Caesarean birth and risk of subsequent preterm birth: a retrospective cohort study

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Accepted 6 October 2020. Published Online 4 November 2020.

Objective To determine the risk of spontaneous and medically indicated preterm birth associated with mode of birth in previous term-born pregnancy.

Design Retrospective cohort study.

Setting Two UK maternity units.

Population or sample A total of 16,340 women with first two consecutive singleton births and the first birth at term.

Methods Retrospective cohort study using routinely collected clinical data.

Main outcome measures Incidence of spontaneous preterm birth and medically indicated preterm birth at less than 37 weeks of gestation after term birth, in relation to mode of birth in first pregnancy. Subgroup analysis on cervical dilatation at the time of first caesarean birth.

Results Compared with vaginal birth, emergency caesarean birth at full dilatation was associated with an increase in spontaneous preterm birth (2.3% vaginal birth versus 4.5% full dilatation caesarean; adjusted odds ratio [aOR] 3.29, 95% CI 2.02–5.13, \(P < 0.001\)). Elective caesarean, emergency caesarean at <4 cm dilatation, and emergency caesarean at 4–9 cm dilatation were associated with increased medically indicated preterm birth (0.8% vaginal births versus 1.9% elective caesarean, 3.3% <4 cm caesarean, 1.3% 4–9 cm caesarean; aOR 2.30, 95% CI 1.19–4.15, \(P = 0.009\); aOR 4.68, 95% CI 2.98–7.24, \(P < 0.001\); and aOR 2.43, 95% CI 1.43–4.00, \(P = 0.001\), respectively).

Conclusions Term caesarean in the first stage of labour or performed prelabour is associated with medically indicated preterm birth. Term caesarean in the second stage of labour is associated with spontaneous preterm birth.

Keywords Caesarean section, mode of birth, pregnancy, preterm birth, preterm labour.

Tweetable abstract Caesarean in the second stage of labour is associated with spontaneous preterm birth.

Linked article This article is commented on by B de Vries, p. 1029 in this issue. To view this mini commentary visit https://doi.org/10.1111/1471-0528.16594.

Introduction

Preterm birth, defined as birth before completing 37 weeks of gestation, is a major public health problem.\(^1\) It is the leading cause of childhood mortality below 5 years of age,\(^2\) and is associated with short-term and long-term morbidities. Around two-thirds of preterm births are ‘spontaneous’, being preceded by spontaneous onset of contractions and/or cervical dilatation, or by spontaneous preterm prelabour rupture of membranes. The remaining third of preterm births are indicated preterm birth, i.e. initiated by care providers because of complications in the mother or baby when the risks of ongoing pregnancy outweigh the risks of delivery.\(^3\)

A number of risk factors have been associated with preterm birth including nulliparity, previous preterm birth, cervical surgery, short interpregnancy interval, social deprivation and smoking.\(^4\) Caesarean delivery has been associated with preterm birth in a subsequent pregnancy in some studies,\(^5\)–\(^7\) but not others.\(^8,9\) The stage in labour at which the caesarean section is performed may be crucial, with some studies suggesting preterm birth risk is higher if the caesarean section is performed in the second stage of labour, when the cervix is fully (10 cm) dilated, compared with caesarean before labour onset.\(^2,5,10–12\) Trauma to the cervix at the time of caesarean section, which is more common at a full dilatation caesarean birth, may impair the cervical function to retain a
pregnancy in a subsequent pregnancy, resulting in spontaneous preterm labour.

Quantifying the risk of subsequent preterm birth associated with index pregnancy mode of birth could have a number of benefits. First, it could help inform decision making around mode of birth in the first pregnancy. Second, it could help identify those at risk of preterm birth in a subsequent pregnancy who may benefit from additional screening and interventions to improve neonatal outcome. Third, it could provide better understanding of the potential mechanisms underlying different types of preterm birth and inform preventive strategies.

The objective of this study was to determine the risk of preterm birth in women who have had one singleton term birth; and determine the influence of mode of first birth on spontaneous and indicated preterm birth in the next pregnancy. The distinction between spontaneous and indicated preterm birth is important, because of their different aetiologies.

Methods

Ethics and reporting

Results are reported according to Strengthening the Reporting of Observational Studies in Epidemiology guidelines. A National Research Ethics Service tool was completed, which indicated that full ethical review was not required (IRAS number 283966). Local registration was granted by NHS Lothian and the University of Edinburgh (Lothian R&D Project No.: 2020/0102 Sponsor Reference: AC20076) in line with local clinical governance procedures.

Core outcome set

This is a retrospective cohort study of routine data with the primary aim of exploring the relationship between mode of birth and subsequent preterm birth. We have used (as far as was possible within the constraints of routinely collected data) the minimum data set required for studies into preterm birth, but no other relevant core outcome set exists for this non-interventional study.

Parental and patient involvement

As our study aims to determine a risk factor for preterm birth it aligns with the number one research priority for preterm birth ‘Which interventions (including diagnostic tests) are most effective to predict or prevent preterm birth?’ identified by a James Lind Alliance Stakeholder Priority Setting Partnership that included parents and preterm born adults. As the study was a data analysis project, parents were not involved in the conduct of the research. However, we have strong links with Tommy’s, the baby charity that supported this work. Tommy’s will be consulted on further dissemination of findings, and we anticipate using their large parental network to leverage this.

Funding

There was no specific funding for this work. SJS is supported by a Wellcome Trust Clinical Career development fellowship (209560/Z/17/Z). The work was carried out at the MRC Centre for Reproductive Health (MR/N022556/1). Infrastructure support was provided through Tommy’s (registered charity in Scotland SC039280).

Study design, setting and population

This was a retrospective cohort study at two UK maternity units: the Royal Infirmary of Edinburgh (a tertiary referral centre with approximately 6500 births per year) between 1 January 2009 and 31 December 2018 and St John’s Hospital Livingston (a district general hospital with approximately 3500 births per year) between 1 July 2009 and 31 December 2018.

Inclusion criteria

Women were included if they received maternity care for their first two consecutive births (i.e. their parity = 0 and parity = 1 pregnancies) in either hospital, and if their first birth was at term (37–43+6 weeks of gestation). Women were excluded if the first birth was a stillbirth, they had a mid trimester loss preceding their first term birth, there was uncertainty about the gestational age at birth in either pregnancy, either pregnancy was a multiple pregnancy, or if mode of birth in the first pregnancy was not recorded.

Data source

The study was a secondary analysis of data extracted from clinical maternity records for service evaluation. Data were extracted from the TrakCare (InterSystems, Cambridge, MA, USA) electronic maternity record that is used to record all antenatal, intrapartum and postnatal care across the two hospital sites. Search criteria to identify women were based on parity, to identify the first two consecutive pregnancy records (Figure 1). Women generally book for maternity care at 9–11 weeks of gestation. Pregnancies ending before this are not captured. Most outcomes and covariates were directly extracted from structured data fields within the maternity record. All structured variables are reported in national birth records (Scottish Morbidity Report 02), and so are quality assured and have high completeness. Structured data were supplemented by hand searching of records to verify cervical dilatation at the time of caesarean in women who had an emergency caesarean birth (3308 records) and onset of preterm birth in women who had a preterm birth (507 records). An anonymised
extract of data was provided identified by a randomly generated study identifier. To preserve anonymity, all dates within pregnancy were converted to gestation (days) and the interpregnancy interval was converted to days (calculated from the birth-to-birth interval minus the gestational age of the second birth). The Scottish Index of Multiple Deprivation (SIMD) quintile was derived from postcode, based on the most recent version of SIMD available before the year of birth. All data were stored and analysed on password-protected university servers.

**Exposures**

The exposure was mode of birth in first pregnancy. This was categorised as vaginal birth (spontaneous vertex deliveries and vaginal breech deliveries), assisted vaginal birth (forceps and ventouse deliveries), planned caesarean birth (scheduled caesarean section), prelabour/early labour emergency caesarean birth (cervical dilatation < 4 cm), emergency caesarean birth in first stage of labour (cervical dilatation 4–9 cm) and emergency caesarean birth in second stage of labour (at full dilatation, 10 cm). Cervical
Maternal smoking status at pregnancy booking was categorised as current smoker or non-smoker. Maternal body mass index (BMI) was categorised according to World Health Organization definitions as underweight (<18.5 kg/m²), normal (18.5–24.9 kg/m²; referent), overweight (25–29.9 kg/m²) and obese (≥30 kg/m²). Where data were not available for BMI, SIMD and smoking, they were categorised as ‘Unknown’ and included in the analysis to prevent loss of information within models (see Supplementary material, Table S1). Maternal ethnicity was initially categorised as recommended by the Information Services Division Scotland Ethnic Group (as White, Mixed or multiple ethnic groups, Asian, Asian Scottish or Asian British, African, Caribbean or Black, Other ethnic group, Refused/Not provided, Not known). However, because a high proportion of the cohort were white (93%), with very low proportions of individual non-white ethnicities (0.2–4%), we collapsed maternal ethnicity into three categories, White, Other ethnic group and Unknown.

**Statistical analysis**
To maximise the power of the study to detect differences between groups we included all eligible births available in the service improvement data set from January 2009 to December 2018 for Royal Infirmary of Edinburgh births, and July 2009 to December 2018 for St John’s Hospital Livingston births. TrakCare was implemented in the Royal Infirmary of Edinburgh in 2008, and in St John’s Hospital Livingston in 2009. All analyses were carried out in R (Version 3.6.3, R Foundation for Statistical Computing, Vienna, Austria).

Summary statistics were derived and stratified by first birth mode of birth (Vaginal birth, Assisted vaginal birth, Elective caesarean birth, Emergency caesarean prelabour or early labour, Emergency caesarean birth in first stage of labour, Emergency caesarean birth in second stage of labour). All hypothesis tests were two-sided, and statistical significance was assumed at P < 0.05. Univariable comparisons of categorical data were performed using chi-square test. The relationship between having a spontaneous or indicated preterm birth in the second pregnancy and mode of birth in the first pregnancy was assessed by multiple logistic regression using potential confounders adjustment variables as fixed effects, with unadjusted and adjusted odds ratio and 95% CI presented. All potential confounders that were pre-specified (gestation of first birth, birthweight centile of first birth, interpregnancy interval, maternal age, ethnicity, BMI category, smoking status and deprivation index) were included in logistic regression models. In a supplementary analysis, we compared patterns seen in logistic regression models (with preterm birth as a binary outcome and presentation of odds ratio [OR] and 95% CI) with patterns seen in Cox proportional hazards models (time-to-event analysis for duration of pregnancy and presentation of hazard ratios [HR] and 95% CI). Kaplan–
Meier curves (unadjusted) were plotted for gestation of spontaneous preterm birth and gestation of indicated preterm birth (in weeks), categorised by the mode of first birth. We right censored for indicated preterm birth in the spontaneous preterm birth plot, and right censored for spontaneous preterm birth plot. As survival curves converge at term we also censored at 37 weeks of gestation. A subgroup analysis was performed for the binary outcome of spontaneous preterm birth (before 37 weeks of gestation), in women who underwent caesarean section in labour, with the exposure being cervical dilatation (cm) considered as a continuous variable.

**Post hoc analyses**

A number of changes to the analyses pre-specified in the protocol were made in response to feedback from reviewers. Maternal age, gestation of first birth, birthweight centile and interpregnancy interval were included in models as continuous variables rather than categorised. Time-to-event analyses were included as supplementary analyses, to increase confidence in the findings from logistic regression models. Elective caesarean births were excluded from the subgroup analyses exploring the relationship between cervical dilatation and spontaneous preterm birth (i.e. this analysis was confined to women having emergency caesarean sections). Cervical dilatation was considered as a continuous variable in this subgroup analysis.

**Results**

**Participant characteristics**

A total of 16343 women (of 67735 women with any pregnancy record during the study period) had records for their first two consecutive singleton births, with the first birth (i.e. when they were parity = 0) a livebirth at term gestation (Figure 1). Three women were excluded from the analysis because data on the gestation of the first birth was missing.

Characteristics of the cohort, stratified by mode of first birth, are shown in the Supplementary material (Table S1). Of the 16340 women included in the analysis, 7743 (47.4%) had a vaginal birth, 4580 (28.0%) had an assisted vaginal birth, 709 (4.3%) had an elective caesarean birth, 1042 (6.4%) had an emergency caesarean birth before or in the early stages of labour, 1755 (10.7%) had an emergency caesarean birth in the first stage of labour and 511 women (3.1%) had an emergency caesarean birth in the second stage of labour.

In the second pregnancy (i.e. when women were parity = 1), after having one previous term birth, 15833 women (96.9%) had another term birth, 333 (2.0%) women had a spontaneous preterm birth at less than 37 weeks of gestation and 174 (1.1%) had an indicated preterm birth at less than 37 weeks of gestation. Rates of early preterm birth were low, with 77 (0.5%) women having a spontaneous preterm birth at less than 34 weeks of gestation and 40 (0.2%) women having an indicated preterm birth at less than 34 weeks of gestation.

**Mode of birth and risk of subsequent spontaneous or medically indicated preterm birth before 37 weeks**

Associations between mode of birth and spontaneous preterm birth and medically indicated preterm birth at less than 37 weeks of gestation are shown in Table 1. Full model details are provided in the Supplementary material (Tables S2 and S3).

Compared with vaginal birth, emergency caesarean birth in the second stage of labour was associated with a three-fold increase in spontaneous preterm birth (adjusted OR [aOR] 3.29, 95% CI 2.02–5.13, P < 0.001) after adjustment for confounders. Other modes of birth were not independently associated with risk of subsequent spontaneous preterm labour.

A different relationship was seen between mode of birth and subsequent medically indicated preterm birth. Compared with vaginal birth (unadjusted risk 0.8%), an increased risk of indicated preterm birth was seen in association with elective caesarean (aOR 2.30, 95% CI 1.19–4.15, P = 0.009), prelabour/early labour emergency caesarean (aOR 4.68, 95% CI 2.98–7.24, P < 0.001) and first stage of labour emergency caesarean (aOR 2.43, 95% CI 1.43–4.00, P = 0.001) on multivariable analysis adjusting for confounders. Second-stage caesarean section (unadjusted risk 1.0%) was not associated with an increased risk of medically indicated preterm birth compared with vaginal birth.

Time-to-event analyses showed relationships between mode of birth and subsequent preterm birth similar to those seen in logistic regression analysis. Figure 2 shows Kaplan–Meier curves of spontaneous preterm births (Figure 2A) and indicated preterm births (Figure 2B) in second pregnancy, stratified by mode of birth of the first birth. Hazard ratios for spontaneous preterm birth and indicated preterm births are shown in the Supplementary material (Tables S4 and S5, respectively). Multivariable time-to-event analysis again indicated an independent effect of second-stage caesarean birth on subsequent spontaneous preterm birth compared with vaginal birth (adjusted HR 3.10, 95% CI 1.99–4.84, P < 0.001). Other modes of birth were not associated with spontaneous preterm birth, when compared with vaginal birth. In contrast, elective caesarean (HR 2.31, 95% CI 1.25–4.26, P = 0.008), prelabour/early labour emergency caesarean (HR 4.51, 95% CI 2.93–6.95, P < 0.001) and first-stage emergency caesarean (HR 2.39, 95% CI 1.434–3.96, P = 0.001), but not second-stage caesarean, were independently associated with medically
indicated preterm birth in the subsequent pregnancy, when compared with vaginal birth.

**Mode of birth and risk of subsequent spontaneous or medically indicated preterm birth at less than 34 weeks**

Associations between mode of birth and spontaneous early preterm birth and medically indicated early preterm birth at less than 34 weeks of gestation are shown in the Supplementary material (Tables S6 and S7). Absolute risks of early preterm birth were very low, at less than 1% for all modes of birth; except for second-stage caesarean birth, which was associated with an absolute risk of 2% (10/493) for spontaneous early preterm birth. Compared with vaginal birth, caesarean birth in the second stage of labour was associated with early spontaneous

Table 1. Univariable and multivariable logistic regression of spontaneous preterm birth and medically indicated preterm birth at <37 weeks of gestation by mode of birth of first pregnancy

| Mode of birth                  | Term birth (97.7) | Spontaneous preterm birth (2.3) | OR (95% CI) (univariable) | OR (95% CI) (multivariable) | Indicated preterm birth (0.8) | OR (95% CI) (univariable) | OR (95% CI) (multivariable) |
|--------------------------------|-------------------|---------------------------------|---------------------------|-----------------------------|-------------------------------|-----------------------------|-----------------------------|
| Vaginal birth                  | 7510 (97.7)       | 174 (2.3)                       | 0.65 (0.48–0.85, P = 0.003) | 0.85 (0.63–1.13, P = 0.263) | 59 (0.8)                      | 1.17 (0.78–1.74, P = 0.449) | 1.44 (0.96–2.16, P = 0.077) |
| Assisted birth                 | 4472 (98.5)       | 67 (1.5)                        | 0.65 (0.48–0.85, P = 0.003) | 0.85 (0.63–1.13, P = 0.263) | 59 (0.8)                      | 1.17 (0.78–1.74, P = 0.449) | 1.44 (0.96–2.16, P = 0.077) |
| Elective caesarean section     | 681 (97.8)        | 15 (2.2)                        | 0.95 (0.53–1.57, P = 0.853) | 0.89 (0.50–1.49, P = 0.680) | 13 (1.9)                      | 2.43 (1.27–4.31, P = 0.004) | 2.30 (1.19–4.15, P = 0.009) |
| Emergency caesarean at dilatation <4 cm | 986 (97.8)       | 22 (2.2)                        | 0.96 (0.60–1.47, P = 0.869) | 1.00 (0.61–1.55, P = 0.999) | 34 (3.3)                      | 4.39 (2.84–6.69, P < 0.001) | 4.68 (2.98–7.24, P < 0.001) |
| Emergency caesarean at dilatation 4–9 cm | 1701 (98.2)      | 32 (1.8)                        | 0.81 (0.55–1.17, P = 0.283) | 1.45 (0.96–2.13, P = 0.064) | 22 (1.3)                      | 1.65 (0.99–2.65, P = 0.047) | 2.43 (1.43–4.00, P = 0.001) |
| Emergency caesarean at dilatation 10 cm | 483 (95.5)       | 23 (4.5)                        | 2.06 (1.28–3.14, P < 0.001) | 3.29 (2.02–5.13, P < 0.001) | 5 (1.0)                       | 1.32 (0.46–2.99, P = 0.556) | 1.76 (0.61–4.05, P = 0.234) |

Multivariable models include gestational age at first birth, birthweight centile, interpregnancy interval, maternal age, maternal ethnicity, maternal BMI category and maternal deprivation index. Full models are shown in the Supplementary material (Tables S2 and S3). For the spontaneous preterm birth model: number in data frame = 16 166, number in model = 16 164, missing = 2, Akaike information criterion = 3026.7, C-statistic = 0.733, Hosmer-Lemeshow χ²(8) = 3.16 (P = 0.924). For the indicated preterm birth model: number in data frame = 16 007, number in model = 16 005, missing = 2, Akaike information criterion = 1837.6, C-statistic = 0.716, Hosmer-Lemeshow χ²(8) = 7.80 (P = 0.453).
preterm birth before 34 weeks of gestation (aOR 7.55, 95% CI 3.42–15.41, \( P < 0.001 \)). Compared with vaginal birth, emergency caesarean section in the first stage of labour was associated with increased risk of early indicated preterm birth (unadjusted risks 0.2% for vaginal birth and 0.7% for pre/early labour caesarean; aOR 4.16, 95% CI 1.55–10.09, \( P = 0.002 \)).

Cervical dilatation and risk of spontaneous preterm birth
Figure 3 shows the relationship between spontaneous preterm birth at less than 37 weeks of gestation, and cervical dilatation in women with emergency caesarean births in their first pregnancy. The full model is shown in the Supplementary material (Table S8). Dilatation at the time of first emergency caesarean birth was independently associated with increased risk of early indicated preterm birth (unadjusted risks 0.2% for vaginal birth and 0.7% for pre/early labour caesarean; aOR 4.16, 95% CI 1.55–10.09, \( P = 0.002 \)).

Discussion
Main findings
Compared with vaginal birth, caesarean birth in the second stage of labour is associated with increased rates of subsequent spontaneous preterm birth at less than 37 weeks of gestation, and early spontaneous preterm birth at less than 34 weeks of gestation. Caesarean birth in the first stage of labour is not associated with an increase in spontaneous preterm birth. In contrast, prelabour, early labour or first-stage of labour caesarean births, but not second-stage of labour caesarean birth, are associated with increased risk of subsequent medically indicated preterm birth.

Strengths and limitations
Strengths of our study are that it is a large cohort study using routinely collected data with high completeness, analysed according to a predefined protocol; the outcomes of all second pregnancies booked at the maternity units were included (including mid-trimester losses); and we provide absolute estimates of the risk of preterm birth. In our analysis, we adjusted for a number of recognised confounding factors including interpregnancy interval and gestation of first term birth that have not been included in other studies. However, despite including more than 16 000 women with first two consecutive singleton pregnancies, the numbers of early preterm births (before 34 weeks of gestation) were low, and so there are wide confidence intervals around some estimates, particularly for medically indicated early preterm birth. These data must therefore be interpreted with caution. The study was based in two hospitals in the same regions, where there are relatively high rates of assisted vaginal birth (28% of all term births), hence the findings may not be generalisable to some other settings. Due to the observational design of the study, causation cannot be inferred. Despite adjusting for potential confounding effects, residual confounding may influence results.

Interpretation
Caesarean birth could be linked to subsequent spontaneous and medically indicated preterm birth by different mechanisms. Trauma to the cervix at the time of caesarean may impair the cervical function predisposing to spontaneous preterm labour. Myometrial scarring might predispose to disorders of placental implantation (e.g. placenta previa, placenta accreta spectrum, vasa previa and velamentous cord insertion), which are indications for indicated preterm birth. Alternatively, conditions that indicate caesarean birth in the first pregnancy (e.g. maternal medical disorders or placental insufficiency) may worsen and increase rates of indicated preterm birth in a subsequent pregnancy.

Our findings are consistent with those of a previous large Canadian cohort study by Wood et al.,\textsuperscript{11} linking second-stage caesarean birth with subsequent spontaneous preterm labour at less than 32 weeks of gestation. A secondary analysis of a cohort study found that second-stage caesarean birth was associated with a higher risk of spontaneous preterm birth when compared with first-stage caesarean birth, but the increase in spontaneous preterm birth was not statistically significant when compared with vaginal birth, although numbers were small (37 second-stage caesarean
births) at term. A US retrospective cohort study of women with the first two consecutive singleton deliveries did not find any association between caesarean birth and subsequent medically indicated or spontaneous preterm birth, after using propensity score analysis to adjust for confounders. However, propensity score matching could only be performed on a subset of eligible pregnancies (approximately one-third), so the generalisability of the findings to the whole cohort of women having caesarean deliveries may be limited, as well as the results having limited power to detect differences in preterm birth rates. A Dutch population study found that overall caesarean births at term was associated with a small increased risk in preterm birth, compared with vaginal birth, and this was mainly driven by an increase in spontaneous preterm birth. However, the study did not differentiate between the stage of labour at which the caesarean section was performed.

Caesarean birth is increasingly used for operative birth in the second stage of labour, with an accompanying reduction in attempted and successful assisted vaginal births. A large US study found that nearly one-quarter of primary caesarean births in 2000 were in the second stage of labour. Recognition that assisted vaginal birth is associated with more than a four-fold lower risk of subsequent preterm birth than second-stage caesarean birth may help influence future decisions around mode of birth in the second stage.

Nevertheless, the absolute risk of preterm birth following term caesarean birth in the second stage of labour is relatively low, being 4.5% for spontaneous preterm birth at less than 37 weeks of gestation and 2% for spontaneous preterm birth at less than 34 weeks of gestation. Current NHS England guidance is that all women who have had a second-stage caesarean birth should have a single cervical length scan in a subsequent pregnancy. However, this is not based on any evidence that cervical length is an effective or cost-effective screening strategy for preterm birth in this population, or that preventive treatments that might be used, such as cervical cerclage, work. A small case–control study suggested that women with a previous second-stage caesarean section at term were more likely to have recurrent preterm birth than women with a previous term vaginal birth. Further research is required to confirm the association between second-stage caesarean sections and early spontaneous preterm birth and to confirm appropriate management strategies.

**Conclusion**

Caesarean birth in the second stage of term labour is associated with increased risk of subsequent spontaneous preterm birth, whereas caesarean birth in early labour or the first stage of labour is associated with subsequent medically indicated preterm birth, compared with vaginal birth.

**Disclosure of interests**

SJS receives grant funding (paid to the institution) from Wellcome Trust, National Institute of Healthcare Research and Chief Scientist Office Scotland. The authors declare no conflicts of interests. Completed disclosure of interests forms are available to view online as supporting information.

**Contribution to authorship**

SJS conceived the study. CW, RF and SJS wrote the protocol. SJS and SM performed the analysis. CW drafted the manuscript. All authors commented on and edited the manuscript.

**Details of ethics approval**

A National Research Ethics Service tool was completed, which indicated that full ethical review was not required (IRAS number 283966). Local registration was granted by NHS Lothian and the University of Edinburgh (ACCORD, R&D No: 2020/0102) in line with local clinical governance procedures.

**Funding**

SJS is supported by a Wellcome Trust Clinical Career development fellowship (209560/Z/17/Z). The work was carried out at the MRC Centre for Reproductive Health (MR/N022556/1). Infrastructure support was provided through Tommy’s (registered charity in Scotland SC039280).

**Acknowledgements**

We are grateful to Allyn Dick for providing clinical audit data.

**Data availability statement**

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available because of privacy or ethical restrictions.

**Supporting Information**

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Table S1. Characteristics of cohort stratified by mode of birth of first pregnancy.

Table S2. Univariable and multivariable logistic regression of spontaneous preterm birth at <37 weeks of gestation.
Table S3. Univariable and multivariable logistic regression of indicated preterm birth at <37 weeks of gestation.

Table S4. Univariable and multivariable Cox proportional hazards of spontaneous preterm birth at <37 weeks of gestation.

Table S5. Univariable and multivariable Cox proportional hazards of indicated preterm birth at <37 weeks of gestation.

Table S6. Univariable and multivariable logistic regression of spontaneous preterm birth at <34 weeks of gestation.

Table S7. Univariable and multivariable logistic regression of indicated preterm birth at <34 weeks of gestation by mode of birth of first pregnancy.

Table S8. Subgroup analysis: univariable and multivariable logistic regression of spontaneous preterm birth at <37 weeks of gestation in women with emergency cesarean birth.

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