Do the poor cost much more?
The relationship between small area income deprivation and length of stay for elective hip replacement in the English NHS from 2001/2 to 2007/8

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Abstract:
Major reforms were introduced into the English NHS in the early to mid 2000s, helping to reduce waiting times and length of stay for elective surgery. One concern, however, is that efficiency-oriented reforms may harm equity by giving hospitals an incentive to select against socio-economically disadvantaged patients who stay longer and cost more to treat. This paper aims to assess the likely magnitude of any such selection incentive in the test case of hip replacement. Anonymous hospital records are extracted on all 235,813 patients admitted to English NHS Hospital Trusts for elective total hip replacement from 2001/2 through 2007/8. The relationship between length of stay and small area income deprivation is modelled using linear regression, allowing for other patient characteristics (age, sex, number and type of diagnoses, procedure type), year effects and Trust effects. Allowing for these factors, patients from the most deprived tenth of areas stayed 6% longer than others in 2001/2, falling to 2% by 2007/8. By comparison, patients aged 85 or over stayed 57% longer than others in 2001/2, rising to 71% by 2007/8, and patients with seven or more diagnoses stayed 58% longer than others in 2001/2, rising to 73% by 2007/8. Potential incentives for NHS hospitals to select hip replacement patients by deprivation status are comparatively small.

Keywords: Health Care Economics and Organizations, Hospital Costs, Length of Stay, Prospective Payment System, Socioeconomic Factors

1. Introduction

Inspired by ideas of "new public management", health system reforms often aim to improve productive efficiency in the delivery of health services by re-aligning provider incentives (Cutler 2002). Major health reforms introduced to the English NHS in the early to mid 2000s are a case in point. These reforms were introduced by a Labour administration led by Prime Minister Tony Blair and his Chancellor Gordon Brown, who subsequently became Prime Minister from 2007-10.

The "Blair/Brown" health reforms included waiting time targets for elective surgery, case based hospital payment, and new entry of private sector hospitals into the market for publicly funded NHS patients. A primary aim of these reforms was to give hospitals stronger incentives to reduce waiting times and length of stay for elective surgery. Both waiting times and length of stay did indeed fall substantially as the reforms were phased in and, at least in the case of waiting time targets, there is good research evidence that this was a causal effect: a well conducted difference-in-difference study using Scotland as a control group (Windmeijer et al. 2009).

Given the importance of equity goals to all publicly funded health systems, however, it is natural to be concerned about possible trade-offs between efficiency and equity. One such concern relates to potential perverse incentives in relation to hospital admission decisions. In theory, hospitals placed under pressure to reduce waiting times and increase patient throughput, within tight budget constraints, might respond not by improving productive efficiency but instead by selecting in favour of short-staying, low-cost patients ("cream skimming") and/or against long-staying, high-cost patients ("patient dumping"). If poor patients tend to stay much longer in hospital and cost much more to treat, hospitals might thereby face an incentive directly or indirectly to discriminate on the basis of socio-economic status (Tudor-Hart 2006, Cookson et al. in press).

For example, imagine a hospital orthopaedic department treats 200 elective hip replacement patients a year with average length of stay 5 days, plus 50 patients with average length of stay 10 days. If the hospital could somehow avoid treating the 50 long staying patients, this would release 500 bed days which could be put to alternative use – for example, in treating 100 additional short staying patients to reduce waiting times.

To influence hospital admission decisions, however, the predicted differentials in length of stay and cost would have to be substantial, given that social and professional norms of medical ethics militate against socio-economic and other forms of discrimination in health care. This paper therefore aims to provide some evidence, in the context of the English NHS, about whether socio-economically disadvantaged patients do indeed stay substantially longer in hospital than other patients.

Our paper does aim to measure actual selection behaviour by NHS hospitals or to identify whether the "Blair/Brown" health reforms led to increased selection behaviour. Our analysis cannot determine the magnitude of any pre-existing selection behaviour in 2001/2 or whether selection behaviour changed over time. Instead, our paper has the more modest aim of investigating the size of potential incentives for NHS hospitals to select against patients on the basis of deprivation, using length of stay differentials between different patient groups as a proxy for these potential incentives. We focus mainly on the year 2001/2, prior to the Blair/Brown health reforms which we hypothesise may have strengthened the link between length of stay differentials and both financial and non-financial selection incentives for NHS hospitals. We then also examine subsequent years, to see how these potential incentives have changed over time.

To avoid problems of case mix confounding when comparing length of stay between heterogeneous patients and treatment categories, we focus narrowly on the specific tracer procedure of elective primary total hip replacement. This is a good test case for our socio-economic patient selection hypothesis, because hip replacement is a common procedure with substantial length of stay and considerable clinical uncertainty about appropriate use. If efficiency-oriented health reforms generate substantial and widespread incentives for socio-economic patient selection, then one would expect to find such incentives in relation to hip replacement. Hip replacement is also a useful and well-studied tracer procedure for examining issues of health care inequality, and there is considerable evidence of pre-existing socio-economic inequality in use of hip replacement in the English NHS prior to the period under study in this paper (Cookson, Dusheiko and Hardman, 2007). Finally, hip replacement is also of interest in its own right, as a high volume procedure (the NHS does about 40 thousand elective primary total hip replacements a year – see table 2 below) with a high political profile during the period under consideration, due to severe waiting time problems and particular difficulty in meeting government waiting time targets.

We use anonymous patient level hospital records covering all NHS Hospital Trusts in England, including data on length of stay, small area deprivation, age, sex, number and type of diagnoses, type of procedure, and hospital of treatment. This includes almost all NHS funded operations – apart from the small fraction carried out under the "Independent Sector Treatment Centre" programme (see below) – but does not include privately funded operations. We use a small area level index of income deprivation as a proxy for socio-economic status, since routine patient level data on income and other aspects of socio-economic status are not available. We use patient level repeated cross section data for an unbalanced panel of all NHS Hospital Trusts followed for seven financial years 2001/2 through 2007/8, which enables us to examine how far the answer to our headline question changes over time throughout the reform period.

We find that patients from the most deprived decile of English small areas stay about 6% longer than other patients in 2001/2, falling to 2% by 2007/8. This differential is small compared with observed differentials in relation to age and co-morbidity. For instance, patients aged 85 or over stayed 57% longer than other patients in 2001/2, rising to 71% by 2007/8, and patients with seven or more diagnoses stayed 58% longer than other patients in 2001/2, rising to 73% by 2007/8. This suggests that, in relation to hip replacement surgery, the poor do not cost much more – but the very elderly and the very sick do.

2. Background

Two decades ago, following the introduction of the Medicare prospective payment system in 1983, a classic US study found that poorer patients stay longer in hospital and cost more to treat (Epstein, Stern and Weissman, 1990). That study of 16,908 patients admitted in 1987 to five

Massachusetts hospitals found that patients in the lowest third of socio-economic status (by patient level income, occupation and education) had between 3 to 30% longer stays and probably also required more resources, after adjusting for case-mix using Diagnosis Related Group (DRG), age, and severity. Unfortunately, however, it is not straightforward to generalise the findings from this US study to a different health system such as the present day English NHS, which has a different set of health care institutions, incentives and professional practice styles and which serves patients facing a different set of socio-economic conditions.

We examine a period of persistently falling length of stay, allowing us to examine whether length of stay declines at different rates across different socio-economic groups. This period encompasses the introduction of a number of reforms that have attracted international interest, including the following. First, an aggressive sequence of maximum waiting time targets for elective surgery coupled with sanctions for poorly performing managers: 18 months from outpatient consultation to inpatient treatment by March 2001 then falling by three months a year to 6 months by March 2005 and ultimately to 18 weeks from GP referral to inpatient treatment by December 2008 (Propper et al., 2008). Second, an ambitious system of fixed price hospital payment, following the US, Australia and several other mostly European countries (Street and Maynard, 2007). This was piloted in 2003/4 and 2004/5 for growth activity in some elective care – including hip replacement – and implemented fully for all elective care from 2005/6. Third, new non-public sector entry into the publicly funded NHS market for high volume, low risk elective hospital procedures under the “Independent Sector Treatment Centre” (ISTC) programme (Propper, Wilson and Burgess, 2006). ISTC activity comprised 0.07% of total NHS elective activity in 2003/4 rising to 0.66%, 0.92% and 1.20% in subsequent years to 2006/7, including 7% of elective hip replacement activity in 2006/7 (Audit Commission, 2008).

The English NHS fixed price hospital payment system is known as "Payment by Results", and uses a DRG-style system known as "Healthcare Resource Groups" (HRGs), which are baskets of clinically similar treatments with similar resource use. In 2007/8, the standard price for a cemented primary elective total hip replacement, code HRG 80, was £5,305 (Department of Health, 2007). This was a simple fixed price with no risk adjustment for pre-operatively observable cost drivers such as age, sex, and the number and type of secondary diagnoses; and no supplementary payment for post-operative complications requiring additional hospital resources. The only supplementary payment was a per diem payment of £222 for length of stay beyond a trim point of 16 days. This supplementary payment was intended to compensate for the extra costs of exceptionally long staying patients, without giving any incentive to increase length of stay.

Since the introduction of the NHS prospective payment system, the price of each elective and non elective procedure has been based on the national average cost of producing the corresponding HRG two years before, as reported by each hospital. Hospital costs are recorded in the national "Reference Cost" dataset, which supplies information on costs in every NHS Hospital Trust in England at level of HRG produced. This Reference Cost dataset is the most disaggregated level of information on hospital costs routinely collected in the NHS, and micro-costing data itemising resource use for individual patients is not available.

2. Methods

Regression analysis is used to examine the relationship between patient level length of stay and small area income deprivation, controlling for other factors. Patient level covariates include age, sex, number of diagnoses, type of diagnosis and type of hip replacement (with or without bone cement). Area income deprivation, age, and number of diagnoses were divided into ordered groups and modelled using dummy variables, to allow for non-linear relationships with length of stay. Age was divided into five age groups: age 45-54, 55-64, 65-74, 75-84 and 85+. Number of diagnoses was divided into seven groups: 1 through 6 diagnoses and 7 or more diagnoses.

We use three different models to allow for national time trends and heterogeneity in hospital level factors such as efficiency, clinical practice style and accounting practices:

- **Model (1):** Trust-year random effects OLS.
- **Model (2):** Trust level fixed effects OLS with year dummies.
- **Model (3):** Generalised Linear Model with gamma log link and Trust dummies.

Model (1) allows us to examine what proportion of the variance in length of stay is at hospital level (i.e. between hospitals) rather than patient level (i.e. within hospitals). The estimated fixed effects from model (2) are also used to examine whether hospitals that take a large percentage of their population from deprived areas tend to have longer stays after adjustment for patient level deprivation. Model (3) is used as a sensitivity analysis, to test the OLS assumption of asymptotic normality in our large sample. For each model, we run a single year regression for 2001/2 to examine the size of potential selection incentives at baseline in 2001/2, as well as a pooled regression 2001/2 to 2007/8 to see how far those potential incentives have changed over time.

We also conducted sensitivity analysis to test for possible age-deprivation and diagnosis-deprivation interactions. We exclude long-staying outliers with length of stay greater than 60 days, making up 1,023 cases or just over 0.4% of the total. In sensitivity analysis we include patients with length of stay no greater than 240 days (975 extra patients). The full results are available from the authors on request.

Trends in adjusted length of stay (Table 7) were obtained using the indirect standardization procedure described in O'Donnell et al. (2008). This allows us to purge the effect of confounders on length of stay (e.g. the patient's age or severity) without removing the influence of the key covariateof interest (i.e. socio-economic group) that might be correlated with the confounding variables.

3. Data

We use anonymous individual hospital records for all patients admitted for elective hip replacement in English NHS Hospital Trusts for each financial year from 2001/2 through 2007/8. We include all elective admissions involving primary total prosthetic replacement of the hip joint. The latter are identified under HRG H01, H02, H80, H81 and OPCS-4 codes W37.1, W38.1 and W39.1 as reported under the main operation of the first episode of care. These OPCS-4 codes represent the three main variants of this procedure – "using cement", "not using cement", and "not elsewhere classified". We exclude patients coming for revisions or conversions of previous hip operations as their length of stay might partially depend on the quality of care received in past admissions. We also exclude other types of hip replacement operation such as hybrid prosthetic replacements, resurfacings, and prosthetic replacement of the neck of femur.

We exclude from the analysis 7 NHS Hospital Trusts with a volume of activity lower than 25 hips operations per year (255 observations in 2001/2-2007/8). These are most likely hospitals that occasionally supply extra capacity to NHS trusts, since a regular orthopaedic speciality manages an average of 258 primary hip operations per year. Due to mergers, the number of NHS Hospital Trusts fell during the period from 166 in 2001/2 to 156 in 2002/3, then 154 in 2003/4, 149 in 2004/5 and finally down to 148 in 2006/7. We exclude activity from "Independent Sector Treatment Centres", which grew from 0% up to about 7% of NHS hip replacement activity from 2003/4 to 2006/7, due to substantially incomplete reporting of this data (Audit Commission, 2008). There are no publicly available data on privately funded hospital activity in England for the period under consideration. The most recent publicly available data is a sample survey in 1997/8, which found that private activity made up 22.5% of all elective total hip replacement activity in England (Williams et al., 2000).

Hospital records are extracted from the national "Hospital Episode Statistics" database as continuous inpatient spells (CIPS), which allow for transfers between different consultants both within the same hospital and between hospitals. The standard unit of activity available to users of the Hospital Episode Statistics database is the "finished consultant episode" (FCE). This is defined as the time the patient spends under the care of the same consultant. However, this can only measure length of stay for the period during which the initial hip replacement procedure is performed, before the patient is transferred to another consultant or hospital for any further treatment that may be necessary. The use of CIPS allows us accurately to measure length of stay for the full period of care from admission to discharge, including treatments for any complications following the first FCE and transfers to different providers of care. The computation of CIPS requires a complex matching algorithm (Lakhani et al., 2005). We use the CIPS matching algorithm set out in Castelli, Laudicella and Street (2008), pp 14-20 Section 2. A non-trivial proportion of elective hip replacement patients are transferred to another consultant or hospital: 5.5% of continuous inpatient spells with length of stay less than or equal to 60 days involved two or more finished consultant episodes, and 3.2 % involved a transfer to another hospital.

The number of diagnoses reported in the HES dataset runs from 1 to a maximum of 14 from 2002/3 onwards (though only a maximum of 7 diagnoses in 2001/2). Number of diagnoses is sometimes referred to as number of co-morbidities (Hamilton and Bramley-Harker, 1999). However, this indicator also includes diagnoses acquired during the first FCE of hospital stay, including any surgical complications and hospital acquired infections. So to some extent this indicator may pick up variations in quality of care, as well as variations in patient co-morbidity.

Small area income deprivation is measured at Lower Super Output Area (LSOA) level using the income deprivation domain of the English Indices of Multiple Deprivation 2004 (IMD 2004). There are 32,482 LSOAs in England with a mean population of about 1,500 individuals and a minimum of 1,000. The IMD 2004 income domain score indicates the proportion of the LSOA population in 2001 who were living in low income households reliant on one or more means tested benefits, based on population census and benefit claims data (Office of the Deputy Prime

Minister, 2004). The income domain score was divided into deciles based on the population of income deprivation scores for all English LSOAs, rather than the population of income deprivation scores for all NHS hip replacement patients in our study. A patient's deprivation decile thus reflects the degree of income deprivation in their neighbourhood relative to England as a whole, and is comparable from one year to another. Simply dividing the study population of hip replacement patients into ten equally sized groups by deprivation score yields a less general and less comparable indicator. The deprivation mix among hip replacement patients may differ from the deprivation mix among the general population, and may vary from one year to the next as a result of changes in hospital admission practices and other aspects of hospital supply and demand. In sensitivity analysis we check the robustness of our results using an alternative measure of LSOA level income deprivation: the income domain of the Index of Economic Deprivation 2008. This index provide a time varying measure of deprivation from 1999/2000 to 2005/6, but it measures deprivation only for people under 60 (Nobel et al. 2009).

4. Results

4.1 Descriptive statistics

Table 1 about here

Table 1 presents global descriptive statistics for the main variables used in regressions, across all seven years from 2001/2 to 2007/8, excluding patients with length of stay over 60 days. The median length of stay is 8 days for the whole period, with mean 9.08 days and standard deviation

5.81 days. The median age is 70, 38% of the patients are male, and 22% receive uncemented hip replacement. The median number of diagnoses is 2, with mean 2.56 and standard deviation 1.74.

Table 2 about here

Table 2 presents descriptive statistics on a year-by-year basis, for all patients and also comparing patients living in the most income deprived tenth of English small areas with other patients. There is a substantial decline over time in length of stay, with overall mean length of stay falling from 10.86 days in 2001/2 to 7.14 days in 2007/8. There is also a substantial increase in activity, with the total number of patients treated rising from 34,088 in 2001/2 to 41,561 in 2007/8.

Mean length of stay is higher in the deprived group than the non-deprived group in all years, though the absolute gap falls from 1.1 days in 2001/2 to only 0.33 days by 2007/8. The ratio between the two groups also declines, with length of stay about 10% higher in 2001/2 but only about 5% higher in 2007/8. Patients from the most deprived tenth of small areas make up about 6% of all patients for most of the period, though this jumps to 7% in 2007/8. This figure is smaller than 10% because patients from more deprived areas are less likely than other patients to receive a hip replacement (Cookson, Dusheiko and Hardman 2007).

The mean number of diagnoses increased throughout the period in both deprived and non-deprived groups, initially at a similar rate though more rapidly in the deprived group in 2005/6. The mean number of diagnoses in the most deprived group was only 1-4% higher between 2001/2 and 2004/5, though this jumps to 10-12% between 2005/6 and 2007/8. There was little difference between the two groups in the gender mix or the proportion of uncemented hip replacements, though the deprived group was on average about one year younger in 2001/2 and two years younger by 2007/8.

Interestingly, the total number of admissions peaks in 2003/4, falls slightly until 2006/7, then jumps back up again in 2007/8. This trend might be partially explained by the growing activity of NHS funded independent sector treatment centres (ISTCs), which become progressively operational in orthopaedic care from 2004/5 but then tailed off from 2007/8. This ISTC activity has been excluded from our dataset due to incomplete reporting.

Figure 1 about here

Figure 1 shows kernel density plots of length of stay for patients in 2001/2, comparing patients living in the most income deprived fifth of English small areas versus others. It is clear that the vast majority of patients stay less than 20 days, though there is a long thin tail of outlier long-staying patients. Patients from income deprived areas stay somewhat longer than others, with a larger proportion in the 5-10 day range and a smaller proportion in the 10-20 day range. There appears to be relatively little difference in the proportion of long staying outlier patients in the two groups. The differences in mean length of stay observed in table 2 thus do not appear to be driven by a small number of outlier patients.

Table 3 about here

Table 3 presents unadjusted mean length of stay by income deprivation tenths for each financial year from 2001/2 through 2007/8, together with the standard deviation and the proportion of patients in each group. The absolute gap in length of stay between the most and least deprived groups fell from 1.5 days to 0.8 days between 2001/2 and 2007/8. The ratio also fell a little: mean length of stay was about 14% higher for patients in the most deprived tenth of small areas than patients in the least deprived tenth in 2001/2, falling to about 12% higher by 2007/8. The standard deviation of length of stay is also slightly higher in the more deprived groups, suggesting slightly higher risk. Again, however, the differentials are not large: 22% in 2001/2 and 26% in 2007/8.

Tables 4 and 5 about here

Tables 4 and 5 present unadjusted means and standard deviations in length of stay by age group and number of diagnoses group. The differences in both means and standard deviations between these age and diagnosis groups are considerably larger than those between deprivation groups. For instance, patients aged 85 or older stay 97% longer than patients age 45-54 in 2001/2, with a standard deviation 154% higher, rising to 123% longer with a standard deviation 183% higher by 2007/8. And patients with seven or more diagnoses stay 71% longer than patients with only one diagnosis in 2001/2, with a standard deviation 112% higher, rising to 106% longer with a standard deviation 149% higher by 2007/8.

We now turn to the regression analysis, to examine how far these unadjusted relationships are modified after adjusting for other patient characteristics and Trust level factors.

4.2 Regression analysis

Table 6 about here

Table 6 presents the regression results from models 1, 2 and 3 as applied to data from our baseline year of 2001/2. All three models show a similar pattern and magnitude of results. The results from OLS models 1 and 2 are easy to interpret, as each coefficient represents an absolute difference in mean length of stay in days compared with the relevant comparator group. The results of model 3 are mainly of interest as a sensitivity analysis, and give us confidence about the large sample asymptotic normality assumption underlying OLS models 1 and 2. The coefficients of model 3 can be interpreted as percentage changes in mean length of stay compared with the mean, and so to compare them with the OLS coefficients they can be multiplied by the mean length of stay of 9 days.

We prefer fixed effects model 2 to random effects model 1, for two main reasons. First, our main interest lies in estimating individual level associations between deprivation and length of stay, after controlling for hospital level factors, rather than estimating hospital level associations after controlling for individual level factors (Rice and Jones 1997). Second, the estimates from model 1 may be slightly biased due to correlation between patient characteristics and hospital random effects, as suggested by the variance decomposition analysis presented below. So in what follows we focus on the results from fixed effects model 2.

In fixed effects model 2, after controlling for patient characteristics (age, sex, number and type of diagnoses, uncemented procedure or not), patients from the least deprived tenth of areas on average stay 0.9 days less than patients from the most deprived tenth of areas in 2001/2. This is smaller than the corresponding 1.5 day unadjusted gap between most and least deprived decile groups, and is only slightly larger than the adjusted 0.8 day gap between men and women.

The gap in length of stay between most and least deprived decile groups rises to 1.0 days in random effects model 1. Estimates from model 1 are influenced by variation between hospitals, as well as variation between patients, and so this suggests that Hospital Trusts with above-average lengths of stay tend to admit a slightly above-average proportion of income deprived patients – an issue explored further below.

Age group and diagnosis group remain substantially more powerful determinants of length of stay after adjusting for other factors. In fixed effects model 2, the adjusted length of stay gap between patients aged 85 and over and patients aged 45-54 in 2001/2 is 7.74 days (slightly lower than the unadjusted gap of 8.39 days), and the adjusted gap between patients with 7 or more diagnoses and one diagnosis is 7.18 days (slightly higher than the unadjusted gap of 7.00 days).

In sensitivity analysis, there were no significant, substantial or systematic interactions between age and deprivation or between diagnosis group and deprivation.

Figure 2 about here

Figure 2 shows mean length of stay by deprivation group and year after adjusting for age, number and type of diagnoses, procedure type, and hospital level factors using fixed effects model 2 as applied to pooled data from 2001/2 to 2007/8. The lines show a shallow adjusted gradient in length of stay from first to tenth income deprivation groups, for each of the years. The lines also illustrate the persistent year-on-year falls in length of stay throughout the period, each one of which is larger than the corresponding year's length of stay gap between most and least deprived decile groups. That is, for any given year, the average difference in length of stay between most and least deprived decile groups is smaller than the average difference in length of stay between this year and next year.

Table 7 about here

Table 7 shows adjusted length of stay differentials by year, for deprivation, age and co-morbidity using fixed effects model 2. Unlike the figures in tables 3, 4 and 5, these adjusted figures allow for correlations between deprivation, age, co-morbidity. For example, deprivation differentials in Table 7 show the gap in average length of stay between top and bottom deprivation deciles after purging heterogeneity in age, sex, number and type of diagnoses across the two groups. This is the difference in length of stay that one would observe if all the confounding characteristics (i.e. age, sex, number and type of diagnoses) were the same across socio-economic groups. Trends in table 7 allow for the fact that deprived and elderly people may also tend to have more diagnoses – and attempt to identify a "purer" association purged of the influence of these other factors.

These adjusted figures show that patients in the most deprived decile group stay about 6% longer than other patients in 2001/2, falling to 2% longer by 2007/8. Whereas patients aged 85 or over stay 57% longer than patients aged 45-54 in 2001/2, rising to 71% longer in 2007/8. And patients with seven or more diagnoses stayed 58% longer in 2001/2, rising to 73% longer by 2007/8. In each case, of course, the absolute length of stay differentials fell over time in line with the general year-on-year fall in length of stay.

Figure 3 about here

Figures 3 and 4 present predictions from fixed effects model 2 as applied to 2001/2. Figure 3 shows the adjusted relationships between length of stay, age group and income deprivation decile. Although there is a deprivation gradient in length of stay within each age group, this gradient is dwarfed by the larger differences between age groups.

Figure 4 about here

Figure 4 shows the predicted relationships between length of stay, number of diagnoses and deprivation decile group. Again, the deprivation gradient within each diagnosis group is dwarfed by the larger differences between diagnoses groups.

Table 8 about here

Table 8 presents a decomposition of hospital level and patient level variance from fixed effects model 2 applied to pooled data from years 2001/2 through 2007/8. This shows that only about 5% or less of the variance is at hospital level in each of the years. For instance, in a model with patient characteristics, only 4.8% of the variance is at hospital level in 2001/2, falling slightly to 4.5% in 2007/8. However, the corresponding figures are slightly higher (5.2% and 4.1%, respectively) in a model without patient characteristics. This difference suggests that one of the independence assumptions of the random effects model is violated: there is a degree of systematic variation between Trusts in the characteristics of patients treated.

Figure 5 about here

Finally, figure 5 presents a scatterplot of the hospital fixed effects from model 2, with confidence intervals, against the mean deprivation score of patients treated by each hospital. The fixed effects can be interpreted as hospital level differences in mean length of stay after adjusting for deprivation and other patient characteristics. There is a slight suggestion of a positive association, suggesting that hospitals treating more deprived patient populations tend to have longer lengths of stay, even after allowing for the composition of their patient populations. However, this association is largely driven by four outlier hospitals with relatively high mean patient deprivation scores, so must be interpreted with caution.

5. Conclusion

On average, NHS elective hip replacement patients living in more income deprived areas of England do stay slightly longer in hospital than patients living in less income deprived areas.

However, this association is small. Age and co-morbidity are considerably more powerful determinants of length of stay for elective total hip replacement than small area deprivation.

This is clearly illustrated in table 7, which compares patients with the relevant “high risk” characteristic (i.e. age over 85, seven or more diagnoses, and the most deprived tenth) with all other patients, after adjusting for other patient characteristics using our preferred fixed effects model 2. This is perhaps the most appropriate comparison for an unscrupulous hospital manager interested to know how large a saving in length of stay could be made by selecting against (or “dumping”) patients with that particular “high risk” characteristic and instead treating other patients. After adjusting for other patient characteristics, patients over 85 stayed 6.06 days longer than other patients in 2001/2 – i.e. 57% longer. Patients with seven or more diagnoses stayed 6.23 days longer than other patients in 2001/2 – i.e. 58% longer. Whereas patients from the most deprived decile group of small areas only stayed 0.62 days longer than other patients – i.e. 6% longer.

Table 7 also shows that the absolute differentials fell during the period 2001/2 to 2007/8, in line with general year-on-year reductions in length of stay. Interestingly, however, the relative differential fell to 2% by 2007/8 in the case of deprivation, whereas the relative differentials for age and co-morbidity grew during this period (to 71% and 73% respectively). This suggests that NHS hospitals have been relatively successful in reducing length of stay for long staying patients such as the elderly and those with severe, multiple co-morbidities. In relative terms, however, this means that age and co-morbidity are even more powerful determinants of length of stay in 2007/8 than they were in 2001/2; and small area deprivation even less powerful.

One reason that people from deprived areas stay slightly longer in hospital on average than others is that they may have more co-morbidity – such as obesity, heart conditions, and other health problems – and hence take longer to recover. Our regression analysis partly allows for this, by controlling for the number and type of diagnoses. However, we do not allow for the severity of co-morbidity. Other possible reasons are that patients from deprived areas may have less pleasant and supportive household environments to return to, and there may be socio-cultural factors relating to patient and professional behaviour, such as the quality of communication and diagnosis and patient adherence to medication and recovery regimes.

Our main conclusion is that deprivation differentials in length of stay are small compared with differentials associated with age and co-morbidity. There may be incentives for NHS hospitals under pressure to cut waiting times to avoid offering elective hip replacements to very elderly patients and patients with substantial co-morbidity. However, any incentives to avoid offering elective hip replacements to patients from deprived areas appear negligibly small. In the case of elective hip replacement, the poor cost a bit more – but not much more.

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Table 1: Global descriptive statistics for key variables (pooled across all years)

Variables	Obs	Mean	Std. Dev.	Median	Min	Max
Patient length of stay (days)	274,679	9.08	5.81	8	0	60
Patient male or not	274,669	0.38	0.49	0	0	1
Patient age	274,679	69.64	9.42	70	45	103
Patient area income deprivation score	274,679	0.12	0.10	0	0	0.96
Patient number of diagnoses	274,679	2.56	1.74	2	1	14
Patients receiving uncemented hip (rather than cemented)	274,679	0.22	0.42	0	0	1
Hospital Trust total activity 2001-2007	184	1,500	1,068	1,473	37	5,141
Hospital Trust total activity by year	184	258	150	229	25	900

Table 2: Descriptive statistics for key variables by year and deprivation group (most deprived decile group versus others)

Variables		2001	2002	2003	2004	2005	2006	2007
Mean length of stay (days)	(1) Most deprived (*)	11.90	11.25	10.49	9.92	9.34	8.42	7.45
	(2) Others	10.79	10.45	9.68	9.23	8.56	7.78	7.12
	(3) All	10.86	10.50	9.73	9.27	8.61	7.82	7.14
	gap (1) - (2)	1.11	0.80	0.81	0.69	0.78	0.64	0.33
	ratio (1) / (2)	1.10	1.08	1.08	1.07	1.09	1.08	1.05
Patients treated	(1) Most deprived (*)	2,095	2,287	2,365	2,239	2,328	2,191	3,105
	(2) Others	31,993	35,457	38,652	37,926	38,431	37,154	38,456
	(3) All	34,088	37,744	41,017	40,165	40,759	39,345	41,561
	ratio (1) / (3)	0.06	0.06	0.06	0.06	0.06	0.06	0.07
Mean age	(1) Most deprived (*)	68.40	67.81	68.24	68.23	68.23	68.35	67.86
	(2) Others	69.40	69.46	69.55	69.86	69.88	70.06	69.89
	(3) All	69.34	69.36	69.48	69.76	69.79	69.96	69.74
	gap (1) - (2)	-1.00	-1.65	-1.32	-1.63	-1.65	-1.71	-2.03
	ratio (1) / (2)	0.99	0.98	0.98	0.98	0.98	0.98	0.97
Mean number of diagnoses	(1) Most deprived (*)	2.27	2.29	2.39	2.62	2.98	3.14	3.19
	(2) Others	2.19	2.24	2.33	2.59	2.67	2.82	2.90
	(3) All	2.19	2.24	2.33	2.59	2.69	2.84	2.92
	gap (1) - (2)	0.08	0.06	0.07	0.02	0.31	0.32	0.29
	ratio (1) / (2)	1.04	1.02	1.03	1.01	1.12	1.11	1.10
Proportion male	(1) Most deprived (*)	0.354	0.374	0.360	0.378	0.372	0.375	0.372
	(2) Others	0.385	0.387	0.388	0.382	0.377	0.377	0.378
	gap (1) - (2)	-0.031	-0.013	-0.028	-0.004	-0.005	-0.002	-0.006
	ratio (1) / (2)	0.920	0.966	0.929	0.990	0.988	0.994	0.985
Proportion of uncemented hips	(1) Most deprived (*)	0.11	0.11	0.15	0.18	0.23	0.32	0.36
	(2) Others	0.11	0.13	0.15	0.20	0.25	0.32	0.37
	gap (1) - (2)	-0.01	-0.02	-0.01	-0.02	-0.02	0.00	-0.01
	ratio (1) / (2)	0.95	0.84	0.96	0.91	0.94	1.00	0.96

Note: (*) = patients resident in the most income deprived 10% of Engish small areas

Table 3: Mean and standard deviation of length of stay by small area deprivation group

Deprivation decile groups		2001	2002	2003	2004	2005	2006	2007
1 - Least deprived	mean length of stay (days)	10.42	9.81	9.19	8.75	8.16	7.47	6.65
	standard deviation	5.49	5.34	5.22	5.43	5.33	4.93	4.14
	% of patients within year	12%	12%	12%	12%	13%	13%	6%
2	mean length of stay (days)	10.29	10.00	9.48	8.90	8.29	7.50	6.82
	standard deviation	5.40	5.50	5.54	5.70	5.50	4.95	5.05
	% of patients within year	8%	8%	8%	9%	8%	8%	6%
3	mean length of stay (days)	10.39	10.11	9.37	8.94	8.24	7.55	6.82
	standard deviation	5.26	5.75	5.55	5.54	5.27	4.84	4.58
	% of patients within year	8%	8%	8%	9%	9%	9%	8%
4	mean length of stay (days)	10.56	10.38	9.45	9.06	8.47	7.61	7.05
	standard deviation	5.66	5.91	5.37	5.80	5.64	5.13	5.08
	% of patients within year	14%	14%	14%	15%	15%	15%	15%
5	mean length of stay (days)	10.74	10.36	9.70	9.28	8.53	7.72	7.12
	standard deviation	5.89	5.70	5.85	5.73	5.81	5.21	5.08
	% of patients within year	11%	11%	11%	11%	11%	11%	13%
6	mean length of stay (days)	10.99	10.62	9.87	9.44	8.75	7.84	7.02
	standard deviation	6.10	6.25	5.90	6.19	5.83	5.28	5.06
	% of patients within year	12%	12%	12%	11%	11%	11%	13%
7	mean length of stay (days)	11.09	10.77	9.98	9.60	8.91	8.13	7.39
	standard deviation	6.21	6.43	6.04	6.16	6.17	5.61	5.62
	% of patients within year	11%	11%	11%	11%	10%	11%	12%
8	mean length of stay (days)	11.48	11.05	9.94	9.55	8.80	8.01	7.32
	standard deviation	6.70	6.38	5.81	6.03	5.68	5.72	5.36
	% of patients within year	10%	10%	9%	9%	9%	9%	11%
9	mean length of stay (days)	11.19	11.08	10.31	9.72	9.06	8.45	7.54
	standard deviation	6.14	6.29	6.14	5.93	6.02	5.88	5.56
	% of patients within year	8%	8%	8%	8%	8%	8%	9%
10 - Most deprived	mean length of stay (days)	11.90	11.25	10.49	9.92	9.34	8.42	7.45
	standard deviation	6.71	6.16	5.93	6.01	6.33	5.59	5.21
	% of patients within year	6%	6%	6%	6%	6%	6%	7%
Gap in means (10) - (1)		1.48	1.44	1.29	1.18	1.18	0.95	0.80
Gap in standard deviations (10) - (1)		1.22	0.82	0.71	0.58	1.00	0.66	1.07
Ratio of means (10) / (1)		1.14	1.15	1.14	1.13	1.14	1.13	1.12
Ratio of standard deviations (10) / (1)		1.22	1.15	1.14	1.11	1.19	1.13	1.26

Note: Deprivation decile groups represent tenths of small area deprivation among the general population, rather than among the study population of hip replacement patients.

Table 4: Mean and standard deviation of length of stay by age group

Age group		2001	2002	2003	2004	2005	2006	2007
(1) 45-54	mean length of stay (days)	8.64	8.39	7.73	7.24	6.78	6.15	5.57
	standard deviation	3.92	3.95	3.50	3.51	3.90	3.19	3.19
	% of patients within year	7%	7%	6%	6%	6%	6%	7%
(2) 55-64	mean length of stay (days)	9.11	8.73	8.00	7.58	6.94	6.37	5.72
	standard deviation	3.91	3.91	3.60	3.97	3.65	3.33	3.11
	% of patients within year	23%	23%	22%	21%	22%	22%	22%
(3) 65-74	mean length of stay (days)	10.20	9.87	9.15	8.58	7.91	7.07	6.47
	standard deviation	4.78	4.97	4.85	4.79	4.49	4.03	4.04
	% of patients within year	38%	38%	40%	40%	39%	39%	38%
(4) 75-84	mean length of stay (days)	12.81	12.52	11.61	11.05	10.29	9.34	8.62
	standard deviation	7.06	7.23	6.95	6.87	6.85	6.38	6.15
	% of patients within year	27%	27%	27%	28%	28%	28%	28%
(5) 85+	mean length of stay (days)	17.02	16.20	15.42	15.34	14.22	12.99	12.42
	standard deviation	9.97	9.33	8.91	9.90	9.79	9.11	9.01
	% of patients within year	5%	4%	4%	4%	5%	5%	5%
Gap in means (5) - (1)		8.39	7.81	7.69	8.11	7.44	6.84	6.85
Gap in standard deviations (5) - (1)		6.05	5.38	5.41	6.40	5.89	5.92	5.82
Ratio of means (5) / (1)		1.97	1.93	1.99	2.12	2.10	2.11	2.23
Ratio of standard deviations (5) / (1)		2.54	2.36	2.55	2.82	2.51	2.85	2.83

Table 5: Mean and standard deviation of length of stay by number of diagnoses group

Number of diagnoses group		2001	2002	2003	2004	2005	2006	2007
(1) 1 diagnosis	mean length of stay (days)	9.82	9.51	8.81	8.30	7.44	6.69	5.96
	standard deviation	4.78	4.83	4.46	4.74	4.40	3.94	3.68
	% of patients w ithin year	44%	44%	41%	34%	32%	28%	27%
(2) 2 diagnoses	mean length of stay (days)	10.48	10.05	9.10	8.58	7.90	7.07	6.31
	standard deviation	5.23	5.33	4.82	4.88	4.68	4.25	3.79
	% of patients w ithin year	24%	23%	24%	24%	23%	24%	23%
(3) 3 diagnoses	mean length of stay (days)	11.43	10.93	10.00	9.31	8.56	7.71	6.92
	standard deviation	6.27	5.96	5.82	5.58	5.26	4.85	4.38
	% of patients w ithin year	15%	15%	16%	18%	18%	19%	20%
(4) 4 diagnoses	mean length of stay (days)	12.43	11.87	11.05	10.16	9.39	8.26	7.58
	standard deviation	6.91	6.77	6.61	6.64	6.18	5.10	5.17
	% of patients w ithin year	8%	8%	9%	11%	12%	13%	13%
(5) 5 diagnoses	mean length of stay (days)	13.61	12.87	12.07	11.20	10.41	9.29	8.74
	standard deviation	8.43	7.58	7.79	7.34	7.03	6.20	6.56
	% of patients w ithin year	4%	4%	5%	6%	7%	7%	8%
(6) 6 diagnoses	mean length of stay (days)	14.92	14.98	13.29	11.98	11.44	10.31	9.49
	standard deviation	8.67	9.32	8.49	7.81	7.95	7.22	6.99
	% of patients w ithin year	2%	2%	2%	3%	4%	4%	4%
(7) 7 diagnoses	mean length of stay (days)	16.82	17.31	16.11	14.35	14.31	12.90	12.28
	standard deviation	10.10	11.03	10.46	9.65	10.03	9.60	9.17
	% of patients w ithin year	2%	2%	2%	3%	4%	5%	5%
Gap in means (7) - (1)		7.00	7.80	7.30	6.05	6.87	6.21	6.33
Gap in standard deviations (7) - (1)		5.33	6.20	6.00	4.91	5.62	5.66	5.49
Ratio of means (7) / (1)		1.71	1.82	1.83	1.73	1.92	1.93	2.06
Ratio of standard deviations (7) / (1)		2.12	2.28	2.35	2.04	2.28	2.44	2.49

Table 6: Length of stay regression results

	(1)	(2)	(3)
Dependent variable: length of stay (days)	OLS RE	OLS FE	GLM gamma
least deprived decile	-1**	-.909**	-.074**
	(.19)	(.192)	(.0155)
2nd deprivation decile	-1.02**	-.925**	-.0809**
	(.181)	(.183)	(.0146)
3rd deprivation decile	-1.02**	-.924**	-.0781**
	(.177)	(.178)	(.0141)
4th deprivation decile	-.886**	-.793**	-.0653**
	(.166)	(.167)	(.0133)
5th deprivation decile	-.757**	-.671**	-.0534**
	(.185)	(.187)	(.0144)
6th deprivation decile	-.651**	-.577**	-.046**
	(.172)	(.173)	(.014)
7th deprivation decile	-.583**	-.51**	-.0395**
	(.168)	(.168)	(.0132)
8th deprivation decile	-.241	-.18	-.0112
	(.176)	(.175)	(.0137)
9th deprivation decile	-.516**	-.475**	-.0328**
	(.161)	(.159)	(.0126)
male	-.796**	-.796**	-.0773**
	(.0681)	(.0681)	(.00571)
age 55-64	.451**	.445**	.0496**
	(.078)	(.0779)	(.00875)
age 65-74	1.38**	1.38**	.149**
	(.088)	(.0885)	(.00927)
age 75-84	3.69**	3.68**	.349**
	(.123)	(.123)	(.0121)
age 85 plus	7.75**	7.74**	.624**
	(.264)	(.265)	(.018)
2 diagnoses	.683**	.71**	.0674**
	(.0788)	(.0798)	(.00714)
3 diagnoses	1.51**	1.54**	.139**
	(.112)	(.114)	(.00975)
4 diagnoses	2.41**	2.46**	.214**
	(.17)	(.171)	(.0137)
5 diagnoses	3.6**	3.67**	.296**
	(.301)	(.303)	(.02)
6 diagnoses	4.9**	5.01**	.396**
	(.427)	(.431)	(.0276)
7 diagnoses	7.03**	7.18**	.529**
	(.539)	(.536)	(.0309)
uncemented hip	.189	.212	.0231*
	(.117)	(.122)	(.0112)
rheumatoid arthritis, unspecified	1.64**	1.63**	.143**
	(.352)	(.352)	(.0276)
arthritis, unspecified	.476	.483	.035
	(.399)	(.401)	(.0316)
primary generalized (osteo)arthrosis	-.488	-.467	-.0269
	(.4)	(.424)	(.0343)
polyarthrosis, unspecified	-.791	-.954	-.0965*
	(.452)	(.647)	(.0452)
primary coxarthrosis, bilateral	-.183	-.167	-.0104
	(.164)	(.172)	(.0145)
other primary coxarthrosis	-.366*	-.356*	-.033**
	(.144)	(.16)	(.0127)
other secondary coxarthrosis	-.198	-.151	-.0207
	(.441)	(.511)	(.0448)
other primary gonarthrosis	-.0811	-.0777	-.00656
	(.342)	(.35)	(.029)
gonarthrosis, unspecified	.46	.467	.0381
	(.367)	(.367)	(.0306)
arthrosis, unspecified	.255	.226	.0133
	(.575)	(.618)	(.0554)
pain in joint	.285	.26	.0309
	(.249)	(.254)	(.0218)
osteonecrosis, unspecified	-.564	-.578	-.0481
	(.591)	(.59)	(.0485)
others	.89**	.864**	.0731**
	(.223)	(.228)	(.0183)
Constant	9.07**	8.83**	2.26**
	(.221)	(.209)	(.0145)
Observations	34086	34086	34086
166 Hospital random effects	yes		
166 Hopspital Fixed effects		yes	yes

Notes:
(1) Robust standard errors in parentheses
(2) ** p<0.01, * p<0.05
(3) The reference group is patients living in most deptived 10% of English LSOA, year 2001, age 45-54, female, cemented hip, one diagnosis at the admission, primary diagnosis: unspecified coxarthrosis.

Table 7: Adjusted length of stay differentials by year
(adjusted for other patient covariates and hospital fixed effects using model 2)

	2001	2002	2003	2004	2005	2006	2007
(1) Most deprived decile	11.43	10.90	10.15	9.61	9.01	8.08	7.25
(2) Others	10.81	10.46	9.70	9.24	8.58	7.79	7.13
Gap: (1)-(2)	0.62	0.44	0.45	0.37	0.43	0.29	0.13
Ratio: (1)/(2)	1.06	1.04	1.05	1.04	1.05	1.04	1.02
(1) age 85 and over	16.62	15.62	14.87	14.88	13.82	12.45	11.81
(2) Others	10.56	10.25	9.50	9.01	8.33	7.55	6.89
Gap: (1)-(2)	6.06	5.37	5.37	5.87	5.48	4.89	4.92
Ratio: (1)/(2)	1.57	1.52	1.56	1.65	1.66	1.65	1.71
(1) 7 diagnoses or more	16.96	17.36	15.98	14.15	14.01	12.55	11.91
(2) Others	10.73	10.33	9.56	9.09	8.39	7.57	6.88
Gap: (1)-(2)	6.23	7.02	6.42	5.06	5.62	4.99	5.03
Ratio: (1)/(2)	1.58	1.68	1.67	1.56	1.67	1.66	1.73

Table 8: Patient level versus hospital level variance in length of stay

	2001	2002	2003	2004	2005	2006	2007
Model without patient characteristics							
Proportion of variance at hospital level	5.2%	4.2%	5.2%	4.8%	4.3%	4.0%	4.1%
Patient level (within hospitals) variance	33.14	34.04	30.78	33.01	30.99	26.31	24.81
Hospital level (between hospitals) variance	1.83	1.50	1.70	1.66	1.39	1.10	1.05
Model with patient characteristics							
Proportion of variance at hospital level	4.8%	4.8%	5.8%	5.1%	4.8%	4.2%	4.5%
Patient level (within hospitals) variance	27.39	28.15	25.55	27.56	25.72	21.66	20.22
Hospital level (between hospitals) variance	1.39	1.42	1.57	1.49	1.29	0.95	0.96

Note 1: Estimates were obtained from the RE OLS model described in Table 6. The model was estimated separately each year on a balanced panel of 129 hospitals which were not involved in

Note 2: LR test rejects the null hypothesis that the between hospitals variance is zero.

Figure 1: Patient length of stay in 2006/7, comparing patients in the most deprived decile group of areas versus others (Kernel density plot, truncated at 60 days)

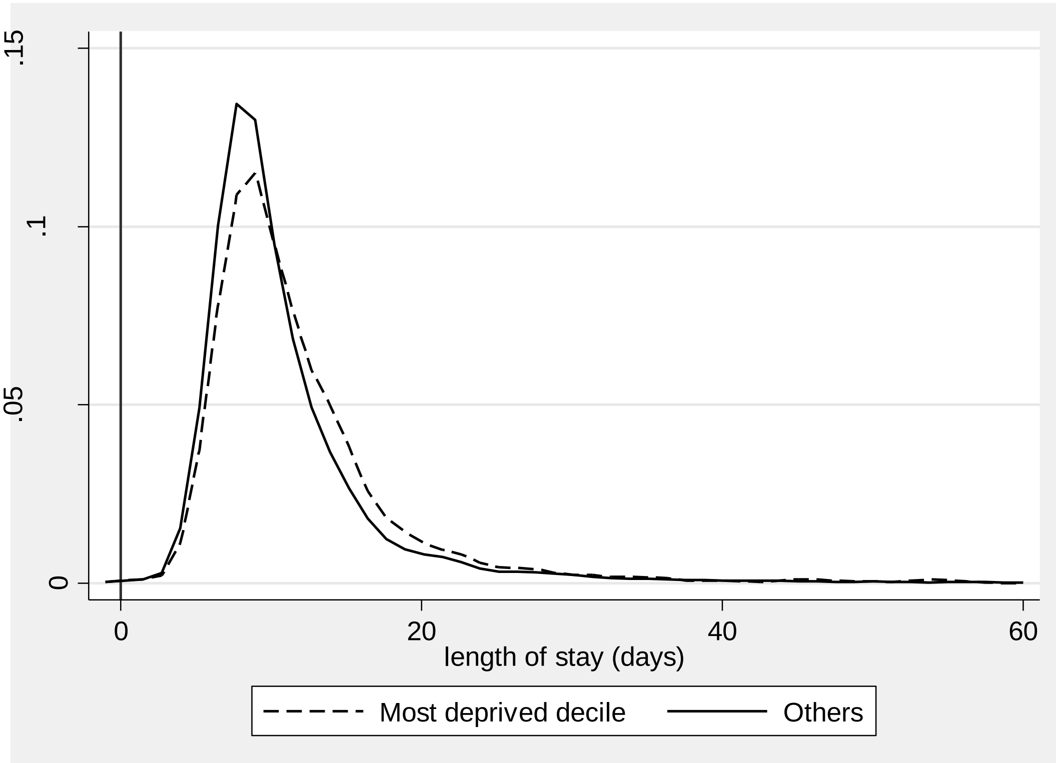

Figure 2: Adjusted mean length of stay by small area income deprivation decile group by financial year from 2001/2 to 2006/7 (adjusted for other patient covariates and hospital fixed effects using model 2)

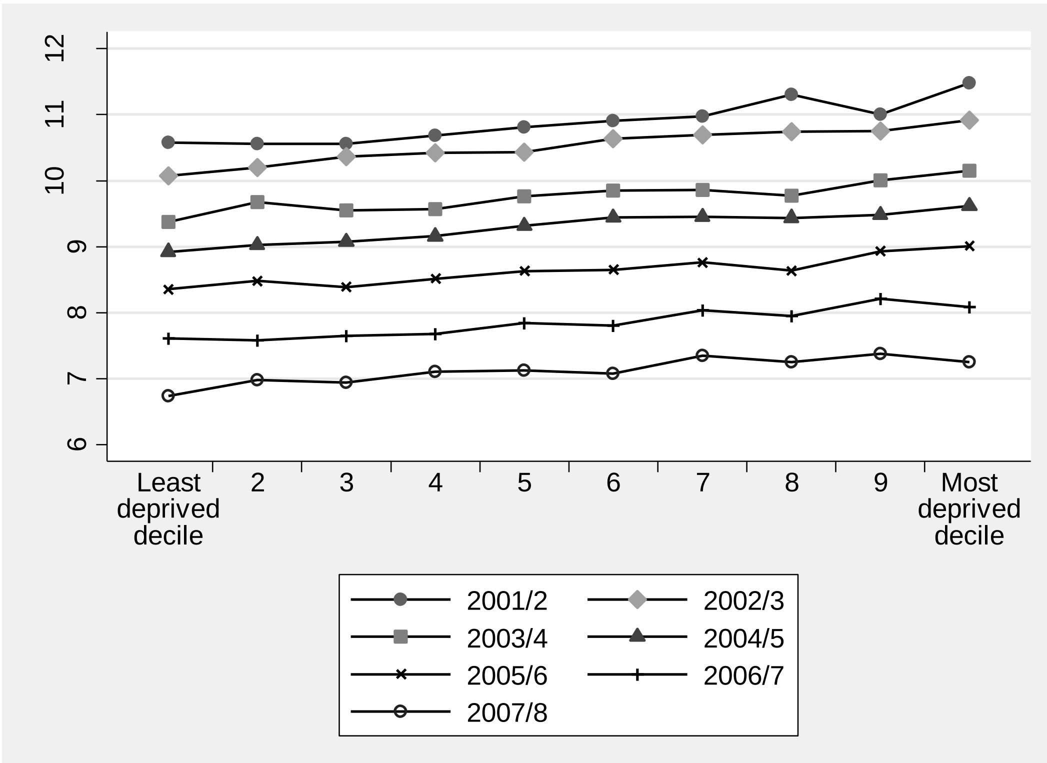

Figure 3: Adjusted mean length of stay by age group and deprivation decile in 2001/2 (adjusted for other patient covariates and hospital fixed effects using model 2)

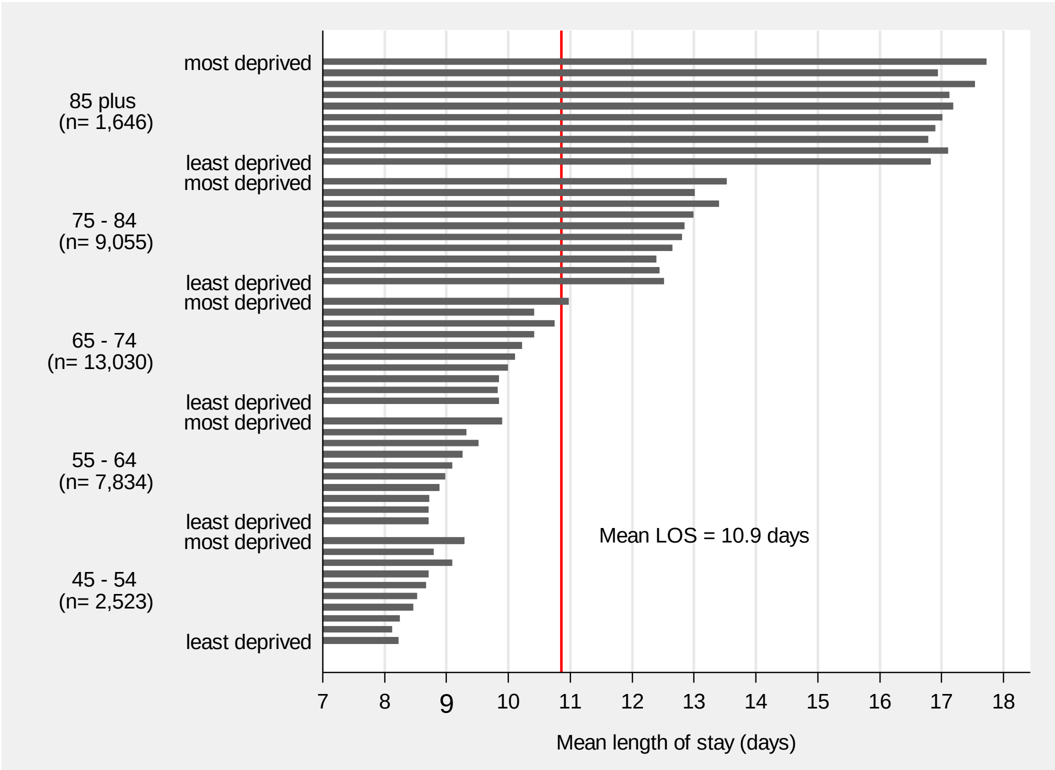

Figure 4: Adjusted mean length of stay by number of diagnoses and deprivation decile (adjusted for other patient covariates and hospital fixed effects using Model 2)

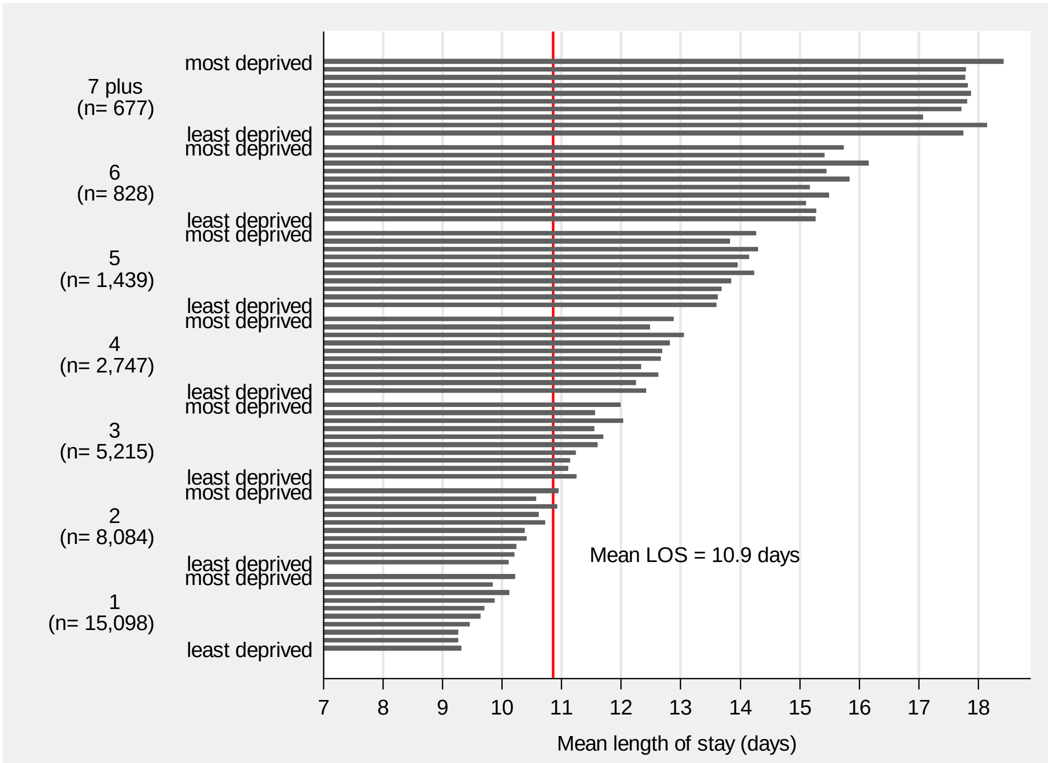

Figure 5: Trust level relationship between the mean deprivation score of patients and mean length of stay, after adjusting for patient covariates and fixed effects using Model 1