Title: Cost variation in diabetes care delivered in English hospitals.

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Abstract:

Background:
Many diabetic patients are admitted to hospital, where care is costly and where there may be scope to improve efficiency.

Aims:
We analyse the costs and characteristics of diabetic patients admitted to English hospitals and aim to assess what proportions of cost variation are explained by patient and hospital characteristics.

Methods:
We apply a multilevel approach recognising that patients are clustered in hospitals. We first analyse the relationship between patient costs and their characteristics, such as HRG, age, gender, diagnostic markers and socio-economic status. We derive the hospital fixed effect and adjust for hospital characteristics such as number of patients treated, factor prices and number of specialties involved in diabetes care. We rank hospitals by their adjusted fixed effect, which measures the extent to which their costs vary from the average after controlling for patient and hospital characteristics. We conduct sensitivity analysis to alternative specifications including different sets of covariates and subsamples.

Data:
We use Hospital Episode Statistics and reference costs for all patients admitted to diabetes care for all English hospitals for the financial year 2005/06. Our sample includes 31.371 admitted patients in 148 hospitals.

Results:
Much of the variation in costs is driven by patient characteristics. Even so, around 8-9% of the variation in costs is across hospitals. Geographical variation in factor prices is significant for cost of diabetes care. The volume of patients, the number and diversity of specialties involved in caring for diabetics was rejected as significant cost drivers. .

Conclusion:
Health Resource Groups (HRGS) and diagnostic markers are significant patient-related cost drivers in diabetes care. Costs are not lower in hospitals with high volume of patients and where diabetes care is concentrated in few specialties.

Introduction

Over two million people in the UK, around 3.5% of the total population, have been diagnosed with diabetes and it is estimated that up to half a million people remain undiagnosed (Diabetes UK, 2007). While the prevalence of diabetes is increasing the exact prevalence of insulin-dependent diabetes and non-insulin-dependent diabetes diabetes patients is unknown (Currie, 2006). Around 1% of total health care expenditure is devoted to diabetes, equivalent to £14 per head of the population each year (Martin, Rice & Smith, 2008). It has been estimated that the economic burden of non-insulin-dependent diabetes diabetes may increase by 40-50% over the next 30 years due to population ageing, affluent lifestyles, eating habits and reductions in the economically active age groups (Bagust, Hopkinson, Maslove & Currie, 2002). Of the forecast increase in diabetes cases in UK between 2005 and 2010, up to 50% are thought to be related to obesity (National Clinical Director for Diabetes, 2008).

Both in terms of human and economic cost this development represents a growing burden on the UK health system and society. The economic cost of a chronic condition such as diabetes includes the cost of care and loss in productivity and other indirect and intangible costs (Kapur, 2007). The cost of diabetes care is influenced by patient characteristics and the way in which care for people with diabetes is organized, for instance, by investing in preventive care and primary management of diabetes to prevent hospital admission. Regarding the organisation of diabetes management in England, the Department of Health has implemented a National Service Framework and strategies for building integrated care to secure every one with diabetes the best possible care (NHS Confederation, 2009; Kenny, 2005; National Clinical Director for Diabetes, 2008). According to the Association of British Clinical Diabetologist (ABCD), these developments have resulted in a transfer of most of chronic disease management from secondary care to primary care (Keen, 2005). One potential justification for this policy may be that countries with strong general practice seem to have lower healthcare costs (Starfield, 2001). Nevertheless a vital part of diabetes care should be provided by secondary care to allow management along the entire care pathway (NHS Confederation, 2009). As stated by ABCD, "without specialist services integrated care will work only if there is something to integrate with" (Keen, 2005).

The overall aim of diabetes care is to enable people with diabetes to achieve a quality of life and life expectancy similar to that of the general population (www.diabetes.org.uk). The provision of diabetes services is necessarily complex. Care is provided by a team of healthcare professionals, including general practice, community healthcare staff and specialist diabetes teams at the hospitals, as well as the patients themselves and their carers. Over time, most patients do, however, move between primary and secondary care according to their needs. Rates of hospitalization of patients with diabetes have been reported to be higher than in the general population, (Bo, Ciccone, Baldi, Benini, Dusio, Forastiere et al. 2007). A Scottish study shows that patients with diabetes had approximately twice (25 vs. 12%) the annual number of consultations compared with subjects without diabetes (Donnan, Leese & Morris, 2000).

In recent years, considerable research has been undertaken using administrative patient data to understand variations in health care costs (Clarke, Kelman & Colagiuri, 2006). Diabetics suffer complications such as cardiovascular disease, renal complications, eye diseases and neuropathy and foot ulcers (Ray, Valentine, Secnik, Oglesby, Cordony, Gordois et al. 2005; Gerdtham, Clarke & Hayes, 2009). A study conducted in Minnesota USA indicates that coronary heart disease (CHD), hypertension, depression and glycated hemoglobin A1c level are significant predictors of care cost in adults with diabetes (Gilmer, O'Connor, Rush, Crain, Whitebird, Hanson et al. 2005).

Diabetes patients are admitted to hospital mainly because of the complications of diabetes (Campbell & Campbell, 1997) and patients with diabetes tend to have slightly longer hospital stays than similar patients without the condition (Sampson, Dozio, Ferguson & Dhatariya, 2007). An Australian study of Diagnosis Related Group (DRG) based cost of hospital care showed that additional cost of treating people with diabetes is due to increased frequency of diseases requiring hospitalization (Clarke et al., 2006). Extra costs were due to additional admissions, increased length of stay and greater treatment cost in subsequent years.

In a recent Italian study, patient characteristics affecting hospitalization costs in diabetes have been explored, (Pagano, Bo, Petrinco, Rosato, Merletti & Gregori, 2009b). Total cost per patient were calculated as the sum of DRG tariffs to all hospitalizations from 1996-2000. Hospitalization costs were significantly increased by the presence of diabetes comorbidities and chronic diabetes complications.

The inpatient cost of diabetes care in the UK has been evaluated by using a diabetes database covering Cardiff and the Vale of Glamorgan (Currie, Morgan, Dixon, McEwan, Marchant, Bearne et al. 2005; Currie, Morgan, Dixon, McEwan, Marchant, Bearne et al. 2004) and in the United Kingdom Prospective Diabetes Study (UKPDS) (Clarke, Gray, Legood, Briggs & Holman, 2003). In UKPDS costs of diabetes-related complications for a sample of 5,102 were estimated by multiplying length of stay by average specialty costs as summarised in the Department of Health´s NHS Financial Returns. In the Welsh study 28% of identified diabetes patients had a least one admission per year, and the costs of these inpatient admission for 2815 patients were calculated using HRG grouper per episode. These studies found that the management of diabetes was costly, the costs were higher than for non-diabetic inpatient stays, and that the cost of diabetes care increased with the number of diabetes complications such as ischemic heart disease, stroke, blindness and limb amputations.

In this study we investigate why hospital costs vary among adult patients admitted with a primary diagnosis of diabetes using data on all such admissions to English hospitals in 2005/6. We assess the extent to which costs are determined by the diagnostic characteristics of patients and by the characteristics of the hospital in which they are treated. This is achieved using two-stage modelling process where, first, we assess the influence of diagnostic characteristics on the costs of each patient and, second, we consider the influence of hospital characteristics on the costs of their patients. We outline our analytical method in the next section, after which we describe our data, present the results of our analysis and offer conclusions.

Methods

A two stage multilevel regression approach is used to explain cost variation in diabetes care (Laudicella, Olsen & Street, 2009). In the first stage we apply a fixed effects multilevel data model that recognises the stratification of patients within hospitals (Olsen & Street, 2007). The model takes the following form:

$$C_{ij} = \alpha + \beta X_{ij} + u_j + v_{ij}, \qquad i = 1,...I, j = 1,...N \qquad (1)$$

Where C_{ij} is the cost of diabetes for patient *i* admitted with diabetes to hospital *j*. In our sample 36% of patients admitted with diabetes are subsequently treated for other conditions during their hospital stay. We are able to identify and analyse the costs relating to their diabetes care only, and exclude the costs associated with these other treatment events from our analysis. X_{ij} is a matrix of explanatory variables containing characteristics of patient *i* in hospital *j*. To explore the sensitivity of results to different diagnostic characteristics we specify four models (1A-4A) with different combinations of four subsets of covariates: the Healthcare Resource Group (HRG) to which the patient is allocated, a set of diagnostic markers based on ICD10 codes, and a clinical description of diabetic patients.

In the second stage, after controlling for patients characteristics, we identify hospitals that have significantly higher cost than others and consider the characteristics of these hospitals. Thus, we regress the estimated hospital fixed effects $\hat{u}_j$ from equation (1) against a set of hospital characteristics to reveal the extent to which any of the remaining cost variation is explained by hospital characteristics. Our equation takes the form:

$$\hat{u}_j = \alpha + \beta Z_j + v_j \qquad (2)$$

Where Z_j is a vector of covariates describing the characteristics of each hospital *j*. We consider the number of diabetics treated in each hospital on the supposition that, if there are economies of scale, the more patients treated, the lower are costs. We also consider the number of specialties in which diabetes patients are treated in each hospital and the concentration of patients in those specialties where diabetic patients are most frequently treated. Costs may be lower in hospitals where diabetes care is divided among more specialties due to economies of scope and competencies. Or costs may be lower in specialist hospitals where diabetes care is concentrated among a few specialties (Schneider, Miller, Ohsfeldt, Morrisey, Zelner & Li, 2008b). Finally we include an index which captures variation in staffing and other factor prices faced by each hospital in each part of England, which drive differences in cost but over which hospitals have limited control (Mason, Street, Miraldo & Siciliani, 2009).

Standard errors in equation (1) are corrected for heteroscedasticity using White's procedure to ensure that statistical tests are valid (White, 1980). To ensure that our second-stage estimates are not contaminated by heteroscedasticity, equation (2) is estimated using Efron robust standard errors (Long & Ervin, 2000).

Common to all models (1A-4A) in (1) is a set of non-diagnostic variables comprising the number of operations, number of diagnoses, age, socio economic status and dummies for sex, type of transfers (admission/discharge) and death. The greater the number of operations or diagnoses a patient has, the higher their costs are likely to be. Gender, age and socio-economics status may also influence costs. Although we are interested in explaining the cost of treatment for diabetes, we include dummy variables identifying whether the patient received care for other conditions during their hospital stay. The expectation is that the cost of treating diabetes itself will be higher for patients treated solely for their diabetes than for patients admitted with diabetes that then go on to receive care for other conditions. Essentially, for such patients attention is quickly diverted from treating (or stabilising) their diabetes to the management of their other condition. We also allow for the possibility that patients transferred from or to other hospitals may have different costs to those that are treated in one hospital alone. Finally, we permit death to influence costs since it has appeared to be a strong cost driver in a similar study (Pagano, Bo, Petrinco, Rosato, Merletti & Gregori, 2009a).

Admitted patients with a primary diagnosis of diabetes were exclusively defined on the primary ICD-10-diagnosis listed in chapter K (Endocrine and metabolic system) in the NHS HRG V3.5 classification-system (NHS, 2005b). This definition is equivalent to HRGs K11-K17 comprising all 4 digit coding within the following diabetes codes: E10 insulin-dependent diabetes, E11 non-insulin-dependent diabetes, E12 malnutrition-related diabetes, E13 other specified diabetes, E14 unspecified diabetes, L97X Ulcer of lower limb and R730 Abnormal glucose tolerance test.

All diagnostic characteristics including all secondary diagnoses have been clustered into three sets of dummy variables. The first set stratifies patients into diabetes HRGs K11-K17. In the regression we exclude K16 as a reference group. A second set consists of diagnostic markers constructed on the basis of the frequency of ICD-10 codes recorded in the fourteen diagnostic fields of the patient record. These markers comprise all information which is captured by the ICD-10 coding such as co-morbidities, complications and some risk related factors. (The 200 most frequent ICD-10 codes (4 digits) descending by volume were applied). The third set is based on clinical stratification of diabetes patients into insulin-dependent diabetes, non-insulin-dependent diabetes, unspecified diabetes, hypoglycaemia and abnormal glucose test). The ICD-10 codes used to construct these covariates are described in table 1.

Data

We analyse the costs of 31,371 patients admitted during 2005/6 to 148 hospitals with a primary diagnosis of diabetes. Our analysis involves combining two datasets 1) Hospital Episode Statistics (HES) and 2) The Reference Costs database. HES comprises individual patient records for all NHS patients treated in England. Each patient record includes demographic data such as age, gender and socioeconomic status, and clinical information such as diagnosis and comorbidities.

The Reference Costs dataset comprises cost data reported by every English hospital for all the patients they treat. These costs are based on a top-down approach where total hospital costs are cascaded down to HRGs in each specialty (NHS, 2005a). We map these cost data to each patient according to their admission type, the hospital and specialty in which they treated and the HRG to which they were allocated, using a mapping procedure described elsewhere (Laudicella et al., 2009).

Descriptive patient characteristics

Descriptive details for patients admitted with diabetes are reported in Table 1. The average cost of diabetes treatment amounted to £1,335.[1] 46% of patients were male, the average patient was 57 years old, and on average 3.76 diagnostic codes were recorded. 36% of patients received treatment during their hospital stay for another condition, of which 6% were treated for several conditions. 0.08% were admitted as transfers, 1.9% were transferred to other hospitals and 0.09% died after being admitted.

The most frequent diagnostic marker, macrovascular disease, was prevalent in 7,773 (24.8%) cases among all 31,371 diabetes patients, followed by hypertension (23.1%) and feet and lower limb complications (18.7%). Smoking is recorded in only 4.2% of patients, though this may be indicative more of coding practice than of the prevalence of smoking behaviour. Diabetes complications such as retinopathy and neuropathy are found in 4% and 3% of patients, respectively. Obesity is recorded in only 1.3% and hypercholesterolemia in as few as 0.8 % of patients. Note that while the HRGs are mutually exclusive categories, each patient may have several diagnostic markers. On average each patient had 1.24 diagnostic markers.

The distribution of patients across the various diabetes HRGs is also reported, with the largest proportion of patients (20%) allocated to K16. The clinical diabetes types indicate that most patients (50%) suffered non-insulin-dependent diabetes.

Table 1 about here

Diabetes care hospital characteristics

Table 2 contains hospital characteristics for the 148 NHS hospitals where the 31,371 patients were treated. We describe hospitals using means, standard deviations (SD) and range for all covariates.

Table 2 around here

[1] As noted, 36% of patients admitted with diabetes are also treated for other conditions. If the cost of these conditions is considered, the average cost amounts to £2,776.

On average each hospital admitted 212 patients with a principal diagnosis of diabetes, but the range is considerable – from 44 to 821 patients. Diabetic patients are admitted to various specialties, with forty different specialties providing care to these patients (the specialty is defined according to the contracted specialty of the physician responsible for the patient). On average, hospitals treat diabetic patients in six different specialties, but patients are more likely to be admitted to some specialties than others. The ten most frequent specialties to which diabetics are admitted are listed in table 2. These specialties capture approximately 98% of patients in the sample. General medicine is clearly the most frequent specialty in diabetes care, to which 76.2% of patients are admitted. This is consistent with the fact that the most UK hospital physicians have acute general inpatient medical responsibilities (www.hesonline.nhs.uk). Geriatrics accounts for 8.4% and general surgery for 4.7% of patients. Finally specialist endocrinologist and diabetologist consultations were provided in 1.0% and 0.8% of secondary diabetes services, respectively.

Results

Table 3 around here

Table 3 shows the results of estimating equation (1) using the four specifications that include different sets of diagnostic factors. These models are able to explain upwards of 25% of the variation in the costs of patients admitted with diabetes, as indicated by the R^2 overall statistic.

Costs are higher the greater the number of operations performed and diagnoses recorded. All models reveal that cost of diabetes care is U-shared as a function of age, younger and older patients having higher costs than the middle-aged. For patients suffering multiple conditions, the cost of treating their diabetes is lower than the cost for patients admitted solely because of the diabetic problems. Patients admitted or discharged as transfers have significantly higher cost than other patients. While under some specifications costs appear higher for women and for patients from more lower income areas, this finding is sensitive to model specification. Furthermore death is a strong cost driver. The additional cost of care in case of death is estimated to approximately £450.

The specifications differ according to which of the three sets of covariates based on HRGs, diagnostic markers and clinical types are included. The coefficients for the HRGs are all measured in relation to the reference group K16. Hence, costs of patients allocated to HRGs K11 and K12 are significant lower than for patients allocated to K16, while the costs of patients allocated to the other HRGs are higher.

As regards the diagnostic markers, we find that patients who suffer infection or complications of the feet or lower limb have significantly higher costs than other patients. In contrast, patients that suffer hypertension or some form of allergy and who smoke tend to have lower costs, as do those who receive dietary surveillance and advice. These conclusions hold whether or not allowance is made for the HRG to which the patient is allocated and for the clinical description of their diabetes.

Table 4 around here.

The *rho* statistic in table 3 indicates that hospital characteristics explain around 9% of the remaining variation in patient costs after we have adjusted for the patient characteristics. In our second stage model (equation 2) we consider which of the hospital characteristics are important in explaining this residual variation. Results are reported in Table 4.

In all four models the number of patients is insignificant in explaining why costs differ from one hospital to another. Nor is it apparent that costs are lower in hospitals that concentrate treatment for diabetics in a smaller number of specialties, as this variable is also insignificant. This implies that there are neither economies of scale nor of specialisation in treating diabetes patients. The inability to identify such economies may be because few diabetic patients are admitted to hospital, with an average of one patient admitted per day.

In contrast, it is evident that costs vary from one hospital to another because of the differences they face in the price of their inputs, predominantly staffing costs. These prices are captured by the market forces factor index, which is used to adjust the funding that hospitals receive in recognition of differences in their factor prices.

Discussion

While there have been a number of studies that evaluate the hospital costs of treatment for diabetes, our study is unique in two important respects. First, rather than a selected sample of diabetics, we analyse the full population of patients admitted with diabetes to English hospitals during 2005/6. Second, as well as analysing variations in cost among patients, we are able to identify and examine cost variations related to the hospital in which care was delivered. Our study combines information from two datasets, the Hospital Episode Statistics which contains detailed patient-level information, and the Reference Costs database which contains cost information reported by each English hospital.

We analyse the costs specifically related to diabetes care for all adults admitted with a primary diagnosis of diabetes. We exclude young diabetics (<18) because it has stated that diabetic children should be considered as a separate issue to adult diabetes and cared for by specialist paediatricians, (British Diabetic Association, 1999). Most studies of cost variation are based on clinical non-routinely collected cost data or limited samples. Instead we make use of routine data. .

Our analysis of variation in costs among patients reveals that, as expected, the HRG to which the patient is allocated is the most powerful predictor of costs. This is reassuring, given that HRGs are the basis for determining the payment received by hospitals for treating patients of particular types. We also find that patient admitted with unspecified diabetes appear more expensive, perhaps because more investigations are required, and that patients who have had an abnormal glucose test appear less expensive, as expected as an abnormal glucose test may present an early stage of the disease.

Age, gender and socio-economic status are not highly predictive of costs, and what limited significance they suggest is conditional upon model specification. Age has shown to be predictive of costs in other studies (Pagano et al., 2009a; Gilmer et al., 2005), gender has also been found to be insignificant (Pagano et al., 2009a; Gilmer et al., 2005), while some have found that costs are related to socio-economic status (Pagano et al., 2009a).

We are able to consider a broad range of diagnostic markers and find that many are significant cost predictors. These findings are in line with the literature (Pagano et al., 2009a; Clarke et al., 2003; Gerdtham et al., 2009; Clarke et al., 2003). Other studies have shown that the presence of co-morbidities and chronic diabetes complications such as micro-vascular and macro-vascular complications, amputations, depression, hypertension and cataract are significant cost drivers. Costs increase with the number of complications, suggesting that minimizing the number of complications would result in considerable cost savings (Currie et al., 2005; Ray et al., 2005). Similarly, we find that patients that suffer infections cost around £150-£200 more to care for than those who do not, amounting to around 10% of the average cost of inpatient care for diabetes. Improved infection control might also yield substantial cost savings. Furthermore, treatment for infections and feet & lower limb are expensive elements of diabetes care, which drives cost due to limb amputations and infection-related illness. Optimal management of diabetic foot ulcers and infections can reduce complications but these are often inadequately managed (Chow, Lemos & Einarson, 2008). Costs are lower for patients that suffer allergy, perhaps because this limits their options for medication, and for those who receive dietary counselling or surveillance. Costs are also lower for patients recorded as being smokers, but this may be due to under-coding. The prevalence of smokers in UK in 2006 at age 35-64 years were 22-24%, though only 10% at age 65+ (The Health and Social Care Information Centre, 2008). In UKPDS is has been found that 31% of newly diagnosed diabetes patients are smokers (Leal, Gray & Clarke, 2009). In HES we have a prevalence of only 4%. This suggests under-coding and it may be that those diabetics who are healthier than average are more likely to admit to being smokers (Rosenzweig & Schultz, 1983).

Our multi-level data structure allows us to identify what proportion of the variation in patient costs is related to their hospital, rather than their own individual characteristics. Only a small proportion, less than 10%, of the variance is attributable to the hospital. This suggests that, even if hospitals manage patients admitted with diabetes in different ways, this has limited impact on the costs of care. When we examine why costs vary among hospitals, only the price index for hospital input prices (the so-called Market Force Factor) demonstrates a positive and significant relationship. This index is used to allocate additional payment to account for geographical variation in the cost of land, buildings and staff, with hospitals with a higher MFF receiving additional revenue. Failure to compensate for these differences in cost would financially advantage hospitals with low input prices. The reasoning behind MFF is that public hospitals are constrained to pay local factor prices (Mason et al., 2009).

Cost differences among hospital are not related to the number of patients treated, which may not be surprising as no hospital admits more than an average of 2.3 inpatients per day – implying little potential to exploit economies of scale. Nor is there any relationship between costs and the number of specialties or the concentration of diabetes care in particular specialities. Changing the configuration of diabetes care specialty services in the range from 1 to 13 specialties or changing the proportion of activity in each specialty do not appear to result in significant effects on costs of care. This evidence supports the existence of constant economies of scope in British diabetes care. However, it should be noticed that a lack of consistent empirical findings limits the ability to confirm these results (Schneider, Miller, Ohsfeldt, Morrisey, Zelner & Li, 2008a).

This analysis of cost variation in diabetes care delivery is limited to care delivered in hospital, and this has limitations. Variation in hospital costs may be due to other cost determinants such as geographical variation in: preventive care and management of diabetes care in primary care, prevalence of diabetes in ethnic minorities, differences in the local interface between secondary and primary care, unobserved differences in the quality of care and economies of scale and scope in relation to integrated care. Such issues cannot be investigated easily in England, where routine data on care provided outside the secondary care setting are not available.

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Table 1 Descriptive patient characteristics		
		mean (SD)
Cost		1,335.9 (1,296.3)
Non-diagnostic markers:		
Number of operations		0.1 (0.5)
Number of diagnosis		3.8 (2.4)
Sex (male=0, female=1)		0.456
Age (year)		57.1 (20.7)
Socio economic status index		0.177 (0.128)
Condition in addition to diabetes		0.362
More conditions in addition to diabetes		0.064
Admitted as transfer		0.008
Transfer to other hospitals (discharge)		0.019
Death		0,009
Diagnostic markers based on ICD-10:	**ICD10 codes**	
Macrovascular disease	E115, I48X, Z869, I259, I209, I258, I252, I500, I792, Z951, I739, E105	0.248
Hypertension	I10X	0.231
Feet & lower limb complications	L97X, E115, I739,E105, R02X, I792	0.187
Infection	N390, L031, B956, J22X, R02X	0.105
Lifestyle	Z911, F102, Z602, Z911,Z864,F102, F101	0.083
Nephropathy	N179, N189, E102, E112, I120, N19X, N083	0.080
Pulmonal disease	J459, J449	0.071
Smoker	Z720	0.042
Retinopathy	H360, E113, E103	0.035
Neuropathia	E114, E104	0.022
Allergy	Z88	0.021
Anaemia	D649	0.020
Depression	F329	0.019
Dehydration	E86X	0.018
Epilepsy	G409	0.018
Obesity	E669	0.013
Arthrosis	M199	0.010
Dietary counselling & advice	Z713	0.009
Hypercholesterolemia	J780	0.008
Diabetes HRG v.3.5 main groups:		
K11 hypoglycaemic emergency>69	E162	0.149
K12 hypoglycaemic emergency<70	E162	0.064
K13 hyperglycaemic emergency>69 K14 hyperglycaemic emergency<70	E100, E101, E110, E111, E120, E121, E130, E131, E140, E141	0.082 0.168
K15 Other hyperglycaemic disorder>69 K16 Other hyperglycaemic disorder<70	E106-E109, E116-E119, E126-E129, E136-E139, E146, E147, E148, E149, R730	0.169 0.204
K17 with lower limb complications	E100, E101, E105-E111, E115-E121, E125-E131, E135-E141, E145-E149, L97X	0.148
Diabetes types:		
Insulin–dependent diabetes	E100-E109	0.409
Non-insulin-dependent diabetes	E110- E119	0.509
Unspecified diabetes	E141, E145, E149	0.040
Hypoglycaemia	E162	0.235
Abnormal glucose test	R730	0.005

Table 2 Diabetes care hospital characteristics				
	mean	SD	min	max
Total number of patients	212.0	117.7	44	821
Total number of specialties	6.095	2.663	1	13
Factor price index	1.123	0.085	1.001	1.446
Specialty proportions:				
General medicine (300)	0.762	0.180	0.000	1.000
Geriatric medicine (430)	0.084	0.102	0.000	0.369
General surgery (100)	0.047	0.039	0.000	0.193
Accident & emergency (180)	0.029	0.065	0.000	0.294
Gastroenterology (301)	0.014	0.039	0.000	0.249
Cardiology (320)	0.012	0.031	0.000	0.218
Endocrinology (302)	0.010	0.031	0.000	0.184
Diabetic medicine (307)	0.008	0.054	0.000	0.610
Thoracic medicine (340)	0.007	0.024	0.000	0.206
Nephrology (361)	0.006	0.019	0.000	0.169

Table 3 Diabetes care cost function estimates, patients admitted for diabetes 2005

	Model 1A	Model 2A	Model 3A	Model 4A
Non-diagnostic markers:				
Number of operations	727.7***	611.8***	668.4***	667.1***
Number of diagnosis	80.51***	84.33***	80.59***	80.74***
Sex (male=0, female=1)	20.72	24.90*	23.37	25.65*
Age (years)	-4.047*	-3.779*	-3.453	-3.675*
Age squared	0.113***	0.118***	0.104***	0.105***
Socio economic status	97.32	106.1*	117.4*	107.9*
Condition in addition to diabetes	-78.08***	-91.49***	-87.54***	-89.67***
More conditions in addition to diabetes	-55.06*	-54.52*	-61.74*	-61.01*
Admitted as transfer	1250.5***	1161.7***	1202.6***	1199.7***
Transfer to other hospitals (discharge)	466.2***	414.0***	433.3***	430.7***
Death	472.7***	434.4***	455.2***	454.6***
Diagnostic HRG-main groups:				
k11-k12 hypoglycamic emergency	-125.5***		-113.3***	-77.13
k13-k14 hyperglycamic emergency	51.98**		68.04***	65.30***
k15 Other hyperglycamic disorder>69	189.9***		201.5***	200.9***
k17 with lower limb complications	855.0***		460.3***	447.1***
Diagnostic markers based on ICD-10:				
Infection		205.2***	172.2***	171.1***
Hypertension		-59.95***	-55.89***	-58.38***
Obesity		47.61	44.45	45.88
Smoker		-120.3***	-120.5***	-121.0***
Lifestyle		-38.44	-39.66	-39.53
Macrovascular disease		-17.56	-26.65	-29.07
Hypercholesterolemia		-66.12	-45.20	-46.22
Pulmonal disease		-25.82	-31.39	-32.97
Retinopathy		-73.07*	-65.19	-65.40
Nephropathy		-52.12*	-37.76	-39.26
Anemia		7.999	-2.985	-3.198
Neuropathia		-72.18	-70.72	-72.83
Feet & lower limb		685.8***	428.3***	435.0***
Allergy		-126.7**	-130.2**	-129.7**
Depression		-48.72	-49.21	-50.74
Dehydration		86.06	74.74	74.35
Epilepsy		17.00	14.99	16.42
Dietary counselling and surveillance		-158.1*	-150.2*	-154.5*
Arthrosis		-18.42	-25.49	-26.35
Clinical diabetes types:				
Insulin-dependent diabetes		40.69		29.49
Non-insulin-dependent diabetes		57.94		45.21
Unspecified diabetes		148.8***		112.2**
Hypoglycaemia		-223.7***		-34.94
Abnormal glucose test		-420.9***		-398.9***
Constant	611.2***	614.1***	607.3***	584.4***
N	31371	31371	31371	31371
sigma_u	336.6	339.6	336.7	336.3
sigma_e	1068.9	1066.9	1063.7	1063.2
Rho	0.0902	0.0920	0.0911	0.0909
r2 within	0.261	0.264	0.268	0.269
r2 between	0.0929	0.0798	0.0916	0.0931
r2 overall	0.252	0.252	0.258	0.259
Number of hospitals/trusts	148	148	148	148

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4 Second stage estimations - cost variation due to hospital characteristics

	Model 1A	Model 2A	Model 3A	Model 4A
Number of patients	0.384	0.411	0.409	0.413
	(0.366)	(0.378)	(0.369)	(0.370)
Total number of specialties	13.09	12.83	12.03	12.44
	(17.94)	(17.99)	(17.89)	(17.86)
Factor price index	1576.8^{***}	1572.4^{***}	1581.7^{***}	1563.3^{***}
	(362.6)	(360.0)	(359.6)	(359.2)
Specialty proportions:				
General medicine (300)	-264.8	-275.1	-274.9	-242.1
	(942.1)	(851.5)	(876.4)	(878.7)
Geriatric medicine (430)	260.8	269.1	261.4	293.7
	(1001.0)	(922.6)	(942.1)	(942.7)
General surgery (100)	33.27	162.4	65.69	114.5
	(1153.1)	(1082.6)	(1097.1)	(1099.7)
Accidents & emergencies (180)	-1051.5	-1103.6	-1075.2	-1050.1
	(1018.3)	(946.5)	(962.4)	(966.1)
Diabetic medicine (307)	-1318.3	-1406.2	-1352.5	-1335.8
	(2346.4)	(2377.9)	(2342.3)	(2350.0)
Gastroenterology (301)	69.48	-15.07	11.23	62.01
	(1637.4)	(1611.7)	(1608.3)	(1619.6)
Cardiology (320)	-684.2	-632.3	-650.0	-618.2
	(1868.5)	(1794.4)	(1824.6)	(1800.8)
Endocrinology (302)	-885.7	-903.2	-872.7	-849.0
	(1259.6)	(1201.5)	(1221.2)	(1213.6)
Nephrology (361)	-836.0	-649.6	-732.8	-678.6
	(2968.3)	(2896.2)	(2893.4)	(2890.2)
Thoracic medicine (340)	-1094.2	-1168.6	-1084.6	-1080.6
	(1379.6)	(1281.9)	(1341.7)	(1307.5)
Constant	-1678.9	-1675.0	-1677.2	-1692.9
	(1026.4)	(928.4)	(957.0)	(958.1)
N	148	148	148	148
R2	0.172	0.172	0.172	0.171
R2 adjusted	0.0922	0.0917	0.0920	0.0907
F	2.297	2.353	2.343	2.332

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$