market competition variable by averaging across years 2002-2005 for each GP.

This competition index is therefore an indicator of market structure for elective procedures in a market zone centered on a patient's GP. The question we ask in our empirical work is whether a GP's patient receives higher quality clinical care under emergency treatment if their GP-centered market for elective care has a more competitive structure. By a more competitive structure, we mean more providers and with more equally distributed patient shares, which results in a higher negative log HHI.

In the regression analysis presented below, we use a pseudo DiD strategy exploiting the NHS choice-policy reforms and IV based methods. We show that other competition indices which are potentially less responsive to differences in hospital quality produce similar results as estimates using our preferred estimate of competition. The first of these alternative indices is derived in an identical way to our 95% variable radius market; however the market radius we employ is set to capture the 75$^{th}$ percentile of distance traveled from a GP to hospitals each year. The second of these alternative indices is derived in a similar way to the variable radius HHI described above, but using a fixed radius from each GP. The third index is an HHI based on travel times along the primary road network from each GP (computed using GIS network analysis tools as described in the Data section). Lastly, the fourth alternative strategy we employ is to use the number of hospital sites within each market as the measure of market concentration, rather than using an HHI.

### *4.3 Specification of the Empirical Model*

In our regression-based empirical analysis, we implement a pseudo DiD estimation strategy to estimate the effect of market structure on time trends in the quality of health care. This pseudo DiD is based around interaction of a continuous treatment intensity variable (the concentration index) with the introduction of choice-based reforms in the NHS.

DiD methods are widely used to capture the impact of a policy reform in a non-experimental setting (Card, 1990, Card and Krueger, 1994, Angrist and Pischke, 2009). Traditional DiD regression compares two groups over two time periods where one treatment group is exposed to a policy-change in the second period and the second control group is not exposed to the policy in either period. Unfortunately, the NHS market based reforms that we are investigating do not fit neatly within the traditional DiD framework.

First, every area in England was exposed to the reforms so, in principle, there are no clear treatment and control groups. In practice, however, the NHS patient choice reforms will have had varying impact intensity across the country, where this intensity varies according to the amount of choice that is feasible given the geographical configuration of homes, GPs and hospital sites. In some places, market structure permits choice e.g. where there are several accessible neighboring hospitals, with similar capacity, offering the same procedures. Here, allowing patients to choose where to go for elective surgery is expected to make a big difference to inter-hospital competition, assuming hospitals have incentives to attract patients. In other areas in England, hospitals operated in de facto monopoly markets. For example, there will be less choice when there is only one hospital within a reasonable travel distance, or where there are many hospitals but other constraints (e.g. waiting times induced by demand from other patients) take most out of the choice set. We assume that the choice reforms will have less 'bite' when market structure precludes feasible choice for patients. Our DiD identification strategy is therefore based on the idea that treatment is more intense in the period after the NHS choice reforms in places where the local market structure is more competitive. Similar ideas have been used in other contexts, for example evaluation of the employment effects of the minimum wage (Card, 1992). The same idea is used in Propper et al. (2008) to study the 1990s internal market NHS reforms.

The second modification to the standard DiD set up is that we look for a deviation in the time trends in AMI mortality, when we compare high and low competition areas, pre and post policy, rather than using the traditional pre/post DiD approach. We adopt this strategy partly because the policy reform was not a single step change, but instead involved several stages rolled out over time. It is also partly because we expected the reforms to take time to bed-in and that the impact of competition would grow over time. A second reason for this modified DiD estimation was that there is also evidence that there were some early teething problems immediately after the reforms were introduced. Early reports were that it took time for GPs to learn how to use the new referral software and become accustomed to providing patients with the opportunity to choose a secondary care provider (Healthcare Commission, 2008, Rosen et al., 2007). As such, the incentives from the reforms likely became sharper over time. A third impetus for our strategy is that the reforms happened during a period when AMI mortality rates were falling rapidly over time due to technological changes (e.g. angioplasty and drug treatments) and demographic changes (reductions in smoking). We therefore needed to control and test for pre-existing differences in mortality trends over time, between high and low competition places rather than comparing mortality before 2006 with mortality after.

Taking into account these issues, our empirical regression model takes the form:

$$(2)\quad \begin{aligned} death_{ijkt} &= \beta_1 t + \beta_2 (t-2006 \mid t>=2006) + \beta_3 nlhhi_{jt} t + \beta_4 nlhhi_{jt} (t-2006 \mid t>=2006) \\ &\quad + \beta_5 nlhhi_{jt} + \gamma' controls_{ijkt} + error_{ijkt} \end{aligned}$$

Here $death_{ijkt}$ is an indicator (1-0 dummy variable) that patient i, from GP market j, treated at hospital site j died within 30 days of admission for AMI in year t. Coefficient $\beta_1$ captures the baseline rate of decline in AMI mortality prior to the 2006 reform, for locations in which *nlhhi*=0. These locations correspond to places with only one hospital as a feasible choice for patients. Coefficients $\beta_1 + \beta_2$ capture the baseline rate of mortality decline in these low-competition places after reform. Now consider a comparator place where there is a high degree of choice (e.g. *nlhhi*=1). The sum $\beta_1 + \beta_3$ is the time trend in mortality in these areas before the reform. The sum $\beta_1 + \beta_2 + \beta_3 + \beta_4$ is the time trend in mortality in high choice areas after the 2006 reform. The second partial derivate of the death rate trend with respect to differences in competition in the post-policy period is $\beta_4$. This is our coefficient of interest, and is a DiD estimate of the effect of the policy on the trends in mortality. This is easily deduced, since:

(3) Effect of policy on AMI mortality trends = (Trend in mortality in high choice places post-policy - Trend in mortality in high-choice places pre-policy) - (Trend in mortality in low choice places post-policy - Trend in mortality in low-choice places pre-policy)

So, for a given gap in competition $\Delta nlhhi$:

Effect of policy on AMI mortality trends = $((\beta_1 + \beta_2 + \beta_3 \Delta nlhhi + \beta_4 \Delta nlhhi) - (\beta_1 + \beta_3 \Delta nlhhi)) - ((\beta_1 + \beta_2) - \beta_1)$

$= \beta_4 \Delta nlhhi$.

The coefficient $\beta_3$ is also informative, in that it provides the basis for test for the existence of pre-policy differences in trends between high and low competition places $\beta_3 \neq 0$. The existence of pre-policy differences in trends would undermine the credibility of the DiD strategy.

Note that the specification in (2) includes a vector of control variables as discussed in the Data section, and can be generalized to include hospital fixed effects and GP fixed effects. Our specifications further include an interaction between Strategic Health Authority (SHA) dummies and time trends.[4] These interactions control for general regional trends and trends associated with SHA policies and changes in regional funding. The time trends and SHA year interactions will also pick up the increases in NHS funding during this period, since funding for the NHS rose almost uniformly across England.

We first estimate (2) using Ordinary Least Squares, and cluster our standard errors at the GP level to allow for error correlation across patients within GP markets. Probit or logit estimation gives similar results, but the non-linearity of the regression function does not make for clean interpretation of $\beta_4$ as the DiD estimate and it is infeasible to include large numbers of fixed effects.

Our estimation sample is restricted to patients who were treated within the market which we used to measure competition. For example, if we define the *nlhhi* using the 95th percentile GP referral share, we restrict our sample to patients who were treated for AMI at hospitals within that radius. This eliminates patients who have an AMI and are treated at hospitals that are remote from their home, for example if the patient had an AMI at work or on vacation.

*4.4 Instrumental Variable Estimation*

Recall that the two main causes for concern are: a) the *nlhhi* in equation (2) is potentially endogenous to hospital quality in the GP-centered market because of the dependence of

[4] There are ten NHS Strategic Health Authorities (SHAs) in England, each representing a different region of the country. SHAs are responsible for implementing the policy that is set by the Department of Health and managing local health care provision. Increasingly, policy-making has been devolved to local SHAs.

the market radius and hospital shares on clinical quality; and b) that the coefficients on the *nlhhi* x t interaction in equation (2) may pick up basic urban-rural differences and are not specific hospital competition differences.

To address these issues, we provide IV estimates of (2) using an instrument for competition based on higher moments of the GP-site distance distribution.
We instrument for competition using the variation in distances from a patient's GP to the four nearest hospitals as an exogenous source of variation in the GP-centered competition indices. We view variation in the GP-to-hospital distances as an exogenous measure of completion because if a patient is registered at a GP where there is a high variance in the distance to local hospitals, each substitution from one hospital to another will have high transportation costs for the patient. This makes the patient less likely to exercise choice and as a result, creates less competitive pressure on local hospitals. For example, we assume patients registered at a GP with its four nearest hospitals located at 1km, 12km, 27 km and 31km away from the GP will have a stronger pull to their nearest hospital than a patient whose GP was located 12km, 15km 17km, and 17km from its four nearest hospitals. The hospital with higher variation in distances will have considerably more monopoly power in this particular market, which will and drives down the *nlhhi*. Further, patients registered at GPs near a location with four hospitals at 13km will have no particular travel cost incentives to attend one hospital over another, so the *nlhhi* increases and competitive pressure is greater.

We therefore use the standard deviation in GP-site distance (amongst the nearest four sites) as an instrument for *nlhhi*, conditional on the mean distance to hospitals in equation (2). This instrument is interacted with the time trends in the pre and post policy periods to provide instruments for the *nlhhi* x *t* interactions. The idea is similar to that of predicting hospital shares from exogenous variables implemented in Kessler and McClellan (2000). However, we implement a more traditional IV, avoiding their non-linear 1st stage prediction and predicting from implicit travel costs, not patient demographics (which we do not regard as exogenous to patient outcomes).

## 5. Results

### *5.1 Empirical Results*

Our estimation sample contains approximately 450,000 patients who had an AMI between 2002 and 2008. There are 227 hospital sites providing care for AMI for patients who were registered at 7,742 separate GP practices. As discussed in the methods section, our preferred index of hospital market structure is the negative log Hirschman Herfindahl Index (*nlhhi*), centered on General Practitioners, and based on the market within the radius to which the GP refers 95% of his/her patients for elective surgery. However, we compute the *nlhhi* based on alternative definitions, some of which are shown in Table 1. The indices from fixed radius and time zone based market definitions are very highly correlated. Indices based on market definitions using GP hospital flows are quite highly correlated with each other, but only moderately correlated with the fixed distance and time-based indices.

Figure 2 illustrates why we favor the variable radius methods that infer markets from de-facto patient choices over hospitals. The first panel shows the competition indices for patient referrals for elective procedures derived from 30-minute travel zone markets. The dark areas are places with unconcentrated market structure, but the map looks (to anyone familiar with England's urban geography) like a map of the major metropolitan areas. London is in the South East, Birmingham in the central West, Manchester and Leeds in the North. The second panel maps the indices from the 95% GP referral-based markets. Now, urban areas are less dominant. Although urbanization is obviously still a factor, there is variation in market structure within both urban and rural areas. These maps therefore suggest that we stand a better chance of identifying competition effects, rather than spurious urban effects, using the GP referral based market definition.

Hospital quality, as measured by thirty-day AMI mortality, improved consistently from 2002 through 2008, as shown in Table 2. This reduction in mortality that we observe is consistent with international trends and is driven in England in part by increasing adoption of new technology in the treatment of AMI and improvements in public health (Walker et al., 2009). Our aim is to determine whether there is a difference between the rate of reduction in AMI mortality in high hospital competition areas in contrast to the rate of reduction in low hospital competition areas. At the same time that mortality was decreasing, there was a steady increase in spatial competition in the NHS, also illustrated in Table 2. Consistent with our policy on/off dates, the biggest jump in competition was measured after the reforms came into effect in 2006 and patients had the ability to freely select a non-local hospital for care.

Table 3 provides our OLS estimates of the DiD specification of equation (2) using our preferred index of market structure. This index is the negative natural log of the HHI using the 95% GP market defined described in the Methods section. The regressions control for patient characteristics and their underlying health status, hospital characteristics, strategic health authority-specific linear time (year) trends, day of the week and month the patient received care, plus various combinations of fixed effects as described in the Table. Our main interest is in the coefficient on 2006-2008 trend * *nlhhi* (corresponding to $\beta_4$ in equation (2)). The coefficient on that term illustrates the impact of the 2006 reforms on the trends in mortality, by comparing markets characterized by potentially competitive structures with more concentrated markets.

In each specification in Table 3, we find that after the formal introduction of choice in January 2006, mortality decreased more quickly in areas where choice was geographically feasible. The coefficient of our interaction term ranges from -0.0050 to -0.0068, and is robust to whether or not we include or exclude patient control variables, hospital fixed effects or GP fixed effects. Our estimates are significant in all specifications. Column (5) is our preferred specification and includes both GP and hospital fixed effects, which control the possibility of changing GP, patient and hospital composition in high competition and low competition areas.[5] Based on Column (5), and taking a one standard deviation gap in nlhhi as our benchmark (a 0.54), 30 day AMI

[5] Appendix 1 includes the fully expanded results from our preferred specifications.

mortality fell 0.3 percentage points faster per year after the reform for patients treated in more competitive markets.

An essential observation to be made here is that the pre-policy trend in AMI mortality in areas with potentially competitive market structures is not statistically different from the trend in markets with concentrated structures. The coefficient on the "2002 – 2005 Trend * nlhhi" interaction is near zero and statistically insignificant in all specifications other than Column 1, which includes no control variables. Conditional on the controls and fixed effects, the pre-policy trends in places with concentrated and dispersed market structures are identical. This shows that these different markets were balanced in terms of the mortality trends pre-reform, and allays fears that the DiD results simply pick up pre-existing differences in trends.

Table 4 shows that the results are not highly sensitive to the choice of market structure index, and presents least squared estimates of (2) using five separate measures. Column (1) of Table 4 repeats our preferred specification and estimates (2) with competition measured as the negative log of the Herfindahl index within our variable 95% market. Column (2) estimates (2) with competition measured as the negative natural log of the HHI within our variable 75% market. Column (3) estimates (2) with competition measured as the negative natural log of the HHI within a fixed 30 km radius around each GP. Column (4) estimates (2) with competition measured as the negative natural log of the HHI within a variable radius market that captures the 30-minute travel time around each GP. We limited the observations to patients who received care within the defined market. Our findings remain consistent and significant across the four different measures of competition. The coefficient on the interaction between competition and the 2006-2008 is always negative and significant, illustrating that higher competition led to lower mortality regardless of how we estimate competition.

Column (5) from Table 4 shows the interaction of competition before and after the reforms with competition measures as the negative natural log of the HHI with a market that captures the distance 95% of patients from each GP practice traveled for care.

However, the HHI used in Column (5) is calculated using pre-reform patient flows, and averaged across 2002, 2003, 2004 and 2005. This was a time period when patients did not have the ability to choose their provider based on quality. In essence, this gives an estimate of competition that is not potentially sensitive to post-reform changes in quality, and not subject to the bias that Kessler and McClellan (2000) discuss. Using this pre-reform measure of competition, we also find that higher competition after the introduction was associated with a statistically significant reduction in AMI mortality.

Column (6) from Table 4 shows the impact of competition after the reforms were introduced, where competition is measured at the hospital level. Our hospital-based index is the average value of our preferred 95% variable GP HHI for the GPs that could refer to a particular hospital. So, if a hospital fell within the market of 6 GPs, the HHI we calculated for the hospital was the average of the GPs who had the option of referring patients to that hospital. Like our previous results, we still find that competition after the reforms was associated with a faster reduction in AMI mortality. Interestingly, the interaction term associated with this competition measure is significantly larger than the measure with our preferred GP-based measure of competition. One possible explanation for this finding is that our GP-based measures are picking up more noise because most of the changes that occurred were driven by hospital-level changes in clinical quality.

In addition to using HHIs as measures of competition, we have generated least squared estimates of (2) using hospital counts within each market as a measure of competition, which are presented in Table 5. While counts are not as sensitive to the underlying market characteristics as an HHI, they are more intuitive and serve as a robustness check on our HHI estimations. If the hospital shares within markets are equal, then our nlhhi index is identical to the log count of hospitals k because the HHI is 1/k. We calculate count measures of competition in four types of markets – two variable radius markets, one fixed radius market, and one variable time radius market. Regardless of the count-based competition measure that we use, we consistently find that the interaction term of interest is negative and significant, indicating that a competitive market structure was associated with a statistically significant reduction in AMI mortality after January 1, 2006.

*5.2 Instrumental Variables estimates, robustness and falsification checks*

The first column of Table 6 presents our instrumental variables estimates. We instrument market structure using the standard deviation of the straight line distance from each GP to the nearest four elective providers, controlling for the average distance to all four as described in the Methods section. The F-Test on our instruments is significant at $p < 0.001$ and the F-statistics are 317.86, 266.29, 218.36, respectively. The IV estimates show a similar pattern to the OLS results in Table 3. The point estimate on our coefficient of interest is more than double that in the equivalent OLS specification (Column 3 of Table 3), although the standard errors are also higher and the Hausman test indicates no statistically significant difference between the IV and OLS coefficient (p=0.08). There is no evidence from the IV estimates that it is the endogeneity of market structure to health service quality that drives our findings.

Column 2 in Table 7 investigates whether our nlhhi index of market structure simply captures non-health specific aspects of dense urban environments. In this specification, we implement a 'placebo/falsification' test in which we replace market structure for hospitals with the market structure amongst state secondary schools. We reconstruct the nlhhi using the shares of secondary school pupils in schools within our GP-centered market definition (defined by the 95% referral radius during the pre-policy period). Clearly, if choice and competition in the health service drive our results, we would not expect to see a significant impact from schooling structure on AMI mortality rates in response to the NHS choice reforms. In contrast, if we are simply picking up changes in mortality trends in dense versus less dense places then the market structure in schooling is just as likely to produce a 'false positive' result. Reassuringly, the coefficient on the interaction between post-reform trends and schooling structure is near zero and insignificant.

To illustrate that our results are the result of changes in hospital quality, rather than the result of different patient populations living in high versus low competition regions, we estimated (2) using hospital * year fixed effects. Hospital * year fixed effects should capture improvements in quality from hospitals year to year. When we estimated (2) and included hospital * year fixed effects, it washed out the effect of competition.

We have also investigated the validity of our choice of 2006 as the start of our "policy on" period in the DiD analysis. As already discussed, there were elements of reform before January 2006, but we argued that: a) these reforms were not general enough to have made any impact; and b) that the correct incentives were not in place. To demonstrate the credibility of our choice of policy-on date, we have re-estimated Equation (2) using a three-part time spline interacted with the nlhhi index of market concentration. We find here that market structure was not linked to declining AMI mortality rates in the 2002-2003 period or the 2004-2005 periods: the coefficients and standard errors are respectively 0.05(0.18) and 0.04(0.30). However, the rate of mortality decline in high-competition areas increases dramatically for the 2006-2008 period, with a coefficient of -0.0059 (0.0032). Although the DiD estimate in the three-way spline is just below significance, the point estimates validate our choice of policy-on date.

## 6. Conclusions

Financial incentives are playing an increasingly large role in health care provision and the management of health care systems. In the US, England and the Netherlands, there has been significant attention paid to the potential for hospital competition to drive increases in quality and efficiency. However, despite the popularity of patient choice and hospital competition as policy tools, there remains considerable uncertainty surrounding how health care markets should be optimally structured. One significant strand of the debate about hospital market structure has been whether or not prices should be fixed when quality signals are noisy. Wider economic theory gives a clear response: under a fixed regime, competition will improve quality. This will improve consumer welfare, but the effect on social welfare is unclear as quality may be improved past an optimal level. Under a variable price regime, the outcome with respect to quality is ambiguous at best.

Research on the impact of competition on clinical quality during the NHS internal market in the 1990s confirms that hospital competition in a market with variable prices may lead to higher mortality (Propper et al., 2008, Propper et al., 2004). More than a decade after the internal market, a new government in the UK introduced a further set of market-based reforms to the English NHS that relied on hospital competition in a market where prices were fixed. These reforms differed from the internal market in several ways. First, the reforms gave patients a choice of where to receive care and aimed to assist and inform decision-making by providing patients with information on hospital quality. Second, the reforms aimed to increase the role of private sector hospitals and increase hospitals' fiscal and managerial autonomy. Third, the second wave of reforms, unlike the initial internal market, had hospitals competing on quality in a market with fixed prices. To this day, these reforms remain controversial and there has been no rigorous assessment of their impact on clinical quality.

This paper offers an empirical assessment of this second wave of reforms and specifically analyzes the impact of hospital competition from 2006 onwards on clinical performance, as indicated by 30-day AMI mortality. In this study, we rely on patient level micro data and take advantage of the fact that the government's 2006 market-based reforms would have significantly more 'bite' in geographic regions where patient choice and hospital competition were possible. We use a modified DiD estimator to examine whether, controlling for patient and hospital characteristics, higher competition was associated with lower AMI mortality. We were also conscious that there is significant debate about how to empirically measure hospital competition. As a result, rather than relying on one single measure of competition or lone market definition, we use four different types of market definitions and two measures of competition to estimate the degree of hospital competition in England.

In our analysis, we consistently find that higher competition was associated with a faster decrease in 30-day AMI mortality after the formal introduction of patient choice in

January 2006. We find that one standard deviation increase in competition was associated with an approximately 1% additional reduction in AMI mortality in the 3-year post policy period that we studied. Our results are robust to a number of specifications. Our results are also robust regardless of how we estimate competition.

The title of our paper asked whether or not hospital competition saved lives in the English NHS. Our results suggest that they did. Consistent with previous work from Kessler and McClellan (2000) and Kessler and Geppert (2005), we find that hospital competition in markets with fixed prices leads to a reduction in AMI mortality. Our results add support to current efforts in England to increase the amount of publicly available information on quality and promote hospital competition. Further, our results likely highlight the importance of agents in health care markets. Patients seldom need the same surgical or clinical procedure twice, so they are rarely able to take advantage of the information they acquire on provider quality *ex post*. However, in England, where GPs serve as agents for multiple patients with the same condition and play an active roll advising patients on where to go for care, it is likely that incentives for quality were sharper because GPs could take advantage of their knowledge of previous patients' clinical outcomes to inform their advice to future patients.

The conclusion, then, is that hospital competition, under the recent NHS reforms, which introduced a fixed priced market, did lead to an increase in the quality of hospital services, as economic theory would predict. This rise in quality has undoubtedly led to an increase in consumer welfare. We postulate that, given the level of quality improvements that can be attributed to these reforms and the assumed quality levels prior to the reforms, these results are consistent with an overall improvement in social welfare (McClellan et al., 1999). However, more research needs to be carried out to prove that assertion empirically.

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Table 1. Correlations Between Different Measures of Competition

| | -log(HHI) - 75% | -log(HHI)- 95% | -log(HHI)- 30Km | -log(HHI)- 30 Minutes | Mean | S.D. |
|---|---|---|---|---|---|---|
| -log(HHI)- 75% | 1.00 | | | | 0.36 | 0.40 |
| -log(HHI)- 95% | 0.71 | 1.00 | | | 0.75 | 0.56 |
| -log(HHI)- 30Km | 0.36 | 0.43 | 1.00 | | 1.27 | 0.81 |
| -log(HHI)- 30 Minutes | 0.41 | 0.48 | 0.92 | 1.0 | 1.49 | 0.91 |

Table 2. Average 30-day AMI mortality and average *nlhhi* within a market defined as the 95th percentile of each GP's maximum travel distance per year.

| Year | Average 30-day AMI Mortality | *nlhhi* |
|---|---|---|
| 2002 | 0.154 | 0.725 |
| 2003 | 0.148 | 0.737 |
| 2004 | 0.139 | 0.747 |
| 2005 | 0.136 | 0.735 |
| 2006 | 0.128 | 0.782 |
| 2007 | 0.122 | 0.835 |
| 2008 | 0.117 | 0.874 |
| Overall | 0.135 | 0.774 |

Sample restricted to patients between 40 and 100 years of age; hospitals which treat more than 25 AMIs per year, and patients who had a length of stay greater than 2 days or who died within the first two days.

Table 3: Least squared estimates of (2). Competition measured as the negative ln of the HHI within a market that captures all hospitals within the 95th percentile of each GP's maximum travel distance.

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| 2002 – 2005 Trend | -0.0071*** | -0.0102*** | -0.0101*** | -0.0094*** | -0.0096* |
| | (0.0008) | (0.0008) | (0.0008) | (0.0000) | (0.0008) |
| 2006 – 2008 Trend | 0.0059** | 0.0051* | 0.0053* | 0.0040 | 0.0043 |
| | (0.0021) | (0.0021) | (0.0021) | (0.0022) | (0.0022) |
| 2002 – 2005 Trend | 0.0016* | 0.0007 | 0.0012 | 0.0004 | 0.0006 |
| * nlhhi | (0.0008) | (0.0008) | (0.0008) | (0.0008) | (0.0008) |
| 2006 – 2008 Trend | -0.0065** | -0.0057* | -0.0068* | -0.0050* | -0.0056* |
| * nlhhi | (0.0023) | (0.0022) | (0.0022) | (0.0023) | (0.0023) |
| Nlhhi | -0.0027 | 0.0027 | -0.0006 | -0.0008 | -0.0013 |
| | (0.0028) | (0.0027) | (0.0029) | (0.0032) | (0.0033) |
| | | | | | |
| Patient Characteristics | No | Yes | Yes | Yes | Yes |
| Hospital Fixed Effects | No | No | Yes | No | Yes |
| GP Fixed Effects | No | No | No | Yes | Yes |
| | | | | | |
| N | 407,882 | 407,882 | 407,882 | 407,882 | 407,882 |
| R2 | 0.037 | 0.110 | 0.110 | 0.093 | 0.126 |

Dependent Variable = 1 if patient died within 30-days of their admission to hospital

Hospital characteristics: Hospital type (foundation trust, teaching hospital or traditional acute hospital), number of AMIs treated at the hospital per year. Patient characteristics: age, gender, Charlson comorbidity score. Patient socioeconomic status measured using the income component of the 2004 Index of Multiple Deprivations at the output area.

Error terms are clustered around GP-practices.

* Significant at 5% level; ** Significant at 1% ,*** Significant at 0.1%

Table 4. Least squared estimates of (2) using five different measures of competition: (1) = negative ln of HHI within 95% variable radius market; (2) = negative ln of HHI within 75% variable radius; (3) = negative ln of HHI within fixed 30km radius market; (4) = negative ln of HHI within market defined by 30-minute drive time from each GP practice; (5) ln of HHI within 95% variable market with competition measured as the average HHI between 2002 and 2005 prior to the reforms.

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| 2002 – 2005 | -0.0096* | -0.0098*** | -0.0105*** | -0.0102*** | -0.0099*** | -0.0120*** |
| Trend | (0.0008) | (0.0008) | (0.0009) | (0.0008) | (0.0008) | (0.0027) |
| 2006 – 2008 | 0.0042 | 0.0026 | 0.0055* | 0.0044 | 0.0028 | 0.0143* |
| Trend | (0.0022) | (0.0022) | (0.0023) | (0.0021) | (0.0020) | (0.0061) |
| 2002 – 2005 | 0.0006 | 0.0010 | 0.0011* | 0.0011* | 0.0011 | 0.0038 |
| Trend * nlhhi | (0.0008) | (0.0014) | (0.0005) | (0.0005) | (0.0009) | (0.0034) |
| 2006 – 2008 | -0.0056* | -0.0081* | -0.0042** | -0.0041** | -0.0048* | -0.0183* |
| Trend * nlhhi | (0.0023) | (0.0038) | (0.0013) | (0.0015) | (0.0024) | (0.0081) |
| nlhhi | -0.0013 | -0.0014 | 0.0022 | 0.0017 | | -0.0109 |
| | (0.0032) | (0.0051) | (0.0069) | (0.0066) | - | (0.0168) |
| Patient Characteristics | Yes | Yes | Yes | Yes | Yes | Yes |
| Hospital Fixed Effects | Yes | Yes | Yes | Yes | Yes | Yes |
| GP Fixed Effects | Yes | Yes | Yes | Yes | Yes | Yes |
| N | 407,882 | 301,957 | 445,041 | 442,844 | 407,882 | 377,218 |
| R2 | 0.126 | 0.132 | 0.126 | 0.126 | 0.126 | 0.128 |

Dependent Variable = 1 if patient died within 30-days of their admission to hospital

Hospital characteristics: Hospital type (foundation trust, teaching hospital or traditional acute hospital), number of AMIs treated at the hospital per year. Patient characteristics: age, gender, Charlson comorbidity score. Patient socioeconomic status measured using the income component of the 2004 Index of Multiple Deprivations at the output area.

Error terms are clustered around GP-practices.

Table 5. Least squared estimates of (2) with competition measured as the count of hospitals within 4 market definitions: (1) 95% variable market; (2) 75% Variable market; (3) Fixed 30km radius market; (4) market defined 30-minute travel time from each GP

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| 2002 – 2005 | -0.0096*** | -0.0095*** | -0.010*** | -0.0098*** |
| Trend | (0.0007) | (0.0007) | (0.0007) | (0.0007) |
| 2006 – 2008 | 0.0031 | 0.0055** | 0.0028 | 0.0031 |
| Trend | (0.0017) | (0.0019) | (0.0016) | (0.0019) |
| 2002 – 2005 | 0.0001 | 0.0002 | 0.0001 | 0.0002 |
| Trend * nlhhi | (0.0001) | (0.0002) | (0.0001) | (0.0001) |
| 2006 – 2008 | -0.0006* | -0.0024*** | -0.0004** | -0.0006** |
| Trend * nlhhi | (0.0003) | (0.0006) | (0.0001) | (0.00020 |
| | | | | |
| Nlhhi | -0.0005 | -0.0006 | 0.0001 | 0.0002 |
| | (0.0004) | (0.0007) | (0.0008) | (0.0004) |
| | | | | |
| Patient Characteristics | Yes | Yes | Yes | Yes |
| Hospital Fixed Effects | Yes | Yes | Yes | Yes |
| GP Fixed Effects | Yes | Yes | Yes | Yes |
| | | | | |
| N | 407,882 | 407,882 | 445,041 | 442,844 |
| R2 | 0.126 | 0.0126 | 0.126 | 0.126 |

Dependent Variable = 1 if patient died within 30-days of their admission to hospital

Hospital characteristics: Hospital type (foundation trust, teaching hospital or traditional acute hospital), number of AMIs treated at the hospital per year. Patient characteristics: age, gender, Charlson comorbidity score. Patient socioeconomic status measured using the income component of the 2004 Index of Multiple Deprivations at the output area.

Error terms are clustered around GP-practices.

* Significant at 5% level; ** Significant at 1% ,*** Significant at 0.1%at 1% ,*** Significant at 0.1%

Table 6. Robustness Tests

| | Instrumented Measure of Competition | Falsification Test |
|---|---|---|
| 2002 – 2005 Trend | -0.0119*** | -0.0112*** |
| | (0.0015) | (0.0013) |
| 2006 – 2008 Trend | 0.0088* | 0.0020 |
| | (0.0044) | (0.0035) |
| 2002 – 2005 Trend * nlhhi | 0.0038 | 0.00056 |
| | (0.0020) | (0.0005) |
| 2006 – 2008 Trend * nlhhi | -0.0118* | -0.0007 |
| | (0.0058) | (0.0009) |
| nlhhi | -0.0188* | - |
| | (0.0072) | |
| | | |
| Patient Characteristics | Yes | Yes |
| Hospital Fixed Effects | Yes | Yes |
| GP Fixed Effects | Yes | Yes |
| | | |
| N | 425,376 | 420, 075 |
| R2 | 0.109 | 0.125 |

Dependent Variable = 1 if patient died within 30-days of their admission to hospital

Hospital characteristics: Hospital type (foundation trust, teaching hospital or traditional acute hospital), number of AMIs treated at the hospital per year. Patient characteristics: age, gender, Charlson comorbidity score. Patient socioeconomic status measured using the income component of the 2004 Index of Multiple Deprivations at the output area.

Error terms are clustered around GP-practices.

* Significant at 5% level; ** Significant at 1% ,*** Significant at 0.1%at 1% ,*** Significant at 0.1%

**Figure 1. Timeline for the second wave of NHS market-based reforms - 2001 - 2008**

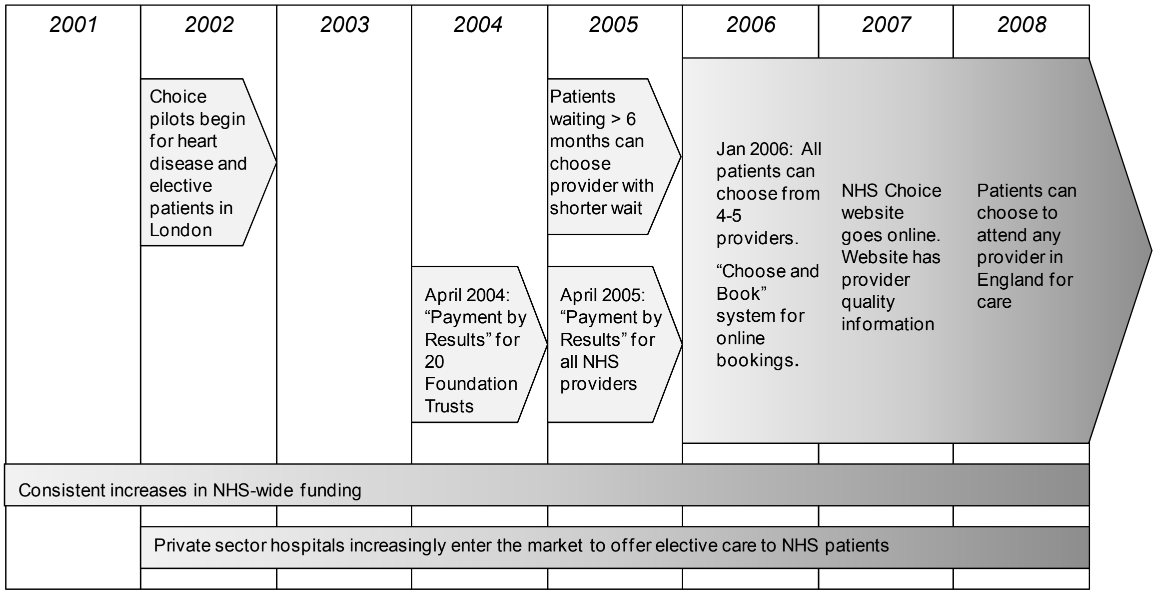


**Figure 2a: Geographical distribution of health market competition index 2008, based on hospital sites within 30 minute drive time from GP**

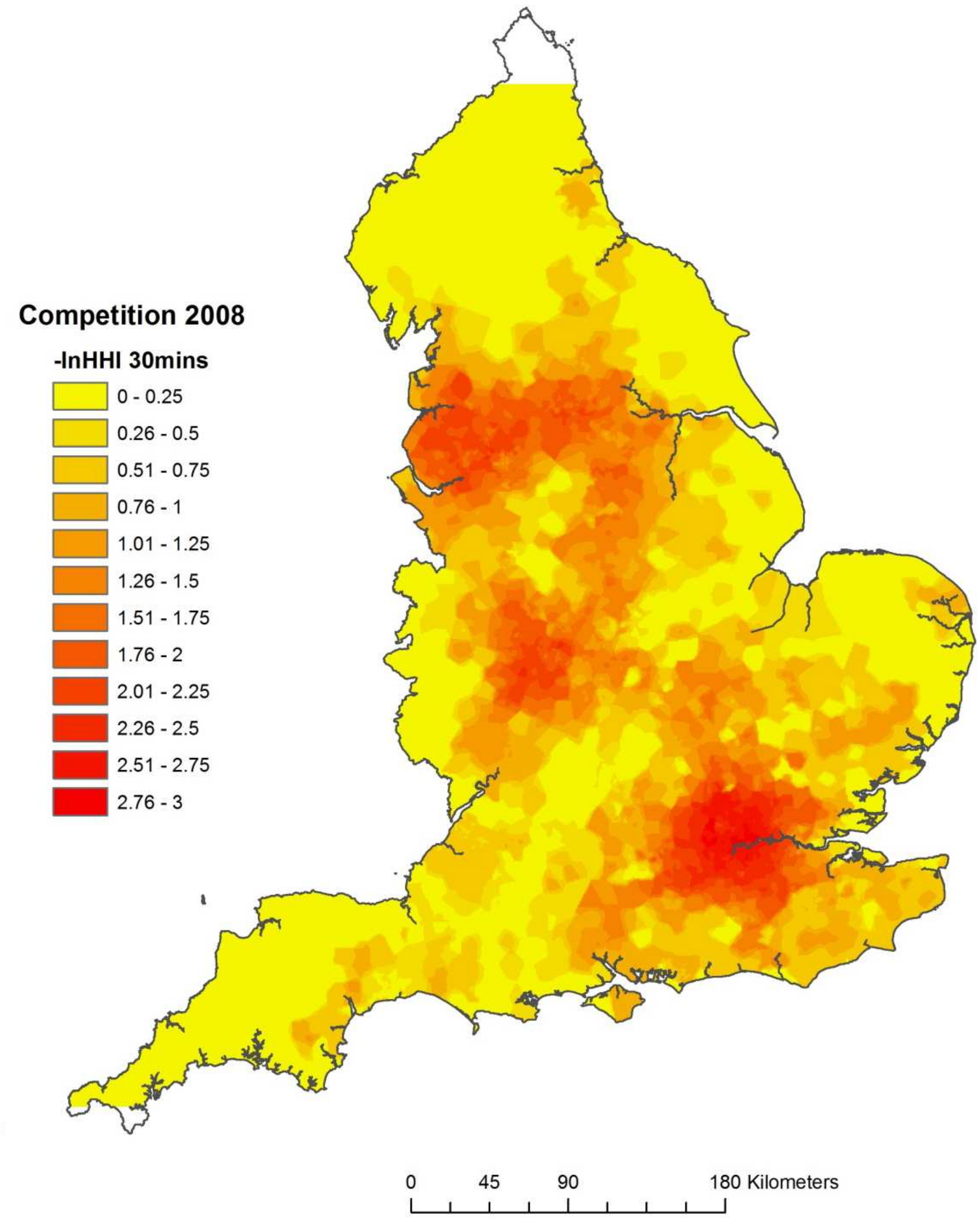
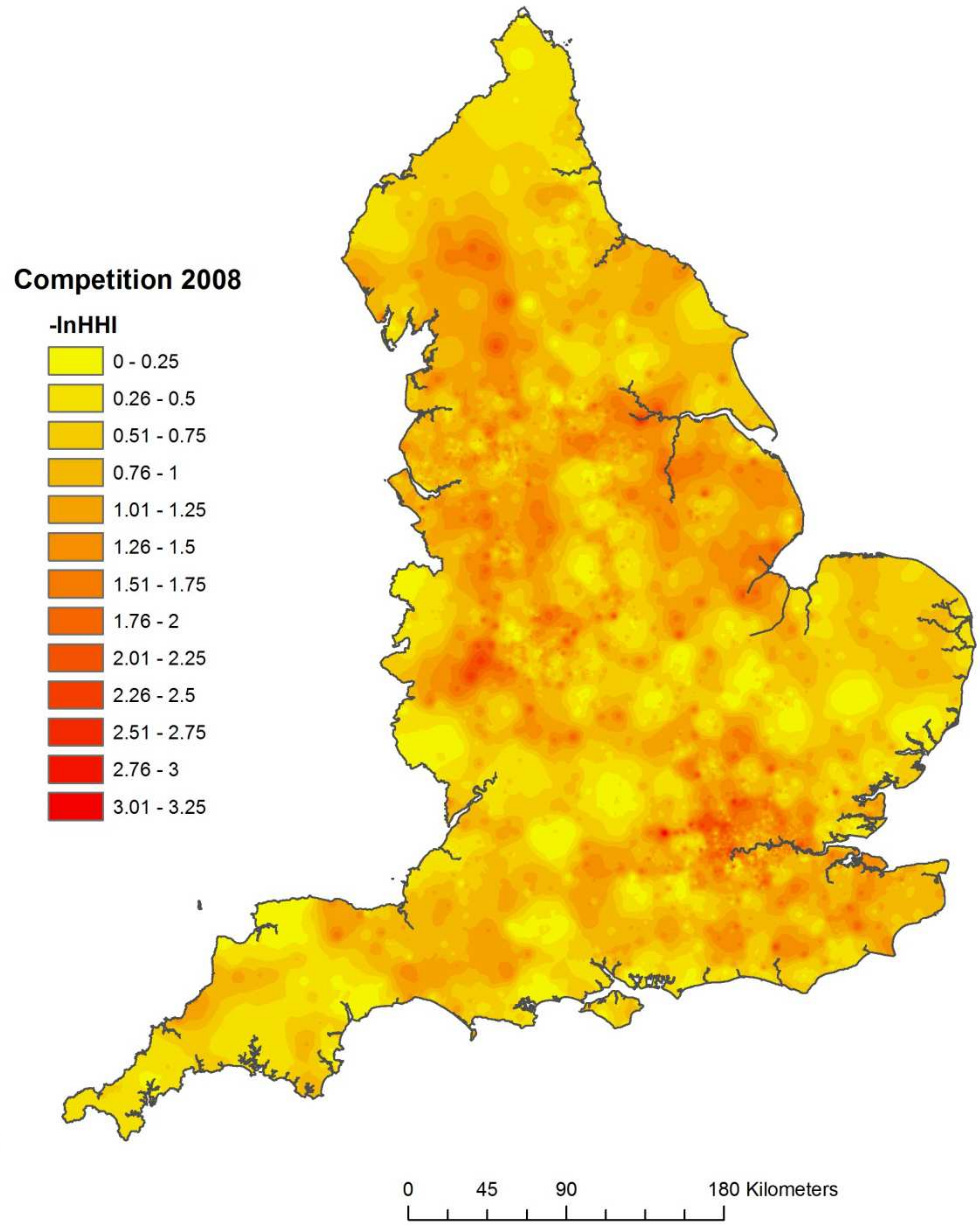


**Figure 2b: Geographical distribution of health market competition index 2008, based on hospital sites within 95th percentile GP referral radius**



Appendix 1 – Least squared estimates of (2)

Appendix 1: Least squared estimates of (2) with competition measured as the negative ln of the HHI within a market that captures all hospitals within the 95th percentile of each GP's maximum travel distance.

| | Coef | Standard Error |
|---|---|---|
| 2002 – 2005 Trend | -0.0096* | 0.0008 |
| 2006 – 2008 Trend | 0.0043 | 0.0022 |
| 2002 – 2005 Trend * nlhhi | 0.0006 | 0.0008 |
| 2006 – 2008 Trend * nlhhi | -0.0056* | 0.0023 |
| Nlhhi | -0.0013 | 0.0033 |
| | | |
| Female | 0.0123*** | 0.0012 |
| Charlson2 | 0.0355*** | 0.0013 |
| Charlson3 | 0.0774*** | 0.0021 |
| Charlson4 | 0.1218*** | 0.0034 |
| Charlson5 | 0.1412*** | 0.0056 |
| Charlson6 | 0.1925*** | 0.0072 |
| IMD Income 2 | 0.0005 | 0.0019 |
| IMD Income 3 | 0.0047* | 0.0019 |
| IMD Income 4 | 0.0044* | 0.0019 |
| IMD Income 5 | 0.0056** | 0.0021 |
| age4549 | -0.0024 | 0.0022 |
| age5054 | 0.0054* | 0.0021 |
| age5559 | 0.0123*** | 0.0021 |
| age6064 | 0.0263*** | 0.0022 |
| age6569 | 0.0453*** | 0.0022 |
| age7075 | 0.0742*** | 0.0023 |
| age7579 | 0.1163*** | 0.0024 |
| age8084 | 0.1544*** | 0.0025 |
| age8589 | 0.1971*** | 0.0028 |
| Age90plus | 0.2573*** | 0.0035 |
| Teaching | -0.0035 | 0.0123 |
| FT | 0.0049 | 0.0022 |
| Site Activity (150-300) | -0.0079* | 0.0036 |
| Site Activity (300-450) | -0.0202*** | 0.0038 |
| Site Activity (450+) | -0.0276*** | 0.0041 |
| Distance | 0.0000*** | 0.0000 |
| February | -0.0041 | 0.0026 |
| March | -0.0087** | 0.0025 |
| April | -0.0082** | 0.0025 |
| May | -0.0119*** | 0.0025 |
| June | -0.0146*** | 0.0026 |
| July | -0.0159*** | 0.0026 |
| August | -0.0148*** | 0.0026 |
| September | -0.0161*** | 0.0026 |
| October | -0.0143*** | 0.0025 |

| | | |
|---|---|---|
| November | -0.0116*** | 0.0026 |
| December | -0.0096*** | 0.0025 |
| North East * Year | -0.0003** | 0.0001 |
| Yorkshire and Humbler * Year | -0.0001 | 0.0001 |
| North West * Year | 0.0001** | 0.0000 |
| East Midlands * Year | 0.0000 | 0.0000 |
| West Midlands * Year | 0.0000 | 0.0000 |
| East of England * Year | 0.0000 | 0.0001 |
| South East Coast * Year | 0.0000 | 0.0000 |
| South Central * Year | -0.0001 | 0.0001 |
| South West * Year | 0.0000 | 0.0000 |
| N | 407,882 | |
| R2 | 0.126 | |

Dependent Variable = 1 if patient died within 30-days of their admission to hospital

Hospital characteristics: Hospital type (foundation trust, teaching hospital or traditional acute hospital), number of AMIs treated at the hospital per year. Patient characteristics: age, gender, Charlson comorbidity score. Patient socioeconomic status measured using the income component of the 2004 Index of Multiple Deprivations at the output area.

Error terms are clustered around GP-practices.
Reference categories: Male, Charlson1, IMD-Income1, Age 40-44, Traditional NHS Trust, Site Activity (0-150), January, London SHA.

* Significant at 5% level; ** Significant at 1% ,*** Significant at 0.1%

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