Efficiency Analysis of English Obstetrics Specialties

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Abstract

Aims
We analyse costs and activity in English obstetrics departments to assess what factors explain the variation in departmental-level and patient-level costs. The key aim is to identify the proportions of variation explained by patient characteristics and by differential departmental performance.

Data
We match Hospital Episode Statistics records for every patient admitted to obstetrics departments to Reference Cost data by HRG reported by all English hospitals for the year 2005/6. Our sample consists of 951,276 patients in 136 departments.

Methods
We estimate fixed effects models analysing patient-level costs and, in a second stage, control for constraining factors on the production possibilities available to obstetrics departments. We explore the sensitivity of results to alternative specifications and to the use of the full sample and a reduced sample of patients with a length of stay within their HRG trimpoint. We rank departments according to their fixed effects purged of the influence of their production constraints.

Results
We find that patient costs depend on the HRG to which the patient is allocated, as expected, but also on various diagnostic characteristics. After controlling for patient characteristics a substantial amount of unexplained variation in average costs remains at departmental level. Higher costs are evident in departments with a higher proportion of maternity (rather than neonatal and antenatal) care and where factor prices (as measured by MFF) are higher.

Conclusions
This study demonstrates the feasibility of performing analysis at departmental level using routine data. Opinion of conference delegates is sought about our methodological assumptions and about extending the work to other departments and multiple time periods.

1 Introduction

Hundreds of academic papers have been written that analyse organisational efficiency, many of which employ stochastic frontier analysis or data envelopment analysis. These techniques have become more sophisticated over time, and the incorporation of estimation routines into standard software packages has contributed to an ever steeper publication trend. Healthcare organisations are the subject of a significant proportion of these papers, partly because of the importance of this sector in the overall economy but mainly, we suspect, because of the ready availability of health service data (Hollingsworth, 2008)(Hollingsworth and Street, 2006).

Yet despite this proliferation of academic research, it has had limited influence on regulatory policy and its impact on organisational behaviour has been negligible. We contend that this is precisely because of the data employed in such studies which, though readily available, suffers two flaws. First, the reporting unit and, hence, the "organisation" that forms the unit of analysis is often at too aggregated a level. This makes it virtually impossible for analysts to make any clear recommendations as too where practical efforts should be directed should one organisation be found less efficient than another. Some (in)famous studies even take the country itself as the analytical unit, which stretches the "organisational" label to its limit (Evans et al., 2001). But even if the health system in Zimbabwe is found to be less efficient than that in Oman, what insight does the analysis provide as to what is to be done about it? The same holds, perhaps to a lesser degree, when considering hospitals or other healthcare providers which tend to be "multi-product" organisations. To take action, management needs to know whether poor performance is a problem in general or is limited to specific "product lines". The standard research methods cannot identify the source of any apparent inefficiency.

The second related, but more fundamental, flaw is that aggregation risks rendering comparisons invalid. Analysis requires comparing like-for-like production processes. Although most studies of performance in the hospital sector take the hospital as the unit of analysis, this is problematic because a common production function cannot be assumed. Indeed the majority of hospitals, particularly non-specialist hospitals, house a range of different specialties, each of which can be considered as having a distinct production function. It is difficult to capture these distinctive features in hospital-level analysis, especially when hospitals are quite heterogeneous with respect to their specialty mix. Any failure to observe and control for this heterogeneity will bias the comparative assessment.

In previous work we have argued that specialty-level analysis is preferable to hospital-level analysis (Harper et al., 2001). This is because each particular specialty is more likely to be undertaking comparable activities, treating similar types of patients and, hence, applying a production technology similar to that in the same specialty in other hospitals. Thus comparing the same specialty across hospitals is more appropriate for both analytical purposes and for informing policy-makers and practitioners about how to respond to the findings.

However, research based on specialty-level analysis is uncommon because routine data are rarely summarised at this level. In this paper, we seek to overcome this drawback by exploiting patient-level data, recognising that patients are clustered within specialties. We focus on all obstetrics specialties in England to assess what explains variation in their total costs and the unit costs of their patients. We use data for every patient discharged from an obstetrics department during 2005/06, this information being routinely collected and compiled into the Hospital Episode Statistics (HES). We map this detailed patient-level information to Reference Cost data provided on a mandatory basis by every English hospital. By combining these datasets we are able to analyse the costs for obstetrics departments and determine what proportion of the variation in these costs is accounted for by the characteristics of the patients treated. We contend that our approach ensures that inferences about performance will be more robust because greater allowance can be made for the characteristics of patients (Jacobs et al., 2006)(Hauck and Street, 2006)(Olsen and Street, 2008).

We assess two broad questions in this paper. Firstly, what factors explain the unit cost of patients admitted to obstetrics departments? Secondly, what factors explain the variation in the total costs of obstetrics specialties in England? We describe our data in section two, including how we have matched data from different sources. Our econometric approach is described in section three, followed by results in section four. We draw some conclusions in section five, where we also raise questions for the consideration of conference delegates.

2 Data

2.1 Data sample

We analyse the hospital episode statistics (HES) for all patients discharged from an obstetrics department in 2005/6. HES comprise individual patient records – defined as a Finished Consultant Episode (FCE) – about every NHS patient treated as a day case or inpatient in England. Each patient record includes a number of data 'fields', containing demographic (e.g. age, gender) and clinical information (e.g. diagnoses, procedures performed). Information is also available about the socio-economic characteristics of where patients live. All NHS providers routinely provide HES data for every inpatient and day case patient they treat.

We focus on obstetrics departments (specialty code=501) for two main reasons. First, there is a limited set of Healthcare Resource Groups (HRGs) to which obstetrics patients are allocated: the majority (95.7%) of activity is confined to twelve HRGs (chapter N, comprising neonatal, maternity and antenatal care). Second, most patients admitted to obstetrics remain under the care of a single consultant during their hospital stay, meaning that activity in obstetrics departments is reasonably self-contained, with patients rarely being transferred to other consultants/specialties. 98.1% of FCEs in obstetrics are single episode spells, compared to 78.9% for all HES records (Castelli et al., 2008).

We apply standard criteria to identify duplicate records in HES (Castelli et al., 2008). This provides us with a starting sample of 1,014,785 FCEs. As Table 1 shows, a number of records were dropped from the analysis for the following reasons.

- We confine our analysis to patients treated in the NHS hospital setting, so activity undertaken in PCTs and elsewhere is excluded. 5,038 FCEs are dropped on this basis.

- We omit ten hospitals where fewer than 1,000 FCEs are recorded in the obstetrics department.[i] 1,122 FCEs are dropped because of this.
- Two hospitals did not use the obstetrics specialty code when making their Reference Cost returns, making it impossible to match their HES and cost data.[ii] 16,990 patients were admitted to obstetrics in these hospitals but are lost to analysis.
- For 14,208 patients, there was no corresponding reference cost reported by the patient's hospital for the HRG to which they were allocated, meaning that a cost could not be assigned to them. These losses were not at random being concentrated among a selective set of hospitals. Despite HES activity being assigned to a particular HRG in these departments, no corresponding cost was reported.[iii]
- After matching,three hospitals have fewer than 1,000 FCEs with costs. These hospitals are excluded, resulting in 13,888 further observations being lost to analysis.[iv]
- A small number of obstetrics patients are recorded as having very long lengths of stay. Some of these values may be due to errors in recording either the date of admission or date of discharge, although some may be genuine values. Conservatively we have decided to drop patients with a length of stay of more 100 days. This means dropping 142 records.
- FCEs assigned to "U" HRG codes are dropped, of which there were 12,098.
- Finally, we exclude 23 observations with a cost in excess of £25,000.

Our final sample comprises 951,276 patients, 93.7% of the original number of patients recorded as being admitted to obstetrics. 47% of our sample were assigned to maternity HRGs. Table 2 shows the distribution of activity in obstetrics departments according to HRGs in the N chapter.

2.2 Assigning reference costs to individual HES records

We have two patient-level measures of resource use: length of stay (L_i) and reference cost (c_i), where i indicates a patient with $i = 1...I$. We shall also use the reference cost data to construct a measure of total departmental cost TC_j, where j indicates an obstetrics department with $j = 1...J$.

Length of stay has the advantage that is measured with a high degree of accuracy (subject to correct recording of admission and discharge dates) for each individual patient. It is also readily intelligible to policy makers, managers and clinicians, making it an obvious performance measure. It suffers as a measure of resource use, however, because costs are not driven solely by how long patients stay in hospital and, indeed, the relationship between length of stay and costs for obstetrics patients is not particularly strong (r=0.776). We shall confine ourselves to analysis of costs in what follows.

To assess the costs of patient care we use the Reference Cost database, which is a unique international resource. England is unique in having made it mandatory for all NHS hospitals to make Reference Cost returns. In no other country are disaggregated cost data routinely available for all providers, even where hospitals are paid on the basis of their activity (Schreyögg et al., 2006). This means that analysis of hospital costs in other countries is always based on either a limited sample of hospitals or utilises data reported at hospital level, such as total expenditure. In England, the Reference Costs form the basis for calculating the national tariff, according to which hospitals are paid under Payment by Results (PbR). To our knowledge, no research has exploited the original data provided by each hospital (although work has been based on cost data aggregated to HRGs or hospital).

The shortcoming of the Reference Cost data is that hospitals in England do not collect detailed information on each patient's resource use that would allow bottom-up costing of patient care. Rather, a top-down approach to costing is adopted, with total hospital costs being progressively cascaded down first to treatment services (wards, theatres, pharmacy, etc), then to specialties, and finally to HRGs. Every hospital is supposed to apply a standard costing methodology to produce a Reference Cost for each HRG it provides in each specialty, with HRGs subdivided according to the method of admission (elective, day case, non-elective). Each hospital also reports the *per diem* excess cost beyond the elective and non-elective HRG trimpoint (to be defined below). Reference Costs are calculated on a full absorption basis, meaning that they should reflect the full and true cost of the service delivered (Department of Health, 2008). But the service is defined as the HRG, not the individual patient. This means that patients of the same admission type assigned to the same HRG in the same specialty in the same hospital are recorded as having the same reference cost if their length of stay is below the HRG-specific trimpoint.

We are able to map a Reference Cost to the vast majority of obstetrics patient records contained in HES (the exceptions being detailed in table 1). In making their Reference Cost returns hospitals report five pieces of cost information for each HRG (h) in each of their specialties. So, for any given obstetrics department, j, the following will be reported:

- Average cost per day case: c_{hj}^{d}
- Average cost for elective patients with a length of stay below HRG-specific trimpoint value c_{hj}^{e}
- Excess per diem cost for an elective patient beyond the HRG-specific trimpoint ex_{hj}^{e}
- Average cost for non-elective patients with a length of stay below HRG-specific trimpoint value c_{hj}^{n}
- Excess per diem cost for a non-elective patient beyond the HRG-specific trimpoint ex_{hj}^{n}

Under Payment by Results, an extra per diem payment is made on top of the national tariff for patients who stay in hospital beyond a specified number of days, termed a "trimpoint". This payment is made in recognition that such patients may have care requirements that are atypical of patients in the same HRG and that hospitals should not be penalised financially when caring for them. Trimpoints are defined for each HRG according to whether the patient was admitted as an elective or non-elective. We define t_{h}^{e} as the elective trimpoint in days and t_{h}^{n} as the nonelective trimpoint for HRG

h. Trimpoints are revised periodically by the Information Centre. We have applied the trimpoints that were published alongside the national tariff for 2005/6.[v]

The Reference Cost information provided by each hospital is assigned to each obstetrics FCE recorded in HES, according to the type of admission and how long each patient stays in hospital, as follows:

- If the patient treated as a day case $if \quad a_{ij}^{d} \rightarrow c_{hj}^{d}$
- If the patient is an elective with length of stay at or below the trimpoint $if\,(a_{ij}^{e}, L_{ij} \leq t_{h}^{e}) \rightarrow c_{hj}^{e}$
- If the patient is an elective with length of stay above the trimpoint $if\,(a_{ij}^{e}, L_{ij} > t_{h}^{e}) \rightarrow c_{hj}^{e} + \left[ex_{hj}^{e} \times (L_{ij} - t_{h}^{e}) \right]$
- If the patient is non-elective (including maternity, baby or a transfer) with length of stay at or below the trimpoint $if\,(a_{ij}^{n}, L_{ij} \leq t_{h}) \rightarrow c_{hj}^{n}$
- If the patient is a non-elective (including maternity baby or a transfer) with length of stay above the trimpoint $if\,(a_{ij}^{e}, L_{ij} > t_{h}^{n}) \rightarrow c_{hj}^{n} + \left[ex_{hj}^{n} \times (L_{ij} - t_{h}^{n}) \right]$

3 Methods

Our objective is to assess the variation in costs across departments after taking account of differences in the patients they treat and of factors that might constrain departments to a particular set of production possibilities. To do this, we perform a two stage analysis of patient-level costs firstly to account for various patient characteristics that might explain costs and secondly to investigate the variations that persist at departmental level once costs have been purged of patients effects. In the first stage we estimate a fixed effects model of the following form:

$$\log(c_{ij}) = f\,(HRG_{ij}, \mathbf{x}_{ij}, \mathbf{d}_{ij}, \mathbf{q}_{ij}) + u_{j} + v_{ij} \qquad (1)$$

Where $\log(c_{ij})$ is the log of the cost for patient i in department j. HRG_{ij} is a casemix index capturing the national average resource intensity of the HRG to which the patient is allocated, standardised relative to the cost of a normal delivery; $\mathbf{x}_{ij}$ is vector of linear, squared and cubed terms to capture non-linear age effects; $\mathbf{d}_{ij}$ is a vector diagnostic and procedural variables, including counts of codes and dummy variables for specific codes (detailed shortly) and an index measuring the relative income deprivation of the area where the patient lives; and $\mathbf{q}_{ij}$ is a vector of variables specific to obstetrics care, including the number of babies delivered; birth weight; and whether or not the baby was still-born.

We construct a series of dummy variables capturing diagnostic characteristics of patients that might explain costs. These are identified after examining the frequency of diagnoses recorded across the diagnostic fields for all the patients in the sample. Table 3 reports the ICD10 codes used to construct these variables and the number of obstetrics and maternity patients to which they apply.

This equation is estimated for different samples of patients as a form of sensitivity analysis. First, we compare equations in which all patients are admitted to the obstetrics department (untrimmed sample) to one including only patients with a length of stay below their HRG-specific trimpoint (trimmed sample) and one including only patients with a length of stay above their trimpoint (long-stay sample). Second, we restrict analysis only to patients receiving maternity care (ie allocated to HRGs N06-N11), again providing separate analyses of the untrimmed, trimmed and long-stay samples. This allows us to assess whether the influence of patient characteristics varies according to length of stay and how representative maternity patients are of obstetrics patients in general. Descriptive details of these variables for the patients included in each equation are shown in table 4.

After estimating equation (1) we derive $\hat{u}_j$, the departmental fixed effect, interpreted as a measure of relative departmental performance after allowing for differences in patient characteristics (Hauck et al., 2003). Higher values imply that the average cost per patient in the department in question is above the average for all obstetrics departments. To explore why costs may vary across departments these estimates are regressed against a set of departmental variables in a second stage regression of the form:

$$\hat{u}_j = f(n_j, L_j, Neonatal_j, Ante_j, Ins_j, MFF_j) + \upsilon_j \qquad (2)$$

Where n_j measures the number of patients (in thousands) treated in department j. If positive, this would suggest that average costs after controlling for patient characteristics are higher in larger departments. L_j measures the number of whole time equivalent obstetricians, gynaecologists and midwives per 100 patients, as reported to the NHS Litigation Authority. This index weighs staff of different types according to their respective wages.[vi] $Neonatal_j$ and $Antenatal_j$ measure the amount of neonatal and antenatal care as a proportion of all departmental activity. The first is a measure of scope – are average costs in stand-alone maternity units different to average costs in departments where maternity and neonatal care is delivered jointly? The same can be said of antenatal care, but in addition departments have some discretion about how many antenatal visits they offer, and this may affect the average cost per patient. Ins_j measures the obstetrics insurance contributions (per birth) made to the NHS Litigation Authority for the Clinical Negligence Scheme for Trusts (CNST) to insure against medical malpractice claims.[vii] These contributions form a significant proportion of costs incurred in obstetrics departments[viii], with each department's contribution being based on staffing levels, number of births, claims history and risk management strategies (Fothergill, personal communication). Finally, MFF_j captures differences in the factor prices faced by providers in different parts of England which are beyond their control. Descriptive details for each of these variables are provided in table 5.

With the exception of differences in factor prices, arguably all the variables included in equation 2 are within the control of the department. Departments have (at least some) discretion about their scale of operation, their staffing complements, and the scope of activity. They are also able to influence their insurance contributions to some extent by improving their risk management strategies. Hence, if considering relative performance, it would not be legitimate to control for these factors. Differences in factor prices, in contrast, are deemed truly exogenous, with it being supposed that MFF accurately compensates for the constraints that these differences place on hospitals in controlling their costs. To allow for these constraints we estimate a third equation in which the department fixed effect is regressed against MFF_j only:

$$\hat{u}_j = f(MFF_j) + \mu_j \quad (3)$$

We interpret μ_j as a measure of relative departmental performance in controlling costs, purged of the effect of factor prices. We rank departments according this residual value, indicating the sensitivity of each department's relative position to our sampling choices.

4 Results

4.1 Patient-level costs

Estimation results for obstetrics patients are presented in Table 6. Results for the full sample of obstetrics patients appear first, with the model explaining 62% of the variation in patient costs (R-sq overall=0.6212). The estimates demonstrate that patient costs increase in the presence of most of the patient characteristics that we consider. The HRG to which the patient is allocated is the most significant explanator of costs, but the other variables are capturing substantial variation among patients over and above the casemix index. Patient costs are higher the more operations are performed, the more diagnoses are recorded, and the older the patients. Costs also appear higher the more babies are delivered and the higher the birth weight although, as we shall see shortly, these variables are probably also picking up the relatively higher cost of maternity care relative to neonatal and antenatal care. Costs are also higher in the presence of most of the diagnostic markers that we have considered, particularly if the patient had pre-eclampsia, eclampsia, haemorrhage, some form of infection or was recorded as being a smoker. Costs are lower if there was a still birth, if the patient was recorded as being obese or suffering from some form of allergy, if they had suffered complications in past pregnancy (although this may be picking up the lower cost of subsequent pregnancies), and if the patient suffered perineal laceration.

The influence of these factors is different for patients whose length of stay is below their HRG trimpoint than for those with longer lengths of stay and, overall, the characteristics that we consider are better able to explain variation in costs for the former than the latter sub-samples, as indicated by the differences in the R^2. The number of operations (diagnoses) is more (less) important in explaining the costs of patients with shorter than longer lengths of stay. Age is not important in explaining costs for the latter group of patients while, for some variables, the direction of influence differs for the two sub-samples. For example, patients who suffered a haemorrhage are likely to have higher costs when compared to other patients discharged before the trimpoint, but lower costs when compared to those who stayed beyond the trimpoint. The opposite is the case for pre/eclampsia, diabetes and infections. This may be because having a haemorrhage may increase length of stay but not as substantially as the other factors.

Table 7 presents results when considering maternity patients only, those assigned to HRGs N06-N11. Results are broadly similar to those for all obstetrics patients, unsurprisingly given that maternity patients comprise 47% of the total. But there are two notable differences. Age is not a significant determinant of variation in cost, also unsurprisingly given that there is limited variation in the age of maternity patients. Maternity episodes that result in babies with lower birth weight are more costly than the average maternity episode, particularly for mothers with long lengths of stay. The cost for patients who suffered complications during previous pregnancy is not significantly different from other maternity episodes.

4.2 Estimation and comparison of department effects

The primary purpose of the patient-level equations to control for a broad range of patient characteristics when assessing variation in patient costs across obstetrics departments. Even after taking these patient characteristics into account, there remains a high degree of unexplained variation in the average cost per patient across departments. This indicated by the value of rho. When considering all obstetrics patients, 38.8% of the remaining variation in costs is between departments rather than due to observed characteristics of the patients within each one. The variation in costs between departments is more pronounced when considering patients discharged before the trimpoint (rho=51%) than for those with longer lengths of stay (rho=15%), suggesting that variation in departmental practice is most in evidence when considering the former group of patients.

Of course, this remaining variation in costs between departments may be due to the characteristics of the departments, over some of which they may have limited control. To explore the impact of these characteristics our second stage equations estimate the departmental fixed effects from three of the patient-level equations. The fixed effects from the equation comprising all obstetrics patients are highly correlated with those from the trimmed sample (r=0.9951) but the correlation is lower when compared to those from the maternity sample (r=0.7137), suggesting that the importance of departmental characteristics may depend on what type of patients are being considered.

The upper part of Table 8 reports the results from estimating equation (2) using the set of "descriptive" characteristics. There appears to be no relationship between the fixed effect and the size of the department, the insurance premium or the staffing ratios. In contrast, it does appear that departments with a greater share of neonatal and antenatal activity have average costs per patient that are lower than in other departments. This suggests that there may be some economies of scope in obstetrics departments. The MFF is also a significant predictor of whether obstetrics departments have higher costs, although this effect is not significant when considering the maternity function alone.

The lower part of Table 8 reports estimates from equation (3) that controls for MFF only which, unsurprisingly, is consistently significant. The residual μ from each of these equations displays significant skewness, implying the presence of inefficiency among the sample of departments. Figure 1 ranks departments according to their residual values from the three equations, with rank=1 indicating that, after taking account of patient characteristics and factor prices, the department's average costs per patient are the lowest of all departments. The diagonal shows departmental ranking when all obstetrics patients are considered. There is little change in the ranking if the assessment is based only on patients who's length of stay was below the trimpoint for their HRG. Departmental rankings vary substantially, however, if only maternity patients are considered.

5 Conclusions

Our analysis of patient costs shows that, as would be expected, the HRG to which the patient is allocated is the most significant explanatory variable. Nevertheless, other diagnostic characteristics are also important in explaining why some patients cost more than others. There may be a case for refining the national tariff to allow for the additional costs of treating such patients, particularly if some departments are routinely more likely to admit such patients. Care would have to be taken, of course, to ensure that attaching price mark-ups to diagnostic characteristics does not encourage up-coding.

Even after taking account of a diverse range of patient characteristics, substantial variation in the average cost per patient persists across departments. Higher average costs are evident in departments with a higher proportion of maternity (rather than neonatal and antenatal) care and where factor prices (as measured by MFF) are higher. The fact that insurance contributions are not significant in explaining variations in costs among departments is reassuring, as it suggests that the burden of these premiums is similar across departments.

We have made a case for ranking departments according to their average costs after purging these of the influence of patient characteristics and factor prices. The ranking we arrive at is not sensitive to whether the assessment is based on all obstetrics patients or just those discharged prior to the trimpoint but varies more substantially if only the maternity function is considered.

Our original intention was also to present results from a total cost function and compare relative performance of departments from this analysis with the ranking emanating when using patient-level data, but this has been dropped for reasons of space. Of course, parameter estimates from these two approaches are not comparable anyway, with the those presented in Table 8 being for an average rather than total cost function. As such the approach described in this paper is uninformative about economies of scale, the average function assuming constant returns. But this is a small price for being able to relax the more stringent assumptions required of the standard cost function approach that either diagnostic characteristics (other than HRG) do not influence costs or that patients are randomly allocated across departments. Our analysis demonstrates that costs do differ according to various patient characteristics. If patients are not randomly distributed, failure to account for these will bias the conclusions of any performance assessment.

There are two potential analytical refinements where we would welcome opinion from conference delegates. The first regards the interpretation of the residual from equation (3) which we have used to rank departmental performance. We note that this residual is skewed, as required for stochastic frontier analysis which it would be straightforward to perform. But, if we have adequately captured the heterogeneous constraints faced by departments in controlling their costs, is stochastic frontier analysis an unnecessary refinement?

Second, although there are precedents for retrieving the fixed effects and regressing these against a set of explanatory variables as a two-stage process (Kerkhofs and Lindeboom, 1997), we wonder whether it would be more appropriate to adopt a single-stage procedure? This would involve specifying a random parameters model, where the department effects are included in equation (1) in a manner analogous to that described by Battese & Coelli in their stochastic frontier model for panel data, which allows for a normally distributed random error at departmental level (Battese and Coelli, 1995). Time constraints precluded us from running this model at the time of writing but we hope to have done so prior to the conference.

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Table 1 Starting and analytical samples		
	observations	%
Starting sample	1,037,519	
FCEs not in obstetrics (identified merely to ascertain how many were multi-episode spells)	22,734	
FCEs with specialty code=501	1,014,785	
Drop activity recorded outside NHS hospitals (PCT)	5,038	0.50%
Drop activity in low volume NHS hospitals	1,122	0.11%
Drop hospitals that did not assign obstetrics specialty code in their Reference Cost return	16,990	1.67%
Drop activity where that could not be matched to Reference Cost data	14,208	1.40%
Drop hospitals with low volumes after matching	13,888	1.37%
Drop activity assigned to U code HRGs	12,098	1.19%
Drop FCEs with LoS more than 100 days	142	0.01%
Drop FCEs with cost more than £25,000	23	0.00%
Sample for analysis	951,276	93.74%
Neonatal patients – N01-N05		
Maternity patients – N06-N11	444,140	46.69%
Antenatal patients – N12		
All other patients – other HRGs		

Table 2 Activity in obstetrics departments, by HRG						
HRG		**FCE**	**%**	**ALoS**	**%Day cases**	**Cost**
N01	Neonates - Died <2 days old	252	0.03%	0.00	1.00	716
N02	Neonates with Multiple Minor Diagnoses	971	0.10%	1.67	0.24	1,094
N03	Neonates with one Minor Diagnosis	6,237	0.66%	1.58	0.20	766
N04	Neonates with Multiple Major Diagnoses	30	0.00%	0.43	0.87	830
N05	Neonates with one Major Diagnosis	183	0.02%	0.73	0.73	756
N06	Normal Delivery w cc	20,777	2.18%	3.42	0.05	1,834
N07	Normal Delivery w/o cc	251,372	26.42%	1.79	0.14	1,109
N08	Assisted Delivery w cc	5,899	0.62%	4.45	0.02	2,228
N09	Assisted Delivery w/o cc	50,197	5.28%	2.62	0.03	1,492
N10	Caesarean Section w cc	19,017	2.00%	6.55	0.00	3,393
N11	Caesarean Section w/o cc	96,874	10.18%	4.04	0.00	2,360
N12	Antenatal Admissions not Related to Delivery Event	465,119	48.89%	0.57	0.73	637
Total N		916,928	96.39%	1.60	0.41	1,091
Other	All other HRGs	34,348	3.61%	0.81	0,62	771
Total		951,276	100.00%	1.57	0.42	1,079

Table 5 Departmental characteristics		
	mean	Std_dev
Number of patients (000s)	6.995	4.114
MFF (x100)	112.404	8.602
Insurance per birth (£)	545.172	17.081
Antenatal share	44.951	14.754
Neonatal share	1.135	5.745
Staff per 100 patients	1.690	0.915
Departments	136	

Table 3 Obstetrics patients with particular diagnostic markers					
Label	**Diagnosis codes**	**All obstetrics patients**		**Maternity patients**	
Pre-eclampsia and eclampsia	O14.0-O15.9	14,335	1.51%	9,124	2.05%
Haemorrhage	O2O.8 O20.9 O44.1 O46 O67 O72 O03-6.1&6	74,946	7.88%	42,220	9.51%
Diabetes	O24 R81 E1	17,995	1.89%	9,395	2.12%
Infection	O23 O44.1 O75.3 O86 R50 J22.X O03-6.0&5	27,258	2.87%	8,709	1.96%
Hypertension	O16 O11 I10	28,089	2.95%	8,551	1.93%
Obesity	E66	2,002	0.21%	947	0.21%
Smoker	Z72.0	19,597	2.06%	14,142	3.18%
Lifestyle risk factors	Z72.1 Z72.2 Z72.4&8&9 Z35.7 Z86.4 Z91.5 Z86.5	9,568	1.01%	6,406	1.44%
Abortion	O01 O02 O03 O04 O05 O06 O07 O08	7,408	0.78%	407	0.09%
Allergy	Z88	15,041	1.58%	10,150	2.29%
Past history of disease	Z85 Z86.0&1&2&3&6&7 Z87.4	8,556	0.90%	5,777	1.30%
Complications in past pregnancy	Z87.5 Z87.6	2,785	0.29%	1,804	0.41%
Perineal laceration	O70.2 O70.3	93,873	9.87%	93,386	21.03%

Table 4 Patient characteristics												
	All obstetrics patients		Obstetrics patients – trimmed sample		Obstetrics patients – above trimpoint		All maternity patients		Maternity patients – trimmed sample		Maternity patients – above trimpoint	
	mean	Std_dev	mean	Std_dev	mean	Std_dev	mean	Std_dev	mean	Std_dev	mean	Std_dev
Cost	1,079.665	835.629	1,029.541	728.244	1,434.375	1,320.271	1,571.585	902.632	1,541.287	779.011	1,760.702	1,439.054
Length of stay	1.574	2.561	1.121	1.585	4.782	4.844	2.690	2.877	2.178	1.749	5.888	5.384
Casemix index	1.034	0.684	1.051	0.703	0.914	0.515	1.526	0.699	1.574	0.708	1.226	0.549
# operations	1.118	1.428	1.076	1.397	1.410	1.604	2.346	1.212	2.299	1.191	2.645	1.292
# diagnoses	2.292	1.432	2.254	1.409	2.564	1.558	3.164	1.411	3.141	1.400	3.310	1.470
Age	28.087	6.920	28.062	6.959	28.263	6.640	28.813	6.419	28.887	6.371	28.352	6.693
# babies	0.404	0.508	0.397	0.506	0.451	0.519	0.839	0.413	0.838	0.413	0.843	0.416
Birth weight (1000g)	1.174	1.629	1.165	1.632	1.235	1.604	2.435	1.560	2.453	1.565	2.323	1.521
Delivered dead	0.002	0.043	0.002	0.043	0.002	0.045	0.004	0.060	0.004	0.060	0.003	0.057
Socio_status	0.177	0.134	0.177	0.134	0.182	0.136	0.170	0.132	0.169	0.132	0.178	0.134
Pre/eclampsia	0.015	0.122	0.011	0.105	0.043	0.202	0.021	0.142	0.015	0.123	0.053	0.225
Haemorrhage	0.079	0.269	0.073	0.261	0.117	0.321	0.095	0.293	0.092	0.289	0.116	0.320
Diabetes	0.019	0.136	0.018	0.132	0.028	0.164	0.021	0.144	0.019	0.137	0.034	0.181
Infection	0.029	0.167	0.023	0.151	0.067	0.250	0.020	0.139	0.016	0.127	0.040	0.196
Hypertension	0.030	0.169	0.029	0.167	0.035	0.184	0.019	0.137	0.019	0.136	0.021	0.144
Obesity	0.002	0.046	0.002	0.047	0.002	0.040	0.002	0.046	0.002	0.046	0.002	0.047
Smoker	0.021	0.142	0.021	0.142	0.021	0.144	0.032	0.176	0.032	0.177	0.030	0.170
Lifestyle risk factors	0.010	0.100	0.010	0.097	0.013	0.115	0.014	0.119	0.014	0.117	0.018	0.131
Abortion	0.008	0.088	0.007	0.086	0.010	0.101	0.001	0.030	0.001	0.030	0.001	0.031
Allergy	0.016	0.125	0.016	0.124	0.017	0.129	0.023	0.149	0.023	0.151	0.020	0.141
Past disease	0.009	0.094	0.009	0.093	0.011	0.106	0.013	0.113	0.013	0.112	0.014	0.119
Comps in past pregnancy	0.003	0.054	0.003	0.055	0.003	0.050	0.004	0.064	0.004	0.065	0.003	0.057
Perineal laceration	0.099	0.298	0.092	0.289	0.147	0.354	0.210	0.407	0.199	0.399	0.281	0.449
Observations	951,276		833,495		117,781		444,136		382,807		61,329	

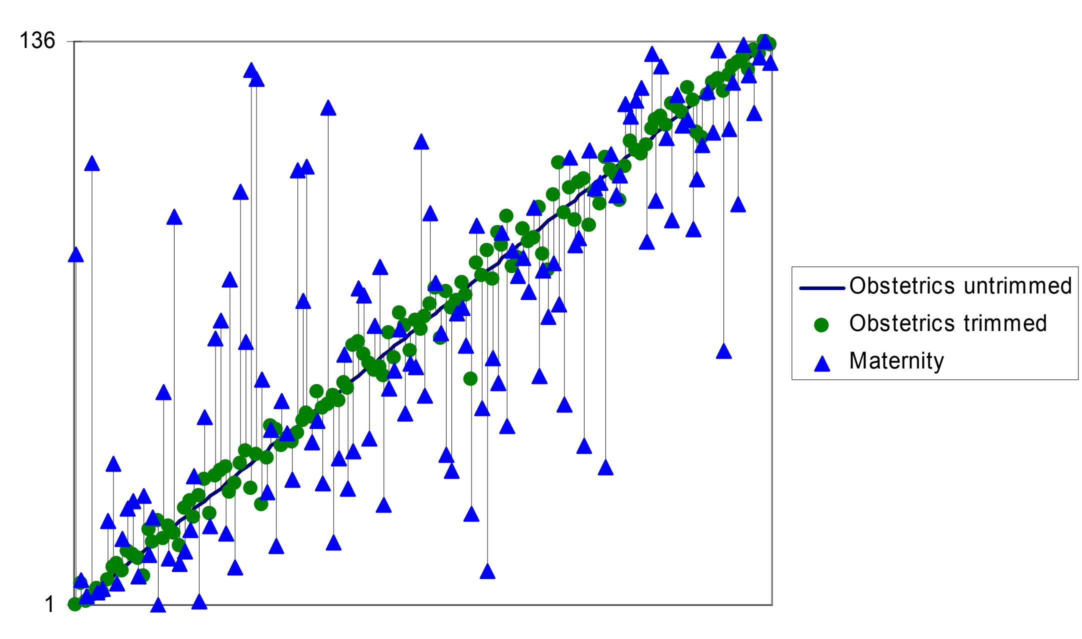
Table 6 Estimates of cost, obstetrics patients									
	All obstetrics patients			Obstetrics patients - trimmed sample			Obstetrics patients – above trimpoint		
	coeff	se	t	coeff	se	t	coeff	se	T
Casemix index	0.51013	0.00064	797.03	0.53800	0.00054	992.89	0.58678	0.00339	172.89
# operations	0.05873	0.00036	165.02	0.05771	0.00031	186.14	0.01853	0.00132	14.00
# diagnoses	0.01191	0.00032	36.70	0.00083	0.00028	2.95	0.02579	0.00120	21.43
Age	0.01021	0.00043	23.56	0.00787	0.00036	21.73	-0.00299	0.00257	-1.16
Age^2	-0.00032	0.00002	-16.68	-0.00023	0.00002	-14.16	0.00014	0.00010	1.39
Age^3	0.00000	0.00000	12.43	0.00000	0.00000	8.76	0.00000	0.00000	-0.84
# babies	0.10089	0.00145	69.75	0.06958	0.00125	55.61	0.08484	0.00556	15.27
Birth weight	0.00002	0.00000	52.11	0.00004	0.00000	99.10	-0.00002	0.00000	-12.27
Delivered dead	-0.02159	0.00706	-3.06	-0.00329	0.00600	-0.55	-0.01776	0.02920	-0.61
Socio_status	0.03436	0.00265	12.95	0.01721	0.00225	7.66	0.00956	0.01123	0.85
Pre/eclampsia	0.11132	0.00252	44.21	-0.01309	0.00246	-5.31	0.11357	0.00662	17.16
Haemorrhage	0.01856	0.00116	16.02	0.00258	0.00101	2.55	-0.01438	0.00416	-3.46
Diabetes	0.00996	0.00227	4.39	-0.01504	0.00198	-7.58	0.03038	0.00805	3.77
Infection	0.08352	0.00185	45.11	-0.00439	0.00173	-2.55	0.07646	0.00539	14.17
Hypertension	0.00287	0.00181	1.58	-0.01502	0.00155	-9.68	-0.00358	0.00720	-0.50
Obesity	-0.05833	0.00673	-8.66	-0.02852	0.00560	-5.09	-0.04696	0.03254	-1.44
Smoker	0.03699	0.00228	16.19	0.04950	0.00193	25.60	0.01944	0.00964	2.02
Lifestyle risk factors	0.00057	0.00315	0.18	-0.01117	0.00273	-4.10	0.02797	0.01177	2.38
Abortion	0.03243	0.00351	9.25	0.01920	0.00304	6.32	-0.04809	0.01303	-3.69
Allergy	-0.01882	0.00255	-7.38	-0.00589	0.00216	-2.72	-0.04217	0.01058	-3.99
Past disease	0.00014	0.00329	0.04	-0.00380	0.00283	-1.34	0.01018	0.01264	0.81
Comps in past pregnancy	-0.02805	0.00570	-4.92	-0.01723	0.00477	-3.61	-0.02065	0.02617	-0.79
Perineal laceration	-0.01542	0.00116	-13.24	-0.00470	0.00101	-4.65	-0.04249	0.00427	-9.95
Constant	5.97807	0.00354	1689.96	5.95925	0.00294	2029.63	6.40845	0.02282	280.88
Sigma_u	0.2358			0.2392			0.1902		
Sigma_e	0.2958			0.2337			0.4464		
Rho	0.3885			0.5114			0.1536		
R-sq within	0.7049			0.8041			0.3833		
R-sq between	0.4871			0.514			0.1482		
R-sq overall	0.6212			0.6917			0.3546		
Patients	951,276			833,495			117,781		
Departments	136			136			136		

Table 7 Estimates of cost, maternity patients									
	All maternity patients			**Maternity patients - trimmed sample**			**Maternity patients - above trimpoint**		
	Coeff	se	t	coeff	se	t	coeff	se	t
Casemix index	0.49887	0.00053	936.92	0.52737	0.00041	1295.25	0.54865	0.00303	180.82
# operations	0.01485	0.00031	47.51	0.01107	0.00024	45.64	0.00018	0.00133	0.14
# diagnoses	0.00744	0.00031	23.66	-0.00008	0.00024	-0.33	0.01749	0.00133	13.19
Age	0.00033	0.00070	0.47	0.00090	0.00055	1.64	-0.00179	0.00279	-0.64
Age^2	-0.00003	0.00003	-0.93	-0.00001	0.00002	-0.40	0.00001	0.00011	0.05
Age^3	0.00000	0.00000	1.58	0.00000	0.00000	-0.55	0.00000	0.00000	0.74
# babies	0.02660	0.00132	20.23	-0.00685	0.00102	-6.74	0.06142	0.00567	10.84
Birth weight	-0.00002	0.00000	-40.29	0.00000	0.00000	2.02	-0.00005	0.00000	-28.98
Delivered dead	-0.01971	0.00534	-3.69	0.01039	0.00405	2.57	-0.03224	0.02538	-1.27
Socio_status	0.00829	0.00283	2.92	-0.00264	0.00217	-1.22	0.02326	0.01249	1.86
Pre/eclampsia	0.09333	0.00227	41.14	-0.02809	0.00200	-14.05	0.12670	0.00663	19.12
Haemorrhage	0.02037	0.00115	17.64	0.01060	0.00090	11.82	0.02392	0.00475	5.04
Diabetes	0.01887	0.00223	8.46	-0.01479	0.00179	-8.26	0.02719	0.00802	3.39
Infection	0.07978	0.00234	34.08	-0.00744	0.00195	-3.82	0.15081	0.00768	19.63
Hypertension	0.00399	0.00234	1.70	-0.01766	0.00180	-9.80	0.06668	0.01008	6.62
Obesity	0.01102	0.00696	1.58	0.01481	0.00533	2.78	0.01215	0.03086	0.39
Smoker	-0.01650	0.00195	-8.46	-0.00621	0.00148	-4.19	-0.01393	0.00906	-1.54
Lifestyle risk factors	0.00907	0.00276	3.29	-0.00237	0.00214	-1.11	0.04417	0.01133	3.90
Abortion	0.02242	0.01049	2.14	0.02729	0.00805	3.39	0.03670	0.04579	0.80
Allergy	-0.01281	0.00222	-5.78	-0.00382	0.00168	-2.27	-0.01436	0.01053	-1.36
Past disease	0.00005	0.00286	0.02	-0.00192	0.00220	-0.87	0.00150	0.01229	0.12
Comps in past pregnancy	-0.00450	0.00506	-0.89	0.00343	0.00380	0.90	-0.01850	0.02530	-0.73
Perineal laceration	-0.02270	0.00085	-26.73	-0.01443	0.00066	-21.82	-0.04051	0.00344	-11.77
Constant	6.43342	0.00634	1014.77	6.37005	0.00496	1284.33	6.64255	0.02516	263.96
Sigma_u	0.1902			0.2347			0.2165		
Sigma_e	0.4464			0.1490			0.3523		
Rho	0.1536			0.7127			0.2741		
R-sq within	0.7404			0.8591			0.478		
R-sq between	0.0759			0.1007			0.0735		
R-sq overall	0.5883			0.6675			0.418		
Patients	444,136			382,807			61,329		
Departments	136			136			136		

Table 8 Results of second stage estimations

	All obstetrics patients			Obstetrics patients - trimmed sample			All maternity patients		
	coeff	se	T	coeff	se	t	coeff	se	t
Number of patients	-0.00382	0.00598	-0.64	-0.00401	0.00641	-0.63	0.00327	0.00565	0.58
MFF	0.00483	0.00188	2.56	0.00459	0.00194	2.36	0.00336	0.00234	1.44
Insurance	0.00064	0.00086	0.74	0.00072	0.00089	0.81	0.00165	0.00097	1.7
Antenatal	-0.00613	0.00137	-4.46	-0.00577	0.00143	-4.03	-0.00384	0.00171	-2.24
Neonatal	-0.00661	0.00190	-3.47	-0.00701	0.00207	-3.39	-0.00672	0.00319	-2.1
Staffing	0.01653	0.01705	0.97	0.01362	0.01779	0.77	0.02409	0.02153	1.12
Constant	-0.57014	0.60112	-0.95	-0.59359	0.61866	-0.96	-1.16021	0.66080	-1.76
R-sq	0.2713			0.2365			0.1227		
Departments	136			136			136		
MFF	0.00807	0.00164	4.92	0.00761	0.00168	4.54	0.00479	0.00197	2.44
Constant	-0.86762	0.18735	-4.63	-0.81395	0.19174	-4.25	-0.53969	0.22230	-2.43
p(skew) μ	0.011			0.006			0.002		
R-sq	0.0867			0.0749			0.0317		
Departments	136			136			136		

Figure 1: Relative departmental performance



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[i] RC1 Bedford Hospital NHS Trust (18 FCEs), RD1 Royal United Hospital Bath NHS Trust (56), RDZ The Royal Bournemouth And Christchurch Hospitals NHS Foundation Trust (10), RG3 Bromley Hospitals NHS Trust (108), RLN City Hospitals Sunderland NHS Foundation Trust (549), RN7 Dartford And Gravesham NHS Trust (124), RNH Newham University Hospital NHS Trust (306), RTQ 2gether NHS Foundation Trust (1), RXG South West Yorkshire Mental Health NHS Trust (7), RXW Shrewsbury And Telford Hospital NHS Trust (1)

[ii] RG2 Queen Elizabeth Hospital NHS Trust (FCEs 11,676), RJ1 Guy's And St Thomas' NHS Foundation Trust (5,354)

[iii] For instance, RAJ Southend University Hospital NHS Foundation Trust failed to report a cost for N12, despite having 6,942 FCEs in this HRG. Other departments have a minimal number of obstetrics patients assigned to a diverse range of HRGs. Examples are RGQ Ipswich Hospital NHS Trust (where 1,214 FCEs are allocated to 27 HRGs for which costs are not reported); RQM Chelsea And Westminster Hospital NHS Foundation Trust (849 FCEs, 63 HRGs); RNJ Barts And The London NHS Trust (1,881 FCEs, 24 HRGs).

[iv] RAJ Southend University Hospital NHS Foundation Trust, RBZ Northern Devon Healthcare NHS Trust RNJ Barts And The London NHS Trust

[v] http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_4091529 accessed 15/9/08

[vi] http://www.ic.nhs.uk/webfiles/publications/esr_earnings_2007-7/July%202007%20Earnings%20Estimates%20Tables.pdf accessed 27/11/08

[vii] http://www.nhsla.com/NR/rdonlyres/8A429D32-B5F2-41CE-A60F-087775DA28DC/0/NHSLAFactsheet5200506.xls accessed 11/11/08

[viii] http://www.timesonline.co.uk/tol/life_and_style/health/article5168353.ece accessed 17/11/08