

Supplementary materials

Neonatal and early childhood outcomes following maternal anaesthesia for caesarean section; a population-based study

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Neonatal and early childhood outcomes following maternal anaesthesia for caesarean section; a population-based study of 140,866 mothers.

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Methods and Materials

All statistical analyses were carried out in R version 3.6.1 (2019-07-05)¹. All data were processed following the procedure detailed in Figure S1.

Data sources and study population

We linked six Scotland-wide databases; the Scottish Morbidity Record 02 (SMR02); the Scottish Birth Record (SBR), the National Records for Scotland (NRS); the Scottish Stillbirth and Infant Death Survey (SSBIDS), The Scottish Morbidity Record 01 (SMR01) and the Child Health Surveillance System Programme Pre-School (CHSP-PS). SMR02 records information on all women discharged from Scottish maternity hospitals, including maternal and infant characteristics, clinical management, obstetric complications and anaesthetic interventions. The Scottish Birth Record records all of a baby's neonatal care in Scotland. The NRS registers all births, stillbirths and infant deaths and the SSBIDS then obtains additional information from the SSBIDS coordinator at the relevant hospital. The General Registrar for Scotland collates information from death certificates including the primary and secondary causes of death. SMR01 records all in-patient and day case admissions throughout life to NHS hospitals and classifies diseases according to the International Classification of Diseases, 9th or 10th revision (ICD-9 and ICD-10). Data for hospital length of stay were obtained from SMR01. The Child Health Surveillance System Pre-School records information obtained from children at defined time-points assessing their health and development.

Data cleaning

We cleaned the data in order to make it more transparent / interpretable. For details of exclusions, please see Figure 1 in the manuscript. In addition, for data modelling processes, we have feature engineered the following variables:

- Anaesthetic type – “spinal”, “epidural” or “GA”
- Age of mother: in years. Truncated at age < 10 years
- Weight of mother: to nearest kg. Truncated at < 15kg and > 544kg.
- Height of mother: to nearest cm. Truncated at <100cm and >200cm
- Ethnic groups: division into five categories “Asian”, “Black”, “Mixed”, “White” and “Other”.
- SIMD decile: “0” to “10”
- Smoker during pregnancy: “current”, “former”, “never”
- Injected illicit drug: “Yes” or “No”
- Spontaneous abortion: count
- Therapeutic abortions: count
- Parity: count
- Previous caesarean section: count
- Induction of labour: “Induction” or “No induction”
- Premature: categorised as “< 37⁺⁰”
- Term: categorised as “≥37⁺⁰ - 43⁺⁶”
- Birthweight: In grams. Truncated at < 500g and > 6500g.
- Sex of neonate: “male” or “female”
- Pre-eclampsia: “Yes” = ICD-10 code (O11, O14, O15) or ICD-9 code (644,645,646,647)

The distribution of data for the non-imputed dataset is summarised using the `tableby` function from “arsenal” R package² and is detailed in Table S1.

Imputation of missing data

Missing values were imputed using a classification and regression tree (CART) methodology, using all variables included in analyses models and any other predictors of missing data in these regressions. In addition, all non-plausible values were imputed. We ran ten multiple imputations and 10 iterations. Data pertaining to elective and emergency caesarean sections were imputed separately. All variables used in any of the analysis models (including exposure and outcome) and any other predictors of missing data were used to predict missing data in these imputations.

Distribution of data for the imputed dataset is described using summary statistics from the `tableby` function from “arsenal” R package² and is detailed in Table S2.

Modelling

Due to the nature of the outcomes, two regression approaches were used. For the first group of outcomes as listed in *Figure S1* (left side), cluster robust Poisson regression was applied (to account for more than one delivery in some women), whereas for the outcomes on the right side of *Figure S1*, multivariate Poisson regression was used. Therefore, for modelling of the educational data, (gross motor, fine motor, communication and social skills assessments) we used the “VGAM” package (version 1.1-2)³ `vglm()` function for fitting generalised linear and additive models. For constructing covariance matrix estimators, we used the “sandwich” package (version 2.5-1)⁴. For the outcome of hospital length of stay, there were six outliers with values of ≥ 200 days. We report results with and without these cases included (*Table 2, Table S11, Figure S4*).

Results

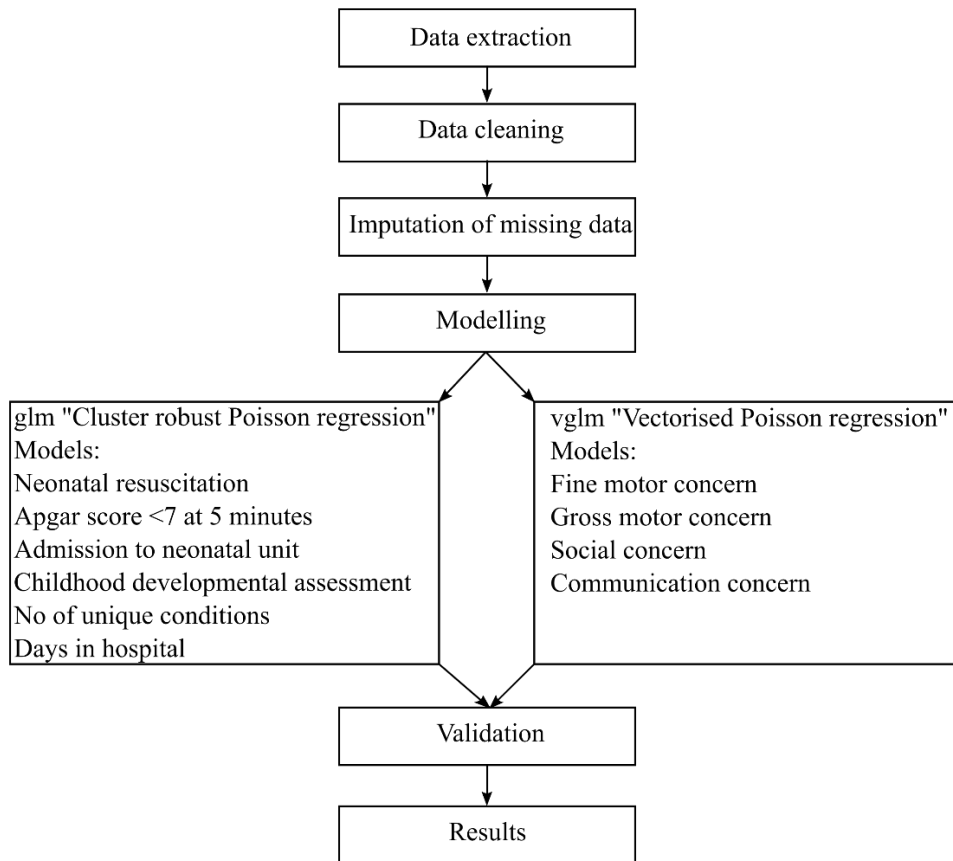
In order to statistically assess our model construction (see *Figure 2*) we used:

- Adjusted absolute risk
- 95% Confidence intervals (CI) in order to evaluate our modelling decisions and provide distribution values computed for the observed data/model

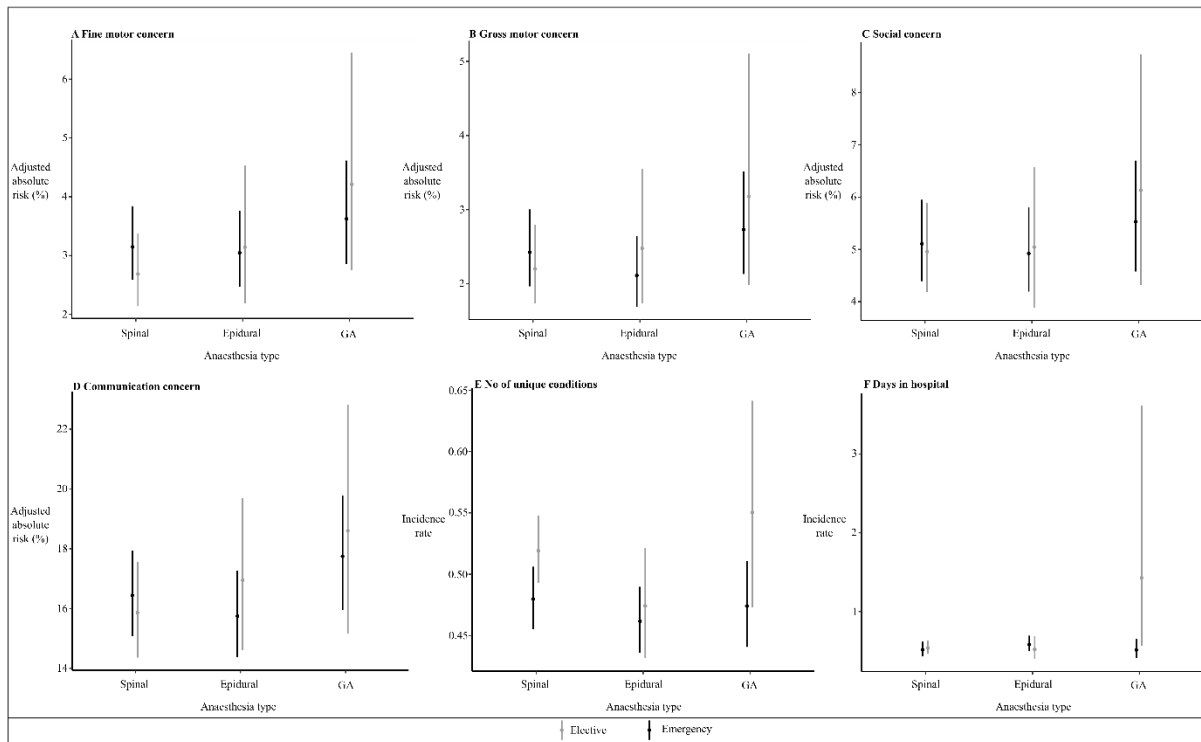
Generation of confidence intervals

Bootstrapping

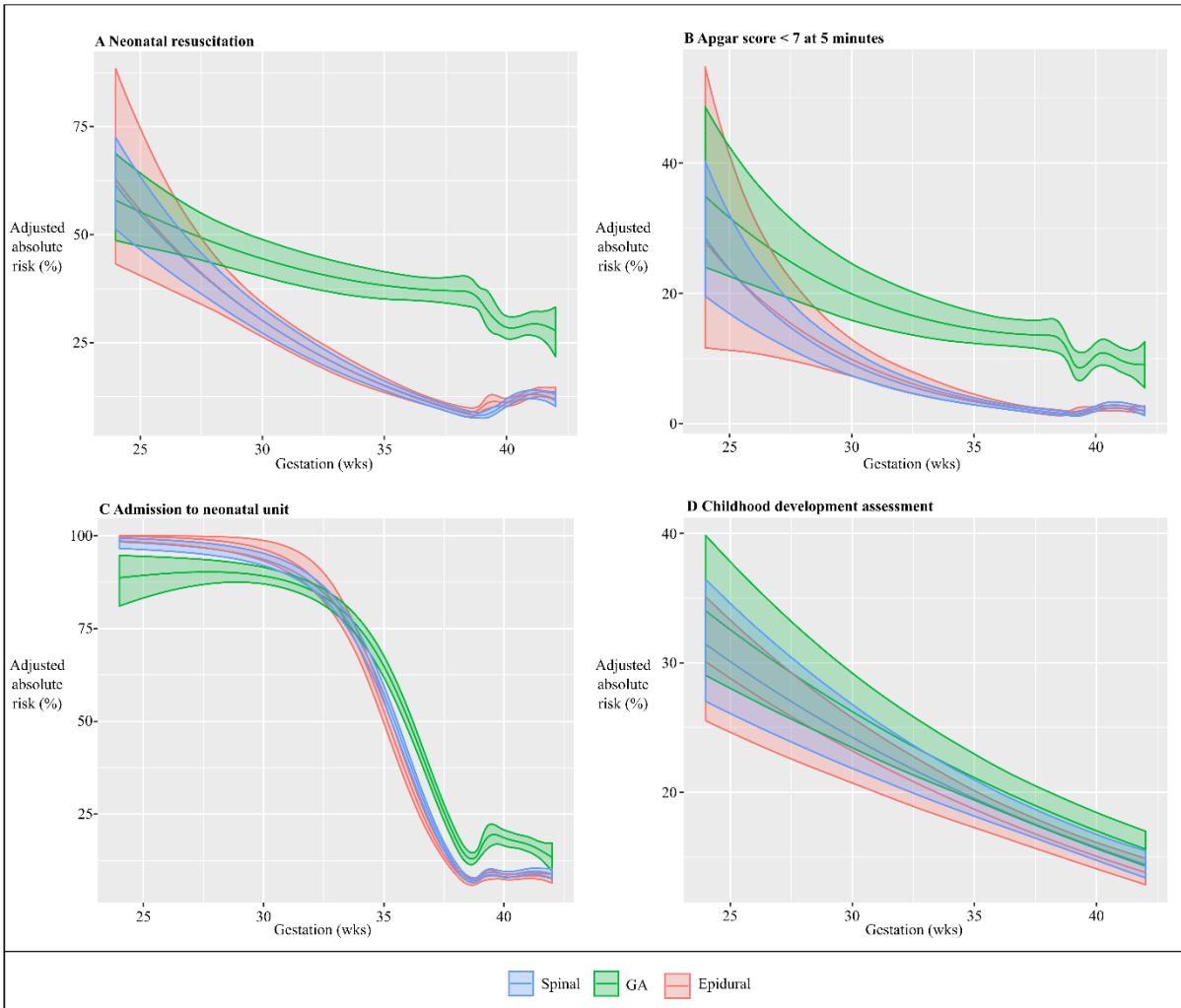
For *Figure 3* we bootstrapped the three models 100 times and calculated what the distribution of the model predictions were. In this process, data were divided into two sets: the training set and the testing set, by multiple resampling from the original models. The samples selected to the training set were chosen randomly. The observations that were not selected to the training set were used to build the testing set. On average, 63.2% of observations were assigned to the training set whereas the remaining 36.8% were assigned to the test set. The procedure was completed 100 times to allow unbiased evaluation of the strength of the model.



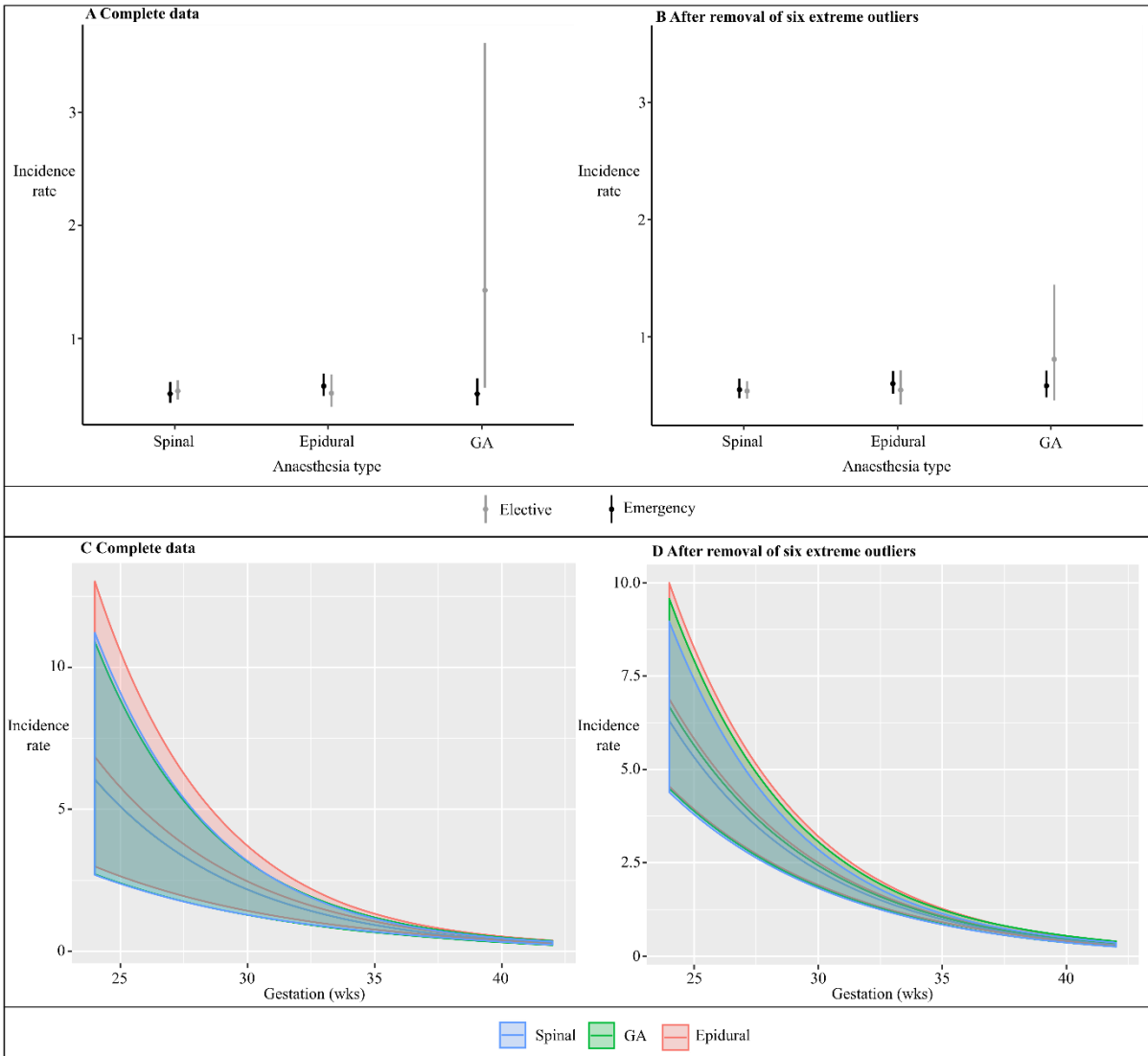
Supplementary Figure 1. Data analysis workflow – figure demonstrating data analysis methodology. *glm* - generalised linear model; *vglm* - vector generalised linear model.



Supplementary Figure 2 – Imputed data - Adjusted absolute risks + 95% CI for neonatal outcomes after birth and childhood development outcomes at 3 years in relation to anaesthetic type and urgency of caesarean section; (A) fine motor concern, (B) gross motor concern, (C) social concern, (D) communication concern, (E) number of unique conditions, (F) days in hospital. Emergency caesarean section is denoted in black and elective caesarean section in grey. Results are adjusted for; maternal age, maternal weight, SIMD decile, ethnicity, smoking history, illicit drug use, induction of labour (in emergency cases), parity, previous caesarean section, previous spontaneous or therapeutic abortion, pre-eclampsia, gestational age, birthweight, and sex of neonate.



Supplementary Figure 3 – Imputed data - Time-varying absolute risks + 95% CI (ribbon) for each outcome in relation to gestation in weeks for each anaesthetic type in emergency caesarean section; (A) fine motor concern, (B) gross motor concern, (C) social concern, (D) communication concern, (E) number of unique conditions, (F) days in hospital. Results are adjusted for; maternal age, maternal weight, SIMD decile, ethnicity, smoking history, illicit drug use, induction of labour, parity, previous CS, previous spontaneous or therapeutic abortion, pre-eclampsia, gestational age, birthweight, and sex of neonate.



Supplementary Figure 4 – Imputed data – Top row - adjusted absolute risks + 95% CI for hospital length of stay in relation to anaesthetic type and urgency of caesarean section (A) complete data, (B) after removal of six extreme outliers; Bottom row - time-varying absolute risks + 95% CI (ribbon) for hospital length of stay in relation to gestation in weeks for each anaesthetic type in emergency caesarean section, (C) complete data, (D) after removal of six extreme outliers for hospital length of stay.

Supplementary Table 1 – Non-imputed data - Maternal and neonatal characteristics of patients delivered by elective and emergency caesarean section in relation to anaesthetic type (after exclusion of data missing for anaesthetic type).

	Elective n = 54,602				Emergency n = 77,274			
	Missing data	Spinal	Epidural	GA	Missing data	Spinal	Epidural	GA
Anaesthetic type, n (%)	0	46531 (85.2)	6401 (11.7)	1670 (3.1)	0	40179 (52.0)	29550 (38.2)	7545 (9.8)
Age of mother, n (%) ^a , median (IQR)	0	32 (28–36)	32 (28–36)	32 (28–36)	0	30 (26–34)	30 (26–34)	29 (24–34)
Weight of mother, n (%) ^a , median (IQR)	4740 (8.7)	71 (62–84)	70 (61–83)	73 (62–89)	7562 (9.8)	70 (61–83)	69 (60–82)	69 (60–82)
Height of mother, n (%) ^a , median (IQR)	5210 (9.5)	163 (159–168)	163 (159–168)	163 (159–167)	9158 (11.9)	163 (159–168)	163 (158–167)	163 (158–167)
Ethnic group, n (%)	20414 (37.4)				31833 (41.2)			
Asian		1175 (3.9)	186 (5.1)	47 (5.8)		1111 (4.7)	981 (5.6)	197 (4.5)
Black		584 (2.0)	87 (2.4)	22 (2.7)		574 (2.4)	402 (2.3)	86 (2.0)
Mixed		166 (0.6)	18 (0.5)	8 (1.0)		120 (0.5)	81 (0.5)	17 (0.4)
Other		256 (0.9)	25 (0.7)	8 (1.0)		232 (1.0)	149 (0.9)	33 (0.8)
White		27581 (92.7)	3306 (91.3)	719 (89.4)		21611 (91.4)	15830 (90.8)	4017 (92.3)
SIMD decile ^b , n (%)	121 (0.2)				181 (0.2)			
1		5619 (12.1)	741 (11.6)	234 (14.0)		5372 (13.4)	3577 (12.1)	1149 (15.3)
2		5063 (10.9)	573 (9.0)	201 (12.1)		4952 (12.4)	3400 (11.5)	1037 (13.8)
3		4788 (10.3)	529 (8.3)	156 (9.4)		4499 (11.2)	3117 (10.6)	940 (12.5)
4		4663 (10.0)	523 (8.2)	182 (10.9)		4371 (10.9)	2936 (10.0)	825 (11.0)
5		4512 (9.7)	537 (8.4)	135 (8.1)		4158 (10.4)	2784 (9.4)	722 (9.6)
6		4434 (9.6)	583 (9.1)	150 (9.0)		3777 (9.4)	2667 (9.0)	648 (8.6)
7		4393 (9.5)	568 (8.9)	135 (8.1)		3589 (9.0)	2729 (9.3)	576 (7.6)
8		4376 (9.4)	777 (12.1)	149 (8.9)		3466 (8.6)	2939 (10.0)	563 (7.5)
9		4466 (9.6)	793 (12.4)	118 (7.1)		3196 (8.0)	2742 (9.3)	565 (7.5)
10		4105 (8.8)	772 (12.1)	206 (12.4)		2709 (6.8)	2582 (8.8)	506 (6.7)
Smoker during pregnancy, n (%)	2472 (4.5)				3725 (4.8)			
Current		6380 (14.4)	906 (14.6)	270 (17.2)		6651 (17.4)	4166 (14.8)	1781 (25.0)
Former		5415 (12.2)	528 (8.5)	166 (10.6)		5078 (13.3)	4184 (14.8)	946 (13.3)

Never		32566 (73.4)	4762 (76.9)	1137 (72.3)		26495 (69.3)	19838 (70.4)	4410 (61.8)
Injected illicit drugs – YES, n (%)	17400 (31.9)	216 (0.7)	20 (0.6)	19 (2.2)	25058 (32.4)	240 (0.9)	102 (0.5)	84 (1.7)
Spontaneous abortion ≥ 1, n (%)	129 (0.2)	13097 (28.2)	1881 (29.4)	455 (27.3)	226 (0.3)	9666 (24.1)	6300 (21.4)	1844 (24.5)
Therapeutic abortion ≥ 1, n (%)	128 (0.2)	3710 (8.0)	641 (10.0)	157 (9.4)	225 (0.3)	3138 (7.8)	2445 (8.3)	672 (8.9)
Parity, n (%) ^a , median (IQR)	194 (0.4)	1 (1–2)	1 (1–2)	1 (1–2)	326 (0.4)	0 (0–1)	0 (0–1)	0 (0–1)
Previous CS, n (%) ^a , median (IQR)	110 (0.2)	1 (0–1)	1 (0–1)	1 (0–1)	177 (0.2)	0 (0–0)	0 (0–0)	0 (0–0)
Induction, n (%)	99 (0.2)	0 (0.0)	0 (0.0)	0 (0.0)	632 (0.8)	13211 (33.2)	13792 (47.0)	2330 (31.1)
Estimated gestation, n (%)	0	39 (38–39)	39 (38–39)	39 (38–39)	0	39 (37–40)	40 (39–41)	39 (37–40)
Premature (< 37 weeks), n (%)	0	0 (0.0)	0 (0.0)	0 (0.0)	19 (0.0)	8051 (20.0)	1642 (5.6)	1875 (24.9)
Birthweight, n (%) ^a , median (IQR)	34 (0.1)	3490 (3180–3810)	3495 (3180–3808)	3400 (3080–3730)	123 (0.2)	3360 (2850–3790)	3600 (3240–3960)	3210 (2620–3670)
Male sex, n (%)	0	23276 (50.0)	3146 (49.1)	839 (50.2)	2 (0.0)	21546 (53.6)	16443 (55.6)	4216 (55.9)
Pre-eclampsia, n (%)	0	190 (0.4)	22 (0.3)	16 (1.0)	0	1451 (3.6)	799 (2.7)	360 (4.8)

a: n (%) calculated only for missing data

b: the degree of social deprivation was categorised using deciles according to the Scottish Index of Multiple Deprivation (SIMD) with deciles of 1 (most deprived) to 10 (least deprived)

Supplementary Table 2 – Non-imputed data – Unadjusted event rates for neonatal and childhood outcomes of patients delivered by elective and emergency caesarean section in relation to anaesthetic type

	Elective				Emergency			
	No. of events, all anaesthesia types (n=54,602)	Spinal (n=46,531)	Epidural (6,401)	GA (n=1,670)	No. of Events, all anaesthesia types (n=77,274)	Spinal (n=40,179)	Epidural (n=29,550)	GA (n=7,545)
Neonatal resuscitation, n (%)	1201/51082 (2.4)	805/43388 (1.9)	111/6136 (1.8)	285/1558 (18.3)	9767/70685 (13.8)	4474/36641 (12.2)	2935/27306 (10.7)	2358/6738 (35.0)
Apgar score < 7 at 5 mins, n (%)	282/54293 (0.5)	177/46282 (0.4)	20/6350 (0.3)	85/1661 (5.1)	2661/76435 (3.5)	1086/39731 (2.7)	614/29305 (2.1)	961/7399 (13.0)
Admitted to neonatal unit, n (%)	2690/54293 (5.0)	2276/46271 (4.9)	270/6392 (4.2)	144/1630 (8.8)	13225/76528 (17.3)	7877/39813 (19.8)	2997/29276 (10.2)	2351/7439 (31.6)
Long term outcomes								
	No. of events, all anaesthesia types (n=27,954)	Spinal (n=25,089)	Epidural (2,142)	GA (n=723)	No. of Events, all anaesthesia types (n=40,434)	Spinal (n=22,223)	Epidural (n=14,221)	GA (n=3,990)
Days in hospital ^{a,b} , n (%)	–	0 (0–0)	0 (0–0)	0 (0–0)	–	0 (0–0)	0 (0–0)	0 (0–0)
No of unique conditions ^a , n (%)	–	0 (0–1)	0 (0–1)	0 (0–1)	–	0 (0–1)	0 (0–1)	0 (0–1)
Gross motor concern, n (%)	539/26031 (2.1)	471/23447 (2.0)	47/1926 (2.4)	21/658 (3.2)	981/37825 (2.6)	588/20858 (2.8)	242/13247 (1.8)	151/3720 (4.1)
Fine motor concern, n (%)	544/25866 (2.1)	472/23304 (2.0)	47/1911 (2.5)	25/651 (3.8)	1057/37626 (2.8)	613/20751 (3.0)	281/13170 (2.1)	163/3705 (4.4)
Communication concern, n (%)	3476/26307 (13.2)	3083/23653 (13.0)	278/1988 (14.0)	115/666 (17.3)	5372/38191 (14.1)	3044/21041 (14.5)	1642/13412 (12.2)	686/3738 (18.4)
Social concern, n (%)	1093/26321 (4.2)	971/23697 (4.1)	85/1963 (4.3)	37/661 (5.6)	1888/38238 (4.9)	1067/21098 (5.1)	567/13402 (4.2)	254/3738 (6.8)
Any concern noted, n (%)	3700/25398 (14.6)	3296/22911 (14.4)	286/1846 (15.5)	118/641 (18.4)	5785/36889 (15.7)	3287/20344 (16.2)	1739/12913 (13.5)	759/3632 (20.9)

a: median (range)

b: Days in hospital are counts of full days. Hospital stays are counted as 0 if less than 24 hours duration

Supplementary Table 3 – Non-imputed data - Unadjusted relative risks and 95% CI for all outcomes in relation to urgency of caesarean section and type of anaesthesia.

Adjusted Relative Risk (95% CI)				
	Elective		Emergency	
	Epidural vs spinal	GA vs spinal	Epidural vs spinal	GA vs spinal
Neonatal Resuscitation (CI)	0.98 (0.80–1.19)	9.86 (8.70–11.18)	0.88 (0.84–0.92)	2.87 (2.75–2.99)
Apgar Score < 7 at 5 mins (CI)	0.82 (0.52–1.31)	13.38 (10.38–17.25)	0.77 (0.70–0.85)	4.75 (4.37–5.16)
Neonatal unit admission (CI)	0.86 (0.76–0.97)	1.80 (1.53–2.11)	0.52 (0.50–0.54)	1.60 (1.54–1.66)
Long term outcomes				
Days in hospital (CI)	0.95 (0.76–1.18)	2.99 (1.12–7.94)	0.77 (0.65–0.90)	1.28 (1.09–1.50)
No of unique conditions (CI)	0.93 (0.85–1.01)	1.13 (0.97–1.32)	0.81 (0.78–0.85)	1.13 (1.06–1.20)
Gross motor concern (CI)	1.22 (0.89–1.67)	1.55 (0.98–2.46)	0.65 (0.55–0.76)	1.49 (1.25–1.79)
Fine motor concern (CI)	1.20 (0.88–1.64)	1.81 (1.19–2.75)	0.74 (0.64–0.85)	1.53 (1.28–1.82)
Communication concern (CI)	1.11 (0.98–1.26)	1.31 (1.08–1.59)	0.84 (0.79–0.90)	1.29 (1.18–1.40)
Social concern (CI)	1.12 (0.89–1.41)	1.34 (0.95–1.90)	0.82 (0.74–0.92)	1.38 (1.20–1.58)
Any concern noted (CI)	1.08 (0.96–1.20)	1.28 (1.08–1.51)	0.83 (0.79–0.88)	1.29 (1.21–1.39)

Abbreviations: CI, 95% confidence intervals;

Supplementary Table 4 – Non-imputed data - Adjusted relative risks and 95% CI for all outcomes in relation to urgency of caesarean section and anaesthetic type. Results are adjusted for; maternal age, maternal weight, SIMD decile, ethnicity, smoking history, illicit drug use, induction of labour (in emergency cases), parity, previous CS, previous spontaneous or therapeutic abortion, pre-eclampsia, gestational age, birthweight, and sex of neonate.

Adjusted Relative Risk (95% CI)				
	Elective		Emergency	
	Epidural vs spinal	GA vs spinal	Epidural vs spinal	GA vs spinal
Neonatal Resuscitation (CI)	0.84 (0.59–1.19)	12.56 (10.53–14.98)	1.02 (0.96–1.09)	2.65 (2.50–2.82)
Apgar Score < 7 at 5 mins (CI)	0.81 (0.37–1.74)	17.05 (11.92–24.39)	0.93 (0.80–1.08)	4.66 (4.12–5.27)
Neonatal unit admission (CI)	0.80 (0.65–0.98)	1.96 (1.56–2.47)	0.80 (0.76–0.85)	1.24 (1.17–1.31)
Long term outcomes				
Days in hospital (CI)	0.83 (0.59–1.18)	1.11 (0.72–1.72)	1.10 (0.88–1.39)	0.92 (0.72–1.16)
No of unique conditions (CI)	0.85 (0.75–0.96)	1.09 (0.91–1.30)	0.93 (0.88–0.99)	0.99 (0.91–1.08)
Gross motor concern (CI)	1.13 (0.72–1.79)	0.55 (0.21–1.49)	0.84 (0.68–1.05)	1.27 (0.99–1.62)
Fine motor concern (CI)	0.98 (0.60–1.57)	1.02 (0.50–2.07)	0.89 (0.72–1.09)	1.20 (0.94–1.53)
Communication concern (CI)	1.06 (0.88–1.28)	1.05 (0.78–1.41)	0.88 (0.80–0.96)	1.12 (0.99–1.26)
Social concern (CI)	1.14 (0.82–1.58)	0.86 (0.48–1.52)	0.84 (0.72–0.98)	1.14 (0.94–1.38)
Any concern noted (CI)	1.06 (0.91–1.24)	1.04 (0.81–1.33)	0.89 (0.82–0.96)	1.11 (1.00–1.22)

Abbreviations: CI, 95% confidence intervals;

Supplementary Table 5 – Data imputed for covariates only - Adjusted relative risks and 95% CI for all outcomes in relation to urgency of caesarean section and anaesthetic type. Results are adjusted for; maternal age, maternal weight, SIMD decile, ethnicity, smoking history, illicit drug use, induction of labour (in emergency cases), parity, previous CS, previous spontaneous or therapeutic abortion, pre-eclampsia, gestational age, birthweight, and sex of neonate.

Adjusted Relative Risk (95% CI)				
	Elective		Emergency	
	Epidural vs spinal	GA vs spinal	Epidural vs spinal	GA vs spinal
Neonatal Resuscitation (CI)	0.97 (0.80–1.18)	8.92 (7.86–10.14)	1.05 (1.00–1.09)	2.54 (2.43–2.65)
Apgar Score < 7 at 5 mins (CI)	0.83 (0.53–1.30)	11.38 (8.83–14.66)	0.97 (0.88–1.07)	3.92 (3.60–4.26)
Neonatal unit admission (CI)	0.88 (0.78–0.99)	1.67 (1.42–1.96)	0.81 (0.78–0.84)	1.20 (1.16–1.25)
Long term outcomes				
Days in hospital (CI)	0.96 (0.76–1.23)	2.65 (1.01–6.95)	1.13 (0.97–1.32)	1.00 (0.84–1.18)
No of unique conditions (CI)	0.91 (0.84–0.99)	1.06 (0.92–1.23)	0.96 (0.92–1.00)	0.99 (0.93–1.05)
Gross motor concern (CI)	1.17 (0.86–1.60)	1.35 (0.85–2.13)	0.87 (0.74–1.02)	1.17 (0.98–1.41)
Fine motor concern (CI)	1.20 (0.89–1.62)	1.48 (0.98–2.25)	0.98 (0.84–1.13)	1.20 (1.00–1.43)
Communication concern (CI)	1.09 (0.96–1.23)	1.16 (0.96–1.42)	0.95 (0.89–1.01)	1.11 (1.02–1.20)
Social concern (CI)	1.06 (0.85–1.33)	1.17 (0.83–1.66)	0.95 (0.85–1.06)	1.12 (0.97–1.28)
Any concern noted (CI)	1.06 (0.95–1.18)	1.13 (0.96–1.34)	0.95 (0.89–1.00)	1.11 (1.03–1.19)

Abbreviations: CI, 95% confidence intervals;

Supplementary Table 6a – Covariate estimates for neonatal and health care utilisation models using imputed data.

	Neonatal resuscitation	Low Apgar (0<7) at 5 min.	Admission	Days in hospital	No. of unique conditions
Intercept	0.33 (0.23-0.46)	0.29 (0.14-0.56)	52.55 (40.21-68.66)	1309.25 (252.82-6779.95)	96.30 (70.60-131.37)
Anaesthesia type					
Epidural	0.96 (0.79-1.17)	0.83 (0.53-1.30)	0.87 (0.77-0.98)	0.96 (0.76-1.23)	0.91 (0.84-0.99)
GA	8.20 (7.20-9.33)	11.44 (8.88-14.75)	1.65 (1.40-1.94)	2.65 (1.01-6.95)	1.06 (0.92-1.23)
Urgency of delivery	4.49 (4.18-4.83)	5.41 (5.03-5.82)	5.57 (4.75-6.53)	2.83 (2.70-2.97)	0.96 (0.83-1.10)
Age of mother	1.00 (0.99-1.00)	1.00 (0.99-1.00)	1.00 (0.99-1.01)	1.00 (1.00-1.00)	0.98 (0.96-0.99)
Weight of mother	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)
Ethnic group					
Black	1.34 (1.14-1.57)	1.31 (0.98-1.74)	1.12 (1.00-1.25)	1.24 (0.82-1.90)	1.16 (1.02-1.31)
Mixed	1.11 (0.83-1.50)	0.88 (0.45-1.73)	1.09 (0.88-1.36)	1.17 (0.33-4.17)	0.95 (0.75-1.21)
Other	1.07 (0.86-1.32)	1.07 (0.69-1.65)	0.94 (0.76-1.15)	3.34 (0.72-15.47)	1.03 (0.85-1.25)
White	1.10 (0.99-1.21)	1.02 (0.84-1.23)	1.13 (1.05-1.21)	1.03 (0.79-1.33)	0.86 (0.81-0.92)
SIMD Decile					
2	0.99 (0.93-1.06)	1.13 (0.99-1.28)	0.98 (0.93-1.03)	0.94 (0.79-1.10)	1.02 (0.97-1.07)
3	0.97 (0.91-1.04)	1.11 (0.97-1.27)	0.98 (0.93-1.03)	0.97 (0.74-1.27)	1.05 (1.00-1.11)
4	1.02 (0.95-1.09)	1.08 (0.94-1.24)	0.97 (0.92-1.02)	1.17 (0.86-1.59)	0.96 (0.91-1.01)
5	1.05 (0.97-1.13)	1.10 (0.96-1.27)	0.96 (0.91-1.01)	0.91 (0.78-1.07)	1.02 (0.97-1.08)
6	1.08 (1.00-1.17)	1.18 (1.03-1.37)	1.01 (0.95-1.06)	1.09 (0.85-1.38)	1.02 (0.96-1.08)
7	0.99 (0.92-1.07)	1.04 (0.89-1.22)	1.01 (0.95-1.06)	0.94 (0.78-1.15)	1.04 (0.98-1.10)
8	1.00 (0.92-1.09)	1.11 (0.96-1.29)	1.00 (0.94-1.05)	0.95 (0.78-1.16)	1.02 (0.96-1.08)
9	1.02 (0.95-1.11)	1.03 (0.88-1.21)	0.90 (0.85-0.96)	0.94 (0.77-1.14)	0.97 (0.91-1.03)
10	1.01 (0.93-1.09)	1.04 (0.88-1.22)	0.86 (0.81-0.92)	0.96 (0.78-1.18)	0.96 (0.90-1.02)
Smoking history					
Former	0.95 (0.90-1.02)	0.98 (0.87-1.12)	0.93 (0.89-0.98)	0.89 (0.73-1.09)	0.92 (0.87-0.97)
Never	0.94 (0.90-0.98)	0.93 (0.85-1.02)	0.98 (0.95-1.02)	0.94 (0.78-1.12)	0.97 (0.93-1.01)
Injected illicit drugs	0.99 (0.84-1.16)	1.15 (0.84-1.56)	2.10 (1.87-2.36)	1.30 (0.95-1.79)	0.97 (0.84-1.12)
Spontaneous abortion	1.00 (0.96-1.04)	1.01 (0.93-1.09)	1.01 (0.98-1.04)	1.11 (0.96-1.27)	1.11 (1.08-1.15)
Therapeutic abortion	0.99 (0.93-1.05)	1.08 (0.96-1.22)	0.96 (0.92-1.01)	0.93 (0.83-1.04)	1.08 (1.03-1.14)

Parity	1.02 (1.00-1.04)	1.01 (0.97-1.05)	1.00 (0.99-1.02)	1.11 (1.04-1.17)	1.02 (1.01-1.04)
Previous caesarean sections	0.88 (0.85-0.92)	0.92 (0.85-0.99)	0.98 (0.96-1.01)	1.08 (0.98-1.19)	1.00 (0.97-1.02)
Induction: None	1.01 (0.97-1.05)	1.06 (0.97-1.16)	1.13 (1.09-1.17)	0.90 (0.78-1.03)	0.89 (0.85-0.92)
Estimated gestation	0.94 (0.94-0.95)	0.91 (0.89-0.93)	0.84 (0.83-0.85)	0.84 (0.80-0.89)	0.89 (0.88-0.90)
Birthweight of baby	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)
Sex of baby: Male	1.16 (1.12-1.20)	1.29 (1.21-1.39)	1.19 (1.16-1.22)	1.21 (1.07-1.38)	1.29 (1.26-1.33)
Pre-eclampsia	1.13 (1.05-1.22)	1.12 (0.97-1.30)	1.12 (1.06-1.17)	1.03 (0.66-1.60)	0.83 (0.76-0.90)
Analgesia urgency					
Epidural	1.09 (0.89-1.32)	1.16 (0.74-1.83)	0.93 (0.82-1.05)	1.17 (0.88-1.57)	1.05 (0.96-1.16)
GA	0.29 (0.26-0.34)	0.34 (0.26-0.44)	0.73 (0.62-0.86)	0.38 (0.14-1.00)	0.93 (0.80-1.09)

Supplementary Table 6b – Covariate estimates for childhood development models using imputed data.

	Gross motor concern	Fine motor concern	Communication concern	Social concern	Any concern noted
Intercept	2.26 (0.78-6.51)	0.38 (0.14-1.07)	1.23 (0.77-1.96)	2.08 (0.94-4.56)	1.91 (1.30-2.82)
Anaesthesia type					
Epidural	1.13 (0.84-1.51)	1.17 (0.86-1.59)	1.07 (0.95-1.20)	1.02 (0.82-1.26)	1.04 (0.94-1.15)
GA	1.44 (0.94-2.22)	1.57 (1.07-2.29)	1.17 (0.98-1.40)	1.24 (0.90-1.70)	1.15 (0.99-1.34)
Urgency of delivery	1.10 (0.96-1.26)	1.17 (1.02-1.34)	1.04 (0.98-1.10)	1.03 (0.93-1.14)	1.03 (0.98-1.08)
Age of mother	0.98 (0.97-0.99)	0.98 (0.97-0.99)	0.98 (0.97-0.98)	0.98 (0.97-0.98)	0.98 (0.98-0.98)
Weight of mother	1.01 (1.00-1.01)	1.01 (1.01-1.01)	1.01 (1.00-1.01)	1.01 (1.00-1.01)	1.01 (1.00-1.01)
Ethnic group					
Black	0.79 (0.46-1.39)	1.04 (0.65-1.65)	1.02 (0.85-1.22)	0.94 (0.70-1.26)	0.98 (0.83-1.15)
Mixed	0.80 (0.28-2.28)	0.65 (0.21-2.08)	0.67 (0.42-1.09)	0.54 (0.27-1.07)	0.65 (0.43-0.97)
Other	1.34 (0.67-2.67)	1.13 (0.57-2.26)	0.94 (0.70-1.26)	0.89 (0.54-1.45)	0.96 (0.75-1.22)
White	0.94 (0.67-1.32)	0.87 (0.63-1.18)	0.74 (0.66-0.83)	0.58 (0.48-0.71)	0.75 (0.68-0.83)
SIMD Decile					
2	0.90 (0.77-1.06)	1.03 (0.88-1.20)	0.92 (0.86-0.98)	0.89 (0.79-0.99)	0.91 (0.86-0.96)
3	0.83 (0.69-0.99)	1.03 (0.88-1.21)	0.90 (0.84-0.97)	0.85 (0.75-0.95)	0.89 (0.84-0.94)
4	0.91 (0.76-1.09)	0.87 (0.73-1.05)	0.85 (0.79-0.92)	0.80 (0.70-0.91)	0.86 (0.80-0.91)
5	0.79 (0.65-0.96)	0.93 (0.77-1.12)	0.82 (0.75-0.88)	0.70 (0.61-0.81)	0.82 (0.77-0.88)
6	0.81 (0.66-0.98)	0.80 (0.66-0.98)	0.78 (0.71-0.85)	0.68 (0.59-0.79)	0.78 (0.72-0.83)
7	0.90 (0.74-1.10)	0.92 (0.75-1.12)	0.77 (0.70-0.84)	0.66 (0.56-0.76)	0.77 (0.71-0.83)
8	0.67 (0.53-0.84)	0.65 (0.52-0.82)	0.66 (0.61-0.73)	0.54 (0.45-0.63)	0.66 (0.61-0.72)
9	0.73 (0.58-0.93)	0.67 (0.53-0.85)	0.60 (0.54-0.66)	0.48 (0.40-0.58)	0.60 (0.55-0.65)
10	0.67 (0.52-0.88)	0.51 (0.38-0.68)	0.56 (0.50-0.63)	0.44 (0.36-0.55)	0.58 (0.53-0.64)
Smoking history					
Former	0.85 (0.72-1.01)	0.77 (0.65-0.92)	0.85 (0.79-0.91)	0.76 (0.67-0.86)	0.85 (0.80-0.90)
Never	0.78 (0.69-0.88)	0.70 (0.63-0.79)	0.77 (0.73-0.81)	0.64 (0.58-0.69)	0.76 (0.73-0.80)
Injected illicit drugs	1.32 (0.95-1.83)	1.67 (1.28-2.18)	1.19 (1.02-1.39)	1.33 (1.04-1.70)	1.20 (1.06-1.37)
Spontaneous abortion	0.99 (0.89-1.11)	1.05 (0.94-1.17)	1.01 (0.96-1.06)	1.10 (1.01-1.19)	1.02 (0.98-1.06)
Therapeutic abortion	0.98 (0.82-1.16)	0.97 (0.83-1.15)	1.01 (0.94-1.09)	1.01 (0.89-1.14)	1.02 (0.96-1.08)

Parity	1.13 (1.08-1.19)	1.14 (1.09-1.19)	1.10 (1.07-1.12)	1.05 (1.01-1.09)	1.09 (1.07-1.11)
Previous caesarean sections	0.99 (0.91-1.08)	1.03 (0.96-1.12)	1.07 (1.03-1.11)	1.04 (0.97-1.11)	1.06 (1.03-1.09)
Induction: None	0.93 (0.80-1.07)	0.98 (0.86-1.12)	0.98 (0.92-1.04)	0.90 (0.82-0.99)	0.95 (0.90-1.00)
Estimated gestation	0.92 (0.89-0.94)	0.96 (0.93-0.98)	0.96 (0.95-0.98)	0.94 (0.92-0.96)	0.96 (0.95-0.97)
Birthweight of baby	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)
Sex of baby: Male	1.41 (1.27-1.55)	2.31 (2.09-2.56)	2.27 (2.17-2.38)	2.43 (2.25-2.63)	2.06 (1.98-2.14)
Pre-eclampsia	0.91 (0.68-1.22)	0.90 (0.67-1.19)	0.92 (0.81-1.06)	0.73 (0.57-0.94)	0.93 (0.84-1.04)
Analgesia urgency					
Epidural	0.77 (0.56-1.07)	0.83 (0.58-1.18)	0.90 (0.79-1.02)	0.95 (0.75-1.21)	0.92 (0.82-1.03)
GA	0.78 (0.49-1.24)	0.74 (0.48-1.12)	0.92 (0.76-1.12)	0.88 (0.62-1.23)	0.94 (0.80-1.11)

Supplementary Table 7a – Covariate estimates for neonatal and healthcare utilisation models using non-imputed data.

	Neonatal resuscitation	Low Apgar (0<7) at 5 min.	Admission	Days in hospital	No. of unique conditions
Intercept	0.38 (0.23-0.62)	0.52 (0.18-1.47)	63.10 (41.66-95.56)	1282.15 (62.59-26265.84)	115.95 (74.26-181.07)
Anaesthesia type					
Epidural	0.84 (0.59-1.19)	0.81 (0.37-1.74)	0.80 (0.65-0.98)	0.83 (0.59-1.18)	0.85 (0.75-0.96)
GA	12.56 (10.53-14.98)	17.05 (11.92-24.39)	1.96 (1.56-2.47)	1.11 (0.72-1.72)	1.09 (0.91-1.30)
Urgency of delivery	5.74 (5.14-6.40)	5.39 (4.27-6.81)	2.77 (2.59-2.96)	0.93 (0.77-1.13)	0.93 (0.88-0.98)
Age of mother	1.00 (0.99-1.00)	1.00 (0.99-1.00)	1.00 (1.00-1.00)	0.97 (0.95-0.99)	0.98 (0.97-0.98)
Weight of mother	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (0.99-1.01)	1.00 (1.00-1.00)
Ethnic group					
Black	1.58 (1.31-1.91)	1.52 (1.07-2.17)	1.30 (1.11-1.52)	1.44 (0.88-2.34)	1.18 (1.00-1.38)
Mixed	1.37 (1.00-1.88)	0.94 (0.43-2.03)	1.20 (0.90-1.60)	1.16 (0.57-2.37)	0.97 (0.75-1.27)
Other	1.00 (0.74-1.36)	0.88 (0.47-1.64)	0.86 (0.65-1.13)	6.59 (1.08-40.13)	1.04 (0.85-1.28)
White	1.19 (1.05-1.35)	0.94 (0.74-1.19)	1.24 (1.12-1.36)	1.13 (0.80-1.6)	0.87 (0.80-0.96)
SIMD Decile					
2	1.04 (0.94-1.15)	0.95 (0.78-1.17)	0.96 (0.89-1.03)	0.87 (0.72-1.06)	0.98 (0.91-1.06)
3	0.99 (0.90-1.10)	1.02 (0.82-1.25)	0.92 (0.85-1.00)	0.92 (0.72-1.19)	0.96 (0.89-1.04)
4	0.97 (0.88-1.08)	0.98 (0.79-1.22)	0.91 (0.84-0.98)	1.41 (0.88-2.26)	0.89 (0.82-0.97)
5	1.08 (0.97-1.20)	1.05 (0.85-1.31)	0.90 (0.83-0.98)	0.96 (0.78-1.18)	0.96 (0.88-1.04)
6	1.09 (0.98-1.22)	1.16 (0.93-1.44)	0.98 (0.90-1.07)	1.04 (0.72-1.52)	0.94 (0.86-1.02)
7	1.06 (0.95-1.18)	0.90 (0.71-1.14)	1.02 (0.94-1.11)	0.97 (0.76-1.24)	0.95 (0.87-1.03)
8	1.06 (0.95-1.19)	1.00 (0.79-1.26)	0.99 (0.91-1.08)	0.93 (0.73-1.19)	0.94 (0.86-1.03)
9	1.06 (0.95-1.19)	0.92 (0.72-1.18)	0.89 (0.81-0.97)	0.96 (0.73-1.25)	0.89 (0.82-0.97)
10	1.04 (0.93-1.17)	1.01 (0.80-1.28)	0.82 (0.75-0.91)	0.98 (0.76-1.25)	0.85 (0.78-0.93)
Smoking history					
Former	0.98 (0.90-1.07)	1.02 (0.85-1.23)	0.92 (0.86-0.98)	0.91 (0.67-1.25)	0.85 (0.80-0.92)
Never	0.96 (0.90-1.03)	1.09 (0.94-1.27)	1.02 (0.96-1.07)	0.92 (0.67-1.26)	0.93 (0.88-0.98)
Injected illicit drugs	0.86 (0.67-1.12)	1.47 (0.99-2.18)	2.33 (2.02-2.68)	1.10 (0.72-1.70)	0.96 (0.80-1.15)
Spontaneous abortion	1.02 (0.96-1.08)	1.08 (0.96-1.21)	1.04 (0.99-1.09)	1.24 (1.01-1.52)	1.14 (1.10-1.19)
Therapeutic abortion	0.97 (0.90-1.06)	1.05 (0.89-1.24)	0.93 (0.87-1.00)	0.93 (0.80-1.08)	1.04 (0.98-1.11)

Parity	1.02 (1.00-1.05)	1.00 (0.95-1.06)	0.97 (0.95-0.99)	1.06 (0.96-1.17)	1.00 (0.98-1.02)
Previous caesarean sections	0.87 (0.82-0.91)	0.90 (0.81-1.01)	0.99 (0.96-1.03)	1.12 (0.98-1.28)	1.00 (0.96-1.03)
Induction: None	1.02 (0.96-1.08)	0.98 (0.86-1.11)	1.10 (1.04-1.16)	0.81 (0.67-0.98)	0.90 (0.85-0.95)
Estimated gestation	0.94 (0.93-0.95)	0.90 (0.87-0.92)	0.83 (0.82-0.85)	0.85 (0.78-0.94)	0.89 (0.88-0.90)
Birthweight of baby	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)
Sex of baby: Male	1.18 (1.13-1.24)	1.32 (1.19-1.47)	1.25 (1.20-1.30)	1.36 (1.13-1.63)	1.26 (1.21-1.31)
Pre-eclampsia	1.12 (1.01-1.24)	1.33 (1.10-1.62)	1.14 (1.06-1.22)	0.95 (0.43-2.08)	0.77 (0.68-0.87)
Analgesia urgency					
Epidural	1.22 (0.85-1.75)	1.15 (0.53-2.52)	1.01 (0.81-1.25)	1.33 (0.87-2.03)	1.10 (0.96-1.26)
GA	0.21 (0.18-0.25)	0.27 (0.19-0.40)	0.63 (0.50-0.80)	0.82 (0.50-1.35)	0.91 (0.75-1.11)

Supplementary Table 7b – Covariate estimates for childhood development models using non-imputed data.

	Gross motor concern	Fine motor concern	Communication concern	Social concern	Any concern noted
Intercept	4.54 (1.02-20.23)	1.24 (0.28-5.47)	2.36 (1.16-4.80)	7.88 (2.49-24.97)	3.40 (1.9-6.06)
Anaesthesia type					
Epidural	1.13 (0.72-1.79)	0.98 (0.61-1.57)	1.06 (0.88-1.28)	1.14 (0.82-1.58)	1.06 (0.91-1.24)
GA	0.55 (0.21-1.49)	1.02 (0.50-2.07)	1.05 (0.78-1.41)	0.86 (0.48-1.52)	1.04 (0.81-1.33)
Urgency of delivery	1.10 (0.90-1.34)	1.16 (0.95-1.40)	1.06 (0.97-1.15)	1.07 (0.93-1.24)	1.04 (0.97-1.11)
Age of mother	0.98 (0.97-0.99)	0.98 (0.97-0.99)	0.97 (0.97-0.98)	0.97 (0.96-0.98)	0.97 (0.97-0.98)
Weight of mother	1.00 (1.00-1.01)	1.01 (1.00-1.01)	1.01 (1.00-1.01)	1.00 (1.00-1.01)	1.01 (1.00-1.01)
Ethnic group					
Black	0.57 (0.25-1.30)	0.86 (0.45-1.64)	0.87 (0.68-1.12)	0.83 (0.56-1.24)	0.81 (0.65-1.01)
Mixed	0.35 (0.05-2.57)	0.29 (0.04-2.10)	0.56 (0.32-0.98)	0.42 (0.16-1.15)	0.54 (0.33-0.90)
Other	2.00 (0.91-4.38)	0.99 (0.39-2.54)	0.88 (0.60-1.30)	0.86 (0.47-1.57)	0.91 (0.65-1.26)
White	0.93 (0.64-1.36)	0.76 (0.53-1.08)	0.65 (0.57-0.75)	0.46 (0.37-0.58)	0.68 (0.60-0.77)
SIMD Decile					
2	0.84 (0.66-1.08)	0.95 (0.74-1.21)	0.94 (0.85-1.05)	0.83 (0.70-1.00)	0.92 (0.84-1.00)
3	0.88 (0.68-1.13)	1.03 (0.81-1.33)	0.89 (0.80-1.00)	0.78 (0.65-0.94)	0.87 (0.80-0.95)
4	0.81 (0.62-1.07)	0.91 (0.70-1.19)	0.79 (0.70-0.89)	0.80 (0.66-0.97)	0.80 (0.73-0.88)
5	0.63 (0.47-0.85)	0.88 (0.67-1.17)	0.78 (0.69-0.88)	0.64 (0.52-0.80)	0.77 (0.69-0.85)
6	0.65 (0.48-0.89)	0.80 (0.59-1.07)	0.75 (0.66-0.85)	0.70 (0.56-0.86)	0.75 (0.67-0.83)
7	0.76 (0.57-1.03)	0.83 (0.61-1.12)	0.77 (0.68-0.88)	0.66 (0.52-0.82)	0.74 (0.67-0.83)
8	0.60 (0.43-0.83)	0.62 (0.44-0.87)	0.63 (0.55-0.72)	0.52 (0.40-0.66)	0.63 (0.56-0.71)
9	0.69 (0.50-0.95)	0.70 (0.50-0.98)	0.55 (0.47-0.64)	0.41 (0.31-0.55)	0.54 (0.47-0.61)
10	0.57 (0.40-0.82)	0.44 (0.29-0.66)	0.51 (0.43-0.59)	0.38 (0.28-0.51)	0.52 (0.45-0.60)
Smoking history					
Former	0.75 (0.59-0.95)	0.75 (0.60-0.94)	0.85 (0.77-0.94)	0.68 (0.57-0.81)	0.86 (0.79-0.93)
Never	0.71 (0.60-0.86)	0.63 (0.52-0.75)	0.76 (0.70-0.82)	0.57 (0.50-0.66)	0.75 (0.70-0.80)
Injected illicit drugs	1.34 (0.80-2.23)	1.82 (1.18-2.80)	1.13 (0.87-1.47)	1.51 (1.06-2.17)	1.24 (1.02-1.52)
Spontaneous abortion	1.01 (0.86-1.19)	1.12 (0.97-1.31)	1.01 (0.94-1.08)	1.11 (0.99-1.25)	1.04 (0.98-1.10)
Therapeutic abortion	0.79 (0.61-1.02)	0.84 (0.66-1.07)	1.00 (0.90-1.10)	0.96 (0.81-1.14)	1.00 (0.92-1.08)

Parity	1.07 (0.99-1.15)	1.06 (0.99-1.14)	1.07 (1.04-1.11)	1.03 (0.98-1.09)	1.06 (1.03-1.09)
Previous caesarean sections	1.03 (0.91-1.16)	1.10 (0.98-1.23)	1.11 (1.06-1.17)	1.05 (0.96-1.14)	1.10 (1.05-1.15)
Induction: None	0.83 (0.68-1.01)	0.89 (0.73-1.08)	0.96 (0.88-1.05)	0.88 (0.76-1.02)	0.93 (0.87-1.00)
Estimated gestation	0.92 (0.88-0.96)	0.93 (0.89-0.97)	0.95 (0.93-0.97)	0.91 (0.89-0.94)	0.95 (0.93-0.96)
Birthweight of baby	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)
Sex of baby: Male	1.44 (1.25-1.67)	2.38 (2.04-2.77)	2.25 (2.10-2.40)	2.48 (2.21-2.79)	2.05 (1.94-2.17)
Pre-eclampsia	0.61 (0.39-0.97)	0.87 (0.59-1.30)	0.84 (0.69-1.02)	0.61 (0.42-0.88)	0.83 (0.71-0.98)
Analgesia urgency					
Epidural	0.74 (0.45-1.23)	0.91 (0.54-1.53)	0.83 (0.67-1.02)	0.73 (0.51-1.05)	0.84 (0.70-1.00)
GA	2.29 (0.83-6.33)	1.17 (0.56-2.47)	1.07 (0.78-1.46)	1.32 (0.72-2.42)	1.07 (0.82-1.39)

Supplementary Table 8a – Covariate estimates for neonatal and healthcare utilisation (data imputed for covariates only).

	Neonatal resuscitation	Low Apgar (0<7) at 5 min.	Admission	Days in hospital	No. of unique conditions
Intercept	0.43 (0.31-0.60)	0.33 (0.17-0.66)	51.72 (39.51-67.7)	1309.25 (252.82-6779.95)	96.30 (70.6-131.37)
Anaesthesia type					
Epidural	0.97 (0.80-1.18)	0.83 (0.53-1.30)	0.88 (0.78-0.99)	0.96 (0.76-1.23)	0.91 (0.84-0.99)
GA	8.92 (7.86-10.14)	11.38 (8.83-14.66)	1.67 (1.42-1.96)	2.65 (1.01-6.95)	1.06 (0.92-1.23)
Urgency of delivery	5.43 (5.04-5.86)	5.49 (4.68-6.45)	2.84 (2.71-2.97)	0.96 (0.83-1.10)	0.92 (0.89-0.96)
Age of mother	1.00 (0.99-1.00)	1.00 (0.99-1.01)	1.00 (1.00-1.00)	0.98 (0.96-0.99)	0.98 (0.97-0.98)
Weight of mother	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)
Ethnic group					
Black	1.38 (1.17-1.63)	1.31 (0.99-1.75)	1.12 (1.00-1.25)	1.24 (0.82-1.90)	1.16 (1.02-1.31)
Mixed	1.13 (0.83-1.54)	0.89 (0.45-1.75)	1.10 (0.88-1.37)	1.17 (0.33-4.17)	0.95 (0.75-1.21)
Other	1.07 (0.86-1.32)	1.06 (0.69-1.63)	0.94 (0.77-1.16)	3.34 (0.72-15.47)	1.03 (0.85-1.25)
White	1.11 (1.00-1.22)	1.02 (0.84-1.24)	1.13 (1.06-1.21)	1.03 (0.79-1.33)	0.86 (0.81-0.92)
SIMD Decile					
2	0.99 (0.92-1.05)	1.12 (0.98-1.27)	0.98 (0.94-1.03)	0.94 (0.79-1.10)	1.02 (0.97-1.07)
3	0.96 (0.90-1.03)	1.11 (0.97-1.27)	0.99 (0.94-1.04)	0.97 (0.74-1.27)	1.05 (1.00-1.11)
4	1.01 (0.94-1.08)	1.08 (0.94-1.24)	0.98 (0.93-1.03)	1.17 (0.86-1.59)	0.96 (0.91-1.01)
5	1.03 (0.97-1.11)	1.10 (0.96-1.27)	0.97 (0.92-1.02)	0.91 (0.78-1.07)	1.02 (0.97-1.08)
6	1.08 (1.01-1.16)	1.19 (1.03-1.37)	1.02 (0.96-1.07)	1.09 (0.85-1.38)	1.02 (0.96-1.08)
7	0.99 (0.92-1.07)	1.05 (0.90-1.23)	1.02 (0.97-1.08)	0.94 (0.78-1.15)	1.04 (0.98-1.10)
8	1.00 (0.93-1.07)	1.11 (0.95-1.28)	1.01 (0.95-1.06)	0.95 (0.78-1.16)	1.02 (0.96-1.08)
9	1.02 (0.94-1.09)	1.02 (0.87-1.19)	0.91 (0.86-0.97)	0.94 (0.77-1.14)	0.97 (0.91-1.03)
10	1.00 (0.92-1.08)	1.04 (0.88-1.22)	0.87 (0.82-0.93)	0.96 (0.78-1.18)	0.96 (0.90-1.02)
Smoking history					
Former	0.96 (0.90-1.02)	0.99 (0.87-1.13)	0.93 (0.88-0.97)	0.89 (0.73-1.09)	0.92 (0.87-0.97)
Never	0.94 (0.90-0.99)	0.94 (0.85-1.03)	0.98 (0.95-1.02)	0.94 (0.78-1.12)	0.97 (0.93-1.01)
Injected illicit drugs	0.95 (0.80-1.14)	1.15 (0.84-1.59)	2.11 (1.87-2.37)	1.30 (0.95-1.79)	0.97 (0.84-1.12)
Spontaneous abortion	1.01 (0.97-1.05)	1.00 (0.92-1.08)	1.01 (0.98-1.04)	1.11 (0.96-1.27)	1.11 (1.08-1.15)
Therapeutic abortion	0.98 (0.93-1.04)	1.08 (0.96-1.21)	0.97 (0.92-1.01)	0.93 (0.83-1.04)	1.08 (1.03-1.14)

Parity	1.02 (1.00-1.04)	1.01 (0.97-1.05)	1.00 (0.99-1.02)	1.11 (1.04-1.17)	1.02 (1.01-1.04)
Previous caesarean sections	0.88 (0.85-0.91)	0.92 (0.85-0.99)	0.98 (0.96-1.01)	1.08 (0.98-1.19)	1.00 (0.97-1.02)
Induction: None	1.01 (0.97-1.06)	1.06 (0.97-1.15)	1.14 (1.09-1.18)	0.90 (0.78-1.03)	0.89 (0.85-0.92)
Estimated gestation	0.94 (0.93-0.95)	0.91 (0.89-0.92)	0.84 (0.83-0.85)	0.84 (0.80-0.89)	0.89 (0.88-0.90)
Birthweight of baby	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)
Sex of baby: Male	1.18 (1.14-1.22)	1.29 (1.21-1.38)	1.19 (1.16-1.22)	1.21 (1.07-1.38)	1.29 (1.26-1.33)
Pre-eclampsia	1.11 (1.03-1.19)	1.13 (0.97-1.31)	1.12 (1.06-1.18)	1.03 (0.66-1.60)	0.83 (0.76-0.90)
Analgesia urgency					
Epidural	1.08 (0.88-1.31)	1.17 (0.74-1.86)	0.92 (0.81-1.05)	1.17 (0.88-1.57)	1.05 (0.96-1.16)
GA	0.28 (0.25-0.33)	0.34 (0.26-0.45)	0.72 (0.61-0.85)	0.38 (0.14-1.00)	0.93 (0.80-1.09)

Supplementary Table 8b – Covariate estimates for childhood development models (data imputed for covariates only).

	Gross motor concern	Fine motor concern	Communication concern	Social concern	Any concern noted
Intercept	2.78 (0.95-8.16)	0.41 (0.14-1.18)	1.26 (0.77-2.06)	2.53 (1.12-5.74)	2.07 (1.38-3.10)
Anaesthesia type					
Epidural	1.17 (0.86-1.60)	1.20 (0.89-1.62)	1.09 (0.96-1.23)	1.06 (0.85-1.33)	1.06 (0.95-1.18)
GA	1.35 (0.85-2.13)	1.48 (0.98-2.25)	1.16 (0.96-1.42)	1.17 (0.83-1.66)	1.13 (0.96-1.34)
Urgency of delivery	1.11 (0.96-1.29)	1.16 (1.01-1.34)	1.03 (0.97-1.09)	1.04 (0.94-1.15)	1.03 (0.98-1.08)
Age of mother	0.98 (0.97-0.99)	0.98 (0.97-0.99)	0.98 (0.97-0.98)	0.97 (0.97-0.98)	0.98 (0.97-0.98)
Weight of mother	1.01 (1.00-1.01)	1.01 (1.01-1.01)	1.01 (1.00-1.01)	1.01 (1.00-1.01)	1.01 (1.00-1.01)
Ethnic group					
Black	0.76 (0.43-1.36)	1.01 (0.58-1.75)	1.00 (0.82-1.22)	0.88 (0.65-1.21)	0.96 (0.80-1.14)
Mixed	0.78 (0.25-2.38)	0.60 (0.17-2.14)	0.65 (0.40-1.06)	0.57 (0.27-1.18)	0.62 (0.40-0.95)
Other	1.36 (0.68-2.74)	1.09 (0.51-2.34)	0.92 (0.67-1.27)	0.85 (0.50-1.44)	0.93 (0.71-1.21)
White	0.93 (0.66-1.30)	0.87 (0.62-1.21)	0.75 (0.66-0.84)	0.58 (0.47-0.71)	0.76 (0.68-0.85)
SIMD Decile					
2	0.90 (0.75-1.07)	1.03 (0.87-1.21)	0.91 (0.85-0.98)	0.87 (0.77-0.98)	0.90 (0.85-0.96)
3	0.78 (0.65-0.95)	1.04 (0.87-1.24)	0.90 (0.84-0.97)	0.83 (0.73-0.95)	0.88 (0.83-0.94)
4	0.89 (0.74-1.08)	0.88 (0.73-1.07)	0.85 (0.78-0.92)	0.79 (0.69-0.91)	0.86 (0.80-0.91)
5	0.76 (0.62-0.94)	0.97 (0.80-1.17)	0.80 (0.74-0.88)	0.69 (0.59-0.80)	0.81 (0.76-0.87)
6	0.78 (0.63-0.96)	0.82 (0.66-1.01)	0.76 (0.70-0.83)	0.66 (0.56-0.77)	0.76 (0.71-0.82)
7	0.87 (0.70-1.07)	0.95 (0.77-1.16)	0.76 (0.70-0.83)	0.63 (0.53-0.74)	0.76 (0.70-0.82)
8	0.67 (0.53-0.85)	0.67 (0.53-0.85)	0.66 (0.60-0.73)	0.53 (0.45-0.64)	0.66 (0.61-0.72)
9	0.73 (0.57-0.93)	0.66 (0.51-0.85)	0.59 (0.53-0.65)	0.46 (0.38-0.56)	0.59 (0.54-0.64)
10	0.66 (0.50-0.86)	0.49 (0.36-0.66)	0.53 (0.47-0.60)	0.40 (0.32-0.50)	0.56 (0.50-0.62)
Smoking history					
Former	0.81 (0.68-0.97)	0.74 (0.62-0.88)	0.84 (0.78-0.90)	0.73 (0.64-0.83)	0.84 (0.79-0.89)
Never	0.75 (0.66-0.86)	0.68 (0.60-0.78)	0.76 (0.72-0.80)	0.62 (0.56-0.68)	0.75 (0.72-0.79)
Injected illicit drugs	1.38 (0.98-1.93)	1.72 (1.30-2.28)	1.16 (0.98-1.38)	1.33 (1.04-1.71)	1.19 (1.03-1.37)
Spontaneous abortion	0.98 (0.87-1.11)	1.06 (0.95-1.19)	1.00 (0.95-1.05)	1.10 (1.01-1.20)	1.02 (0.98-1.06)
Therapeutic abortion	0.95 (0.79-1.14)	0.92 (0.77-1.10)	1.01 (0.94-1.09)	1.00 (0.87-1.13)	1.01 (0.95-1.08)

Parity	1.13 (1.07-1.19)	1.14 (1.09-1.20)	1.10 (1.07-1.12)	1.05 (1.01-1.10)	1.09 (1.07-1.11)
Previous caesarean sections	0.98 (0.90-1.08)	1.03 (0.95-1.12)	1.07 (1.03-1.11)	1.03 (0.97-1.10)	1.07 (1.03-1.10)
Induction: None	0.91 (0.79-1.06)	0.98 (0.85-1.13)	0.97 (0.91-1.03)	0.90 (0.81-1.00)	0.94 (0.89-0.99)
Estimated gestation	0.92 (0.89-0.94)	0.96 (0.93-0.99)	0.96 (0.95-0.98)	0.93 (0.91-0.96)	0.96 (0.95-0.97)
Birthweight of baby	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)
Sex of baby: Male	1.35 (1.22-1.50)	2.31 (2.07-2.57)	2.28 (2.17-2.39)	2.46 (2.27-2.68)	2.07 (1.99-2.15)
Pre-eclampsia	0.86 (0.64-1.16)	0.90 (0.67-1.21)	0.88 (0.76-1.02)	0.67 (0.51-0.89)	0.89 (0.79-1.00)
Analgesia urgency					
Epidural	0.74 (0.52-1.05)	0.82 (0.58-1.14)	0.87 (0.76-1.00)	0.90 (0.70-1.15)	0.89 (0.79-1.01)
GA	0.87 (0.53-1.42)	0.81 (0.51-1.27)	0.95 (0.77-1.18)	0.95 (0.65-1.39)	0.98 (0.81-1.17)

Supplementary Table 9 – Comparison of maternal and neonatal characteristics between cases who had and did not have data for developmental outcomes.

	Missing data	Elective		Emergency	
		No data for development outcomes (n=29,083)	Data for development outcomes (n=28,888)	No data for development outcomes (n=40,602)	Data for development outcomes (n=42,293)
Anaesthetic type, n (%)	8990				
Epidural		4259 (16.0)	2142 (7.7)	15329 (41.6)	14221 (35.2)
GA		947 (3.6)	723 (2.6)	3555 (9.6)	3990 (9.9)
Spinal		21442 (80.5)	25089 (89.8)	17956 (48.7)	22223 (55.0)
Age of mother, median (IQR)	0	32 (28–36)	32 (28–36)	30 (26–34)	30 (25–34)
Weight of mother, median (IQR)	18696	71 (62–84)	71 (62–85)	69 (60–82)	70 (60–83)
Height of mother, median (IQR)	18687	163 (159–168)	163 (159–168)	163 (158–167)	163 (159–167)
Ethnic group, n (%)	59283				
Asian		679 (4.4)	750 (3.8)	1200 (6.0)	1140 (4.3)
Black		365 (2.4)	340 (1.7)	580 (2.9)	521 (1.9)
Mixed		105 (0.7)	89 (0.5)	120 (0.6)	105 (0.4)
Other		179 (1.2)	116 (0.6)	273 (1.4)	153 (0.6)
White		13964 (91.3)	18319 (93.4)	17773 (89.1)	24812 (92.8)
SIMD decile ^a , n (%)	321				
1		3302 (11.4)	3838 (13.3)	5164 (12.8)	6086 (14.4)
2		2972 (10.2)	3209 (11.1)	4601 (11.4)	5407 (12.8)
3		2835 (9.8)	2940 (10.2)	4302 (10.6)	4809 (11.4)
4		2730 (9.4)	2904 (10.1)	4172 (10.3)	4436 (10.5)
5		2691 (9.3)	2776 (9.6)	3980 (9.8)	4167 (9.9)
6		2707 (9.3)	2746 (9.5)	3615 (8.9)	3939 (9.3)
7		2672 (9.2)	2695 (9.3)	3625 (9.0)	3680 (8.7)
8		2997 (10.3)	2708 (9.4)	3865 (9.5)	3650 (8.6)
9		3073 (10.6)	2677 (9.3)	3834 (9.5)	3206 (7.6)

10		3031 (10.4)	2339 (8.1)	3330 (8.2)	2835 (6.7)
Smoker during pregnancy, n (%)	9566				
Current		3604 (13.4)	4248 (15.6)	5768 (15.4)	7473 (18.8)
Former		2943 (11.0)	3341 (12.2)	4800 (12.8)	5772 (14.5)
Never		20321 (75.6)	19695 (72.2)	26831 (71.7)	26504 (66.7)
Injected illicit drugs – YES, n (%)	50112	87 (0.6)	171 (0.8)	107 (0.5)	329 (1.0)
Spontaneous abortion ≥1, n (%)	378	7944 (27.4)	8480 (29.4)	9087 (22.4)	10059 (23.9)
Therapeutic abortion ≥1, n (%)	375	2310 (8.0)	2366 (8.2)	3057 (7.5)	3508 (8.3)
Parity, median (IQR)	554	1 (1–2)	1 (1–2)	0 (0–1)	0 (0–1)
Previous CS, median (IQR)	378	1 (0–1)	1 (0–1)	0 (0–0)	0 (0–0)
Induction, n (%)	1021	0 (0.0)	0 (0.0)	15309 (38.1)	16041 (38.3)
Est gestation, median (IQR)	0	39 (38–39)	39 (38–39)	40 (38–41)	40 (38–41)
Premature (< 37 weeks), n (%)	20	0 (0.0)	0 (0.0)	5703 (14.1)	6769 (16.0)
Birthweight, median (IQR)	181	3490 (3185– 3820)	3480 (3170– 3800)	3470 (3010–3860)	3440 (2960–3840)
Male sex, n (%)	6	14465 (49.7)	14471 (50.1)	22080 (54.4)	23221 (54.9)
Pre-eclampsia, n (%)	0	122 (0.4)	122 (0.4)	1377 (3.4)	1428 (3.4)

a: the degree of social deprivation was categorised using deciles according to the Scottish Index of Multiple Deprivation (SIMD) with deciles of 1 (most deprived) to 10 (least deprived)

Supplementary Table 10 – Imputed data - Adjusted relative risks for outcomes in relation to anaesthetic type and urgency of caesarean section referent to spinal anaesthesia (RR = 1) following removal of six outliers for the outcome of (length of hospital stay > 200 days). Results are adjusted for maternal age, maternal weight, SIMD decile, ethnicity, smoking history, illicit drug use, induction of labour (in emergency cases), parity, previous CS, previous spontaneous or therapeutic abortion, pre-eclampsia, gestational age, birthweight, and sex of neonate.

Adjusted Relative Risk (95% CI)				
	Elective		Elective	
	Epidural vs spinal	GA vs spinal	Epidural vs spinal	GA vs spinal
Neonatal resuscitation	0.96 (0.79–1.17)	8.20 (7.21–9.33)	1.04 (1.00–1.09)	2.40 (2.30–2.50)
Apgar Score < 7 at 5 mins	0.83 (0.53–1.30)	11.45 (8.88–14.75)	0.96 (0.87–1.06)	3.87 (3.56–4.20)
Neonatal unit admission	0.87 (0.77–0.98)	1.65 (1.40–1.94)	0.81 (0.78–0.84)	1.20 (1.15–1.25)
Long term outcomes				
Days in hospital	1.01 (0.80–1.28)	1.50 (0.86–2.60)	1.09 (0.95–1.25)	1.06 (0.91–1.23)
No of conditions	0.91 (0.84–0.99)	1.02 (0.89–1.16)	0.96 (0.92–1.00)	0.99 (0.93–1.05)
Gross motor	1.13 (0.84–1.51)	1.43 (0.93–2.21)	0.87 (0.75–1.01)	1.13 (0.95–1.34)
Fine motor	1.17 (0.86–1.59)	1.57 (1.07–2.29)	0.97 (0.84–1.12)	1.15 (0.97–1.37)
Communication	1.07 (0.95–1.20)	1.17 (0.98–1.40)	0.96 (0.90–1.02)	1.08 (1.00–1.17)
Social	1.02 (0.82–1.26)	1.23 (0.90–1.70)	0.96 (0.87–1.07)	1.08 (0.95–1.24)
Any concern noted	1.04 (0.94–1.15)	1.14 (0.98–1.33)	0.96 (0.91–1.01)	1.08 (1.01–1.16)

Abbreviations: CI, 95% confidence intervals;

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