THE UNIVERSITY of York

ESHCRU Economics of Social and Health Care Research Unit

CHE Centre For Health Economics

Estimating the Costs of Specialised Care: Updated Analysis Using Data for 2009/10

CHE Research Paper 71

Estimating the Costs of Specialised Care: Updated Analysis Using Data for 2009/10

Silvio Daidone
Andrew Street

Centre for Health Economics, University of York, UK

December 2011

Background to series

CHE Discussion Papers (DPs) began publication in 1983 as a means of making current research material more widely available to health economists and other potential users. So as to speed up the dissemination process, papers were originally published by CHE and distributed by post to a worldwide readership.

The CHE Research Paper series takes over that function and provides access to current research output via web-based publication, although hard copy will continue to be available (but subject to charge).

Acknowledgements

We would like to thank Sam Alderson, Jake Gommon, Eileen Robertson, and members of the Department of Health's analytical sub-group for Payment by Results. This is an independent report commissioned and funded by the Policy Research Programme in the Department of Health from the Economics of Social and Health Care Research Unit (ESHCRU). ESHCRU is a joint collaboration between the University of York, London School of Economics and University of Kent. The views expressed are those of the authors and may not reflect those of the funder.

Disclaimer

Papers published in the CHE Research Paper (RP) series are intended as a contribution to current research. Work and ideas reported in RPs may not always represent the final position and as such may sometimes need to be treated as work in progress. The material and views expressed in RPs are solely those of the authors and should not be interpreted as representing the collective views of CHE research staff or their research funders.

Further copies

Copies of this paper are freely available to download from the CHE website www.york.ac.uk/che/publications/ Access to downloaded material is provided on the understanding that it is intended for personal use. Copies of downloaded papers may be distributed to third-parties subject to the proviso that the CHE publication source is properly acknowledged and that such distribution is not subject to any payment.

Printed copies are available on request at a charge of £5.00 per copy. Please contact the CHE Publications Office, email che-pub@york.ac.uk, telephone 01904 321458 for further details.

Centre for Health Economics
Alcuin College
University of York
York, UK
www.york.ac.uk/che

Contents

Executive summary

Overview

Payment by Results is predicated on the assumption that patients allocated to the same Healthcare Resource Group (HRG) are equally costly to treat. This may be untrue for some patients, such as those who receive specialised care or who are transferred between hospitals. We assess whether and by how much such patients have higher costs than those allocated to the same HRG. Hospitals that treat such patients might be paid a top-up to the HRG tariff to reflect these higher costs.

Data and methods

We combine Hospital Episode Statistics data for all NHS patients treated in England during 2009/10 with cost data reported by all English hospitals. Our analytical sample consists of almost 13 million patients (provider spells), of whom 1.5 million received some form of specialised care and 620,000 were transferred.

We estimate econometric models to explore why costs vary from among patients. Our explanatory variables include: (i) the type of specialised care received, if any; (ii) whether or not the patient was transferred between hospitals; (iii) a range of other patient characteristics; and (iv) the hospital in which the patient was treated. We perform a range of sensitivity analyses.

Additional costs of specialist care

In general, results are stable between 2008/9 and 2009/10 and are consistent across model specifications. The main points are of note:

- Sixteen of the specialised markers are insignificant, meaning that patients that receive these types of specialised care do not have significantly higher costs than other patients allocated to the same HRG.

- For five of the markers, patients who received this type of specialised care had higher costs than those allocated to the same HRG who did not. The numbers of patients and the percentage increase in costs associated with specialised care are:

    - cancer (n=11,907, 24%)
    - infectious disease (n=2,246, 37%)
    - cystic fibrosis (n=101,770, 33%)
    - colorectal (n=7,355, 11%)
    - children (n=131,657, 20%).

- Five specialised markers (spinal, neurosciences, rheumatology, vascular diseases, orthopaedics) that were significant ($p<0.01$) in 2008/9, are either less significant ($p<0.05$) or insignificant in 2009/10. This appears to be due primarily to greater polarisation among providers in their reported costs.

- Results for the pain management specialised marker differ markedly from one year to the next. This is related to the increase in the number of patients defined as having this specialised marker and to changes in their cost distribution.

Patient transfers

We find that patients who were transferred between hospitals have significantly higher costs than those who do not. A reimbursement policy based on this evidence would have to consider the practical implications of redistributing resources across hospitals to reflect patient flows and any consequent changes to hospital behaviour.

1. Introduction

We were commissioned by the Department of Health's Payment by Results (PbR) team to use 2009/10 data update the analysis we performed using 2008/9 data to estimate the marginal costs of providing specialised care (Daidone and Street, 2011). The objectives of the original work were to investigate:

1. Whether the costs associated with specialised activity are significantly different from non-specialised activity within the same HRG;
2. Whether any differences in costs between specialised and non-specialised activity are due to differences in productive efficiency.

The objective of the update is:

1. To see whether the results obtained on the 2008-09 data are robust to 2009-10 data.
2. To investigate whether there is a case for differentiating payment on the basis of marginal cost differences arising when patients transferred between providers.

In the next section we describe various data issues, including how patients are identified as having received specialised care, how proxy patient-level costs are linked to HES records, and how the analytical sample is determined. In section three, we summarise the estimation models used to assess the marginal costs associated with receipt of specialised care and whether or not the patient was transferred between providers. Following a summary of descriptive statistics (section four), results are presented in section five for a variety of modelling choices. Estimates for 2009/10 are also compared to those derived from analysis of 2008/9 data.

2. Data

There are four major issues regarding the data that need to be addressed:

- How to determine whether or not a patient received specialised care;
- How to assign costs to each patient record in the Hospital Episode Statistics;
- How to determine the cost of a provider spell for those patients who have multiple consultant episodes;
- How to arrive at an analytical sample.

2.1 Identifying whether a patient received specialised care

Information in each patient's first diagnostic and procedural fields is examined to ascertain whether or not specialised care was received. A patient is assigned a specialised care marker if:

- One of the ICD10 in the primary diagnosis field or one of the OPCS codes[a] in any of the procedure fields designated in the Specialised Services National Definition Set (SSNDS) is present in their HES record (an individual might have more than one marker) (NHS Specialised Services, 2010);
- They were treated at an eligible provider, because non-eligible providers should not be providing specialised services.

Specialised activity may not necessarily be more costly or complex, since the SSNDS defines activity as specialised if it requires a planning population of over 1 million people, without any specific relation to resource use.

2.2 Mapping of reference costs to HES records

To assign patient-level costs we follow the cascade procedure implemented with 2008-09 data, where each episode in HES is linked to the reference cost database based on: i) the hospital in which the patient is treated, ii) the HRG where the patient is categorized, iii) the type of admission – day case/elective/non-elective, and iv) the type of specialty. Further for elective and non-elective cases, when the length of stay goes beyond HRG specific trimpoints, we add the hospital's excess *per diem* cost for each additional day.

The matching between HES and RC databases has slightly improved with respect to the previous year's analysis. This is driven mainly by ensuring consistent coding of specialty in the HES and Reference Cost data by Great Ormond Street Hospital. This allowed a move from a 10% to 90% match of this provider's data.

2.3 Assessing the cost of provider spells

Each observation in HES comprises a Finished Consultant Episode (FCE), measuring the time the patient spends under the care of a particular consultant. As in 2008-09, 91% of patients remain under the care of a single consultant during their entire hospital stay. The remainder are cared for by more than one consultant, most usually because they are transferred from one specialty to another. We track the consultant episodes pertaining to each individual patient, allowing us to construct a provider spell for each patient, measuring the time from admission to discharge.

Multi-episode spells are likely to be more costly than single-episode spells, but there is no agreed method for determining the additional cost. In our previous report we found that estimation results were not sensitive to whether the cost of multi-episode spells was based on the Sum, Maximum or First of the costs of the constituent FCEs. Consequently, in the analysis that follows, the cost of a provider spell is calculated as the Sum of the cost of each FCE comprising the patient's spell in hospital.

[a] ICD10: International Statistical Classification of Diseases and Related Health Problems 10th Revision; OPCS: Office for Population Censuses and Surveys Classification of Surgical Operations and Procedures

Irrespective of how costs are defined, patients that receive specialised care appear to have higher costs than those who do not, as can be seen in Table 1. The questions then are:

- Do cost differentials vary according to the particular type of specialised care that is provided?
- Are these higher costs due solely to the receipt of specialised care or are they (at least partially) related to the hospital in which care was provided?

Table 1: Mean (SD) costs by type of activity

	2008-2009			2009-2010		
	NOT SPEC	SPEC	TOT	NOT SPEC	SPEC	TOT
Sum	1,385	1,884	1,436	1,452	2,057	1,521
	(2,079)	(3,790)	(2,320)	(2371)	(4054)	(2625)
Max	1,219	1,673	1,265	1,272	1,854	1,338
	(1,730)	(3,210)	(1,940)	(1987)	(3536)	(2226)
Epi1	1,142	1,540	1,183	1,189	1,727	1,251
	(1,587)	(2,929)	(1,777)	(1825)	3282)	(2051)

2.4 Selection of the analytical sample

From an initial sample of 18.1m HES episodes, our analytical sample is reduced to 14.5m episodes (and 12.9m spells) for the following reasons:

- We consider only those patients treated in NHS acute hospitals. Hence, patients treated in mental health, ambulance and primary care trusts and private providers are excluded;
- Duplicate HES records, those showing data inconsistencies and those missing key fields (eg epistart or epiend) are dropped;
- Some observations are excluded either because the reference costs for some hospitals could not be matched to HES records, because of miscoding of one of the variables used for mapping as described in section 2.2 (this is especially so for some renal dialysis, mental health, cystic fibrosis records); or they are unbundled services; or they are excluded from reference costs (eg intermediate care, well babies);[b]
- We excluded those episodes with a length of stay in excess of 365 days.

In Table 2 we report how we reduced the full HES dataset to our analytical sample. Improvements in coding of data have allowed us to retain more of the data than in the previous years, with 80% of the full set of HES observations included in the 2009/10 analysis, up from 78% in the previous year.

[b] See Department of Health (2009,2010)

Table 2: Eligibility and selection criterion

	2008/9		2009/10	
Step	**# episodes**	**# episodes dropped**	**# episodes**	**# episodes dropped**
Starting observations	17,411,542		18,126,831	
Acute care trusts only		425,179		470,272
	16,986,363		17,656,559	
Duplicates and inconsistent coding		852,326		908,904
	16,134,037		16,747,655	
Unmatched reference cost		2,502,599		2,189,667
	13,631,438		14,557,988	
Unmatched trimpoint and excess bed days or zero cost per day		57,678		31,451
Total episodes	13,573,760	3,837,782	14,526,537	3,600,294
Total spells	12,154,599		12,971,384	

In Table 11 (see appendix) we provide details for each provider under the following columns:

- Totactivity: the total number of episodes reported in HES after eliminating duplicates and inconsistencies.
- Norefcost: the number of provider episodes with unmatched costs.
- Finalepi and finalspell: the number of episodes and spells used for the econometric analysis.
- %MISS and %SPEC: the percentage of missing episodes and the percentage of episodes with specialised care markers.

3. Estimation models

3.1 Estimating the additional costs of specialised care

As in our previous report (Daidone and Street, 2011), we define our dependent variable as the patient's standardised cost $y_{ik} = {}^{c_{ihk}}/_{\hat{c}_h}$ where c_{ihk} is the cost of patient *i* in HRG *h* in hospital *k* and $\hat{c}_h$ is the national average cost of all patients allocated to HRG *h.*

If no account is taken of the possibility that costs may be partly related to the hospital in which care is provided, the marginal costs associated with receipt of specialised care are estimated by regressing each patient's standardised cost against the set (*n*=1…*N*) of specialised care markers (*S*) indicating the type of specialised care received (if any). The model takes the form:

$$y_i = \propto + \sum_{n=1}^{N} \beta_n S_{ni} + \varepsilon_i \qquad \text{(EQ1)}$$

where β are the parameters to be estimated: if positive and significant, a patient with the specialist care marker has higher costs than do other patients allocated to the same HRG. ε_i captures random error.

As we have previously argued, this model fails to recognise that costs may be driven partly by the hospital in which the patient is treated. This can be examined by specifying a hierarchical model of the form:

$$y_{ik} = \propto + \sum_{n=1}^{N} \beta_n S_{nik} + u_k + v_{ik} \qquad \text{(EQ2)}$$

This is a multi-level model that recognises that patients (*i*=1…*I*) are clustered within hospitals (*k*=1…*K*). u_k is the hospital random effect: patients treated in hospitals with higher effects have higher costs than those treated elsewhere. v_{ik} captures random measurement error. We argue that this is the preferred model on which top-up payments should be made as it identifies the additional costs associated with receipt of specialised care, after controlling for the influence on costs of the hospital where treatment was provided.

The models are estimated using both ordinary least squares (OLS) and as a generalised linear model (GLM), and results are shown for both specifications.

3.2 Sensitivity analyses

We consider the sensitivity of estimates derived from applying equation 2 to:

- Analysing costs in their original form;
- Exclusion from the analysis of patients in HRGs in which everyone receives specialised care; and
- Dropping the requirement that specialised care is defined as being provided in eligible providers only.

Costs in original units

As an extension to the previous year's analysis, we now explore results when costs are not standardised to the national average. This involves incorporating additional explanatory variables that capture information about the HRG to which each patient is allocated. In this way we still account for the HRG to which patients are allocated by incorporating two additional variables, namely $\hat{c}_h$ the national average cost of all patients allocated to HRG *h* and $\tilde{c}_h$ the standard deviation in cost of all patients allocated to HRG *h.* This model does not risk the possibility of endogeneity that occurs when the independent variable is correlated with the error term. The model is specified as:

$$c_{ik} = \propto + \delta_1 \hat{c}_h + \delta_2 \tilde{c}_h + \sum_{n=1}^{N} \beta_n S_{nik} + u_k + v_{ik} \qquad \text{(EQ3)}$$

Fully specialised HRGs

The construction of some HRGs means that everyone allocated to them receives specialised care. This is because the HRG itself is defined using the ICD or OPCS codes that are also used as indicators of specialised care. Conversely, some HRGs contain no patients that received specialised care. The HRGs where the former situation occurs are listed in Table 10 in the appendix.

Estimates might be biased by including in the analysis HRGs exclusively populated by patients who did receive specialised services. This is because for these HRGs there is no comparative reference group of patients allocated to the HRG who did not receive specialised care. This makes it impossible to calculate the differential costs associated with receipt of specialised care for patients allocated to these HRGs. The extent to which this introduces bias to the estimates of the specialised care marker depends on how representative patients allocated to these fully specialised HRGs are of all patients who receive the particular type of specialised care in question.

Dropping patients in those HRGs in which everyone is identified as having received specialised care and those HRGs in which no-one is identified as having received specialised care reduces the analytical sample by 1.9% (256,861 spells).

Eligible providers

Some hospitals are or have been designated by the Department of Health as eligible for top-up payments for some specialised services. As would be expected, hospitals which are or have been eligible for top-ups now or in the past undertake more specialised spells than do other hospitals.

As described in section 2.1, a patient is defined as receiving specialised care if one of the SSNDS ICD10 or OPCS codes was present in their medical record *and* they were treated at an eligible provider. We assess the sensitivity of results to relaxation of the condition that specialised services have to be delivered by eligible providers, so that the marker is assigned on the basis of the ICD10 or OPCS codes alone.

3.3 Estimating the additional costs of being transferred between hospitals

We also assess whether patients who are transferred between institutions have higher costs than other patients. This involves adding a vector of additional patient characteristics to equation 1, among which are dummy variables indicating the type of transfer experienced by the patient, if any. The model is specified as:

$$y_{ik} = \propto + \sum_{n=1}^{N} \beta_n S_{nik} + \sum_{m=1}^{M} \gamma_m X_{mik} + u_k + v_{ik} \qquad \text{(EQ4)}$$

where X is the set (m=1…M) of patient characteristics and γ is the vector of parameters to be estimated. If positive and significant, patients with the particular characteristics have higher costs than those who do not.

Among this set of variables are four which describe the type of transfer, if one took place. Patients admitted as transfers are coded 51, 52 and 53 in the admission source field of their HES record; analogously, those transferred from hospital to other institutions are coded 51, 52 and 53 in the discharge destination field of their HES record (NHS Information Centre, 2011). We define four dummy variables:

- Transfer from an eligible provider, whereby the patient was admitted to hospital having been transferred from a provider that is eligible for specialised payments (tr_in_el);
- Transfer from a non-eligible provider, whereby the patient was admitted to hospital having been transferred from a provider that is not eligible for specialised payments (tr_in_nonel);
- Transfer to an eligible provider, whereby the patient is transferred to a provider that is eligible for specialised payments (tr_out_el);
- Transfer to a non-eligible provider, whereby the patient is transferred to a provider that is not eligible for specialised payments (tr_out_nonel).

4. Descriptive statistics

In 2009/10, for approximately 1.5m (11.4%) of patients it was indicated that some kind of specialised care was delivered as part of the treatment package. Table 3 reports the number of patients with particular conditions who receive specialised services and are included in the analysis. For a few specialised services, provision has declined compared to 2008/9 – notably cancer (-2,000), liver (-2,600) and respiratory (-3,500). For others, more patients received specialised care than in the previous year. Most noticeable were the increases for renal (+150,000), cystic fibrosis (+10,000), cleft lip (+15,000) and children (+27,000). For children, much of the increase is due to inclusion of a greater proportion of data from Great Ormond Street. For the vast majority of patients, just one specialised service was delivered but more than 35,000 patients received more than one specialised service.

Table 3: Number of patients receiving specialised services for whom costs are available

Service	2008/9	2009/10	Service	2008/9	2009/10
Cancer	14,035	11,907	Dermatology	10,790	12,298
BMT	1,050	364	Rheumatology	358	338
Haemophilia	146	153	Endocrinology	7,028	7,306
Women	22,551	24,389	Respiratory	71,824	68,374
Spinal	2,167	2,507	Vascular diseases	801	1,215
Neurosciences	23,848	26,204	Pain Management	753	1,266
Cystic fibrosis	91,868	101,770	Ear surgery	1,704	1,655
Renal	360,957	510,847	Colorectal	6,838	7,355
Intestinal failure	2,380	2,246	Orthopaedic	3,671	4,207
Cardiology	89,127	90,381	Morbid obesity	7,905	11,458
Cleft lip	222,939	238,141	Metabolic disorders	3,182	3,236
Infectious diseases	2,203	2,039	Ophthalmology	6,345	7,006
Liver	14,807	12,244	Haemoglobinopathy	146,403	159,788
Children	104,764	131,657	More than 1 service	32,311	35,972

In Table 4 we provide some descriptive statistics of the explanatory variables used to describe patient characteristics (ie X_m in equation 4). Patients receiving specialised services are more likely to be male, younger (probably mainly because infants are more likely to require specialised care, 16% of them at birth), and to have been transferred between hospitals. Notably, there are no major differences in the proportions of patients with each particular characteristic between the two years of data. Variable definitions are provided in Table 14 in the appendix.

Table 4: Descriptive statistics of explanatory variables (mean above, st.dev. below)

	2008/9			2009/10		
	NOT SPEC	SPEC	TOT	NOT SPEC	SPEC	TOT
female1	0.574	0.445	0.56	0.577	0.442	0.558
	(0.495)	(0.497)	(0.496)	(0.495)	(0.497)	(0.497)
age	51.61	49.94	51.44	51.56	50.42	51.43
	(24.24)	(25.7)	(24.4)	(24.49)	(25.76)	(24.64)
urban1	0.818	0.817	0.818	0.818	0.827	0.819
	(0.386)	(0.387)	(0.386)	(0.386)	(0.378)	(0.385)
episodes	1.118	1.108	1.117	1.122	1.102	1.12
	(0.426)	(0.545)	(0.440)	(0.442)	(0.546)	(0.455)
emerg	0.383	0.159	0.36	0.396	0.145	0.367
	(0.486)	(0.366)	(0.48)	(0.489)	(0.352)	(0.482)
die	0.0155	0.0181	0.0158	0.0143	0.0153	0.0145
	(0.124)	(0.133)	(0.125)	(0.119)	(0.123)	(0.119)
tr_in_el	0.0000394	0.00016	5.20E-05	0.0000493	0.000158	0.0000617
	(0.00628)	(0.0128)	(0.0072)	(0.00702)	(0.0126)	(0.00785)
tr_in_nonel	0.0265	0.0414	0.028	0.03	0.0376	0.0308
	(0.161)	(0.199)	(0.165)	(0.17)	(0.19)	(0.173)
tr_out_el	0.00501	0.00491	0.005	0.00532	0.00498	0.00528
	(0.0706)	(0.0699)	(0.0705)	(0.0728)	(0.0704)	(0.0725)
tr_out_nonel	0.0113	0.0135	0.0116	0.0115	0.0128	0.0117
	(0.106)	(0.115)	(0.107)	(0.107)	(0.112)	(0.107)
pregnancy	0.104	0.00528	0.0941	0.107	0.0039	0.0951
	(0.306)	(0.0725)	(0.292)	(0.309)	(0.0623)	(0.293)
drug	0.00324	0.00203	0.00312	0.00355	0.00211	0.00339
	(0.0568)	(0.045)	(0.056)	(0.0595)	(0.0459)	(0.0581)
alcohol	0.017	0.00732	0.016	0.0198	0.00692	0.0183
	(0.129)	(0.0852)	(0.125)	(0.139)	(0.0829)	(0.134)
smoke	0.0369	0.0348	0.0367	0.0468	0.0367	0.0456
	(0.189)	(0.183)	(0.188)	(0.211)	(0.188)	(0.209)
obesity	0.0072	0.014	0.00791	0.00993	0.0154	0.0106
	(0.0845)	(0.118)	(0.089)	(0.0991)	(0.123)	(0.102)
allergy	0.0276	0.0191	0.0267	0.0328	0.0201	0.0313
	(0.164)	(0.137)	(0.161)	(0.178)	(0.14)	(0.174)
diabetes	0.0785	0.0626	0.0769	0.0869	0.0603	0.0838
	(0.269)	(0.242)	(0.266)	(0.282)	(0.238)	(0.277)
hypertens	0.171	0.121	0.165	0.192	0.117	0.184
	(0.376)	(0.326)	(0.372)	(0.394)	(0.322)	(0.387)
haemorr	0.00393	0.00899	0.00445	0.00452	0.00781	0.00489
	(0.0626)	(0.0944)	(0.067)	(0.0671)	(0.088)	(0.0698)
histdis	0.108	0.0866	0.106	0.124	0.0862	0.119
	(90.31)	(0.281)	(0.307)	(0.329)	(0.281)	(0.324)
riskfact	0.00729	0.00265	0.00681	0.00907	0.0032	0.0084
	(0.0851)	(0.0514)	(0.082)	(0.0948)	(0.0565)	(0.0913)
congmalf	0.0113	0.0487	0.0151	0.0124	0.0522	0.0169
	(0.106)	(0.215)	(0.122)	(0.111)	(0.222)	(0.129)
risk_phys	0.000643	0.00119	0.0007	0.000675	0.00125	0.000741
	(0.0254)	(0.0345)	(0.027)	(0.026)	(0.0354)	(0.0272)
risk_psysoc	0.00384	0.00157	0.00361	0.00447	0.00148	0.00413
	(0.0619)	(0.0395)	(0.060)	(0.0667)	(0.0384)	(0.0641)

5. Results

5.1 Additional costs of specialist care

We have estimated various equations and explored the sensitivity of estimates to a range of modelling choices. The cost of a provider spell is calculated as the sum of the cost of the constituent episodes and each patient is assigned a specialist marker if one of the SSNDS ICD10 or OPCS codes appears in their record and they were treated at an eligible provider. In this section we focus on the estimates associated with the specialised markers. Rather than reporting the coefficients, we report the predicted percentage increase in costs for specialised services calculated as described in our earlier report (Daidone and Street, 2011). The specialised markers where estimates are statistically significant appear in bold if p<0.01 and underlined if p<0.05.

Table 5: Equations 1 and 2 on standardised dependent variable

	Equation 1				Equation 2			
	2008-2009		2009-2010		2008-2009		2009-2010	
	OLS	GLM	OLS	GLM	OLS	GLM	OLS	GLM
Cancer	**0.217**	**0.218**	**0.307**	**0.313**	**0.184**	**0.185**	**0.242**	**0.244**
BMT	-0.055	-0.035	-0.037	-0.037	-0.105	-0.086	-0.297	-0.222
Haemophilia	-0.089	-0.090	-0.132	-0.129	-0.144	-0.142	-0.159	-0.157
Womens	-0.003	-0.002	0.063	0.061	-0.019	-0.018	0.046	0.046
Spinal	**0.323**	**0.336**	0.140	0.154	**0.276**	**0.279**	-0.115	-0.084
Neurosciences	**0.279**	**0.276**	**0.280**	**0.275**	**0.229**	**0.225**	0.171	0.171
Cystic Fibrosis	**0.397**	**0.394**	**0.357**	**0.354**	**0.379**	**0.380**	**0.331**	**0.335**
Renal	-0.112	-0.114	0.228	0.230	-0.112	-0.112	0.175	0.180
Intestinal Failure	-0.007	-0.004	-0.003	-0.002	0.002	0.004	0.008	0.009
Cardiology	**0.138**	**0.138**	**0.118**	0.119	0.001	0.000	0.007	0.011
CleftLip	-0.017	-0.018	0.034	0.035	-0.042	-0.044	0.022	0.023
Infectious Diseaes	**0.264**	**0.240**	**0.408**	**0.393**	**0.213**	**0.189**	**0.379**	**0.372**
Liver	0.098	0.099	**0.125**	0.128	0.075	0.076	0.003	0.018
Children	**0.280**	**0.278**	**0.301**	**0.302**	**0.200**	**0.193**	**0.215**	**0.204**
Dermatology	0.009	0.009	-0.003	-0.007	-0.009	-0.009	-0.019	-0.022
Rheumatology	**0.183**	**0.184**	**0.331**	**0.337**	**0.130**	**0.130**	0.102	0.089
Endocrinology	0.045	0.041	0.061	0.057	-0.007	-0.010	-0.014	-0.011
Respiratory	0.046	0.041	0.078	0.072	-0.038	-0.041	0.001	-0.002
Vascular Diseases	**0.246**	**0.241**	**0.343**	**0.323**	**0.211**	**0.203**	0.218	0.198
Pain Management	0.188	0.157	**2.255**	**2.283**	0.190	0.169	**2.129**	**2.101**
EarSurgery	0.057	0.058	0.082	0.086	-0.001	-0.001	-0.111	-0.078
Colorectal	**0.214**	**0.214**	**0.129**	**0.129**	**0.211**	**0.214**	**0.112**	**0.114**
Orthopaedic	**0.244**	**0.238**	**0.164**	**0.161**	**0.213**	**0.207**	0.004	0.011
Morbid Obesity	-0.027	-0.027	-0.068	-0.068	-0.008	-0.007	-0.068	-0.071
Metabolic Disorders	0.022	0.011	0.427	0.430	-0.016	-0.021	0.312	0.295
Ophthalmology	0.080	0.076	0.074	0.069	0.057	0.055	0.057	0.053
Haemoglobinopathy	0.013	0.009	0.065	0.066	0.003	0.000	0.052	0.056

Notes: Bold figures 1% significant, underlined figures 5%

Table 5 shows estimates of additional costs associated with receipt of specialised care from applying equations 1 and 2, estimated using OLS and GLM models and for the two years of data. The estimates are not sensitive to the choice of OLS and GLM. As to year-on-year comparisons, estimates are very similar in most of the cases, both in terms of magnitude and statistical significance. This is despite the fact that the reference populations have changed, as they are composed of two entirely different sets of patients.

Focussing on equation 2, the main points are the following:

- Sixteen of the specialised markers are insignificant, across both the OLS and GLM specifications and for the two years of data. This means that patients that receive specialised care of the nature indicated by the specialised marker do not have significantly higher costs than other patients allocated to the same HRG.
- For five of the markers, patients who received this type of specialised care had higher costs than those allocated to the same HRG who did not. These markers are cancer,

cystic fibrosis, infectious disease, children and colorectal. The significance (p<0.01) of these markers holds across specifications and over time. The estimates of the amount by which costs are higher do vary from one year to the next though. The estimates are higher for cancer (from 18% to 24%) and infectious disease (21% to 37%) and are lower for cystic fibrosis (38% to 33%) and colorectal (21% to 11%). The estimates are unchanged for children's specialised services (20%).

- Five specialised markers (spinal, neurosciences, rheumatology, vascular diseases, orthopaedics) that were significant in 2008/9, are no longer significant at p<0.01, though results remain significant at p<0.05 for neurosciences and vascular diseases (under the GLM specification). Compare these estimates to those derived from applying equation 1. We find that, with the exception of the marker for spinal services, the other four specialised markers are significant in 2009/10 provided that no account is taken of the hospital in which patients are treated. This suggests greater polarisation in 2009/10 among providers in the costs of treating patients allocated to the HRGs in which these specialised markers tend to appear.
- In Table 6 we report the number of hospitals where mean costs decrease or increase by more than 0.5 standard deviations of the mean across all patients in 2009/10. Polarisation is evident if there are large reductions in cost for some providers and large increases for others.
- Consider first the specialised care for cystic fibrosis. For these services, no hospital reported large decreases in cost, and few very experienced increases. The estimates reported in Table 5 for this specialist marker are quite stable across specifications and over time.
- In contrast, Table 6 shows that mean hospital costs changed considerably for a sizeable large numbers of hospitals providing specialised care in rheumatology, vascular diseases and orthopaedics. This variance across hospitals is captured by the hospital effect, rather than by the specialist marker which appears non-significant in Eqn 2 for 2009/10 (Table 5).
- Polarisation in mean costs across hospitals is less extreme for specialised neurosciences care than for rheumatology, vascular diseases and orthopaedics. Consequently in 2009/10, the coefficient on this specialised marker remains significant in Eqn 2, albeit at a lower significance level.
- For specialised spinal care, there is little change from one year to the next in the location and shape of the overall distribution of costs for patients who received this form of specialised care. In contrast to 2008/9, the non-significance of this marker in 2009/10 is partly due to changes in costs for patients who did not receive specialised spinal care who are allocated to the same HRGs as patients who did and partly due to the handful of hospitals (5-6%) for which mean costs changed by +/- 0.5 standard deviations of the overall mean.

Table 6: Number (%) of hospitals in which mean costs vary from 2008/9 and 2009/10 by +/- 0.5SD of the underlying distribution

	Decrease by <0.5SD		Increase by >0.5SD	
Cystic fibrosis	0	0%	4	3%
Rheumatology	10	15%	16	25%
Vascular Diseases	9	9%	17	17%
Orthopaedics	14	10%	19	13%
Neurosciences	4	3%	5	3%
Spinal	9	6%	8	5%

- Finally, returning to Table 5, the pain management marker was insignificant in 2008/9 but is remarkably so in 2009/10. This is explained partly by the 50% increase in the number of patients with this specialised marker Table 3) and by changes in the location and

shape of the cost distribution for these patients, the lower peak and longer tail in 2009/10 being most notable (figure 1). These changes are reflected in the dramatic change between the two years in the estimated coefficients associated with this specialised marker.

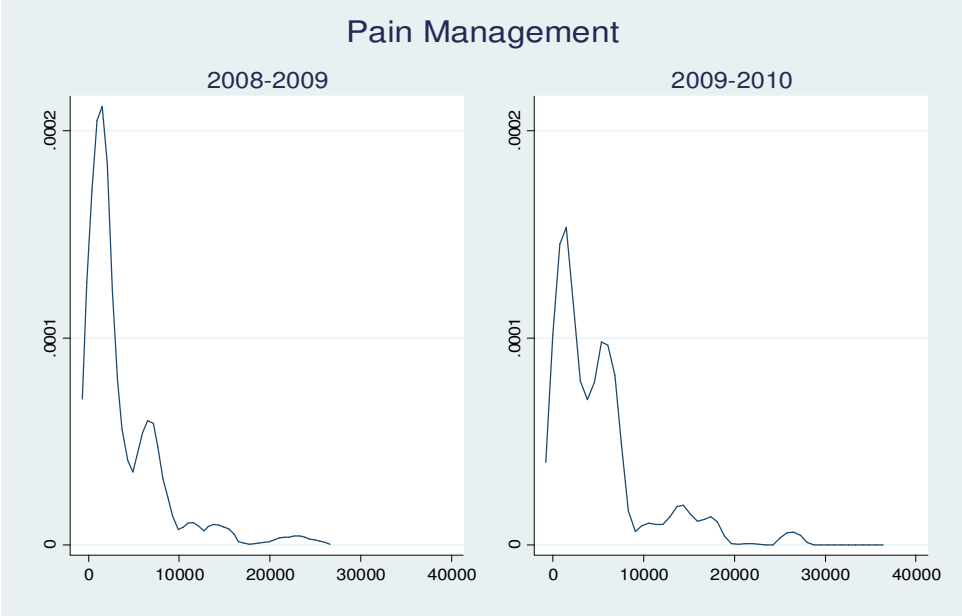

Figure 1: Kernel density estimation of specialised services costs

5.2 Sensitivity analyses

The OLS estimates for 2009/10 reported in Table 5 are reproduced in column 1 in Table 7 alongside estimates from the sensitivity analyses, namely:

- Analysing costs in their original form (EQ3, column 2);
- Exclusion from the analysis of patients in HRGs in which everyone receives specialised care (column 3); and
- Dropping the requirement that specialised care is defined as being provided in eligible providers only (column 4).

The main points of note are:

- For the majority of specialised care markers, the estimates are unchanged across all forms of sensitivity analysis. Twenty of the markers that were insignificant ($p>0.01$) under the original specification remain so under the three alternatives.
- The receipt of specialised cancer care is consistently estimated to increase costs by 24%.
- The magnitude and (sometimes) significance of the estimates for four of the markers are sensitive to whether costs are standardised (EQ2, column 1) or estimated in original units (EQ3, column 2). Estimates are higher if applying EQ3 for neurosciences (17% to 32%), cystic fibrosis (33% to 61%) and infectious diseases (38% to 49%). For pain management, the cost differential no longer appears significant.
- Results are not sensitive to dropping HRGs in which everyone is identified as having received specialised care and those HRGs in which no-one is identified as having received specialised care. The signs and, where significant, the magnitudes of the estimates reported in columns 1 and 3 are virtually identical. Interestingly, this is true even for cardiology, where a high proportion of HRGs are populated entirely by patients defined as having received specialised care (Table 10 in Appendix).

Table 7: Sensitivity analysis, equation 2 - 2009/2010

	2009-2010			
	(1)	(2)	(3)	(4)
	Standardised Dependent Variable – equation 2	Raw Dependent Variable - equation 3	100% fully specialized HRGs dropped - equation 2	No eligibility requirements - equation 2
Cancer	**0.242**	**0.238**	**0.240**	**0.242**
BMT	-0.297	-0.366	-0.347	-0.296
Haemophilia	-0.159	-0.120	-0.162	-0.160
Womens	0.046	-0.005	0.046	0.046
Spinal	-0.115	0.138	-0.120	-0.077
Neurosciences	0.171	**0.315**	0.166	**0.151**
Cystic Fibrosis	**0.331**	**0.611**	**0.339**	**0.330**
Renal	0.175	0.054	0.176	0.174
Intestinal Failure	0.008	-0.007	0.009	0.008
Cardiology	0.007	0.065	0.008	0.016
CleftLip	0.022	0.014	0.022	0.021
Infectious Diseases	**0.379**	**0.491**	**0.379**	**0.379**
Liver	0.003	0.126	-0.004	0.011
Children	**0.215**	**0.211**	**0.223**	**0.102**
Dermatology	-0.019	0.002	-0.024	-0.021
Rheumatology	0.102	0.149	0.102	0.101
Endocrinology	-0.014	0.028	-0.016	-0.014
Respiratory	0.001	0.089	0.014	0.029
Vascular Diseases	0.218	0.790	0.276	0.214
Pain Management	**2.129**	1.181	**2.127**	**2.125**
EarSurgery	-0.111	0.141	-0.036	-0.113
Colorectal	**0.112**	0.127	**0.112**	**0.111**
Orthopaedic	0.004	0.112	0.003	0.003
Morbid Obesity	-0.068	-0.259	-0.071	-0.069
Metabolic Disorders	0.312	-0.076	0.306	0.303
Ophthalmology	0.057	0.030	0.058	0.056
Haemoglobinopathy	0.052	0.053	0.053	0.053

Notes: Bold figures 1% significant, underlined figures 5%

- In the fourth column of Table 7 we present the effects for the specialist markers followed by the effects generated after relaxing the condition that specialised services have to be delivered only by eligible providers. Again comparing these estimates with those in column 1, the results are generally not sensitive to whether or not specialised care is defined as being confined to eligible providers.
- There is, however, one notable exception: the cost increase associated with specialised children services is now estimated to amount to just 10%, rather than 22%. This would suggest that the cost of specialised children's care is lower in non-eligible than eligible providers.

5.3 Transfers between providers

Providers have raised the question of whether patients who are transferred between providers should receive a top-up and, if so, what value the top-up should take. In answering this we first evaluate how many patients are transferred and the marginal cost consequences of being transferred.

Table 8 provides details of the number of patients who were transferred into or from other institutions, according to whether or not their hospital was eligible for specialised top-ups and to whether or not they received specialised care. The proportion of patients who were transferred into hospital increased from 2.8% in 2008/9 to 3.1% in 2009/10. The proportion of patients transferred to other providers was 1.7% in both years.

Table 8: Number of spells with patients transferred

	Number of spells					
	2008-2009			2009-2010		
Transfer type	**Not Spec**	**Spec**	**Tot**	**Not Spec**	**Spec**	**Tot**
From eligible	445	216	661	567	233	800
From non-eligible	289,139	51,800	340,939	344,445	55,457	399,902
To eligible	54,609	6,153	60,762	61,203	7,345	68,548
To non-eligible	123,722	16,879	140,601	132,290	18,896	151,186

Those who were transferred have significantly higher costs than those who do not (Table 9). Patients transferred from non-eligible providers have costs 24% higher than those who do not (all else equal), and those transferred to other providers have 11-13% higher costs.

Table 9: Coefficient estimates of transfer variables, equation 4.

	Co efficient estimates	
	2008-2009	**2009-2010**
From eligible	0.008	-0.061
	(0.070)	(0.057)
From non-eligible	0.16**	0.235***
	(0.071)	(0.040)
To eligible	0.14***	0.132***
	(0.016)	(0.017)
To non-eligible	0.129***	0.110***
	(0.020)	(0.015)

Notes: standard errors in parentheses. * 1% significant - ** 5% significant**

Even though patients who are transferred have higher costs than those who do not, introducing top-up payments to reflect this might not be straightforward, for two main reasons:

- First, in effect, any payment adjustment should reflect patient flows, with funding being redistributed from providers that transfer patients elsewhere to providers that admit them. This would be prohibitively costly to implement on a case-by-case basis, so probably the redistribution would have to be undertaken centrally and retrospectively.
- Second, payments of this nature might lead to changes in decisions about whether or not to transfer patients elsewhere. This may be no bad thing, but an evaluation of potential behavioural change might be required.

6. Conclusion

In general, results are stable from one year to the next and are consistent across model specifications. Of note are the following points:

- Sixteen of the specialised markers are insignificant, meaning that patients that receive these types of specialised care do not have significantly higher costs than other patients allocated to the same HRG.
- For five of the markers, patients who received this type of specialised care had higher costs than those allocated to the same HRG who did not. The numbers affected and the percentage increase in costs associated with each form of specialised care are:
  - cancer (n=11,907, 24%)
  - infectious disease (n=2,246, 37%)
  - cystic fibrosis (n=101,770, 33%)
  - colorectal (n=7,355, 11%)
  - children (n=131,657, 20%).
- Five specialised markers (spinal, neurosciences, rheumatology, vascular diseases, orthopaedics) that were significant ($p<0.01$) in 2008/9, are either less significant ($p<0.05$) or insignificant in 2009/10. This appears to be due primarily to greater polarisation among providers in their reported costs.
- Results for pain management marker differ markedly from one year to the next. This is related to the increase in the number of patients defined as having this specialised marker and to changes in the overall distribution of their costs.

We also find that, after controlling for whether or not they receive specialised care and for a range of other characteristics, patients who were transferred between hospitals have significantly higher costs than those who do not. This evidence is a necessary but not sufficient condition for introducing top-up payments for such patients. Any such policy would have to consider the practical implications of redistributing resources to reflect patient flows and any consequent changes to hospital behaviour toward patients who might be transferred.

7. References

Daidone S & Street A. 2011. *Estimating the costs of specialised care, CHE Research Paper 61: Yo*rk, Centre for Health Economics.

Department of Health. 2010. *Reference Costs 2009-10, Collection Guidance Final*

Department of Health 2009. *Reference Costs 2008-09, Collection Guidance Final*

NHS Information Centre (2011) "Data Dictionary: Inpatients" in HESonline - Hospital Episode Statistics, available at http://www.hesonline.nhs.uk

NHS Specialised Services (2010) Specialised Services National Definition Set (3rd edition) http://www.specialisedservices.nhs.uk/documents/index/document_category_id:26

Appendix

Table 10: Fully specialised HRGs

hrg4	Episodes	HRG description
EA14Z	11,467	Coronary Artery Bypass Graft (First Time)
DZ18Z	4,292	Sleeping Disorders Affecting Breathing
EA17Z	3,624	Single Cardiac Valve Procedures
EA51Z	3,170	Coronary Artery Bypass Graft with valve replacement or repair
GC01B	2,742	Liver Failure Disorders without Interventions
LB29B	2,532	Urethra Major Open Procedures 18 years and under
AA28Z	2,432	Motor Neuron Disease
EA16Z	2,403	Coronary Artery Bypass Graft (First Time) with Percutaneous Coronary Intervention, Pacing, EP of RFA
FZ24D	1,351	Major Therapeutic Open or Endoscopic Procedures 18 years and under
EA20Z	1,295	Other Complex Cardiac Surgery and Re-do's
EA19Z	1,087	Single Cardiac Valve Procedures with Percutaneous Coronary Intervention, Pacing, EP or RFA
GC01A	921	Liver Failure Disorders with Interventions
SA26A	857	Peripheral Blood Stem Cell Transplant - Autologous 19 years and over
EA52Z	856	Repair or replacement of more than one heart valve
CZ26Z	741	Bone Anchored Hearing Aids
JC19U	707	Electrical and other invasive therapy 4 - 18 years and under
LB46Z	693	Live Donation of Kidney
EA26Z	638	Standard Congenital Surgery
CZ25Q	633	Cochlear Implants without CC
LA03A	614	Kidney Transplant 19 years and over from Live donor
SA14Z	494	Plasma Exchanges 2 to 9
LA02A	469	Kidney Transplant 19 years and over from Cadaver Heart beating donor
DZ33Z	433	Hyperbaric Oxygen Treatment
EA23Z	363	Major Complex Congenital Surgery
SA28A	346	Peripheral Blood Stem Cell Transplant - Allogeneic 19 years and older
DZ21G	238	Chronic Obstructive Pulmonary Disease or Bronchitis with NIV without Intubation without CC
LA01A	230	Kidney Transplant 19 years and over from Cadaver non-Heart beating donor
SA19A	229	Bone Marrow Transplant - Autograft 19 years and over
CZ25N	218	Cochlear Implants with CC
HC09Z	174	Intradural Spine Intermediate 2
SA15Z	142	Plasma Exchanges 10 to 19
EA22Z	129	Other Complex Cardiac Surgery with Percutaneous Coronary Intervention, Pacing, EP or RFA
FZ01C	116	Complex Oesophageal Procedures 18 years and under
HC08Z	103	Intradural Spine Major 1
DZ01Z	89	Lung Transplant
SA20A	88	Bone Marrow Transplant - Allogeneic Graft (Sibling) 19 years and over
EA02Z	84	Heart Transplant
EA43Z	81	Implantation of Prosthetic Heart or Ventricular Assist Device
SA26B	50	Peripheral Blood Stem Cell Transplant - Autologous 18 years and under
LA03B	44	Kidney Transplant 18 years and under from Live donor
LA02B	42	Kidney Transplant 18 years and under from Cadaver Heart beating donor
SA28B	31	Peripheral Blood Stem Cell Transplant - Allogeneic 18 years and under
SA20B	30	Bone Marrow Transplant - Allogeneic Graft (Sibling) 18 years and under
SA21B	20	Bone Marrow Transplant - Allogeneic Graft (Volunteer Unrelated Donor) 18 years and under
LA12A	19	Kidney pre-transplantation work-up of recipient 19 years and over
SA22A	16	Bone Marrow Transplant - Allogeneic Graft (Cord Blood) 19 years and over
LA11Z	15	Kidney pre-transplantation work-up of live donor
SA16Z	13	Plasma Exchanges 20 or more
WA01Y	12	Manifestations of HIV/AIDS without CC
SA19B	11	Bone Marrow Transplant - Autograft 18 years and under
WA01W	10	Manifestations of HIV/AIDS with CC
SA22B	10	Bone Marrow Transplant - Allogeneic Graft (Cord Blood) 18 years and under
GA01B	9	Hepatobiliary Transplant 2 to 17 years
GA01A	6	Hepatobiliary Transplant 1 year and under
LA10Z	5	Live Kidney donor screening
DZ46Z	4	Respiratory Muscle Strength Studies
LA01B	3	Kidney Transplant 18 years and under from Cadaver non-Heart beating donor
SA27A	2	Peripheral Blood Stem Cell Transplant - Syngeneic 19 years and over
SA23A	2	Bone Marrow Transplant - Allogeneic Graft (Haplo-Identical) 19 years and over
DZ45Z	1	Lung Volume Studies
EA01Z	1	Heart & Lung Transplant

Table 11: Provider Information

Key: **Totactivity**: the total number of episodes reported in HES after eliminating duplicates and inconsistencies. **Norefcost**: the number of provider episodes with unmatched costs. The two columns **finalepi** and **finalspell** represent respectively the number of episodes and spells used for the econometric analysis. **%MISS** and **%SPEC** indicate the percentage of missing episodes and the percentage of episodes with specialised care markers.

procode3	Hospital Name	totactivity	norefcost	finalepi	finalspell	% MISS	% SPEC
RR1	Heart of England NHS Foundation Trust	306,731	23,410	283,258	250,038	7.65	28.04
RHQ	Sheffield Teaching Hospitals NHS Foundation Trust	297,715	37,869	259,812	238,867	12.73	44.61
RWE	University Hospitals of Leicester NHS Trust	267,803	27,009	240,791	208,738	10.09	11.97
RR8	Leeds Teaching Hospitals NHS Trust	257,225	23,209	232,903	205,721	9.46	13.98
RW6	Pennine Acute Hospitals NHS Trust	245,134	24,616	220,305	197,757	10.13	5.42
RX1	Nottingham University Hospitals NHS Trust	221,639	34,608	186,049	162,883	16.06	13.00
RM1	Norfolk and Norwich University Hospital NHS Trust	217,319	24,134	193,017	169,225	11.18	23.53
RTH	Oxford Radcliffe Hospitals NHS Trust	216,582	14,036	202,545	190,223	6.48	36.42
RXN	Lancashire Teaching Hospitals NHS Foundation Trust	210,031	34,078	175,816	165,898	16.29	6.40
RTE	Gloucestershire Hospitals NHS Foundation Trust	206,097	48,664	157,373	138,514	23.64	4.80
RJE	University Hospital of North Staffordshire NHS Trust	202,646	15,084	187,312	167,766	7.57	16.41
RTD	The Newcastle Upon Tyne Hospitals NHS Foundation Trust	201,320	31,149	169,545	158,189	15.78	15.07
RJ1	Guy's and St Thomas' NHS Foundation Trust	199,824	11,696	187,820	180,341	6.01	13.36
RVJ	North Bristol NHS Trust	188,638	4,860	183,475	171,464	2.74	40.64
RW3	Central Manchester and Manchester Children's University Hospitals NHS Trust	184,726	15,574	169,071	153,979	8.47	40.85
RAL	Royal Free Hampstead NHS Trust	183,398	90,998	90,792	81,666	50.49	9.95
RGT	Cambridge University Hospitals NHS Foundation Trust	183,327	60,823	122,437	114,937	33.21	13.96
RYJ	Imperial College Healthcare NHS Trust	183,307	26,395	156,802	142,066	14.46	13.65
RYQ	South London Healthcare NHS Trust	175,337	12,194	162,733	150,014	7.19	4.52
RTG	Derby Hospitals NHS Foundation Trust	174,860	18,580	156,269	133,093	10.63	5.61
RWD	United Lincolnshire Hospitals NHS Trust	172,582	16,647	155,675	136,247	9.80	4.33
RWA	Hull and East Yorkshire Hospitals NHS Trust	171,457	10,070	161,250	138,984	5.95	10.45
RTR	South Tees Hospitals NHS Trust	163,455	24,016	139,426	118,578	14.70	10.97
RHU	Portsmouth Hospitals NHS Trust	162,693	24,310	137,466	118,261	15.51	6.67
RXF	Mid Yorkshire Hospitals NHS Trust	158,609	9,087	149,522	129,702	5.73	4.15
RH8	Royal Devon and Exeter NHS Foundation Trust	157,081	13,214	143,211	120,320	8.83	13.39
RVV	East Kent Hospitals NHS Trust	155,994	20,966	132,610	124,896	14.99	5.89
REF	Royal Cornwall Hospitals NHS Trust	155,785	15,660	140,087	121,770	10.08	8.41

procode3	Hospital Name	totactivity	norefcost	finalepi	finalspell	% MISS	% SPEC
RHM	Southampton University Hospitals NHS Trust	154,564	14,015	140,390	113,195	9.17	18.51
RF4	Barking, Havering and Redbridge Hospitals NHS Trust	154,117	16,922	137,173	118,376	10.99	5.08
RXK	Sandwell and West Birmingham Hospitals NHS Trust	153,787	12,097	141,688	126,597	7.87	4.69
RA7	United Bristol Healthcare NHS Trust	149,437	21,943	126,756	109,364	15.18	20.53
RKB	University Hospitals Coventry and Warwickshire NHS Trust	148,717	13,878	134,788	117,514	9.37	9.10
RXR	East Lancashire Hospitals NHS Trust	144,248	18,102	126,146	111,334	12.55	3.81
RXP	County Durham and Darlington NHS Foundation Trust	139,859	6,820	133,038	118,895	4.88	3.83
RNA	Dudley Group of Hospitals NHS Trust	136,450	26,609	109,783	98,713	19.54	8.29
RLN	City Hospitals Sunderland NHS Foundation Trust	135,553	18,762	116,791	102,281	13.84	5.76
RTF	Northumbria Healthcare NHS Foundation Trust	134,105	14,130	119,945	102,856	10.56	3.81
RM3	Salford Royal NHS Foundation Trust	132,649	48,480	83,871	72,445	36.77	7.30
RHW	Royal Berkshire NHS Foundation Trust	132,345	8,801	123,544	120,564	6.65	35.23
RL4	The Royal Wolverhampton Hospitals NHS Trust	131,927	18,392	113,507	102,254	13.96	16.77
RQ6	Royal Liverpool and Broadgreen University Hospitals NHS Trust	131,740	8,985	122,755	107,476	6.82	13.59
RK9	Plymouth Hospitals NHS Trust	131,563	11,210	120,251	106,152	8.60	11.26
RJZ	King's College Hospital NHS Foundation Trust	130,211	21,753	101,609	90,596	21.97	25.21
RYR	Western Sussex Hospitals NHS Trust	128,301	8,842	119,170	106,965	7.12	4.67
RVL	Barnet and Chase Farm Hospitals NHS Trust	126,442	18,341	107,724	95,522	14.80	5.71
RDZ	The Royal Bournemouth and Christchurch Hospitals NHS Foundation Trust	126,373	23,934	102,236	83,507	19.10	2.87
RXW	Shrewsbury and Telford Hospital NHS Trust	125,974	14,871	111,103	99,258	11.80	15.25
RWY	Calderdale and Huddersfield NHS Foundation Trust	123,799	10,204	113,429	100,545	8.38	4.26
REM	Aintree University Hospitals NHS Foundation Trust	123,542	10,063	113,193	89,699	8.38	23.53
RRK	University Hospital Birmingham NHS Foundation Trust	122,971	8,288	114,675	105,630	6.75	36.73
RP5	Doncaster and Bassetlaw Hospitals NHS Foundation Trust	122,479	9,485	112,992	101,020	7.75	4.85
RJ7	St George's Healthcare NHS Trust	118,887	11,285	107,292	103,192	9.75	13.09
RWP	Worcestershire Acute Hospitals NHS Trust	118,010	13,047	104,955	97,144	11.06	3.91
RXL	Blackpool, Fylde and Wyre Hospitals NHS Foundation Trust	117,989	9,616	107,792	91,881	8.64	9.89
RAE	Bradford Teaching Hospitals NHS Foundation Trust	117,687	7,970	109,536	101,829	6.93	5.27
RRV	University College London Hospitals NHS Foundation Trust	115,293	14,568	100,554	95,633	12.78	17.06
RBL	Wirral University Teaching Hospital NHS Foundation Trust	112,525	8,940	103,560	89,657	7.97	3.52

procode3	Hospital Name	totactivity	norefcost	finalepi	finalspell	% MISS	% SPEC
RXH	Brighton and Sussex University Hospitals NHS Trust	110,739	3,381	107,301	95,393	3.10	10.30
RWH	East and North Hertfordshire NHS Trust	110,530	8,755	100,823	89,528	8.78	4.46
RTX	University Hospitals of Morecambe Bay NHS Trust	109,052	14,061	94,911	86,381	12.97	4.53
RJL	Northern Lincolnshire and Goole Hospitals NHS Foundation Trust	108,267	25,142	83,117	72,775	23.23	5.86
RNJ	Barts and The London NHS Trust	107,558	33,715	72,547	71,240	32.55	23.38
RV8	North West London Hospitals NHS Trust	107,009	15,421	91,531	82,549	14.46	4.22
RXC	East Sussex Hospitals NHS Trust	106,409	8,207	98,186	89,502	7.73	5.63
RQ8	Mid Essex Hospital Services NHS Trust	106,207	11,146	95,061	84,546	10.49	5.26
RDD	Basildon and Thurrock University Hospitals NHS Foundation Trust	105,718	24,582	81,037	69,026	23.35	10.18
RBN	St Helens and Knowsley Hospitals NHS Trust	104,510	32,007	72,499	61,916	30.63	2.00
RWF	Maidstone and Tunbridge Wells NHS Trust	100,757	12,622	88,135	81,321	12.53	6.00
RVR	Epsom and St Helier University Hospitals NHS Trust	99,896	10,984	88,811	78,629	11.10	6.07
RNS	Northampton General Hospital NHS Trust	98,636	12,350	86,286	77,805	12.52	6.18
RDE	Essex Rivers Healthcare NHS Trust	98,523	19,199	79,098	65,866	19.72	4.11
RAJ	Southend University Hospital NHS Foundation Trust	96,533	30,837	65,696	61,164	31.94	4.11
RVW	North Tees and Hartlepool NHS Foundation Trust	96,358	8,049	88,309	74,998	8.35	2.66
RXQ	Buckinghamshire Hospitals NHS Trust	95,159	8,518	85,872	80,538	9.76	4.76
RDU	Frimley Park Hospital NHS Foundation Trust	94,091	7,390	86,699	75,881	7.86	3.86
RGN	Peterborough and Stamford Hospitals NHS Foundation Trust	93,019	10,649	82,366	71,552	11.45	5.45
RNL	North Cumbria Acute Hospitals NHS Trust	92,816	6,355	86,461	78,268	6.85	7.82
RK5	Sherwood Forest Hospitals NHS Foundation Trust	92,793	43,012	49,745	47,179	46.39	3.45
RGQ	Ipswich Hospital NHS Trust	92,126	12,969	79,117	67,677	14.12	5.38
RWJ	Stockport NHS Foundation Trust	91,509	12,413	79,083	75,421	13.58	3.51
RWW	North Cheshire Hospitals NHS Trust	91,279	5,227	86,052	74,482	5.73	4.26
RRF	Wrightington, Wigan and Leigh NHS Trust	90,698	1,346	89,269	77,178	1.58	5.56
RWG	West Hertfordshire Hospitals NHS Trust	90,560	4,206	86,030	76,236	5.00	5.58
RM2	University Hospital of South Manchester NHS Foundation Trust	90,239	26,453	63,721	60,013	29.39	13.43
RD7	Heatherwood and Wexham Park Hospitals NHS Foundation Trust	89,430	17,165	72,265	61,416	19.19	5.15
RN3	Swindon and Marlborough NHS Trust	88,792	6,543	82,177	70,710	7.45	5.87
RCB	York Hospitals NHS Foundation Trust	87,571	3,498	83,774	73,717	4.34	4.61

procode3	Hospital Name	totactivity	norefcost	finalepi	finalspell	% MISS	% SPEC
RD3	Poole Hospital NHS Foundation Trust	86,093	9,745	76,325	67,614	11.35	5.67
RC9	Luton and Dunstable Hospital NHS Foundation Trust	85,284	5,719	79,223	67,503	7.11	6.76
RGC	Whipps Cross University Hospital NHS Trust	84,498	8,017	76,480	69,458	9.49	5.34
RBA	Taunton and Somerset NHS Foundation Trust	84,387	12,017	72,370	65,144	14.24	5.64
RGP	James Paget University Hospitals NHS Foundation Trust	84,194	23,244	60,950	53,362	27.61	4.24
RBD	Dorset County Hospital NHS Foundation Trust	83,767	6,230	77,537	72,115	7.44	10.31
RBT	Mid Cheshire Hospitals NHS Trust	83,383	5,968	76,777	64,959	7.92	2.34
RMC	Bolton Hospitals NHS Trust	81,271	3,749	77,397	69,944	4.77	5.03
RPA	Medway NHS Trust	78,936	11,955	66,762	59,397	15.42	4.21
RD1	Royal United Hospital Bath NHS Trust	78,089	2,891	75,115	65,188	3.81	6.25
RNQ	Kettering General Hospital NHS Trust	78,067	4,100	73,966	65,938	5.25	5.65
RCX	The Queen Elizabeth Hospital King's Lynn NHS Trust	78,021	5,341	72,680	62,166	6.85	4.03
RFR	The Rotherham NHS Foundation Trust	77,929	3,001	74,908	71,690	3.88	4.97
RJR	Countess of Chester Hospital NHS Foundation Trust	77,873	14,195	63,668	54,593	18.24	4.02
RFS	Chesterfield Royal Hospital NHS Foundation Trust	77,856	8,251	69,592	62,471	10.61	4.70
RTK	Ashford and St Peter's Hospitals NHS Trust	76,917	19,201	57,705	54,980	24.98	5.59
RTP	Surrey and Sussex Healthcare NHS Trust	76,289	4,756	71,338	64,308	6.49	4.22
RJ6	Mayday Healthcare NHS Trust	76,062	17,555	58,358	51,999	23.28	4.90
RA9	South Devon Healthcare NHS Foundation Trust	76,018	5,631	70,387	59,770	7.41	7.00
RAX	Kingston Hospital NHS Trust	75,735	6,400	69,137	58,671	8.71	4.45
RQM	Chelsea and Westminster Hospital NHS Foundation Trust	73,612	22,465	50,976	48,130	30.75	8.94
RFF	Barnsley Hospital NHS Foundation Trust	72,290	8,314	63,915	54,122	11.59	5.33
RA2	Royal Surrey County Hospital NHS Trust	72,268	7,199	64,905	59,136	10.19	9.01
RNZ	Salisbury NHS Foundation Trust	70,013	11,582	58,328	52,877	16.69	7.28
RD8	Milton Keynes Hospital NHS Foundation Trust	67,913	18,577	49,302	42,685	27.40	4.23
RJD	Mid Staffordshire NHS Foundation Trust	67,644	5,927	61,717	56,492	8.76	4.19
RBK	Walsall Hospitals NHS Trust	64,866	9,180	55,589	48,058	14.30	7.44
RNH	Newham University Hospital NHS Trust	64,738	6,478	58,260	53,115	10.01	1.59
RQW	The Princess Alexandra Hospital NHS Trust	64,080	5,778	58,163	55,201	9.23	5.87
RVY	Southport and Ormskirk Hospital NHS Trust	63,471	1,797	61,646	54,926	2.88	4.05

procode3	Hospital Name	totactivity	norefcost	finalepi	finalspell	% MISS	% SPEC
RGR	West Suffolk Hospitals NHS Trust	63,242	8,309	54,933	47,546	13.14	4.57
RJ2	The Lewisham Hospital NHS Trust	59,122	11,198	47,848	45,320	19.07	7.30
RMP	Tameside Hospital NHS Foundation Trust	58,050	1,391	56,648	49,679	2.42	3.22
RCF	Airedale NHS Trust	57,362	5,197	52,147	45,489	9.09	3.74
RJC	South Warwickshire General Hospitals NHS Trust	55,073	3,212	51,861	46,827	5.83	4.12
RAS	The Hillingdon Hospital NHS Trust	54,496	4,425	50,041	47,786	8.17	2.87
RN5	Basingstoke and North Hampshire NHS Foundation Trust	54,441	3,859	50,534	45,956	7.18	3.88
RN7	Dartford and Gravesham NHS Trust	54,147	11,065	43,058	39,113	20.48	3.05
RJF	Burton Hospitals NHS Trust	54,115	6,598	47,517	42,873	12.19	3.61
RBZ	Northern Devon Healthcare NHS Trust	53,831	3,836	49,966	40,255	7.18	5.15
RAP	North Middlesex University Hospital NHS Trust	53,669	7,191	46,419	35,715	13.51	3.59
RQX	Homerton University Hospital NHS Foundation Trust	52,174	4,358	47,562	42,805	8.84	4.43
RFW	West Middlesex University Hospital NHS Trust	51,550	5,134	46,410	38,903	9.97	5.26
RN1	Winchester and Eastleigh Healthcare NHS Trust	51,503	8,999	42,390	37,113	17.69	4.51
RC1	Bedford Hospital NHS Trust	51,497	8,157	43,257	39,143	16.00	6.23
RPY	The Royal Marsden NHS Foundation Trust	51,482	1,329	50,103	50,103	2.68	6.42
RKE	The Whittington Hospital NHS Trust	51,189	4,535	46,654	42,413	8.86	7.70
RCC	Scarborough and North East Yorkshire Health Care NHS Trust	48,161	3,598	44,558	39,934	7.48	3.09
RBS	Royal Liverpool Children's NHS Trust	47,033	7,116	39,913	35,265	15.14	32.43
RR7	Gateshead Health NHS Foundation Trust	46,978	3,027	43,951	37,444	6.44	2.24
RCD	Harrogate and District NHS Foundation Trust	46,008	2,282	43,659	42,161	5.11	3.66
RA4	Yeovil District Hospital NHS Foundation Trust	45,977	3,310	42,204	34,619	8.21	4.78
RC3	Ealing Hospital NHS Trust	45,900	1,458	44,442	39,577	3.18	3.03
RLT	George Eliot Hospital NHS Trust	43,694	3,611	40,083	36,600	8.26	4.78
RJN	East Cheshire NHS Trust	42,061	4,743	37,318	33,596	11.28	3.37
RE9	South Tyneside NHS Foundation Trust	40,365	3,423	36,938	31,108	8.49	3.71
RQQ	Hinchingbrooke Health Care NHS Trust	37,751	2,310	35,441	32,047	6.12	5.97
RA3	Weston Area Health NHS Trust	37,582	4,234	33,096	27,935	11.94	3.38
RLQ	Hereford Hospitals NHS Trust	37,305	1,721	35,570	31,536	4.65	4.99
RQ3	Birmingham Children's Hospital NHS Foundation Trust	35,660	3,159	32,464	31,368	8.96	49.59

procode3	Hospital Name	totactivity	norefcost	finalepi	finalspell	% MISS	% SPEC
RP4	Great Ormond Street Hospital For Children NHS Trust	33,746	5,197	28,549	26,041	15.40	71.42
RT3	Royal Brompton and Harefield NHS Trust	32,282	4,458	27,575	25,901	14.58	55.92
RM4	Trafford Healthcare NHS Trust	31,683	2,183	29,500	26,163	6.89	6.09
REP	Liverpool Women's NHS Foundation Trust	29,012	638	28,374	28,351	2.20	0.62
RP6	Moorfields Eye Hospital NHS Foundation Trust	27,388	1,561	25,817	25,817	5.74	6.91
RCU	Sheffield Children's NHS Foundation Trust	26,358	2,420	23,928	22,821	9.22	39.06
RGM	Papworth Hospital NHS Foundation Trust	22,437	4,402	18,035	17,665	19.62	62.49
RBV	Christie Hospital NHS Foundation Trust	22,424	4,274	18,145	17,945	19.08	21.47
RPC	Queen Victoria Hospital NHS Foundation Trust	18,725	1,121	17,598	17,567	6.02	11.68
RLU	Birmingham Women's NHS Foundation Trust	17,840	2,413	15,427	14,830	13.53	1.49
RRJ	The Royal Orthopaedic Hospital NHS Foundation Trust	15,541	68	15,473	15,473	0.44	10.58
RET	Walton Centre for Neurology and Neurosurgery NHS Trust	11,830	5,643	6,130	6,060	48.18	22.99
RAN	Royal National Orthopaedic Hospital NHS Trust	11,203	54	11,142	11,130	0.54	20.49
RBQ	The Cardiothoracic Centre - Liverpool NHS Trust	11,018	341	10,676	10,212	3.10	58.53
RL1	Robert Jones and Agnes Hunt Orthopaedic and District Hospital NHS Trust	10,942	921	10,011	9,990	8.51	5.94
RBF	Nuffield Orthopaedic Centre NHS Trust	9,881	457	9,424	9,372	4.63	4.02
REN	Clatterbridge Centre for Oncology NHS Foundation Trust	4,264	986	3,190	3,182	25.19	8.36
RBB	Royal National Hospital for Rheumatic Diseases NHS Foundation Trust	3,576	91	3,485	3,485	2.54	0.11

Table 12: Equation 4 full results, OLS

	2008-2009 b/signif	2009-2010 b/signif		2008-2009 b/signif	2009-2010 b/signif
Cancer	0.186 ***	0.243 ***	obesity	0.013	0.041 ***
BMT	-0.089	-0.293 **	allergy	0.026 ***	0.030 ***
Haemophilia	-0.200 *	-0.232 **	diabetes	-0.008	0.001
Womens	-0.016	0.056	hypertens	0.047	-0.012
Spinal	0.269 ***	-0.119	haemorr	0.081 **	0.088 ***
Neurosciences	0.167 ***	0.108	histdis	0.020 *	0.021 **
Cystic fibrosis	0.330 ***	0.283 ***	riskfact	0.001	-0.004
Renal	-0.086	0.199	congmalf	0.051 ***	0.033
Intestinal failure	-0.019	-0.004	risk_phys	-0.007	0.045
Cardiology	-0.059	-0.049	risk_psysoc	0.192 ***	0.164 ***
Cleft lip	-0.014	0.047	tr_in_el	0.008	-0.061
Infectious diseases	0.202 ***	0.355 ***	tr_in_nonel	0.160 **	0.235 ***
Liver	0.063	-0.021	tr_out_el	0.140 ***	0.132 ***
Children	0.172 ***	0.183 ***	tr_out_nonel	0.129 ***	0.110 ***
Dermatology	-0.004	-0.013	die	0.072 ***	0.068 ***
Rheumatology	0.160 ***	0.127 *	emerg	-0.013	-0.017
Endocrinology	0.011	0.008	episodes	0.108 ***	0.116 ***
Respiratory	-0.073	-0.041	dreg2	0.115	-0.035
Vascular diseases	0.173 **	0.194 *	dreg3	0.160 ***	0.065
Pain Management	0.217	2.168 ***	dreg4	0.022	-0.015
Ear surgery	0.018	-0.088	dreg5	0.009	-0.041
Colorectal	0.212 ***	0.119 ***	dreg6	0.068	-0.021
Orthopaedic	0.222 ***	0.007	dreg7	0.007	-0.069
Morbid obesity	-0.010	-0.074	dreg8	0.044	0.050
Metabolic disorders	0.002	0.323	dreg9	0.055	-0.004
Ophthalmology	0.077	0.080	urban1	-0.003	0.002
Haemoglobinopathy	0.013	0.069	white1	0.015 **	-0.002
imd04c	0.000	-0.004	female1	0.599	0.184
imd04ed	0.000	0.000	male1	0.600	0.179
imd04hd	-0.009	0.002	age	0.085	0.000
imd04hs	0.000	0.000	age2	-0.002	0.000
imd04i	0.090 **	0.042	age3	0.000 *	0.000
imd04ia	-0.047 *	0.053	femage	-0.086	-0.002
imd04ic	-0.078 ***	-0.050	femage2	0.002	0.000
imd04le	0.000	0.000	femage3	0.000 *	0.000
imd04rk	0.000 ***	0.000	malage	-0.087	-0.003
pregnancy	0.079 ***	0.077 ***	malage2	0.002	0.000
drug	-0.001	0.001	malage3	0.000 *	0.000
alcohol	-0.041 ***	-0.036 ***	_cons	0.260	0.689 ***
smoke	-0.008	-0.009	N	12,154,599	12,971,384

Notes: Significance level: *** 1%, ** 5%, * 10%.

Table 13: Equation 4 full results, GLM

	2008-2009 b/signif	2009-2010 b/signif		2008-2009 b/signif	2009-2010 b/signif
Cancer	0.194 ***	0.268 ***	obesity	0.026	0.055 ***
BMT	-0.025	-0.034	allergy	0.024 **	0.030 ***
Haemophilia	-0.163	-0.220	diabetes	-0.018	0.000
Womens	-0.002	0.062	hypertens	0.056	-0.022 **
Spinal	0.257 ***	0.126 *	haemorr	0.071 **	0.082 ***
Neurosciences	0.187 ***	0.184 ***	histdis	0.020	0.036 ***
Cystic fibrosis	0.290 ***	0.255 ***	riskfact	-0.012	-0.003
Renal	-0.091	0.216	congmalf	0.058 ***	0.045 **
Intestinal failure	-0.023	-0.010	risk_phys	0.004	0.065 **
Cardiology	0.059 *	0.058	risk_psysoc	0.175 ***	0.162 ***
Cleft lip	0.003	0.049	tr_in_el	0.012	-0.004
Infectious diseases	0.183 ***	0.290 ***	tr_in_nonel	0.157 ***	0.174 ***
Liver	0.075	0.084 **	tr_out_el	0.122 ***	0.117 ***
Children	0.216 ***	0.212 ***	tr_out_nonel	0.129 ***	0.118 ***
Dermatology	0.016	-0.012	die	0.073 ***	0.072 ***
Rheumatology	0.197 ***	0.292 ***	emerg	-0.023	-0.033 *
Endocrinology	0.050	0.065	episodes	0.106 ***	0.116 ***
Respiratory	-0.012	0.012	dreg2	0.109	-0.039
Vascular diseases	0.164 ***	0.241 ***	dreg3	0.14 ***	0.053
Pain Management	0.209	1.226 ***	dreg4	0.033	0.016
Ear surgery	0.084	0.099	dreg5	-0.017	-0.069
Colorectal	0.200 ***	0.125 ***	dreg6	0.081 *	0.011
Orthopaedic	0.227 ***	0.158 ***	dreg7	-0.021	-0.104 *
Morbid obesity	-0.042	-0.109	dreg8	0.03	0.003
Metabolic disorders	0.025	0.342	dreg9	0.08 **	0.033
Ophthalmology	0.095	0.081	urban1	0.005	0.011
Haemoglobinopathy	0.002	0.073	white1	0.008	-0.011
imd04c	0.021 *	0.007	female1	0.431 *	0.063
imd04ed	0.000	0.000	male1	0.434 *	0.056
imd04hd	-0.022	0.000	age	0.07 *	-0.015
imd04hs	0.001	0.000	age2	-0.002 **	0.000
imd04i	-0.075	-0.027	age3	0 **	0.000
imd04ia	0.104 **	0.119 *	femage	-0.071 *	0.014
imd04ic	-0.014	0.025	femage2	0.002 **	0.000
imd04le	-0.001 *	0.000	femage3	0 **	0.000
imd04rk	0.000	0.000	malage	-0.071 **	0.014
pregnancy	0.057 *	0.053 **	malage2	0.002 **	0.000
drug	-0.009	-0.012	malage3	0 **	0.000
alcohol	-0.051 ***	-0.049 ***	_cons	-0.63 ***	-0.240
smoke	-0.005	0.002	N	12154599	12,971,384

Notes: Significance level: *** 1%, ** 5%, * 10%.

Table 14: Variables label and definition

Variable name	Description
imd04c	Index of Multiple Deprivation: Crime
imd04ed	Index of Multiple Deprivation: Education, Skills and training
imd04hd	Index of Multiple Deprivation: Health Deprivation and Disability
imd04hs	Index of Multiple Deprivation: Barriers to Housing and Services
imd04i	Index of Multiple Deprivation: Income deprivation
imd04ia	Index of Multiple Deprivation:Income Deprivation Affecting Older People
imd04ic	Index of Multiple Deprivation: Income Deprivation Affecting Children
imd04le	Index of Multiple Deprivation: Living Environment
imd04rk	Index of Multiple Deprivation: Overall ranking
pregnancy	=1, One of the patient diagnosis is: pregnancy,childbirth or puerperium
drug	=1, Patient is drug user or drug dependent
alcohol	=1, Patient is alcohol user or alcohol dependent
smoke	=1, Patient is tobacco user or tobacco dependent
obesity	=1, Patient with obesity problems
allergy	=1, Patient with personal history of allergy
diabetes	=1, Patient with diabetes problems
hypertens	=1, Patient with hypertension problems
haemorr	=1, Patient with haemorrage/coagulation problems
histdis	=1, Patient with personal history of diseases
riskfact	=1, Patient with other lifestyle risk factors
congmalf	=1, Patient with congenital malformations
risk_phys	=1, Patient exposed to physical risk factors
risk_psysoc	=1, Patient with problems related to psychosocial circumstances
tr_in_el	=1, Patient transferred from an eligible provider
tr_in_nonel	=1, Patient transferred from a non-eligible provider
tr_out_el	=1, Patient transferred to an eligible provider
tr_out_nonel	=1, Patient transferred to a non-eligible provider
die	=1, Patient died
emerg	=1, Patient admitted as emergency
episodes	Number of episodes in the spell
East of England	=1, Region of treatment: East of England
London	=1, Region of treatment: London
North-East	=1, Region of treatment: North-East
North-West	=1, Region of treatment: North-West
South-East	=1, Region of treatment: South-East
South-West	=1, Region of treatment: South-West
West Midlands	=1, Region of treatment: West Midlands
Yorkshire	=1, Region of treatment: Yorkshire
urban1	=1, Urban area
white1	=1, ethnicity is white
female1	=1, Patient is female
male1	=1, Patient is male
age	Patient age at the beginning of the spell

age2	Squared patient age
age3	Cubic power of patient age
femage	Interaction: Age*Female
femage2	Interaction: Squared age*Female
femage3	Interaction: Cubic age*Female
malage	Interaction: Age*Male
malage2	Interaction: Squared age*Male
malage3	Interaction: Cubic age*Male