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Abstract

Estimating the risk of adverse birth outcomes in pregnant women undergoing non-obstetric surgery using routinely collected NHS data: an observational study

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Background: Previous research suggests that non-obstetric surgery is carried out in 1–2% of all pregnancies. However, there is limited evidence quantifying the associated risks. Furthermore, of the evidence available, none relates directly to outcomes in the UK, and there are no current NHS guidelines regarding non-obstetric surgery in pregnant women.

Objectives: To estimate the risk of adverse birth outcomes of pregnancies in which non-obstetric surgery was or was not carried out. To further analyse common procedure groups.

Data Source: Hospital Episode Statistics (HES) maternity data collected between 2002–3 and 2011–12.

Main outcomes: Spontaneous abortion, preterm delivery, maternal death, caesarean delivery, long inpatient stay, stillbirth and low birthweight.

Methods: We utilised HES, an administrative database that includes records of all patient admissions and day cases in all English NHS hospitals. We analysed HES maternity data collected between 2002–3 and 2011–12, and identified pregnancies in which non-obstetric surgery was carried out. We used logistic regression models to determine the adjusted relative risk and attributable risk of non-obstetric surgical procedures for adverse birth outcomes and the number needed to harm.

Results: We identified 6,486,280 pregnancies, in 47,628 of which non-obstetric surgery was carried out. In comparison with pregnancies in which surgery was not carried out, we found that non-obstetric surgery was associated with a higher risk of adverse birth outcomes, although the attributable risk was generally low. We estimated that for every 287 pregnancies in which a surgical operation was carried out there was one additional stillbirth; for every 31 operations there was one additional preterm delivery; for every 25 operations there was one additional caesarean section; for every 50 operations there was one additional long inpatient stay; and for every 39 operations there was one additional low-birthweight baby.

Limitations: We have no means of disentangling the effect of the surgery from the effect of the underlying condition itself. Many spontaneous abortions will not be associated with a hospital admission and, therefore, will not be included in our analysis. A spontaneous abortion may be more likely to be reported if it occurs during the same hospital admission as the procedure, and this could account for the associated increased risk with surgery during pregnancy. There are missing values of key data items to determine parity, gestational age, birthweight and stillbirth.

Conclusions: This is the first study to report the risk of adverse birth outcomes following non-obstetric surgery during pregnancy across NHS hospitals in England. We have no means of disentangling the effect of the surgery from the effect of the underlying condition itself. Our observational study can never attribute a causal relationship between surgery and adverse birth outcomes, and we were unable to determine the risk of not undergoing surgery where surgery was clinically indicated. We have some reservations over associations of risk factors with spontaneous abortion because of potential ascertainment bias. However, we believe that our findings and, in particular, the numbers needed to harm improve on previous research, utilise a more recent and larger data set based on UK practices, and are useful reference points for any discussion of risk with prospective patients. The risk of adverse birth outcomes in pregnant women undergoing non-obstetric surgery is relatively low, confirming that surgical procedures during pregnancy are generally safe.

Future work: Further evaluation of the association of non-obstetric surgery and spontaneous abortion. Evaluation of the impact of non-obstetric surgery on the newborn (e.g. neonatal intensive care unit admission, prolonged length of neonatal stay, neonatal death).

Funding: The National Institute for Health Research Health Services and Delivery Research programme.

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Glossary

Attributable risk The difference in rate of a condition between an exposed population and an unexposed population.

Hospital Episode Statistics An administrative database covering the main types of patient-level NHS hospital activity.

Hospital Episode Statistics maternity tail In Hospital Episode Statistics, each episode related to delivery of a baby can capture details about the labour and delivery (e.g. parity, gestational age, birthweight) in supplementary data fields known as Hospital Episode Statistics 'maternity tail'.

Low birthweight A weight at birth of < 2500 g (5.5 lb) (World Health Organization definition).

Multiparous The medical term used to describe a woman who has given birth before.

Number needed to harm The number of patients who would have to undergo non-obstetric surgery for one of them to experience an adverse effect.

Preterm Live birth before 37 weeks' gestation (World Health Organization definition).

Primiparous The medical term used to describe a woman who is giving birth for the first time.

Relative risk A measure of association between a disease or condition and a factor under study.

Spontaneous abortion A premature loss of a fetus up to 23 weeks of pregnancy and weighing up to 500 g (World Health Organization definition).

Stillbirth A child that had issued forth from its mother after week 24 of pregnancy and which did not at any time, after being completely expelled from its mother, breathe or show any signs of life.

List of abbreviations

ACOG	American College of Obstetricians and Gynecologists
CI	confidence interval
ENT	ear, nose and throat
HES	Hospital Episode Statistics
ICD-10	*International Classification of Diseases*, Tenth Edition
NIHR	National Institute for Health Research
NNH	number needed to harm
OPCS	Office of Population, Censuses and Surveys's *Classification of Surgical Operations and Procedures*
OPCS-4	Office of Population, Censuses and Surveys's *Classification of Surgical Operations and Procedures*, version 4
OR	odds ratio
RCM	Royal College of Midwives
RCOG	Royal College of Obstetricians and Gynaecologists
RR	relative risk

Plain English summary

We set out to estimate the risk of adverse birth outcomes following an unrelated surgical procedure (non-obstetric surgery) during pregnancy. Using English NHS hospital administrative data, we identified 6,486,280 pregnancies in the period April 2002 to March 2012. Women had surgery in 0.7% of these pregnancies.

We found that having an operation was associated with a small additional risk of all adverse birth outcomes compared with not having an operation. We took into account factors including maternal age, social class and illnesses that women had during pregnancy.

We estimated that there was one additional preterm delivery for every 31 procedures carried out during pregnancy; one additional caesarean section for 25 procedures; one additional long inpatient stay for every 50 procedures; one additional stillbirth for every 287 procedures; and one additional low-birthweight baby for every 39 procedures. The risk of adverse birth outcomes in pregnant women undergoing non-obstetric surgery is relatively low, confirming that surgical procedures during pregnancy are generally safe.

It is not possible to tell whether the worse outcomes in pregnancies in which surgery was carried out were attributable to the surgery or the health problems that were being treated, and we do not know if the outcomes would have been better or worse if the surgery had not been carried out. However, we believe that our findings improve on previous research, by utilising a more recent and larger data set based on UK practices, and that they may help to inform mothers of the expected risks of having a procedure during pregnancy.

Scientific summary

Background

This study began as a result of questions posed by pregnant women who were scheduled to have cancer surgery during their pregnancy. Women wanted to know the risks of surgery to pregnancy, including the risks of a spontaneous abortion, stillbirth and premature delivery. However, there is limited available evidence quantifying these risks. Furthermore, of the evidence that is available, none relates directly to NHS outcomes and there are no current NHS guidelines regarding non-obstetric surgery in pregnant women.

Objectives

Our main objectives were to:

1. carry out a descriptive analysis of the data, describing counts of each adverse outcome by year, maternal age, procedure type, socioeconomic status and trimester of pregnancy
2. estimate the risk of each adverse outcome in women who have had surgery and compare this with the risks in those women who have not had surgery
3. estimate the risk associated with common procedure groups.

Methods

Hospital Episode Statistics (HES) is an administrative database that includes records of all patient admissions and day cases in all English NHS hospital trusts. We analysed HES maternity data collected between 2002–3 and 2011–12, and identified women who underwent non-obstetric surgery while pregnant.

The study outcomes were based on mothers' records (spontaneous abortion, preterm delivery, caesarean delivery, maternal death and long inpatient stays) and infants' records (stillbirth and low birthweight).

We used the adjusted odds ratio obtained directly from the logistic regression model to estimate the relative risk (RR) of each adverse birth outcome in pregnancies in which non-obstetric surgery was carried out compared with pregnancies with no record of surgery.

We used the logistic regression model to estimate marginal probabilities of each outcome of interest. This allowed us to compare outcomes between two populations whose only difference was in the exposure, permitting us to estimate adjusted RR, attributable risk and the number of operations associated with one additional adverse birth outcome [number needed to harm (NNH)]. Confidence intervals (CIs) for each measure of effect were estimated using the non-parametric bootstrap method. The end points of 95% CIs were defined as the 2.5th and 97.5th percentiles measured across the bootstrap samples.

Results

A total of 6,486,280 pregnancies were identified in the period April 2002 to March 2012. Spontaneous abortions accounted for 5.8% of all pregnancies. The number of maternal deaths following spontaneous abortion or delivery was very small and corresponded to a rate of 4 per 100,000 pregnancies. Among our cohort, 7.5% of deliveries ended in preterm birth and 23.9% ended in elective or emergency caesarean section. We identified 47,628 (0.7%) women who had non-obstetric surgery during their pregnancy. The most common surgical group was abdominal (26.2%), followed by dental (11.3%), nail and skin

(10.0%), musculoskeletal (9.6%), and ear, nose and throat (ENT) (6.4%). There were 3062 cases of appendectomy and 1306 cases of cholecystectomy.

After adjusting for potential confounders, we found that pregnant women who underwent non-obstetric surgery had a higher risk of adverse birth outcomes than those women who did not have surgery. The RR for spontaneous abortion was 1.13 (95% CI 1.09 to 1.17); for preterm delivery was 1.43 (95% CI 1.39 to 1.47); for maternal death was 4.72 (95% CI 2.61 to 8.52); for caesarean section was 1.21 (95% CI 1.19 to 1.23); for long inpatient stay was 1.22 (95% CI 1.19 to 1.25); for stillbirth was 1.64 (95% CI 1.50 to 1.81); and for low birthweight was 1.49 (95% CI 1.44 to 1.54). For NNHs, we estimated that, for every 143 pregnancies in which a surgical procedure was carried out, there was one associated additional spontaneous abortion; for every 287 procedures there was one associated additional stillbirth; for every 31 procedures there was one associated additional preterm delivery; for every 25 procedures there was one associated additional caesarean section; for every 50 procedures there was one associated additional long inpatient stay; for every 39 procedures there was one associated additional low-birthweight baby; and for every 7692 procedures there was one associated additional maternal death.

The additional risk of having an adverse birth outcome associated with abdominal surgery was higher than for women who did not have surgery during their pregnancy. Abdominal surgery during pregnancy was associated with an increase in the risk of spontaneous abortion and caesarean delivery of 5.0 percentage points.

We found that musculoskeletal, ENT, breast or dental procedures during pregnancy were associated with higher risks of some adverse birth outcomes.

Limitations

We have no means of disentangling the effect of the surgery from the effect of the underlying condition itself. Many spontaneous abortions will not be associated with a hospital admission and, therefore, will not be included in our analysis. A spontaneous abortion may be more likely to be reported if it occurs during the same hospital admission as the procedure, and this could account for the increased risk associated with surgery during pregnancy. Key data items that are necessary to determine parity, gestational age, birthweight and stillbirth are missing.

Conclusions

This is the first study to report the risk of adverse birth outcomes following non-obstetric surgery during pregnancy across NHS hospitals in England. We have no means of disentangling the effect of the surgery from the effect of the underlying condition itself. We found that non-obstetric surgery during pregnancy was associated with a significantly higher risk of all the outcomes we looked at, although, because of data completeness issues and the potential for ascertainment bias, we have some reservations over the findings associated with spontaneous abortion. The overall attributable risk of an adverse birth outcome in women who underwent surgery during pregnancy compared with women who did not was generally low.

Our observational study can never attribute a causal relationship between surgery and adverse birth outcomes. However, we believe that our findings and, in particular, the NNHs improve on previous research, utilise a more recent and larger data set based on UK practice and are useful reference points for any discussion of risk with prospective patients.

Future work

Further research is needed to evaluate the impact of non-obstetric surgery on the baby (e.g. neonatal intensive care unit admission, prolonged length of neonatal stay, neonatal death) and could be assessed by linking the maternal and baby records within the HES database. The use of large clinical databases, such as EuroKing Maternity systems (www.euroking.com/), linked to the HES database could be usefully exploited for this purpose.

Funding

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Chapter 1 Background and research objectives

Patient concerns

Our study arose as a direct result of questions posed in the high-risk obstetric anaesthetic clinic by patients who were scheduled to undergo cancer surgery while pregnant. Patients wanted to know the statistical risks of an adverse outcome to the pregnancy, including miscarriage, stillbirth, premature delivery or problems following birth such as admission to neonatal intensive care. Unfortunately, the current evidence base is not sufficient to answer these questions and, therefore, this constitutes a 'knowledge gap'.

A postal survey of women who had undergone non-obstetric surgery during pregnancy in our maternity unit over a 5-year period was then conducted. All respondents (75% response rate) expressed concern regarding the lack of availability of statistical data that could guide their decision. Although they felt that they were adequately counselled, they all agreed that, if there had been more information available, they would have been more confident in their decision-making and less anxious regarding the pregnancy outcome.

Previous literature

Previous literature suggested that non-obstetric surgery is carried out in approximately 1–2% of pregnancies,[1] with common operations being appendectomy, cancer surgery and orthopaedic procedures. In this situation, women and their doctors are understandably anxious about the risk of harm to the fetus. However, there is limited available evidence quantifying the risks of miscarriage (fetal loss before 24 weeks' gestation), stillbirth (fetal loss after 24 weeks' gestation), premature labour or infant death post delivery.

A Canadian study investigated data from 2656 women between 1971 and 1978.[2] Patients were matched to controls by age and geographical area. There was no statistically increased risk of fetal loss among the group as a whole. However, there was an increased risk of fetal loss in women undergoing a general anaesthetic, which was most marked for women undergoing general anaesthesia for obstetric or gynaecological procedures. Some of these obstetric procedures were cervical cerclages, procedures to prevent recurrent fetal loss, and some bias will therefore have resulted. The study did not differentiate between fetal loss at different stages of pregnancy, did not look at prematurity and did not control for coexisting illness, parity or smoking.

Mazze and Källén *et al.*[3] analysed outcomes of 5405 Swedish women who had undergone surgery during pregnancy between 1973 and 1981 (during which period there were a total of 720,000 births in Sweden). There was no increase in rates of congenital malformations or stillbirth; however, there were significant increases in death within 7 days of delivery and in prematurity.

The other Swedish studies involved subsets of the original data – specifically investigating appendicectomy[4] and laparoscopic surgery (here the data were expanded to include 2,015,000 deliveries from 1973 to 1993).[5] Sixteen per cent of women undergoing appendectomy after 24 weeks' gestation delivered on the day of their operation, with 22% delivering within 1 week. This resulted in a significant increase in prematurity and death within 7 days of delivery, but not in stillbirth.

A systematic review of the literature from 1966 to 2002 identified 54 papers, involving a total of 12,452 patients.[6] The miscarriage rate among patients undergoing surgery during pregnancy was 5.8% (10.5% if surgery took place in the first trimester); stillbirth occurred in approximately 2% of surgeries and premature

delivery in 8.2%. There were, however, no controls for comparison. The clearest data (although still poorly controlled) exist for appendicitis, with surgery-induced delivery occurring in 4.6% of women undergoing appendectomy and stillbirth in 2.6%, compared with 1.2% for other surgical procedures ($p < 0.001$). Fetal loss in the presence of peritonitis was 10.9%, which suggests that the condition itself rather than the operation may lead to fetal harm.

There are a number of problems with the currently available evidence. It all dates back 20–40 years and is therefore unlikely to be representative of current outcomes given the improvements in anaesthetic drugs, surgical techniques and neonatal care. Furthermore, the Swedish data[4,5] were collected with the aim of studying births and, therefore, patients who miscarry, the largest group of adverse birth outcomes, are unrecorded in these studies. The studies are also, in general, poorly controlled and have conflicting results regarding the risk of surgery. Duncan *et al.*[2] suggest that surgery is associated with an increased risk of fetal loss (including miscarriage), and the Swedish studies[4,5] suggest that there is no increase in stillbirth but that there is an increase in prematurity and early neonatal death, particularly in the case of appendectomy. Furthermore, although it is clear from the data on appendectomy that the risk to the fetus when a pregnant woman undergoes surgery is not uniform, there have been few attempts to quantify the risk by other types of surgery.

Nonetheless, of the evidence that is available, none relates directly to NHS outcomes, and there is no current NHS policy regarding carrying out non-obstetric surgery in pregnant women.

The project had three main objectives:

1. to carry out a descriptive analysis of the data, describing counts of each adverse outcome by year, maternal age, procedure type, socioeconomic status and trimester of pregnancy
2. to calculate the absolute risk and the relative odds of each adverse outcome in those women who have undergone surgery compared with those who have not
3. to independently analyse broad groups, such as elective and emergency operations, as well as common procedures such as appendectomy, cholecystectomy, specific cancer surgeries and orthopaedic surgery.

Chapter 2 Methods

Hospital Episode Statistics database

Hospital Episode Statistics (HES) is an administrative database that includes records of all patient admissions and day cases in all English NHS hospital trusts (www.hscic.gov.uk/hes). In HES, each record contains data on patient demographics (e.g. age, ethnicity and socioeconomic deprivation based on postcode of residence), the episode of care (e.g. hospital name, date of admission and discharge) and clinical information.[7,8] Diagnoses for each patient are recorded using the *International Classification of Diseases,* Tenth Edition (ICD-10). Procedures performed during an episode are coded using the Office of Population, Censuses and Surveys's *Classification of Surgical Operations and Procedures* (OPCS), version 4 (OPCS-4). In addition, each episode relating to the delivery of a baby contains details about the labour and delivery (e.g. parity, mode of delivery, gestational age, birthweight) in supplementary data fields known as the HES 'maternity tail'.

In HES, each patient is assigned a unique identifier. This makes it possible to link historical medical records.

Each record represents the continuous period of time during which patient is under the care of a consultant and is called an 'episode'. Episodes can be linked into admissions (also called a 'spell') to one hospital provider.

Selection of the cohort

We examined 10 years of HES maternity data from 2002–3 to 2011–12. Pregnancy records were defined as those that contained information about a delivery in either the OPCS procedure fields or the maternity tail[9] (*Table 1*), or information about a spontaneous abortion in the ICD-10 diagnosis fields (*Table 2*).

Duplicate records were identified on the basis of the date of admission, the date on which the episode started, provider code, HES identification number and consultant code.[11,12] The resulting sample was restricted to women aged between 15 and 49 years.[11,13–15]

TABLE 1 The OPCS-4 codes and maternity tail method of delivery 'delmeth' codes for identifying delivery episode

Code	OPCS-4 code	Delmeth code	Method of delivery description
1	R17	7	Elective caesarean section
2	R18, R25.1	8	Emergency caesarean section
3	R19, R20	5, 6	Breech vaginal delivery
4	R21	2, 3	Forceps delivery
5	R22	4	Vacuum delivery
6	R23, R24	0, 1	Cephalic vaginal delivery without instruments
7	R25.2	9	Other methods of delivery, including destructive operation to facilitate delivery
8	R25.8, R25.9	X	Unknown

TABLE 2 Outcomes and their definitions

Outcome	Definition
Spontaneous abortions associated with hospitalisation	Pregnancy episodes with an ICD-10 code for spontaneous abortion (O03, O05, O06)
Preterm delivery	Pregnancy episodes with an ICD-10 code for preterm delivery (O60) or using length-of-gestation field in the HES maternity tail
Maternal death	Method of discharge field (value: 4 = 'died') in delivery or spontaneous abortion admission
Caesarean section	Pregnancy episodes with an OPCS code or using delivery method field in the HES maternity tail (see *Table 1*)
Long inpatient stay (delivery admission only)	Upper quartile of length of stay plus 1.5 times the interquartile range (separate values for caesarean and vaginal delivery)[10]
Stillbirth	ICD-10 code that identifies the outcome of delivery in the mother's record (Z37.1, Z37.3, Z37.4, Z37.6, Z37.7) or using birth status field in the HES maternity tail. Values were recoded into three categories: one or more stillborn; all live; unknown
Low birthweight	Birthweight field in the HES maternity tail. Values were recoded into three categories: one or more newborn with low birthweight (< 2500 g); all newborns weighed > 2500 g; unknown

Definition of outcomes and risk factors

In our original proposal we aimed to examine six outcomes: miscarriage, stillbirth, preterm labour, low birthweight, prolonged length of neonatal stay and neonatal death prior to discharge from hospital. Following receipt of data, it became clear that the linkage process on which the maternity tails were derived did not allow prolonged length of neonatal stay and neonatal death prior to discharge from hospital to be determined. We therefore substituted three new outcomes related to delivery: caesarean section, maternal death in hospital and a long inpatient stay (maternal). Our final list of adverse outcomes, based on mothers' records, was spontaneous abortion (associated with hospitalisation), preterm delivery, caesarean section, maternal death and long maternal inpatient stays. Our adverse outcomes based on infants' records were low birthweight and stillbirth. The definitions of these outcomes are listed in *Table 2*.

Adjustment for potential confounders is important to account for any differences between those women who received non-obstetric surgery during pregnancy and those who did not. We examined risk factors identified from previous research literature[16–23] and these are defined in *Table 3*.

Risk factors such as maternal age, multiple pregnancy, socioeconomic deprivation, gestational diabetes, comorbidities, hypertension/pre-eclampsia and cardiac diseases were identified using information recorded within the hospital episode relating to the delivery or spontaneous abortion. Operations on the amniotic cavity and obstetric surgery were included in the analyses if they occurred during pregnancy (not during delivery or spontaneous abortion admission). Comorbidities (prior to pregnancy) were identified using women's historical admission records for 3 years prior to pregnancy. The list of non-obstetric procedures, based on operating theatre procedures defined in previous research,[26] was derived from the OPCS procedure fields. A non-obstetric procedure was included in the analysis if it occurred during pregnancy.

We estimated the beginning of pregnancy as:

- for delivery: admission day minus gestational age (if available) or admission day minus 36 weeks (if gestational age not available, but diagnosis field indicates preterm delivery) or admission day minus 40 weeks (otherwise)
- for spontaneous abortions: 3 months prior to admission day.

TABLE 3 Risk factors and their definitions

Risk factors	Definition
Maternal age	Age at start of delivery admission field in HES. Values were recoded into six categories: 15–19 years, 20–24 years, 25–29 years, 30–34 years, 35–39 years and ≥ 40 years
Multiple pregnancy	ICD-10 code in any diagnosis field (O30) derived from delivery or spontaneous abortion admission
Parity	Number of previous pregnancies 'numpreg' field in the HES maternity tail; however, where this value was missing, we identified previous pregnancies by linking historical health records using the woman's HES identification number back to 1997. Values were recoded into two categories: primiparous and multiparous
Previous emergency admission (year prior to pregnancy)	Method of admission field in HES (value: 21–28) from admission records in the previous year
Socioeconomic deprivation	Carstairs deprivation quintile[24] based on postcode from delivery or spontaneous abortion admission
Comorbidities	Charlson Comorbidity Index score[25] derived from secondary diagnosis fields in delivery or spontaneous abortion admission
Comorbidities (prior to pregnancy)	Charlson Comorbidity Index score[25] (from admissions within 3 years prior to pregnancy)
Gestational diabetes	ICD-10 code in any diagnosis field (from delivery or spontaneous abortion admission): O24 – diabetes mellitus in pregnancy
Hypertension/pre-eclampsia	ICD-10 code in any diagnosis field (from delivery or spontaneous abortion admission): • O10 – pre-existing hypertension complicating pregnancy, childbirth and the puerperium • O11 – pre-existing hypertensive disorder with superimposed proteinuria • O12 – gestational (pregnancy-induced) oedema and proteinuria without hypertension • O13 – gestational (pregnancy-induced) hypertension without significant proteinuria • O14 – gestational (pregnancy-induced) hypertension with significant proteinuria • O15 – eclampsia • O16 – unspecified maternal hypertension
Cardiac diseases	ICD-10 code in any diagnosis field (from delivery or spontaneous abortion admission): • I05 – rheumatic mitral valve diseases • I06 – rheumatic aortic valve diseases • I07 – rheumatic tricuspid valve diseases • I08 – multiple valve diseases • I09 – other rheumatic heart diseases • I10 – essential (primary) hypertension • I11 – hypertensive heart disease • I12 – hypertensive renal disease • I13 – hypertensive heart and renal disease • I15 – secondary hypertension • I20 – angina pectoris • I23 – certain current complications following acute myocardial infarction • I24 – other acute ischaemic heart diseases • I25 – chronic ischaemic heart disease (excluding I25.2 – old myocardial infarction) • I27 – other pulmonary heart diseases • I28 – other diseases of pulmonary vessels • I30–I52 – other forms of heart disease • Q20 – congenital malformations of cardiac chambers and connections • Q21 – congenital malformations of cardiac septa • Q22 – congenital malformations of pulmonary and tricuspid valves • Q23 – congenital malformations of aortic and mitral valves • Q24 – other congenital malformations of heart • Q25 – congenital malformations of great arteries

continued

TABLE 3 Risk factors and their definitions (*continued*)

Risk factors	Definition
Operations on amniotic cavity	OPCS code in any procedure field (R10) from admissions within pregnancy
Obstetric surgery	OPSC code in any diagnosis field (from admissions within pregnancy): • R01 – therapeutic endoscopic operations on fetus • R02 – diagnostic endoscopic examination of fetus • R04 – therapeutic percutaneous operations on fetus • R05 – diagnostic percutaneous examination of fetus • R07 – therapeutic endoscopic operations for twin–twin transfusion syndrome • R08 – therapeutic percutaneous operations for twin–twin transfusion syndrome • R12 – operations on gravid uterus • R27 – other operations to facilitate delivery • R34 – other obstetric operations
Previous caesarean section	Previous pregnancy episodes with an OPCS code or using the delivery method field in the HES maternity tail (from 1997–8 to 2011–12) (see *Table 1*)
Non-obstetric surgery	An operating theatre procedure based on OPCS procedure field defined in previous research.[26] From the list we excluded obstetric and male-associated procedures. Furthermore, after discussion with clinicians, two OPCS codes were excluded (K66.1 – cardiotachyography, S06 – other excision of skin)

We assumed that the procedure was related to cancer or acute appendicitis if the ICD-10 code in any diagnosis field in the procedure admission was C00–C97 or K35, respectively.

From this point onwards, when we describe pregnancies in which surgery was or was not carried out we are referring specifically to non-obstetric surgery.

Statistical methods

We carried out a descriptive analysis of the data, describing total number and rates of risk factors, outcomes and missing data, and counts of each adverse outcome by year. We described counts of outcomes by common surgery groups and trimester of surgery.

We calculated the crude risk, odds ratio (OR), relative risk (RR), attributable risk, numbers needed to harm (NNHs) and associated 95% confidence intervals (CIs) of adverse birth outcomes in pregnancies in which surgery was carried out compared with pregnancies in which surgery was not carried out.[27] All pregnancy records were included in the analysis when spontaneous abortion associated with hospitalisation and maternal death were the outcomes of interest. For the remaining outcomes, only pregnancy records that ended in delivery were included. In addition, we made some comparisons of risk between surgical groups. We independently analysed broad groups of procedure (see detailed definition of groups in *Appendix 1*) and estimated RR and associated 95% CIs, attributable risk and NNHs of adverse birth outcome in pregnancies where surgery occurred compared with pregnancies where surgery did not occur. We also repeated these analyses by trimester of procedure.

We calculated adjusted ORs, RR and attributable risk using two approaches:

- We calculated the adjusted RR using a simple relationship:[28]

$$RR = \frac{OR_{adj}}{(1-P_0) + (P_0 \times OR_{adj})}, \quad (1)$$

where P_0 denotes the proportion of untreated subjects who experience the outcome of interest and OR_{adj} denotes the OR obtained from a logistic regression model. The 95% CIs for the RR were estimated by substituting the upper and lower CIs for the OR from the multivariate logistic regression model.[29] It is a

simple method that approximates a risk ratio from the adjusted OR and derives an estimate of an association or treatment effect that better represents the true RR. We used backwards elimination regression, and only explanatory variables with a p-value < 0.05 were considered significant. The overall model evaluation was presented by the Akaike information criterion, the R^2 and c-statistic.

- We calculated the adjusted RR, attributable risk and NNH using Austin's method.[30] We assumed that a dichotomous outcome variable Y is observed for each subject (with $Y = 1$ denoting success and $Y = 0$ denoting failure). Furthermore, let T_i denote treatment status of the ith subject (with $T = 1$ denoting treatment and $T = 0$ denoting no treatment), whereas X_{1i}, X_{2i} . . . X_{ki} denotes the value of k confounding variables. The following logistic regression model relates the odds of the outcome to treatment status and baseline confounding variables:

$$\log\left(\frac{\Pr\left(Y_i=1\right)}{1-\Pr\left(Y_i=1\right)}\right)=\alpha_0+\beta T_i+\alpha_1 X_{1i}+\alpha_2 X_{2i}+\ldots+\alpha_k X_{ki}, \tag{2}$$

where β denotes the log-OR and e^{β} denotes the OR. Using this formula, one can determine the probability of the outcome if a given subject were treated and the same subject were untreated. The probability of the outcome if a subject were treated is:

$$\frac{e^{\alpha_0+\beta+\alpha_1 X_{1i}+\alpha_2 X_{2i}+\ldots+\alpha_k X_{ki}}}{e^{\alpha_0+\beta+\alpha_1 X_{1i}+\alpha_2 X_{2i}+\ldots+\alpha_k X_{ki}}+1}. \tag{3}$$

If a subject were not treated, then the probability of the outcome is:

$$\frac{e^{\alpha_0+\alpha_1 X_{1i}+\alpha_2 X_{2i}+\ldots+\alpha_k X_{ki}}}{e^{\alpha_0+\alpha_1 X_{1i}+\alpha_2 X_{2i}+\ldots+\alpha_k X_{ki}}+1}. \tag{4}$$

The mean probability ($\bar{p}_{T=1}$) of success in the cohort if all patients were treated and the mean probability ($\bar{p}_{T=0}$) of success in the cohort if all patients were untreated is then calculated. These are also referred to as the marginal probabilities of success for treated and untreated subjects. The risk difference and the RR can be estimated as $\bar{p}_{T=0}-\bar{p}_{T=1}$ and $\bar{p}_{T=1}/\bar{p}_{T=0}$, respectively. The NNH is defined as the inverse of the risk difference.[31,32]

The CIs for each measure of effect were estimated using a non-parametric bootstrap method.[33] A bootstrap sample is a random sample drawn with replacement from the original sample such that the random sample has the same size as the original sample. We created 1000 bootstrap samples and estimated the quantity of interest in each of them. The end points of the non-parametric 95% CIs would be the 2.5th and 97.5th percentiles of that quantity across the bootstrap samples. This method allows for comparison of outcomes between two populations whose only difference was the exposure (non-obstetric surgery during pregnancy). It permits an estimate of the adjusted attributable risk and NNH.

We carried out two-level logistic regression to investigate the effects of hospitals on the adverse birth outcome.[34] To test for significant differences between proportions we used chi-squared tests. Data were analysed using the SAS 9.2 software package (SAS Institute, Cary, NC, USA).

Missing data and sensitivity analysis

Our analysis assumed a live birth where the birth status in the maternity tail was unknown and there was no Z37 diagnosis code to indicate a stillbirth. We assumed a weight of > 2500 g if the birthweight was not recorded. Furthermore, we assumed that pregnancy was full term (40 weeks) where the gestational age in the maternity tail was unknown and there was no O60 diagnosis code to indicate preterm delivery. In a sensitivity analysis, we excluded all records with missing data in these fields and recalculated the adjusted RR, attributable risk and NNH. We also examined the effect of excluding gestational diabetes, obstetric surgery and operations on the amniotic cavity from the risk adjustment model for spontaneous abortion (associated with hospitalisation).

Chapter 3 Results

The following section provides the descriptive characteristics for the study sample. The unadjusted risks are then reported. Finally, we present the adjusted risk of each adverse outcome in pregnancies in which surgery was carried out compared with pregnancies in which no surgery was carried out, together with the attributable risk and the NNH.

Descriptive analysis

We identified 6,486,280 pregnancies in the period April 2002 to March 2012. Two-thirds of the study population were aged between 20 and 34 years (73.4%) and the majority were multiparous (55.5%) (*Table 4*). Twenty-seven per cent of women were living in the most socioeconomically deprived area based on the Carstairs measure of socioeconomic deprivation quintile. More than 10% of our population had an emergency admission to hospital a year prior to pregnancy and nearly 10% had previously had a

TABLE 4 Characteristics of risk factors in the study population

Risk factor	Frequency (%)		
	Total pregnancies	Pregnancies in which surgery was not carried out	Pregnancies in which surgery was carried out
Total number of pregnancies	6,486,280 (100)	6,438,652 (100)	47,628 (100)
Maternal age (years)*			
15–19	423,482 (6.5)	420,045 (6.5)	3437 (7.2)
20–24	1,228,398 (18.9)	1,217,961 (18.9)	10,437 (21.9)
25–29	1,702,845 (26.3)	1,690,140 (26.3)	12,705 (26.7)
30–34	1,830,026 (28.2)	1,817,982 (28.2)	12,044 (25.3)
35–39	1,049,786 (16.2)	1,042,638 (16.2)	7148 (15.0)
≥ 40	251,743 (3.9)	249,886 (3.9)	1857 (3.9)
Multiple pregnancy** (yes)	70,758 (1.1)	70,198 (1.1)	560 (1.2)
Parity*			
Primiparous	2,888,248 (44.5)	2,867,468 (44.5)	20,780 (43.6)
Multiparous	3,598,032 (55.5)	3,571,184 (55.5)	26,848 (56.4)
Previous emergency admission*	672,946 (10.4)	664,019 (10.3)	8927 (18.7)
Carstairs deprivation quintile*			
1 = least deprived	1,054,232 (16.3)	1,047,238 (16.3)	6994 (14.7)
2	1,064,704 (16.4)	1,057,376 (16.4)	7328 (15.4)
3	1,195,999 (18.4)	1,187,080 (18.4)	8919 (18.7)
4	1,371,638 (21.2)	1,360,905 (21.2)	10,733 (22.5)
5 = most deprived	1,754,815 (27.0)	1,741,297 (27.0)	13,518 (28.4)
6 = unknown	44,892 (0.7)	44,756 (0.7)	136 (0.3)

continued

TABLE 4 Characteristics of risk factors in the study population (*continued*)

Risk factor	Frequency (%)		
	Total pregnancies	Pregnancies in which surgery was not carried out	Pregnancies in which surgery was carried out
Charlson Comorbidities Index score*			
0	6,254,984 (96.4)	6,210,332 (96.4)	44,652 (96.8)
1+	231,296 (3.6)	228,320 (3.6)	2976 (3.2)
Charlson Comorbidities Index score* (prior pregnancy)			
0	6,375,029 (98.3)	6,329,356 (98.3)	45,673 (95.9)
1+	111,251 (1.7)	109,296 (1.7)	1955 (4.1)
Gestational diabetes* (yes)	98,196 (1.5)	97,179 (1.5)	1017 (2.1)
Hypertension/pre-eclampsia* (yes)	222,312 (3.4)	220,481 (3.4)	1831 (3.8)
Cardiac diseases* (yes)	16,951 (0.3)	16,626 (0.3)	325 (0.7)
Other operations on amniotic cavity* (yes)	32,491 (0.5)	32,214 (0.5)	277 (0.6)
Obstetric surgery* (yes)	327,050 (5.0)	325,036 (5.1)	2014 (4.2)
Previous caesarean deliveries* (yes)	640,405 (9.8)	635,174 (9.8)	5231 (11.0)
Non-obstetric surgery	47,628 (0.7)	0	47,628 (100)

Chi-squared test: *$p < 0.05$; **$p < 0.1$.

caesarean delivery. *Table 4* also includes information about maternal complications such as gestational diabetes (1.5%), hypertension/pre-eclampsia (3.4%) and cardiac disease (0.3%).

Spontaneous abortions associated with hospitalisation accounted for 5.8% of all pregnancies (*Table 5*). The numbers of maternal deaths following spontaneous abortion associated with hospitalisation or delivery were very small; only 235 cases were identified, and this corresponds to a maternal death rate of 4 per 100,000 pregnancies. Among our cohort there were more than 450,000 (7.5%) preterm deliveries and nearly 1.5 million (23.9%) elective or emergency caesarean deliveries.

Table 6 presents total number and rates of missing records for gestational age, socioeconomic deprivation, birth status and birthweight. In nearly 40% of all pregnancies, no information about gestational age was available. Less than 1% of records included no information about socioeconomic deprivation.

We identified 47,628 pregnancies in which surgery had been carried out at some time (0.7%). Of these surgeries, 25,445 (53.4%) were elective procedures and 22,183 (46.6%) were non-elective. The most common type of surgical procedure was abdominal (12,493, 26.2%), followed by dental (5365, 11.3%), nail and skin (4762, 10.0%), musculoskeletal (4563, 9.6%), ear, nose and throat (ENT) (3060, 6.4%) and perianal (2977, 6.2%) (*Table 7*). There were 3062 cases of appendectomy and 1306 cases of cholecystectomy. The most frequent procedures were diagnostic endoscopic examination of the peritoneum (5518), drainage of a lesion of the skin (1662) and emergency excision of an abnormal appendix (1448) (*Table 8*).

The proportions of common procedure groups for different outcomes were similar to the overall proportions, except for abdominal procedures and spontaneous abortion associated with hospitalisation (see *Table 7*).

TABLE 5 Total number and rates of outcomes by pregnancy, with and without surgery

Outcome	Frequency (%)		
	Total pregnancies	Pregnancies in which surgery was not carried out	Pregnancies in which surgery was carried out
Total number of pregnancies	6,486,280 (100)	6,438,652 (100)	47,628 (100)
Spontaneous abortion associated with hospitalisation	376,323 (5.8)	373,203 (5.8)	3120 (6.6)
Preterm delivery	457,793 (7.5)	452,877 (7.5)	4916 (11.1)
Preterm delivery by weeks			
22–27	37,968 (8.3)	37,630 (8.3)	338 (6.9)
28–33	87,557 (19.1)	86,509 (19.1)	1048 (21.3)
34–37	190,703 (41.7)	188,707 (41.7)	1996 (40.6)
Unknown	141,565 (30.9)	140,031 (30.9)	1534 (31.2)
Maternal death	235 (0.004)	223 (0.003)	12 (0.025)
Caesarean section	1,461,707 (23.9)	1,448,871 (23.9)	12,836 (28.8)
Long inpatient stay	578,709 (9.5)	573,471 (9.5)	5238 (11.8)
Stillbirth			
One or more stillborn	33,774 (0.6)	33,363 (0.6)	411 (0.9)
All live	5,996,017 (98.1)	5,952,658 (98.1)	43,359 (97.4)
Unknown	80,166 (1.3)	79,428 (1.3)	738 (1.7)
Low birthweight			
≥ 1 child with a low birthweight	342,631 (5.6)	338,800 (5.6)	3831 (8.6)
All newborns weighing > 2500 g	4,499,574 (73.6)	4,468,782 (73.7)	30,792 (69.2)
Unknown	1,267,752 (20.8)	125,7867 (20.7)	9885 (22.2)

TABLE 6 Total number and percentage of missing data

Outcome	Frequency (%)		
	Total pregnancies	Pregnancies in which surgery was not carried out	Pregnancies in which surgery was carried out
Gestational age	2,550,455 (39.3)	2,530,344 (39.3)	20,111 (42.2)
Socioeconomic deprivation	44,892 (0.7)	44,756 (0.7)	136 (0.3)
Birth status	80,166 (1.3)	79,428 (1.3)	738 (1.7)
Birthweight	1,267,752 (20.8)	125,7867 (20.7)	9885 (22.2)

TABLE 7 Proportion of common procedure groups for outcomes of interest[a]

Outcome	Common operation group (%)							
	Abdominal	Breast	Dental	ENT	Nail and skin	Perianal	Musculoskeletal	Other
Number of procedures (%)	12,493 (26.2)	1884 (4.0)	5365 (11.3)	3060 (6.4)	4762 (10.0)	2977 (6.2)	4563 (9.6)	12,524 (26.3)
Spontaneous abortion associated with hospitalisation	46.8	2.9	10.8	7.0	5.6	3.4	8.5	15.0
Preterm delivery	27.4	5.2	8.9	5.4	8.9	3.9	7.8	32.5
Caesarean section	25.4	4.0	9.3	5.3	9.2	6.4	9.0	31.4
Long inpatient stay	26.5	3.7	9.7	6.1	9.8	6.0	9.1	29.1
Stillbirth	28.0	2.9	11.0	6.6	8.8	2.4	8.5	31.8
Low birthweight	26.5	4.9	10.0	6.2	9.0	4.2	8.5	30.7

a Maternal death excluded because of small numbers.

TABLE 8 The OPCS-4 code, description, total number and percentage of the top three procedures in each surgical group

OPCS-4 code	Description	*n* (%)
Abdominal		
T43.9	Diagnostic endoscopic examination of peritoneum, unspecified	5518 (44.2)
H01.2	Emergency excision of abnormal appendix NEC	1448 (11.6)
J18.3	Total cholecystectomy NEC	1091 (8.7)
Breast		
B28.3	Excision of lesion of breast	663 (35.2)
B33.1	Drainage of lesion of breast	220 (11.7)
B35.3	Extirpation of lesion of nipple	148 (7.9)
Dental		
F09.1	Surgical removal of impacted wisdom tooth	1344 (25.1)
F09.3	Surgical removal of wisdom tooth NEC	1329 (24.8)
F10.4	Extraction of multiple teeth NEC	594 (11.1)
ENT		
F34.1	Bilateral dissection tonsillectomy	637 (20.8)
E03.6	Septoplasty of nose NEC	167 (5.5)
D02.1	Excision of lesion of external ear	177 (5.8)
Nail and skin		
S47.2	Drainage of lesion of skin NEC	1662 (34.9)
S42.1	Primary suture of skin NEC	276 (5.8)
F02.1	Excision of lesion of lip	230 (4.8)
Perianal		
H60.3	Drainage of pilonidal sinus	1062 (35.7)
H58.2	Drainage of perianal abscess	707 (23.7)
H52.4	Rubber band ligation of haemorrhoid	138 (4.6)

TABLE 8 The OPCS-4 code, description, total number and percentage of the top three procedures in each surgical group (*continued*)

OPCS-4 code	Description	*n* (%)
Musculoskeletal		
A65.1	Carpal tunnel release	769 (16.9)
T67.6	Primary simple repair of tendon	338 (7.4)
A64.2	Primary repair of peripheral nerve NEC	207 (4.5)

NEC, not elsewhere classifiable.

Spontaneous abortion associated with hospitalisation

Among our cohort, we identified 376,323 (5.8%) spontaneous abortions associated with hospitalisation, 3120 of which occurred in women who had undergone surgery during their pregnancy. The percentage of spontaneous abortions associated with hospitalisation has decreased from 6.4% to 5.3% since 2002–3 (*Figure 1*).

Preterm delivery

Of the 457,793 (7.5%) preterm deliveries between 2002–3 and 2011–12 in England, 1.1% were to women who had undergone surgery during pregnancy. The percentage of all deliveries that occurred preterm increased from 6.7% in 2002–4 to 8.0% in 2011–12 (*Figure 2*).

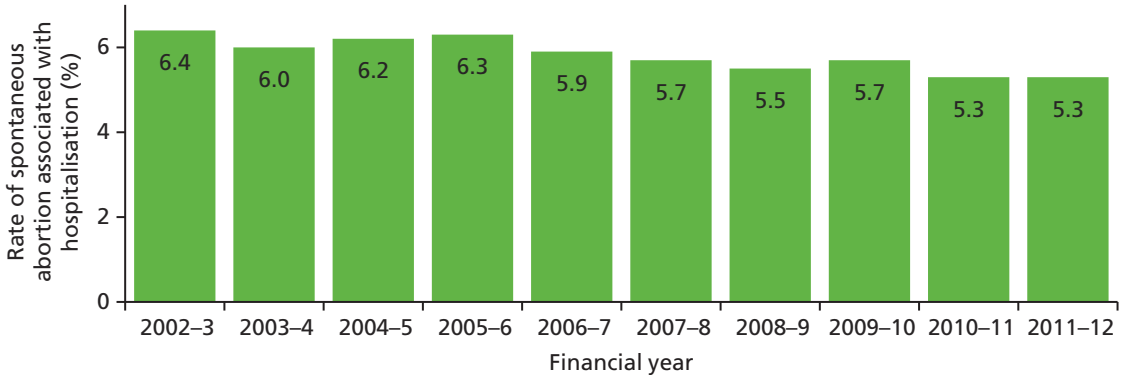

FIGURE 1 Rate of spontaneous abortion associated with hospitalisation per year in England.

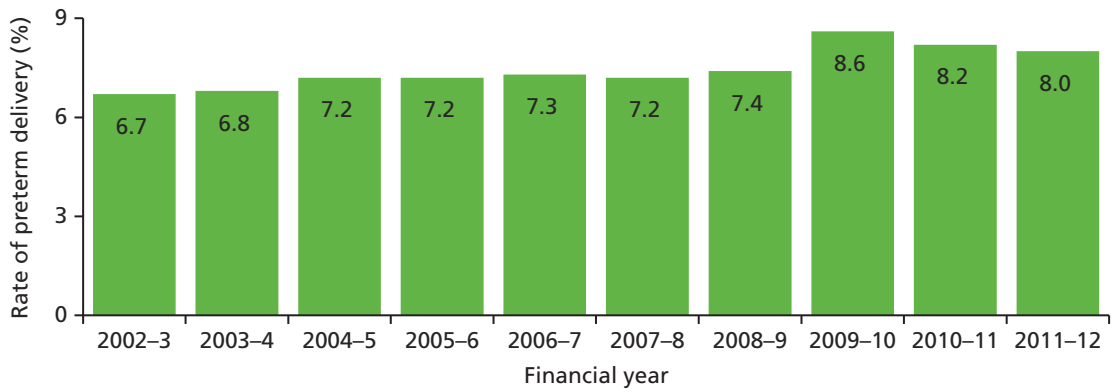

FIGURE 2 Rate of preterm delivery per year in England.

Maternal death

The number of maternal deaths following delivery (or spontaneous abortion associated with hospitalisation) was small. Only 235 cases were identified, and this corresponded to a maternal death rate of 4 per 100,000 pregnancies (*Figure 3*). Moreover, only 12 of these women had undergone surgery during pregnancy.

Caesarean section

We identified 1,461,707 (23.9%) pregnancies resulting in delivery by caesarean section over the 10-year period of the study; 12,836 of these caesarean sections were carried out in women who had undergone surgery during that pregnancy. *Figure 4* shows that the proportion of caesarean deliveries slightly increased from 22.6% (in 2002–3) to 24.9% (in 2011–12).

Long inpatient stay

A long inpatient stay for a delivery episode was defined as the upper quartile of length of stay plus 1.5 times the interquartile range (10 days or longer for a caesarean delivery, 4 days or longer for a vaginal delivery). *Figure 5* represents the trends in long inpatient stays from 2002–3 to 2011–12.

Stillbirth

Over the past 10 years, the stillbirth rate has remained relatively stable, at 0.54% (*Figure 6*). In our study population, 33,774 pregnancies resulted in stillbirth, of which only 411 occurred in women who had undergone surgery during their pregnancy. Not all records contained information about stillbirth; however, the percentage of missing data decreased from 2.8% in 2002–3 to 0.15% in 2011–12.

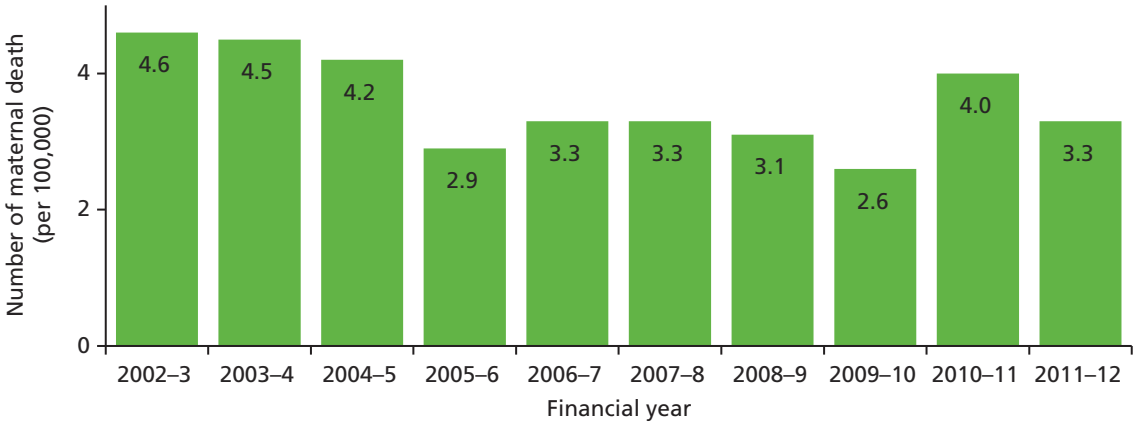

FIGURE 3 Number of maternal deaths per 100,000 pregnancies per year in England.

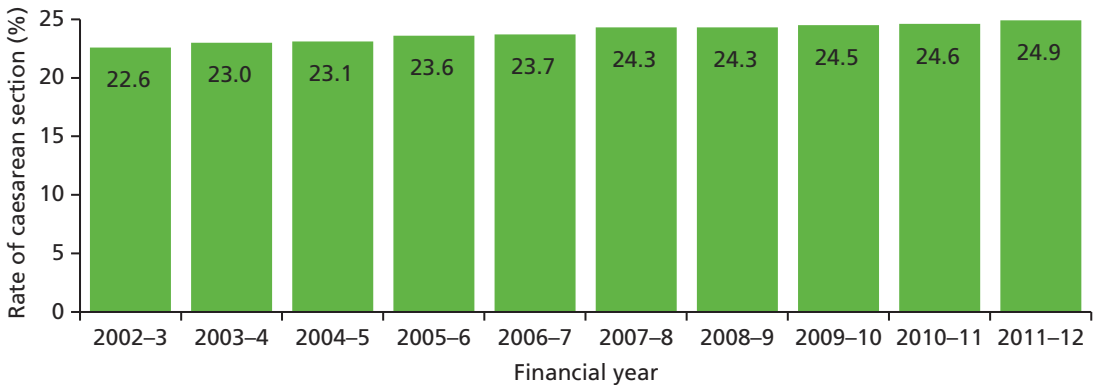

FIGURE 4 Rate of caesarean section per year in England.

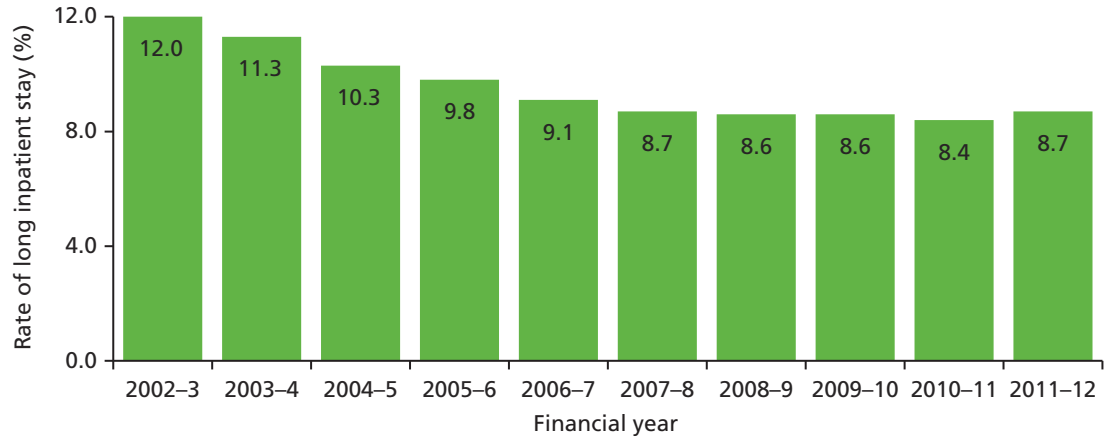

FIGURE 5 Rate of long inpatient stay per year in England.

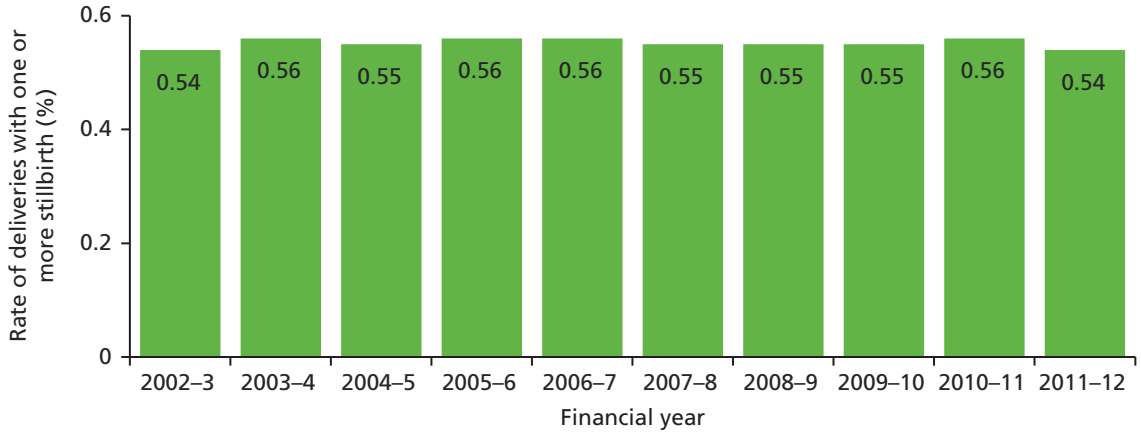

FIGURE 6 Proportion of deliveries resulting in one or more stillborn child per year in England.

Low birthweight

A total of 342,631 (5.6%) pregnancies between 2002–3 and 2011–12 in England resulted in the delivery of one or more low-birthweight newborns, of which 3846 were to women in whom surgery had been performed. There was little change in the proportion of low-birthweight deliveries over the 10-year period (*Figure 7*). A notable decrease in 2007–8 can be explained by a high percentage of missing birthweight fields for that year. The proportion of birthweight values that are missing has fallen greatly over the period: from 26.0% (in 2002–3) to 10.0% (in 2011–12).

Unadjusted analyses

Table 9 gives the crude risk for each outcome by risk factor. Almost 6% of all pregnancies resulted in spontaneous abortion associated with hospitalisation. A higher risk was estimated for women aged > 40 years (14.5%) or women who had cardiac disease (11.4%). The risk of spontaneous abortion associated with hospitalisation was higher if surgery was carried out during pregnancy (6.6%). The risk of a spontaneous abortion associated with hospitalisation in pregnancies in which surgery occurred was 13% higher than in pregnancies in which surgery did not occur (RR 1.13, 95% CI 1.09 to 1.17).

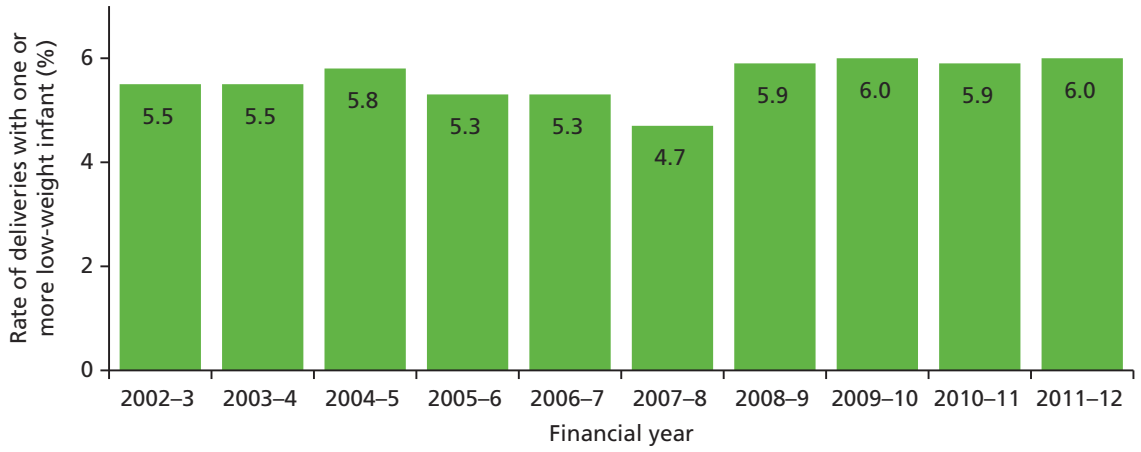

FIGURE 7 Proportion of deliveries resulting in one or more low-birthweight newborns per year in England.

TABLE 9 Crude outcome rates by risk factors

Risk factor	Spontaneous abortion associated with hospitalisation (%)	Preterm delivery (%)	Caesarean section (%)	Long inpatient stay (%)	Stillbirth (%)	Low birthweight (%)
Crude risk	5.8	7.5	23.9	9.5	0.6	5.6
Maternal age (years)						
15–19	7.2	8.2	13.4	11.5	0.6	6.8
20–24	5.2	7.5	17.1	9.6	0.5	6.1
25–29	4.7	7.3	21.7	9.5	0.5	5.4
30–34	4.9	7.1	26.7	9.3	0.5	5.1
35–39	7.1	7.8	32.0	8.9	0.6	5.6
≥ 40	14.5	9.1	38.4	9.4	0.9	6.7
Multiple pregnancy						
Yes	1.8	49.9	64.7	17.9	2.6	51.8
No	5.9	7.0	23.5	89.3	0.5	5.1
Parity						
Primiparous	7.4	7.6	25.0	12.8	0.6	5.9
Multiparous	4.5	7.5	23.1	6.9	0.5	5.4
Previous emergency admission						
Yes	6.7	9.0	69.7	10.8	0.6	6.9
No	5.7	7.3	19.0	9.3	0.6	5.5
Carstairs deprivation quintile						
1	5.1	6.3	26.3	8.9	0.4	4.2
2	5.3	6.6	25.4	9.1	0.5	4.6
3	5.6	7.0	24.5	9.3	0.5	5.0
4	5.8	7.8	23.1	9.5	0.6	5.8
5	6.3	8.8	21.7	10.1	0.7	7.3
Unknown	23.9	11.4	28.1	10.7	1.3	7.5

TABLE 9 Crude outcome rates by risk factors (*continued*)

Risk factor	Spontaneous abortion associated with hospitalisation (%)	Preterm delivery (%)	Caesarean section (%)	Long inpatient stay (%)	Stillbirth (%)	Low birthweight (%)
Charlson Comorbidities Index score						
0	5.8	7.5	23.8	9.4	0.5	6.9
1+	6.0	8.6	28.5	10.6	0.6	5.6
Charlson Comorbidities Index score (prior pregnancy)						
0	5.8	7.4	23.8	9.4	0.7	8.3
1+	7.1	11.8	30.0	11.4	0.6	5.6
Gestational diabetes						
Yes	0.6	16.6	54.4	19.7	1.0	7.9
No	5.9	7.4	23.4	9.4	0.6	5.6
Hypertension/pre-eclampsia						
Yes	0.1	13.2	41.2	19.3	1.1	11.9
No	6.0	7.3	23.3	9.1	0.5	5.4
Cardiac diseases						
Yes	11.4	11.6	36.6	13.4	0.8	9.0
No	5.8	7.5	23.9	9.5	0.6	5.6
Operations on amniotic cavity						
Yes	1.2	12.2	30.9	10.8	3.1	10.9
No	5.8	7.5	23.9	9.5	0.5	5.6
Obstetric surgery						
Yes	0.4	6.3	6.2	13.0	0.4	4.2
No	6.1	7.6	24.9	9.3	0.6	5.7
Previous caesarean section						
Yes	6.6	9.1	69.7	3.4	0.6	6.1
No	5.7	7.3	18.9	10.1	0.6	5.6
Non-obstetric surgery						
Yes	6.6	11.1	28.8	11.8	0.9	8.6
No	5.8	7.5	23.9	9.5	0.6	5.6
Crude RR (95% CI)	1.13 (1.09 to 1.17)	1.48 (1.44 to 1.52)	1.21 (1.19 to 1.23)	1.24 (1.21 to 1.28)	1.68 (1.53 to 1.86)	1.57 (1.52 to 1.62)

Maternal death was excluded from this table because of small numbers. Crude risk is 0.004 and RR is 7.28 (95% CI 4.07 to 13.01) for maternal death.

A little over 6 million deliveries took place in NHS hospitals in England between 2002–3 and 2011–12, 7.5% of which were preterm. In approximately half of pregnancies with multiple gestations (i.e. more than one baby), delivery occurred preterm. Women with gestational diabetes, hypertension/pre-eclampsia or cardiac diseases were at higher risk of a preterm delivery. Pregnancies in which surgery occurred had a 48% higher risk of a preterm delivery (RR 1.48, 95% CI 1.44 to 1.52) than in pregnancies in which surgery did not occur.

Nearly 24% of all deliveries were by caesarean section. Previous caesarean delivery was associated with a higher risk of caesarean section. Moreover, two-thirds of women (69.7%) who had an emergency admission in the year prior to their pregnancy had a caesarean delivery. Furthermore, women who had gestational diabetes during pregnancy, or hypertension/pre-eclampsia, had a higher risk of caesarean delivery. Women had a 21% higher risk of a caesarean delivery (RR 1.21, 95% CI 1.19 to 1.23) if they had undergone surgery during their pregnancy.

Nearly 10% of women had a long hospital stay following delivery, and the risk was higher for women with gestational diabetes, hypertension/pre-eclampsia or cardiac diseases (19.7%, 19.3% and 13.4%, respectively). The risk of a long inpatient stay was similar in women who underwent obstetric or non-obstetric surgery (13.0% and 11.8%, respectively). Women had a 24% higher risk of a caesarean delivery (RR 1.24, 95% CI 1.21 to 1.28) if they had undergone non-obstetric surgery during their pregnancy.

The percentage of deliveries ending in a stillbirth was 0.6%. Multiple pregnancy and surgery on the amniotic cavity were associated with a higher risk of stillbirth. The risk of stillbirth was 68% higher if the woman had undergone surgery during pregnancy than if she had not (RR 1.68, 95% CI 1.53 to 1.86).

The percentage of women who gave birth to one or more low-birthweight babies was 5.6%. Moreover, among women with multiple pregnancy the risk of low-birthweight babies was much higher (51.8%). The risk of delivering a baby with a low birthweight was 57% higher for women who underwent a procedure during pregnancy than for those who did not (RR 1.57, 95% CI 1.52 to 1.62).

Tables 10 and *11* present information about the timing of surgery. In almost half of cases (42.0%), information about when in pregnancy the procedure was carried out (i.e. gestational age) was not provided. Only 4% of surgeries and 0.2% of elective operations occurred during the same admission as the delivery or spontaneous abortion (associated with hospitalisation). Of the surgeries carried during pregnancy for which gestational age was recorded, 45% were carried out in the first trimester, 26% in the second trimester and 29% in the third trimester.

A closer examination of timing between delivery (or spontaneous abortion associated with hospitalisation) and surgery suggests that < 6% of operations occurred within 1 week of the end of the pregnancy. In the

TABLE 10 Number of surgical operations by trimester for each outcome

Outcome	First trimester	Second trimester	Third trimester	Trimester unknown	Same admission
Number of surgical operations (%)	12,544 (26.3)	7160 (15.0)	7942 (16.7)	19,982 (42.0)	1696 (3.6)
Planned surgery	8185	3273	2806	11,181	49
Spontaneous abortion associated with hospitalisation	–	–	–	3120	56
Preterm delivery	1483	873	1133	1427	396
Maternal death	1	1	1	9	6
Caesarean section	3338	1975	2628	4895	893
Long inpatient stay	1402	829	973	2034	190
Stillbirth	85	59	70	197	62
Low birthweight	1322	769	948	792	280

–, data not available.

TABLE 11 Number of operations carried out prior to delivery or spontaneous abortion associated with hospitalisation

Time period	All (%)	Abdominal (%)	Abdominal laparoscopic (%)	Abdominal open (%)	Appendectomy (%)
Deliveries					
24 hours	1872 (4.2)	462 (4.2)	53 (0.7)	409 (10.3)	51 (1.7)
48 hours	1913 (4.3)	463 (4.2)	54 (0.8)	409 (10.3)	51 (1.7)
1 week	2407 (5.4)	484 (4.4)	59 (0.8)	425 (10.7)	61 (2.1)
Total	44508	11041	7073	3968	2925
Spontaneous abortion					
24 hours	65 (2.1)	27 (1.9)	15 (1.2)	12 (7.6)	3 (2.2)
48 hours	85 (2.7)	38 (2.6)	26 (2.0)	12 (7.6)	3 (2.2)
1 week	340 (10.9)	231 (15.9)	209 (16.1)	22 (14.0)	11 (8.0)
Total	3120	1452	1295	157	137

case of pregnancies ending in spontaneous abortion associated with hospitalisation, 11% of operations occurred during the week prior to the abortion. Among women who underwent abdominal surgery and whose pregnancy ended in spontaneous abortion associated with hospitalisation, 16% of procedures occurred in the week prior to the abortion (see *Table 11*).

Table 12 shows the numbers of adverse birth outcomes in pregnant women undergoing laparoscopic and open abdominal surgeries. Approximately two-thirds of all abdominal operations were laparoscopic. Where gestational age was known, the number of abdominal operations in the first trimester that were laparoscopic was nearly five times (3102) the number of open procedures (643). This ratio was reversed in the second trimester (606 laparoscopic vs. 995 open), and by the third trimester 2.5 times as many procedures were open (698) as were laparoscopic (284).

TABLE 12 Numbers of adverse pregnancy outcomes in pregnant women undergoing laparoscopic and abdominal surgery

Outcome	Abdominal laparoscopic	Abdominal open
Total	8368	4125
Spontaneous abortion	1295	157
Preterm delivery	1421	683
Caesarean section	3243	1469
Long inpatient stay	1580	667
Maternal death	0	2
Stillbirth	75	41
Low birthweight	754	1106

Regression analysis

We used a logistic regression model to determine the relationship of surgery with adverse birth outcomes, while adjusting for other risk factors. *Tables 13–20* give the ORs and total numbers of cases (*n*) of the final model for each outcome of interest. The choices of explanatory variables were constrained by previous studies and by their significance (with $p < 0.05$) in each model, and are given as follows.

- Multiple pregnancy, parity, previous emergency admission, gestational diabetes, hypertension/pre-eclampsia, cardiac disease, operation on amniotic cavity, obstetric and non-obstetric surgery – binary coded with 'NO' as reference group.

TABLE 13 Adjusted ORs and 95% CIs for spontaneous abortion associated with hospitalisation ($n = 6{,}486{,}280$)

Risk factors	Value	OR (95% CI)	*p*-value
Maternal age (years)	15–19	1.17 (1.15 to 1.18)	< 0.0001
	20–24	0.98 (0.97 to 0.99)	
	25–29	1	
	30–34	1.14 (1.13 to 1.15)	
	35–39	1.80 (1.78 to 1.82)	
	≥ 40	4.03 (3.98 to 4.09)	
Multiple pregnancy	Yes	0.27 (0.26 to 0.29)	< 0.0001
Parity	Yes	0.53 (0.52 to 0.54)	< 0.0001
Previous emergency admission	Yes	1.22 (1.21 to 1.24)	< 0.0001
Carstairs deprivation quintile	1 (least deprived)	1	< 0.0001
	2	1.08 (1.07 to 1.09)	
	3	1.17 (1.16 to 1.19)	
	4	1.27 (1.26 to 1.29)	
	5 (most deprived)	1.46 (1.44 to 1.48)	
	6 (unknown)	5.97 (5.82 to 6.12)	
Charlson Comorbidities Index score	1+ vs. 0	1.03 (1.01 to 1.05)	0.0039
Previous Charlson Comorbidities Index score	1+ vs. 0	1.32 (1.28 to 1.35)	< 0.0001
Gestational diabetes	Yes	0.083 (0.077 to 0.091)	< 0.0001
Pre-eclampsia/hypertension	Yes	0.021 (0.018 to 0.023)	< 0.0001
Cardiac disease	Yes	1.93 (1.84 to 2.03)	< 0.0001
Operation on amniotic cavity	Yes	0.16 (0.14 to 0.18)	< 0.0001
Obstetric surgery	Yes	0.057 (0.054 to 0.06)	< 0.0001
Year (or per year since 2002–3)		1.008 (1.007 to 1.009)	< 0.0001
Non-obstetric surgery	Yes	1.14 (1.10 to 1.18)	< 0.0001
AIC			2,873,160.1
R^2			0.24
c-statistic			0.66

AIC, Akaike information criterion.

TABLE 14 Adjusted ORs and 95% CIs for spontaneous abortion associated with hospitalisation ($n = 6,486,280$) (gestational diabetes, obstetric surgery and operation on amniotic cavity excluded)

Risk factors	Value	OR (95% CI)	*p*-value
Maternal age (years)	15–19	1.19 (1.17 to 1.21)	< 0.0001
	20–24	0.99 (0.98 to 1.00)	
	25–29	1	
	30–34	1.13 (1.12 to 1.14)	
	35–39	1.77 (1.76 to 1.79)	
	≥ 40	3.91 (3.86 to 3.96)	
Multiple pregnancy	Yes	0.28 (0.26 to 0.29)	< 0.0001
Parity	Yes	0.54 (0.53 to 0.55)	< 0.0001
Previous emergency admission	Yes	1.22 (1.21 to 1.24)	< 0.0001
Carstairs deprivation quintile	1 (least deprived)	1	< 0.0001
	2	1.08 (1.07 to 1.09)	
	3	1.17 (1.16 to 1.19)	
	4	1.28 (1.26 to 1.29)	
	5 (most deprived)	1.46 (1.44 to 1.48)	
	6 (unknown)	5.71 (5.82 to 6.12)	
Charlson Comorbidities Index score	1+ vs. 0	1.02 (1.01 to 1.05)	0.0011
Previous Charlson Comorbidities Index score	1+ vs. 0	1.27 (1.24 to 1.30)	< 0.0001
Pre-eclampsia/hypertension	Yes	0.020 (0.018 to 0.022)	< 0.0001
Cardiac disease	Yes	1.93 (1.84 to 2.03)	< 0.0001
Year (or per year since 2002–3)		0.98 (0.97 to 0.99)	< 0.0001
Non-obstetric surgery	Yes	1.14 (1.10 to 1.18)	< 0.0001
AIC			2,755,361.3
R^2			0.18
c-statistic			0.64

AIC, Akaike information criterion.

- Maternal age, in six categories: 15–19 years, 20–24 years, 25–29 years (reference group), 30–34 years, 35–39 years and ≥ 40 years.
- Socioeconomic deprivation (Carstairs deprivation quintile), in six categories: 1 (least deprived, reference group), 2, 3, 4, 5 (most deprived) and 6 (unknown).
- Comorbidities (Charlson Comorbidities Index score): 0 (reference group) and 1+.
- *Tables 13–20* show that, after adjusting for risk factors, pregnancies in which surgery was carried out compared with pregnancies in which surgery was not carried out had significantly higher odds of a spontaneous abortion associated with hospitalisation (OR 1.14, 95% CI 1.10 to 1.18); preterm delivery (OR 1.48, 95% CI 1.44 to 1.53); caesarean section (OR 1.30, 95% CI 1.27 to 1.33); long inpatient stay (OR 1.25, 95% CI 1.21 to 1.28); maternal death (OR 4.72, 95% CI 2.61 to 8.52); stillbirth (OR 1.65, 95% CI 1.50 to 1.82); and low birthweight (OR 1.53, 95% CI 1.48 to 1.59).

TABLE 15 Adjusted ORs and 95% CIs for preterm delivery ($n = 6,109,957$)

Risk factors	Value	OR (95% CI)	*p*-value
Maternal age (years)	15–19	1.12 (1.11 to 1.14)	< 0.0001
	20–24	1.01 (1.00 to 1.02)	
	25–29	1	
	30–34	0.99 (0.98 to 1.00)	
	35–39	1.06 (1.05 to 1.07)	
	≥ 40	1.18 (1.16 to 1.20)	
Multiple pregnancy	Yes	13.12 (12.92 to 13.33)	< 0.0001
Parity	Yes	0.98 (0.97 to 0.99)	< 0.0001
Previous emergency admission	Yes	1.18 (1.17 to 1.19)	< 0.0001
Carstairs deprivation quintile	1 (least deprived)	1	< 0.0001
	2	1.06 (1.05 to 1.08)	
	3	1.14 (1.13 to 1.15)	
	4	1.28 (1.27 to 1.30)	
	5 (most deprived)	1.47 (1.46 to 1.49)	
	6 (unknown)	1.83 (1.76 to 1.89)	
Charlson Comorbidities Index score	1+ vs. 0	1.02 (1.01 to 1.04)	0.0118
Previous Charlson Comorbidities Index score	1+ vs. 0	1.43 (1.40 to 1.46)	< 0.0001
Gestational diabetes	Yes	2.23 (2.19 to 2.27)	< 0.0001
Pre-eclampsia/hypertension	Yes	1.78 (1.76 to 1.81)	< 0.0001
Cardiac disease	Yes	1.52 (1.45 to 1.60)	< 0.0001
Operation on amniotic cavity	Yes	1.68 (1.62 to 1.74)	< 0.0001
Obstetric surgery	Yes	0.77 (0.75 to 0.77)	< 0.0001
Year (or per year since 2002–3)		1.023 (1.021 to 1.024)	< 0.0001
Non-obstetric surgery	Yes	1.48 (1.44 to 1.53)	< 0.0001
AIC			3,129,848.1
R^2			0.20
c-statistic			0.60

AIC, Akaike information criterion.

TABLE 16 Adjusted ORs and 95% CIs for caesarean delivery ($n = 6,109,957$)

Risk factors	Value	OR (95% CI)	*p*-value
Maternal age (years)	15–19	0.528 (0.523 to 0.534)	< 0.0001
	20–24	0.74 (0.73 to 0.75)	
	25–29	1	
	30–34	1.30 (1.29 to 1.31)	
	35–39	1.66 (1.65 to 1.67)	
	≥ 40	2.27 (2.24 to 2.29)	
Multiple pregnancy	Yes	6.74 (6.63 to 6.85)	< 0.0001
Parity	Yes	0.389 (0.387 to 0.391)	< 0.0001
Previous emergency admission	Yes	1.18 (1.17 to 1.19)	< 0.0001
Carstairs deprivation quintile	1 (least deprived)	1	< 0.0001
	2	1.00 (0.99 to 1.01)	
	3	1.03 (1.02 to 1.04)	
	4	1.04 (1.03 to 1.05)	
	5 (most deprived)	1.03 (1.02 to 1.04)	
	6 (unknown)	1.38 (1.34 to 1.41)	
Charlson Comorbidities Index score	1+ vs. 0	1.24 (1.23 to 1.26)	< 0.0001
Previous Charlson Comorbidities Index score	1+ vs. 0	1.15 (1.13 to 1.17)	< 0.0001
Gestational diabetes	Yes	3.12 (3.08 to 3.17)	< 0.0001
Pre-eclampsia/hypertension	Yes	2.18 (2.16 to 2.20)	< 0.0001
Cardiac disease	Yes	1.68 (1.62 to 1.74)	< 0.0001
Previous caesarean delivery	Yes	15.07 (15.00 to 15.17)	< 0.0001
Operation on amniotic cavity	Yes	1.12 (1.09 to 1.15)	< 0.0001
Obstetric surgery	Yes	0.152 (0.150 to 0.154)	< 0.0001
Year (or per year since 2002–3)		1.026 (1.025 to 1.027)	< 0.0001
Non-obstetric surgery	Yes	1.30 (1.27 to 1.33)	< 0.0001
AIC			5,654,992.0
R^2			0.30
c-statistic			0.75

AIC, Akaike information criterion.

TABLE 17 Adjusted ORs and 95% CIs for long inpatient stay ($n = 6,109,957$)

Risk factors	Value	OR (95% CI)	*p*-value
Maternal age (years)	15–19	0.96 (0.94 to 0.97)	< 0.0001
	20–24	0.94 (0.93 to 0.95)	
	25–29	1	
	30–34	1.02 (1.01 to 1.03)	
	35–39	1.03 (1.02 to 1.04)	
	≥ 40	1.08 (1.06 to 1.10)	
Multiple pregnancy	Yes	2.13 (2.09 to 2.17)	< 0.0001
Parity	Yes	0.501 (0.498 to 0.504)	< 0.0001
Previous emergency admission	Yes	1.24 (1.23 to 1.25)	< 0.0001
Carstairs deprivation quintile	1 (least deprived)	1	< 0.0001
	2	1.03 (1.02 to 1.04)	
	3	1.05 (1.04 to 1.06)	
	4	1.10 (1.09 to 1.11)	
	5 (most deprived)	1.24 (1.23 to 1.25)	
	6 (unknown)	1.13 (1.09 to 1.17)	
Charlson Comorbidities Index score	1+ vs. 0	1.14 (1.12 to 1.16)	< 0.0001
Previous Charlson Comorbidities Index score	1+ vs. 0	1.18 (1.16 to 1.21)	< 0.0001
Gestational diabetes	Yes	1.62 (1.59 to 1.65)	< 0.0001
Pre-eclampsia/hypertension	Yes	2.13 (2.11 to 2.15)	< 0.0001
Cardiac disease	Yes	1.46 (1.39 to 1.53)	< 0.0001
Operation on amniotic cavity	Yes	1.20 (1.16 to 1.24)	< 0.0001
Obstetric surgery	Yes	1.81 (1.79 to 1.83)	< 0.0001
Year (or per year since 2002–3)		0.938 (0.937 to 0.939)	< 0.0001
Non-obstetric surgery	Yes	1.25 (1.21 to 1.28)	< 0.0001
AIC			371,889.6
R^2			0.18
c-statistic			0.63

AIC, Akaike information criterion.

TABLE 18 Adjusted ORs and 95% CIs for maternal death ($n = 6,486,280$)

Risk factors	Value	OR (95% CI)	*p*-value
Maternal age (years)	15–19	0.27 (0.10 to 0.76)	< 0.0001
	20–24	0.76 (0.48 to 1.18)	
	25–29	1	
	30–34	1.32 (0.93 to 1.89)	
	35–39	1.53 (1.04 to 2.25)	
	≥ 40	2.23 (1.34 to 3.69)	
Multiple pregnancy	Yes	4.19 (2.33 to 7.55)	< 0.0001
Carstairs deprivation quintile	1 (least deprived)	1	< 0.0001
	2	1.81 (1.07 to 3.06)	
	3	1.78 (1.07 to 3.03)	
	4	2.23 (1.35 to 3.68)	
	5 (most deprived)	2.70 (1.67 to 4.36)	
	6 (unknown)	4.20 (1.44 to 12.25)	
Charlson Comorbidities Index score	1+ vs. 0	5.05 (3.62 to 7.04)	< 0.0001
Pre-eclampsia/hypertension	Yes	3.54 (2.42 to 5.18)	< 0.0001
Cardiac disease	Yes	79.23 (57.36 to 109.44)	< 0.0001
Year (or per year since 2002–3)		0.90 (0.86 to 0.95)	< 0.0001
Non-obstetric surgery	Yes	4.72 (2.61 to 8.52)	< 0.0001
AIC			4721.4
R^2			0.001
c-statistic			0.58

AIC, Akaike information criterion.

TABLE 19 Adjusted ORs and 95% CIs for stillbirth ($n = 6,109,957$)

Risk factors	Value	OR (95% CI)	*p*-value
Maternal age (years)	15–19	1.05 (1.00 to 1.10)	< 0.0001
	20–24	0.97 (0.94 to 1.00)	
	25–29	1	
	30–34	1.03 (1.00 to 1.07)	
	35–39	1.23 (1.19 to 1.27)	
	≥ 40	1.53 (1.46 to 1.61)	
Multiple pregnancy	Yes	4.63 (4.41 to 4.87)	< 0.0001
Parity	Yes	0.82 (0.81 to 0.84)	< 0.0001
Carstairs deprivation quintile	1 (least deprived)	1	< 0.0001
	2	1.10 (1.06 to 1.15)	
	3	1.21 (1.16 to 1.26)	
	4	1.44 (1.39 to 1.50)	
	5 (most deprived)	1.79 (1.73 to 1.86)	
	6 (unknown)	2.96 (2.68 to 3.27)	
Charlson Comorbidities Index score	1+ vs. 0	0.79 (0.74 to 0.84)	< 0.0001
Previous Charlson Comorbidities Index score	1+ vs. 0	1.33 (1.24 to 1.44)	< 0.0001
Gestational diabetes	Yes	1.51 (1.42 to 1.62)	< 0.0001
Pre-eclampsia/hypertension	Yes	1.85 (1.77 to 1.93)	< 0.0001
Cardiac disease	Yes	1.38 (1.15 to 1.65)	0.0005
Operation on amniotic cavity	Yes	5.63 (5.28 to 6.01)	< 0.0001
Obstetric surgery	Yes	0.66 (0.63 to 0.70)	< 0.0001
Non-obstetric surgery	Yes	1.65 (1.50 to 1.82)	< 0.0001
AIC			410,495.3
R^2			0.13
c-statistic			0.60

AIC, Akaike information criterion.

TABLE 20 Adjusted ORs and 95% CIs for low birthweight ($n = 6,109,957$)

Risk factors	Value	OR (95% CI)	*p*-value
Maternal age (years)	15–19	1.18 (1.16 to 1.20)	< 0.0001
	20–24	1.07 (1.06 to 1.08)	
	25–29	1	
	30–34	0.97 (0.96 to 0.98)	
	35–39	1.05 (1.04 to 1.06)	
	≥ 40	1.20 (1.18 to 1.23)	
Multiple pregnancy	Yes	20.98 (20.66 to 21.32)	< 0.0001
Parity	Yes	0.91 (0.90 to 0.92)	< 0.0001
Previous emergency admission	Yes	1.22 (1.21 to 1.23)	< 0.0001
Carstairs deprivation quintile	1 (least deprived)	1	< 0.0001
	2	1.11 (1.09 to 1.13)	
	3	1.23 (1.22 to 1.25)	
	4	1.47 (1.45 to 1.49)	
	5 (most deprived)	1.89 (1.87 to 1.92)	
	6 (unknown)	1.72 (1.65 to 1.80)	
Charlson Comorbidities Index score	1+ vs. 0	1.13 (1.11 to 1.15)	< 0.0001
Previous Charlson Comorbidities Index score	1+ vs. 0	1.32 (1.28 to 1.34)	< 0.0001
Gestational diabetes	Yes	1.23 (1.20 to 1.26)	< 0.0001
Pre-eclampsia/hypertension	Yes	2.26 (2.23 to 2.30)	< 0.0001
Cardiac disease	Yes	1.60 (1.51 to 1.70)	< 0.0001
Operation on amniotic cavity	Yes	2.15 (2.07 to 2.23)	< 0.0001
Obstetric surgery	Yes	0.72 (0.71 to 0.74)	< 0.0001
Year (or per year since 2002–3)		1.007 (1.005 to 1.008)	< 0.0001
Non-obstetric surgery	Yes	1.53 (1.48 to 1.59)	< 0.0001
AIC			2,483,423.9
R^2			0.25
c-statistic			0.64

AIC, Akaike information criterion.

Final analysis

This section presents the final results: adjusted RR and attributable risk and NNH for pregnancies in which surgery occurred compared with pregnancies in which surgery did not occur (*Table 21*). The risk of an adverse birth outcome for pregnancies with specific types of operations is also presented.

After adjusting for potential confounders, the RR associated with hospitalisation was 1.13 (95% CI 1.09 to 1.17) for spontaneous abortion, 1.43 (95% CI 1.39 to 1.47) for preterm delivery, 4.72 (95% CI 2.61 to 8.52) for maternal death, 1.21 (95% CI 1.19 to 1.23) for caesarean section and 1.22 (95% CI 1.19 to 1.25) for long inpatient stay in pregnancies in which surgery was carried out compared with pregnancies in which it was not. The RR for maternal death was high but was based on very small numbers with very wide CIs. The RR for stillbirth and low birthweight was 1.64 (95% CI 1.50 to 1.81) and 1.49 (95% CI 1.44 to 1.54), respectively. Using Austin's method,[30] we found little or no difference in our estimated RRs except for caesarean section (which is a relatively common outcome). NNH represents the number of operations associated with one additional adverse birth outcome. We estimated that, for every 143 pregnancies in which a surgical operation was carried out, compared with pregnancies in which a surgical operation was not carried out, there was one additional spontaneous abortion (associated with hospitalisation); for every 31 operations during pregnancy there was one additional preterm delivery; for every 25 operations there was one additional caesarean section; for every 50 operations there was one additional long inpatient stay; for every 287 operations there was one additional stillbirth; for every 39 operations there was one additional newborn with low birthweight; and for every 7692 operations there was one additional maternal death. Again, this estimate came with very wide 95% CIs (3571 to 33,333 operations); see *Table 21*. We repeated our analysis excluding records with missing values for preterm delivery, stillbirth

TABLE 21 Adjusted RR, attributable risk and NNH for adverse birth outcomes

Outcome	Baseline, %	RR (95% CI)	RR (95% CI)[a]	Attributable risk, % (95% CI)[a]	NNH (95% CI)[a]
Non-obstetric surgery vs. no non-obstetric surgery					
Spontaneous abortion associated with hospitalisation	5.8	1.13 (1.09 to 1.17)	1.12 (1.08 to 1.16)	0.7 (0.4 to 0.9)	143 (107 to 230)
Preterm delivery (missing values considered as full term)	7.5	1.43 (1.39 to 1.47)	1.42 (1.39 to 1.46)	3.2 (2.9 to 3.4)	31 (29 to 34)
Preterm delivery (missing values excluded)	11.3	1.48 (1.44 to 1.51)	1.45 (1.42 to 1.50)	5.0 (4.7 to 5.6)	20 (18 to 21)
Maternal death	0.004	4.72 (2.61 to 8.52)	4.67 (1.79 to 8.93)	0.013 (0.003 to 0.028)	7692 (3571 to 33,333)
Caesarean section	23.9	1.21 (1.19 to 1.23)	1.17 (1.15 to 1.19)	4.0 (3.6 to 4.5)	25 (22 to 28)
Long inpatient stays	9.5	1.22 (1.19 to 1.25)	1.21 (1.18 to 1.26)	2.0 (1.7 to 2.4)	50 (41 to 60)
Stillbirth (missing values consider as live)	0.6	1.64 (1.50 to 1.81)	1.64 (1.47 to 1.80)	0.4 (0.3 to 0.4)	287 (227 to 386)
Stillbirth (missing values excluded)	0.6	1.65 (1.50 to 1.82)	1.65 (1.48 to 1.81)	0.4 (0.3 to 0.5)	275 (220 to 369)
Low birthweight (missing values consider as birthweight > 2500 g)	5.6	1.49 (1.44 to 1.54)	1.46 (1.43 to 1.53)	2.6 (2.5 to 2.9)	39 (37 to 42)
Low birthweight (missing values excluded)	7.1	1.54 (1.49 to 1.59)	1.50 (1.47 to 1.55)	3.5 (3.3 to 3.8)	28 (27 to 30)

a Austin method.[30]

and low birthweight, and found little difference in RR, but attributable risk and NNH changed more because of the differences in baseline incidence.

We identified 47,628 pregnancies in which surgery was carried out (0.7% of all pregnancies); in 25,445 cases (53.4%) the procedure was elective and in 22,183 (46.6%) it was non-elective. In general, the risks of adverse outcomes were higher for non-elective surgery than for planned surgery, although non-elective surgery was not associated with a significantly higher risk of spontaneous abortions associated with hospitalisation. Twenty-six per cent (12,493) of all surgical operations were abdominal. The RR of adverse birth outcomes (excluding maternal death) was higher for pregnancies in which surgery was carried out than for pregnancies in which it was not. The RR of spontaneous abortion associated with hospitalisation was 1.90 (95% CI 1.81 to 1.99), with a NNH of 20 (*Table 22*). Laparoscopic abdominal surgery was associated with an even higher RR for spontaneous abortion associated with hospitalisation (RR 2.47, 95% CI 2.34 to 2.60) and seemed to contribute most of the risk associated with abdominal surgery, as open abdominal surgery was not associated with a raised risk (RR 0.65, 95% CI 0.56 to 0.76). Appendectomy was not associated with an increased risk of spontaneous abortion associated with hospitalisation, but was associated with a raised risk of preterm delivery (RR 1.49, 95% CI 1.34 to 1.64),

TABLE 22 Adjusted RRs, attributable risks and NNHs for common procedure groups

Outcome	RR (95% CI)	RR[a]	Attributable risk[a] (%)	NNH[a]
Elective surgery vs. no surgery				
Spontaneous abortion associated with hospitalisation	1.12 (1.08 to 1.18)	1.12	0.7	141
Preterm delivery	1.31 (1.25 to 1.35)	1.29	2.2	46
Caesarean section	1.15 (1.12 to 1.17)	1.12	2.8	36
Long inpatient stay	1.12 (1.08 to 1.16)	1.11	1.1	92
Stillbirth	1.35 (1.17 to 1.55)	1.34	0.2	531
Low birthweight	1.38 (1.32 to 1.43)	1.41	2.3	43
Non-elective surgery vs. no surgery				
Spontaneous abortion associated with hospitalisation	1.00 (0.95 to 1.06)	N/A	N/A	N/A
Preterm delivery	1.57 (1.51 to 1.62)	1.54	4.0	25
Caesarean section	1.28 (1.25 to 1.32)	1.23	5.4	18
Long inpatient stay	1.33 (1.28 to 1.37)	1.32	3.0	33
Stillbirth	1.87 (1.63 to 2.13)	1.86	0.5	210
Low birthweight	1.60 (1.53 to 1.67)	1.56	3.1	32
Abdominal surgery vs. no surgery				
Spontaneous abortion associated with hospitalisation	1.90 (1.81 to 1.99)	1.87	5.0	20
Preterm delivery	1.62 (1.54 to 1.70)	1.51	3.6	28
Caesarean section	1.27 (1.23 to 1.30)	1.21	5.0	20
Long inpatient stays	1.30 (1.24 to 1.37)	1.29	2.8	36
Stillbirth	1.76 (1.47 to 2.11)	1.76	0.4	240
Low birthweight	1.61 (1.51 to 1.71)	1.57	3.2	32

continued

TABLE 22 Adjusted RRs, attributable risks and NNHs for common procedure groups (*continued*)

Outcome	RR (95% CI)	RR[a]	Attributable risk[a] (%)	NNH[a]
Abdominal laparoscopic surgery vs. no surgery				
Spontaneous abortion associated with hospitalisation	2.47 (2.34 to 2.60)	2.41	8.2	12
Preterm delivery	1.52 (1.43 to 1.62)	1.50	3.7	27
Caesarean section	1.21 (1.16 to 1.26)	1.17	4.0	25
Long inpatient stay	1.29 (1.21 to 1.37)	1.28	2.7	37
Stillbirth	1.72 (1.37 to 2.16)	1.72	0.3	253
Low birthweight	1.54 (1.43 to 1.66)	1.51	2.8	35
Abdominal open surgery vs. no surgery				
Spontaneous abortion associated with hospitalisation	0.65 (0.56 to 0.76)	0.66	–1.9	N/A
Preterm delivery	1.80 (1.67 to 1.96)	1.77	5.8	17
Caesarean section	1.37 (1.30 to 1.44)	1.29	7.0	14
Long inpatient stay	1.32 (1.22 to 1.43)	1.31	2.9	34
Stillbirth	1.84 (1.36 to 2.50)	1.84	0.4	217
Low birthweight	1.72 (1.57 to 1.89)	1.67	3.8	26
Appendectomy vs. no surgery				
Spontaneous abortion associated with hospitalisation	0.78 (0.66 to 0.92)	0.79	–1.2	N/A
Preterm delivery	1.49 (1.34 to 1.64)	1.46	3.5	28
Caesarean section	1.13 (1.06 to 1.21)	1.11	2.6	39
Long inpatient stays	1.32 (1.20 to 1.46)	1.32	3.0	33
Stillbirth	1.05 (0.65 to 1.68)	N/A	N/A	N/A
Low birthweight	1.43 (1.26 to 1.62)	1.40	2.2	44
Abdominal surgery vs. other surgery				
Spontaneous abortion associated with hospitalisation	2.52 (2.36 to 2.69)	2.48	7.0	14
Preterm delivery	1.19 (1.12 to 1.26)	1.18	1.9	52
Caesarean section	1.08 (1.04 to 1.12)	1.06	1.7	58
Long inpatient stays	1.10 (1.04 to 1.16)	1.10	1.2	86
Stillbirth	1.24 (1.00 to 1.54)	1.24	0.2	477
Low birthweight	1.14 (1.05 to 1.22)	1.13	1.1	90
Musculoskeletal surgery vs. no surgery				
Spontaneous abortion associated with hospitalisation	0.94 (0.84 to 1.07)	N/A	N/A	N/A
Preterm delivery	1.18 (1.08 to 1.30)	1.18	1.3	75
Caesarean section	1.11 (1.05 to 1.17)	1.09	2.1	47
Long inpatient stays	1.19 (1.09 to 1.29)	1.18	1.7	57
Low birthweight	1.34 (1.21 to 1.49)	1.32	1.8	56

TABLE 22 Adjusted RRs, attributable risks and NNHs for common procedure groups (*continued*)

Outcome	RR (95% CI)	RR[a]	Attributable risk[a] (%)	NNH[a]
Cholecystectomy vs. no surgery				
Spontaneous abortion associated with hospitalisation	1.36 (1.12 to 1.64)	1.31	1.8	56
Preterm delivery	1.12 (0.93 to 1.34)	N/A	N/A	N/A
Caesarean section	1.07 (0.95 to 1.19)	N/A	N/A	N/A
Long inpatient stays	1.18 (1.00 to 1.39)	1.09	0.8	122
Stillbirth	1.17 (0.58 to 2.32)	N/A	N/A	N/A
Low birthweight	1.04 (0.82 to 1.32)	N/A	N/A	N/A
ENT surgery vs. no surgery				
Spontaneous abortion associated with hospitalisation	1.07 (0.93 to 1.23)	N/A	N/A	N/A
Preterm delivery	1.22 (1.09 to 1.36)	1.22	1.6	63
Caesarean section	1.01 (0.94 to 1.07)	N/A	N/A	N/A
Long inpatient stay	1.15 (1.05 to 1.27)	1.15	1.4	71
Stillbirth	1.52 (1.04 to 2.21)	1.51	0.3	356
Low birthweight	1.39 (1.22 to 1.57)	1.36	2.0	49
Breast surgery vs. no surgery				
Spontaneous abortion associated with hospitalisation	0.74 (0.60 to 0.91)	0.74	–1.5	N/A
Preterm delivery	1.94 (1.74 to 2.17)	1.90	6.7	15
Caesarean section	1.17 (1.08 to 1.27)	1.14	3.4	30
Long inpatient stay	1.13 (0.98 to 1.27)	N/A	N/A	N/A
Stillbirth	1.19 (0.67 to 2.08)	N/A	N/A	N/A
Low birthweight	1.94 (1.70 to 2.21)	1.87	4.9	20
Dental surgery vs. no surgery				
Spontaneous abortion associated with hospitalisation	1.01 (0.91 to 1.12)	N/A	N/A	N/A
Preterm delivery	1.13 (1.04 to 1.24)	1.12	1.1	91
Caesarean section	0.97 (0.92 to 1.02)	N/A	N/A	N/A
Long inpatient stay	1.12 (1.04 to 1.21)	1.12	1.3	77
Stillbirth	1.62 (1.23 to 2.16)	1.62	0.3	292
Low birthweight	1.32 (1.20 to 1.46)	1.30	1.7	59
Nail and skin surgery vs. no surgery				
Spontaneous abortion associated with hospitalisation	0.58 (0.50 to 0.67)	0.59	–2.4	N/A
Preterm delivery	1.24 (1.14 to 1.36)	1.24	1.8	56
Caesarean section	1.09 (1.03 to 1.15)	1.08	1.9	53

continued

TABLE 22 Adjusted RRs, attributable risks and NNHs for common procedure groups (*continued*)

Outcome	RR (95% CI)	RR[a]	Attributable risk[a] (%)	NNH[a]
Long inpatient stay	1.16 (1.07 to 1.26)	1.18	1.7	58
Stillbirth	1.33 (0.96 to 1.84)	N/A	N/A	N/A
Low birthweight	1.29 (1.17 to 1.43)	1.27	1.5	65
Perianal surgery vs. no surgery				
Spontaneous abortion associated with hospitalisation	0.56 (0.46 to 0.67)	0.56	–2.5	N/A
Preterm delivery	0.86 (0.75 to 0.99)	0.89	–0.8	N/A
Caesarean section	1.17 (1.10 to 1.25)	1.18	3.9	25
Long inpatient stay	1.08 (0.97 to 1.20)	N/A	N/A	N/A
Stillbirth	0.59 (0.32 to 1.11)	N/A	N/A	N/A
Low birthweight	0.93 (0.80 to 1.08)	N/A	N/A	N/A
Cancer-related surgery vs. no surgery				
Spontaneous abortion associated with hospitalisation	0.53 (0.36 to 0.78)	0.54	–2.7	N/A
Preterm delivery	5.31 (4.82 to 5.82)	5.09	30.5	3
Caesarean section	1.66 (1.50 to 1.83)	1.53	12.6	10
Long inpatient stay	1.48 (1.23 to 1.79)	1.47	4.5	22
Stillbirth	3.12 (1.73 to 5.60)	3.11	1.2	86
Low birthweight	4.44 (3.86 to 5.08)	4.16	17.7	6
Acute appendicitis-related surgery vs. no surgery				
Spontaneous abortion associated with hospitalisation	0.62 (0.35 to 1.08)	N/A	N/A	N/A
Preterm delivery	2.03 (1.57 to 2.62)	1.99	7.4	14
Caesarean section	1.13 (0.92 to 1.36)	N/A	N/A	N/A
Long inpatient stay	1.49 (1.13 to 1.93)	1.47	4.5	22
Stillbirth	1.08 (0.27 to 4.27)	N/A	N/A	N/A
Low birthweight	1.71 (1.21 to 2.39)	1.66	3.7	27

N/A, not available.
a Austin method.[30]

caesarean section (RR 1.13, 95% CI 1.06 to 1.21), long inpatient stay (RR 1.32, 95% CI 1.20 to 1.46) and low birthweight (RR 1.43, 95% CI 1.26 to 1.62).

Approximately 2.5% (1306) of all surgeries during pregnancy were cholecystectomy. A comparison with no surgery during pregnancy showed a difference only in spontaneous abortions associated with hospitalisation (RR 1.36, 95% CI 1.12 to 1.64).

Approximately 1.5% (710) of all operations were in patients with a diagnosis of cancer. The RR of adverse birth outcomes was higher for pregnancies in which cancer-related surgery was carried out than for pregnancies in which surgery was not carried out, with the exception of spontaneous abortion associated with hospitalisation (RR 0.53, 95% CI 0.36 to 0.78). The RR was 5.31 (95% CI 4.82 to 5.82) for preterm

delivery, 1.66 (95% CI 1.50 to 1.83) for caesarean section, 1.48 (95% CI 1.23 to 1.79) for long inpatient stay, 3.12 (95% CI 1.73 to 5.60) for stillbirth and 4.44 (95% CI 3.86 to 5.08) for low birthweight.

Our analysis comparing outcomes following laparoscopic and open appendectomy (RR 2.36, 95% CI 1.71 to 3.26) and all abdominal surgery (RR 3.82, 95% CI 3.29 to 4.41) further illustrates the apparent increased associated risk of spontaneous abortion with laparoscopic procedures (*Table 23*).

Tables 24–26 present adjusted RRs and their 95% CIs, attributable risks and NNHs for pregnancies in which surgery was or was not carried out, by trimester. The RR of preterm delivery, caesarean section, stillbirth and low birthweight was between 20% and 30% higher for operations carried out in the third trimester than for those carried out in the first trimester. There was little difference by trimester of operation in the RR of a long inpatient stay.

TABLE 23 Adjusted RRs for laparoscopic vs. open surgery

Outcome	RR (95% CI)	RR[a]
Laparoscopic appendectomy vs. other appendectomy		
Spontaneous abortion	2.36 (1.71 to 3.26)	2.38
Laparoscopic surgery vs. open abdominal surgery (any kind)		
Spontaneous abortion	3.82 (3.29 to 4.41)	3.73
Preterm delivery	0.85 (0.77 to 0.94)	0.85
Caesarean section	0.88 (0.83 to 0.94)	0.90

a Austin method.[30]

TABLE 24 Adjusted RR and 95% CI for pregnancies with surgery compared with pregnancies without surgery by trimester

Outcome	First trimester	Second trimester	Third trimester
Preterm delivery	1.51 (1.44 to 1.58)	1.57 (1.48 to 1.68)	1.82 (1.72 to 1.93)
Caesarean section	1.13 (1.10 to 1.17)	1.17 (1.12 to 1.21)	1.39 (1.34 to 1.44)
Long inpatient stay	1.22 (1.16 to 1.28)	1.26 (1.19 to 1.35)	1.29 (1.21 to 1.37)
Stillbirth	1.21 (0.98 to 1.50)	1.47 (1.13 to 1.90)	1.56 (1.23 to 1.97)
Low birthweight	1.83 (1.73 to 1.92)	1.89 (1.77 to 2.03)	2.21 (2.06 to 2.38)

TABLE 25 Adjusted attributable risk (%) for pregnancies with surgery compared with pregnancies without surgery by trimester

Outcome	First trimester	Second trimester	Third trimester
Preterm delivery	3.6	4.1	5.9
Caesarean section	2.5	3.1	7.4
Long inpatient stay	2.1	2.4	2.7
Stillbirth	–	0.2	0.3
Low birthweight	4.3	4.7	5.6

–, data not available.

TABLE 26 Number needed to harm for pregnancies with surgery compared with pregnancies without surgery by trimester

Outcome	First trimester	Second trimester	Third trimester
Preterm delivery	28	24	17
Caesarean section	40	32	13
Long inpatient stay	49	42	37
Stillbirth	–	394	330
Low birthweight	23	21	18

–, data not available.

Table 27 presents the results of two-level logistic regression for adverse birth outcomes. The intraclass correlation coefficients were close to 0 (from 0.0939 for spontaneous abortion associated with hospitalisation to 0.008 for low birthweight), meaning that only 1.0–10.0% of the variance is attributable to trust level. Random parameters of level 2 for stillbirth and maternal death were even smaller, and these are not presented here.

TABLE 27 Parameter estimates, standard error and random estimates of multilevel logistic regression

	Multilevel models (SE)				
Fixed coefficients or random parameters	Spontaneous abortion associated with hospitalisation	Preterm delivery	Caesarean section	Long inpatient stay	Low birthweight
Fixed coefficients					
Maternal age	0.0141*** (0.0001)	0.0008*** (0.0001)	0.0412*** (0.0001)	0.0019*** (0.0001)	–0.0002** (0.0001)
Multiple pregnancy	–0.0414*** (0.0009)	0.4234*** (0.001)	0.3784*** (0.0015)	0.0831*** (0.0011)	0.4647*** (0.0009)
Parity	–0.0391*** (0.0002)	–0.0054*** (0.0002)	–0.1413*** (0.0003)	–0.0597*** (0.0002)	–0.0083*** (0.0002)
Previous emergency admission	0.0099 *** (0.0003)	0.0157*** (0.0003)	0.0273*** (0.0005)	0.0181*** (0.0004)	0.0114*** (0.0003)
Carstairs deprivation quintile	0.0068*** (0.0001)	0.0054*** (0.00008)	0.0003** (0.0001)	0.0029*** (0.0001)	0.0069*** (0.0001)
Charlson Comorbidities Index score	0.0007* (0.0005)	0.0059*** (0.0006)	0.0359*** (0.0009)	0.0113*** (0.0007)	0.0073*** (0.0005)
Charlson Comorbidities Index score (prior to pregnancy)	0.0161*** (0.0007)	0.0316*** (0.0008)	0.0229*** (0.0013)	0.0159*** (0.001)	0.0184*** (0.0007)
Gestational diabetes	–0.0571*** (0.0007)	0.0811*** (0.0008)	0.2071 (0.0012)	0.0494*** (0.0009)	0.0133*** (0.0007)
Hypertension/ pre-eclampsia	–0.0638*** (0.0005)	0.0488*** (0.0005)	0.1437*** (0.0008)	0.089*** (0.0006)	0.0576*** (0.0005)
Cardiac disease	0.0524*** (0.0018)	0.039*** (0.0020)	0.0887*** (0.0031)	0.0335*** (0.0024)	0.0293*** (0.0018)
Other operations on amniotic cavity	–0.0528*** (0.0013)	0.0502*** (0.0014)	0.0237*** (0.0022)	0.0139*** (0.0016)	0.0496*** (0.0013)

TABLE 27 Parameter estimates, standard error and random estimates of multilevel logistic regression (*continued*)

Fixed coefficients or random parameters	Multilevel models (SE)				
	Spontaneous abortion associated with hospitalisation	Preterm delivery	Caesarean section	Long inpatient stay	Low birthweight
Obstetric surgery	–0.06*** (0.0004)	–0.0185*** (0.0005)	–0.1964*** (0.0007)	0.0518*** (0.0006)	–0.0155*** (0.0004)
Year	0.0005*** (0.00003)	0.0007*** (0.00004)	0.0039*** (0.0001)	–0.0052*** (0.0001)	0.0002*** (0.00003)
Previous caesarean section			0.5406*** (0.0006)		
Non-obstetric surgery	0.0071*** (0.0011)	0.0366*** (0.0049)	0.0426*** (0.0018)	0.0202*** (0.0014)	0.0266*** (0.0011)
Random parameters					
Level 1: pregnancies	0.0531 (0.00003)	0.06178 (0.00004)	0.1475 (0.0001)	0.0836 (0.00004)	0.0498 (0.00003)
Level 2: trust	0.0055 (0.0007)	0.004299 (0.00045)	0.0028 (0.0003)	0.0008 (0.0001)	0.0004 (0.00004)
Intraclass correlation	0.0939	0.0651	0.0186	0.0095	0.008

*$p < 0.1$; *$p < 0.05$; ***$p < 0.0001$.
SE, standard error.

Chapter 4 Discussion

We aimed to estimate the risk of adverse birth outcomes in pregnancies in which surgery was carried out and to compare this with the risk in pregnancies in which no surgery was recorded, and, also, to estimate the risk associated with common procedure groups.

In this chapter we summarise the main results and their relation to previous studies. We then note the strengths and limitations of our analysis and suggest future work.

Key findings

- We identified 6,486,280 pregnancies, among which non-obstetric surgery was carried out in 47,628 (0.7%), in the period April 2002 to March 2012.
- The most common surgical procedure group was abdominal (26.2%), followed by dental (11.3%), nail and skin (10.0%), musculoskeletal (9.6%), ENT (6.4%) and perianal (6.2%). There were 3062 cases of appendectomy and 1306 cases of cholecystectomy.
- Non-obstetric surgery during pregnancy was associated with a higher risk of adverse birth outcomes than if no surgery was carried out. We estimated that for every 143 pregnancies in which a surgical procedure was performed, there was one additional spontaneous abortion (with a hospital admission); for every 31 procedures there was one additional preterm delivery; for every 7692 procedures there was one additional maternal death in hospital; for every 25 procedures there was one additional caesarean section; for every 50 procedures there was one additional long inpatient stay; for every 287 procedures there was one additional stillbirth; and for every 39 procedures there was one additional low-birthweight baby.
- Dental, perianal, breast, cancer, abdominal, ENT and musculoskeletal procedures were associated with a higher risk of adverse birth outcomes than no surgery.
- For almost half of operations (42.0%), no information about when in pregnancy the procedure was carried out was recorded.
- For pregnancies in which gestational age was recorded, the RR for preterm delivery, caesarean section, stillbirth and low birthweight was between 20% and 30% higher for those operations carried out in the third trimester than for those performed in the first trimester. There was little difference by trimester of operation in the risk of a long inpatient stay.

Findings in relation to other studies

Spontaneous abortion associated with hospitalisation and preterm delivery

We found a high RR (1.13) for spontaneous abortion associated with hospitalisation for surgery during pregnancy. Duncan *et al.*[2] found an even higher RR (1.58) of abortion associated with a general anaesthetic in their 1986 Canadian study of 2565 pregnant women. Our study is much larger and more recent, perhaps reflecting improvements in surgery, but (like Duncan *et al.*'s[2] study) is unable to dissociate the risk of surgery from the risk of anaesthesia or the underlying condition for which the procedure was carried out. Other studies have focused on abdominal surgery. We found that, compared with no surgery, abdominal surgery was associated with an even higher risk of spontaneous abortion (associated with a hospital admission) (RR 1.90, 95% CI 1.81 to 1.99) and of preterm delivery (RR 1.62, 95% CI 1.54 to 1.70). Our study's definition of spontaneous abortion is limited by the information that is held in administrative databases which includes spontaneous abortion only if this is recorded during a hospital admission. A large number of women whose pregnancies end in spontaneous abortions are never hospitalised. Gerstenfeld *et al.*[35] performed a retrospective review of all non-obstetric abdominal procedures in a women's hospital at the University of Southern California School of Medicine during a 7-year period from 1991 to 1998. They found no significant difference in preterm delivery rates between

women who underwent abdominal surgery and those who did not (OR 1.13, 95% CI 0.56 to 2.25; $p = 0.84$), and only two cases of spontaneous abortion following surgery. The post-surgical follow-up period in this study was short (a maximum of 4 weeks) and only 67% of subjects were followed up. The study was small and included only 106 women who underwent surgery. We found a significant difference between laparoscopic and open abdominal surgery for risk of spontaneous abortion (RR 3.82, 95% CI 3.29 to 4.41). Gerstenfeld *et al.*[35] found no significant difference, but, again, their study was limited by small numbers. There may be reluctance by surgeons to perform laparoscopic surgery beyond 26–28 weeks' gestation because of previous evidence which suggests that 'A gestational age of 26 to 28 weeks seems to be the limit for successful completion of laparoscopic surgery'[36] and, although this evidence has since been refuted,[37] the perception and practice may persist. Our analysis of open versus laparoscopic abdominal procedures by trimester (where gestational age at delivery was recorded) confirms that this remains the case, as the number of laparoscopic operations performed during the first trimester was nearly five times the number of open operations, whereas, in the third trimester, the number of open operations was 2.5 times the number of laparoscopic procedures. Unfortunately, in the case of spontaneous abortion, gestational age was frequently not recorded, so we were unable to examine the relationship between timing of procedures and outcome. However, there is no reason to doubt that the pattern would be similar. Within our definition of spontaneous abortion (associated with hospitalisation), we look only for operations 3 months prior to the event (which, by definition, occurs before week 24 of pregnancy) and women are likely to be admitted to hospital only during the second trimester. We are, therefore, picking up selected cases that are more likely to have a higher proportion of laparoscopies. We are unable to identify women who suffer spontaneous abortions who are not admitted. In addition, as is true for other studies and all our outcomes, we have no means of disentangling the effect of the surgery from the effect of the underlying condition itself.

For abdominal surgery, we found a reduced risk of preterm delivery (RR 0.85, 95% CI 0.77 to 0.94); Gerstenfeld *et al.*[35] found no significant difference in preterm delivery rate, but we suspect that, again, the small sample size and period from which their cohort was drawn may explain this difference. Two other studies compared pregnancy outcomes following laparoscopic and open appendicectomy[38,39] and found no difference in the rates of preterm delivery. Sadot *et al.*[38] performed a hospital-based retrospective review of 65 pregnant women who underwent appendectomy for presumed appendicitis from 1999 to 2008. They calculated the overall preterm delivery rate and the rate of preterm delivery within 1 month of operation. In neither case was there any statistically significant difference between the laparoscopic and open groups. The authors did not analyse rates of spontaneous abortion.

Maternal death in hospital

In our study we identified 235 maternal deaths, which corresponds to a maternal death rate of 4 per 100,000 pregnancies. Our estimate is much lower than national estimates (10 per 100,000 according to the report *Saving Lives, Improving Mothers' Care*[40]) because we identified only maternal deaths occurring in the same admission as the delivery or spontaneous abortion. We were not able to capture maternal deaths of women who did not deliver or deaths occurring following discharge. We estimated the RR of non-obstetric surgery during pregnancy to be 4.72 (95% CI 2.61 to 8.52). The baseline risk of maternal death is fortunately very low and translates into a NNH of 7692, which is the number of procedures associated with one additional maternal death. This number was based on only 12 deaths among pregnant women undergoing surgery in our cohort, and so the CIs are wide. Again, we have no means of disentangling the effect of the surgery from the effect of the underlying condition itself. Only one previous study has reported the maternal death of a woman undergoing non-obstetric surgery during pregnancy.[41] This study compared laparoscopic cholecystectomy with open cholecystectomy in pregnant women during the period 1992–6. During the 5-year period of the study, 46 pregnant women who underwent cholecystectomy were identified. The maternal death occurred in a 27-year-old woman who underwent elective laparoscopic cholecystectomy at 20 weeks' gestation. On postoperative day 15, she presented to the emergency department and died following a laparotomy.

Stillbirth and low birthweight

Our study revealed that non-obstetric surgery during pregnancy is associated with an increased risk of stillbirth and low birthweight. We found that pregnant women who underwent non-obstetric surgery had an attributable risk of 0.4% for stillbirth and 2.6% for low birthweight compared with women who did not have surgery. However, there were no significant differences in the risk of low birthweight and stillbirth between those women undergoing laparoscopic and those undergoing open abdominal surgery. A Swedish study[3] analysed outcomes of 5405 patients who had had an operation during pregnancy, out of a total of 720,000 Swedish births between 1973 and 1981, and concluded that the incidence of stillbirth was not increased in women having an operation. However, the incidence of very low birthweight and low-birthweight infants was increased. Mazze and Källén[4] investigated appendectomy and laparoscopic surgery, and did not observe a statistically significant increase in stillbirth. However, the authors concluded that the mean birthweight in the operated group was, on average, 78 g less than the expected birthweight. Furthermore, compared with the general population, women undergoing operations during 3–23 weeks' gestation demonstrated a shift in distribution towards an excess of infants with a birthweight < 3000 g. Another Swedish study[5] found no difference in the birthweight of singleton infants born to women who underwent laparoscopy between 4 and 20 weeks of gestation. More recent studies on appendicectomy[39,42] compared the effects of laparoscopic appendectomy with those of open appendectomy during pregnancy. There were no significant differences in the birthweight between the two groups. Moreover, Jenkins *et al.*[43] reported that general anaesthesia, longer surgery duration and intra-abdominal procedures are associated with lower birthweight.

Caesarean section and long inpatient stays

We found a significant effect in the adjusted RR for caesarean section of 1.21 (95% CI 1.19 to 1.23); however, this reduced to 1.17 (1.15 to 1.19) when the more appropriate Austin method[30] was used for common outcomes. We also found a higher risk of long inpatient stays (RR 1.22, 95% CI 1.19 to 1.25). We could not find any previous studies reporting caesarean delivery and long inpatient stays in women who had surgery during their pregnancy.

Study strengths and limitations

This is the first study to report the risk of adverse birth outcomes following non-obstetric surgery during pregnancy across NHS hospitals in England. One important strength of this research is the use of the large and rich administrative data set. We extracted data for nearly 6.5 million pregnancies between 2002–3 and 2011–12, 10 times the total in the published literature to date. Furthermore, our data are much more recent and better represent current outcomes.

Another strength is that we estimated adjusted attributable risk and the NNH. The use of Austin's analytical method[30] was a particular strength here, as this allowed us to compare outcomes between two populations whose only difference was the exposure (non-obstetric surgery during pregnancy). These measures are more useful than an OR to women who want to be informed of the risk associated with a non-obstetric procedure, above and beyond the background risk.

Appropriateness of controls

The absolute key limitation of our study is that we have no means of disentangling the effect of the surgery from the effect of the underlying condition itself. Thus, we are able to compare only women who have surgery during pregnancy with women who do not. The ideal study population would be all women who require surgery during pregnancy to enable us to compare outcomes in women who actually had surgery with those who did not. Ideally, participants would be randomised into each group. However, withholding surgery in pregnant women who require treatment would be ethically challenging. From our study we have no way of determining the risk that the underlying condition would result in an adverse birth outcome. However, we still believe that the NNH, in particular, is a useful reference point for any discussion of risk with prospective patients. A further limitation, although certainly not unique to our study, is that we treat

surgery during pregnancy as a homogeneous intervention and are unable to disentangle the independent effects of anaesthesia, pre-/peri- and post-operative care, as well as the surgery itself, all of which may influence the outcome of pregnancy. Therefore, we are not able to estimate the independent contribution to the risks of an adverse outcome during pregnancy of each component of this complex intervention.

Our study arose as a direct result of questions posed in the high-risk obstetric anaesthetic clinic by patients who wanted to know the statistical risks of an adverse outcome to their pregnancy. For some combinations of procedures and outcomes we have found no excess risk, and that may help to reassure mothers and remove barriers to potentially unnecessary delays to treatment.

Data quality

The second limitation relates to data quality and completeness. Submission of HES records is mandatory and, in general, coverage is very high. Most debates around HES data quality concern the primary and secondary diagnostic and procedure field.[9,44–46] Nonetheless, a recent systematic review of discharge coding accuracy in routine UK data found that primary diagnosis accuracy has improved from 73.8% to 96.0% in the 10 years since the introduction of Payment by Results.[47] Not all delivery records contain supplementary information, although the percentage of records with a complete maternity tail has improved over time.[48] We found that the proportion of missing values for the key data items of parity, gestational age, birthweight and stillbirth decreased from 24%, 48%, 26% and 2.8%, respectively, in 2002–3 to 16%, 12%, 10% and 0.15%, respectively, in 2011–12. We also carried out sensitivity analyses, comparing analyses based on assumptions about missing variables with analyses in which we excluded records with missing variables and found no major differences in RR and its 95% CIs. Administrative data have more general limitations in the recording of other potential confounders. It is well known that body mass index, smoking status and environmental factors, such as air pollution, are important risk factors for adverse outcomes in pregnancy.[49–52] However, these variables are not recorded in the HES data set.

There are previously documented missing or invalid values in the HES database for patient identifiers, dates of admission, discharge or procedure, method of admission or other key fields.[24,53] Improvements in the quality of the HES data are visible but, importantly, there are unlikely to be biases in recording for women undergoing non-obstetric surgery during their pregnancy, which means that data incompleteness and inaccuracy are unlikely to wholly account for findings.

Spontaneous abortion

A specific limitation around spontaneous abortion is that many spontaneous abortions will not be associated with a hospital admission and these will not be included in our analysis. It is certain, therefore, that our category of spontaneous abortion associated with hospitalisation is only a small proportion of all spontaneous abortions. A spontaneous abortion may be more likely to be reported if it occurs during the same hospital admission as a procedure, and this could account for the increased risk associated with surgery during pregnancy. However, only 1.8% (56/3176) of spontaneous abortions associated with hospitalisation actually occurred in the same admission as the procedure. Gestational age at delivery was essential to determine the trimester in which the procedure was carried out, but was not present on our records for spontaneous abortions associated with hospitalisation. We have already discussed the probable explanation for the increased risk for laparoscopic versus open abdominal surgery for spontaneous abortion. In addition, some of the risk factors that appear to be protective for this outcome, such as gestational diabetes and obstetric surgery, may simply reflect the fact that most spontaneous abortions occur before there is an opportunity for these potential risk factors to occur or be recorded. We carried out a sensitivity analysis in our logistic regression to exclude gestational diabetes, obstetric surgery and operations on the amniotic cavity from the model for spontaneous abortion associated with hospitalisation and found that the adjusted ORs did not change.

Because of the serious potential for ascertainment bias, temporal issues around the recording of risk factors and other unaccounted for confounding related to gestational age, we urge caution when interpreting the risk of spontaneous abortion associated with non-obstetric surgery during pregnancy.

Statistical analyses

Despite the evident advantage of the method introduced by Austin,[30] particularly for common outcomes (e.g. caesarean section), the size of the database meant that the calculation of the CIs for one outcome took several days of computing time to run. We therefore had to be selective and were forced to make a priori judgements about which statistical analysis to present. Consequently, not all CIs were estimated. However, the RRs estimated using adjusted ORs obtained directly from the logistic regression, in most cases, were the same as or only slightly different from the RRs obtained using the Austin method.[30]

We carried out two-level logistic regression to investigate the effects of hospitals on the adverse birth outcomes. The interclass correlation coefficients were close to 0, meaning that adjusting for the clustering of pregnancies within each trust would be unlikely to affect our results.

Recommendations for further research

Our study has demonstrated that there is a statistically significant increase in the risk of adverse birth outcomes following non-obstetric surgery during pregnancy in England. However, we have identified a number of limitations that would benefit from further research to usefully inform a variety of medical practitioners and the general public. We offer a small set of recommendations for further research:

1. Further research is required to evaluate the association of non-obstetric surgery and spontaneous abortion.
2. Further research is needed to evaluate the impact of non-obstetric surgery on the baby (e.g. neonatal intensive care unit admission, prolonged length of neonatal stay, neonatal death) and could be assessed by linking the maternal and baby records within the HES database. Use of large clinical databases, such as EuroKing Maternity systems (www.euroking.com/), linked to the HES database could be usefully exploited for this purpose.

Dissemination activity

- To date, we have disseminated findings from this project as an oral presentation at the Applied Epidemiology Scientific Meeting in Warwick University, March 2015.
- We presented some results to an international science competition FameLab (Lithuania) in April 2015 (www.famelab.lt/apie/).
- We shall give an oral presentation at the Dame Hilda Lloyd Congress Medal plenary session at the Royal College of Obstetricians and Gynaecologists (RCOG) World Congress in June 2016.
- We have written up our findings in an academic peer-reviewed journal.[54]
- We have already engaged with the British Society of Endocrine and Thyroid Surgeons and the Association of Breast Surgery, both of which have guidelines. Both organisations have agreed to consider hosting guidance that we produce on their websites.
- The data will also be used by institutions such as RCOG and the American College of Obstetricians and Gynecologists (ACOG). We are in contact with the RCOG, and it is supportive of our study and would assist in the dissemination of findings to both health-care professionals and the public.
- We shall contact the ACOG directly following publication to ensure that they are aware of our study. We shall also discuss the possibility of publishing a British guideline taking into account all available evidence, with the RCOG, the Anaesthetists Association of Great Britain and Northern Ireland and the Royal College of Midwives (RCM).
- We shall contact the RCM directly to ensure that it is aware of our study, and to make sure that it is included in any joint guidelines produced.
- We shall ensure that a lay summary of our peer-reviewed findings is available online, initially on the Imperial College London website.

Chapter 5 Conclusions

This is the first study to report the risk of adverse birth outcomes following non-obstetric surgery during pregnancy across NHS hospitals in England. We have no means of disentangling the effect of the surgery from the effect of the underlying condition itself. We found that non-obstetric surgery during pregnancy was associated with a significantly higher risk of all the outcomes we looked at, although, because of the potential for ascertainment bias, we have some reservations over the findings associated with spontaneous abortion. The overall attributable risk of an adverse birth outcome in women who had surgery during their pregnancy compared with women who did not was generally low. We estimated that, for every 287 pregnancies in which a surgical procedure was carried out, there was one additional stillbirth; for every 31 procedures there was one additional preterm delivery; for every 25 procedures there was one additional caesarean section; for every 50 procedures there was one additional long inpatient stay; for every 39 procedures there was one additional low-birthweight baby; and for every 7692 procedures there was one additional maternal death in hospital.

Our observational study can never attribute a causal relationship between surgery and adverse birth outcomes. However, we still believe that our findings and, in particular, the NNHs, improve on previous research, by utilising a more recent and larger data set based on UK practice, and are useful reference points for any discussion of risk with prospective patients.

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Contributions of authors

Paul Aylin was instrumental in securing the data.

Paul Aylin, **Alex Bottle** and **Violeta Balinskaite** carried out the analysis and wrote the first draft.

All authors contributed to the original research proposal, helped to refine the classification of outcomes used and the procedure groups for further analysis, and commented on subsequent drafts of the report.

Ethics

We have permission from the Confidentiality Advisory Group under Section 251 of the NHS Act 2006 (formerly Section 60 approval from the Patient Information Advisory Group) to hold confidential data and analyse them for research purposes [PIAG 2–05(d)/2007]. We have approval to use them for research and measuring quality of delivery of health care from the South East Ethics Research Committee (10/H1102/25).

Publications

Balinskaite V, Bottle A, Sodhi V, Rivers A, Bennett PR, Brett SJ, *et al.* The risk of adverse pregnancy outcomes following nonobstetric surgery during pregnancy: estimates from a retrospective cohort study of 6.5 million pregnancies [published online ahead of print September 14 2016]. *Ann Surg* 2016.

Data sharing statement

Under the terms of our contract with the Health and Social Care Information Centre, we are allowed to hold our data only for as long as is specified in our data release agreement (usually 3 years unless renewed) and we are unable to share these data with other organisations. At the end of our contract we are obliged to delete the data. All source data, however, are available on application to the Health and Social Care Information Centre.

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Appendix 1 Office of Population, Censuses and Surveys's *Classification of Surgical Operations and Procedures*, codes and descriptions of procedures of common surgical groups

TABLE 28 The OPCS-4 code and description of musculoskeletal procedure group

Description	Code
Other specified excision of peripheral nerve	A598
Radiofrequency controlled thermal destruction of peripheral nerve	A604
Injection of destructive substance into peripheral nerve	A605
Selective denervation of peripheral nerve	A606
Other specified destruction of peripheral nerve	A608
Unspecified destruction of peripheral nerve	A609
Excision of lesion of peripheral nerve	A611
Cryotherapy to lesion of peripheral nerve	A612
Secondary microsurgical graft to peripheral nerve	A622
Primary microsurgical repair of peripheral nerve NEC	A624
Microsurgical repair of multiple peripheral nerves NEC	A627
Unspecified microsurgical repair of peripheral nerve	A629
Primary repair of peripheral nerve NEC	A642
Unspecified other repair of peripheral nerve	A649
Carpal tunnel release	A651
Unspecified release of entrapment of peripheral nerve at wrist	A659
Cubital tunnel release	A671
Other specified release of entrapment of peripheral nerve at other site	A678
Primary neurolysis of peripheral nerve and transposition of peripheral nerve	A681
Neurolysis of peripheral nerve and transposition of peripheral nerve NEC	A683
Primary neurolysis of peripheral nerve NEC	A684
Unspecified other release of peripheral nerve	A689
Revision of carpal tunnel release	A692
Implantation of neurostimulator into peripheral nerve	A701
Biopsy of lesion of peripheral nerve	A731
Decompression of peripheral nerve NEC	A733
Exploration of peripheral nerve	A734
Transfer and reimplantation of peripheral nerve NEC	A736

continued

TABLE 28 The OPCS-4 code and description of musculoskeletal procedure group (*continued*)

Description	Code
Other specified other operations on peripheral nerve	A738
Endoscopic excision of infrapatellar fat pad	O192
Unspecified prosthetic replacement of head of radius using cement	O249
Other specified other prosthetic replacement of head of radius	O268
Extra-articular ligament reconstruction for stabilisation of joint	O271
Repair of capsule and anterior labrum for stabilisation of glenohumeral joint	O273
Subacromial decompression	O291
Excision of lesion of chest wall	T013
Correction of pectus deformity of chest wall	T021
Removal of prosthesis from chest wall	T024
Removal of wire from chest wall	T054
Other specified other operations on chest wall	T058
Palmar fasciectomy	T521
Plantar fasciectomy	T523
Other specified excision of other fascia	T528
Excision of lesion of fascia	T531
Destruction of lesion of fascia	T532
Division of palmar fascia	T541
Unspecified division of fascia	T549
Release fasciotomy of forearm	T552
Release fasciotomy of anterior compartment of lower leg	T554
Release fasciotomy of posterior compartment of lower leg	T555
Release fasciotomy of leg NEC	T556
Other specified release of fascia	T558
Unspecified release of fascia	T559
Dermofasciectomy	T561
Biopsy of lesion of fascia	T572
Repair of fascia	T573
Excision of ganglion of wrist	T591
Excision of ganglion of hand NEC	T592
Excision of ganglion of knee	T593
Excision of ganglion of foot	T594
Other specified excision of ganglion	T598
Unspecified excision of ganglion	T599
Re-excision of ganglion of wrist	T601
Re-excision of ganglion of hand NEC	T602
Re-excision of ganglion of foot	T604

TABLE 28 The OPCS-4 code and description of musculoskeletal procedure group (*continued*)

Description	Code
Total excision of bursa	T621
Excision of bursa NEC	T622
Aspiration of bursa	T624
Injection into bursa	T625
Other specified operations on bursa	T628
Multiple transfer of tendon to tendon	T641
Transfer of tendon to tendon NEC	T642
Insertion of tendon into bone NEC	T644
Tenodesis	T645
Other specified transposition of tendon	T648
Excision of lesion of tendon	T652
Other specified excision of tendon	T658
Primary repair of tendon using tendon transfer procedure	T671
Primary repair of tendon using lengthening procedure	T672
Primary repair of tendon using permanent prosthesis	T673
Primary repair of tendon using temporary prosthesis	T674
Primary repair of tendon using graft	T675
Primary simple repair of tendon	T676
Other specified primary repair of tendon	T678
Unspecified primary repair of tendon	T679
Secondary repair of tendon using tendon transfer procedure	T681
Secondary repair of tendon using temporary prosthesis	T684
Secondary repair of tendon using graft	T685
Primary tenolysis	T691
Other specified freeing of tendon	T698
Tenotomy NEC	T702
Adjustment to muscle origin of tendon	T703
Lengthening of tendon	T705
Tenosynovectomy	T711
Other specified excision of sheath of tendon	T718
Reconstruction of sheath of tendon	T721
Biopsy of lesion of sheath of tendon	T722
Release of constriction of sheath of tendon	T723
Exploration of sheath of tendon	T724
Other specified other operations on sheath of tendon	T728
Exploration of tendon NEC	T743

continued

TABLE 28 The OPCS-4 code and description of musculoskeletal procedure group (*continued*)

Description	Code
Injection of therapeutic substance into tendon NEC	T744
Other specified other operations on tendon	T748
Microvascular free tissue transfer of flap of muscle	T761
Unspecified transplantation of muscle	T769
Excision of whole muscle group	T771
Wide excision of muscle	T772
Partial excision of muscle NEC	T773
Debridement of muscle NEC	T774
Other specified excision of muscle	T778
Plastic repair of rotator cuff of shoulder NEC	T791
Other specified repair of muscle	T798
Unspecified repair of muscle	T799
Other specified release of contracture of muscle	T808
Biopsy of neuromuscular junction	T812
Biopsy of lesion of muscle NEC	T813
Other specified biopsy of muscle	T818
Unspecified biopsy of muscle	T819
Exploration of muscle	T834
Catheter manometry of muscle compartment	T835
Other specified other operations on muscle	T838
Excision of lesion of soft tissue NEC	T962
Other specified other operations on soft tissue	T968
Primary anterior decompression of cervical spinal cord and fusion of joint of cervical spine	V221
Other specified primary decompression operations on cervical spine	V228
Primary decompression of thoracic spinal cord NEC	V242
Other specified decompression operations on thoracic spine	V248
Primary posterior decompression of lumbar spine and intertransverse fusion of joint of lumbar spine	V253
Primary posterior laminectomy decompression of lumbar spine	V254
Primary posterior decompression of lumbar spine NEC	V255
Primary lateral foraminotomy of lumbar spine	V256
Other specified primary decompression operations on lumbar spine	V258
Unspecified primary decompression operations on lumbar spine	V259
Other specified revisional decompression operations on lumbar spine	V268
Primary insertion of lumbar interspinous process spacer	V281
Primary anterior excision of cervical intervertebral disc and interbody fusion of joint of cervical spine	V294
Primary anterior excision of cervical intervertebral disc NEC	V295

TABLE 28 The OPCS-4 code and description of musculoskeletal procedure group (*continued*)

Description	Code
Primary microdiscectomy of cervical intervertebral disc	V296
Other specified primary excision of cervical intervertebral disc	V298
Revisional excision of thoracic intervertebral disc, unspecified	V329
Primary laminectomy excision of lumbar intervertebral disc	V331
Primary fenestration excision of lumbar intervertebral disc	V332
Primary anterior excision of lumbar intervertebral disc NEC	V334
Primary microdiscectomy of lumbar intervertebral disc	V337
Other specified primary excision of lumbar intervertebral disc	V338
Unspecified primary excision of lumbar intervertebral disc	V339
Revisional laminectomy excision of lumbar intervertebral disc	V341
Revisional microdiscectomy of lumbar intervertebral disc	V347
Primary fusion of joint of thoracic spine	V381
Other specified primary fusion of other joint of spine	V388
Revisional transforaminal interbody fusion of joint of lumbar spine	V397
Posterior attachment of correctional instrument to spine	V411
Anterior attachment of correctional instrument to spine	V412
Removal of correctional instrument from spine	V413
Other specified instrumental correction of deformity of spine	V418
Excision of lesion of cervical vertebra	V431
Excision of lesion of thoracic vertebra	V432
Biopsy of cervical vertebra	V471
Biopsy of lumbar vertebra	V473
Radiofrequency controlled thermal denervation of spinal facet joint of cervical vertebra	V481
Denervation of spinal facet joint of thoracic vertebra NEC	V484
Radiofrequency controlled thermal denervation of spinal facet joint of lumbar vertebra	V485
Denervation of spinal facet joint of lumbar vertebra NEC	V486
Unspecified denervation of spinal facet joint of vertebra	V489
Manipulation of spine using traction	V501
Other specified manipulation of spine	V508
Unspecified manipulation of spine	V509
Destruction of intervertebral disc NEC	V522
Discography of intervertebral disc	V523
Biopsy of lesion of intervertebral disc NEC	V524
Other specified other operations on intervertebral disc	V528
Other specified other operations on spine	V548

continued

TABLE 28 The OPCS-4 code and description of musculoskeletal procedure group (*continued*)

Description	Code
One level of spine	V551
Two levels of spine	V552
Primary hemilaminectomy decompression of lumbar spine	V672
Complex reconstruction of soft tissue of hand NEC	W024
Osteotomy of multiple metatarsals	W032
Total correction of claw toe	W033
Localised fusion of joints of mid-foot and forefoot	W035
Other specified complex reconstruction of forefoot	W038
Implantation massive endoprosthetic replacement of bone	W052
Attention to massive endoprosthesis of bone	W054
Total excision of cervical rib	W061
Total excision of rib NEC	W062
Total excision of bone of foot NEC	W065
Other specified total excision of bone	W068
Unspecified total excision of bone	W069
Excision of periarticular ectopic bone	W072
Unspecified excision of ectopic bone	W079
Excision of natural protuberance of bone	W081
Excision of overgrowth of bone	W082
Excision of excrescence of bone	W083
Excision of fragment of bone	W084
Partial excision of bone NEC	W085
Excision of accessory ossicle	W087
Other specified other excision of bone	W088
Unspecified other excision of bone	W089
Excision of lesion of bone NEC	W091
Curettage of lesion of bone and graft HFQ	W092
Curettage of lesion of bone NEC	W093
Destruction of lesion of bone NEC	W094
Curettage of tumour of bone NEC	W096
Excision of tumour of bone	W097
Angulation periarticular osteotomy and internal fixation NEC	W122
Biosseus angulation periarticular osteotomy and external fixation HFQ	W123
Other specified angulation periarticular division of bone	W128
Displacement osteotomy	W132
Relocation and derotation osteotomy	W134
Other specified other periarticular division of bone	W138
Unspecified other periarticular division of bone	W139

TABLE 28 The OPCS-4 code and description of musculoskeletal procedure group (*continued*)

Description	Code
Angulation diaphyseal osteotomy and internal fixation HFQ	W141
Angulation diaphyseal osteotomy NEC	W143
Rotation diaphyseal osteotomy and internal fixation HFQ	W144
Osteotomy of neck of first metatarsal bone	W151
Osteotomy of base of first metatarsal bone	W152
Osteotomy of first metatarsal bone NEC	W153
Osteotomy of head of metatarsal bone	W154
Cuneiform osteotomy of proximal phalanx with resection of head of first metatarsal	W156
Osteotomy of bone of foot and fixation HFQ	W157
Other specified division of bone of foot	W158
Unspecified division of bone of foot	W159
Multiple osteotomy and internal fixation HFQ	W161
Osteotomy and internal fixation NEC	W164
Osteotomy and external fixation NEC	W165
Other specified other division of bone	W168
Unspecified other division of bone	W169
Shortening of bone	W174
Decompression of fourage of bone	W184
Unspecified drainage of bone	W189
Secondary open reduction of intra-articular fracture of bone	W233
Secondary open reduction of fracture of bone and external fixation HFQ	W235
Remanipulation of fracture of bone and skeletal traction NEC	W263
Remanipulation of fracture of bone NEC	W264
Application of internal fixation to bone NEC	W281
Adjustment to internal fixation of bone NEC	W282
Removal of internal fixation from bone NEC	W283
Other specified other internal fixation of bone	W288
Application of skeletal traction to bone NEC	W291
Removal of skeletal traction from bone	W293
Application of external fixation to bone NEC	W301
Adjustment to external fixation of bone NEC	W302
Removal of external fixation from bone NEC	W303
Cancellous chip autograft of bone	W314
Other specified other autograft of bone	W318
Allograft of bone NEC	W322

continued

TABLE 28 The OPCS-4 code and description of musculoskeletal procedure group (*continued*)

Description	Code
Open biopsy of lesion of bone	W331
Debridement of bone NEC	W336
Other specified other open operations on bone	W338
Therapeutic drilling of bone NEC	W354
Primary total prosthetic replacement of hip joint using cement	W371
Primary total prosthetic replacement of hip joint not using cement	W381
Primary total prosthetic replacement of hip joint NEC	W391
Attention to total prosthetic replacement of hip joint NEC	W394
Closed reduction of dislocated total prosthetic replacement of hip joint	W396
Primary total prosthetic replacement of knee joint using cement	W401
Primary total prosthetic replacement of joint using cement NEC	W431
Primary total prosthetic replacement of joint not using cement NEC	W441
Primary total prosthetic replacement of joint NEC	W451
Other specified other total prosthetic replacement of other joint	W458
Conversion to prosthetic replacement of head of femur not using cement	W472
Primary prosthetic replacement of articulation of bone not using cement NEC	W531
Attention to prosthetic replacement of articulation of bone NEC	W544
Primary interposition arthroplasty of joint NEC	W562
Primary excision arthroplasty of joint NEC	W572
Primary resurfacing arthroplasty of joint	W581
Unspecified other reconstruction of joint	W589
Fusion of first metatarsophalangeal joint and excision of lesser metatarsophalangeal joint	W592
Fusion of first metatarsophalangeal joint NEC	W593
Fusion of interphalangeal joint of great toe	W594
Fusion of interphalangeal joint of toe NEC	W595
Revision of fusion of joint of toe	W596
Primary arthrodesis and internal fixation of joint NEC	W621
Primary arthrodesis and external fixation of joint NEC	W622
Other specified other primary fusion of other joint	W628
Unspecified other primary fusion of other joint	W629
Revision of arthrodesis and internal fixation NEC	W631
Other specified primary open reduction of traumatic dislocation of joint	W658
Unspecified primary open reduction of traumatic dislocation of joint	W659
Primary closed reduction of traumatic dislocation of joint and skeletal traction NEC	W662
Other specified primary closed reduction of traumatic dislocation of joint	W668
Unspecified primary closed reduction of traumatic dislocation of joint	W669
Secondary open reduction of traumatic dislocation of joint NEC	W674
Remanipulation of traumatic dislocation of joint	W676

TABLE 28 The OPCS-4 code and description of musculoskeletal procedure group (*continued*)

Description	Code
Other specified secondary reduction of traumatic dislocation of joint	W678
Total synovectomy	W691
Partial synovectomy	W693
Open biopsy of synovial membrane of joint	W694
Other specified open operations on synovial membrane of joint	W698
Unspecified open operations on synovial membrane of joint	W699
Open excision of semilunar cartilage NEC	W702
Open excision of intra-articular osteophyte	W712
Forage of joint	W713
Other specified other open operations on intra-articular structure	W718
Unspecified prosthetic reinforcement of ligament	W739
Reconstruction of intra-articular ligament NEC	W742
Reconstruction of extra-articular ligament NEC	W743
Other specified other reconstruction of ligament	W748
Unspecified other reconstruction of ligament	W749
Open repair of multiple ligaments NEC	W751
Open repair of intra-articular ligament NEC	W752
Open repair of extra-articular ligament NEC	W753
Other specified other open repair of ligament	W758
Unspecified other open repair of ligament	W759
Excision of ligament	W761
Other specified other operations on ligament	W768
Repair of capsule of joint for stabilisation of joint NEC	W771
Transposition of muscle for stabilisation of joint	W772
Blocking operations on joint using prosthesis for stabilisation of joint	W773
Periarticular osteotomy for stabilisation of joint	W775
Annular ligament reconstruction for stabilisation of joint	W776
Transposition of ligament for stabilisation of joint	W777
Other specified stabilising operations on joint	W778
Unspecified stabilising operations on joint	W779
Release of contracture of knee joint	W783
Limited release of contracture of capsule of joint	W784
Other specified release of contracture of joint	W788
Soft tissue correction of hallux valgus	W791
Excision of bunion NEC	W792
Syndactylisation of lesser toes	W793

continued

TABLE 28 The OPCS-4 code and description of musculoskeletal procedure group (*continued*)

Description	Code
Unspecified soft tissue operations on joint of toe	W799
Open debridement and irrigation of joint	W801
Open debridement of joint NEC	W802
Open irrigation of joint NEC	W803
Unspecified debridement and irrigation of joint	W809
Excision of lesion of joint NEC	W811
Open removal of loose body from joint	W812
Drainage of joint	W813
Incision of joint NEC	W814
Exploration of joint NEC	W815
Other specified other open operations on joint	W818
Endoscopic total excision of semilunar cartilage	W821
Endoscopic resection of semilunar cartilage NEC	W822
Endoscopic repair of semilunar cartilage	W823
Other specified therapeutic endoscopic operations on semilunar cartilage	W828
Unspecified therapeutic endoscopic operations on semilunar cartilage	W829
Endoscopic drilling of lesion of articular cartilage	W831
Endoscopic shaving of articular cartilage	W833
Endoscopic articular abrasion chondroplasty	W834
Endoscopic articular thermal chondroplasty	W835
Endoscopic excision of articular cartilage NEC	W836
Other specified therapeutic endoscopic operations on other articular cartilage	W838
Endoscopic repair of intra-articular ligament	W841
Endoscopic division of synovial plica	W843
Endoscopic decompression of joint	W844
Endoscopic drilling of epiphysis for repair of articular cartilage	W845
Endoscopic excision of synovial plica	W846
Other specified therapeutic endoscopic operations on other joint structure	W848
Unspecified therapeutic endoscopic operations on other joint structure	W849
Endoscopic removal of loose body from knee joint	W851
Endoscopic irrigation of knee joint	W852
Other specified therapeutic endoscopic operations on cavity of knee joint	W858
Unspecified therapeutic endoscopic operations on cavity of knee joint	W859
Endoscopic removal of loose body from joint NEC	W861
Other specified therapeutic endoscopic operations on cavity of other joint	W868
Unspecified therapeutic endoscopic operations on cavity of other joint	W869
Diagnostic endoscopic examination of knee joint and biopsy of lesion of knee joint	W871
Other specified diagnostic endoscopic examination of knee joint	W878

TABLE 28 The OPCS-4 code and description of musculoskeletal procedure group (*continued*)

Description	Code
Unspecified diagnostic endoscopic examination of knee joint	W879
Diagnostic endoscopic examination of joint and biopsy of lesion of joint NEC	W881
Other specified diagnostic endoscopic examination of other joint	W888
Unspecified diagnostic endoscopic examination of other joint	W889
Endoscopic chondroplasty NEC	W891
Unspecified other manipulation of joint	W919
Replantation of thumb	X014
Replantation of finger NEC	X015
Replantation of toe	X023
Amputation of phalanx of finger	X083
Amputation of finger NEC	X084
Other specified amputation of hand	X088
Amputation of leg below knee	X095
Amputation through metatarsal bones	X104
Amputation of phalanx of toe	X112
Other specified amputation of toe	X118
Unspecified amputation of toe	X119
Reamputation at higher level	X121
Revision of coverage of amputation stump	X124
Drainage of amputation stump	X125
Other specified operations on amputation stump	X128
Other specified operations for sexual transformation	X158
Other specified correction of congenital deformity of hand	X218
Primary osteotomy of pelvis for correction of congenital deformity of hip	X222
Other specified primary correction of congenital deformity of foot	X248
Unspecified primary correction of congenital deformity of foot	X249
Osteotomy of body of os calcis	X251
Wedge tarsectomy for correction of congenital deformity of foot	X252
Other specified other correction of congenital deformity of foot	X258
Release of syndactyly of toes	X272
Correction of curly fifth toe	X274
Other specified correction of minor congenital deformity of foot	X278
Unspecified correction of minor congenital deformity of foot	X279
Donation of bone marrow	X461

HFQ, however further qualified; NEC, not elsewhere classifiable.

TABLE 29 The OPCS-4 code and description of breast procedure group

Description	Code
Total mastectomy and excision of both pectoral muscles and part of chest wall	B271
Total mastectomy and excision of pectoralis minor muscle	B273
Total mastectomy NEC	B274
Subcutaneous mastectomy	B275
Skin sparing mastectomy	B276
Other specified total excision of breast	B278
Unspecified total excision of breast	B279
Quadrantectomy of breast	B281
Partial excision of breast NEC	B282
Excision of lesion of breast NEC	B283
Re-excision of breast margins	B284
Wire-guided partial excision of breast	B285
Excision of accessory breast tissue	B286
Wire-guided excision of lesion of breast	B287
Other specified other excision of breast	B288
Unspecified other excision of breast	B289
Revision of reconstruction of breast	B295
Other specified reconstruction of breast	B298
Unspecified reconstruction of breast	B299
Insertion of prosthesis for breast	B301
Revision of prosthesis for breast	B302
Removal of prosthesis for breast	B303
Renewal of prosthesis for breast	B304
Other specified prosthesis for breast	B308
Reduction mammoplasty	B311
Augmentation mammoplasty	B312
Mastopexy	B313
Revision of mammoplasty	B314
Other specified other plastic operations on breast	B318
Percutaneous biopsy of lesion of breast	B321
Biopsy of lesion of breast NEC	B322
Wire-guided biopsy of lesion of breast	B323
Other specified biopsy of breast	B328
Unspecified biopsy of breast	B329
Drainage of lesion of breast	B331
Capsulotomy of breast	B332
Exploration of breast	B333
Other specified incision of breast	B338

TABLE 29 The OPCS-4 code and description of breast procedure group (*continued*)

Description	Code
Subareolar excision of mammary duct	B341
Excision of mammary duct NEC	B342
Excision of lesion of mammary duct	B343
Microdochotomy	B344
Other specified operations on duct of breast	B348
Unspecified operations on duct of breast	B349
Excision of nipple	B352
Extirpation of lesion of nipple	B353
Plastic operations on nipple	B354
Biopsy of lesion of nipple	B355
Eversion of nipple	B356
Other specified operations on nipple	B358
Operations on nipple, unspecified	B359
Tattooing of nipple	B364
Unspecified reconstruction of nipple and areola	B369
Reconstruction of breast using free deep inferior epigastric perforator flap	B393
Unspecified destruction of lesion of breast	B409
Block dissection of axillary lymph nodes	T852
Excision or biopsy of axillary lymph node	T873

NEC, not elsewhere classifiable.

TABLE 30 The OPCS-4 code and description of dental procedure group

Description	Code
Surgical removal of impacted wisdom tooth	F091
Surgical removal of impacted tooth NEC	F092
Surgical removal of wisdom tooth NEC	F093
Surgical removal of tooth NEC	F094
Surgical removal of retained root of tooth	F095
Other specified surgical removal of tooth	F098
Unspecified surgical removal of tooth	F099
Full dental clearance	F101
Upper dental clearance	F102
Lower dental clearance	F103
Extraction of multiple teeth NEC	F104
Other specified simple extraction of tooth	F108

continued

TABLE 30 The OPCS-4 code and description of dental procedure group (*continued*)

Description	Code
Unspecified simple extraction of tooth	F109
Augmentation of alveolar ridge using autobone graft	F112
Endosseous implantation into jaw	F115
Preprosthetic oral surgery, unspecified	F118
Apicectomy of tooth	F121
Root canal therapy to tooth	F122
Drainage of abscess of alveolus of tooth	F161
Surgical arrest of postoperative bleeding from tooth socket	F162
Scaling of tooth	F164
Application of fissure sealant	F165
Other specified operations on tooth	F168
Enucleation of dental cust of jaw	F181
Marsupialisation of dental lesion of jaw	F182
Other specified excision of dental lesion of jaw	F188
Excision of dental lesion of jaw, unspecified	F189
Excision of gingiva	F201
Excision of lesion of gingiva	F202
Biopsy of lesion of gingiva	F203
Gingivoplasty	F204
Other specified operation on gingiva	F208
Operation on gingiva, unspecified	F222

NEC, not elsewhere classifiable.

TABLE 31 The OPCS-4 code and description of ENT procedure group

Description	Code
Partial excision of external ear	D012
Excision of preauricular abnormality	D013
Other specified excision of external ear	D018
Excision of lesion of external ear	D021
Other specified extirpation of lesion of external ear	D028
Unspecified extirpation of lesion of external ear	D029
Reconstruction of external ear using graft	D031
Reconstruction of external ear NEC	D032
Pinnaplasty	D033
Meatoplasty of external ear	D034
Other specified plastic operations on external ear	D038

TABLE 31 The OPCS-4 code and description of ENT procedure group (*continued*)

Description	Code
Drainage of haematoma of external ear	D041
Drainage of abscess of external ear	D042
Other specified drainage of external ear	D048
Biopsy of lesion of external ear	D061
Repair of lobe of external ear	D062
Repair of external ear NEC	D063
Other specified other operations on external ear	D068
Irrigation of external auditory canal for removal of wax	D071
Removal of wax from external auditory canal NEC	D072
Removal of foreign body from external auditory canal	D073
Other specified clearance of external auditory canal	D078
Unspecified clearance of external auditory canal	D079
Extirpation of lesion of external auditory canal	D081
Drainage of external auditory canal	D083
Irrigation of external auditory canal NEC	D085
Other specified other operations on external auditory canal	D088
Modified radical mastoidectomy	D102
Cortical mastoidectomy	D103
Simple mastoidectomy	D104
Excision of lesion of mastoid	D105
Revision of mastoidectomy	D106
Unspecified exenteration of mastoid air cells	D109
Atticotomy	D122
Biopsy of mastoid	D123
Exploration of mastoid	D124
Atticoantrostomy	D127
Other specified other operations on mastoid	D128
Attention to fixtures for bone-anchored hearing prosthesis	D134
Fitting of external hearing prosthesis to bone-anchored fixtures	D136
Other specified attachment of bone-anchored hearing prosthesis	D138
Tympanoplasty using graft	D141
Tympanoplasty NEC	D142
Revision of tympanoplasty	D143
Combined approach tympanoplasty	D144
Other specified repair of eardrum	D148
Unspecified repair of eardrum	D149
Myringotomy with insertion of ventilation tube through tympanic membrane	D151

continued

TABLE 31 The OPCS-4 code and description of ENT procedure group (*continued*)

Description	Code
Suction clearance of middle ear	D152
Incision of eardrum NEC	D153
Prosthetic replacement of ossicular chain	D161
Graft replacement of ossicular chain	D162
Other specified reconstruction of ossicular chain	D168
Stapedectomy	D171
Other specified other operations on ossicle of ear	D178
Other operations on ossicle of ear, unspecified	D179
Excision of lesion of middle ear	D191
Destruction of lesion of middle ear	D192
Biopsy of lesion of middle ear	D201
Maintenance of ventilation tube through tympanic membrane	D202
Removal of ventilation tube from tympanic membrane	D203
Transtympanic injection to middle ear	D207
Other specified other operations on middle ear	D208
Other specified operations on Eustachian canal	D228
Implantation of intracochlear prosthesis	D241
Transtympanic electrocochleography	D245
Examination of ear under anaesthetic	D282
Other specified other operations on ear	D288
Unspecified excision of nose	E019
Reconstruction of nose NEC	E022
Septorhinoplasty using implant	E023
Septorhinoplasty using graft	E024
Reduction rhinoplasty	E025
Rhinoplasty NEC	E026
Other specified plastic operations on nose	E028
Unspecified plastic operations on nose	E029
Submucous excision of septum of nose	E031
Excision of lesion of septum of nose	E032
Biopsy of lesion of septum of nose	E033
Closure of perforation of septum of nose NEC	E034
Septoplasty of nose NEC	E036
Other specified operations on septum of nose	E038
Unspecified operations on septum of nose	E039
Submucous diathermy to turbinate of nose	E041
Excision of turbinate of nose NEC	E042
Biopsy of lesion of turbinate of nose	E045

TABLE 31 The OPCS-4 code and description of ENT procedure group (*continued*)

Description	Code
Cauterisation of turbinate of nose	E046
Other specified operations on turbinate of nose	E048
Cauterisation of internal nose	E051
Ligation of artery of internal nose	E052
Embolisation of artery of internal nose	E053
Other specified surgical arrest of bleeding from internal nose	E058
Packing of posterior cavity of nose NEC	E061
Packing of anterior cavity of nose NEC	E062
Removal of packing from cavity of nose	E063
Balloon packing of cavity of nose	E064
Other specified packing of cavity of nose	E068
Unspecified packing of cavity of nose	E069
Septorhinoplasty NEC	E073
Polypectomy of internal nose	E081
Extirpation of lesion of internal nose NEC	E082
Division of adhesions of internal nose	E084
Removal of foreign body from cavity of nose	E085
Other specified other operations on internal nose	E088
Excision of lesion of external nose	E091
Destruction of lesion of external nose NEC	E092
Suture of external nose	E093
Shave of skin of nose	E094
Biopsy of lesion of external nose	E095
Laser destruction of lesion of external nose	E096
Other specified operations on external nose	E098
Biopsy of lesion of nose NEC	E101
Other specified other operations on nose	E108
Transantral neurectomy of Vidian nerve using sublabial approach	E124
Other specified operations on maxillary antrum using sublabial approach	E128
Excision of lesion of maxillary antrum	E132
Intranasal antrostomy	E133
Biopsy of lesion of maxillary antrum	E134
Closure of fistula between maxillary antrum and mouth	E135
Puncture of maxillary antrum	E136
External frontoethmoidectomy	E141
Intranasal ethmoidectomy	E142

continued

TABLE 31 The OPCS-4 code and description of ENT procedure group (*continued*)

Description	Code
External ethmoidectomy	E143
Transantral ethmoidectomy	E144
Other specified operations on frontal sinus	E148
Unspecified operations on frontal sinus	E149
Other specified operations on sphenoid sinus	E158
Excision of lesion of nasal sinus NEC	E172
Biopsy of lesion of nasal sinus NEC	E173
Other specified operations on unspecified nasal sinus	E178
Unspecified operations on unspecified nasal sinus	E179
Total adenoidectomy	E201
Biopsy of adenoid	E202
Unspecified repair of pharynx	E219
Open excision of lesion of pharynx	E231
Endoscopic extirpation of lesion of pharynx NEC	E242
Other specified therapeutic endoscopic operations on pharynx	E248
Unspecified therapeutic endoscopic operations on pharynx	E249
Drainage of retropharyngeal abscess	E272
Removal of foreign body from pharynx	E274
Examination of pharynx under anaesthetic	E276
Other specified other operations on pharynx	E278
Vocal cord medialisation using implant	E335
Other specified other open operations on larynx	E338
Microtherapeutic endoscopic extirpation of lesion of larynx using laser	E341
Microtherapeutic endoscopic resection of lesion of larynx NEC	E342
Microtherapeutic endoscopic destruction of lesion of larynx NEC	E343
Other specified microtherapeutic endoscopic operations on larynx	E348
Endoscopic resection of lesion of larynx	E352
Endoscopic destruction of lesion of larynx	E353
Endoscopic removal of foreign body from larynx	E355
Other specified other therapeutic endoscopic operations on larynx	E358
Injection into larynx	E381
Other specified other operations on larynx	E388
Closure of tracheostomy	E425
Replacement of tracheostomy tube	E426
Removal of tracheostomy tube	E427
Unspecified exteriorisation of trachea	E429
Closure of tracheocutaneous fistula	E435
Diagnostic endoscopic examination of lower respiratory tract and biopsy of lesion of lower respiratory tract using rigid bronchoscope	E511

TABLE 31 The OPCS-4 code and description of ENT procedure group (*continued*)

Description	Code
Unspecified diagnostic endoscopic examination of lower respiratory tract using rigid bronchoscope	E519
Bilateral dissection tonsillectomy	F341
Bilateral guillotine tonsillectomy	F342
Bilateral laser tonsillectomy	F343
Bilateral excision of tonsil NEC	F344
Excision of remnant of tonsil	F345
Excision of lingual tonsil	F346
Bilateral coblation tonsillectomy	F347
Other specified excision of tonsil	F348
Unspecified excision of tonsil	F349
Destruction of tonsil	F361
Biopsy of lesion of tonsil	F362
Drainage of abscess of peritonsillar region	F363
Removal of foreign body from tonsil	F364
Other specified other operations on tonsil	F368
Osteotomy of maxilla involving nasal complex	V103

NEC, not elsewhere classifiable.

TABLE 32 The OPCS-4 code and description of perianal procedure group

Description	Code
Insertion of encircling suture around perianal sphincter	H421
Excision of mucosal prolapse of rectum NEC	H425
Other specified perineal operations for prolapse of rectum	H428
Examination of rectum under anaesthetic	H444
Excision of polyp of anus	H481
Excision of skin tag of anus	H482
Excision of perianal wart	H483
Other specified excision of lesion of anus	H488
Unspecified excision of lesion of anus	H489
Cauterisation of lesion of anus	H491
Other specified destruction of lesion of anus	H498
Anterior repair of anal sphincter	H502
Other specified repair of anus	H508
Unspecified repair of anus	H509
Haemorrhoidectomy	H511

continued

TABLE 32 The OPCS-4 code and description of perianal procedure group (*continued*)

Description	Code
Partial internal sphincterotomy for haemorrhoid	H512
Stapled haemorrhoidectomy	H513
Other specified excision of haemorrhoid	H518
Unspecified excision of haemorrhoid	H519
Cryotherapy to haemorrhoid	H521
Injection of sclerosing substance into haemorrhoid	H523
Rubber band ligation of haemorrhoid	H524
Other specified destruction of haemorrhoid	H528
Evacuation of perianal haematoma	H531
Forced manual dilation of anus for haemorrhoid	H532
Manual reduction of prolapsed haemorrhoid	H533
Other specified other operations on haemorrhoid	H538
Unspecified other operations on haemorrhoid	H539
Anorectal stretch	H541
Laying open of low anal fistula	H551
Laying open of high anal fistula	H552
Laying open of anal fistula NEC	H553
Insertion of seton into high anal fistula and partial laying open of track HFQ	H554
Probing of perineal fistula	H556
Repair of anal fistula using plug	H557
Other specified other operations on perianal region	H558
Biopsy of lesion of anus	H561
Lateral sphincterotomy of anus	H562
Incision of septum of anus	H563
Excision of anal fissure	H564
Other specified other operations on anus	H568
Unspecified other operations on anus	H569
Drainage of ischiorectal abscess	H581
Drainage of perianal abscess	H582
Drainage of perirectal abscess	H583
Other specified drainage through perineal region	H588
Unspecified drainage through perineal region	H589
Excision of pilonidal sinus and skin flap NEC	H592
Excision of pilonidal sinus and suture HFQ	H594
Other specified excision of pilonidal sinus	H598
Unspecified excision of pilonidal sinus	H599
Destruction of pilonidal sinus	H601

TABLE 32 The OPCS-4 code and description of perianal procedure group (*continued*)

Description	Code
Laying open of pilonidal sinus	H602
Drainage of pilonidal sinus	H603
Injection of radiocontrast substance into pilonidal sinus	H604
Other specified other operations on pilonidal sinus	H608

HFQ, however further qualified; NEC, not elsewhere classifiable.

TABLE 33 The OPCS-4 code and description of skin and nail procedure group

Description	Code
Excision of lesion of lip	F021
Destruction of lesion of lip	F022
Other specified extirpation of lesion of lip	F028
Unspecified extirpation of lesion of lip	F029
Revision of primary closure of cleft lip	F032
Reconstruction of lip using skin flap	F042
Other specified other reconstruction of lip	F048
Excision of excess mucosa from lip	F051
Suture of lip	F053
Removal of suture from lip	F054
Other specified other repair of lip	F058
Unspecified other repair of lip	F059
Biopsy of lesion of lip	F062
Shave of lip	F063
Other specified other operations on lip	F068
Unspecified other operations on lip	F069
Facelift NEC	S012
Brow lift NEC	S014
Abdominoplasty	S021
Thigh lift	S032
Excision of redundant skin or fat of arm	S033
Other specified plastic excision of skin of other site	S038
Excision of sweat gland bearing skin of axilla	S041
Excision of sweat gland bearing skin of groin	S042
Excision of sweat gland bearing skin NEC	S043
Other specified other excision of skin	S048
Unspecified other excision of skin	S049

continued

TABLE 33 The OPCS-4 code and description of skin and nail procedure group (*continued*)

Description	Code
Microscopically controlled excision of lesion of skin of head or neck using fresh tissue technique	S051
Unspecified microscopically controlled excision of lesion of skin	S059
Curettage and cauterisation of lesion of skin of head or neck	S081
Curettage and cauterisation of lesion of skin NEC	S082
Curettage of lesion of skin of head or neck NEC	S083
Other specified curettage of lesion of skin	S088
Unspecified curettage of lesion of skin	S089
Laser destruction of lesion of skin of head or neck	S091
Laser destruction of lesion of skin NEC	S092
Photodestruction of lesion of skin of head or neck NEC	S093
Other specified photodestruction of lesion of skin	S098
Unspecified photodestruction of lesion of skin	S099
Cauterisation of lesion of skin of head or neck NEC	S101
Cryotherapy to lesion of skin of head or neck	S102
Electrodessication of lesion of skin of head or neck	S105
Other specified other destruction of lesion of skin of head or neck	S108
Cauterisation of lesion of skin NEC	S111
Cryotherapy to lesion of skin NEC	S112
Electrodessication of lesion of skin NEC	S115
Other specified other destruction of lesion of skin of other site	S118
Other specified other distant flap of skin	S208
Neurovascular island sensory flap of skin NEC	S222
Z-plasty to head or neck	S231
Z-plasty NEC	S232
W-plasty NEC	S234
Other specified flap operations to relax contracture of skin	S238
Unspecified local flap of skin and muscle	S249
Local fasciocutaneous subcutaneous pedicle flap NEC	S252
Other specified local flap of skin and fascia	S258
Local subcutaneous pedicle flap of skin to head or neck NEC	S265
Other specified local subcutaneous pedicle flap of skin	S268
Unspecified local subcutaneous pedicle flap of skin	S269
Axial pattern local flap of skin NEC	S272
Random pattern local flap of skin to head or neck NEC	S273
Random pattern local flap of skin NEC	S274
Local flap of skin to head or neck NEC	S275
Other specified other local flap of skin	S278
Unspecified other local flap of skin	S279

TABLE 33 The OPCS-4 code and description of skin and nail procedure group (*continued*)

Description	Code
Transfer of flap of skin to head or neck	S302
Revision of flap of skin to head or neck	S303
Meshed split autograft of skin to head or neck	S351
Meshed split autograft of skin NEC	S352
Split autograft of skin to head or neck NEC	S353
Other specified split autograft of skin	S358
Unspecified split autograft of skin	S359
Full thickness autograft of skin to head or neck	S361
Full thickness autograft of skin NEC	S362
Composite autograft of skin NEC	S364
Other specified other autograft of skin	S368
Allograft of skin NEC	S372
Unspecified other graft of skin	S379
Other specified graft of other tissue to skin	S398
Tape closure of skin NEC	S401
Tissue adhesive closure of skin NEC	S402
Tape closure of skin of head or neck	S403
Tissue adhesive closure of skin of head or neck	S404
Other specified other closure of skin	S408
Unspecified other closure of skin	S409
Primary suture of skin of head or neck NEC	S411
Delayed primary suture of skin of head or neck	S412
Other specified suture of skin of head or neck	S418
Unspecified suture of skin of head or neck	S419
Primary suture of skin NEC	S421
Delayed primary suture of skin NEC	S422
Secondary suture of skin NEC	S423
Resuture of skin NEC	S424
Unspecified suture of skin of other site	S429
Removal of clip from skin NEC	S432
Removal of suture from skin of head or neck	S433
Removal of suture from skin NEC	S434
Other specified removal of repair material from skin	S438
Unspecified removal of repair material from skin	S439
Removal of metal from skin of head or neck	S441
Removal of metal from skin NEC	S442
Removal of glass from skin of head or neck	S443

continued

TABLE 33 The OPCS-4 code and description of skin and nail procedure group (*continued*)

Description	Code
Removal of glass from skin NEC	S444
Removal of inorganic foreign body from skin of head or neck NEC	S445
Removal of inorganic foreign body from skin NEC	S446
Removal of organic material from skin NEC	S454
Removal of foreign body from skin of head or neck NEC	S455
Removal of foreign body from skin NEC	S456
Other specified removal of other substance from skin	S458
Drainage of lesion of skin of head or neck	S471
Drainage of lesion of skin NEC	S472
Incision of lesion of skin of head or neck	S473
Incision of lesion of skin NEC	S474
Incision of skin of head or neck	S475
Incision of skin NEC	S476
Other specified opening of skin	S478
Unspecified opening of skin	S479
Adjustment to skin expander in subcutaneous tissue	S491
Removal of skin expander from subcutaneous tissue of breast	S493
Other specified attention to skin expander in subcutaneous tissue	S498
Toilet to burnt skin of head or neck NEC	S543
Debridement of burnt skin NEC	S551
Removal of slough from burnt skin NEC	S552
Cleansing and sterilisation of burnt skin NEC	S556
Debridement of skin of head or neck NEC	S561
Removal of slough from skin of head or neck NEC	S562
Toilet to skin of head or neck NEC	S563
Unspecified exploration of other skin of head or neck	S569
Debridement of skin NEC	S571
Removal of slough from skin NEC	S572
Toilet of skin NEC	S573
Cleansing and sterilisation of skin NEC	S576
Dressing of skin using vacuum-assisted closure device NEC	S577
Other specified exploration of other skin of other site	S578
Unspecified exploration of other skin of other site	S579
Larvae debridement therapy of skin NEC	S582
Dermabrasion of skin of head or neck	S601
Dermabrasion of skin NEC	S602
Refashioning of scar NEC	S604
Epilation NEC	S607

TABLE 33 The OPCS-4 code and description of skin and nail procedure group (*continued*)

Description	Code
Other specified other operations on skin	S608
Liposuction of subcutaneous tissue NEC	S622
Removal of inserted substance from subcutaneous tissue	S623
Removal of pack from subcutaneous tissue	S624
Removal of hormone implant from subcutaneous tissue	S625
Other specified other operations on subcutaneous tissue	S628
Excision of nail bed	S641
Chemical destruction of nail bed	S642
Destruction of nail bed NEC	S643
Other specified extirpation of nail bed	S648
Biopsy of lesion of nail bed	S661
Repair of nail bed	S662
Incision of nail bed	S663
Other specified other operations on nail bed	S668
Total excision of nail	S681
Excision of wedge of nail	S682
Partial excision of nail NEC	S683
Other specified excision of nail	S688
Unspecified excision of nail	S689
Avulsion of nail	S701
Removal of foreign body from nail	S703
Other specified other operations on nail	S708

NEC, not elsewhere classifiable.

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