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The association between midwifery staffing and outcomes in maternity services in England: observational study using routinely collected data.

Preliminary report and feasibility assessment.

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Overview

This report presents a preliminary analysis which aims to assess the feasibility of using routinely available data to measure the impact midwifery staffing has on birth outcomes in maternity services at trust level in England. It uses the 2008 *Maternity Matters Benchmarking* dataset and the *Admitted Patients HES* data for England. The preliminary results suggest that it may be viable to explore the relationship between midwifery staffing and birth outcomes using routinely collected data. Due to limitations in data access we were only able to consider one outcome measure for this report – maternal readmissions to any hospital within 28 days of the birth.

Higher numbers of full time equivalent (FTE) midwives per birth was associated with a lower probability of readmission. A higher ratio of consultant obstetrician FTE to midwives FTE was also associated with a lower probability of readmission, as was a higher ratio of consultant midwives FTE to midwives. A higher ratio of registered nurses FTE to midwives FTE was associated with a higher probability of readmission. The relationships demonstrated with our simple model are certainly plausible with better outcomes consistently associated with higher levels of more experienced and more highly qualified staff.

However risk adjustment was limited in this model and the possibility remains that further risk adjustment might alter the relationships. Given that we only used one outcome and that there will be differing risk factors for other birth outcomes we could have considerably more confidence in the conclusions if results were consistent across outcomes.

Introduction

BACKGROUND

Growing research evidence suggests that there is a strong link between nurse staffing and patient outcomes (Aiken et al. 2002; Commission for Healthcare Audit and Inspection 2005; Kane et al. 2007; Needleman et al. 2002; Rafferty et al. 2007; Royal College of Nursing 2006). At the same time there is a gap in the literature addressing other clinical and non-clinical workforce groups within the NHS, including a lack of empirical evidence on the relationship between midwifery staffing (midwife-birth ratio), midwifery workforce characteristics and birth outcomes.

One of the key concerns of the Care Quality Commission (formerly the Healthcare Commission), which carried out a review of maternity services in 2008, was staffing levels – in some trusts “levels of staffing were well below average, indicating that they may have been inadequate” (Commission for Healthcare Audit and Inspection 2008). The review also found wide variations in staffing levels between trusts even when standardised against the number of births; variations in provision of midwife supervisors within the trusts; variations in clinical outcomes, poor attendance at in-service training courses and evidence of cultural separation between doctors and midwives.

The Government and NHS policies for the maternity services over the last two decades (and particularly recently) have pursued the following principles: a) all women should have a choice of place of birth – at home, in a midwifery stand-alone or integrated unit or in an obstetric unit; b) continuity of care and c) one-to-one midwifery support during labour. In January 2008, the Government announced extra funding for maternity, totalling £330 million over the next three years to ensure that mothers get the best possible care and are guaranteed a full range of birthing choices (choice of how to access maternity care; choice of type of antenatal care; choice of place of birth and postnatal care, i.e. ‘national choice guarantee’ policy for all women depending on their circumstances by 2009 (Department of Health 2007). Other important issues relate to: safety of maternity services including maternal mortality, which did not decline in 2003-2005 from the previous triennial confidential enquiry (Confidential Enquiry into Maternal and Child Health 2007); increases in adverse obstetric events (Safer Childbirth 2007); increased social inequalities (CEMACH 2007); demographic changes including rising birth rates; older mothers; more complex health needs; and mergers of NHS trusts.

There are implicit staffing implications of all these issues and a resulting pledge by the Department of Health to increase the number of midwives employed in the NHS by 4000 by 2012 (3400 full time equivalent). National policy in England advocates ‘normal birth’ (i.e. birth without medical intervention) as a desirable outcome (Department of Health 2007) and inadequate midwife staffing levels are consistently cited as an impediment to achieving this goal (Page 2003) and to safe care in general (Smith et al. 2009). Similar concerns are expressed over low numbers and lack of experience among doctors (Smith et al. 2009).

RESEARCH EVIDENCE

There is little empirical evidence from the UK of association between midwifery staffing, midwifery workforce and workplace characteristics and birth outcomes. Research in midwifery includes a Cochrane review of 11 trials from Australia, Canada, New Zealand and the United Kingdom, which examined the effects of models of midwifery-led care compared to other models of care on birth outcomes (Hatem et al. 2008). Midwife-led care was associated with certain benefits for women including less use of analgesia, fewer episiotomies or instrumental births, more spontaneous vaginal births, increased chance of being cared by a midwife they knew, being more in control during labour and initiating breastfeeding with no identified adverse effects. Other research has focused on maternal and staff satisfaction; on issues of safety on maternity services (Smith et al. 2009); staffing in neonatal care (Redshaw and Harris 1995); midwives' risk perception and intrapartum intervention rates (Mead and Kornbrot 2004); and staffing on postnatal units (Forster et al. 2006)**.** One earlier British study considered midwifery deployment during adverse intrapartum events using a prospective semi-structured observational design (Ashcroft et al. 2003). Most of the studies which have specifically focused on staffing issues are descriptive in nature, relying primarily on staff opinions, but confirm the perception that lower staffing levels are associated with adverse outcomes in terms of safety and experience. However these studies cannot provide estimates of the impact of changes to staffing or provide robust evidence to guide policy about staffing levels. There are also limitations with respect to application to NHS care of studies undertaken in other countries.

The only relevant cross-sectional study directly investigating the association between maternity staff (consultant obstetrician and gynaecologist (O&G), junior O&G and midwives) and birth outcomes (caesarean section rate (CS), instrumental vaginal delivery rate (IVD) and epidural for labour rate) considered 1994-96 data for all Thames maternity units (Joyce et al. 2002). The data are relatively old but the issues discussed in the paper are relevant to the current debate of rising rates of obstetric interventions. Overall the results from their multifactorial analysis suggested that staffing levels appear unrelated to either epidural or IVD rates. Variations in epidural and instrumental vaginal delivery rate between units were most significantly explained by socio-demographic factors. Variations in CS rates were related to the levels of monitoring and the experience of the obstetric staff, and independent of the correlation between caesarean and epidural rates. The level of junior but not consultant medical staff was positively correlated with caesarean section rates. There was no association between midwifery staffing levels and caesarean section rates in the multifactorial analysis after adjusting for confounders, which included epidurals, parity, induction rate and other. The National Perinatal Epidemiology Unit at the University of Oxford and their Birthplace in England programme are currently evaluating outcomes for women and babies at low-risk of complications at the start of labour of births planned at home, in different types of midwifery units and in hospital units with obstetric services. Study findings are expected to be reported in 2011.

Thus the evidence reviewed presents a somewhat contradictory picture with descriptive studies suggesting the potential adverse consequences of low midwife staffing levels but larger scale observational studies failing to find such a relationship.

Initial objectives and planned work

This research aimed to assess the feasibility of using routinely available data on a larger scale than has been done previously to assess the relationship between midwifery staffing levels and birth outcomes in maternity services at trust level.

Initially we sought to include midwifery staff (midwife full-time equivalent (FTE) - birth ratio) and all other maternity staff (medical and non-medical) at trust level and assess impact of staffing levels on the following outcomes:

- Mode of birth
- Adverse obstetric event
- Perineal tear
- Re-admissions (mothers)
- Length of stay (women hospitalised >4 days)
- Incidence of episiotomy
- The use of epidurals
- Women breast feeding post-natal

We considered the following main data sources:

- Secondary Uses Service (SUS) data from Dr Foster Intelligence;
- NHS Maternity Matters Database (2008) from Healthcare Workforce Portal (Maternity Benchmarking Database).
- Dr Foster Birth Guide – at birth unit level in England, 2007 and by service configuration (consultant-led and/or midwife-led)
- NHS Maternity Statistics, England: 2006-07. The NHS Information Centre (IC)
- NHS Workforce Statistics, England: 2007/08. The NHS IC

Actual work and data assessment

Data issues

We used *Admitted Patients HES* data from Dr Foster for the period April 2008 – March 2009. The *Admitted Patients HES* data does not contain the 'maternity tail', where most of the birth clinical outcomes are recorded. HES data, which includes the ‘maternity tail’, arrived too late for the purposes of the current work.

We used data for 144 trusts out of 150 which provide maternity care in England; 615042 mothers and included the following variables in our models:

- readmissions within 28 days of the birth to any hospital (outcome);
- age of mother (13-53 in 8 groups);
- ethnicity (White, Mixed, Asian or Asian British; Black or Black British; not known/not stated);
- Carstairs deprivation index (1-least deprived; 5 – most deprived);
- Charlson co-morbidity index (0, 1+ co-morbidities)[1]
- delivery type (1 – normal delivery without complications; 2 – normal delivery with complications; 3 – assisted delivery with complications; 4 – assisted delivery without complications; 5 – caesarean section (there was no separate information on planned and emergency CS); 6 – caesarean section with complications);
- professional delivering (midwife versus consultant obstetrician + other);
- number of admissions in the previous 12 months (0, 1, 2, 3);
- pre- and post-birth length of stay (0 days, 1-4; 5-16; 17+ days) .

We selected the staff variables from the *Maternity Matters Benchmarking* dataset (2008) and matched them at trust level to the *Admitted Patients HES* data. We selected:

- Consultant obstetrician and gynaecologist (O&G) FTE - birth ratio
- Associate Specialist and Staff Grade O&G FTE - birth ratio
- O&G registrar FTE - birth ratio
- O&G senior house officer FTE - birth ratio
- Number of O&G junior house officer FTE - birth ratio
- Midwife consultant FTE - birth ratio
- Midwife FTE - birth ratio
- Registered nurse FTE - birth ratio
- Nursery nurse FTE - birth ratio
- Healthcare assistant FTE - birth ratio

[1] Charlson co-morbidity index - has a good predictive power for mortality, it is 23 years old and was initially “tested for its ability to predict risk of death from comorbid disease” (Charlson et al. 1987) in a cohort of breast cancer patients. The index does not include major complications of pregnancy and birth, as a lot of women would have some morbidity (backache, incontinence, pain etc).

The 'FTE - birth ratio' is defined as number of births per health professional FTE. They were available at trust level (the total number of births per year in each trust is divided to the total FTE for each professional group). Only 27 trusts had data on all staff groups FTE-birth ratios. It was not clear whether some trusts did not employ all of those staff groups or whether the data was missing. In addition changes in configuration and mergers of trusts meant that the two data sets did not fully match (for example RYQ is the new code for South East London NHS Trust, which is a new merger of RG2 Woolwich Queen Elizabeth, RG3 Bromley, RGZ Queen Mary Sidcup). Clearly averaging the staff FTE-birth ratios across the merged trusts would have been misleading, so we decided to drop the trusts that did not fully match in both datasets (the 144 trusts in our analysis exclude those). There was considerable variation in the staffing configurations between trusts. See table 1 for available staffing data.

Table 1: Staff groups FTE-birth ratio descriptive

	N	Minimum	Maximum	Mean	Std. Dev
Consultant obstetrician and gynaecologist (O&G) FTE - birth ratio	140	79	971	430.49	130.96
Associate Specialist and Staff Grade O&G FTE - birth ratio	113	190	8553	1956.04	1512.02
O&G registrar FTE – birth ratio	140	56	1133	324.73	163.72
O&G senior house officer FTE – birth ratio	115	273	7887	1776.92	1338.28
O&G junior house officer FTE - birth ratio	105	311	5912	1901.18	1245.03
Midwife consultant FTE - birth ratio	124	89	6803	1642.54	1322.74
Midwife FTE - birth ratio	140	9	81	31.47	7.89
Registered nurse FTE - birth ratio	133	26	5070	257.60	521.54
Nursery nurse FTE - birth ratio	63	266	5992	1598.94	1291.49
Healthcare assistant FTE - birth ratio	141	18	1030	144.21	125.67
Valid N (listwise)	27				

Source: NHS *Maternity Matters Benchmarking* dataset, 2008, Healthcare Workforce Portal

Analysis

The outcome variable "28 days readmission", defined as number of women being readmitted within 28 days after discharge from the postnatal ward, was chosen as an example. We ran a logistic regression at patient level and Poisson regression at trust level, using SPSS. Expected readmissions were estimated from the patient level model and used as an offset in the trust level model.

Expected readmissions were estimated by controlling for the following factors: age of mother; ethnicity; Carstairs deprivation index; Charlson co-morbidity index; delivery method; professional delivering; number of admissions in the previous 12 months; pre- and post-birth length of stay. We were unable to include in our risk model variables such as: previous delivery type, parity, multiple pregnancies, multiple births, gestational age, or assess completeness of this data in the maternity tail because of the data's late delivery. For each patient the model saves the predicted probability of occurrence of the event (in this case re-admission).

Results

Mean maternal age was 29 years and the biggest group (28%) were 26-30 years old; 70% of all mothers were white; 96% had no co-morbidities; 15% of mothers lived in least deprived areas, compared to 27% in the most deprived areas; 57% of the births were normal deliveries without complications, while 23% were CS with and without complications; 19% of births had a midwife, rather than an obstetrician as the responsible clinician 77% had 1-4 days post-birth length of stay and 37% had 1-4 days pre-birth length of stay; and about 10% had admissions in the previous 12 months. Table 5 in the Appendix presents the descriptive statistics of the variables used in the risk model.

Risk Model

There was a higher probability of being readmitted among some age groups (particularly for age groups 16-20 and 41-45 compared to the youngest age group of 13-15 years), though overall age was not significant. Women with no co-morbidities were less likely to be readmitted compared those with 1+ co-morbidities[2]. Mothers with one or more than one admission in the previous 12 months; Black and Black British mothers (compared to White), those living in the most deprived areas and mothers who had long pre-birth and post-birth length of stay were all more likely to be readmitted. Women delivering under midwife were less likely to be readmitted compared to those delivering under consultant obstetrician or other. The predictive power of the risk model is moderate – area under the Receiver Operating Characteristic (ROC) curve = 0.622. ROC curve is a measure of model performance. Table 6 in the Appendix contains the full results of the logistic regression.

The relative risk of being readmitted for each woman in each trust was calculated by dividing the actual number of readmissions at 28 days to expected readmissions, obtained from the logistic regression model. The individual (actual, expected and relative) readmissions were added to obtain the relevant readmissions for each trust. Table 2 below shows the variability in the relative risk, which ranges from 0 to 3.5 (i.e. the observed number of readmissions in one trust, was 3.5 times higher than would be expected).

[2] Charlson co-morbidity index assigns weights for each condition that a patient has, taking into account the number and seriousness of comorbid diseases: 1 – myocardial infarction, congestive heart failure, peripheral vascular, cerebrovascular, chronic pulmonary, dementia, connective tissue, ulcer, mild liver and diabetes diseases; 2 – hemiplegia, moderate or severe renal disease, diabetes with end organ damage, any tumor, leukemia, lymphoma; 3 – moderate or severe liver disease; 6 – metasatic solid tumor, AIDS. The total score is the sum of the individual disease weights. (Charlson et al. 1987)

Table 2: Actual, expected and relative risk of readmissions at 28 days

	N	Minimum	Maximum	Mean	Std. Deviation
actual readmissions at 28 days	144	0	137	33.63	21.28
expected readmissions	144	0.01	92.03	33.39	16.89
relative risk of being readmitted	144	0	3.48	1.02	0.51

Effect of staffing

As we have partially removed the women's and some of the trusts' contributions to these variations, the next step was to find out whether the staffing variables would explain some of the remaining variations. We ran a second model at trust level (Poisson regression) including the actual readmissions as a dependent variable, the staff variables, and using expected readmissions as an offset. We checked for colinearity between the staff groups and only included the following standardised (z-scored) staff ratios: midwife FTE-births; obstetrician FTE-births/midwife FTE-births; consultant midwife FTE-births/midwife FTE-births and registered nurses FTE-births/midwife FTE-births.

Table 3 below shows the actual FTE-birth ratios of the selected professional groups at trust level. For example, there were on average 31.5 births per midwife FTE per year across the trusts, which were close to the Birthrate Plus recommendation of 28 hospital births per w.t.e midwife per annum (Ball et al. 2003, p.266), but the results also show a considerable variation in the midwife FTE/birth ratios across the trusts. 66% of all trusts have between 24 and 39 births per midwife FTE, but there was also a trust with 9 times more births per midwife FTE compared to another (range 9-81). This variation was in part offset by a variation in the number of births per consultant midwife who comprised a substantial part of the workforce in some trusts but not others (FTE/birth ratio range 89 to 6803).

Table 3: Staff FTE-birth ratio in the Poisson Regression at trust level

	N	Minimum	Maximum	Mean	Std. Deviation
Consultant O&G FTE-birth ratio	140	79	971	430.49	130.96
Midwife consultant FTE-birth ratio	124	89	6803	1642.54	1322.74
Midwife FTE-birth ratio	140	9	81	31.47	7.89
Registered nurse FTE-birth ratio	133	26	5070	257.60	521.54
Valid N (listwise)	116				

There was a significant relationship between all staffing variables and readmissions ($p<0.001$), Higher numbers of midwives FTE per births was associated with a lower probability of readmission. A higher ratio of consultant O&G FTE to midwives FTE was associated with a lower probability of readmission, as was a higher ratio of consultant midwives FTE to midwives. A higher ratio of registered nurses FTE to midwives FTE was associated with a higher probability of readmission. See Table 4.

Table 4: Poisson regression – association between staffing and readmissions (risk adjusted)

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	-75.054	0.017	-75.086	-75.021	20379389.885	1.000	0.000
Midwife FTE/ birth	-4.810	0.032	-4.873	-4.746	21908.783	1.000	0.000
Consultant FTE/Midwife FTE	-3.563	0.021	-3.605	-3.522	27781.511	1.000	0.000
Consultant Midwife FTE /Midwife FTE	-4.348	0.031	-4.408	-4.289	20314.699	1.000	0.000
Registered Nurse FTE/Midwife FTE	3.133	0.009	3.115	3.151	114557.365	1.000	0.000
(Scale)	1[a]						

a. Fixed at the displayed value.

Dependent Variable: actual readmissions at 28 days

Model: (Intercept), *Mdf FTE-birth; Cnslt FTE/ Mdf FTE; SrMdf FTE/Mdf FTE; Reg Nur FTE/Mdf FTE*, offset = expected readmissions at 28 days

Discussion

The preliminary analysis presented in this paper results from our initial attempt to assess the quality of the available data. The limitations described apply to both the use of the *Maternity Matters Benchmarking* dataset and the *Admitted Patients HES* data, the first in terms of the quality of staffing variables and trust codes and for the second, the lack of clinical birth outcomes. We only explored 'readmissions within 28 days' as an outcome and found it negatively related to the standardised staff/birth ratios of midwives. Readmissions were negatively related to the standardised consultant midwives to midwives birth ratios and; the consultant obstetricians to midwives birth ratios and; positively related to the standardised registered nurses to midwives birth ratios.

The preliminary analysis suggests that it may be viable to explore the relationship between midwifery staffing and birth outcomes using routinely collected data. The relationships demonstrated with our simple model are certainly plausible with better outcomes consistently associated with higher levels of more experienced and more highly qualified staff. However risk adjustment was limited in this model and the possibility remains that further risk adjustment might alter the relationships.

Safer Childbirth (2007) recommended for 40 to 60[3] hours per week presence of obstetricians on labour wards. The evidence here seems to support an increase in units with lower levels of consultant cover. The HCC *Towards Better Births* review of maternity services (Commission for Healthcare Audit and Inspection 2008) reported that 68% of trusts met the 40 hour standard but some trusts had as little as 10 hours per week consultant obstetrician time. Obstetricians are also expected to attend antenatal and postnatal wards, antenatal clinics, theatre activities and to audit and supervise junior doctors as well as to have variable amounts of gynaecological work. Around a quarter of the midwives and doctors surveyed (voluntary maternity staff survey as part of the HCC review, 86 of the 150 trusts took part) felt that more consultant obstetricians and more senior midwife presence is needed in the delivery suits. In addition issues like leadership and communication between staff groups were seen as paramount for the provision of safe and effective care on maternity wards.

The finding of poorer outcomes associated with a higher ratio of registered nurses to midwives is interesting and warrant further investigation into the role of nurses and supporting staff on maternity wards. The relationship of higher readmissions related to higher ratio of registered nurses to midwives in maternity services is worthy of further exploration in order to understand how nurses are deployed and whether there is some work substitution between RN and midwives. These findings also have potentially significant economic implications in terms of cost of readmissions and the related staff costs but also the costs associated with the higher staffing ratios implied. The data available to us had information on the level of healthcare assistants FTE in maternity services, which did not differentiate between maternity support workers and maternity care assistants. Healthcare assistants were excluded from the model because of colinearity with other staff groups. The support workers may become a more significant part of the workforce in future (Prowse and Prowse 2008) and therefore including them in future analysis will be of interest.

There are several issues we need to address when fine-tuning the model in the future. Emergency readmission rates can be an effective measure of treatment or an outcome of substandard care and follow-up. However the question remains of whether the reasons for readmission are a direct consequence of the original procedure/interventions, or to do with the level of aftercare, or the patient's own actions. Most literature on maternity readmissions also considers six weeks (not 28 days) as the conventional postpartum period. It is an arbitrary and not scientifically justified period but “complications that occur within this time frame commonly are assumed to be related, or potentially related, to the pregnancy or events of delivery” (Belfort et al. 2010). Furthermore we have so far considered only a single outcome. We have confidence that patient safety indicators related to delivery can be extracted from HES (Bottle and Aylin 2009). Given that there will be differing risk factors for some of these outcomes we could have considerably more confidence in the conclusions if results were consistent across outcomes.

[3] 60 hours for units with over 5000 births per annum.

Implications & Future work

There is considerable scope to pursue this work further. Although our preliminary work was limited by the late arrival of HES our single exemplar outcome has identified potential in a limited model. The results presented so far support assertions that adverse outcomes are potentially associated with lower staffing levels, with implications for the current safety and quality of care policy agenda (Department of Health 2007). The evidence is consistent with moves to increase staffing levels across midwifery and obstetrics/gynaecology. However there is a limitation to what can ultimately be learned by modelling associations between staffing levels without consideration of the complex interactions involved. For example it is unclear how maternity staff, including registered nurses are deployed within trusts (for example between delivery suites, post natal wards, operating theatres/recovery area and community) and it is unclear how to maximise the effectiveness of staffing within a limited budget. Crudely we need to consider if it is better to have more, less qualified staff or fewer more skilled staff and how staff should be deployed to maximise clinical and cost effectiveness. There is considerable scope for economic modelling if the underlying effectiveness model is robust.

Clearly future methods should include multilevel logistic regression model at trust and patient level and should strive to incorporate additional variables such as midwifery and other maternity staff workforce characteristics, midwifery grades, skill mix, job relevant training, supervision and turnover. We believe this staff information and other on maternal outcomes and interventions are available for 2007 at trust level (possibly even at maternity unit level) from the CQC (formerly HCC) data which formed the basis of their report *Towards Better Births*. We are in correspondence with CQC in attempt to acquire their 2007 trust level data and are particularly interested in the following mandatory collected information on:

- Interventions (induction, assisted vaginal birth, planned CS, emergency CS, vaginal birth after CS, episiotomy)
- Outcomes (postpartum haemorrhage, perineal trauma – 3^{rd}-4^{th} degree tear, normal birth)
- Staffing (midwives, obstetricians, maternity support workers, community midwives)
- Skill mix
- Midwives grades, turnover and age structure
- Training and supervision

The use of these variables therefore will depend on accessing this data and matching it at trust level to HES data, as well as the quality of the data and consensus on definitions.

Additional maternal characteristics such as previous mode of birth, parity, multiple births, gestational age, and co-morbidities such as diabetes, hypertension, renal disease, cardiac disease and obesity should be considered to attempt to improve the predictive power of the risk model. We also hope to get a more disaggregated maternity staff data at maternity unit level from the IC. Hopefully we may be able to incorporate self-reported variables from the *Maternity Survey* on antenatal, labour and postnatal care. These include important aspects of care processes and experience such as reality of choice of place of birth and main care provider, support during labour, practical and consistent help and advice with infant feeding and aspects of infant care, and impact of pregnancy and birth on physical and psychological health and well-being.

The use of this broader range of outcomes will give more confidence in findings, in the face of uncertainty about risk adjustment, but also a clearer picture of the real impact of staffing deployment on the overall birth outcomes and birth experience of women.

Appendix

Table 5: Variables in the risk model at patient level, count and per cent of all mothers

		Count	%
Mother's age	13-15	1068	0.17
	16-20	59068	9.60
	21-25	129660	21.08
	26-30	174486	28.37
	31-35	157528	25.61
	36-40	79430	12.91
	41-45	13233	2.15
	46-53	569	0.09
Delivery method grouped	Normal delivery without complications	351233	57.11
	Normal delivery with complications	88437	14.38
	Assisted delivery with complications	11398	1.85
	Assisted delivery without complications	20838	3.39
	Caesarean section	53832	8.75
	Caesarean section with complications	89304	14.52
Deprivation	least deprived	97222	15.81
	2	100061	16.27
	3	113570	18.47
	4	132872	21.60
	most deprived	167045	27.16
	not known	4272	0.69
Ethnicity	White	428069	69.60
	Black or Black British	33556	5.46
	Mixed	3834	0.62
	Asian or Asian British	50371	8.19
	Other	38588	6.27
	Not known, not stated	60624	9.86
Charlson co-morbidity	no co-morbidities	593070	96.43
	1,2,3+ co-morbidities	21972	3.57
Post-birth LoS	0 days	107549	17.49
	1-4 days	470629	76.52
	5-16 days	36249	5.89
	17+ days	615	0.10
N of admissions in previous 12 months	0	555872	90.38
	1	46442	7.55
	2	8799	1.43
	3	3929	0.64
Pre-birth LoS	0 days	382754	62.23
	1-4 days	225018	36.59
	5-16 days	6401	1.04
	17+ days	869	0.14
Lead professional delivering	midwife	115056	18.71

	consultant obstetrician + other	499986	81.29
All mothers		615042	100

Table 6: Risk Model - logistic regression results, method - backward stepwise (Wald)

Variables in the Equation	B	S.E.	Wald	df	Sig.
no admissions in the prev 12 months			264.926	3	**.000**
1 admission in the prev 12 months	.499	.044	129.729	1	**.000**
2 admissions in the prev 12 months	.741	.083	79.456	1	**.000**
3 admissions in the prev 12 months	.995	.108	85.273	1	**.000**
professional delivering – midwife vs consultant + other	-.098	.042	5.372	1	**.020**
no co-morbidities vs 1,2,3+ co-morbidities	-.168	.068	6.058	1	**.014**
mother's age 13-15			27.753	7	**.000**
mother's age 16-20	.495	.412	1.441	1	.230
mother's age 21-25	.373	.411	.826	1	.364
mother's age 26-30	.310	.411	.571	1	.450
mother's age 31-35	.269	.411	.428	1	.513
mother's age 36-40	.390	.412	.897	1	.344
mother's age 41-45	.542	.419	1.678	1	.195
mother's age 46-53	.363	.581	.391	1	.532
normal delivery without complications			216.585	5	**.000**
normal delivery with complications	.360	.041	75.327	1	**.000**
assisted delivery with complications	.444	.094	22.395	1	**.000**
assisted delivery without complications	.015	.088	.028	1	.866
caesarean section	.472	.050	90.542	1	**.000**
caesarean section with complications	.518	.041	160.995	1	**.000**
White			78.510	5	**.000**
Black or Black British	.238	.056	17.909	1	**.000**
Mixed	.054	.179	.093	1	.761
Asian or Asian British	.028	.052	.279	1	.598
Other	.003	.059	.003	1	.955
Not known, not stated	-.444	.060	54.048	1	**.000**
1 least deprived			27.107	5	**.000**
2	.089	.051	2.978	1	.084
3	.008	.051	.027	1	.869
4	.055	.049	1.251	1	.263
5 most deprived	.133	.048	7.475	1	**.006**
6 not known	-2.695	.708	14.466	1	**.000**
0 days prebirth length of stay			39.439	3	**.000**
1-4 days prebirth LoS	.114	.030	13.867	1	**.000**
5-16 days prebirth LoS	.452	.100	20.581	1	**.000**
17+ days prebirth LoS	.746	.223	11.170	1	**.001**
0 days postbirth LoS			43.314	3	**.000**
1-4 days postbirth LoS	.231	.047	24.249	1	**.000**
5-16 days postbirth LoS	.437	.067	42.366	1	**.000**
17+ days postbirth LoS	.405	.340	1.419	1	.234
Constant	-5.570	.419	176.540	1	.000

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