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Patient Choice and the Effects of Hospital Market Structure on Mortality for AMI, Hip Fracture and Stroke Patients

CHE Research Paper 106

Patient choice and the effects of hospital market structure on mortality for AMI, hip fracture and stroke patients

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Abstract

We examine (a) the effect of market structure on the level of mortality for AMI, hip fracture, and stroke between 2002/3 and 2010/11 and (b) whether this effect changed after the introduction of Choice policy in 2006 which gave patients the right to a wider choice of hospital. For AMI and hip fracture, hospitals with more rivals had higher mortality at the beginning of the period but this effect became smaller over the period. We find that the decline in the detrimental effect of market structure predated the introduction of Choice. Market structure had no effect on stroke mortality.

JEL Nos: H51, I11, I18, L32, L33
Keywords: competition, quality, hospital, choice

Executive Summary

1. It is often suggested that if the price per patient treated is fixed then hospitals will have an incentive to raise quality to attract more patients and that this incentive is greater if hospitals face more rivals and if patient choice amongst hospitals is not restricted.

2. From 2003 onwards the English NHS has encouraged the entry of new providers of elective (non-emergency) hospital treatment. In April 2006 patients were given the right to be offered a choice from at least four providers for elective (non-emergency) hospital treatment. In 2008 this was extended to a right to choose any hospital in contract with the NHS.

3. Most studies of the effects of market structure on quality have used mortality for patients with acute myocardial infarction (AMI) as the quality measure because AMI is well recorded and mortality can be reduced by appropriate hospital treatment. Moreover, because AMI is not an elective condition, the quality measure is not biased by unobservably sicker patients choosing higher quality providers. But because hospitals can compete only for elective patients it must be assumed that quality of care for AMI (or other emergency admissions used to measure quality) is correlated with quality of care for elective patients.

4. Studies from the US have produced mixed results with some finding that providers with more rivals have lower AMI mortality and others that they have higher mortality or that there is no relationship.

5. Two recent studies of the English NHS examine how the introduction of Choice in 2006 changed the effect of market structure on AMI mortality. Both find that there was a bigger reduction in mortality for hospitals with more rivals after the introduction of Choice. But these findings do not distinguish between Choice increasing the beneficial effect of more rivals in reducing mortality and Choice reducing the detrimental effect of more rivals in increasing mortality.

6. Policy makers should also be interested in the effect of the number of rivals on quality, not just in the change in this effect after the introduction of Choice. We therefore test directly for the effect of market structure on quality as well as testing for changes in this effect after the introduction of Choice.

7. We use individual level data on AMI, hip fracture, and stroke patients admitted to English NHS hospitals between 2002/3 and 2010/11. We measure the market structure facing a hospital by (a) the number of sites (NHS and private) providing elective care within 30km and (b) the predicted equivalent number of rivals (the reciprocal of the Herfindahl index computed from predicted patient flows). We estimate models with site fixed effects, year effects, and with patient covariates including morbidity, age, gender, deprivation, and distance to hospital.

8. We estimate two main models. The policy break model assumes that the effect of market structure is the same in the four pre Choice years (2002/3 to 2005/6) and the same in the five post Choice years (2006/7 to 2010/11) but possibly different from the effect in the pre-Choice years. The model provides a simple test for whether the effect of market structure changed after the introduction of Choice in 2006. We use it to investigate the robustness of findings to the measure of mortality, to the age range of patients, and whether the effect of market structure depends on the type of hospital and whether it is competition from NHS hospitals or private providers that affects quality.

9. If there is an underlying trend in the effect of market structure, the policy break specification will incorrectly attribute all the difference between the average post Choice and the average pre Choice effect of market structure to the introduction of Choice. Our second, flexible, model allows the effect of market structure to vary across all years, not just after the introduction of Choice, and so avoids this problem.

10. Results from the policy break model show that in the pre-Choice period providers facing more rivals had higher AMI and hip fracture mortality. In the post-Choice period the detrimental effect of rivals was smaller and statistically significant only for hip fracture. This suggests that Choice reduced the detrimental effect of having more rivals.

11. Broadly similar results are obtained with mortality in any location, rather than just in-hospital mortality, and for different types of hospital (Foundation Trusts, Teaching hospitals, hospitals located in London). The qualitative pattern of results is not sensitive to the measure of market structure, though effects are less precisely estimated when using the predicted equivalent number of rivals derived from estimated patient demand, perhaps because there is less variation in this measure. Results are also sensitive to the age range of patients. For example, with all patients aged over 35, the effects of market structure on AMI mortality and the change in these effects are statistically insignificant.

12. The extension of Choice in 2008 did not change the effect of market structure and the effect of market structure did not vary with the proportion of patients who reported being aware of their right to a choice or being offered a choice.

13. The flexible model, in which the effect of market structure was allowed to vary across all years, suggested that the effect in 2002/3 of having more rivals was to increase mortality for AMI and hip fracture and that this detrimental effect became smaller over time. The change in the effect of market structure started before the introduction of Choice in 2006. The time series plot of the effects of market structure does not exhibit any obvious structural breaks in 2006/7 or in 2008/9 following the extension of Choice. Market structure did not affect stroke mortality in any year.

14. AMI, hip fracture, and stroke mortality probabilities fell by 2.65, 1.09, and 5.01 percentage points between 2002/3 and 2010/11. This implies that there were 661, 119, and 1165 fewer deaths from these conditions in 2010/11 than would have been the case in 2002/3. The beneficial changes in the patient mix and the effects of patient characteristics were the most important factors contributing to these reductions. The reduction in the mortality contributed by the reduction in the detrimental effect of rivals was 1.15 percentage points for hip fracture and 0.37 percentage points for AMI.

15. For AMI and hip fracture there was a reduction in the detrimental effect on mortality of having more rivals over the period 2002/3 to 2010/11. This did not appear to be due to the introduction of Choice. We conjecture, and plan to test in future work, that the beneficial change in the effect of market structure was due to a combination of policies including the increase in the proportion of hospital revenue arising from prices rather than negotiated budgets.

Contents

1 Introduction

The introduction of competition policies in the health care sector is the subject of an intense political and academic debate, both in England and internationally (Bevan and Skellern, 2011; Bloom et al, 2011; 2012; Gaynor et al, 2012a; OHE, 2012; Pollock et al 2011a; 2011b). It has been argued that if the price per patient treated is fixed then hospitals have an incentive to raise quality to attract more patients and that this incentive is greater if hospitals face more rivals and if patient choice amongst hospitals is not restricted.

Since 2003 the English National Health Service (NHS) has been subject to policies intended, inter alia, to promote competition amongst hospitals. Prospective payment for hospitals was introduced from 2003/4 onwards, so that funding followed the patient. Private providers were encouraged to enter the market for elective care for NHS patients from 2003. In January 2006 NHS patients were given the right to be offered a choice of at least four providers and from April 2008 they had the right to choose any qualified provider. An electronic booking service for outpatient appointments was introduced from 2006 to help patients and their GPs make a firm booking during a consultation. Since 2007 the NHS Choices website has provided public information on services and quality of providers. Whether these pro-competition reforms had a positive effect on quality in the NHS has implications for policy in England and other OECD countries that plan to encourage competition policies in the hospital sector (OECD, 2012).

The empirical evidence on competition and hospital quality in fixed price systems is mixed. Most studies have used mortality for patients with acute myocardial infarction (AMI) as the quality measure because AMI is well recorded and mortality can be reduced by appropriate treatment. Moreover, because AMI is not an elective condition, the quality measure is not biased by unobservably sicker patients choosing higher quality providers. But because hospitals can compete only for elective patients it must be assumed that quality of care for AMI (or other emergency admissions used to measure quality) is correlated with quality of care for elective patients.[1]

For the US, Kessler and McClellan (2000) and Kessler and Geppert (2005) find that mortality for AMI is lower in more competitive markets. Gowrisankaran and Town (2003) report that more competition reduced heart attack and pneumonia mortality for patients with some types of insurance but increased it for others. Shen (2003) finds mixed effects of competition. Mukamel et al (2001) find no effect of market concentration on all-cause mortality. Colla et al (2014) report that competition reduces AMI mortality rates, has no effect on quality for hip and knee replacements (as measured by 30-day emergency readmission rates) and reduces quality for dementia patients. Chou et al (2014) find that report cards on the quality of providers reduced CABG mortality for more severely ill patients in more competitive areas.

In England, Propper et al (2004) report that providers facing more competition during the first NHS internal market in the 1990s had higher AMI mortality and Propper et al (2008) also find that when competition was allowed during this period, providers in more competitive areas had a slower rate of decline of AMI mortality. Recent papers have examined competition in the new post 2002/3 NHS internal market. Bloom et al (2013) find that hospitals in more competitive areas had lower AMI mortality. Cooper et al. (2011) and Gaynor et al (2013) use the introduction of Choice policy in 2006 as a natural experiment, arguing that it would have a bigger effect for providers facing a more competitive market structure. Using 2002-2008 individual level data for AMI patients aged 39-100 Cooper et al (2011) find that AMI mortality fell by 0.31 percentage points per year faster after the introduction of Choice in areas where competition was more intense by one standard deviation.

[1] See Cooper et al (2011), Gaynor et al (2013) for a detailed discussion of the justification of using AMI.

Gaynor et al (2013) use hospital Trust level data for 2003/4 and 2007/8.[2] They find that hospitals which had a 10% smaller Herfindahl index (i.e. facing more competition) in 2003 had a 2.9% larger decrease in age 35-74 AMI mortality rates between 2003 and 2007. There was a similar association for overall mortality rates, though the effect was smaller. Hospitals facing more competition in 2003 also had a reduction in overall length of stay between 2003 and 2007 relative to providers facing less competition.

In this paper we use individual level data to investigate the effect of market structure on hospital quality between 2002/3 and 2010/11. We make a number of contributions. First, in addition to AMI mortality, we examine mortality for hip fracture and stroke. The lifetime risk of hip fracture in industrialised countries is 18% in women and 6% in men. Around 30% of people with hip fracture die within one year (Roche et al, 2005). Stroke causes 10-12% of deaths in the western world (Donnan et al, 2008). Average in-hospital age 35-74 mortality rates are 16% for stroke, 3% for hip fracture and 6% for AMI in our sample. There are low correlations (under 0.1) of hip fracture and stroke mortality with AMI mortality across hospitals (see section 4.1). This suggests that market structure and Choice policy may have different effects in different conditions.

Second, we use a longer panel for 2002/3 to 2010/11. This enables us to test if there was a change in the effect of market structure after 2006 and to examine whether there was a further change following the 2008 extension of Choice policy which gave patients the right to choose any qualified provider. We also use the longer panel to test whether differences in the effect of markets structure before and after the introduction of Choice were part of a longer term trend and whether Choice led to changes in this trend.

Third, in addition to models which assume that Choice policy had an immediate and uniform effect across providers from 2006 onward, we estimate models using cross sectional and time series differences in the proportion of patients in different areas who report being offered a choice of provider.

Fourth, we examine whether the effect of market structure on mortality varies across age bands. Fifth, we test whether market structure and Choice have different effects on mortality at different types of hospitals (such as Foundation Trusts which, unlike other NHS hospitals, can retain profits).

Last, but not least, we suggest that policy makers should be interested in the overall effect of market structure on quality, not just in how Choice policy may have changed this effect. Consider **Figures 1** and **2**, depicting two situations in which mortality depends on market structure as measured by the number of rivals and on Choice policy. The introduction of Choice has the same beneficial effect in reducing mortality (by $\gamma_1 M < 0$) at any given number of rivals in the two figures. In Figure 1 having more rivals leads to a reduction in mortality in both periods ($\delta_0 < 0$, $\delta_0 + \gamma_1 < 0$), whereas in Figure 2 providers with more rivals have higher mortality ($\delta_0 > 0$, $\delta_0 + \gamma_1 > 0$). In addition to knowing whether Choice changed the effect of market structure (γ_1), it is clearly important for policy makers to know whether more competitive market structure will lead to higher or lower mortality.

To investigate these questions we use individual level data on AMI, hip fracture, and stroke patients admitted to English NHS hospitals between 2002/3 and 2010/11. We measure market structure facing a hospital by (a) the number of sites (NHS and private) providing elective care within 30km and (b) the predicted equivalent number of rivals (the reciprocal of the Herfindahl index computed from predicted patient flows). We allow for site fixed effects, year effects, and patient covariates including morbidity, age, gender, deprivation and distance to hospital.

[2] 2002/3 etc are NHS financial years from April 1 to March 31.

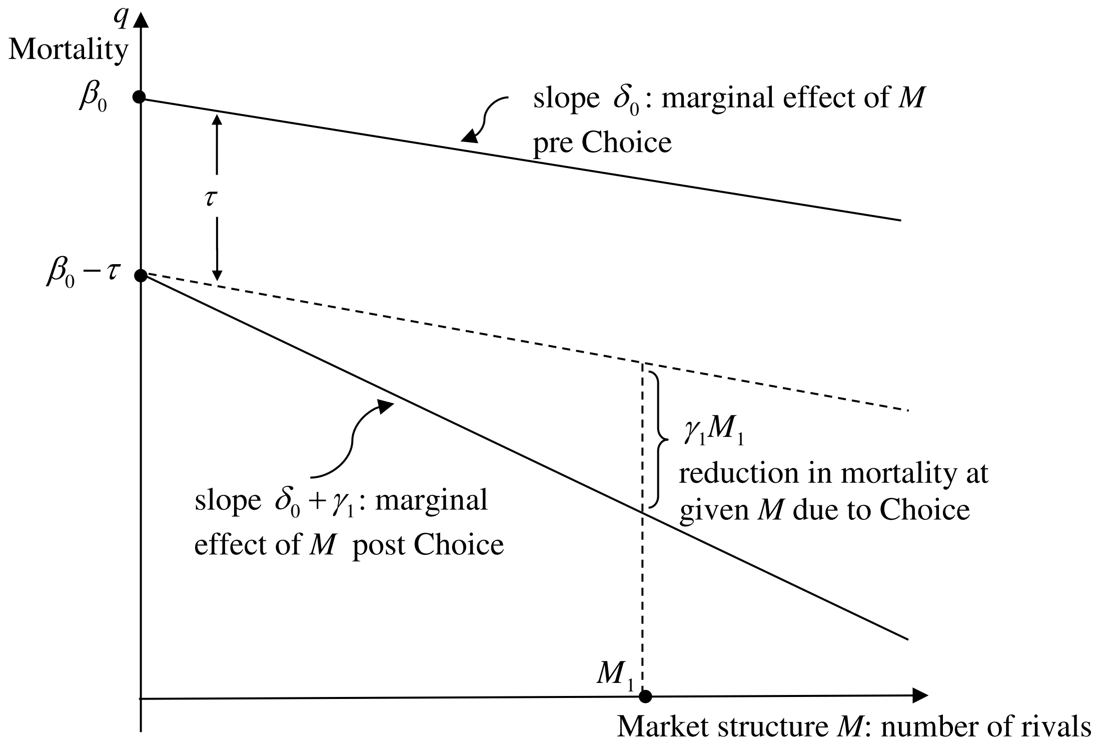

Figure 1. Effects of market structure and introduction of Choice on mortality: Choice increases beneficial effect of more competitive market structure

Note. In the pre-Choice period providers faced with more rivals have lower mortality: $q_0 = \beta_0 + \delta_0 M$, where the marginal effect of more rivals $\delta_0 < 0$. In the post choice period mortality risk is $q_1 = \beta_0 - \tau + (\delta_0 + \gamma_1)M$, where τ is the change in risk due to changes in all other factors and $\gamma_1 < 0$ is the change in the marginal effect of the number of rivals. Since $\delta_0 + \gamma_1 < \delta_0 < 0$, an increase in the number of rivals reduces mortality both pre and post Choice and an increase in the number of rivals leads to a greater reduction in mortality post Choice.

We estimate two main models. The policy break model assumes that the effect of market structure is the same in the four pre Choice years (2002/3 to 2005/6) and the same in the five post Choice years (2006/7 to 2010/11), but possibly different from the effect in the pre-Choice years. The model provides a simple test for whether the effect of market structure changed after the introduction of Choice in 2006. We use it to investigate the robustness of findings to the precise definition of mortality, to the age range of patients, and whether the effect of market structure depends on the type of hospital and whether it is competition from NHS hospitals or private providers that affects quality.

However, if there is an underlying trend in the effect of market structure, the policy break specification will incorrectly attribute all the difference between the average post Choice and the average pre Choice effect of market structure to the introduction of Choice. Our second, flexible, model allows the effect of market structure to vary across all years, not just after the introduction of Choice, and so it avoids this problem.

Results from the policy break model show that, in the pre Choice period, providers facing more rivals had higher AMI and hip fracture mortality, though the effects are statistically significant at the conventional 5% level only for hip fracture. In the post Choice period the detrimental effect of rivals was smaller and statistically significant only for hip fracture. The reduction in the detrimental effect was significant for both AMI and hip fracture. This suggests that Choice reduced the detrimental effect of having more rivals. Broadly similar results are obtained with mortality in any location, rather than just in-hospital mortality.

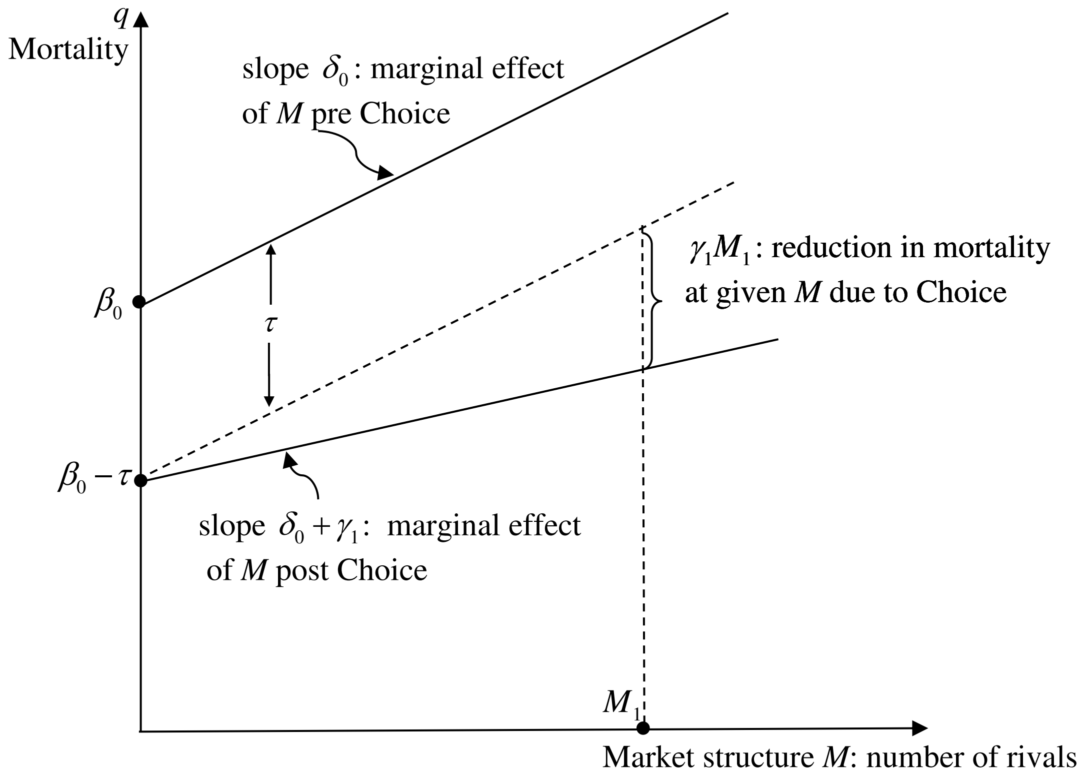

Figure 2. Effects of market structure and introduction of Choice on mortality: Choice reduces deleterious effect of more competitive market structure

Note. In the pre-Choice period providers faced with more rivals have higher mortality: $q_0 = \beta_0 + \delta_0 M$, where the marginal effect of more rivals is $\delta_0 > 0$. In the post choice period mortality risk is $q_1 = \beta_0 - \tau + (\delta_0 + \gamma_1)M$ where τ is the change in risk due to changes in all other factors and $\gamma_1 < 0$ is the change in the marginal effect of the number of rivals. Since $\delta_0 > \delta_0 + \gamma_1 > 0$, an increase in the number of rivals is less harmful (leads to a smaller increase in mortality) post Choice, even though increases in the number of rivals increase mortality in both periods ($\delta_0 + \gamma_1 > 0$).

The effects of market structure on AMI mortality before and after introduction of Choice did not differ between Foundation Trust and other hospitals. Post Choice, the deleterious effect of market structure on hip fracture mortality was smaller for Foundation Trusts but not for other sites. For hospitals located in London there was no statistically significant difference in the effect of market structure pre and post Choice.

The qualitative pattern of results is not sensitive to the measure of market structure, though effects are less precisely estimated when using the predicted equivalent number of rivals derived from estimated patient demand, perhaps because there is less variation in this measure. Results are also sensitive to the age range of patients. For example, with all patients aged over 35, rather than the baseline age range of 35-74, the effects of market structure on AMI mortality and the change in these effects are statistically insignificant.

When we employ direct measures of the extent to which patients were offered choice we find that hospitals with more rivals do not respond differently in areas where a higher proportion of patients reported being offered a choice of provider or of being aware of their right to be offered a choice. Neither do we find that there was any difference in the effect of having more rivals in the period from 2008/9 onwards when patients had a right to an unrestricted choice, compared to the period 2006/7 to 2007/8 when patients had a more restricted choice of at least 4 providers.

The flexible model, in which the effect of market structure is allowed to vary across all years, suggested that the effect in 2002/3 of having more rivals was to increase mortality for AMI and hip fracture and that this detrimental effect became smaller over time. The change in the effect of market structure started before the introduction of Choice in 2006. The time series plot of the effects of market structure does not exhibit any obvious structural breaks in 2006/7 or in 2008/9 following the extension of Choice. Market structure did not appear to have any effect on stroke mortality.

AMI, hip fracture, and stroke mortality probabilities for patients aged 35-74 fell by 2.65, 1.09, and 5.01 percentage points between 2002/3 and 2010/11. This implies that there were 661, 119, and 1165 fewer deaths from these conditions in 2010/11 than would have been the case in 2002/3. Beneficial changes in the patient mix and the effects of patient characteristics were the most important contributory factor in these reductions. The reduction in the detrimental effect of rivals was more important for hip fracture (1.15 percentage points) than for AMI (0.37 percentage points).

In the next section of the paper we sketch a theoretical framework for the empirical analysis of the effects of market structure and of Choice. It shows that the assumptions required for Choice to have a beneficial impact on the effect of more rivals on quality are much stronger than those required for more rivals to increase quality. Section 3 sets out the econometric approach. Section 4 describes the institutional set up and the data. Section 5 has the results and Section 6 discusses their implications.

2 Theoretical framework

We provide a simple model to examine the implications of more competitive market structures and of removing restrictions on patients' choices to guide our interpretation of the empirical model.[3]

Consider a market with *n* hospitals where the payoff function of hospital j is

$$v^j(q_j, q_{-j}, \theta) = B^j(q_j) + pD^j(q_j, q_{-j}, \theta) - C^j(D^j(q_j, q_{-j}, \theta), q_j) \quad (1)$$

q_j is the quality of hospital j, q_{-j} is the vector of qualities of potential rival hospitals, $B^j(q)$ $\left(B_q^j(q) > 0\right)$ captures intrinsic provider motivation (McGuire, 2000). p is the price set by a regulator. $D^j(q_j, q_{-j}, \theta)$ is demand for hospital j which is increasing in own quality and decreasing in the quality of its rivals. θ is a policy parameter which captures the degree to which patient choice is encouraged. $C^j(.)$ is the cost function which is increasing in the number of patients treated (C_D > 0) and in quality (C_q > 0). We do not put restrictions on the cost function, and allow for increasing (C_{DD} < 0, C_{qq} < 0) or decreasing (C_{DD} >0, C_{qq} > 0) returns to scale in volume and quality, and cost complementarity (C_{qD} < 0) or substitutability (C_{qD} > 0) between quality and volume. Cost complementarity can arise in the presence of learning-by-doing so that the marginal cost of providing quality decreases with higher volumes.[4]

When the market is in equilibrium all firms choose quality to satisfy the first and second order conditions

$$v_q^j(q_j, q_{-j}, \theta) = B_q^j(q_j) + \left[p - C_D^j(D^j(q_j, q_{-j}, \theta), q_j)\right] D_q^j(q_j, q_{-j}, \theta)$$
$$-C_q^j(D^j(q_j, q_{-j}, \theta), q_j) = 0, \; j = 1, \ldots, n \quad (2)$$
$$v_{qq}^j = B_{qq}^j + (p - C_D^j) D_{qq}^j - (C_{DD}^j D_q^j + 2C_{Dq}^j) D_q^j - C_{qq}^j < 0, \qquad j = 1, \ldots, n \quad (3)$$

If hospitals are identical and the equilibrium is symmetric, so that all hospitals choose the same quality q^e, the market equilibrium is defined by the single condition

$$v_q^e(q^e, n, \theta) = B_q(q^e) + \left[p - C_D^e(D(q^e, n, \theta), q^e)\right] D_q^e(q^e, n, \theta) - C_q(D^e(q^e, n, \theta), q^e) = 0 \quad (4)$$

where $D^e(q^e, n, \theta) = D(q^e, q_{-j}^e, \theta)$.

The effects of more competitive market structure (*n*) and choice policy (θ) on equilibrium quality $q^e(n, \theta)$ are

$$q_n^e = \frac{-v_{qn}^e(q^e, n, \theta)}{v_{qq}^e(q^e, n, \theta)} = -\frac{(p - C_D) D_{qn}^e - (C_{DD} + C_{Dq}) D_n^e}{B_{qq} + (p - C_D) D_{qq}^e - (C_{DD} D_q^e + 2C_{Dq}) D_q^e - C_{qq}} \quad (5)$$

$$q_\theta^e = \frac{-v_{q\theta}^e(q^e, n, \theta)}{v_{qq}^e(q^e, n, \theta)} = -\frac{(p - C_D) D_{q\theta}^e - (C_{DD} + C_{Dq}) D_\theta^e}{B_{qq} + (p - C_D) D_{qq}^e - (C_{DD} D_q^e + 2C_{Dq}) D_q^e - C_{qq}} \quad (6)$$

[3] See Gaynor (2006), Katz (2013), Brekke et al (2014) for reviews of the theoretical literature.
[4] The model does not allow for profit constraints. The literature suggests that profits constraints typically reduce the effect of competition on quality since providers are less responsive to financial incentives (Glaeser and Shleifer, 2001; Brekke et al, 2012). In the English context this implies that Foundation Trusts should respond more to competition, since they have more discretion in managing surpluses. Brekke et al (2012) show that in the presence of non-monetary benefits of quality, profit constraints reduce the marginal profitability from an increase in quality so that the increase in quality resulting from greater competition will be smaller.

where the expressions are evaluated at equilibrium quality $q^e(n,\theta)$. Since (3) implies that $v^e_{qq} < 0$, the effects of n and θ depend on the numerators $v^e_{qn}, v^e_{q\theta}$.

If the price-cost margin is positive, and if more competing providers or more choice increase responsiveness of demand to quality ($D^e_{qn} > 0, D^e_{q\theta} > 0$), then they will tend to increase quality via the first term in the numerators in (5) and (6). If the marginal cost of treatment is increasing in volume ($C_{DD} > 0$) or the marginal cost of treatment is increasing in quality ($C_{Dq} > 0$), then the positive effects of n or θ on quality due to a higher demand responsiveness to quality can be dampened if they also lead to higher aggregate demand for each hospital since the cost of treating additional patients is increased (Brekke et al, 2011). Conversely if the marginal cost of treatment is decreasing in volume or in quality (due to for example to learning-by-doing effects), then the positive effects of n and θ on quality are reinforced. A larger number of providers implies that each hospital has a smaller share of total demand. But with more providers potential patients have less far to travel to a hospital, so that total demand could increase as more patients choose to be treated. Hence the sign of D^e_n is ambiguous. If giving patients greater choice from the set of providers leads some patients now decide to seek treatment in the NHS rather than going private or doing without care, then $D^e_\theta > 0$.[5]

It has been argued (Gaynor et al, 2013; Cooper et al, 2011) that the introduction of Choice policy in 2006 made the elective care market more competitive and that the effect on quality would be greater in areas where there were more competing providers. This argument is intuitively plausible, but it requires much stronger assumptions than are required for quality to be higher in markets with more competitive market structure (higher n).

In terms of the model we are interested in the second order cross partial derivative of equilibrium quality $q^e_{n\theta}(n,\theta)$. Differentiating (5) with respect to θ gives

$$q^e_{n\theta} = \frac{\partial}{\partial\theta}\left(\frac{-v^e_{qn}(q^e(n,\theta),n,\theta)}{v^e_{qq}(q^e(n,\theta),n,\theta)}\right) = -\frac{v^e_{qq}\left(v^e_{qnq}q^e_\theta + v^e_{qn\theta}\right) - v^e_{qn}\left(v^e_{qqq}q^e_\theta + v^e_{qq\theta}\right)}{\left(v^e_{qq}\right)^2}$$

$$= -\frac{v^e_{qn\theta} + v^e_{qqn}q^e_\theta + v^e_{qq\theta}q^e_n + v^e_{qqq}q^e_\theta q^e_n}{v^e_{qq}} \qquad (7)$$

Signing the second order comparative static effects of the Choice policy on the effect of market structure on quality ($q^e_{n\theta}$) requires assumptions about the *third* order cross partials of $v^e(q^e,n,\theta)$. Predictions about the first order comparative static effects of n and θ (q^e_n, q^e_θ), only required assumptions about the *second* order cross partials. Equation (7) shows that even if v^e_{qn} and $v^e_{q\theta}$ are both positive, which ensures that more competitive market structure and encouragement of choice both lead providers to increase quality ($q^e_n > 0$, $q^e_\theta > 0$), it is not in general true that encouragement of choice will have a bigger effect on quality in markets with more providers.

[5] Altruistic preferences alter and potentially reverse the positive effect of competition on quality. Re-writing (2) as $(p - C_D)D^e_q = C_q - B_q$, we see that sufficiently altruistic providers will be making a loss on the marginal patient. This will reduce their willingness to increase quality to attract yet more unprofitable patients (Brekke et al, 2011; Siciliani et al, 2013).

Consider a simple case in which benefit and demand are linear in quality ($B_{qq} = 0, D^e_{qq} = 0$) and cost is separable and linear in quantity ($C_{DD} = 0$, $C_{qD} = 0$). Then

$$v^e_{qq} = -C_{qq} < 0 \tag{8}$$

and since

$$v^e_{qn} = (p - C_D) D^e_{qn} > 0 \tag{9}$$

$$v^e_{q\theta} = (p - C_D) D^e_{q\theta} > 0 \tag{10}$$

more providers and more choice increase quality. Consider now the terms in the numerator of (7) which determine the sign of $q^e_{n\theta}$. The assumptions which gave clear and intuitive predictions about q^e_n and q^e_θ imply

$$v^e_{qn\theta} = (p - C_D) D^e_{qn\theta} \tag{11}$$

$$v_{qqn} = -2C_{Dq} D_{qn} = 0 \tag{12}$$

$$v^e_{qq\theta} = -2(C_{Dq} D_{q\theta} + D_q C_{Dqq} q_\theta) = 0 \tag{13}$$

$$v^e_{qqq} = -2D_q C_{Dqq} - C_{qqq} = -C_{qqq} \tag{14}$$

and so

$$q^e_{n\theta} = -\frac{1}{v^e_{qq}} [(p - C_D) D^e_{qn\theta} - C_{qqq} q^e_\theta q^e_n]. \tag{15}$$

Thus, even with a positive price-cost margin, the plausible assumption that choice policy amplifies the effect of market structure on demand responsiveness to quality ($D_{qn\theta} > 0$) is not sufficient for the choice policy to increase the effect of market structure on equilibrium quality, i.e. for $q^e_{n\theta} > 0$. If the convexity of the cost function in quality is increasing in quality ($C_{qqq} > 0$), then (15) is ambiguously signed.

This simple model suggests that apparently plausible assertions about the effect of the number of rivals on quality and about this effect changes when greater choice is introduced rest on implicit assumptions about cost and demand functions, some of which are difficult to verify. In general, having more rivals or more choice could increase or reduce quality, and having more choice could increase or reduce the impact of having more rivals. Empirical analysis is thus required to both investigate the signs of these effects and their magnitude.

3 Econometric Specification

We estimate separate models for each condition. Our first specification is the policy break specification

$$q_{iht} = \beta_0 + \sum_{t'\neq 2005/6} \beta_{t'} \mathbf{1}_{(t=t')} + \delta_0 M_{ht} + \gamma_1 M_{ht} \mathbf{1}_{(t\geq 2006/7)} + \varphi_1 X_{1iht} + \varphi_2 X_{2ht} + \mu_h + \varepsilon_{iht} \qquad (16)$$

where q_{iht} is equal to 1 if patient i treated in site h in year t (t = 2002/3,…,2010/11) died in hospital within 30 days of admissions and zero otherwise. M_{ht} is the market structure facing site h in year t. X_{1iht} is a vector of individual-specific covariates, X_{2ht} is a vector of hospital-specific time-varying covariates, μ_h is a time invariant hospital site effect and ε_{iht} is an error term. $\mathbf{1}_{(t=t')}$ is a year indicator variable equal to 1 in year t' and to 0 otherwise. $\mathbf{1}_{(t\geq 2006/7)}$ is the Choice policy indicator variable being equal to 0 in the four pre Choice years (2002/3 to 2005/6) and to 1 in the five post Choice years (2006/7 to 2010/11). The effect of market structure is constrained to be the same (δ_0) in all pre Choice years and in all post Choice years ($\delta_0 + \gamma_1$).

This specification is similar, but not equivalent, to the standard Difference-in-Difference (DID) specification which compares the changes in outcomes before and after treatment for the treated and untreated. Here the treatment is the introduction of Choice policy (as represented by the indicator $\mathbf{1}_{(t\geq 2006/7)}$) but there is no clear distinction between treatment and control groups, given that all hospitals in England were exposed to the policy change.[6]

Identification of γ_1 as the change in the effect of market structure due the introduction of Choice requires the assumption that market structure M_{ht} affects the economic incentive to provide quality q_{iht}. This assumption means that hospital were not equally affected by the policy change, so that the final effect of the Choice policy depended on the level of M_{ht}. A similar model has been used in Card (1992).[7]

We focus on two policy relevant questions: what is the effect of market structure on mortality (δ_0 and $\delta_0 + \gamma_1$) and did the introduction of Patient Choice in 2006 change the relationship between market structure and quality (γ_1)?

We estimate (16) as a linear probability panel model, with hospital site fixed effects, and standard errors which are robust to heteroscedasticity and to clustering of patients at hospital site level.[8] We have a rich set of patient variables X_{1iht} (see data section). The year effects will account for common

[6] If the market structure measure was binary (say "many" and "few" rivals) and if no hospital changed category (or if we define market structure as having many or few rivals in a particular year), then the specification would be identical to the standard DID:

$$q_{iht} = \beta_0 + \sum_{t'\neq 2005/6} \beta_{t'} \mathbf{1}_{(t=t')} + \delta_0 \mathbf{1}_{(f(\mathbf{M_{ht}})\geq f^o)} + \gamma_1 \mathbf{1}_{(f(\mathbf{M_{ht}})\geq f^o)} \mathbf{1}_{(t\geq 2006/7)} + \varphi_1 X_{1iht} + \varphi_2 X_{2ht} + \mu_h + \varepsilon_{iht}$$

where $\mathbf{1}_{(f(\mathbf{M_{ht}})\geq f^o)}$ is an indicator for provider h being in the "many" rivals group according some rule f.

[7] Card (1992) investigates the state by state effect of an increase in the Federal minimum wage on teenage employment, arguing that the effect would be greater in states with a higher proportion of the teenage workforce who were earning less than the Federal minimum in the previous period.

[8] We also estimated (16) with unconditional logit maximum likelihood with hospital fixed effects. Since the number of hospital site clusters is around 200 in each year, and each cluster includes at least 100 patients, the coefficients of interest on market structure are likely to be unbiased according to Monte Carlo simulations results by Katz (2001), Coupé (2005) and Greene (2004). The qualitative results were very similar to those from the linear probability model (see Appendix **Table A2**).

secular changes and the site fixed effects will account for unobserved site time-invariant heterogeneity. It is therefore reasonable to assume that the model will identify the effects of market structure pre Choice (δ_0) and post Choice ($\delta_0 + \gamma_1$) and hence the change in the effect due to Choice (γ_1). The model would also identify the change in the effect if the estimates of the pre and post Choice effects are biased to the same extent.

The policy break specification assumes that Choice policy is fully described by the indicator function $\mathbf{1}_{(t\geq 2006/7)}$, implying that the effect of Choice was the same in all post-Choice years and for all sites. Choice policy was extended in April 2008 when patients were given the right to choose any qualified provider. We investigate whether this extension of Choice amplified the effects of the introduction of Choice in 2006 by estimating

$$q_{iht} = \beta_0 + \sum\nolimits_{t'\neq 2005/6} \beta_{t'} \mathbf{1}_{(t=t')} + \delta_0 M_{ht} + \gamma_1 M_{ht} \mathbf{1}_{(t=2006/7,2007/8)} + \gamma_2 M_{ht} \mathbf{1}_{(t\geq 2009/10)} + \varphi_1 X_{1iht} + \varphi_2 X_{2ht} + \mu_h + \varepsilon_{iht} \quad (17)$$

We also have time and site varying measures of Choice policy C_{ht} (see Section 4.5) for a subset of years and estimate

$$q_{iht} = \beta_0 + \sum\nolimits_{t'} \beta_{t'} \mathbf{1}_{(t\neq 2006/7)} + \delta_0 M_{ht} + \omega_0 C_{ht} + \omega_1 \left[\left(C_{ht} - \bar{C} \right) \left(M_{ht} - \bar{M} \right) \right] + \varphi_1 X_{1iht} + \varphi_2 X_{2ht} + \mu_h + \varepsilon_{iht} \quad (18)$$

where $\bar{C}$ and $\bar{M}$ are the overall means of C_{ht} and M_{ht} and t = 2006/7,…,2010/11. This allows us to test both whether the amount of Choice (captured by C_{ht}) changed the effect of market structure ($q^e_{n\theta}$ in the theory model) and whether C_{ht} had a direct effect on mortality (q^e_n in the theory model).

The policy break specification imposes the constraint that the effects of market structure are the same in all pre Choice periods and all post Choice periods. This simplifies presentation of results and robustness tests (for example whether the effect of market structure is different for hospitals based in London), but it has the disadvantage that it could lead to misleading conclusions about the effect of Choice if there are underlying trends in the effects of market structure on mortality. For example, if there was a trend reduction in the effect of market structure over the whole period 2002/3 to 2010/11, then this could produce a significant estimated difference in the effect of market structure before and after Choice. However, this effect would not be due to Choice, but rather to fitting a step function to an underlying trend.

Our second main model is the *flexible* specification

$$q_{iht} = \beta_0 + \sum\nolimits_{t'\neq 2005/6} \beta_{t'} \mathbf{1}_{(t=t')} + \delta_0 M_{ht} + \sum\nolimits_{t'\neq 2005/6} \gamma_t M_{ht} \mathbf{1}_{(t=t')} + \sum\nolimits_{t'\neq 2005/6} \varphi_{1t} X_{1iht} \mathbf{1}_{(t=t')} + \sum\nolimits_{t'\neq 2005/6} \varphi_{2t} X_{2ht} \mathbf{1}_{(t=t')} + \mu_h + \varepsilon_{iht} \quad (19)$$

with time invariant site fixed effects. The specification allows the effect of market structure (δ_0 in 2005/6 and $\delta_0 + \gamma_t$ in other years) and of the covariates to vary across all years. It provides a more rigorous test for whether the introduction of Choice in 2006/7 altered the relationship between market structure and mortality risk. It controls for any underlying trends in the effect of market structure before and after the implementation of the Choice policy. A similar specification was used in Propper et al (2008) to investigate changes in the effect of market structure on AMI mortality in the first NHS internal market.

4 Data

4.1 Institutional background

The NHS provides universal access to healthcare, funded by taxation and free to patients at point of use. Geographically-defined local health authorities receive budgets from the Department of Health to purchase health care for their populations. Most NHS hospital care is provided by public hospitals, which are separate from local purchasing bodies. NHS hospitals are public bodies (Hospital Trusts) which are subject to tight financial and regulatory control. Some are Foundation Trusts which do not have to break even, have discretion in use of surpluses, and can borrow from the capital market. They are also less constrained in staff remuneration and can invest in buildings, and manage their own assets (Marini et al, 2007). Foundation Trusts may therefore respond more to competition. Foundation Trusts status was introduced in 2004 and by 2010 60% of NHS trusts were Foundation Trusts. About 20% of the NHS hospitals have Teaching status, undertaking additional activities including teaching and research, and treating more complex patients. From 2003 private sector providers have been able to enter the NHS market. By 2010/11 they treated (4%) of NHS elective patients (Hawkes, 2012).

4.2 Data sources

We examine the effects of market structure and Choice on quality of care provided by sites belonging to NHS Trusts for three categories of emergency patients. Our main data source is Hospital Episodes Statistics (HES) for financial years 2002/3 to 2010/11. HES has information on all admissions to NHS providers and all NHS-funded hospital admissions to private providers.[9] HES includes information on the hospital trust and the site within the trust at which care was provided, the ownership of the provider (public or private), and whether Foundation Trust (FT) status has been achieved.[10] Teaching Hospital status was retrieved from the NHS Patient Safety website.[11]

Each HES record is for a finished consultant episode (FCE) for a patient whilst under the care of a specific hospital consultant. We link FCEs for the same patient to form continuous inpatients spells (CIPS), which cover all FCEs within the same spell and include transfers between hospitals.

HES information on patients includes age, gender, the Lower Super Output Area (LSOA) of residence, dates of admission and discharge, discharge method (dead or alive), and detailed information on ICD10 diagnoses and treatments.[12] Information on deaths after discharge is held by the Office for National Statistics (ONS) and is linked to HES records.[13]

We measure straight line distances between hospital sites using TRUD data for postcodes and an ONS look up table between postcodes geographic coordinates. Straight line distances between patients and sites are measured from the centroid of the LSOA where the patient resides.

[9] HES distinguishes between two types of private (non-NHS) providers treating NHS patients. Independent Sector Treatment Centres (ISPCs), often co-located with NHS hospitals, specialise in common elective treatments such as hip replacement or cataract surgery. Independent Providers are generally larger and treat a wider range of patients, both NHS and private. The HES classification of the two types is poorly coded and so we categorise both as private.

[10] Information on the address of the trust and of the site is from TRUD (Technology Reference data Update Distribution) and linked to HES. TRUD is a service provided by NHS Information Centre (HSCIC).

[11] http://www.nrls.npsa.nhs.uk/resources/?entryid45=135255

[12] There are 32,482 Lower Super Output Areas (LSOAs) in England. They have a mean population of around 1600.

[13] http://www.hscic.gov.uk/article/2677/Linked-HES-ONS-mortality-data.

4.3 Quality

Most NHS hospitals treat both emergency and elective (non-emergency) patients. We follow the empirical literature on hospital competition and quality by measuring hospital quality for emergency patients. Using measures of the quality of elective care creates possible selection bias. Patients who are unobservably sicker pre-treatment are more likely to select hospitals they perceive as higher quality, thereby biasing measured quality downward. Emergency patients do not choose their provider and so emergency quality is not subject to selection bias. However, since hospitals can only compete for elective patients, the use of emergency quality measures is sensible only if emergency and elective quality are positively correlated. Such correlation may occur if quality in all departments is influenced by the overall managerial quality of the hospital (Bloom et al, 2013) or if investments in information systems or capital equipment, such as MRI scanners, raises quality across the hospital.[14]

We measure quality as mortality for AMI, hip fracture and stroke patients aged at least 35 with an emergency admission at an NHS hospital site with at least 100 admissions per year for their condition.[15] We focus on patients aged 35 to 74.[16] These patients have lower mortality rates than older patients but their risk of death is likely to be more responsive to interventions by hospitals.[17] Preventing premature deaths in people under 75 years is a domain of the NHS Outcomes Framework.

To reduce mis-coding we exclude patients with a length of stay of 2 days or less who were discharged alive. Our main patient level quality indicator is whether the patient died in hospital within 30 days of admission. We also use an indicator for whether the patient died inside or outside the hospital within 30 days of admission. We assign patients who were transferred to another site during their spell to the first site of their spell since patients are usually treated and stabilised in the Emergency Department of the first provider.

There were around 30,000 admissions aged 35-74 per year for AMI, 24,000 for stroke and 10,000 for hip fracture (see **Table 1**). The number of AMI and stroke admissions fell between 2002/3 and 2010/11, whilst hip fracture admissions increased. Average in-hospital 30-day mortality rates for this age group were 6% for AMI, 3% for hip fracture, and 16% for stroke. ONS 30-day mortality rates were higher (8%, 6% and 20% for AMI, hip fracture and stroke). In-hospital mortality rates for all three conditions declined between 2002/3 and 2010/11. The trends for in-hospital raw (unconditional) mortality rates are shown in **Figure 3** for patients aged 35-74 and in **Figure 4** for patients aged over 35.

[14] Gravelle et al (2014) report that 16 quality indicators for emergency and elective conditions and patient satisfaction are not highly correlated for English Trusts in 2009/10 and often not correlated at all.

[15] ICD10 codes: I21-I22 for AMI; S720-S721 for hip fracture; I60-I64, G46, I672, I698, R470 for stroke. NHS Community and Mental Health Trusts treat some AMI, stroke or hip-fracture emergency patients but are excluded because they do reach the volume threshold for our analysis.

[16] Very few AMI, hip fracture, or stroke patients are under 35.

[17] See the large literature on amenable mortality, stimulated by Rutstein (1976), and reviewed in Castelli and Nizalova (2011). Nolte and McKee (2012) limit their study population to individuals aged under 75 "to reflect uncertainty about the extent to which deaths at older ages can be prevented by health care and about the reliability of death certificates for older people with multiple disease processes."

Table 1. Descriptive statistics - patients 35 to 74 years old

	AMI sample				Hip Fracture sample				Stroke sample			
	mean	**sd**	**min**	**max**	**mean**	**sd**	**min**	**max**	**mean**	**sd**	**min**	**max**
Providers												
N rival sites - 30 km	12.15	15.04	0	76	13.63	16.80	0	76	14.40	17.51	0	76
N rival trusts - 30 km	5.61	6.78	0	28	6.16	7.41	0	28	6.55	7.72	0	28
1/predicted HHI 30km	2.69	1.35	1.09	8.76	2.81	1.45	1.09	9.47	2.87	1.47	1.09	8.83
N rival NHS sites - 30 km	11.34	14.45	0	66	12.62	16.08	0	66	13.43	16.81	0	66
N rival ISP sites - 30 km	0.81	1.58	0	12	10.01	1.79	0	12	0.97	1.79	0	12
N patients treated per year	229	106	1	624	70	28	1	177	157	64	1	359
NHS Trust[1]	0.64	0.48	0	1	0.60	0.49	0	1	0.60	0.49	0	1
Teaching Trust[1]	0.16	0.36	0	1	0.18	0.38	0	1	0.20	0.40	0	1
Foundation Trust[1]	0.25	0.43	0	1	0.28	0.45	0	1	0.26	0.44	0	1
Patients												
In-hospital 30-day mortality	0.06	0.24	0	1	0.03	0.17	0	1	0.16	0.37	0	1
ONS 30-day mortality	0.08	0.27	0	1	0.06	0.24	0	1	0.20	0.40	0	1
Patient age	61.18	9.38	35	74	64.84	8.74	35	74	62.74	9.52	35	74
Female Patient	0.26	0.44	0	1	0.63	0.48	0	1	0.42	0.49	0	1
N diagnoses	4.66	2.67	1	20	5.01	2.72	1	20	4.82	2.82	1	20
Charlson index	0.69	1.10	0	14	0.75	1.26	0	13	0.81	1.28	0	13
Distance to provider	12.86	30.65	0	607	13.54	32.36	0	572	12.06	27.32	0	610
IMD income	0.16	0.12	0	0.96	0.16	0.12	0	0.96	0.17	0.13	0	0.96
IMD environment	21.39	16.59	0.08	94	22.02	16.72	0.08	94	22.67	16.98	0.13	94
Incapacity claims	0.0387	0.0252	0	0.2519	0.0388	0.0263	0	0.2519	0.0391	0.0255	0	0.2519
Disability claims	0.0579	0.0305	0	0.2491	0.0571	0.0313	0	0.2491	0.0574	0.0305	0	0.2491

Notes. Number of sites with at least 100 patients: AMI 238; Hip Fracture; 213; Stroke 236. Number of patients aged 35 to 74 years: 288,287 (AMI); 91,005 (Hip Fracture); 214,103 (Stroke). All years 2002/3 – 2010/11. [1] Indicator = 1/0 if site belongs/does not belong to NHS Trust with this characteristic. ISP = Independent Sector Provider.

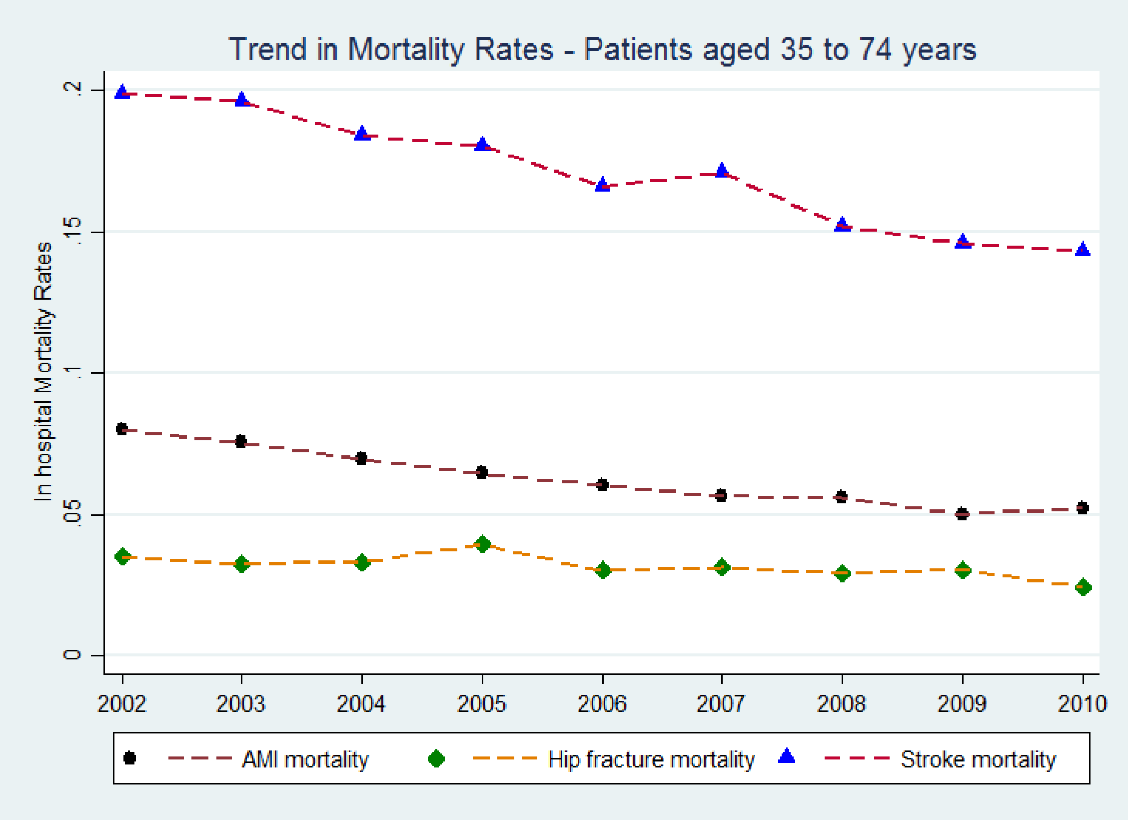

Figure 3. In hospital mortality rates, patients aged 35-74 years

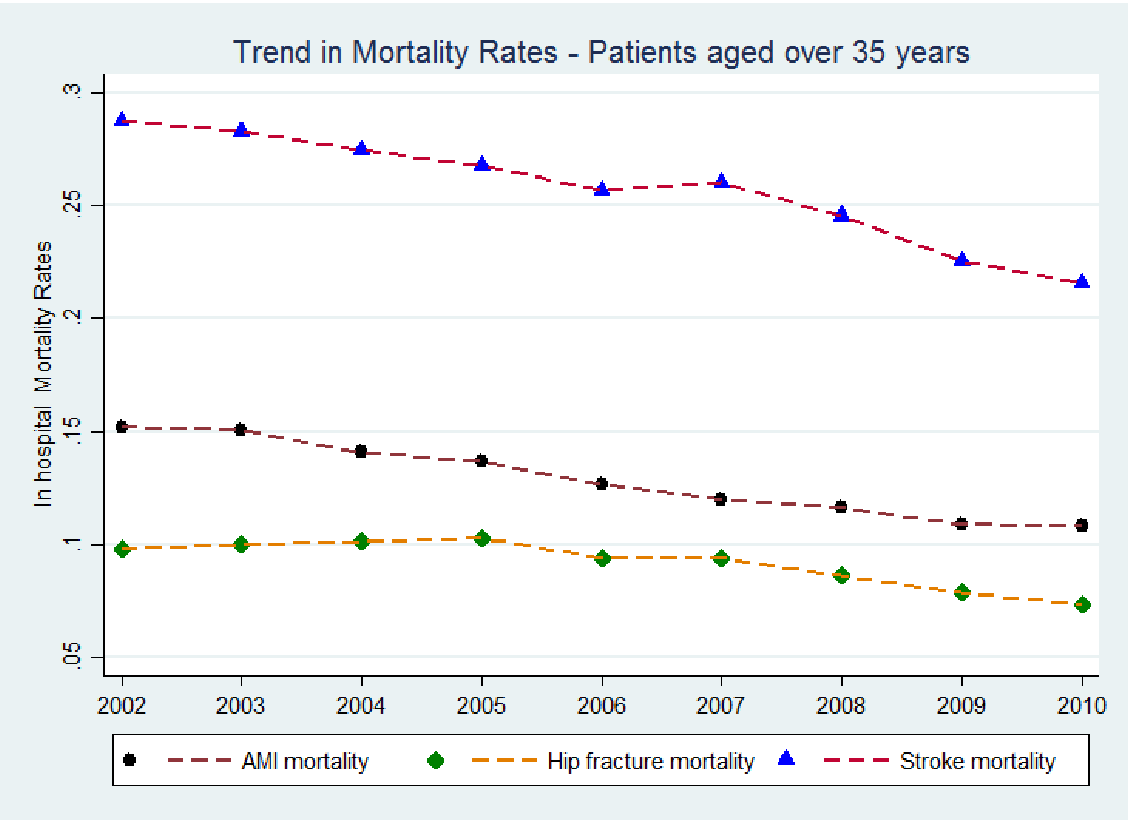

Figure 4. In hospital mortality rates, patients aged over 35 years

Table 2 reports the correlations amongst risk adjusted mortality for the three conditions.[18] The correlations at Trust and at site level over the whole sample period 2002/3-2010/11 are positive and significant, but below 10% in magnitude. This suggests that the effects of market structure and Choice on mortality may differ across the three conditions.

Table 2. Correlation of risk adjusted mortality across sites and trusts 2002/3-2010/11

	Trust level correlation	N trust observations	Site level correlations	N sites observations
AMI & hip fracture	0.0959***	1284	0.0700***	1479
AMI & stroke	0.0599**	1298	0.0769***	1569
Hip fracture & stroke	0.0481*	1312	0.0483*	1535

Notes. Correlations for Trusts (sites) are over all Trust (site) by year observations where Trust (site) had at least 100 cases for both conditions. Adjusted mortality for Trusts (sites) is the ratio of actual to expected mortality, where expected mortality is predicted from an individual level logit model with age, gender, Charlson Index co-morbidities, number of diagnosis, seasonality factors (day of week, admission month, admission year).

4.4 Market structure

NHS Hospital Trusts can have more than one site providing care for AMI, hip fracture and stroke patients. In our sample there are 238 sites and 165 Trusts for AMI patients, 213 sites and 160 Trusts for hip fracture patients, and 236 sites and 163 Trusts for stroke patients. In most of our analysis we examine the effect on competition facing the site on site quality, but we also test whether competition measured at Trust level affects site quality. We measure market structure in two ways: the number of rival providers within a specified distance and the predicted equivalent number of providers.

Count of rival providers. Since many providers have several sites, we count for each year for each hospital site providing care for AMI, hip fracture, or stroke patients, the number of rival organisations (NHS Trusts or chains of private providers) with at least one site within 30km and with at least 100 HES elective patients in that year.[19, 20]

Predicted equivalent number of sites. The Herfindahl-Hirschman Index (HHI) for a market is the sum of the square of provider market shares. For a market with N firms it varies between 1 (monopoly) and 1/N (when all firms have the same share). The reciprocal of the HHI is the equivalent number of equal sized firms which would yield the same HHI. Given the spatial dispersion of patients and providers, patients in different locations face different choice sets of providers and providers face different sets of potential patients and rivals. We follow Kessler and McClellan (2000) and subsequent papers by using a provider level measure of competition derived from the HHI but adapted to spatially dispersed markets.

The HHI for patients in LSOA j is the sum of the squared shares of their elective admissions at the providers they use. It is a measure of the amount of choice they have amongst elective care providers. We compute the HHI for site h as a weighted average of the HHIs for patients in LSOAs within k km of site h:

[18] Risk adjusted mortality is the ratio of actual to predicted deaths. Predicted deaths were computed from logit models with explanatories including age, gender, number of diagnoses, Charlson index, the day of the week and month of year admitted, year of admission, IMD income deprivation. In the models testing for effects of market structure and Choice we use the same dependent variable but add measures of market structure, Choice, site fixed effects, and year dummies.

[19] We also constructed counts of rivals within radii of 20, 40 and 50 km.

[20] We consider only *booked* and *waiting list* patients. The third category of *planned* electives is not included as their admissions are part of a planned course of treatment (for example, patients on dialysis, or cancer patients on a course of chemotherapy).

$$HHI_h^k = \sum_j s_{hj}^k \times HHI_j^k = \sum_j s_{hj}^k \times \left[\sum_{h'} \left(s_{jh'}^k \right)^2 \right] \qquad (20)$$

where $j=1,...,J$ indexes English LSOAs, s_{jh}^k is the proportion of patients from LSOA j treated at a site h within k km of their LSOA, s_{hj}^k is the proportion of site h patients from LSOA j within k km of site h.

Since quality may affect patients' choice of provider for elective care, computing HHI_h^k from observed use of providers may mean that any correlation between provider quality and HHI_h^k is due to reverse causation from quality to market structure. To remove this source of bias we compute *predicted HHIs* derived from models of patient choice of provider (NHS or private) for elective care in which choice is not allowed to depend on quality.

We estimate a discrete choice model for elective care for each year. Given the large number of elective patients, we estimate Poisson choice models with the number of patients n_{jht} from LSOA j choosing provider h in year t having conditional mean

$$\mathrm{E}\left(n_{jht} \mid \xi_j, d_{jh}, X_{ht}\right) = \exp\left\{\xi_{jt} + \lambda_{1t} d_{jh} + \lambda_{2t} d_{jh}^2 + X_{ht}\lambda_t + d_{jh} X_{ht} \lambda_{1t}^X + d_{jh}^2 X_{ht} \lambda_{2t}^X \right\} \qquad (21)$$

where d_{jh} is the distance from the centroid of LSOA j to hospital site h and X_{ht} is a vector of dummies for hospital characteristics (NHS or private, belonging to a Foundation Trust, belonging to a teaching Trust, located in London). The model yields the same estimated coefficients as the conditional logit model (Guimaraes et al, 2003; Guimaraes, 2004), but it is faster to estimate.[21]

The predicted $\hat{n}_{jht}$ from (21) are used to compute the predicted shares $\hat{s}_{jht}^k = \hat{n}_{jht} / \sum_h \hat{n}_{jht}$ and $\hat{s}_{hjt}^k = \hat{n}_{jht} / \sum_j \hat{n}_{jht}$, which are then used in (20), instead of the actual flows, to compute the predicted HHI indices at given radii.

Since the reciprocal of the HHI is the number of equal sized firms which would yield the HHI, we use the reciprocal of the *predicted* HHI as the measure of competition facing a provider. The models are estimated for choice of elective provider within 30km of the LSOA centroid, to preserve consistency with the count of rival providers within 30 km.[22] Around 75% of booked or waiting list elective patients use a provider within 30km. We also computed market structure measures based on models for choice of provider within 100km (around 90% of booked or elective waiting list patients use a provider within 100km).

Our analysis differs from Gaynor et al (2013) in that we examine choices by patients located in 32,482 LSOAs rather than 6781 Medium Super Output Areas. It also differs from Cooper et al (2011) in that we use choices of provider for *all* types of elective care, rather than aggregating results from separate choice models for five high volume procedures.[23]

[21] We also estimated patient choice models including patient characteristics. The results were very similar, in terms of predicted patient flows, to those from a model with no patient characteristics apart from distance to provider.
[22] **Appendix Table D1** provides the estimates of the Poisson choice models for elective secondary care within 30 km from patients' LSOA of residence.
[23] Cooper et al (2011) use general practices rather than LSOAs to compute HHIs. Having computed HHI_h they then compute a HHI for each general practice as the weighted average of the HHI_h where the weights are the predicted share of practice patients at each provider h. Thus their measure of market structure varies with the practice of the patient, not with the hospital they were treated in. This has the peculiar implication that two patients who are treated by the same provider, and are identical except that they are registered with different practices, have different predicted mortality.

Table 3. Correlation among competition measures (all years: 2002-2010)

	1/(actual HHI 30km)	1/(predicted HHI 30km)	1/(actual HHI 100km)	1/(predicted HHI 100km)	N rival sites 30km	N rival trusts 30km	Average N rival sites 30km
1/(actual HHI 30km)	1						
1/(predicted HHI 30km)	0.7996	1					
1/(actual HHI 100km)	0.9092	0.6291	1				
1/(predicted HHI 100km)	0.816	0.9833	0.6547	1			
N rival trusts 30km	0.6944	0.7936	0.5513	0.8412	1		
N rival trusts 30km	0.6876	0.8109	0.5338	0.8522	0.9756	1	
Average N rival sites 30km	0.6704	0.7604	0.5364	0.8106	0.9506	0.9268	1

Notes. Predicted HHIs are computed from a Poisson choice model using patient-provider distances and and hospital characteristics except quality. All correlations significant at 99% confidence level. Average number of rival sites computed as the yearly average of the number of sites belonging to a same trust.

Our two main competition measures, the predicted equivalent number of equally-sized sites (1/predicted HHI 30km) and the count of number of rival sites (or trusts) within 30km of a site are highly correlated (0.79). The number of rival sites is very highly correlated with the number of rival trusts (0.98; see **Table 3**). **Figures 5** and **6** map our two measures of market structure (measured by the number of rivals and the inverse predicted Herfindhal index) at the beginning (2002/03) and end (2010/11) of our sample. Unsurprisingly there is greater competition in large urban conurbations such as London, Birmingham, Manchester, Newcastle and Bristol. Both measures of the competitiveness of the market structure increased over the period: from 12.24 to 18.1 rival sites within 30km faced by a site and from 2.64 to 3.65 for the predicted equivalent number within 30km.

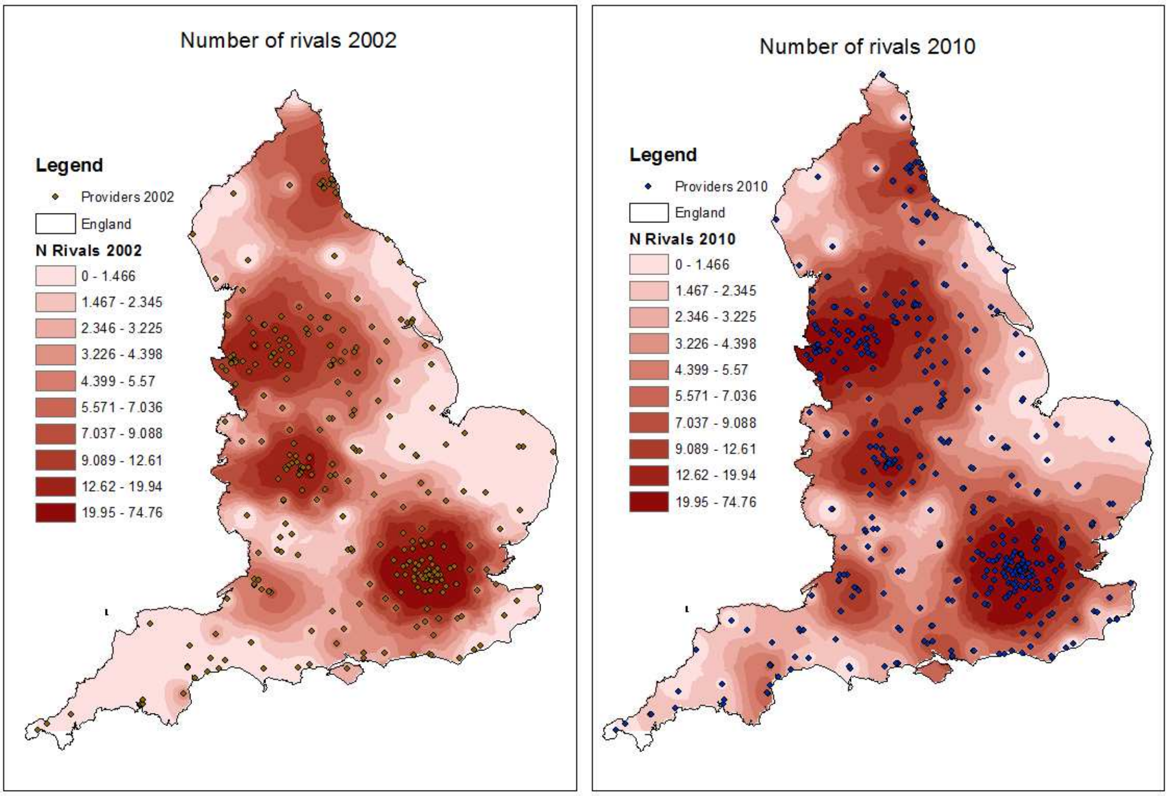

Figure 5. Number of rival sites within 30km in 2002/03, 2010/11

The inverse predicted HHI appears conceptually to be a better measure of market structure. The count of rivals assumes that having an additional rival 1km away will have the same effect as having a rival 30km away. Nor does it take account of whether the additional rival is large or small. This seems intuitively implausible. The inverse predicted HHI is based on patient flows predicted from a model of patient choice of provider in which providers further away from patients attract fewer patients. Thus it takes account of the size and location of possible rivals. But the predicted equivalent number of rivals has a much smaller coefficient of variation (0.50) than the count of rivals (1.24). Possibly because of this, models with the simple count of rivals have slightly better overall goodness of fit for AMI and hip fracture and have more of the estimated effects of market structure being statistically significant.

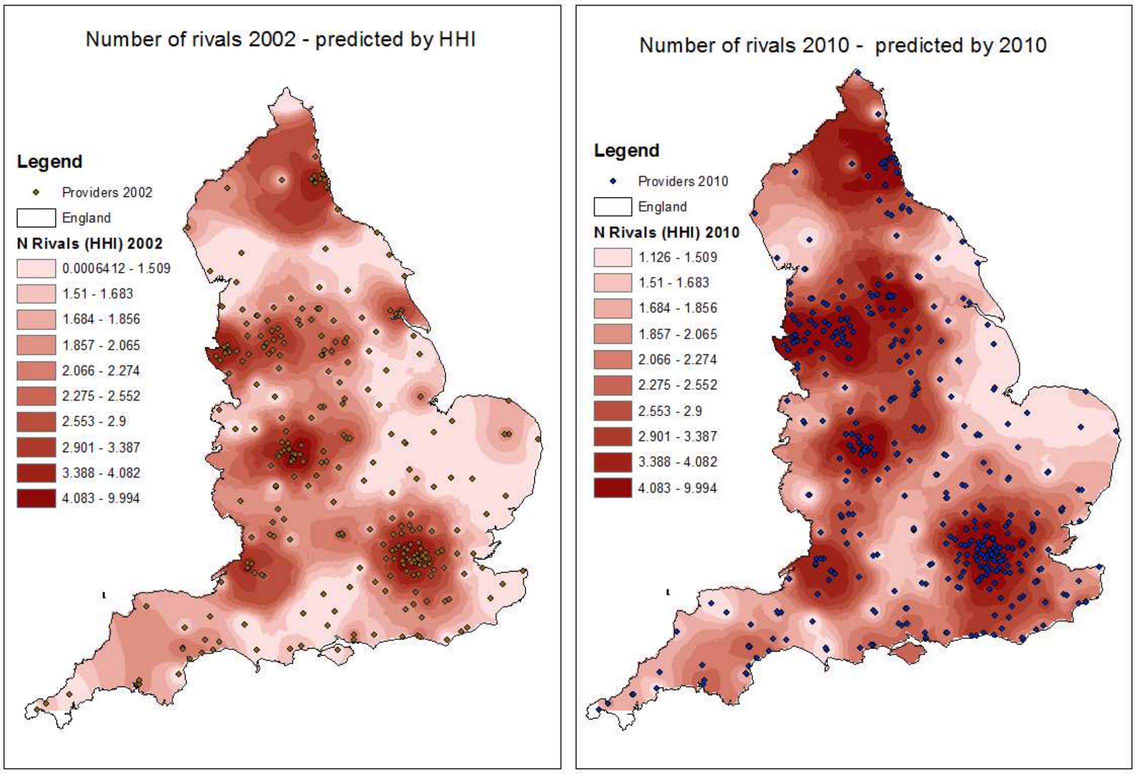

Figure 6. Equivalent predicted number of rival sites within 30km in 2002/03, 2010/11

4.5 Measures of choice policy

In most models we assume, in common with Cooper et al (2011) and Gaynor et al (2013), that Choice policy affected all providers immediately from its introduction in 2006. Thus we distinguish the pre and post Choice policy periods by a dummy variable taking the value 0 for years up and including 2006/7 and the value 1 from 2006/7 onwards.

We also use measures of Choice policy which vary over time and across providers. National Patient Choice Surveys were conducted between May/June 2006 and February 2010. The surveys provide information on the proportion of patients in each of 151 PCTs reporting that they were offered a choice of provider by their GP and on the proportion reporting that they were aware that they had a choice of provider. We assign these variables to sites providing AMI, hip fracture and stroke by the PCT in which they were located. We then estimate specification (18) to test whether the effect of market structure on quality is stronger for providers where a higher proportion of patients report being offered a choice or being aware that they had a choice.

4.6 Patient covariates

We have a very detailed set of patient level covariates available from HES: age in years, age in ten year bands, gender, number of diagnoses, Charlson index, source of admission (home, nursing home, temporary location), type of stroke (haemorragic, infarction, occlusion, unspecified, and other), type of hip fracture (pertrochanteric, subtrochanteric, unspecified), day of the week and month of year admitted. We also attribute to each patient the IMD income deprivation, IMD environment deprivation, incapacity benefit claims rate and disability claims rate of the patient's LSOA of residence. Finally, we also have a straight line measure of the distance from their LSOA centroid to the treatment site.

5 Results

5.1 Policy Break specification

In this section we report the results from the Policy Break specification where models contain the full set of patient and provider covariates, site fixed effects and year effects. The year and covariate effects are very similar across models and are therefore omitted from the tables (the full results are available in **Appendix Table A1**).

5.1.1 Baseline model

Table 4 reports results from our baseline policy break specification (16) in which we interact a measure of market structure with a policy break indicator taking the value of 1 from 2006/7 onwards. Before the introduction of Choice policy in 2005/6 AMI and hip fracture mortality was higher in providers in more competitive markets ($\delta_0 > 0$), though whether the effect was statistically significant for AMI even at 10% depends on the measure of market structure. The absolute magnitude of the effect of market structure is larger for the reciprocal of the predicted HHI than for the number of rivals count, in part because the mean of the number of rivals is over four times as large as the mean of 1/pHHI. After the introduction of Choice the detrimental marginal effect of competition on mortality was reduced for AMI and hip fracture ($\delta_0 + \gamma_1 < \delta_0$). Post-Choice, the detrimental effect of more rivals was positive and significant at 5% only for hip fracture when market structure was measured by the number of rival sites. The change in the effect of market structure post Choice (γ_1) was significant for AMI and for hip fracture for both measures of market structure.

Table 4. Effect of market structure on mortality pre and post Choice

	AMI		Hip-fracture		Stroke	
	(1)	(2)	(3)	(4)	(5)	(6)
Market structure measure:	Equivalent N rival sites 30km	N. Rival sites 30km	Equivalent N rival sites 30km	N. Rival sites 30km	Equivalent N rival sites 30km	N. Rival sites 30km
Rivals pre Choice (δ_0)	0.0016	0.0007*	0.0048**	0.0010***	0.0044	0.0002
	(0.80)	(1.78)	(2.29)	(3.24)	(1.22)	(0.46)
PolBk*Rivals (γ_1)	-0.0025**	-0.0003**	-0.0025**	-0.0003***	0.0012	-0.0000
	(-2.21)	(-2.43)	(-2.39)	(-3.25)	(0.73)	(-0.32)
Rivals post Choice ($\delta_0+\gamma_1$)	-0.001	0.0004	0.0024	0.0007***	0.0056*	0.0002
	(-0.65)	(1.18)	(1.43)	(2.75)	(1.85)	(0.43)
F-stat	93.74	95.14	39.80	40.05	141.73	141.56
Adjusted R^2	0.0405	0.0405	0.0472	0.0473	0.0888	0.0887
Patients	288287	288287	91005	91005	214103	214103
Sites	238	238	213	213	236	236

Notes. Dependent variable: patient aged 35-74 died in hospital within 30 days of admission. Period: 2002/3-2010/11 (financial years). Market structure measured at site level. Equivalent N rival sites = 1/(predicted HHI). PolBk: indicator for 2006/7 onwards. All models include site fixed effects, patient and hospital covariates. t-statistics in parentheses; p<0.1, ** p<0.05, *** p<0.01

For stroke, there was a positive but insignificant effect of market structure on mortality before Choice. After Choice, there was a small and insignificant increase in the positive effect of market structure and the effect was significant only with one of the market structure measures and then only at the 10% level.

The estimates in Table 4 suggest that the post Choice change in the effect of market structure for a provider with the average number of post Choice equivalent rivals (($\gamma_1 M_1$ in Figures 1 and 2) reduced the probability of death post Choice for AMI patients by 0.73 percentage points [95% CI: -1.38, -0.08].[24] Thus the mean probability of death in the post-policy period fell from 5.35% to 4.62% for a hospital facing the average number of competitors. For hip fracture patients the reduction was 0.74 percentage points [95% CI: -1.34, -0.13] compared with the mean probability post Choice of 2.74%. Applied to the average annual number of patients in the post Choice period these mortality risk reductions suggest that the change in the effect of market structure reduced the annual number of AMI deaths by 208 [95% CI: -392, -23] and hip fracture deaths by 77 [95% CI: -140, -14].[25] The effect of the change in the policy on probability of death for stroke patients is insignificant.

5.1.2 30-day mortality in or outside hospital

Table 5 has results from the baseline specification but with mortality defined as death inside or outside hospital within 30 days of admission. The pattern of results is similar to those from models using 30 day in-hospital mortality. The effects of the number of rivals on mortality are positive pre and post Choice, though significant at 5% only for hip fracture pre Choice using the equivalent number of rivals. There is a statistically significant reduction in the detrimental effect of the number of rivals post Choice for AMI and hip fracture, though only at 10% for AMI with the simple count of rivals.

Table 5. Effect of market structure on 30-days mortality in or outside hospital (ONS)

	AMI		Hip-fracture		Stroke	
	(1)	(2)	(3)	(4)	(5)	(6)
Market structure measure:	Equivalent N rival sites 30km	N. Rival sites 30km	Equivalent N rival sites 30km	Equivalent N rival sites 30km	N. Rival sites 30km	Equivalent N rival sites 30km
Rivals pre Choice (δ_0)	0.0026	0.0004	0.0067**	0.0007	0.0045	0.0003
	(1.21)	(1.10)	(2.01)	(1.55)	(1.16)	(0.49)
PolBk*Rivals (γ_1)	-0.0026**	-0.0002*	-0.0055***	-0.0004***	0.0010	-0.0000
	(-2.26)	(-1.89)	(-3.71)	(-3.09)	(0.57)	(-0.31)
Rivals post Choice (δ_0+γ_1)	0.000	0.0002	0.0012	0.0003	0.0055*	0.0002
	(0.00)	(0.61)	(0.45)	(0.76)	(1.67)	(0.47)
F-stat	129.22	129.26	78.81	77.89	174.43	177.15
Adjusted R^2	0.0561	0.0561	0.0974	0.0973	0.0833	0.0833
Patients	288287	288287	91005	91005	214103	214103
Sites	238	238	213	213	236	236

Notes. Dependent variable: patient aged 35-74 died in hospital or outside hospital within 30 days of admission. Period: 2002/3-2010/11 (financial years). PolBk: indicator for 2006/7 onwards. Equivalent N rival sites = 1/(predicted HHI). Otherwise same specification as models in Table 3. t-statistics in parentheses; p<0.1, ** p<0.05, *** p<0.01

5.1.3 Age specific mortality

In **Table 6** we report results from policy break models estimated separately for different age bands. The effects of market structure are clearly sensitive to the age band. For AMI, the effect of market structure is statistically significant at 5% (and deleterious) only for the 35-44 age group. The deleterious effect is smaller post Choice for all age bands up to 94 but the reduction is significant only for those aged 65-74 and 85-94. When all patients aged 35 and over are included and the effect

[24] This is computed by multiplying γ_1= - 0.002536 with average market structure in the post-policy period M_1 = 2.8749.
[25] All computations based on regressions results and statistics for the treated patients aged 35 to 74 years old.

of market structure is constrained to be the same for all age groups, market structure has no significant effect pre or post Choice and the change in the effect is not significant.

Table 6. Effect of market structure and Choice on mortality by age band

AMI	(1) 35-44	(2) 45-54	(3) 55-64	(4) 65-74	(5) 75-84	(6) 85-94	(7) 95+	(8) 35+
Rivals pre Choice (δ_0)	0.0083**	0.0011	-0.0004	0.0020	0.0012	0.0038	-0.0341	0.0012
	(2.15)	(0.43)	(-0.14)	(0.51)	(0.23)	(0.45)	(-1.48)	(0.43)
PolBk*Rivals (γ_1)	-0.0009	-0.0021	-0.0014	-0.0043**	-0.0008	-0.0068**	0.0096	-0.0019
	(-0.49)	(-1.64)	(-0.91)	(-2.09)	(-0.36)	(-1.98)	(0.88)	(-1.34)
Rivals post Choice (δ_0+γ_1)	0.0074**	-0.001	-0.0017	-0.0023	0.0004	-0.003	-0.0245	-0.0006
	(2.24)	(-0.53)	(-0.82)	(-0.76)	(0.1)	(-0.43)	(-1.3)	(-0.28)
F-stat	4.22	14.01	27.70	47.56	72.83	29.59	6.37	259.20
Adjusted R^2	0.0150	0.0209	0.0232	0.0295	0.0251	0.0223	0.0335	0.0762
Patients	17350	52951	93207	124779	153650	82656	6618	531211
Sites	237	238	238	238	238	238	233	238
Hip Fracture	(1) 35-44	(2) 45-54	(3) 55-64	(4) 65-74	(5) 75-84	(6) 85-94	(7) 95+	(8) 35+
Rivals pre Choice (δ_0)	0.0070	-0.0006	0.0038	0.0059*	0.0056**	0.0021	0.0214**	0.0048**
	(1.22)	(-0.12)	(1.29)	(1.91)	(2.29)	(0.55)	(2.34)	(2.08)
PolBk*Rivals (γ_1)	-0.0032	-0.0022	0.0001	-0.0037**	-0.0040***	-0.0009	0.0001	-0.0020*
	(-1.34)	(-1.00)	(0.04)	(-2.52)	(-3.26)	(-0.54)	(0.03)	(-1.96)
Rivals post Choice (δ_0+γ_1)	0.0038	-0.0029	0.0039	0.0022	0.0017	0.0012	0.0215***	0.0028
	(0.89)	(-0.74)	(1.59)	(0.92)	(0.86)	(0.39)	(2.9)	(1.48)
F-stat	0.70	2.98	11.07	31.49	93.34	117.98	3.08	197.23
Adjusted R^2	0.0307	0.0602	0.0468	0.0444	0.0537	0.0608	0.0569	0.0706
Patients	3612	8376	22558	56459	172025	173047	23595	459672
Sites	211	213	213	213	214	213	213	214
Stroke	(1) 35-44	(2) 45-54	(3) 55-64	(4) 65-74	(5) 75-84	(6) 85-94	(7) 95+	(8) 35+
Rivals pre Choice (δ_0)	0.0115	0.0148**	-0.0011	0.0036	0.0089*	0.0072	0.0106	0.0069*
	(1.18)	(2.19)	(-0.26)	(0.69)	(1.90)	(1.04)	(0.64)	(1.88)
PolBk*Rivals (γ_1)	-0.0038	-0.0037	0.0013	0.0029	0.0037*	0.0041	0.0146*	0.0029
	(-0.81)	(-1.21)	(0.63)	(1.23)	(1.75)	(1.24)	(1.80)	(1.64)
Rivals post Choice (δ_0+γ_1)	0.0077	0.0111*	0.0002	0.0066	0.0126***	0.0113**	0.0252*	0.0099***
	(1.01)	(1.93)	(0.05)	(1.48)	(2.97)	(1.99)	(1.75)	(2.99)
F-stat	28.40	44.75	69.41	115.86	175.55	162.75	29.04	417.92
Adjusted R^2	0.0764	0.1010	0.0932	0.0861	0.0890	0.0884	0.0849	0.1127
Patients	12876	29610	58993	112624	195644	128295	12160	550202
Sites	234	236	236	236	236	236	235	236

Notes. Dependent variable: patient died in hospital within 30 days of admission. Policy break: indicator for 2006/7 onwards. Market structure: Equivalent N rival sites = 1/(predicted HHI). Years: 2002/3 to 20010/11. All models contain year effects, site fixed effects, patient and hospital covariates. t-statistics in parentheses; p<0.1, ** p<0.05, *** p<0.01.

For hip fracture, results again vary across age bands. More rivals pre Choice increases mortality significantly (at 5%) for two age bands and for all patients over 35. After the introduction of Choice, the deleterious effect of market structure on mortality decreased significantly for patients aged 65-74 and 75-84. The overall effect of market structure on hip-fracture patients over 35 is positive and significant before Choice policy, and still positive but not significant after 2006.

Having more rivals increases stroke mortality pre Choice for all age bands but the effect is significant at 5% only for those aged 45-54. This detrimental effect is reinforced in the post Choice period for older patients and more rivals increases mortality significantly all patients 35+ and for two of the older age bands (75-84 and 85-94).

5.1.4 Alternative measures of Choice policy

Table 7 is similar to our baseline specifications of Choice policy in assuming that Choice policies had immediate effects, but it distinguishes between the two phases of Choice policy: 2006/7 and 2007/8 when patients had to be offered a choice of at least 4 providers and 2008/9 onwards when they had the right to choose any qualified provider. Before the introduction of Choice providers in more competitive areas had significantly higher hip fracture mortality (δ_0 = 0.0051**). The first and second phases of Choice policy had similar reductions in the deleterious effect of competition on mortality for AMI (γ_1 = –0.0026**, γ_2 = –0.0024*). This was also the case for hip fracture, though the change was significant only during the second phase of Choice policy (γ_2 = –0.0029**). For stroke, the only (weakly) significant effect of market structure on mortality is in the second phase of the Choice policy. Overall, having a choice of any qualified provider had similar effects to having a choice of at least four.

Table 7. Effect of market structure and introduction and extension of Choice on mortality

	AMI (1)	Hip Fracture (2)	Stroke (3)
Rivals pre Choice (δ_0)	0.0015	0.0051**	0.0040
	(0.77)	(2.39)	(1.10)
Rivals*Choice Introduction (γ_1)	-0.0026**	-0.0019	0.0004
	(-2.06)	(-1.59)	(0.22)
Rivals*Choice Extension (γ_2)	-0.0024*	-0.0029**	0.0019
	(-1.87)	(-2.57)	(1.00)
Rivals post Choice Introduction (δ_0+γ_1)	-0.0011	0.0032*	0.0043
	(-0.64)	(1.7)	(1.37)
Rivals post Choice Extension (δ_0+γ_2)	-0.0009	0.0022	0.0059*
	(-0.6)	(1.34)	(1.93)
Rivals*Choice Extension – Rivals*Choice Intro (γ_2-γ_1)	0.0002	-0.0009	0.0015
	(0.16)	(-0.92)	(1.11)
F-stat	93.23	38.95	139.45
Adjusted R^2	0.0405	0.0472	0.0888
Patients	288287	91005	214103
Sites	238	213	236

Notes. Dependent variable: patient aged 35-74 died in hospital within 30 days of admission. Specification is model (16). Market structure: Equivalent N rival sites = 1/(predicted HHI). Choice Introduction: indicator for financial years 2006/7, 2007/8; Choice Extension: indicator for financial years 2008/9 onwards. Years: 2002/3 to 20010/11. All models contain year dummies, site fixed effects, patient and hospital covariates. Same number of observations, clusters as Table 3. t-statistics in parentheses; p<0.1, ** p<0.05, *** p<0.01.

In **Table 8** we report results from models for the period 2006/7 to 2009/10 in which we measure exposure to Choice as the proportions of patients reporting that they were offered a choice of provider or aware of their right to have a choice of provider. These measures of choice vary both across providers and over time, compared to our other specifications which assume that the impact of Choice was immediate and the same for all providers. Providers facing more rivals had lower AMI mortality and higher hip fracture and stroke mortality throughout the period, though the effect is statistically insignificant. The effect of market structure did not vary with either measure of the amount of choice for patients of different providers (ω_1 is statistically insignificant in all cases). However, there does appear to be a direct impact of Choice: when a higher proportion of elective patients have been offered choice mortality for hip-fracture patients reduces ($\omega_0 = -0.0348^{**}$).

Table 8. Effect of market structure and proportion of patients reporting offered or aware of choice on mortality 2006/7-2009/10

	AMI (1)	Hip Fracture (2)	Stroke (3)	AMI (4)	Hip Fracture (5)	Stroke (6)
Choice measure:		**Choice Awareness**			**Offered Choice**	
Rivals (δ_0)	-0.0042	0.0016	0.0044	-0.0043	0.0026	0.0043
	(-1.52)	(0.44)	(0.93)	(-1.56)	(0.77)	(0.88)
Choice (ω_0)	-0.0252	-0.0123	-0.0412	-0.0111	-0.0348**	0.0024
	(-0.92)	(-0.42)	(-1.13)	(-0.69)	(-2.33)	(0.09)
Rivals*Choice (ω_1)	-0.0003	0.0021	0.0103	0.0050	0.0061	0.0124
	(-0.04)	(0.29)	(1.09)	(0.56)	(0.75)	(0.90)
F-stat	52.29	21.58	78.73	52.81	21.28	79.27
Adjusted R^2	0.0340	0.0466	0.0848	0.0340	0.0468	0.0847
Patients	117326	41132	90538	117326	41132	90538
Sites	199	183	201	199	183	201

Notes. Dependent variable: patient aged 35-74 died in hospital within 30 days of admission. Specification is model (17). Market structure: Equivalent N rival sites = 1/(predicted HHI). Choice proportions: proportions of patients reporting they were aware of their right be offered a choice of provider or were offered a choice. Interaction variable is product of demeaned market structure and demeaned choice proportion. All models contain year dummies, site fixed effects, patient and hospital covariates. t-statistics in parentheses; p<0.1, ** p<0.05, *** p<0.01.

5.1.5 Hospital characteristics

The baseline model contains hospital characteristics as covariates. In **Table 9** we report results from specified models where we also allow the effects of market structure to vary by whether the site belongs to a Foundation Trust, a Teaching Trust, or is in London.

For sites which were not part of an FT, having more rivals increased mortality for hip fracture pre and post Choice and had positive but statistically insignificant effects for AMI and stroke. FTs with more rivals had higher mortality pre and post Choice for stroke but market structure had no effect for FTs pre or post Choice for AMI and hip fracture.

Pre Choice the detrimental effect of rivals was smaller and insignificant for sites in Teaching Trusts for hip fracture. For stroke the deleterious effect of rivals was significant larger and significant for Teaching Trusts pre and post Choice.

The effects of market structure do not vary with whether a site is in London.

Table 9. Effect of market structure, Choice, and Trust type (Foundation Trust, Teaching Trust, London location) on mortality.

Foundation Trusts sensitivity	AMI (1)	Hip Fracture (2)	Stroke (3)
Rivals pre Ch. (δ0)	0.0015	0.0048**	0.0040
	(0.78)	(2.28)	(1.12)
FT*Rivals pre Ch. (γ2)	0.0025	-0.0013	0.0059
	(1.17)	(-0.57)	(1.50)
Pol Bk* Rivals (γ1)	-0.0037***	-0.0015	0.0006
	(-2.92)	(-1.40)	(0.31)
Pol Bk*FT*Rivals (γ3)	0.0009	-0.0017	-0.0034
	(0.57)	(-1.03)	(-1.21)
Rivals post Ch. (δ0+γ1)	-0.0022	0.0033*	0.0046
	(-1.42)	(1.93)	(1.48)
FT & non-FT Rivals pre Ch. (δ0+γ2)	0.004	0.0035	0.0099*
	(1.31)	(1.15)	(1.86)
Pol Bk* FT & non-FT Rivals (γ1+γ3)	-0.0027	-0.0032*	-0.0028
	(-1.25)	(-1.68)	(-0.83)
Rivals post Ch. (δ0+γ1+γ2+γ3)	0.0013	0.0003	0.0071*
	(0.72)	(0.16)	(1.95)
F-stat	91.6053	38.3960	138.0232
Adjusted R^2	0.0406	0.0473	0.0888
Patients	288287	91005	214103
Sites	238	213	236

Teaching Trusts sensitivity	AMI (1)	Hip Fracture (2)	Stroke (3)
Rivals pre Ch. (δ0)	0.0009	0.0062**	-0.0002
	(0.43)	(2.45)	(-0.05)
Teach*Rivals pre Ch. (γ2)	0.0021	-0.0035	0.0111**
	(0.69)	(-1.41)	(2.31)
Pol Bk* Rivals (γ1)	-0.0027**	-0.0028**	0.0007
	(-2.26)	(-2.49)	(0.42)
Pol Bk*Teach*Rivals (γ3)	0.0003	0.0010	0.0008
	(0.19)	(0.87)	(0.40)
Rivals post Ch. (δ0+γ1)	-0.0017	0.0034*	0.0005
	(-1.04)	(1.68)	(0.14)
Teach & non-Teach Rivals pre Ch. (δ0+γ2)	0.003	0.0027	0.0109**
	(0.94)	(1.21)	(2.25)
Pol Bk* Teach & non-Teach Rivals (γ1+γ3)	-0.0024	-0.0018	0.0015
	(-1.38)	(-1.52)	(0.71)
Rivals post Ch. (δ0+γ1+γ2+γ3)	0.0007	0.0009	0.0124***
	(0.28)	(0.5)	(3.39)
F-stat	90.5624	38.1756	138.1145
Adjusted R^2	0.0405	0.0472	0.0888
Patients	288287	91005	214103
Sites	238	213	236

London Sites sensitivity	AMI (1)	Hip Fracture (2)	Stroke (3)
Rivals pre Ch. (δ0)	0.0005	0.0047*	0.0028
	(0.26)	(1.86)	(0.68)
London*Rivals pre Ch. (γ2)	0.0050	0.0017	0.0006
	(0.90)	(0.42)	(0.10)
Pol Bk* Rivals (γ1)	-0.0021*	-0.0027*	0.0031
	(-1.65)	(-1.90)	(1.46)
Pol Bk* London *Rivals (γ3)	-0.0011	0.0002	-0.0026
	(-0.69)	(0.18)	(-1.39)
Rivals post Ch. (δ0+γ1)	-0.0016	0.002	0.0059
	(-1.04)	(1.07)	(1.82)
London & non- London Rivals pre Ch. (δ0+γ2)	0.0056	0.0064*	0.0034
	(1.04)	(1.76)	(0.57)
Pol Bk* London & non-London Rivals (γ1+γ3)	-0.0032**	-0.0025**	0.0006
	(-2.1)	(-2.36)	(0.32)
Rivals post Ch. (δ0+γ1+γ2+γ3)	0.0024	0.0039	0.004
	(0.52)	(1.28)	(0.75)
F-stat	91.1790	39.2904	137.5182
Adjusted R^2	0.0405	0.0472	0.0888
Patients	288287	91005	214103
Sites	238	213	236

Notes. Dependent variable: patient aged 35-74 died in hospital within 30 days of admission. Pol Bk: Policy break indicator for years 2006/7 onwards. Market structure: Equivalent N rival sites = 1/(predicted HHI). FT: site in Foundation Trust. Teach: site in teaching hospital. London: site in London. Years: 2002/3 to 20010/11. All models contain year effects, site fixed effects, patient and hospital covariates (including Foundation Trust, Teaching status, London location). Same number observations, clusters as Table 4. t-statistics in parentheses. p<0.1, ** p<0.05, ***p<0.01.

5.1.6 Market structure measured at trust level

It is of interest whether sites are motivated by competition they face or by the overall level competition faced by the Trust to which they belong. In **Table 10** we report results from the policy break model when market structure for a site as the average number of rivals of sites belonging to the same Trust. The results are very similar to those in Table 4 where market structure is the number of rival sites facing the site. This may be because most Trusts (around 60%) have only one site for treatment of these emergency patients. Moreover, hospital sites within a Trust may be close together and thus face very similar market structures.

Table 10. Effect of market structure measured at Trust level on mortality

	AMI	AMI	Hip Fracture	Hip Fracture	Stroke	Stroke
	(1)	(2)	(3)	(4)	(5)	(6)
	Equivalent N rival sites 30km	N. Rival sites 30km	Equivalent N rival sites 30km	N. Rival sites 30km	Equivalent N rival sites 30km	N. Rival sites 30km
Rivals pre Ch. (δ0)	0.0003	0.0004	0.0047**	0.0007**	0.0032	0.0001
	(0.12)	(1.25)	(2.11)	(2.55)	(0.94)	(0.20)
Pol Bk* Rivals (γ1)	-0.0019*	-0.0003**	-0.0024**	-0.0003***	0.0023	0.0001
	(-1.80)	(-2.30)	(-2.35)	(-2.98)	(1.33)	(0.46)
Rivals Post Choice (δ0+γ1)	-.0017	.0001	.0023	.0004**	.0055*	.0002
	(-.93)	(.47)	(1.33)	(1.99)	(1.9)	(.38)
F-stat	107.6698	109.0394	41.9623	41.6690	214.3432	212.8411
Adjusted R^2	0.0399	0.0399	0.0473	0.0473	0.0873	0.0873
Patients	288287	288287	91005	91005	214103	214103
Sites	165	165	160	160	163	163

Notes. Dependent variable: patient aged 35-74 died in hospital within 30 days of admission. Market structure: mean of the site level measures for sites owned by the Trust. Hospital clusters and fixed effects at trust level. Otherwise specification as for models in Table 3. t-statistics in parentheses; p<0.1, ** p<0.05, *** p<0.01.

5.1.7 Competition from NHS and private providers

The most salient change in the market structure for providers of care to NHS patients since 2002/3 has been the entry of private sector providers, with 14 non-NHS sites providing elective care in 2002/3 and 146 in 2010/11. **Table 11** has results from the policy break specification but using separate measures of market structure from NHS and private (ISP) providers. The number of private rivals has no effect on mortality pre or post Choice for any of the conditions.

5.2 Flexible specification

The policy break specification forces the effects of market structure to be the same in all pre Choice years and in all post-Choice years: it estimates the effects of market structure as a step function of time. If there is a trend in the effect of market structure, the policy break specification may therefore misleadingly suggest that Choice changed the effect of market structure. The flexible specification allows the effect of market structure and all the covariates to vary for all years.[26]

[26] We also estimated specifications in which the effect of the covariates was forced to be constant over all nine years and obtained similar temporal patterns of estimated effects of market structure (see Appendix Table B3).

Table 11. Effect of competition from NHS and private rivals on 30 day hospital mortality

	AMI (1) N rival sites	Hip Fracture (2) N rival sites	Stroke (3) N rival sites
NHS rivals pre Ch. (δ0_1)	0.0008	0.0013***	0.0005
	(1.65)	(3.39)	(0.84)
Private rivals pre Ch. (δ0_2)	0.0006	-0.0013	-0.0030
	(0.26)	(-0.52)	(-0.80)
Pol Bk*NHS Rivals (γ1_1)	-0.0003**	-0.0003***	-0.0001
	(-2.19)	(-3.14)	(-0.51)
Pol Bk*Private Rivals (γ1_2)	-0.0006	0.0014	0.0028
	(-0.23)	(0.53)	(0.74)
NHS rivals post Ch. (δ0_1+γ1_1)	0.0005	0.001**	0.0004
	(1.14)	(2.89)	(0.81)
Private rivals post Ch. (δ0_2+γ1_2)	0	0.0001	-0.0002
	(0.04)	(0.14)	(-0.17)
F-stat	93.3143	38.6420	136.2846
Adjusted R^2	0.0405	0.0473	0.0887
Patients	288287	91005	214103
Sites	238	213	236

Notes. Dependent variable: patient aged 35-74 died in hospital within 30 days of admission. Same specification as Table 3 models apart from competition measures. t-statistics in parentheses; p<0.1, ** p<0.05, *** p<0.01.

Figure 4 showed that there were clear downward trends in unconditional (raw) mortality risk over the period. The year effects estimated with the policy break specification also had a downward trend (see the full results in **Appendix Table A1**). **Figure 7** shows that the year effects estimated with the flexible model are almost never significant and do not exhibit any obvious trends. Thus once we allow for time varying coefficients on the covariates there are no unexplained year effects, suggesting that the flexible model is doing a good job of capturing improvements in treatment over time via the changing effects of patient characteristics. Figure 7 also suggests that there was no obvious direct effect of the introduction of Choice in 2006 (corresponding to q_{θ}^{e} in the theory model of section 2).

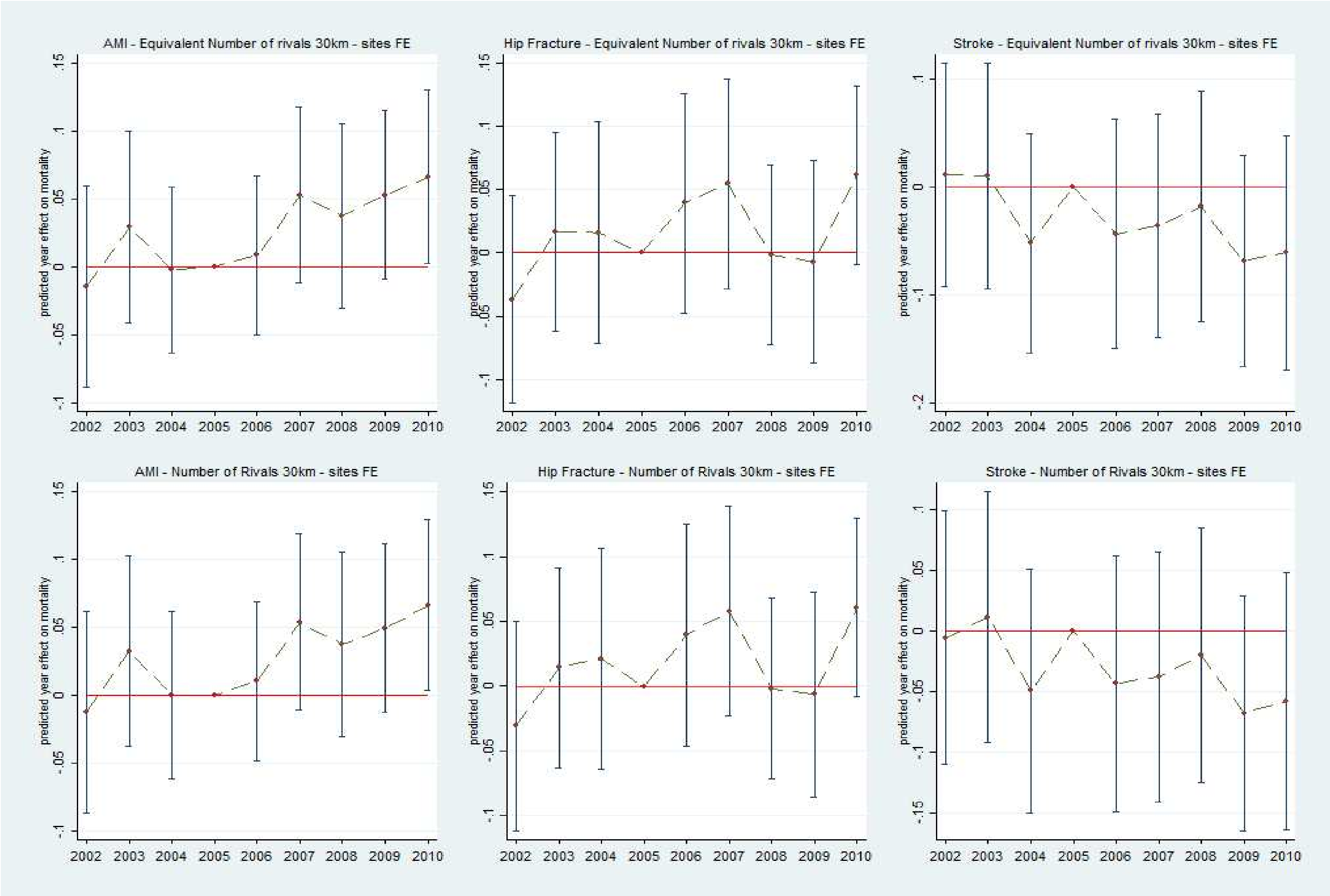

Figure 7. Estimated year effects relative to 2005/6 after allowing for all explanatories

Notes. Plot of estimated year effects, relative to 2005/6, from the flexible specification with year effects, site fixed effects, patient and hospital covariates and with the effects of covariates allowed to vary by year.

Table 12 reports the estimated effects of market structure for each year ($\delta_0 + \gamma_t$) and these are plotted in **Figure 8**. The changes over time in the effects estimated with the two market structure measures are fairly similar for a given condition, though the model with the simple count of rivals has more statistically significant coefficients for AMI and hip fracture. For both AMI and hip fracture sites with more rivals initially have higher mortality. There is a downward trend in this detrimental effect of the rivals until around 2007/8 after which the effect of market structure is roughly constant. These results explain why the policy break specification suggested that the introduction of Choice in 2006/7 reduced the detrimental effect of having more rivals on AMI and hip fracture mortality: on average, the deleterious effect was larger before 2006/7 than afterwards. But as Figure 8 shows, the reduction in the deleterious effect of rivals started before the introduction of Choice.[27, 28]

Table 12. Year varying effects of market structure and covariates on mortality

	AMI (1) Equivalent N rival sites 30km	AMI (2) N. Rival sites 30km	Hip Fracture (3) Equivalent N rival sites 30km	Hip Fracture (4) N. Rival sites 30km	Stroke (5) Equivalent N rival sites 30km	Stroke (6) N. Rival sites 30km
Rivals 2002/3 ($\delta_0+\gamma_{02}$)	0.0005**	0.0010**	0.0075**	0.0017***	-0.0040	-0.0006
	(0.2049)	(2.0673)	(2.0653)	(3.2344)	(-0.7773)	(-0.7173)
Rivals 2003/4 ($\delta_0+\gamma_{03}$)	0.0019	0.0012**	0.0032	0.0018***	0.0026	-0.0007
	(0.75)	(2.3503)	(1.1451)	(3.2208)	(0.5393)	(-0.7805)
Rivals 2004/5 ($\delta_0+\gamma_{04}$)	0.0007	0.001**	0.0072***	0.0019***	0.0052	-0.0004
	(0.3337)	(2.19)	(2.6182)	(3.7186)	(1.2871)	(-0.4434)
Rivals 2005/6 (δ_0)	0.0009	0.0010**	0.0057**	0.0016***	0.0035	-0.0004
	(0.44)	(2.29)	(2.27)	(3.71)	(0.92)	(-0.53)
Rivals 2006/7 ($\delta_0+\gamma_{06}$)	0.0001	0.0008**	.0034	0.0013***	0.0024	-0.0006
	(0.0333)	(2.0278)	(1.5266)	(3.1208)	(0.6716)	(-0.8169)
Rivals 2007/8 ($\delta_0+\gamma_{07}$)	-0.0014	0.0007*	0.0039*	0.0013***	0.0024	-0.0005
	(-0.7074)	(1.6921)	(1.9275)	(3.0394)	(0.6571)	(-0.6707)
Rivals 2008/9 ($\delta_0+\gamma_{08}$)	-0.0012	0.0008**	0.0029	0.0013***	0.0008	-0.0007
	(-0.642)	(1.9729)	(1.2364)	(3.104)	(0.2194)	(-0.9286)
Rivals 2009/10 ($\delta_0+\gamma_{09}$)	-0.0015	.0008**	0.003	0.0012***	0.0039	-0.0003
	(-0.7945)	(2.0955)	(1.5274)	(2.9996)	(1.07)	(-0.4987)
Rivals 2010/11 ($\delta_0+\gamma_{10}$)	-0.0006	0.0007*	0.0039**	0.0012***	0.0024	-0.0006
	(-0.3274)	(1.9288)	(2.0715)	(3.3743)	(0.7293)	(-0.9447)
Adjusted R^2	0.0422	0.0423	0.0487	0.0488	0.0915	0.0914
Patients	288287	288287	91005	91005	214103	214103
Sites	238	238	213	213	236	236

Notes. Dependent variable: patient aged 35-74 died in hospital within 30 days of admission. Equivalent N rival sites = 1/(predicted HHI). Specification is model (18). Financial years: 2002/3 to 2010/11. All models contain year effects, site fixed effects, patient and hospital covariates. All covariates are interacted with year indicators. Same number observations, clusters as Table 3. t-statistics in parentheses; p<0.1, ** p<0.05, *** p<0.01.

[27] We also estimated a specification, similar to that used by Cooper et al. (2011), in which the effect of market structure follows possibly different linear trends before and after Choice. We find that there was no statistically significant change in the trend in the effect of having more rivals after the introduction of Choice in 2006 for AMI or hip fracture patients (see Appendix **Tables B1, B2**). We prefer our fully flexible specification as a means of examining whether the effect of market structure varied over time and whether any changes were associated with the introduction of Choice since it does not constrain changes over time to follow linear trends and the results are easier to interpret. We discuss the reasons for the difference between our results and those in Cooper et al (2011).

[28] We also estimated difference in difference specifications similar to those used by Gaynor et al (2013) and following them in using data for only two years 2002/3 and 2007/8. Like Gaynor et al (2013) we find that providers exposed to more competition in 2003/4 have significantly lower 2007/8 AMI mortality. However, providers exposed to more competition in 2003/4 had insignificantly higher hip fracture and stroke mortality in 2007/8 (see Appendix **Table B3**). Use of these two years to identify an effect of Choice assumes that there is no underlying trend in the effect of market structure.

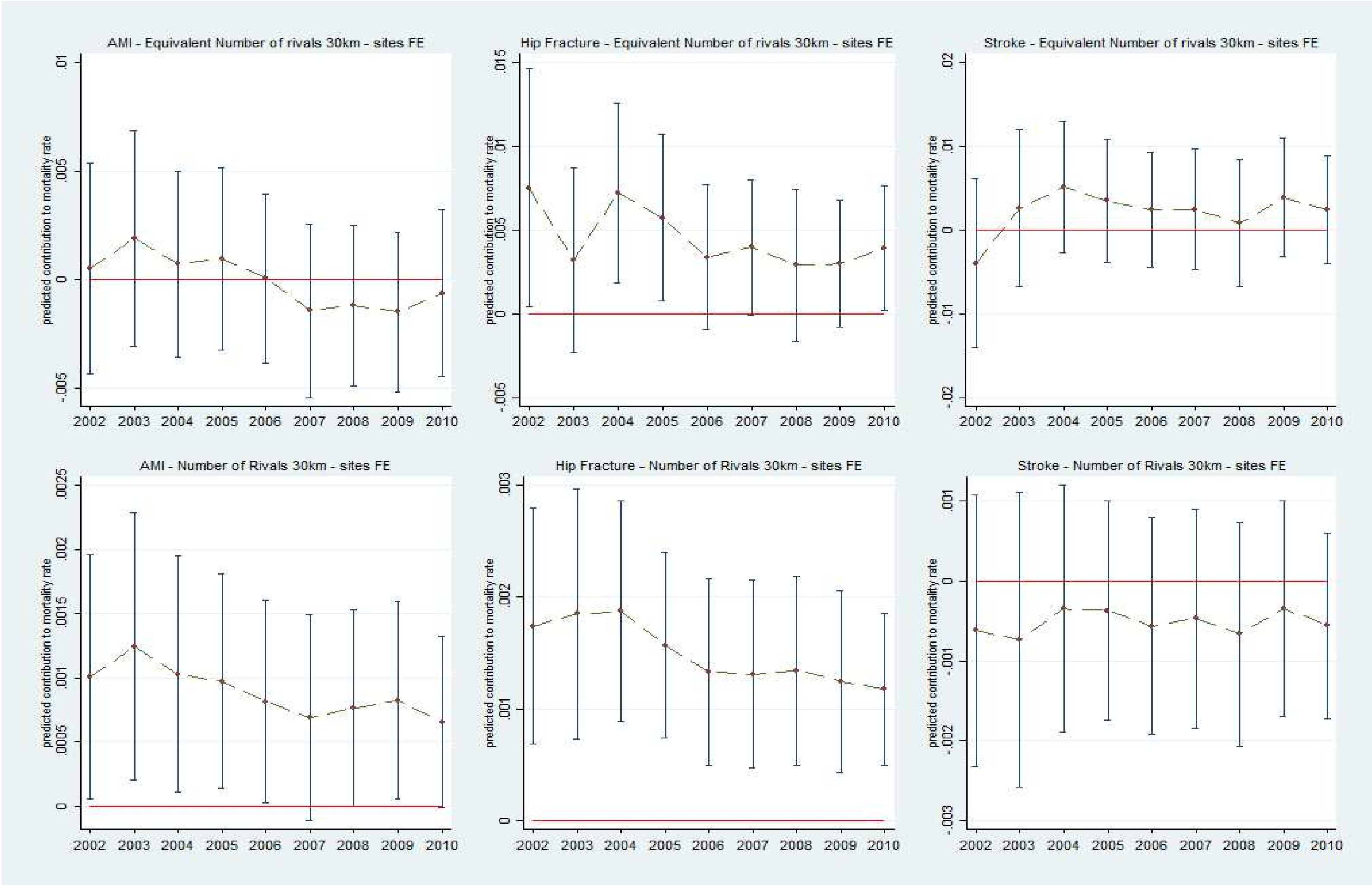

Figure 8. Trends in effect of number of rivals on mortality risk

Notes. Estimated effects of number of rivals in each year from the flexible specification with year effects, site fixed effects, patient and hospital covariates and with the effects of covariates allowed to vary by year.

The estimated effect of more rivals on stroke mortality risk is statistically insignificant in all years for both market structure measures. Nor do the point estimates exhibit any trend.

For AMI an increase in 1 standard deviation in the number of rivals increases the number of deaths by around 550 (95% CI: 30 to 1133) in 2002/3, with the effect declining to around 375 (95% CI: -6 to 711) in 2010/11. For hip fracture the increase in the number of deaths from a 1 standard deviation increase in the number of rivals was around 275 (95% CI: 103 to 420) in 2002/3 and did not change much over the period.

5.3 Decomposition of change in mortality

We use the results from our flexible specification to make a Blinder-Oaxaca decomposition of the change in the average mortality probability between 2002/3 and 2010/11. In **Table 13** we decompose the change (A) into five parts: the change in the year effect (B) , the change in the mix of sites (C),[29] the change in the effect of market structure (D), the change in average market structure (E), and the change in the covariates and in their effects (F). Both the magnitude of the change in mortality risk and the importance of the factors responsible for the changes vary considerably across the three conditions. Changes in the mix of patients and in changes in the effect of patient characteristics (F) make the largest contribution to the reduction in mortality risk. The change in year effect makes a small and insignificant contribution (B) for AMI and for stroke. This is as expected given the lack of statistical significance for year effects with the flexible specification (see Figure 7). Figure 7 also suggests that the positive, large, and significant contribution of the difference in year effects for hip fracture is due to the particular pair of years considered.

The distribution of patients across sites with different time invariant effects makes small but statistically significant contribution (C) for all three conditions. For AMI and stroke patients seem to have shifted to sites with lower inherent mortality risk whereas for hip fracture the reverse is true.

Column D reports the contribution of the change in the effect of the number of rivals $(\gamma_{10} - \gamma_2)$ applied to the average number of rivals in 2010/11 ($\bar{M}_{10}$). For AMI the reduction in the deleterious effect of rivals reduces mortality but the contribution is small and not statistically significant. For hip fracture the reduction in the deleterious effect of rivals is greater and as the overall reduction in hip fracture mortality is smaller, it accounts for a greater proportion than for AMI. The change in the average market structure (column E) has a statistically insignificant contribution for AMI and hip fracture. For all three conditions the absolute size of the contribution of the change in the effect of the number of rivals is much greater than the change in the number of rivals.

[29] Site fixed effects are constant over the period but the set of providers and their share of patients changed, so this term is the change in mortality risk due to the change in the weighted average of the site fixed effects. See Appendix C for details of the decomposition.

Table 13. Blinder-Oaxaca decomposition of the change in mortality risk

AMI - Mortality decomposition 2002/3 vs 2010/11

	A	B	C	D	E	F
Mortality change	-0.0265					
Contribution to mort. change		0.0077	-0.0021	-0.0037	0.0004	-0.0289
Lower Bound		-0.0009	-0.0023	-0.0075	-0.0044	
Upper Bound		0.0163	-0.0018	0.0002	0.0053	
% age Contribution to mort. change		29.06%	-7.88%	-13.87%	1.55%	-108.86%
Lower Bound		-3.21%	-8.83%	-28.30%	-16.67%	
Upper Bound		61.37%	-6.95%	0.56%	19.79%	

Hip Fracture - Mortality decomposition 2002/3 vs 2010/11

	A	B	C	D	E	F
Mortality change	-0.0109					
Contribution to mort. change		0.0113	0.0008	-0.0115	0.0055	-0.0169
Lower Bound		0.0028	0.0004	-0.0167	-0.0017	
Upper Bound		0.0198	0.0012	-0.0063	0.0126	
% age Contribution to mort. change		103.86%	6.98%	-105.60%	50.23%	-155.46%
Lower Bound		25.90%	3.23%	-154.00%	-15.13%	
Upper Bound		182.00%	10.76%	-57.57%	115.00%	

Stroke - Mortality decomposition 2002/3 vs 2010/11

	A	B	C	D	E	F
Mortality change	-0.0501					
Contribution to mort. change		-0.0080	-0.0013	0.0212	-0.0031	-0.0590
Lower Bound		-0.0210	-0.0018	0.0141	-0.0132	
Upper Bound		0.0050	-0.0007	0.0283	0.0070	
% age Contribution to mort. change		-15.98%	-2.49%	42.31%	-6.22%	-117.61%
Lower Bound		-41.96%	-3.54%	28.17%	-26.33%	
Upper Bound		9.99%	-1.46%	56.47%	13.89%	

Notes. A = mortality change; B = difference in year effects; C = difference in site distribution of patients; D = change in effect of Mkt Structure times Mkt Structure in year 2010; E = effect of Mkt Structure in year 2002 times change in Mkt Structure (2010/11–2002/3); F = change in covariates plus change in effect of covariates. Derived from flexible specification (18) with year varying effects for all covariates. Market structure measure: predicted equivalent number of rival sites (1/pHHI) within 30km. Lower and upper bounds are 95% confidence intervals. See Appendix C for details on the decomposition.

6 Conclusions

Results from the policy break model, in which the effect of market structure was constrained to be the same in all pre-Choice and in all post-Choice years, suggest that in the pre-Choice period providers facing more rivals (more competition) had higher AMI and hip fracture mortality. In the post-Choice period, the detrimental effect of rivals was smaller and statistically significant only for hip fracture. Market structure never appears to have any effect on stroke mortality.

The policy break model suggests that introduction of Choice could have reduced the detrimental effect of having more rivals for AMI and hip fracture. We do not find evidence that the detrimental effect of rivals was further reduced when Choice was extended in 2008. Neither we find that the effect of market structure varied with the proportion of patients who reported being aware of their right to a choice or being offered a choice. Thus we did not find any evidence that expanding Choice further changed the effect of market structure.

Our flexible model in which the effect of market structure was allowed to vary across all years suggested that the effect at the start of the period in 2002/3 of having more rivals was to increase mortality for AMI and hip fracture and that this detrimental effect became smaller over time. However, the decline in the detrimental effect of more rivals started before the introduction of Choice, suggesting that it was not due Choice policy. We speculate that the reduction in the detrimental effect of rivals may have been due to changes in medical knowledge and to the roll out of Payment by Results which increased the proportion of site income that varied with the number of patients. We plan to investigate this further in future work.

Even if Choice does not systematically change the effect of market structure on mortality, this does not mean that the introduction of Choice did not benefit patients. Patients may place an intrinsic value on having a choice of provider. Even if Choice did not change the quality of providers, patients could gain from being able to switch to providers they preferred, either because they had higher quality, or for other reasons such as lower waiting times (Gaynor et al, 2012b).

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Appendix A. Policy break model

A1. Baseline model: full results

	AMI		Hip Fracture		Stroke	
	(1)	(2)	(3)	(4)	(5)	(6)
	Equivalent N rival sites 30km	N Rival sites 30km	Equivalent N rival sites 30km	N Rival sites 30km	Equivalent N rival sites 30km	N Rival sites 30km
2002	0.0166***	0.0171***	0.0063**	0.0063**	0.0123***	0.0110***
	(7.12)	(7.54)	(2.30)	(2.35)	(2.92)	(2.64)
2003	0.0121***	0.0132***	0.0017	0.0030	0.0115***	0.0109**
	(5.59)	(5.85)	(0.66)	(1.13)	(2.88)	(2.58)
2004	0.0060***	0.0067***	-0.0011	-0.0003	0.0027	0.0025
	(3.07)	(3.34)	(-0.42)	(-0.13)	(0.82)	(0.71)
2006	0.0020	-0.0012	-0.0027	-0.0054*	-0.0120**	-0.0078*
	(0.57)	(-0.51)	(-0.65)	(-1.71)	(-2.28)	(-1.90)
2007	-0.0034	-0.0067***	-0.0042	-0.0070**	-0.0076	-0.0032
	(-0.98)	(-2.70)	(-1.03)	(-2.28)	(-1.36)	(-0.71)
2008	-0.0069*	-0.0106***	-0.0094**	-0.0121***	-0.0196***	-0.0141***
	(-1.94)	(-3.91)	(-2.27)	(-3.89)	(-3.55)	(-3.18)
2009	-0.0144***	-0.0185***	-0.0129***	-0.0160***	-0.0205***	-0.0147***
	(-4.00)	(-6.53)	(-3.05)	(-4.95)	(-3.55)	(-3.28)
2010	-0.0161***	-0.0212***	-0.0247***	-0.0290***	-0.0118**	-0.0056
	(-4.02)	(-6.33)	(-6.16)	(-9.44)	(-2.07)	(-1.34)
Rivals pre Choice (δ0)	0.0016	0.0007*	0.0048**	0.0010***	0.0044	0.0002
	(0.80)	(1.78)	(2.29)	(3.24)	(1.22)	(0.46)
Pol Brk * Rivals (γ1)	-0.0025**	-0.0003**	-0.0025**	-0.0003***	0.0012	-0.0000
	(-2.21)	(-2.43)	(-2.39)	(-3.25)	(0.73)	(-0.32)
Rivals post Choice (δ0+γ1)	-0.001	0.0004	0.0024	0.0007***	0.0056*	0.0002
	(-0.65)	(1.18)	(1.43)	(2.75)	(1.85)	(0.43)
IMD Income 2002/10	-0.0028	-0.0026	0.0373***	0.0377***	0.0187	0.0183
	(-0.34)	(-0.32)	(3.26)	(3.30)	(1.56)	(1.53)
IMD Living Environment 2002/10	0.0001**	0.0001**	-0.0000	-0.0000	0.0001	0.0000
	(2.06)	(2.16)	(-0.97)	(-0.92)	(0.80)	(0.73)
Incapacity Claims %	0.0724	0.0700	-0.0197	-0.0230	0.0741	0.0768
	(1.26)	(1.22)	(-0.28)	(-0.33)	(0.83)	(0.86)
Disability Claims %	0.0704	0.0713	-0.0233	-0.0220	0.0943	0.0938
	(1.58)	(1.61)	(-0.40)	(-0.38)	(1.32)	(1.31)
Female patient	0.0119***	0.0119***	-0.0107***	-0.0107***	0.0156***	0.0156***
	(10.02)	(10.03)	(-7.87)	(-7.85)	(9.46)	(9.46)
Patient's Age	0.0034***	0.0034***	0.0012***	0.0012***	0.0042***	0.0042***
	(2.65)	(2.64)	(5.85)	(5.85)	(15.69)	(15.69)
Number of diagnosis	0.0018***	0.0018***	0.0078***	0.0078***	-0.0144***	-0.0144***
	(3.68)	(3.67)	(19.28)	(19.23)	(-20.09)	(-20.04)

	AMI		Hip Fracture		Stroke	
	(1)	(2)	(3)	(4)	(5)	(6)
	Equivalent N rival sites 30km	N Rival sites 30km	Equivalent N rival sites 30km	N Rival sites 30km	Equivalent N rival sites 30km	N Rival sites 30km
Charlson Index - Medium Comorbidities	0.0244***	0.0244***	0.0101***	0.0101***	0.0284***	0.0283***
	(17.42)	(17.40)	(7.08)	(7.07)	(13.43)	(13.42)
Charlson Index - High Comorbidities	0.0852***	0.0852***	0.0557***	0.0557***	0.0771***	0.0770***
	(32.94)	(32.92)	(18.95)	(18.95)	(21.95)	(21.92)
Teaching Trust	0.0077*	0.0067	0.0093***	0.0082***	0.0106	0.0093
	(1.69)	(1.61)	(3.92)	(2.89)	(0.79)	(0.63)
Foundation Trust	-0.0004	-0.0003	0.0007	0.0005	0.0024	0.0013
	(-0.19)	(-0.13)	(0.30)	(0.22)	(0.60)	(0.32)
Distance to provider	0.0000	0.0000	-0.0000***	-0.0000***	-0.0001**	-0.0001**
	(0.01)	(0.03)	(-4.09)	(-4.09)	(-2.41)	(-2.42)
Age band 35 to 44 years	-0.0277***	-0.0276***	-0.0062**	-0.0061**	-0.0127***	-0.0127***
	(-14.90)	(-14.88)	(-2.09)	(-2.07)	(-3.17)	(-3.17)
Age band 45 to 54 years	-0.0457***	-0.0456***	-0.0149***	-0.0149***	-0.0298***	-0.0298***
	(-14.21)	(-14.19)	(-3.34)	(-3.34)	(-4.95)	(-4.95)
Age band 55 to 64 years	-0.0419***	-0.0418***	-0.0182***	-0.0182***	-0.0275***	-0.0275***
	(-8.99)	(-8.97)	(-2.87)	(-2.87)	(-3.31)	(-3.31)
Admitted from home	-0.0159***	-0.0158***	-0.0003	-0.0003	-0.0035	-0.0037
	(-3.66)	(-3.63)	(-0.10)	(-0.09)	(-0.35)	(-0.37)
Admitted from temporary location	-0.0155**	-0.0155**	-0.0062	-0.0061	0.0098	0.0097
	(-2.12)	(-2.11)	(-1.05)	(-1.03)	(0.57)	(0.57)
DOA = Sunday	0.0017	0.0017	0.0013	0.0014	0.0194***	0.0193***
	(0.90)	(0.90)	(0.63)	(0.65)	(6.77)	(6.77)
DOA = Tuesday	-0.0027*	-0.0027*	0.0002	0.0003	0.0029	0.0029
	(-1.69)	(-1.70)	(0.12)	(0.13)	(1.12)	(1.13)
DOA = Wednesday	-0.0025	-0.0025	-0.0015	-0.0014	0.0053**	0.0053**
	(-1.46)	(-1.46)	(-0.72)	(-0.70)	(2.08)	(2.07)
DOA = Thursday	-0.0009	-0.0010	-0.0024	-0.0024	0.0006	0.0006
	(-0.58)	(-0.59)	(-1.22)	(-1.22)	(0.23)	(0.23)
DOA = Friday	-0.0006	-0.0006	-0.0019	-0.0019	-0.0032	-0.0032
	(-0.35)	(-0.35)	(-0.96)	(-0.95)	(-1.35)	(-1.35)
DOA = Saturday	-0.0012	-0.0012	-0.0026	-0.0026	0.0137***	0.0137***
	(-0.67)	(-0.67)	(-1.34)	(-1.34)	(4.46)	(4.46)
MOA = February	-0.0018	-0.0018	-0.0006	-0.0007	0.0001	0.0001
	(-0.79)	(-0.79)	(-0.23)	(-0.24)	(0.04)	(0.03)
MOA = March	-0.0017	-0.0017	-0.0020	-0.0020	-0.0105***	-0.0105***
	(-0.84)	(-0.84)	(-0.79)	(-0.81)	(-2.99)	(-3.00)
MOA = April	0.0036*	0.0035*	-0.0011	-0.0012	-0.0014	-0.0014

	AMI		Hip Fracture		Stroke	
	(1)	(2)	(3)	(4)	(5)	(6)
	Equivalent N rival sites 30km	N Rival sites 30km	Equivalent N rival sites 30km	N Rival sites 30km	Equivalent N rival sites 30km	N Rival sites 30km
	(1.70)	(1.69)	(-0.40)	(-0.43)	(-0.40)	(-0.40)
MOA = May	-0.0034	-0.0034	0.0008	0.0008	-0.0097***	-0.0097***
	(-1.59)	(-1.59)	(0.31)	(0.30)	(-2.66)	(-2.67)
MOA = June	0.0001	0.0001	0.0027	0.0027	-0.0061*	-0.0061*
	(0.04)	(0.04)	(0.96)	(0.96)	(-1.75)	(-1.75)
MOA = July	0.0009	0.0009	-0.0005	-0.0006	-0.0076**	-0.0076**
	(0.39)	(0.39)	(-0.20)	(-0.20)	(-2.10)	(-2.11)
MOA = August	-0.0002	-0.0002	-0.0006	-0.0007	-0.0143***	-0.0143***
	(-0.08)	(-0.09)	(-0.23)	(-0.25)	(-3.77)	(-3.77)
MOA = September	-0.0016	-0.0016	-0.0020	-0.0021	-0.0082**	-0.0082**
	(-0.71)	(-0.71)	(-0.79)	(-0.82)	(-2.23)	(-2.22)
MOA = October	-0.0015	-0.0015	-0.0020	-0.0020	-0.0033	-0.0033
	(-0.65)	(-0.66)	(-0.74)	(-0.74)	(-0.91)	(-0.91)
MOA = November	-0.0003	-0.0003	-0.0003	-0.0004	0.0026	0.0026
	(-0.14)	(-0.14)	(-0.12)	(-0.13)	(0.66)	(0.65)
MOA = December	0.0051**	0.0051**	0.0010	0.0010	0.0113***	0.0113***
	(2.25)	(2.24)	(0.43)	(0.41)	(2.85)	(2.85)
Hip Fracture: Pertrochanteric			-0.0014	-0.0014		
			(-0.96)	(-0.99)		
Hip Fracture: Subtrochanteric			-0.0010	-0.0009		
			(-0.32)	(-0.32)		
Stroke: Haemorragic					0.1842***	0.1843***
					(41.75)	(41.78)
Stroke: Infarction					-0.0456***	-0.0456***
					(-11.83)	(-11.81)
Stroke: Occlusion					-0.0327***	-0.0327***
					(-2.71)	(-2.70)
Stroke: Other					-0.0989***	-0.0987***
					(-19.64)	(-19.62)
Constant	-0.1348***	-0.1385***	-0.0805***	-0.0800***	-0.0839***	-0.0740***
	(-13.46)	(-14.68)	(-6.67)	(-7.29)	(-4.51)	(-4.19)
F-stat	93.74	95.14	39.80	40.05	141.73	141.56
Adjusted R^2	0.0405	0.0405	0.0472	0.0473	0.0888	0.0887
R^2	0.0415	0.0415	0.0499	0.0500	0.0900	0.0899
Patients	288287	288287	91005	91005	214103	214103
Sites	238	238	213	213	236	236

Notes. Dependent variable: patient aged 35-74 died in hospital within 30 days of admission. Market structure measured at site level. Financial years (e.g. 2008 is April 2008 to March 2009). PolBk: indicator for 2006/7 onwards. All models include site fixed effects, patient and hospital covariates. DOA = day of admission; MOA = month of admission; t-statistics in parentheses; * p<0.1, ** p<0.05, *** p<0.01

A2. Logistic model of patient mortality

	AMI (1) Equivalent N rival sites 30km	AMI (2) N Rival sites 30km	Hip Fracture (3) Equivalent N rival sites 30km	Hip Fracture (4) N Rival sites 30km	Stroke (5) Equivalent N rival sites 30km	Stroke (6) N Rival sites 30km
Rivals pre Choice (δ_0)	0.0204	0.0118**	0.1536**	0.0305***	0.0342	0.0002
	(0.60)	(1.96)	(2.06)	(3.00)	(1.19)	(0.04)
PolBk*Rivals (γ_1)	-0.0310	-0.0046**	-0.0668*	-0.0103***	0.0049	-0.0006
	(-1.61	(-2.15)	(-1.91)	(-3.17)	(0.36)	(-0.55)
Rivals post Choice ($\delta_0+\gamma_1$)	-0.0106	0.0074	0.0868	0.02020**	0.03918	-0.00049
	(-0.40)	(1.44)	(1.40)	(2.34)	(1.62)	(-0.14)
Pseudo R^2	0.0846	0.0847	0.1615	0.1617	0.1001	0.1001
Patients	288287	288287	90527	90527	214103	214103
Sites	238	238	204	204	236	236
Average Marginal Effects of Market Structure						
Rivals pre Choice (δ_0)	0.00117	0.000674	0.00458	0.000890**	0.00417	0.0000188
	(0.60)	(1.94)	(1.94)	(2.87)	(1.18)	(0.04)
Rivals post Choice ($\delta_0+\gamma_1$)	-0.000567	0.000397	0.00221	0.000525*	0.00481	-0.0000599
	(-0.40)	(1.44)	(1.41)	(2.36)	(1.62)	(-0.14)

Notes. Policy break specification (15) run with unconditional logit fixed-effects. Dependent variable: patient aged 35-74 died in hospital within 30 days of admission. Equivalent N rival sites = 1/(predicted HHI at 30 km). All models include site fixed effects, patient and hospital covariates. t-statistics in parentheses; *p<0.1, ** p<0.05, *** p<0.01.

Appendix B. Additional specifications

In this appendix we report results from specifications similar to those in Cooper et al (2011) and Gaynor et al (2013) but using our data set and market structure measures.

B1. Cooper et al (2011) replication

Tables B1 and **B2** have the results from a specification similar to the preferred specification in Cooper et al (2011), in which year effects and the effects of market structure are constrained to follow possibly different linear trends pre and post Choice:

$$q_{iht} = \beta_1 t + \beta_2 t \mathbf{1}_{(t \geq Q_1 2006/7)} + \alpha_0 M_{ht} + \alpha_1 M_{ht} t + \alpha_2 M_{ht} t \mathbf{1}_{(t \geq Q_1 2006/7)} + \mu_h + \varphi_1 X_{1iht} + \varphi_2 X_{2ht} + \varepsilon_{iht} \quad \text{(B1)}$$

where now t is a running count of quarters from t = 1 (first quarter 2002/03) to t = 36 (fourth quarter 2010/11). t = 17 (first quarter 2006/07) is the first post Choice quarter. The market structure variables and hospital covariates are measured for years, rather than quarters. The marginal effect of market structure in a pre-Choice period t is $\alpha_0 + \alpha_1 t$ and in a post Choice period it is $\alpha_0 + (\alpha_1 + \alpha_2) t$. Thus the key parameter for testing whether there is a different trend post Choice is α_2.

In none of the models (with different periods and different patient age ranges) for AMI or hip fracture is there a statistically significant change in the trend in the effect of market structure after the introduction of Choice in April 2006. There is a greater negative trend in the effect of market structure after Choice for stroke when the model is estimated over the same 2002/3 to 2008/9 period as Cooper et al (2011) but the change in trend is smaller and significant only at 10% for our longer period and for our set of patients aged 35-74). With the Cooper et al (2011) age range of 39 to 100 the negative trend is insignificant for our time period.

Table B1. Effect of market structure and Choice on mortality aged 35-74: Cooper et al (2011) time trend specification

	Patients: age 35-74					
	Period: 2002/3-2008/9			Period: 2002/3-2010/11		
	AMI	Hip Fracture	Stroke	AMI	Hip Fracture	Stroke
	(1)	(2)	(3)	(4)	(5)	(6)
Trend (β1)	0.0009	-0.0010	-0.0030**	0.0017*	-0.0003	-0.0017
	(0.87)	(-1.11)	(-2.43)	(1.81)	(-0.33)	(-1.36)
Change in trend post 2006 (β2)	-0.0028*	0.0033**	0.0037*	-0.0031***	0.0014	0.0017
	(-1.67)	(2.08)	(1.67)	(-2.77)	(1.33)	(0.93)
Rivals (α0)	0.0019	0.0037	-0.0067	0.0032	0.0053*	-0.0024
	(0.54)	(1.02)	(-1.15)	(0.99)	(1.68)	(-0.44)
Trend * Rivals (α1)	-0.0003**	-0.0001	0.0007***	-0.0003**	-0.0002	0.0005**
	(-2.06)	(-0.55)	(3.05)	(-2.18)	(-1.30)	(2.43)
Change in trend post 2006 * Rivals (α2)	0.0003	-0.0002	-0.0013**	0.0004	0.0001	-0.0006*
	(0.85)	(-0.64)	(-2.50)	(1.54)	(0.53)	(-1.92)
F-stat	66.91	26.93	95.94	74.69	40.94	120.94
Adjusted R^2	0.0485	0.0496	0.0907	0.0454	0.0477	0.0889
Patients	235385	68918	166672	287437	90734	213733
Sites	229	204	227	238	213	236

Notes: Dependent variable: patient aged 35-74 died in hospital within 30 days of admission. Market Structure: Equivalent N rival sites = 1/(predicted HHI at 30 km). Time: quarters. Specification (B1). All models contain year*Government Office Region interactions, site fixed effects, patient and hospital covariates. t-statistics in parentheses; * p<0.1, ** p<0.05, *** p<0.01.

Table B2. Effect of market structure and Choice on mortality aged 39-100: Cooper et al (2011) time trend specification

	Patients: age 39-100					
	Period: 2002/3-2008/9			Period: 2002/3-2010/11		
	AMI	Hip Fracture	Stroke	AMI	Hip Fracture	Stroke
	(1)	(2)	(3)	(4)	(5)	(6)
Trend (β1)	0.0008	0.0012*	-0.0037***	0.0012	0.0017**	-0.0020*
	(0.84)	(1.70)	(-3.47)	(1.30)	(2.52)	(-1.96)
Change in trend post 2006 (β2)	-0.0025	0.0025*	0.0040**	-0.0021*	0.0018**	0.0018
	(-1.56)	(1.84)	(2.09)	(-1.96)	(2.07)	(1.23)
Rivals (α0)	0.0005	0.0056	-0.0038	0.0017	0.0085**	-0.0018
	(0.13)	(1.65)	(-0.59)	(0.47)	(2.55)	(-0.32)
Trend * Rivals (α1)	-0.0002	-0.0003**	0.0007**	-0.0002	-0.0003**	0.0005**
	(-1.23)	(-2.06)	(2.52)	(-1.29)	(-2.44)	(2.08)
Change in trend post 2006 * Rivals (α2)	0.0002	0.0002	-0.0013**	0.0003	0.0003	-0.0004
	(0.49)	(0.51)	(-2.18)	(1.00)	(1.23)	(-1.07)
F-stat	200.62	133.49	308.47	252.21	166.02	402.90
Adjusted R^2	0.0816	0.0733	0.1169	0.0788	0.0705	0.1126
Patients	428120	347992	425468	525976	455176	544991
Sites	229	205	227	238	214	236

Notes: Dependent variable: patient aged 35-74 died in hospital within 30 days of admission. Market Structure: Equivalent N rival sites = 1/(predicted HHI at 30 km). Time: quarters. Specification (B1). All models contain year*Government Office Region interactions, site fixed effects, patient and hospital covariates. t-statistics in parentheses; * p<0.1, ** p<0.05, *** p<0.01

B2. Gaynor et al (2013) replication

Gaynor et al (2013) use only two periods of data (2003/4 and 2007/8) to avoid possible confounding the effect of Choice with other policy changes and estimate a form of difference in differences (DID) specification. Their unit of analysis is the hospital trust and they measure quality as mortality rate for the Trust, and Trust level casemix variables. In terms of our individual level data their specification is :

$$q_{iht} = \beta_0 + \mu_h + \beta_1 \mathbf{1}_{(t=2007/8)} + \alpha M_{h2003} \mathbf{1}_{(t=2007/8)} + \varphi_1 X_{1iht} + \varphi_2 X_{2ht} + \varepsilon_{iht} \quad \text{(B2)}$$

In this case γ_1 is change in the effect of 2003 market structure between 2003 and 2007 rather than the change in the effect of period t market structure between t = 2003/4 and t = 2007/8.

Table B3 (columns 1 to 3) reports results from this DID specification. In all cases mortality is lower in the 2007/8 ($\hat{\beta}_1 < 0$). For AMI (column 1) our results are line in with Gaynor et (2013): in 2007/8 providers exposed to more competition in 2003/4 have a lower AMI mortality ($\alpha < 0$). However for hip fracture and stroke being exposed to more competition in 2002/3 increases hip fracture and stroke mortality, though α is insignificant.

Columns 4 to 6 report results from the conventional DID formulation

$$q_{iht} = \beta_0 + \mu_h + \beta_1 \mathbf{1}_{(t=2007/8)} + \delta_0 M_{ht} + \gamma_1 M_{ht} \mathbf{1}_{(t=2007/8)} + \varphi_1 X_{1iht} + \varphi_2 X_{2ht} + \varepsilon_{iht} \quad \text{(B3)}$$

Column 4 shows that having more rivals increases mortality before Choice for AMI (though the effect is significant only at 10%) and has no effect for hip fracture and stroke. Post Choice in 2007/8 market structure has no significant effect for any of the conditions. For AMI, the deleterious effect of more competitive market structure is significantly smaller in the post Choice period. For hip fracture and stroke it is insignificantly larger post Choice. The results for AMI are qualitatively similar to Gaynor et al (2013) [30] and compatible with there being a secular reduction in the effect of rivals over this period which is not caused by the introduction of Choice, as suggested by the results from our flexible specification.

[30] Results from the conventional DID specification are reported in an earlier version (Gaynor et al, 2011; Appendix Table A4, model (3)). There is an insignificant negative estimated effect of HHI in 2002/3 on 2002/3 AMI mortality of –0.622 (SE: 0.773) and a significant DID coefficient of 0.301 (SE: 0.117), so that the estimated effect of 2007/8 HHI on 2007/8 AMI mortality is –0.321, though the standard error in the latter is not reported so it is not possible to tell if it is significant.

Table B3. Market structure and Choice: difference in difference specification (Gaynor et al (2013))

	AMI	Hip Fracture	Stroke	AMI	Hip Fracture	Stroke
	(1)	(2)	(3)	(4)	(5)	(6)
2007 (β1)	-0.0170***	-0.0156**	-0.0167*	-0.0160***	-0.0156**	-0.0168*
	(-2.91)	(-2.54)	(-1.65)	(-2.77)	(-2.53)	(-1.67)
2007*Rivals 2003 (α)	-0.0058**	0.0013	0.0029			
	(-2.28)	(0.60)	(0.86)			
Rivals pre Choice (δ0)				0.0133*	-0.0020	-0.0068
				(1.94)	(-0.30)	(-0.63)
2007* Rivals (γ1)				-0.0067**	0.0014	0.0033
				(-2.54)	(0.58)	(0.91)
Rivals post Choice (δ0+γ1)				0.0066	-0.0007	-0.0034
				(1.18)	(-0.12)	(-0.39)
F-stat	41.77	11.52	68.60	42.19	11.42	68.17
Adjusted R^2	0.0481	0.0468	0.0916	0.0479	0.0471	0.0923
Patients	65384	18968	45744	67856	19668	47664
Sites	192	176	197	205	187	211

Notes. Dependent variable: patient aged 35-74 died in hospital within 30 days of admission. Market structure: Equivalent N rival sites = 1/(predicted HHI at 30 km). Specification (B2) for columns (1) to (3); specification (B3) for columns (4) to (6). All models include site fixed effects, patient and hospital covariates. t-statistics in parentheses; * p<0.1, ** p<0.05, *** p<0.01.

B3. Semi-flexible specification

Table B4 reports the effects of market structure from the semi-flexible specification in which the effects of covariates are constrained to be the same in all years:

$$q_{iht} = \beta_0 + \sum_{t' \neq 2005/6} \beta_{t'} \mathbf{1}_{(t=t')} + \delta_0 M_{ht} + \sum_{t' \neq 2005/6} \gamma_t M_{ht} \mathbf{1}_{(t=t')} + \varphi_1 X_{1iht} + \varphi_2 X_{2ht} + \mu_h + \varepsilon_{iht} \quad \text{(B4)}$$

Table B4 Year varying effects of market structure on mortality from semi flexible model

	AMI		Hip Fracture		Stroke	
	(1) Equivalent N rival sites 30km	(2) N. Rival sites 30km	(3) Equivalent N rival sites 30km	(4) N. Rival sites 30km	(5) Equivalent N rival sites 30km	(6) N. Rival sites 30km
Rivals 2002/3 (δ_0+γ_{02})	0.0011	0.0008*	0.0071**	0.0014***	-0.0034	-0.0001
	(0.5)	(1.87)	(2.14)	(2.72)	(-0.68)	(-0.16)
Rivals 2003/4 (δ_0+γ_{03})	0.003	0.0011**	0.0027	0.0015***	0.0015	-0.0003
	(1.18)	(2.18)	(1.07)	(2.73)	(0.31)	(-0.32)
Rivals 2004/5 (δ_0+γ_{04})	0.0021	0.0009**	0.0063**	0.0015***	0.0049	0
	(0.98)	(2.07)	(2.47)	(3.08)	(1.21)	(0.06)
Rivals 2005/6 (δ_0)	0.0007	0.0008**	0.0050**	0.0013***	0.0037	0.0000
	(0.35)	(2.09)	(2.17)	(3.10)	(0.99)	(0.03)
Rivals 2006/7 (δ_0+γ_{06})	-0.0004	0.0006	0.0029	0.0011***	0.0028	-0.0002
	(-0.23)	(1.57)	(1.34)	(2.64)	(0.8)	(-0.3)
Rivals 2007/8 (δ_0+γ_{07})	-0.0016	0.0005	0.0036*	0.0011***	0.0027	-0.0001
	(-0.8)	(1.29)	(1.89)	(2.64)	(0.71)	(-0.11)
Rivals 2008/9 (δ_0+γ_{08})	-0.0008	0.0006*	0.0018	0.0011**	0.0039	-0.0001
	(-0.48)	(1.67)	(0.84)	(2.54)	(1.06)	(-0.12)
Rivals 2009/10 (δ_0+γ_{09})	-0.0014	0.0006*	0.0023	0.001**	0.0059*	0.0002
	(-0.78)	(1.71)	(1.22)	(2.43)	(1.66)	(0.28)
Rivals 2010/11 (δ_0+γ_{10})	-0.0002	0.0005	0.0028	0.0009***	0.0033	-0.0001
	(-0.11)	(1.56)	(1.58)	(2.75)	(0.99)	(-0.19)
F-stat	82.87	85.71	35.01	35.48	129.11	131.82
Adjusted R^2	0.0405	0.0405	0.0472	0.0472	0.0888	0.0888
Patients	288287	288287	91005	91005	214103	214103
Sites	238	238	213	213	236	236

Notes. Dependent variable: patient aged 35-74 died in hospital within 30 days of admission. Equivalent N rival sites = 1/(predicted HHI). Years are financial years e.g. 2008 is April 2008 to March 2009. Years: 2002/3 to 20010/11. All models contain year effects, site fixed effects, patient and hospital covariates. Patient and hospital covariate effects are the same in all periods. Same number observations, clusters as Table 4. t-statistics in parentheses; * p<0.1, ** p<0.05, *** p<0.01.

Appendix C. Decomposition of change in mortality risk

In the text we use the fully flexible model for the decomposition of the change in average mortality probability between 2002/3 and 20010/11. In the estimated linear probability model the residuals sum to zero, so that the average mortality probability in year t (not the baseline year t = 0 = 2005/6) is

$$q_t = \frac{1}{N_t} \sum_{h\geq 1}^{H_t} \sum_{i=1}^{N_{ht}} \left\{ \hat{\beta}_0 + \hat{\beta}_t + \left(\hat{\delta}_0 + \hat{\gamma}_t \right) M_{ht} + \hat{\varphi}_t X_{iht} + \hat{\mu}_h \right\}$$

$$= \hat{\beta}_0 + \hat{\beta}_t + \left(\hat{\delta}_0 + \hat{\gamma}_t \right) \bar{M}_t + \hat{\varphi}_t \bar{X}_t + \bar{\hat{\mu}}_t \qquad \text{(C1)}$$

where we have collapsed the vectors of patient and site covariates X_{1iht}, X_{2ht} into a single vector and

$$\bar{\hat{\mu}}_t = \frac{1}{N_t} \sum_{h\geq 2}^{N_h^t} \sum_{i=1}^{N_{ht}^t} \hat{\mu}_h = \sum_{h\geq 2}^{N_h^t} \left(\frac{N_{ht}^t}{N_t} \right) \hat{\mu}_h \qquad \text{(C2)}$$

is the average difference between the fixed effect of hospital h and the baseline hospital 1.

Hence the decomposition of the change in average mortality probability between year 2002/3 and 2010/11 is

$$q_{10} - q_2 = \hat{\beta}_0 + \hat{\beta}_{10} + \left(\hat{\delta}_0 + \hat{\gamma}_{10} \right) \bar{M}_{10} + \hat{\varphi}_{10} \bar{X}_{10} + \bar{\hat{\mu}}_{10}$$

$$- \left[\hat{\beta}_0 + \bar{\hat{\mu}}_2 + \hat{\beta}_2 + \left(\hat{\delta}_0 + \hat{\gamma}_2 \right) \bar{M}_2 + \hat{\varphi}_2 \bar{X}_2 \right] \qquad \text{(C3)}$$

or

$q_{10} - q_{02}$	A: change in average mortality risk
$= \hat{\beta}_{10} - \hat{\beta}_{02}$	B: change in year effects
$+ \bar{\hat{\mu}}_{10} - \bar{\hat{\mu}}_2$	C: change in average site effects
$+ \left(\hat{\gamma}_{10} - \hat{\gamma}_{02} \right) \bar{M}_{10}$	D: change in effect of market structure
$+ \left(\hat{\delta}_0 + \hat{\gamma}_{02} \right) \left(\bar{M}_{10} - \bar{M}_{02} \right)$	E: change in average market structure
$+ \left(\hat{\varphi}_{10} - \hat{\varphi}_2 \right) \bar{X}_{10} + \hat{\varphi}_2 \left(\bar{X}_{10} - \bar{X}_{02} \right)$	F: change in effect of covariates and change in mean covariates

The decomposition is reported in Table 13.

Appendix D. Patient choice model results

Table D1 reports the results from the year specific Poisson models of patient choice of elective provider with the number of patients from LSOA j choosing provider h in year t having conditional mean

$$\mathrm{E}\left(n_{jht} \mid \xi_j, d_{jh}, X_{ht}\right) = \exp\left\{\xi_{jt} + \lambda_{1t} d_{jh} + \lambda_{2t} d_{jh}^2 + X_{ht}\lambda_t + d_{jh} X_{ht} \lambda_{1t}^X + d_{jh}^2 X_{ht} \lambda_{2t}^X\right\} \quad \text{(D1)}$$

where d_{jh} is the distance from the centroid of LSOA j to hospital site h and X_{ht} is a vector of dummies for hospital characteristics (NHS or private, belonging to a Foundation Trust, belonging to a teaching Trust).

Table D1. Poisson models of patient choice of elective provider

	2002	2003	2004	2005	2006	2007	2008	2009	2010
	coef	coef	coef	coef	coef	coef	coef	coef	coef
Distance	-0.2218***	-0.2221***	-0.2213***	-0.2187***	-0.1986***	-0.1988***	-0.1656***	-0.1686***	-0.1642***
Distance^2	0.0026***	0.0028***	0.0029***	0.0029***	0.0021***	0.0021***	0.0012***	0.0013***	0.0012***
Private Hospital	-4.3093***	-4.9789***	-4.3093***	-3.6677***	-3.1165***	-3.0299***	-2.5119***	-2.1926***	-2.0811***
Teaching Trust	0.2960***	0.1450***	-0.0055	-0.0971***	-0.1062***	-0.0641***	0.1288***	0.0069	-0.0743***
Specialist Hospital	-1.8382***	-1.9368***	-1.9708***	-1.9506***	-2.1845***	-2.2383***	-2.0953***	-2.1830***	-2.2349***
Multiservice Hospital	0.2706***	0.2596***	0.2979***	0.0198*	0.2331***	0.1581***	0.1302***	-0.0876***	-0.1708***
Site in London	0.3378***	0.3198***	0.2631***	0.1836***	0.2848***	0.3952***	0.5465***	0.6193***	0.6997***
Private Hospital * Distance	0.2036***	0.3126***	0.1261***	0.0415***	0.0776***	0.0694***	0.0331***	0.0400***	0.0278***
Teaching Trust * Distance	-0.0658***	-0.0610***	-0.0266***	-0.0141***	-0.0118***	-0.0264***	-0.0315***	-0.0225***	-0.0189***
Specialist Hospital * Distance	0.0799***	0.0944***	0.1050***	0.0928***	0.1139***	0.1040***	0.1010***	0.1017***	0.1057***
Multiservice Hospital * Distance	-0.0815***	-0.0717***	-0.0592***	-0.0296***	-0.0779***	-0.0724***	-0.0901***	-0.0667***	-0.0709***
Site in London * Distance	-0.1156***	-0.1110***	-0.1264***	-0.1350***	-0.1456***	-0.1494***	-0.1939***	-0.1972***	-0.1990***
Private Hospital * Distance^2	-0.0059	-0.0079***	-0.0015***	0.0004**	-0.0003**	-0.0001	0.0004***	-0.0002***	-0.0001
Teaching Trust * Distance^2	0.0025***	0.0024***	0.0016***	0.0014***	0.0013***	0.0018***	0.0011***	0.0011***	0.0012***
Specialist Hospital * Distance^2	-0.0008***	-0.0013***	-0.0016***	-0.0010***	-0.0015***	-0.0013***	-0.0015***	-0.0014***	-0.0014***
Multiservice Hospital * Distance^2	0.0032***	0.0022***	0.0031***	0.0025***	0.0039***	0.0035***	0.0039***	0.0032***	0.0035***
Site in London * Distance^2	0.0036***	0.0034***	0.0039***	0.0041***	0.0046***	0.0046***	0.0061***	0.0061***	0.0059***
Foundation Trust			-0.1177***	0.1303***	0.5184***	0.2881***	0.4379***	0.3984***	0.4569***
Foundation Trust * Distance			0.0145***	-0.0192***	-0.0696***	-0.0395***	-0.0785***	-0.0606***	-0.0562***
Foundation Trust * Distance^2			-0.0005***	0.0001**	0.0019***	0.0011***	0.0025***	0.0019***	0.0017***
Patients Group LSOAs	175946	184324	187504	197304	201694	213538	237493	243430	267771
LSOAs	29974	29436	29614	29740	29884	30669	30915	31108	31552
Chi^2 model	2187257	2202837	2065478	2196952	2380851	2759517	3177565	3240990	3558575
Efron R^2	0.249	0.2485	0.2493	0.2629	0.2592	0.2661	0.2411	0.2447	0.2426

Notes. Specification (20). All booked or waiting list patients treated in hospitals with at least 100 admissions per year and within 30km from LSOA of residence. Efron R^2 is the squared correlation between actual and predicted numbers choosing each site. *p<0.10, ** p<0.05, *** p<0.01