Do the poor still cost more? The relationship between small area income deprivation and length of stay for elective hip replacement in the English NHS from 2001/2 to 2006/7

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Abstract:
This paper examines whether hospital patients living in low income areas of England cost more to treat, using elective hip replacement as a tracer procedure and length of stay as a proxy for cost. Hospital Episode Statistics are used to construct a patient-level repeated cross-section dataset, covering all 235,813 patients admitted to English NHS Hospital Trusts for elective hip replacement in financial years 2001/2 through 2006/7. A new algorithm is used to compute Continuous Inpatient Spells, which track length of stay for the whole period of care, including any transfers between consultants and hospitals. Linear regression is used to model the relationship between length of stay and small area income deprivation, controlling for patient need covariates (age, sex, number of diagnoses), time trends and interactions, and Trust fixed effects to allow for supply factors such as hospital efficiency and practice style. Allowing for these factors, patients living in the most income deprived fifth of lower layer super output areas stay 0.62 days longer than others. This relationship has not changed despite a substantial decline in average length of stay. However, the most important determinants of length of stay are age and number of diagnoses. Under the current NHS fixed price payment system, there are financial incentives for NHS hospitals to avoid offering elective hip replacements to patients over 75, patients with substantial co-morbidity and, to a lesser extent, patients from low income areas.

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

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1. Introduction

The relationship between socio-economic status and treatment cost is of interest in all publicly funded health systems responsible for delivering socio-economic equality of access. It is of particular interest in the English NHS, which has recently introduced a case-based prospective payment system of fixed hospital prices per patient treated, following the US, Australia and several other mostly European countries (Street and Maynard 2007). If patients from low socio-economic groups stay longer in hospital and cost more to treat than others, and yet attract the same fixed price payment, then hospitals may have a financial incentive to delay, dilute, divert or deny their treatment.

Two decades ago, following the introduction of the Medicare prospective payment system in 1983, a classic US study found that the poor do indeed cost more (Epstein, Stern and Weissman 1990). This 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.

The present study aims to collect evidence on this issue using routine patient level hospital records covering all NHS Hospital Trusts in England – but not NHS funded activity performed by the private sector. We use length of stay as a proxy for cost, since detailed micro-costing data is not routinely available. 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 is not available. We use patient level repeated cross section data for a panel of all NHS Hospital Trusts followed for six financial years 2001/2 through 2006/7, which enables us to examine how far the answer to our headline question persists or changes over time.

We focus on the tracer procedure of elective hip replacement, which is a good clear indicator procedure for our headline question because it has (i) substantial length of stay, (ii) a simple fixed price with no risk adjustment for age, sex or severity of illness, and (iii) considerable evidence of pre-existing socio-economic inequality in use of care prior to the introduction of fixed price payment (Cookson, Dusheiko and Hardman 2007). Hip replacement is also of interest in its own right, as a high volume procedure 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.

2. Background

This six year period we examine is interesting for two reasons. First, it is a period of persistently falling length of stay. This allows us to examine whether length of stay declines at different rates across different socio-economic groups. Second, this period encompasses the introduction of a number of policy initiatives that have attracted international interest, including the following. First, an aggressive sequence of maximum waiting time targets for first elective hospital admission coupled with sanctions for poorly performing managers: 18 months by March 2001 then falling by three months a year to 6 months by March 2005 (Propper et al. 2008). Second, from 2001/2, the targeting of additional health care resources (about half of one percent of total health expenditure) to areas with the largest avoidable mortality, initially through the NHS resource allocation formula then from 2004/5 in a separately funded initiative known as the "Spearhead Group" (Smith 2008 and Department of Health 2004). Third, an ambitious system of fixed price hospital payment, 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 (Street and Maynard 2007). Fourth, substantial private sector entry into the publicly funded NHS market for high volume, low risk elective hospital procedures – including hip replacement – with a first wave in 2003/4 and smaller subsequent waves in 2004/5 and 2005/6 (Propper, Wilson and Burgess 2006).

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). In 2006/7, the simple price for elective hip replacement, HRG 80, was £5,176. This was a simple fixed price with no risk adjustment for observable cost drivers such as age, sex, and number of diagnoses; and no supplementary payment for complications requiring additional hospital resources. The only supplementary payment was a per diem payment of £217 for length of stay beyond a trim point of 16 days. This supplementary payment aims to compensate for the extra costs of exceptionally long staying patients, without giving any incentive to increase length of stay. By comparison, the Personal Social Services Research Unit estimate a somewhat higher cost per bed day of £233 - a weighted average of all patient rehabilitation stays excluding patients with brain injuries (Curtis 2007).

This HRG price is based on data from the national “Reference Cost” dataset, which supplies data on costs in every NHS Hospital Trust in England. This data is derived from a top down decomposition of the total costs borne by each Trust following specific accountancy guidelines. 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

Linear regression is used to examine the relationship between patient level length of stay and small area income deprivation, controlling for observed patient level need covariates (age, sex and number of diagnoses), with year dummies to allow for time trends and NHS Hospital Trust level fixed effects to allow for organisation-specific supply factors such as hospital efficiency and practice style. To allow for non-linear relationships with length of stay, area income deprivation, age, and number of diagnoses were divided into ordered groups and modelled using dummy variables. Area income deprivation was divided into deciles (i.e. ten equally sized groups ordered from most to least deprived). 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.

A number of different models were explored in sensitivity analysis, to examine how far cross-sectional relationships changed over time, and to check for possible age-deprivation interactions and diagnosis-deprivation interactions.

The main models explored in sensitivity analysis have the following covariates:

- **Model A1 (time trend only):** deprivation decile, year dummies, deprivation decile * year
- **Model A2 (year interactions only):** deprivation decile, year dummies, sex, deprivation decile * year, age group (using five age groups:, age group * year, diagnosis group (with seven groups:, diagnosis group * year

- **Model A3 (deprivation interactions only)**: deprivation decile, year dummies, sex, age group, diagnosis group, diagnosis group * deprivation decile, age group * deprivation decile.
- **Model A4 (no interactions):** deprivation decile, year dummies, sex, age group, diagnosis group
- **Model A5 (year interactions only, with fewer deprivation and diagnosis groups):** deprivation group (with only two categories: the most deprived fifth versus others), diagnosis group (with only three categories: 1, 2 and 3 or more diagnoses), age group, sex, deprivation group * year, age group * year, and diagnosis group * year.

In Models A2 and A3, there are too many interaction terms to display on a single page – for instance, the deprivation * diagnosis interaction alone produces 54 coefficients (nine deprivation dummies each multiplied by six diagnosis group dummies). We therefore used the information from Models A2 and A3 to develop Model A5 as a simplified model for presentational purposes. Model A5 strikes a balance between keeping the number of coefficients small enough to present on a single page, while still illustrating all the most important and significant patterns in the data. Even with Model 5, fitting the results on a single page still requires us to suppress interaction terms of limited interest (age * year interactions for 2002 through 2004 and diagnosis group * year interactions for 2002 through 2004 and for 2 diagnoses). The full results are available from the authors on request.

All regressions apply patient level importance weights based on global total elective hip replacement activity for the NHS Hospital Trust of treatment.

We exclude long-staying outliers with length of stay greater than 60 days, making up 1,265 cases or just over half of 1% of the total.

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 2006/7. These 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). 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 during which the patient remains in hospital, including treatment for any complications. The computation of CIPS requires a complex matching algorithm. We use a new CIPS matching algorithm developed and tested by one of the authors (ML), which improves upon the algorithm used by Lakhani et al (2005). The new algorithm, and the rigorous process of validation it has undergone, is detailed 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: 6.01% of continuous inpatient spells with length of stay less than or equal to 60 days involved two ore more finished consultant episodes, and 3.9% involved a transfer to another hospital.

Patient covariates include age, sex and the total number of diagnoses at the time of admission to hospital (including secondary diagnoses as well as the primary diagnosis of osteoarthritis). The number of diagnoses runs from 1 to a maximum of 12 from 2002/3 onwards (though only a maximum of 7 diagnoses in 2001/2) and we interpret this as an indicator of co-morbidity. Individual socio-economic status is proxied using the small area income deprivation index from the 2004 Index of Multiple Deprivation: the proportion of residents claiming low income benefits within each lower super output area (LSOA). There are 32,378 LSOAs in England with a mean population of 1,500 individuals and a minimum of 1,000.

Due to mergers, the number of NHS Hospital Trust organisations fell during the period from 167 in 2001/2 to 155 in 2002/3, then 155 in 2003/4, and finally down to 151 in 2006/7. We constructed a frozen 2006/7 NHS Trust variable, which does not change from year to year, by matching patients to 2006/7 NHS Trust organisational boundaries (i.e. the name of the Trust in 2006/7). This allows us to specify time-invariant frozen 2006/7 NHS Hospital Trust level fixed effects which do not vary from year to year, on the assumption that professional practice styles, hospital buildings and facilities, and other organisational level influences on length of stay do not change rapidly from one year to another, even after a merger. We also use time-varying dummies for actual NHS Hospital Trusts in sensitivity analysis.

4. Results

4.1 Descriptive statistics

Table 1 presents global descriptive statistics for the main variables used in regressions. The median length of stay across all patients is 8 days, with mean 9.5 days and standard deviation 6.02 days. The median age is 70, 38% of the patients are male, and the median number of diagnoses is 2, with mean 2.82 and standard deviation 2.65. Continuous inpatient spells involving more than one finished consultant episode make up 6.01% of the total number with length of stay of 60 days or less.

Figure 1 shows a histogram of length of stay for all patients in 2006/7, truncated below 60 days. It is clear that the vast majority of patients stay between 3 and 30 days, though there is a long thin tail of outlier long-staying patients, some of whom stay considerably longer than this (including four who stayed longer than a year).

Table 2 presents mean length of stay by year and deprivation group (most deprived 20% by IMD area income deprivation score versus others). Length of stay falls year-on-year in both groups at a similar rate, though slightly more rapidly in the most deprived group. The most income deprived fifth of patients stay longer than other patients by about 9% in 2001/2 (equivalent to 1.02 days) falling to about 6% in 2006/7 (equivalent to 0.53 days).

Table 3 presents mean length of stay by income deprivation deciles for each financial year from 2001/2 through 2006/7. The absolute gap in length of stay between the most and least income deprived deciles fell substantially from 1.6 days to 0.8 days between 2001/2 and 2006/7. However, the ratio between the two remained constant at about 1.1 in each year. Length of stay thus remained about 10% higher in the most deprived decile than the least deprived decile throughout the six year period.

Figure 2 illustrates the same information in a line chart. The lines show little difference in length of stay among the first four income deprivation deciles (the least deprived part of the distribution), but a clear upward “social gradient” thereafter. In each year, length of stay increases fairly consistently from the fifth through tenth deciles of income deprivation.

We now turn to the regression analysis, to see how far these descriptive associations are modified after controlling for other determinants of length of stay – i.e. patient need covariates and organisation-level supply factors – that may vary with area deprivation.

4.2 Regression analysis

Table 4 presents the main regression results from Model A5. After controlling for patient need factors (age, sex and number of diagnoses) and organisation-level supply factors (Trust level fixed effects), patients from the most income deprived fifth of areas stay 0.62 days longer than other patients. This figure does not change significantly across the six years: none of the coefficients on deprivation * year interactions are significant. The magnitude of this association is comparable to that of gender, with women staying 0.68 days longer than men.

The largest determinants of length of stay are age group and diagnosis group. In the reference year of 2001/2, patients age 75-84 stayed on average 3.639 days longer than patients age 45-54, and patients age 85 or above stayed 7.725 days longer. The magnitude of these associations fell slightly over time, and by 2006/7 had fallen to 3.009 days (3.639 minus 0.630) and 6.621 days (7.725 minus 1.104) respectively. Turning to diagnosis group, in 2001/2 patients with three or more diagnoses stayed on average 2.509 days longer than those with only one diagnosis, falling to 1.897 days (2.509 – 0.612) by 2006/7. This pattern of results is consistent with the findings from the other regression models A1 to A4.

Model A3 found no significant, substantial or systematic interactions between age and deprivation or between diagnosis group and deprivation.

Figures 2 and 3 present predictions from Model A2 in graphical form. This is the full version of Model A5, with ten income deprivation groups (rather than two) and seven diagnosis groups (rather than three). Figure 2 shows the model predicted relationships between length of stay, age group and income deprivation decile. Age is a larger determinant of length of stay than deprivation, especially for age 75-85 and age 85 plus. However, there is nevertheless a fairly smooth “social gradient” within each age group, as length of stay increases with each income deprivation decile.

Figure 3 shows the predicted relationships between length of stay, diagnosis group (with three groups: 1, 2 and 3 or more diagnoses), and income deprivation decile. Diagnosis group is also a larger determinant of length of stay than deprivation. Again, however, there is a fairly smooth "social gradient" within each diagnosis group.

Figure 5 shows the distribution of frozen 2006/7 NHS Hospital Trust fixed effects on length of stay, ranked from the lowest (-2.95 days) to highest (+3.33 days).

Finally, figure 6 shows mean length of stay by deprivation and year, after adjusting for age, sex and number of diagnoses using Model A4 (with no interaction terms). This shows a declining absolute gap in length of stay between patients living in deprived and non-deprived areas declines over time. However, as the regression coefficients make clear, this decline is driven by a diminution in role of age and number of diagnoses as drivers of length of stay. The "pure" association between area-based income deprivation and length of stay, purged of the changing role of patient need covariates over time, has remained constant at an absolute difference of 0.62 days between deprived and non-deprived groups.

5. Discussion

On average, elective hip replacement patients living in more income deprived small areas of England stay longer in hospital than patients living in other areas. For instance, without allowing for other factors, patients in the most deprived decile of areas stay on average 10% longer than patients living in the least deprived decile, or 0.8 days in 2006/7. Between 2001/2 and 2006/7, observed length of stay declined at a similar rate across all area income deprivation groups. This has resulted in declining absolute gaps in length of stay between income deprivation groups, even though the corresponding ratios have not changed much.

The most important determinants of length of stay for hip replacement remain age and number of diagnoses, although the strength of these associations has declined slightly in recent years. In 2006/7, patients with three or more diagnoses stayed 1.90 days longer than those with only one diagnosis, after controlling for other factors. Patients aged 75-84 stayed 3.00 days longer than those aged 45-54, and patients aged 85 plus stayed 6.62 days longer.

Patients living in the most income deprived fifth of areas of England stay on average 0.62 days longer than patients in other areas, after controlling for organisation-level supply factors, sex, age and number of diagnoses – including the somewhat reduced effect of the latter two factors over time. This underlying relationship between area-based income deprivation and length of stay has not changed over time from 2001/2 to 2006/7, despite a substantial decline in the average length of stay over the period from 10.95 days to 7.91 days.

Under the current NHS fixed price payment system, therefore, there are financial incentives for NHS hospitals to avoid offering elective hip replacements to patients over 75, patients with substantial co-morbidity and, to a lesser extent, patients from low income areas.

One reason for a significant association between length of stay and area income deprivation is that people in income deprived areas tend to 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 patient's number of diagnoses. However, we do not allow for the type or severity of co-morbidity. Another reason may be that patients from deprived areas may have less pleasant and supportive household environments to return to. Finally, there may also be socio-cultural factors relating to patient and professional behaviour, such as the quality of communication and diagnosis and patient adherence to medication and physical recovery regimes.

Whatever the reasons, there is a clear and statistically significant positive association between length of stay and area-based income deprivation. This association remained remarkably stable from 2001/2 to 2006/7, despite substantial falls in length of stay across all patient groups. The poor, it would seem, still cost more.

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

Variable	mean	median	min	max	sd	N
Patient length of stay (days)	9.52	8	0	60	6.06	235,813
Patient age	69.64	70	45	103	9.42	235,760
Patient male or not	0.38		0	1		235,773
Patient number of diagnoses	2.83	2	1	82	2.65	235,813
Patient area income deprivation score	0.098	0.064	0.003	0.786	0.09	235,813
Hospital Trust total activity 2001-2006	1,570.05	1,443	213	4,307	863.77	151
Hospital Trust total activity by year	234.00	261.7	4	905	154.07	906

Table 2: Descriptive statistics for key variables by year and deprivation group (most deprived 20% of IMD income deprivation score versus others)

Variable	Deprivation group	2001/2	2002/3	2003/4	2004/5	2005/6	2006/7
Mean length of stay (days)	**(1) non-deprived**	10.78	10.42	9.70	9.27	8.59	7.80
	(2) deprived	11.62	11.27	10.31	9.87	9.17	8.39
	gap (2) - (1)	0.84	0.85	0.61	0.60	0.58	0.59
	ratio (2) / (1)	1.08	1.08	1.06	1.07	1.07	1.08
Mean age	**(1) non-deprived**	69.50	69.47	69.61	69.95	70.03	70.18
	(2) deprived	68.83	68.99	69.01	69.05	68.85	69.05
	gap (2) - (1)	-0.67	-0.48	-0.60	-0.90	-1.18	-1.12
Proportion male (%)	**(1) non-deprived**	0.39	0.39	0.39	0.39	0.38	0.38
	(2) deprived	0.37	0.37	0.37	0.36	0.37	0.36
	gap	-0.02	-0.02	-0.02	-0.02	-0.01	-0.02
Mean number of diagnoses	**(1) non-deprived**	2.44	2.60	2.68	2.95	2.99	3.13
	(2) deprived	2.50	2.64	2.69	2.98	3.20	3.43
	gap (2) - (1)	0.07	0.05	0.01	0.03	0.20	0.30
	ratio (2) / (1)	1.03	1.02	1.00	1.01	1.07	1.10
Mean area income deprivation score (%)	**(1) non-deprived**	0.07	0.06	0.06	0.06	0.06	0.06
	(2) deprived	0.27	0.26	0.26	0.24	0.24	0.24
	gap (2) - (1)	0.20	0.20	0.19	0.19	0.18	0.18
Total number of patients treated		34,632	38,173	41,486	40,547	41,210	39,765

Note
"deprived" is the most deprived fifth of patients by area-based income deprivation; "non-deprived" is all other patients

Table 3: Mean length of stay by financial year and small area income deprivation decile

	2001/2	2002/3	2003/4	2004/5	2005/6	2006/7
Least deprived decile 1	11.0	10.3	9.6	9.5	8.6	8.0
2	10.9	10.7	10.2	9.5	8.8	8.0
3	10.9	10.6	10.1	9.5	8.9	8.0
4	11.3	10.9	10.0	9.8	8.9	7.9
5	11.0	11.0	10.3	9.7	9.0	8.2
6	11.5	11.2	10.7	10.0	9.2	8.3
7	11.7	11.5	10.4	10.2	9.5	8.5
8	12.1	11.3	10.8	10.2	9.4	8.7
9	12.0	11.9	10.8	10.3	9.5	8.6
Most deprived decile 10	12.6	11.9	11.2	10.5	10.0	8.8
Gap (10) - (1)	1.6	1.5	1.6	1.1	1.4	0.8
Ratio (10) / (1)	1.1	1.1	1.2	1.1	1.2	1.1

Table 4: Length of stay regression results (Model A5)

Dependent variable: length of stay (days)	Coefficient	Standard error
deprived (most deprived 20% of IMD income domain)	0.620***	(0.149)
2 or more diagnoses	0.614***	(0.132)
3 or more diagnoses	2.509***	(0.186)
male	-0.683***	(0.0369)
year_2002	-0.236	(0.150)
year_2003	-0.865***	(0.169)
year_2004	-1.418***	(0.187)
year_2005	-1.849***	(0.198)
year_2006	-2.571***	(0.180)
age 55-64	0.268***	(0.0837)
age 65-74	1.185***	(0.0969)
age 75-84	3.639***	(0.161)
age 85 plus	7.725***	(0.349)
deprived * year_2002	-0.0809	(0.146)
deprived * year_2003	-0.271*	(0.156)
deprived * year_2004	-0.230	(0.202)
deprived * year_2005	-0.313	(0.200)
deprived * year_2006	-0.250	(0.176)
age 55-64 * year_2005	-0.155	(0.148)
age 55-64 * year_2006	0.00383	(0.126)
age 65-74 * year_2005	-0.305*	(0.168)
age 65-74 * year_2006	-0.364***	(0.136)
age 75-84 * year_2005	-0.518**	(0.252)
age 75-84_* year_2006	-0.630***	(0.203)
age 85plus * year_2005	-0.518	(0.528)
age 85 plus * year_2006	-1.104**	(0.450)
3 or more diagnoses * year_2005	-0.415*	(0.249)
3 or more diagnoses * year_2006	-0.612***	(0.223)
constant	8.153***	(0.128)
Observations (individual patients)	235,773	151
Number of Frozen 2005/6 Trusts (fixed effects)	151	0.159
R-squared	0.159	

Notes

(1) *** p<0.01, ** p<0.05, * p<0.1

(2) Reference category: year 2001/2, female, age 45-54, not deprived, one diagnosis, average hospital

(3) Hospital fixed effects and interaction terms of limited interest have not been displayed

Figure 1: Histogram of patient length of stay in 2006/7 (truncated at 60 days)

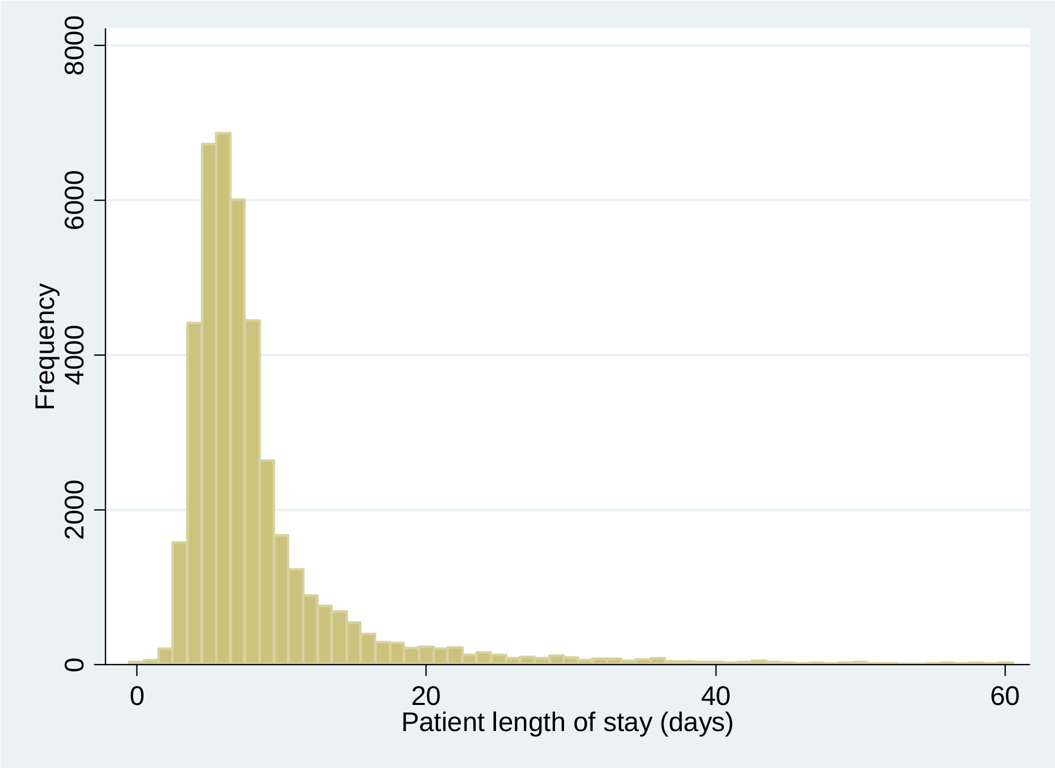

Figure 2: Mean length of stay by small area income deprivation decile for each financial year from 2001/2 to 2006/7

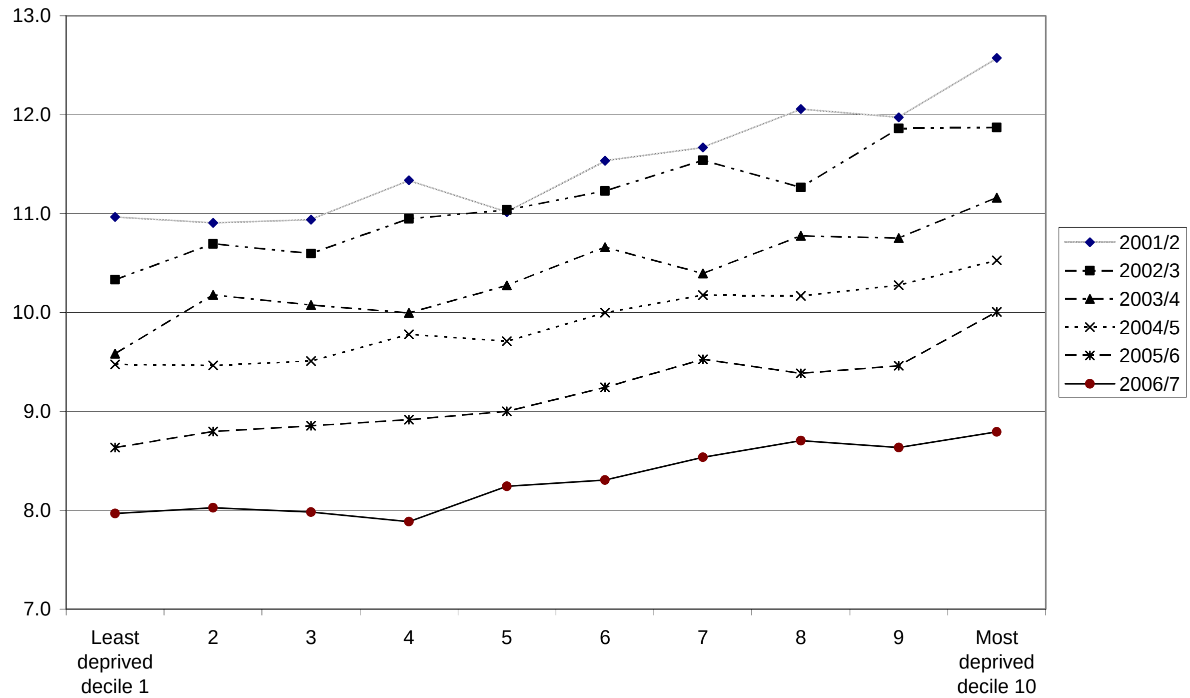

Figure 3: Modelled length of stay by age group and income deprivation decile (Model A2)

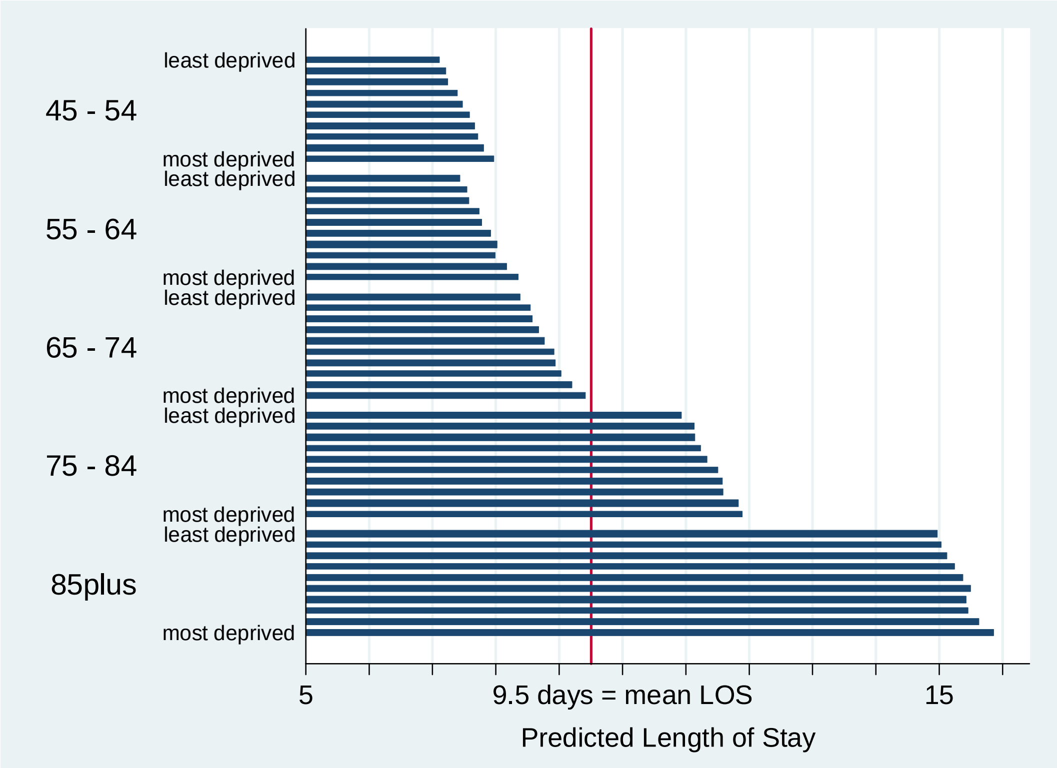

Figure 4: Modelled length of stay by number of diagnoses and income deprivation decile (Model A2)

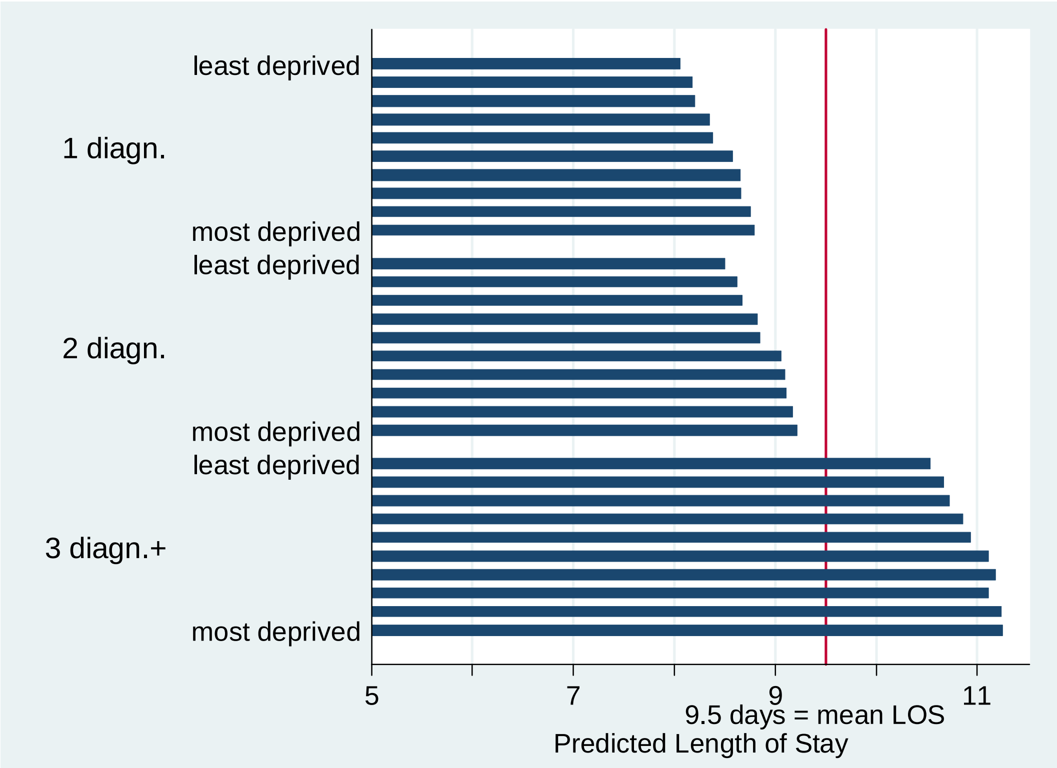

Figure 5: Distribution of 151 frozen 1996/7 Hospital Trust fixed effects on length of stay, ranked from lowest to highest

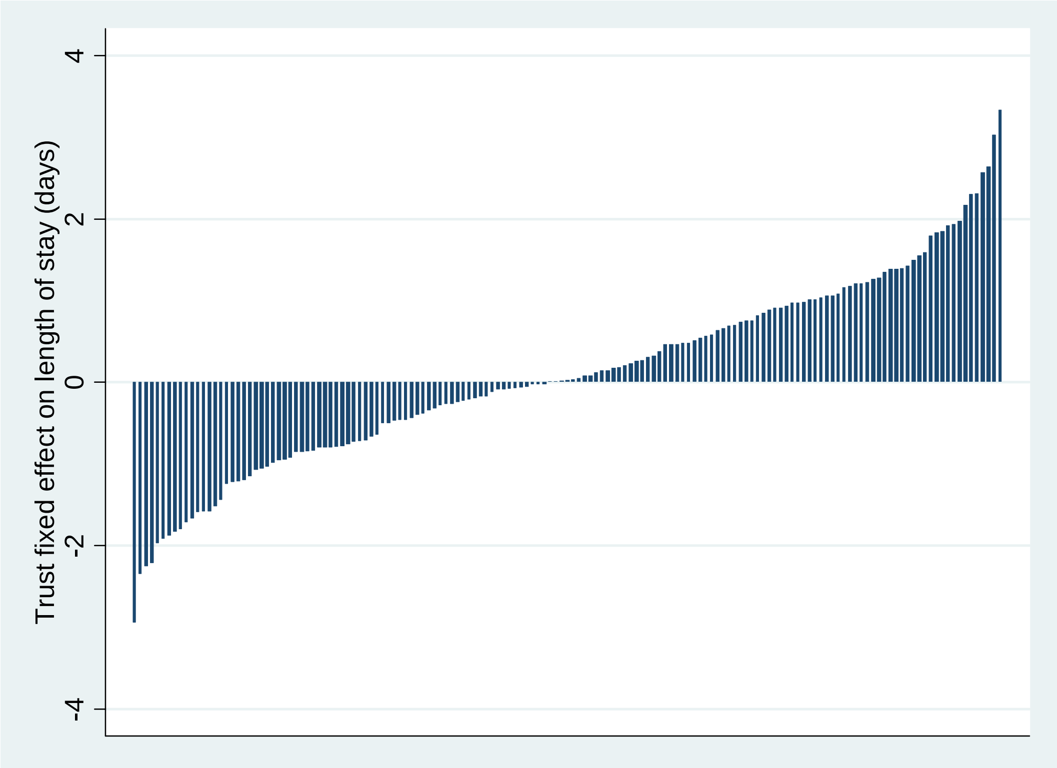

Figure 6: Length of stay by deprivation and year (standardised for age, sex and number of diagnoses using Model A4)