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Does Competition between Hospitals Improve the Quality of Care? Hospital Death Rates and the NHS Internal Market

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Abstract
Payer-driven competition has been widely advocated as a means of increasing efficiency in health care markets. The 1990s reforms to the UK health service followed this path. We examine whether competition led to better outcomes for patients, as measured by death rates after treatment following heart attacks. Using data that until 1999 was not publicly available in any form on hospital level death rates, we find that the relationship between competition and quality of care appears to be negative. Greater competition is associated with higher death rates, controlling for patient mix and other observed characteristics of the hospital and the catchment area for its patients. However, the estimated impact of competition is small.

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1. Introduction

The Conservative administration of the late 1980s introduced payer-driven competition into the publicly funded sector of the UK health care market[1]. The argument for the widesweeping reforms of 1991 was that competition would both reduce costs and improve quality. However, economic models indicate that an increase in quality is not necessarily the only outcome: under certain conditions it can be shown that payer-driven competition may bring about reductions, rather than increases, in quality (Spence, 1975, Dranove and Satterthwaite 1998). In particular, if quality signals are weak or noisy, the impact of competition on price may dominate. Quality may fall, rather than rise, as the result of greater competition. This is the question we address in this paper: did competition in the UK health care market raise or lower quality?

Since the introduction of payer-driven competition has been one of the primary forms of health care reform during the last two decades, establishing the impact of the UK reform on quality is an important issue for research. But, to date, there has been little empirical appraisal of the introduction of competition in the UK NHS. Empirical research has shown some impact of competition upon price: prices appear to be lower in more competitive markets, and also for buyers who have greater bargaining power (Propper 1996, Propper *et al* 1998). Studies of the behaviour of buyers of health care indicate considerable changes in behaviour, and some evidence of patients waiting less for non-emergency treatment (Dowling 1997, Propper *et al* 2000). But there is no systematic evidence that giving the sellers of care – the hospitals - greater control over their budgets increased the quality of care for patients (Le Grand *et al* 1998).

One of the reasons for the lack of empirical appraisal is the absence of easily accessible data on the quality of care. However, in mid-1999 the UK government made available, for the first time, limited data on the quality of care of hospitals. It published data on age-standardised death rates at hospital level, from three causes. The causes of death are general surgery, acute myocardial infarction (AMI) and fractured neck of femur (FNF).

[1] This sector accounts for about 85 percent of the health care market.

Mortality from AMI has been used to assess the quality of care of hospitals in the US health care market and it is this measure that we analyse here.

This paper uses these recently published data to examine the impact of competition between hospitals on quality of care. AMI death rates for hospitals are matched to administrative data from a number of sources. These data provide information on the hospital and on the socio-economic characteristics of each hospital's catchment area, where the catchment area is defined in terms of travel times. These data allow us to calculate measures of competition based on potential rather than actual patient travel patterns. This allows us to avoid the problem, present in several studies of the impact of competition in the US health care market, that measures of competition based on actual patient flows are endogenous (Kessler and McClellan 1998). We are also able to control for the potential effects of hospital size and type on quality of care. We estimate the impact of competition from cross-sectional variation across hospitals in the degree of competition that they face.

Our results support the hypothesis that where quality signals are weak or noisy, the impact of competition is to reduce rather than increase quality. Five years or so after the introduction of the internal market the linear relationship between quality and competition is negative. Hospitals located in more competitive areas have higher death rates. Geographical small areas in which there are more hospitals have higher death rates. Our results are robust to two different measures of competition, both of which use potential travel times of patients as a measure of choice. However, the size of the association that we find is small: an increase in competition equivalent to a movement from the 25^{th} to the 75^{th} decile in the competition distribution increases the death rate by only .01, or about 20% of the standard error of AMI death rates. While these effects are not large, what we do not find is the positive relationship between competition and quality found in recent US studies.

The organisation of the paper is as follows. Section 2 presents the key characteristics of the NHS internal market and outlines a simple model of the relationship between competition and quality in this market. Section 3 reviews the literature on the relationship between quality and competition and the impact of competition in the NHS. Section 4 presents the data. The results are in Section 5. The final section presents our conclusions.

2. The UK health care market and the potential impact of competition in this market

(a) Health care delivery in Britain in the mid 1990s

The 1990 NHS internal market reforms sought to introduce competition among suppliers by separating the roles of financier and supplier of health care services previously performed in tandem by local health authorities. Finance continued to be raised through general taxation, and was allocated to public agents who were responsible for purchasing health care for their populations. Two types of purchaser were created. District health authorities (DHAs), which each covered a discrete geographical area, were responsible for purchasing hospital services for all the population in their area, except for patients of the second type of purchaser, General Practice Fund-Holders (GPFHs)[2]. Health care services were provided by public and private suppliers, who competed for contracts with the purchasers. Public hospitals, which were originally under the control of health authorities, became separate legal entities, NHS Trusts. Contracting between purchasers and providers took place on an annual basis. Patients had relatively little choice of buyer of health care. This is because, in the UK system, they have little choice of family doctor. Patients whose family doctor chose to become fundholders therefore had a purchaser who was a fundholder, while patients whose family doctors chose not to enter the scheme had a purchaser who was the DHA for the area in which they were resident.

The scheme was modified in 1998 when the two different types of purchaser were merged into one, composed of groups of General Practitioners, given a budget to purchase all health care (known as Primary Care Groups). However, the essential split between buyer and seller of NHS health care still remains. In our discussion below we focus on the scheme as it operated 1991 to 1998, as this is the period covered by our data.

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[2] These were a self-selected group who cover the patients for whom they already provided primary care and are given a budget for a limited set of health services sold by providers.

Although purchasers were given the right to buy from whichever supplier of health care they wished, in practice, almost all care purchased by NHS purchasers was bought from NHS Trusts. Relatively little business went to the (limited in size and scope) private health care sector. NHS Trusts were encouraged to compete for contracts. In setting prices of these contracts, Trusts were heavily regulated. They were supposed to set price equal to average costs, to earn a certain return on assets, and were not able to carry surpluses across financial years (Propper 1995). However, in spite of these regulation, there is evidence that there is scope for competition from the location of hospitals (Appleby et al. 1994) and, that faced with very low margins between revenues and costs, Trusts had incentives to compete with each other for contracts (Propper 1996).

Both sets of buyers were allocated funds from central government, to be spent on hospital care. DHAs were not free to carry over surpluses from one year to the next. GPFHs were allowed to retain surpluses provided that they invested them in their practices. This regulation was not strictly monitored. Further, surpluses from practices provide income on retirement from the profession for the physicians who own the practices. So GPFHs have incentives to 'shop around' between health care sellers (Dixon & Glennerster 1995) and it is assumed in various analyses that they do so (Dowling 1997; Malcomson 1999).

Broadly, on the supply side, the hospital market in the UK is characterised by monopolistic competition. The cost of travel for patients, and the lack of full information on the buyers' part, means hospitals are not perfect substitutes. But few hospitals have no competitors with 30 minute travel distance (Propper, 1996). Entry and exit are relatively easy because entry is entry into a specialty and exit is the reallocation of state funds from one set of managers to another. There are sufficient hospitals to assume that hospitals take the actions of others as given.

On the buyer side, buyers are not individual patients but agents (the GPFHs and the DHAs) who place contracts on behalf of patients. These agents are cash constrained, and have relatively hard budget constraints in the case of DHAs, and incentives to make savings from their budgets in the case of GPFHs. Patients are interested in quality, since they pay zero price at point of demand as care is free. Agents, on the other hand, are interested in price, and, to the extent that they are constrained by the wishes of patients, also quality. So the net effect is that agents are interested in both price and quality, though they may give considerably less weight to the latter if there is no monitoring of their behaviour (since patients can not change agents very easily and there is little scope for ‘voice')[3].

The outcome can broadly be characterised as ‘payer-driven competition' where the demand curve facing each hospital is downward sloping and a function of price and quality of output. The impact of competition in such a market has been analysed for a profit-maximising hospitals by Dranove & Satterthwaite (1998). The hospital chooses both price and quality. The effect on quality depends on the effect of competition on the price and quality elasticities of demand. If competition increases the price elasticity alone, then the effect of competition will be to decrease quality. If competition increases the sensitivity to both price and quality, then the effect on quality is ambiguous. If competition increases the elasticity of the quality signal more than that of the price signal then quality will rise. If quality signals are measured with greater noise than price signals this will decrease the elasticity with regard to quality relative to the elasticity with regard to price. Investigation of the effect of a change in one of the parameters (say the cost of producing a unit of quality) on one choice variable will result in biased results unless the analysis takes into account the fact that both are chosen simultaneously. So the typical approach in the literature to the analysis of competition, which is a single equation estimation of costs, price or price-cost mark up on competition may give biased results. Similarly (though less commonly estimated in the literature) single equation estimates of quality on costs and competition will give biased results.

The Dranove and Sattherthwaite model assumes profit maximisation and that hospitals are free to set price and quality. While there is no profit in the UK case, surpluses can be used within year for NHS hospitals, and deficits were seen as evidence of failure on the part of hospital management[4]. More importantly, UK hospitals faced regulatory rules with respect to price: they were supposed to set price equal to average cost. The question is whether hospitals were bound by this rule. At a specialty level the answer is probably no (Propper 1996, Propper et al 1998), as abiding by the rule is difficult to observe at this

[3] Kessler and McClellan’s (1998) study uses data on Medicare patients where there is no price competition.
[4] Note profit maximisation is often put forward as a maximand even for not-for-profits in the US.

level. However, at the whole hospital level the rule probably did more or less bind, as at this level it is easy to monitor.

Making the assumption that price equals average cost simplifies matters as hospitals then only choose quality. Quality will be a function of both price and quality elasticities. The impact of differences in competition on quality could go either way: competition forces hospitals to cut prices and cut quality, or to improve quality. However, the simultaneity of price and quality choice is no longer an issue. To investigate the relationship between quality and competition, the appropriate reduced form model is to regress quality on competition and other factors affecting cost, where competition is hypothesised to affect both price and quality elasticities. The expected impact of competition would depend on the effect of competition on the two elasticities and the relative noise in the two signals. This is the approach taken here.

In estimating such a model at the hospital level it is necessary to control for factors that may be spatially associated with competition but are not due to competition and to take into account the impact of selection. There are factors that may be related to competition (or its obverse, concentration) and to quality, but are not the result of competition on quality. Estimation of the effect of competition on quality without taking these into account will give misleading results. In the UK case there would appear to be two candidates. First, areas with low concentration are inner-city areas. These tend to have sicker people because they are poorer. So quality, as measured by death rates, and competition are positively correlated. This implies that we need to control for the type of patient. If there is no selection then we can control for either the actual patient mix or the potential patient mix. Second, scale economies may mean costs are lower in larger markets, so quality can be higher simply because it is less expensive to produce. Scale economies may also mean there is less investment in high tech equipment in areas with small catchment areas (small in terms of population) so there will be a negative association between concentration and quality. This means we need to control for hospital size.

One of the incentives provided by competition where price does not fully reflect patient severity (as in the UK system) is patient selection. If buyers don't care at all about quality (or can't observe it) then sellers of hospital care have an incentive to select the patients who are cheaper to treat and/or give less treatment to patients. If buyers also can monitor quality, sellers have less incentive to skimp on the production of quality from a given patient but have incentives to select patients who are cheaper to treat and who will also be less likely to have poor outcomes.

Patient selection might be practised in either high or low competition areas. In the UK context it might be argued that patient selection would be higher in less competitive areas. Less competitive areas contain less densely populated areas. Hospitals in these areas tend not to be teaching hospitals, are often smaller and so benefit less from scale economies, and have less investment in high tech equipment. Prior to the 1991 reforms, complicated cases might have been sent not to these hospitals but to teaching hospitals that are located further away. If competitive forces remain low in these less populated areas, such hospitals have no incentives to take the more complex, more costly, patients. Hospitals in highly competitive areas will have greater incentives to accept patients (provided the marginal benefit from an additional patient is positive). If cheaper patients are also less severely ill then there will be a negative association between quality and competition. This is not due to the effect of the relative strength of quality signals, as in the model presented above, but is the outcome of the selection that might accompany competition. Alternatively, it could be that sicker patients are sent to better hospitals that tend to be located in less concentrated areas. Either way, patient selection needs to be addressed. To control for this effect, it is necessary therefore to control for selection.

In summary, the model we estimate has the following form:

$$x = f(c, s, z : \varepsilon) \quad (1)$$

where x is quality, c is competition, s is severity/case mix of the potential patient population, z is a vector of observed other factors pertaining to the hospital (including scale) and ε is an unobserved hospital specific error.

3. Empirical evidence on competition in health care

The empirical evidence on the impact of competition in the UK is limited. The evidence is primarily provided from the US experience. This empirical literature has tended to analyse the impact of competition on either price/cost or quality; Kessler & McClellan (1998) is an exception and considers both.

(a) US Literature on the impact of competition on Health Care

A large empirical literature has examined the impact of competition in markets for health care services and, until recently, most of it has focused on the consequences for prices and costs (Dranove and White, 1994)). The literature can be split into work based on data prior to the mid-1980s and work using more recent data. The former finds that competition among hospitals leads to increases in excess capacity, costs, and prices, and serves to support the medical arms race model (Joskow 1980; Robinson and Luft 1985, 1987; Noether 1988, Robinson 1988; Robinson et al. 1988; Hughes and Luft 1991). The latter generally finds that competition between hospitals leads to reductions in excess capacity, costs, and prices, and quite clearly supports the managed care model (Zwanziger and Melnick 1988; Wooley 1989; Dranove et al. 1992, Melnick et al. 1992; Dranove et al. 1993; Gruber 1994), with some exceptions that find negative effects of competition even post-1983 (Robinson and Luft 1988; Mannheim et al. 1994). Keeler, Melnick and Zwanziger (1998) test whether the nature of competition has indeed changed and they find strong evidence that price in the late 1980s and early 1990s played a much more significant role. Specifically, even non-profit hospitals located in less competitive areas charged significantly higher prices than those in more competitive areas did by 1994.

The amount of research into the impact of competition on quality is smaller, but growing rapidly. Shortell and Hughes (1988) examined the association between in-hospital mortality among Medicare patients and concentration, and found a small and insignificant association between them. However, their methodology has since been criticised for their use of a fixed radius measure of geographic markets (see below). Hamilton and Ho (1998) found that hospital mergers had no effect on either heart attack or stroke mortality. Kessler and McClellan (1998) analyse the impact of competition on both costs and patient health outcomes. They use comprehensive longitudinal Medicare claims data for the majority of elderly non-rural beneficiaries who were admitted to a hospital with Acute Myocardial Infraction in 1985, 1988, 1991, and 1994. They find, before 1990, competition led to higher costs and lower rates of adverse health outcomes: after 1990, competition led to both substantially lower costs and rates of adverse outcomes. Therefore, whilst the welfare effects of competition in the 1980s were ambiguous, post 1990 competition was unambiguously welfare improving.

(b) UK Literature on the impact of competition on Health Care

There is much less UK evidence on the impact of competition, despite this being a central plank of the internal market reforms. Glennerster (1998) draws together the empirical literature in this area by reviewing all references relating to district-based purchasing, and GP fundholding and commissioning and concludes that little evidence exists on this score. Exceptions include the work of Propper (1996), Propper et al. (1998), and Söderlund et al. (1997) who investigate the impact of the internal market on prices, costs and productivity.

Propper (1996) addresses pricing in the NHS internal market. Prices quoted on the spot market for services sold by Trusts to District Health Authorities for four specialties (general surgery, orthopaedics, ear nose and throat (ENT) and gynaecology) were examined. She concluded that the results offer some support to the view that competition will result in lower prices in the NHS internal market. Propper et al. (1998) re-address the issue of pricing in the NHS internal market by examining the posted prices for GP Fund Holders. They argue that despite regulation, market forces may have an impact on price. Using the same specialties as Propper (1996) they find that NHS internal market regulatory rules of no cross subsidisation between activities and price equal to average (total) cost plus 6 percent, are not observed. However, they also find that the effect of market forces on prices is relatively weak. Söderlund et al. (1997) evaluate the effect of purchaser mix, market competition, and trust status on hospital productivity within the

NHS internal market. Using panel data on costs and activity for 510 acute hospitals in England for 1991-2 to 1993-4 they find that market concentration is not associated with productivity gains. They do find that gaining trust status and increasing host district purchaser share were associated with productivity increases after adjustment for casemix, regional salary differences, and hospital size. To date there have been no systematic studies of the impact of competition in this market on quality.

(c) Empirical issues in the measurement of competition and quality of care

In measuring the impact of competition on quality at hospital level it is necessary to define the degree of competition a hospital faces. Kessler and McClellan (1998) assert that the commonly used measures of market competitiveness may result in biased estimates of the impact of competition on prices, costs, and outcomes. The two most common approaches to defining markets for hospitals assume that a hospital's relevant geographic market consists roughly of a circular area around its geographic location. The fixed radius technique defines a hospital's competitors to include all other hospitals located within a fixed distance around the hospital. The fixed distance is arbitrary and will overstate the true size of some markets and understate others. The key problem of the fixed radius measure is that it does not depend on the determinants of demand for hospital services in a geographic area. The second technique, the variable radius method, attempts to address this problem by defining the radius of each hospital's geographic market to be equal to the minimum required to include a set proportion of that hospital's patients. Any measure that is based on actual realised hospital choices is likely to produce biased estimates: unobservable hospital heterogeneity in hospital quality affects individual choices and may also affect the variable being analysed. For this reason Kessler and McClellan (1998) use patient level data in order to calculate predicted patient choices based on exogenous factors. We adopt an approach that is similar in spirit, though not derived from actual patient flows.

The issue of how to measure quality in health care is both long standing and contentious. Various potential proxies for quality have been put forward, including length of stay and mortality rates. Since the United States Health Care Financing Administration began publishing hospital mortality data in 1986 a large literature has appeared on its usefulness and reliability as a measure of quality: Thomas and Hofer (1998) provide a comprehensive review. They cite evidence that poor quality care increases patients risk of mortality and that, on average the quality of care provided in hospitals identified as high-mortality rate outliers is poorer than that of low-mortality rate outliers. Despite this they conclude from the existing evidence that when used as a measure of quality for individual hospitals, risk-adjusted mortality rates can be seriously inaccurate. More recent work by McClellan and Staiger (1999) argues that suitably adjusted measures of death rate correlate well with other measures of quality. The fact remains that while mortality rates may not be perfect measures of quality, in the UK no better outcome measures are available.

In this paper we use death rates from acute myocardial infarction (AMI). AMI was chosen on the basis that the nature of such care is, in part, under the control of hospital management and senior physicians within the hospitals, and so outcomes are in part a choice decision of the hospital. Thomas et al (1993) model mortality risks from AMI (amongst other measures) in the US, and use a database of quality findings to determine whether the ratio of observed to expected deaths relates validly to quality. Their results provide some support for AMI as a quality indicator. AMI has also been used in recent studies of quality and competition in the US (Kessler & McClellan 1998). McClellan and Staiger (1999) show that suitably adjusted death rates from AMI after 30 days are, in fact, good predictors of other measures of outcome that require much more detailed data. The precise definition of our variable is given below.[5]

4. Data

Our unit of analysis is a hospital Trust, and the main focus of interest is the relationship between the Trust's death rate and the degree of competition it faces. We also control for

[5] The adjustments McClellan and Staiger make require a longer time series of death rates than we have available here, but we do take into account the noise inherent in annual data by averaging across three years. We also adjust for the age and gender of the AMI patient population of each hospital: see below for details.

features of the Trust's catchment area and features of the hospital that may affect quality irrespective of competition. In this section, we define our measures of the death rate, of competition and of the control variables. Both the competition measures and the background variables are geographically based, so we also define the geography we use. Details of the sources of the data are in Table A1 of the Appendix.

(a) Measurement of Death Rates

We examine deaths rates[6] from AMI. The measure of deaths we use is a '30-day' rate and measures in-hospital deaths within 30 days of emergency admission with a myocardical infarction for patients aged 50 and over[7]. Use of emergency admissions may reduce the problem of patient selection. 30-day rates, adjusted to reduce noise, have been shown to be good predictors of 7 day, and one-year death rates in US data (McClellan and Staiger, 1999). The UK data are available for three years: the financial years 1995/6 through 1997/8. While these data could be analysed as a panel, the death rates are quite variable over time trust-by-trust, reflecting, in part, the issue of small denominators (hospitals may treat relatively few patients for this condition in any one year)[8]. This problem is common in the analysis of AMI death rates (McClellan and Staiger, 1999) and the noise in the measures of death rates can lead to misclassification of the quality of hospitals.

One indication of the amount of noise is to examine the change in ranking of hospitals over time. Table 1 takes the "best" (in the lowest 10% of death rates) hospitals in the first year of the data window (1995/6) and examines their ranking in the two ensuing years. The table shows that of hospitals ranked as best in 1995/6, 28.6% are still ranked as in the best 10% in the following year and 21% are still in the best two years later. Only 5% had shifted into the worst group after one year and a similar number had moved into this group after two years. Mean mortality difference between these hospitals and all others was negative and significant. McClellan and Staiger (1999) present this analysis for a sample of nearly 4000 hospitals in the USA. Our data exhibit less variability than the US

[6] The number of deaths is normalised by the number of cases admitted to the hospital.
[7] Deaths occuring after transfer to another provider are credited to the provider where the patient was first admitted. Deaths following discharge are omitted. Deaths following readmission are not included.

data. For the US data, hospitals ranked as in the best group were, two years later, nearly as likely to be ranked amongst the worst (14.7%) as amongst the best (16.7%). Average mortality amongst these hospitals was in fact higher than the average of all others after 2 years.

McClellan and Staiger (1999) suggest a method of filtering out the noise in annual estimates. They have at their disposal 10 years of data at patient level. Using their 'filtered' estimates they find that 52% of hospitals ranked in the best group were still ranked in top decile two years later, and less than one percent were ranked in the bottom decile. Clearly, our data lie somewhere between the US unadjusted data and the filtered data. This may be due to the fact that the hospitals in our data set are on average larger than those in the USA. The mean annual number of admissions for AMI in our data set is over 300, while in the US sample used in McClellan and Staiger the average hospital admits between 50-60 AMI patients per year.

The filtered method uses individual data at hospital level, which we do not have. With only three years of available data we consider the best adjustment we can make to reduce noise is to use the data to generate one observation per hospital and to omit hospitals with fewer than 10 admissions per year. We therefore use the weighted average of death rates at each hospital over the three-year period as our dependent variable (and we also remove a small number of observations: this is discussed below). The average death rate in our sample, weighted by AMI admissions, is 19%, with a standard error of 5%. These death rates are not adjusted for the composition of the patients using the hospital. To allow for this, we use the age distribution (for each gender) of the AMI patient population at each hospital as control variables in our analyses. We also repeat our analyses using a set of standardised AMI '30 day' emergency admission death rates published by the UK government, where each hospital's standardised death rate is that which is would have had it had its own age specific death rates but the European average age distribution[9].

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[8] Below we also note that as competition varies little over time, we only have one observation of competition per hospital. Thus, even with a longer panel of death rates, our analysis would still rest on cross sectional variation.

[9] As our analysis controls for the actual patient population distribution by gender as well as age, for the purposes of comparability our analyses using this second measure of death rate also control for the actual patient population by age and gender.

(b) Defining Areas

To derive our competition measures and to define the background characteristics of the trust's potential patient pool we need to define each hospital's 'catchment' area. In general it is argued that administrative boundaries do not measure catchment areas well (e.g. Kessler and McClellan, 1998), and the obvious administrative area in the UK case, the health authority, is also likely to be a poor candidate, especially in more competitive areas. The reforms were introduced in part because health authority boundaries were not co-terminous with patient flows, leading to cross-boundary flows that were not easily remunerated in the pre-reform NHS. Instead, we use a definition of catchment area that reflects patient costs. This is one based on potential patient travel times to each hospital.

In contrast with much of the data used in recent US analyses, we do not have access to individual patient addresses. Instead, we assume that individuals are potential patients of any trust that they are close to. To be specific, we draw a boundary around each trust that defines the area within 30 minutes drive from the trust. Clearly, the choice of 30 minutes is arbitrary. This boundary delineates the 'service area' or catchment area of the trust. The details of the construction of this are as follows. We extracted a postcode for each Trust from NHS Yearbooks, and then converted this to a map grid reference using *Postzon* software. This allows us to locate each trust on an electronic map; we then superimpose on that the road network[10]. Using assumed speeds for three different road types, we can locate a set of points exactly 30 minutes drive time away. Joining these up gives us a zone around each trust. Finally, we can also superimpose the ward map of England. These are 1991 census wards, of which there are approximately 8000, compared to some 250 trusts. We tag a ward as belonging to the service area of a particular trust if any portion of the ward falls within the 30-minute zone. Note that many wards are likely to fall into the service area of many trusts. This double counting is quite severe: adding up the total population of all our service areas yields 590m, relative to an actual population for England of around 49m.[11]

[10] Using *Arcview* software.
[11] This will mean there is less variation in service area level averages of ward data.

(c) Measures of competition

Our measures of competition are geographically based since treatment for AMI requires the physical presence of the patient at the hospital. Our competition measures can be calculated only once for each hospital, as there is little change in the population of an area in any three-year window. So we assume that competition is fixed for the three years we analyse. While our dependent variable potentially allows panel analysis (if we were prepared to accept the higher noise associated with the annual measures of death rates) we can only identify the impact of competition from cross-sectional variation.

The simplest measure of competition is the number of trusts in the catchment area of hospital *j*:

$$C_j^0 = T_j$$

This measures the number of potential competitors that *j* faces, but doesn't take into account the population to be served by the hospital. The smaller this population for a given number of trusts, the more spare capacity and so the larger the potential amount of competition. To allow for this, we normalise the number of trusts in an area by the population of the area (P_j)

$$C_j^1 = T_j / P_j \ .$$

The higher this is, the more competitive the environment.

Our second measure takes the population of the wards that fall into each hospital's catchment area and determines how many trusts this population has within a 30-minute radius. Then for each trust *j* we calculate the share of the population in all the wards it serves that have a choice between different numbers of hospitals. So for each particular trust we can calculate the share of its population that have access to only that trust, or that can access only 2 etc. As noted above, many wards fall into the service area of several trusts, so the measure of competition we use in our analyses is the share of each trust's catchment population that can reach over 20 trusts. This is measure C^2_j. Note that unlike measure C^1_j this second measure is independent of the size of the population in the catchment area[12].

The measures are obviously related, but are by no means identical. Figure 1 plots the number of trusts in the catchment area of trust j (T_j) (the numerator of measure C^1_j) against C^2_j. The graph shows a strong positive relationship. Normalising the first measure by the population of the catchment area and so deriving C^1_j and plotting this against C^2_j we see a weaker relationship, brought about in part by the more even distribution of hospitals per head than hospitals per area.

We can also construct other measures of the market share of each trust that use actual admissions in their construction. For example, we can derive the ratio of all admissions relative to the total admissions of all the trusts in trust *j*'s service area. But this measure, because it is a trust-based measure rather than a market-based measure, is likely to be endogenous for quality measures like the death rate (features of a hospital that affect its death rate may also influence its share of business). Second, it only approximates the trust's share of business in its service area; for example, some of the admissions to trust *i* in *j*'s service area may rise from individuals outside *j*'s service area. Another measure normalises the total number of admissions in a service area by the number of trusts, and so relates the total amount of business done by trusts in a service area to the number of trusts in the area. But this measure has the same problem as the previous one: some of the admissions included in the numerator will actually be irrelevant for *j*'s market. We therefore use only C^1 and C^2 in our analyses.

(d) Controls

We include three sets of controls, the first set based on actual patients treated for AMI, the second on Trust characteristics that may affect death rates irrespective of the level of competition, and the third on measures of the characteristics of each trust's potential patient population. As controls for actual patients (case-mix) we use the distribution of AMI admissions by age and by gender and, in some analyses of the data, we also control for length of stay. (This, however, may be endogenous: for example, a trust that had such poor quality that it had few patients that survive very long would also have a short

[12] We are very grateful to an anonymous referee for suggesting this measure.

average length of stay). As controls for trust characteristics (that might affect quality or costs) we use the size/throughput of the trust (measured by the number of beds, total admissions, and the number of emergency AMI admissions) and dummies for whether the trust is a teaching hospital, or a heart specialist, or is in London. Higher volumes of patients have been shown to be associated with better success rates. Teaching hospitals are often thought to have better facilities but also to attract harder cases. The London dummy is simply to ensure that our results are not driven by any special features of hospitals in the capital (our results are robust to exclusion of this control).

As controls for the severity of the potential population of the hospital we use area (1991 Census ward) characteristics that might affect the general level of health of the potential patients of the trust. For each ward, we have all cause mortality and AMI mortality (both split by age and gender), and the proportion of the population with long-term limiting illness. We have demographic data on the age and gender structure of the population. We also have data on unemployment and inactivity rates (by gender) and measures of wealth or deprivation such as proportion of homes owner-occupied, or proportion of homes without indoor bathrooms. These measures of deprivation are quite collinear, and in our analyses we use only a subset of these.

Table A2 provides details of the dependent variables, the measures of competition and the controls. Table A3 presents the pairwise, within sample, correlation between the controls.

(e) Sample Definition

We begin with data on 258 Hospital trusts. These are English trusts that provide any acute service. We first exclude from the analysis trusts that admit less than 10 AMI cases in all of the three years. For those trusts that admit less than 10 cases in any one year, we exclude just this year from our calculation of the death rate for that trust. We do this as using such small denominators in the calculation of the death rate means that very few deaths can create a high overall rate. To some extent these small volume trusts may also be considered as outside the set of potential competitors. We then exclude a handful of outliers: those trusts at each end of the scale of size or activity defined as those that fall into the top or bottom percentile of FCE's, beds or admissions. This leaves us with a sample of 206 hospital trusts. We exclude a further 4 that are missing data on one or other of the controls (generally length of stay).

To recap, the model we estimate is:

$$x_{ha} = f(COMP_h, W_h, Z_a) \qquad (2)$$

where x is quality, as measured by death rates from AMI, $COMP$ is the competitiveness of the hospital, W is a vector of hospital specific factors (distribution of AMI patients, size, teaching status etc), Z is a vector of area specific factors (measures of potential patient health status) and h indexes the hospital and a the area.

5. Results

(a) The impact of competition at hospital level

Table 2 reports on the estimate of (2), using the measure of competition C^1. The controls used are given in the Table. The table shows the estimated impact of competition is significant at conventional levels and positive: hospitals that face more competition have higher death rates. Column 1 shows the impact of competition, with controls for the fixed characteristics of hospital, but no controls for size of hospital. The estimated effect of competition is positive. Column 2 repeats column 1 but allows for non-linearity in the impact of competition. Neither the linear nor the quadratic terms in competition are well defined. Column 3 includes a control for size (measured as total admissions, as this is more likely to be exogenous to AMI emergency admissions than total AMI cases[14]) and column 4 repeats this allowing for non-linearity in size. In neither case is the coefficient on size significant and the coefficient on competition remains unchanged.

The controls for the composition of the population admitted to the hospital are significant as a group. They show that hospitals with a higher proportion of elderly men and women, and middle-aged women, have higher death rates. This sign on older people is as

[14] AMI admissions account for only a small percent of total admissions (Table A2).

expected. The estimated effect of the controls for hospital characteristics coefficients are of consistent sign but are often not well defined. Location in London is significantly associated with lower levels of in hospital death rates. Teaching hospitals have higher death rates, possibly because they attract sicker individuals, but the coefficient is not precisely estimated. Hospitals that specialise in the treatment of heart patients have lower death rates but again the coefficient is not precisely estimated. Death rates do not appear to be determined by the age structure of the population in the hospital catchment area, after controlling for the age-gender structure of actual admissions[15]. Collinearity between different measures of local area deprivation means that only one measure, male unemployment, is used in these estimates. This measure is positively (as expected) associated with death rates.

We repeated these analyses using C^2 as the measure of competition. Table 3, panel A, reports the coefficients for the competition variable only. The same controls are used as in Table 2. These results show again a linear positive relationship between death rates and competition. Again there is no evidence of a non-linear relationship. To show the linear relationship Figure 2 presents the adjusted variable plots of competition and death rates. Panel A is for C^1, Panel B is for C^2. The adjusted variable plots show the relationship between each of the two variables, controlling separately for any relationship between the variables of interest (death rates and competition) and the controls used in Table 2 (including size). The line through the plots is the (marginal) regression coefficient of death rates on competition. Both graphs show a positive relationship, albeit a weak one. The elasticities, calculated at the mean, are small: for C^1, 0.15, and for C^2, 0.07. To give an estimate of the magnitude of this effect, we calculate the impact on death rates of increasing competition from the 25^{th} to the 75^{th} percentile of the distribution of competition. For measure C^1, the effect is to increase death rates by 0.009, which is approximately one fifth of a standard error of death rates. For C^2, the impact is very similar.

[15] This may either be evidence that there is little selection (not unlikely as our death rates are for emergency admissions) and/or that the ward population measures overlap between trusts. Catchment area deprivation measures are constructed using data from several wards. One ward may fall into a number of hospitals' catchment areas as the catchment areas of many hospitals overlap. So the area characteristics of hospitals are also not unique to them. This will attenuate any relationship found at ward level.

The next two panels of Table 3 report further robustness checks. Panel B uses the standardised measure of death rates, where standardization is to the European population distribution. The pre-standardisation death rate is exactly the same as used in Table 2. Again, we use a three-year weighted average for the years 1995/6-97/8. To allow for the fact that the standardisation is based on the European population distribution, we control for the population of actual admissions (i.e. we use the same controls as in Table 2). The results for competition are, as they should be, very similar to those in Table 2, though the overall explanatory power of the regression is lower. The last panel of Table 3 reports the impact of competition, adding length of stay to the set of controls used in Table 2. The results show that the estimated effect of competition remains unchanged. The estimated effect of length of stay is positive, but this is only significant when the impact of competition is constrained to be equal to zero. The coefficient on length of stay may be biased because of endogeneity, but this does not appear to affect the estimated impact of competition.

Previous literature has found that higher volumes of a medical activity are associated with better outcomes. The analyses of Table 2 shows no effect of volume, as measured by total admissions. This measure is not of the activity under consideration, but was used to capture a general impact of size and to avoid the possible endogeneity of AMI admissions. In Table 4, we present the estimated effect of competition controlling for AMI admissions and another measure of size, total hospital beds. We allow for linear and, separately, linear and quadratic terms in these measures. The table shows the estimated effect of competition, using measures C^1, is pretty much unchanged, while none of the measures of activity or size were significant with the set of controls used here. If we do not control for the age-gender distribution of admitted emergency AMI patients, the estimated effect of total admissions, AMI admissions and beds are all negative and generally well defined. The estimated impact of competition remains unchanged[17]. This suggests that there is some relationship between size and admissions but this relationship does not affect the magnitude of the estimated effect of competition.

[17] Similar results were found using competition measure C^2, though the estimated effect of competition is often not significant at conventional levels using this measure.

Examination of the data shows that there is a relationship between volume and case-mix: hospitals with smaller volumes tend to admit a more restricted part of the potential age-gender distribution of cases. So our data show the volume-quality relationship found elsewhere, but once we control for competition this effect disappears.

(b) The impact of competition at ward level

The analyses above use the hospital as the unit of analysis. We complement this by an examination of the relationship between competition and death rates at small area (electoral ward) level. The unit of observation in this case is the ward, rather than the hospital. This supplementary analysis has no obvious behavioural interpretation, as the unit of observation is a collection of individuals, rather than a unit (a hospital) that can change medical behaviour. In addition, we examine all deaths from AMI in the ward and not just those that occur in a hospital setting. So the issue being addressed is a rather more oblique take on the impact of competition between hospitals, as it is an investigation of whether small area variations in AMI death rates reflect the nature of the hospitals located in the area, after controlling for the characteristics of the area.

The literature on variation in death rates by area in the UK provides evidence of established variations in mortality according to age or region of residence. British Heart Foundation Statistics (1999) detail mortality rates from coronary heart disease (CHD). Death rates from CHD are higher in Scotland and the North of England than in Wales and the South of England. The premature death rate (deaths in those aged 35-74) for men living in the North of England is over 50% higher than in East Anglia and almost 90% higher for women. Detailed figures of CHD mortality by local authority show that within Wales, Scotland and the North of England the highest mortality rates are concentrated in certain urban areas (see also Eames, Ben-Shlomo and Marmot (1993)). Drever and Whitehead (1995) study the interaction between socioeconomic and geographic variables at local authority level and find a strong relationship between mortality and deprivation. Ben-Shlomo, White & Marmot (1996) examine the relationship between mortality at regional health authority level and the degree of socioeconomic variation within that area, as well as the average level of deprivation. Their results confirm a strong relationship between deprivation and mortality, together with a positive association between degree of variation within an area and increased mortality. Thus, despite the lack of behavioural interpretation, the interest in small area variations in the health care literature makes this supplementary analysis an interesting one.

The dependent variable we examine is the total number of AMI deaths in a ward for individuals aged 55 and over at ward level, divided by the respective ward population. This death rate includes individuals who die outside hospitals or within 30 days of discharge, as well as those who die in hospital (the dependent variable in the analyses above). Using these ward-level data, we would expect a strong association between population ill health and death rates[20], but we can examine whether competition has an effect independent of population ill health. As wards are small geographical areas, there are many wards that have no hospitals located within them. The first measure of competition we use is therefore the number of trusts that have a catchment area that includes the ward. This is a measure of the number of trusts that the population in the ward can access. The greater the number, the larger the extent of competition on the supply side for individuals living in that ward. We also normalize this measure to derive a second measure of competition: the number of trusts with a catchment area that includes the ward divided by the population of the ward. The means and correlations of the variables used in the analysis are reported in Tables A4 and A5.

If the number of trusts is not a measure of competition but is simply an outcome of planning and so is a measure of population ill health, we would expect a positive association between the number of trusts a ward can access and the ward death rate. Controlling for population ill health we would expect this association to disappear, and for there to be no impact of competition. If, on the other hand, competition reduces quality, we would expect to see some negative relationship between the number of trusts accessible by a ward and death rates.

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[20] We would also expect that this association is stronger than the association between the death rates of a hospital that has the ward in its catchment area and the ill health of that hospital's catchment area.

The results in Table 5 indicate that ward death rates are, as expected, strongly associated with measures of ward ill health and the population structure of the ward. Wards with a high proportion of their population ages 55-64 have lowest rates. The age group with the highest impact on death rates is the very old. The deprivation of the ward is generally positively associated with death rates. The proportion of the male labour force unemployed and the proportion of men who are long term ill are all positively and significantly associated with death rates[21]. But on top of these commonly found associations between demography, deprivation and death rates, we also find an association of competition with ward death rates in these ward level data. For both competition measures the association appears non-linear. The ward level results appear to point in the opposite direction to the association in the hospital level analyses: ward level death rates appear to decrease with competition. However, if we look at the turning points in the non-linear relationship between competition and death rates for the ward level analysis we find that the two sets of results are more compatible than it first seems. The turning point indicates that the effect of competition on death rates is positive in those wards that have levels of competitiveness right up to the 80th percentile of the ward competition measure 1. At the 80th percentile a ward falls in the catchment area of at least 15 trusts. So it is only the most competitive wards in which there is a positive effect of competition on quality (this is about 1500 wards out of the sample of nearly 8000). In the main, we conclude that the negative effects of competition on quality, which can be seen in the hospital level analysis, can also be found in the ward level results.

6. Conclusion

The introduction of payer-driven competition has been one of the primary forms of health care reform advocated in the last two decades. It was introduced in the UK in 1991. The effect of this on quality of outcomes is, as yet, not established in the UK. In this paper we try to establish the impact of competition on the quality of care provided by UK hospitals. We use recently published data on hospital death rates from acute myocardial infarction

[21] The male deprivation measures are also available for females, but collinearity between these measures

(AMI) within 30 days of admission to hospital. These death rates are widely used as a measure of quality of patient care. These were published for the first time in the UK in 1999. We match this information to administrative data from a number of sources. These data provide information on the hospital and on the socio-economic characteristics of each hospital's catchment area, where the catchment area is defined in terms of travel times. These data allow us to calculate measures of competition based on potential rather than actual patient travel and to control for potential patient severity.

We find the impact of competition is to reduce quality. Hospitals located in more competitive areas have higher death rates, controlling for hospital characteristics, actual and potential patient characteristics. The estimated effect of competition is small, but is robust to different measures of competition and hospital volume. We also find evidence that AMI death rates in small local areas that are served by many hospitals are higher (again conditioning on population characteristics) for all but the wards that are located in the most competitive areas.

Whilst the estimated impact of competition on quality is small, what it is not is positive. So our findings differ from those emerging from the USA, which suggest that competition is associated with better quality. The many differences between the two health care systems means we cannot know what accounts for the different impact of competition. Our study is one of a very few that examine outcomes in the UK internal market at more than a case study level, and the first to examine the relationship between competition and death rates. The results therefore should be taken as preliminary, and need confirmation by other studies, particularly ones that (once the data become available) can use either patient level data, or a long enough times series of information on death rates to control for hospital effects. However, taken at face value, the current results suggest that the lack of quality signals in this market has resulted in a weak cross-sectional association between higher competition and lower quality. This suggests that it may have been a mistake to delay the publication of quality signals until some ten years after the introduction of a market meant to rely on them.

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meant that the additional explanatory power of the variables for females was very small.

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Appendix

Table A1: Data Sources

Variable	Year	Source	Level provided
AMI deaths and cases Standardised AMI deaths	95/96, 96/97 & 97/98. 3 year weighted average	National Centre for Health Outcomes Development (NCHOD) Public access site, tables 2B & 3B Http://www.doh.gov.uk/ indicat/nhsci.htm	Trust
AMI deaths	1996/97	Office for National Statistics (ONS)	Electoral Ward
Finished Consultant Episodes Specialty dummies Hospital Beds	1995/96 1996/97 1996/97	Chartered Institute of Public Finance and Accounting (CIPFA)	Trust
Total admissions Average length of stay for AMI cases.	1996/97	Hospital Episode Statistics (HES)	Trust
Deprivation measures Population measures	1991	1991 Census of population (Census91)	Electoral Ward (Aggregated to trust level using Arcview software)

* Detailed technical Annex of data set construction also available.

Table A2: Variable Definitions for Trust-level data

Variable name	Variable Details	Mean (s.e)	Min	Max
Death Rate 1	Weighted AMI emergency death rates for 1995/6-97/8. Weights are # emergency admissions. Source: Table A1	0.19(0.05)	0.066	0.53
Death Rate 2	Weighted AMI emergency death rates for 1995/6-97/8. Weights are the European Standard Population in the age group. Source: Table A1	0.12(0.04)	0	0.36
Competition Measure 1	(Number of trusts in catchment area/population of catchment area) x 100,000	0.54 (0.02)	0.024	1.72
Competition Measure 2	Percentage of population in trust catchment area who can reach between 0 and 5 trusts	0.35 (0.41)	0	1
	Percentage of population in trust catchment area who can reach between 6 and 20 trusts	0.38 (0.36)	0	1
	Percentage of population in trust catchment area who can reach 21 trusts or more	0.26 (0.36)	0	1
Distribution of AMI emergency cases by gender and age	Proportion of total emergency AMI admissions that were female aged 0-49	1.29 (0.72)	0	6.27
	Proportion of total emergency AMI admissions that were female aged 50-64	5.62 (2.24)	0	25.89
	Proportion of total emergency AMI admissions that were female aged 65-74	10.41 (2.07)	0	16.96
	Proportion of total emergency AMI admissions that were female aged 75 plus	22.49 (9.77)	2.36	75.76
	Proportion of total emergency AMI admissions that were male aged 0-49	1.30 (0.72)	0	6.27
	Proportion of total emergency AMI admissions that were male aged 50-64	18.17 (4.74)	0	33.11
	Proportion of total emergency AMI admissions that were male aged 65-74	18.55 (3.28)	0	27.71
	Proportion of total emergency AMI admissions that were male aged 75 plus	18.89 (5.39)	2.99	46.75
% economically active males aged 16+ unemployed in catchment area		11.26 (2.86)	5.80	18.36
Hospital is heart specialist	Hospital coded as heart specialist in 1996/7.	0.69 (0.25)	0	1
Teaching hospital	Hospital coded as teaching hospital in 1996/7.	0.11 (0.32)	0	1
London hospital	Hospital located in London.	0.13 (0.34)	0	1
Age distribution of male population in catchment area	Percentage of total male catchment area population aged 0-54	76.36 (2.32)	67.77	80.68
	Percentage of total male catchment area population aged 55-64	10.37 (0.55)	8.95	12.26
	Percentage of total male catchment area population aged 65-74	8.29 (1.04)	6.20	11.77
	Percentage of total male catchment area population aged 75-84	4.21 (0.78)	3.22	8.09
Total hospital admissions		43315.87 (19597.65)	3592	97638
Total AMI emergency admissions		319.16 (154.16)	10	847
Total beds in hospital		694.21(276.28)	183	1420

Table A3: Correlations between Controls and competition Measures for Trust-level Data

	Comp1	comp2	%f50_64	%f65_74	%f75	%m50_64	%m65_74	%m75	Heartspec	teach	london	admissions	AMI adms	beds	male_unem
comp1	1.00														
comp2	0.07	1.00													
%f50_64	-0.02	0.16*	1.00												
%f65_74	-0.06	-0.13	0.57*	1.00											
%f75	0.16*	-0.09	-0.59*	-0.53*	1.00										
%m50_64	-0.17*	0.18*	0.46*	0.36*	-0.90*	1.00									
%m65_74	-0.18*	-0.19*	0.12	0.42*	-0.68*	0.67*	1.00								
%m75	0.17*	-0.22*	-0.68*	-0.48*	0.64*	-0.77*	-0.38*	1.00							
Heartspec	0.00	0.16*	0.13	-0.01	-0.10	0.09	0.00	-0.14	1.00						
Teach	0.02	0.22*	0.11	-0.06	-0.09	0.12	-0.07	-0.15*	0.45*	1.00					
London	0.08	0.72*	0.14	-0.11	-0.10	0.13	-0.19*	-0.12	0.18*	0.27*	1.00				
Admissions	-0.26*	-0.07	0.19*	0.22*	-0.31*	0.24*	0.20*	-0.18*	0.18*	0.40*	-0.01	1.00			
AMI adms	-0.26*	-0.26*	0.13	0.33*	-0.29*	0.20*	0.37*	-0.15*	-0.03	-0.04	-0.23*	0.65*	1.00		
Beds	-0.18*	0.00	0.07	0.03	-0.03	0.01	-0.08	-0.07	0.19*	0.48	-0.00	0.80*	0.47*	1.00	
male_unem	-0.03	0.31*	0.39*	0.27*	-0.18*	0.16*	-0.07	-0.34*	0.11	0.13	0.24*	0.15*	0.11	0.17*	1.00

Notes: * indicates P ≤ 0.05. % variables are controls for age-gender composition of AMI patients

Table A4: Variable Definitions for Ward-level data

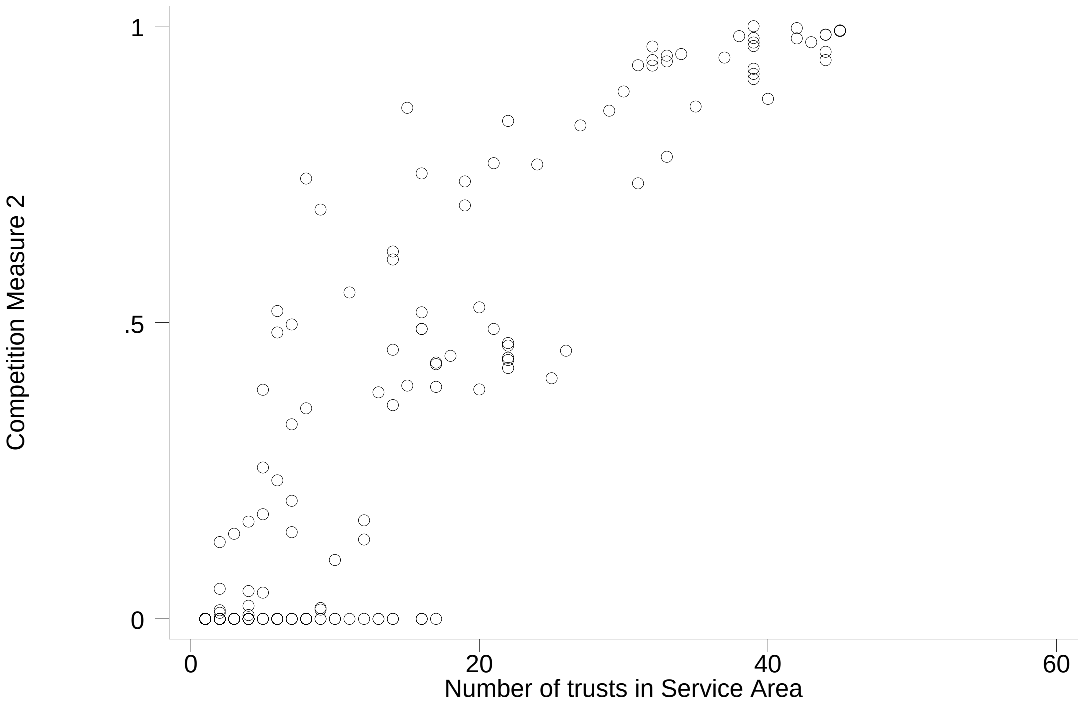
Variable name	Variable Details	Mean (s.e)	Min	Max
AMI Death Rate for over 45's	(Number of AMI deaths in age category 45+/total ward population aged 45+) x 100	0.55 (0.24)	0	1.96
Ward Competition Measure 1	Number of trust catchment areas a ward falls into.	9.87 (11.56)	1	47
Ward Competition Measure 2	(Number of trust catchment areas a ward falls into/total ward population) x 100	0.19 (0.22)	0.01	3.37
London hospital	Hospital located in London	0.21 (0.41)	0	1
Age distribution of ward population	Percentage of total ward population aged 55-64 Percentage of total ward population aged 65-74 Percentage of total ward population aged 75-84 Percentage of total ward population aged 85plus	10.61 (2.04) 9.19 (2.47) 5.68 (2.07) 1.58 (0.89)	1.15 0.73 0.35 0.09	20.39 26.61 25.29 13.90
% economically active males aged 16+ unemployed		5.471 (3.10)	0.54	24.98
% males with a long-term limiting illness		11.52 (3.50)	2.88	46.10
% households owner occupied		27.46 (6.22)	0.35	47.73
% households with no indoor plumbing		0.50 (0.58)	0.01	8.20

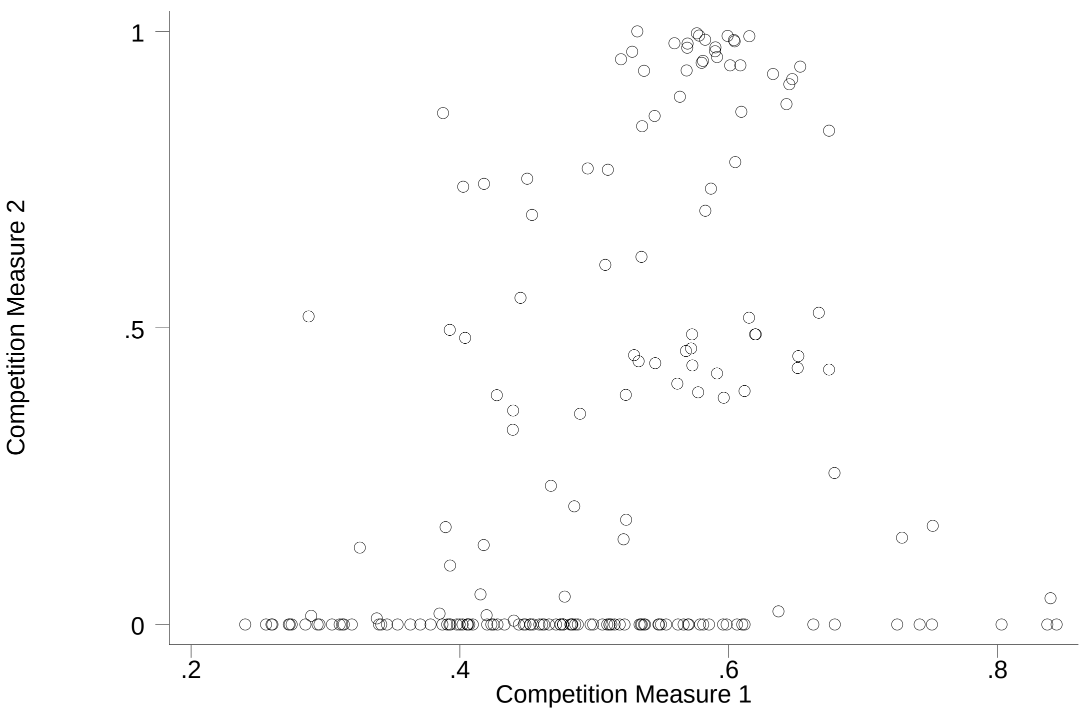
Table A5: Correlation between Controls and competition Measures for Ward-level Data

	comp1	Comp2	%pop55_64	%pop65_74	%pop 75_84	% pop 85+	male_unemp	%males_ long term_illness	%homeowner	%no plumbing	london
comp1	1.00										
comp2	0.69*	1.00									
% pop 55_64	-0.17*	0.03*	1.00								
% pop 65_74	-0.23*	-0.13*	0.70*	1.00							
% pop 75_84	-0.13*	-0.10*	0.46*	0.80*	1.00						
% pop85+	-0.10*	-0.07*	0.32*	0.58*	0.83*	1.00					
male_unemp	0.31*	0.01	-0.22*	-0.05*	-0.08*	-0.11*	1.00				
%males_long-term_illness	-0.03*	-0.14*	0.28*	0.53*	0.43*	0.30*	0.57*	1.00			
%homeowner	-0.26*	-0.14*	0.24*	0.21*	0.27*	0.24*	-0.53*	-0.26*	1.00		
%no_plumbing	0.15*	0.09*	-0.08*	0.05*	0.25*	0.29*	0.21*	0.14*	-0.07*	1.00	
London	0.72*	0.60*	-0.13*	-0.24*	-0.13*	-0.08*	0.12*	-0.26*	-0.14*	0.1012*	1.00

Notes:
* indicates P $\leq$ 0.05.
% variables are controls for age distribution of male catchment area population.

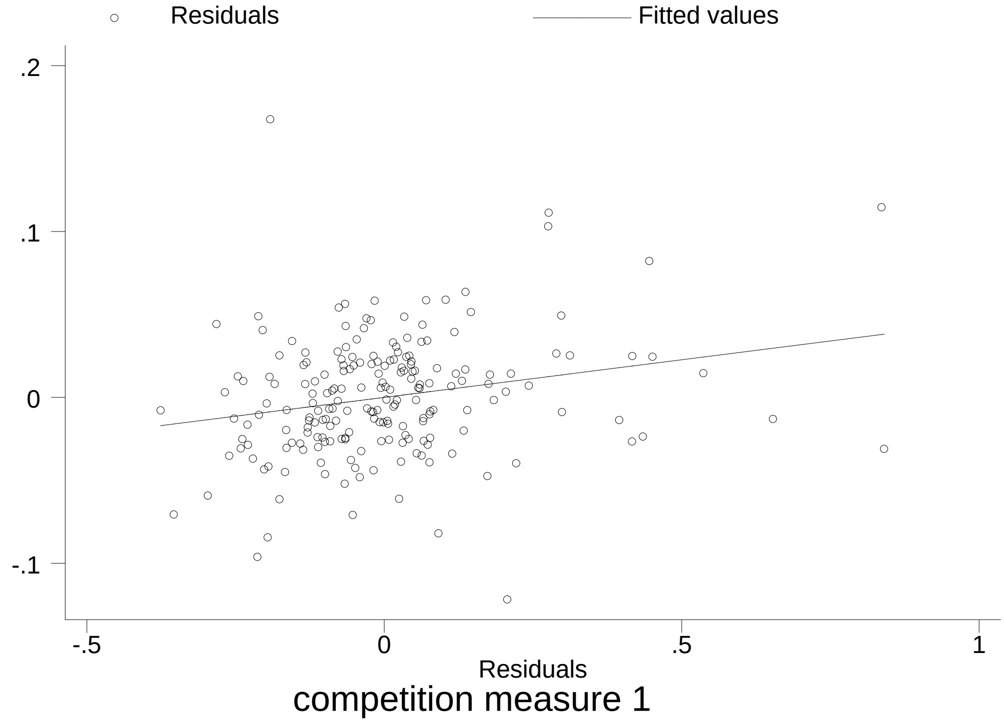
Figure 1: Measures of competition

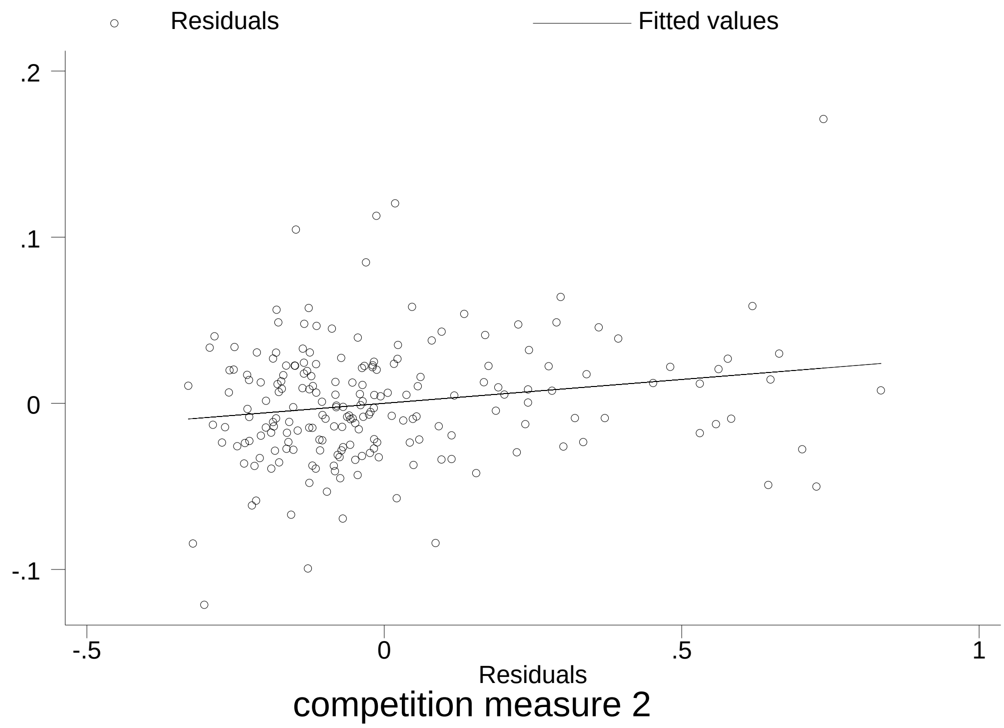




Notes:
1. Competition measure 1 is the number of trusts in catchment area/population of catchment area) x 100,000
2. Competition measure 2 is the share of catchment area population that can reach > 20 trusts

Figure 2: Adjusted Variable Plots for Competition and Death Rates, Trust Data





Notes:
1. Competition Measure 1 is (the number of trusts in catchment area/population of catchment area) x 100,000
2. Competition Measure 2 is the share of the catchment area population that can reach > 20 trusts

Table 1: Comparisons of hospital rankings of AMI emergency death rates: 1995, 1996 and 1997.

	Of the hospitals ranked in best 10% in 1995
In 1996:	
What percent were still ranked in the best 10%? (lowest mortality rates)	28.6%
What percent were ranked in the worst 10%? (highest mortality rates)	4.8%
Average difference in mortality rate from all other hospitals (standard error of estimate)	-0.028** (0.011)
In 1997:	
What percent were still ranked in the best 10%? (lowest mortality rates)	21.05%
What percent were ranked in the worst 10%? (highest mortality rates)	5.26%
Average difference in mortality rate from all other hospitals (standard error of estimate)	-0.029* (0.016)

*significant at 5% **significant at 1%

Table 2: Least squares regressions of AMI death rate at trust level, competition measure 1

	1	2	3	4
Competition	5.35**	-4.71	5.40**	5.38**
	(1.95)	(6.05)	(1.97)	(1.97)
Competition^2	-	6.68	-	-
		(4.30)		
Percent female emergency AMI cases aged 50-64	0.05	0.00	0.05	0.05
	(0.36)	(0.35)	(0.36)	(0.36)
Percent female emergency AMI cases aged 65-74	0.72*	0.60*	0.72*	0.71*
	(0.31)	(0.30)	(0.32)	(0.31)
Percent female emergency AMI cases aged 75+	0.48*	0.44*	0.48*	0.48*
	(0.20)	(0.20)	(0.19)	(0.19)
Percent male emergency AMI cases aged 50-64	0.65~	0.53	0.65	0.64~
	(0.34)	(0.34)	(0.34)	(0.34)
Percent male emergency AMI cases aged 65-74	-0.01	0.01	-0.01	0.00
	(0.25)	(0.24)	(0.25)	(0.25)
Percent male emergency AMI cases aged 75+	0.65*	0.57*	0.65*	0.64*
	(0.26)	(0.26)	(0.26)	(0.26)
Percent males aged 0-54 in catchment area	30.30	46.28	29.42	26.39
	(65.40)	(65.58)	(65.97)	(66.61)
Percent males aged 55-64 in catchment area	-4.01	-2.11	-4.17	-4.82
	(11.10)	(11.21)	(11.21)	(11.38)
Percent males aged 65-74 in catchment area	-4.77	-5.31	-4.84	-5.05
	(11.14)	(10.99)	(11.12)	(11.15)
Percent males aged 75-84 in catchment area	6.76	9.83	6.63	6.38
	(8.24)	(8.25)	(8.43)	(8.44)
Percent males unemployed in catchment area	0.36*	0.43**	0.36*	0.36*
	(0.15)	(0.14)	(0.15)	(0.15)
Heart specialist hospital	-0.19	-0.27	-0.18	-0.24
	(1.17)	(1.11)	(1.17)	(1.17)
Teaching specialist hospital	1.65	1.68~	1.59	1.57
	(0.90)	(0.88)	(1.00)	(1.00)
London hospital	-3.02**	-3.07**	-3.00**	-2.97**
	(1.12)	(1.12)	(1.15)	(1.13)
Total hospital admissions	-	-	0.215	-2.01
			(1.40)	(5.19)
Total hospital admissions^2	-	-	-	2.26
				(4.85)
Intercept	-151.25	-219.98	-146.96	-130.71
	(319.80)	(322.80)	(322.71)	(326.16)
R^2	0.57	0.58	0.57	0.57
N	202	202	202	202

~Significant at the 10% level *Significant at the 5% level **Significant at the 1% level.

Notes:

1. Robust standard errors in parentheses
2. Admissions and the competition measure are in 100 000's

Table 3: Robustness checks

	Panel A Competition measure 2			Panel B Alternative measure of death rates			Panel C Including Length of Stay as a control		
Competition	2.66 (1.64)	-0.60 (3.49)	2.52 (1.66)	5.65* (2.30)	-7.20 (7.40)	5.84* (2.29)	4.23* (1.94)	-4.16 (6.07)	4.43* (1.96)
Competition^2	-	4.42 (5.05)	-	-	8.53 (5.51)	-	-	5.62 (4.43)	-
Including total admissions	No	No	Yes	No	No	Yes	No	No	Yes
R^2	0.54	0.54	0.54	0.27	0.30	0.27	0.59	0.59	0.59
N	202	202	202	202	202	202	201	201	201

~Significant at the 10% level *Significant at 5% ** Significant at 1%.
Notes:
1. Robust standard errors in parentheses
2. Regressions run with controls in table 2

Table 4: The effect of size

	With controls for age-gender composition of AMI patients						Without controls for age-gender composition of AMI patients					
	Size measured by:						Size measured by:					
	Total Admissions		AMI admissions		Beds		Total Admissions		AMI admissions		Beds	
Competition	5.40** (1.97)	5.38** (1.97)	5.48** (2.00)	5.50** (1.99)	5.2 (1.96)	5.29** (1.99)	6.45~ (3.50)	5.89~ (3.15)	7.10~ (3.80)	7.03* (3.45)	7.41* (3.57)	7.47* (3.56)
Size	0.22 (1.40)	-2.01 (5.19)	65.77 (151)	-376.99 (554.5)	-0.54 (1.12)	4.61 (4.43)	-4.14 (2.67)	-28.10* (12.52)	-531.9~ (303.5)	-2547* (1235)	-0.19 (1.36)	1.55 (5.97)
Size^2	-	2.26 (4.85)	-	0.61 (0.71)	-	-3.5E-06 2.9E-06	-	25.17* (11.06)	-	3.00* (1.51)	-	-1.7E-06 3.6E-06
R^2	0.57	0.57	0.57	0.570	0.57	0.57	0.17	0.22	0.17	0.22	0.14	0.14
N	202	202	202	202	202	202	202	202	202	202	202	202

~Significant at the 10% level, *Significant at the 5% level, **Significant at the 1% level
Notes:
1. Robust standard errors in parentheses
2. The beds variable is in 1,000's, Admissions variables are in 100,000's
3. Regressions run with controls in table 2
4. Measure of competition is C1

Table 5: Least squares regressions of AMI death rate at ward level

	Competition Measure 1		Competition Measure 2	
	1	2	3	4
Competition	-0.01**	0.04**	-0.01	0.04
	(0.00)	(0.01)	(0.01)	(0.02)
Competition^2	-	-1.32**	-	-3.66*
	-	(0.20)	-	(1.56)
Percent population aged 55-64	-2.46**	-2.54**	-2.46**	-2.49**
	(0.18)	(0.18)	(0.19)	(0.19)
Percent population aged 65-74	0.38~	0.48*	0.45*	0.48*
	(0.21)	(0.21)	(0.21)	(0.21)
Percent population aged 75-84	-0.09	-0.02	-0.11	-0.11
	(0.18)	(0.18)	(0.18)	(0.10)
Percent population aged 85+	1.08**	1.08**	1.08**	1.08**
	(0.09)	(0.10)	(0.10)	(0.09)
Percent males unemployed	0.24**	0.24**	0.20*	0.21**
	(0.08)	(0.08)	(0.08)	(0.08)
Percent males long term ill	2.04**	1.90**	1.99**	1.97**
	(0.15)	(0.15)	(0.15)	(0.15)
Percent homes owner occupied	0.06	-0.05	0.07	0.08
	(0.10)	(0.10)	(0.10)	(0.10)
Percent homes no indoor Plumbing	-0.07*	-0.03	-0.07**	-0.07**
	(0.03)	(0.03)	(0.03)	(0.03)
London hospital	0.08	0.09	-0.13	-0.18*
	(0.01)	(0.10)	(0.08)	(0.08)
Intercept	0.01**	0.01**	0.01**	0.01**
	(0.00)	(0.00)	(0.00)	(0.00)
R^2	0.16	0.16	0.16	0.16
N	7861	7861	7861	7861

~Significant at the 10% level *Significant at the 5% level **Significant at the 1% level

Notes:

1. Standard errors in parentheses
2. All variables except competition measure 2 are multiplied by 1000