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Title: Risk of postpartum haemorrhage is associated with ethnicity: a cohort study of 981 801 births in England

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Abstract

Objective: To determine the association between ethnic group and risk of postpartum haemorrhage in women giving birth.

Design: Cohort study.

Setting: Maternity units in England.

Population or Sample: 981 801 records of births between 1st April 2015 and 31st March 2017 in a national clinical database.

Methods: Multivariable logistic regression analyses with multiple imputation to account for missing data and robust standard errors to account for clustering within hospitals.

Main Outcome Measures: Postpartum haemorrhage of 1500ml or more (PPH).

Results: 28 268 (2.9%) of births were complicated by PPH. Risks were higher in women from black (3.9%) and other (3.5%) ethnic backgrounds. Following adjustment for maternal and fetal characteristics, and care at birth, there was evidence of an increased risk of PPH in women from all ethnic minority groups, with the largest increase seen in black women (adjusted odds ratio 1.54 (1.45 to 1.63)). The increase in risk was robust to sensitivity analyses which included changing the outcome to PPH of 3000ml or more.

Conclusions: In England, women from ethnic minority backgrounds have an increased risk of PPH, when maternal, fetal and birth characteristics are taken into account. Factors contributing to this increased risk need further investigation. Perinatal care for women from ethnic minority backgrounds should focus on preventative measures to optimise maternal outcomes.

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Tweetable abstract

Women with an ethnic minority background giving birth in England have an increased risk of postpartum haemorrhage, even when characteristics of the mother, the baby, and the care received are taken into account.

Introduction

Postpartum haemorrhage (PPH), an increased loss of blood at the time of or after birth, is associated with significant morbidity and is a leading cause of maternal death in all settings.[1,2] The experience of PPH is traumatic,[3] and recovery is associated with secondary consequences including an increased risk of postpartum depression and lower rates of breastfeeding.[4,5]

PPH is the result of an interplay of pre-existing risk factors, and events which occur during the labour and birth, and immediate management. It is generally considered that initiatives to reduce the risks related to PPH require a three-step process of prevention, treatment, and rescue.[6] The risk of PPH can be reduced, at least partially, by the use of interventions such as the administration of oxytocin and tranexamic acid.[7,8]

Ethnic background is known to be a determinant of variation in the outcomes of women receiving maternity care across the world.[1] Women from black and south Asian ethnic groups are more likely to experience severe morbidity at the time of birth.[1,9] We have previously demonstrated that black women in the UK have an increased risk of maternal admission to intensive care (ICU) and that haemorrhage is the leading cause of an ICU admission among black women.[10] However, not all women with PPH require intensive care, and significant morbidity is not confined to those with ICU admission. In the US, it has been shown that women from Hispanic and Pacific Islander ethnic backgrounds have an increased risk of PPH,[11] and among non-Hispanic black women, there is an increased risk of severe sequelae of PPH.[12] A national study in Sweden demonstrated that women born outside Sweden were at higher risk of haemorrhage requiring a large transfusion.[13] However, current clinical guidelines do not consider the differential experience of severe morbidity, including postpartum haemorrhage, according to a woman's ethnic background.[8,14–16]

The aim of this study was to understand the association between ethnic background and the risk of PPH using routinely collected data available in England, whether this association differs by level of socioeconomic deprivation, and to what extent the association between ethnic background and PPH is explained by maternal, fetal and birth characteristics.

Methods

Data source

We used a national maternity dataset that was created for the purpose of the National Maternity and Perinatal Audit, a national programme to evaluate care for women giving birth and their babies in Britain (www.maternityaudit.org.uk). This included data routinely collected in the course of clinical care, which was extracted from the maternity information systems (MIS) used in National Health Service (NHS) hospitals in England. These were cleaned, collated and linked to the Hospital Episode Statistics (HES), an administrative dataset which contains information about all hospital admissions within NHS hospital trusts. Trusts are administrative organisations which provide hospital and hospital-associated community care, including home births, in a particular area in England. In England, all women are eligible to give birth in the NHS and almost all do; in 2015-17, only 0.4% of births occurred in non-NHS settings (these are most commonly private hospitals).[17] The dataset collated for the NMPA includes approximately 94% of births which occurred in England in the time period.[18,19]

Definition of cohort

The eligible population was all births between 1st April 2015 and 31st March 2017 in the NHS in England. We restricted the cohort to births in NHS hospital trusts in which over 80% of MIS records contained information about blood loss. Records were included if they recorded either a live or stillbirth that occurred at or after 24 completed gestational weeks and if the delivery record contained complete information about blood loss. Characteristics of included and excluded records are described in Table S1 and the data flow is summarised in Figure 1.

Definition of variables

The primary outcome of this study was maternal blood loss at birth of 1500ml or more. Blood loss is typically estimated using a combination of visual estimates, physiological assessment, and the results of weighing drapes and pads.[20,21] Clinical guidelines in the UK suggest that blood loss of 1500ml or more should be treated as severe PPH with the mobilisation of appropriate staff.[14] In other countries, clinical guidelines include thresholds of 500 and 1000ml.[22,23] Estimated blood loss has been identified as a core outcome for studies related to prevention and treatment of PPH.[24] In our study, we defined PPH as blood

loss of 1500ml or more in line with the UK definition of severe PPH, but also examined risk of PPH at 500, 1000, 1500, 2000 and 3000ml.

Ethnicity was primarily derived from the hospital admission record (Hospital Episode Statistics (HES)) and infilled where not useable (unknown (ethnos codes 9, X, Z) or missing) from the MIS record. Ethnic background was classified using the ethnic groups defined for the 2001 UK Census. For the purposes of this analysis, these ethnic groups were collapsed into five groups: 'white', 'south Asian', 'black', 'mixed' and 'other'.[25] This was done because there is evidence that in routinely collected records, more granular analyses can lead to misclassification bias,[26] and to avoid small numbers for some of the ethnic groups.

From the MIS, Information was available about maternal characteristics including age, body mass index (BMI), parity, and whether the woman had previously had a caesarean section; and about fetal characteristics including live or stillbirth, multiple birth, and birthweight. Information was also available about the birth: the onset of labour, mode of birth (unassisted vertex, breech vaginal, instrumental vaginal, emergency caesarean or elective caesarean), and whether there was an episiotomy or manual removal of the placenta. Where this information was missing in the MIS record, it was infilled if available from the HES record, with information about parity and previous caesarean section derived from historical records in HES as described elsewhere.[19] Maternal health conditions complicating pregnancy (grouped into hypertensive disorders including pre-existing or gestational; diabetes pre-existing or gestational; conditions which make bleeding more likely; or placental abnormalities including placenta praevia or accreta) were identified using ICD-10 codes[27] recorded in HES in the birth episode.[23] Information about socioeconomic group was available from the Index of Multiple Deprivation (IMD), an area-level measure that encompasses information about social deprivation, economic status, employment and health deprivation of each local area of approximately surrounding a woman's postcode at the time of birth as recorded in the MIS.[28]

Statistical analyses

Descriptive statistics, including the presence of risk factors, were tabulated according to ethnic background, with continuous risk factors dichotomised for brevity. Chi squared statistics were used to compare distributions of characteristics between groups. Logistic regression was used to estimate odds ratios between each included characteristic and risk of PPH.

Multivariable logistic regression models, with robust standard errors to account for clustering within hospital trusts (the Huber/White/sandwich estimator of variance, affecting the standard errors of the estimates but not the estimated coefficients)[29], were used to estimate odds ratios for PPH by ethnic group, with sequential adjustment for characteristics related to the mother, the baby, and the care received. Within the models, we categorised continuous variables (7 categories for maternal age, 6 categories for BMI, 3 categories for gestational age and 4 categories for birthweight). We also recategorised parity of 3 or more into the same group to account for smaller numbers with parity above 3. Details of all coding frameworks used are available in Table S1.

Crude odds ratios for PPH by ethnic group were estimated by logistic regression. The first multivariable model adjusted for maternal characteristics: the mother's age, socioeconomic group, parity, BMI, previous caesarean, and maternal health conditions complicating pregnancy. The second model included these maternal characteristics, as well as fetal characteristics at birth: multiple birth, stillbirth and birthweight. The third, 'full' model additionally included factors relating to the woman's maternity care: induction of labour, mode of birth, episiotomy, and manual removal of placenta. All models also adjusted for the financial year of birth.

For multiple births, the highest birthweight was used, and the birth was treated as a stillbirth if one baby was stillborn.

Interactions between ethnic and socioeconomic background and between parity and previous caesarean were considered plausible a priori. We evaluated whether there was evidence for these interactions by including an additional interaction term in the full model and using a global Wald test to compare this to the model without the interaction term. For both tests $p>0.1$, so neither interaction was included in the full model.

Missing values were imputed using multiple imputation by chained equations with statistical coefficients obtained in 40 imputed data sets, with the number of datasets chosen to mirror the proportion of cases with any missing data, and pooled using Rubin's rules.[30] Multiple imputation requires the assumption that data is missing at random given the variables used in the imputation model. To test the sensitivity of findings to this assumption, we conducted a sensitivity analysis in which the fully adjusted analysis was repeated in cases with complete information about all covariates; analyses using complete cases have been found to be robust to a wider range of missingness assumptions.[31]

We conducted two further sensitivity analyses to address concerns regarding incomplete information about known risk factors for PPH. In the second sensitivity analysis, to address the lack of information about previous PPH, we restricted the cohort to primiparous women. In the third, to address incomplete information about augmentation of labour, we included additional adjustment for whether the labour was augmented (as a binary variable) in 650 941 women where this was available. This variable was not included in the primary analysis due to concerns about its quality and the high proportion of missing data.[19]

In two further sensitivity analyses, we changed the outcome to PPH of 500ml or more and to 3000ml or more to assess whether the same relationship was observed. These thresholds was chosen to, first, represent the WHO definition of PPH;[16] and second, to represent a cohort of women who were likely to require additional care, such as in an intensive care unit.

All analyses were performed in Stata v16.

Results

The records of 981 801 births between 1st April 2015 and 31st March 2017 were included in the analysis. Of these, 906 961 (92.4%) had complete information about ethnic background.(Figure 1, Table 1) 705 948 of those with complete ethnicity information (77.8%) were white, 107 382 (11.8%) were south Asian, 42 170 (4.6%) were black, 16 456 (1.8%) were mixed and 35 005 (3.9%) were from other ethnic backgrounds.(Table 1)

28 268 (2.9%) of 981 801 births had a recorded blood loss of 1500ml or more (Table 2). When different thresholds were examined, 322 606 (32.9%) of births had a recorded blood loss of 500ml or more; 75 674 (7.7%) had a recorded blood loss of 1000ml or more; 28 268 births (1.2%) had a blood loss of 2000ml or more; and 249 (0.3%) births 3000ml or more. Regardless of definition, the risk of PPH was higher in black women and in women from other ethnic backgrounds. Women with no recorded information about ethnic group had elevated risk of PPH at all thresholds compared to the population average (Table 2).

Compared to white women, the unadjusted risk of PPH of 1500ml or more was increased in black women (crude odds ratio 1.42, 95% CI: 1.35 to 1.50), and in women from other ethnic backgrounds (crude odds

ratio 1.27, 95% CI: 1.20 to 1.35) (Table 3). These associations were not substantially altered by adjustment for maternal characteristics, fetal characteristics, or information about the woman's maternity care (aOR for black women including all available information 1.54, 95% CI 1.45 to 1.63; aOR for women from other groups 1.37, 95% CI 1.29 to 1.46).

There was evidence of an increase in the risk of PPH in women from mixed and south Asian ethnic groups only following risk adjustment. For women from south Asian groups, the unadjusted odds of PPH was lower than in white women (crude OR 0.94. 95% CI 0.90 to 0.97); however following adjustment for maternal and fetal characteristics, the direction changed. Following adjustment for all maternal, fetal and birth characteristics, women from south Asian groups had increased odds of PPH compared to white women (aOR 1.14, 95% CI 1.09 to 1.19). For women from mixed groups, however, a stronger effect emerged after adjustment for maternal and fetal characteristics at the time of birth (aOR 1.17, 95% CI 1.07 to 1.28) and persisted following adjustment for birth characteristics (aOR 1.20, 95% CI 1.09 to 1.32) (Table 3). When fetal characteristics were compared between ethnic groups, women in south Asian groups had smaller babies than women from other ethnic groups; women from mixed ethnic groups were also more likely to have a smaller baby than white women (Table S3).

Many of the maternal, fetal and birth characteristics were strongly associated with an increased risk of PPH. We found evidence of a substantially elevated risk of PPH in older women, women with higher BMI and placental abnormalities; in women with stillbirth, preterm birth, multiple birth and increased fetal weight, as well as with assisted or caesarean birth and births with episiotomy (Table S4). While increasing socioeconomic deprivation was associated with a reduction in the risk of PPH (Table S4), we found no evidence of any effect modification of the observed association with ethnicity by socioeconomic deprivation (Table S5).

In sensitivity analyses restricting the cohort to primiparous women, including augmentation as an additional covariate in the model and changing the outcome to PPH of 500ml or more and to 3000ml or more, very similar patterns of association with ethnic group were seen (Table S6).

Discussion

Summary of findings

Women from black and other ethnic groups are more likely to experience postpartum haemorrhage at the time of birth, regardless of the volume of blood loss used to define PPH. Following adjustment for maternal and fetal characteristics, particularly birthweight, women from all ethnic minority groups have an increased risk of PPH. This association remains following adjustment for characteristics of the woman's birth.

Strengths and Limitations

This study uses data routinely collected in the course of clinical care, with a diverse population that covers approximately 85% of births that occurred in England between 1st April 2015 and 31st March 2017. Strengths of this study include its large size of nearly one million births, and the detailed information available about the woman, her baby and her care, including maternal BMI, comorbidities occurring prior to and during pregnancy, and care at the time of birth. These characteristics were not available to other research groups evaluating association between ethnic group and PPH. [12,32]

Our dataset contains limited information regarding some risk factors for PPH, including the administration of oxytocin for augmentation, previous PPH, maternal anaemia, and length of labour. Although there is a diagnosis code in ICD for PPH, which may be considered to enable 'look-back' it gives substantially lower ascertainment of PPH than in our data, as found previously, and so was not used (Table S7).[33] Our analyses were, however, robust to sensitivity analyses for inclusion of a binary variable for augmentation, and restriction to primiparous women in whom historical PPH is not a factor.

Our central limitation is that, like many observational studies in maternity care, this study lacks information about the measures taken to mitigate the risk of PPH such as the administration of prophylactic synthetic oxytocin or tranexamic acid.[7,8] As a consequence, the observed associations are likely to be influenced by the risk mitigation measures and the initial treatment which may have weakened the association that we report in this paper between the women's ethnic background and the occurrence of post-partum haemorrhage.[34]

A further limitation in this study is the lack of information about the methods used to estimate blood loss at the time of birth. Measurement of blood loss through visual, or other, estimation is heterogenous;

more robust methods of estimation include the weighing of drapes or swabs.[35] Method of estimating blood loss is, however, unlikely to vary by ethnic group.

Interpretation

In the UK, although maternity care is free at the point of access, ethnic and socioeconomic inequalities are still observed in maternal and perinatal mortality.[1,36] This association between maternal ethnic group and risk of PPH, while observed by others, has not been recently evaluated in a setting where healthcare availability is not associated with ethnic group and ability to pay.[12]

It is unlikely that the observed increased risk of PPH is mediated through a woman's socioeconomic background: in our study, we observed no evidence of an increase in postpartum haemorrhage associated with increased socioeconomic deprivation. This concurs with findings of a previous study using registry data from the UK Obstetric Surveillance System, which demonstrated no statistically significant relationship between maternal socioeconomic group and severe maternal morbidity,[37] and with a previous study in our dataset which demonstrated no association between maternal intensive care admission and socioeconomic deprivation. Postpartum haemorrhage is an emergency which occurs when women are usually already in a healthcare setting: more widely, it has been shown that differences in outcome by socioeconomic group are largely driven by richer individuals presenting earlier in their illness and utilising their ability to exercise choice to improve their waiting periods, with little evidence of differential quality of care based on socioeconomic group within the NHS once that care is accessed.[38,39]

Our finding that women from an ethnic minority background are more likely to experience PPH has two possible explanations. First, there may be additional confounding factors not accounted for in our analysis that are associated with both PPH and ethnic minority group. Second, that women from ethnic minority groups are not given the same level of intra- and postpartum observation and prophylactic treatment to prevent PPH.

With respect to the first potential explanation, we were in our dataset unable to adjust for, or examine through sensitivity analysis, the potential association with prolonged labour or previous PPH. However, this is unlikely to have accounted for our results. There is some limited observational evidence that women from black ethnic groups have shorter, rather than longer second stages of labour.[40] In a sensitivity analysis restricting to primiparous women, who have no previous history of PPH, similar results were seen. We were also unable to adjust for maternal anaemia, levels of which may be higher in women

from some ethnic groups[41]. Furthermore, while we were able to adjust for the presence of fibroids where they were coded as a diagnosis, it is possible that this does not capture all fibroids present as not all will be identified on antenatal scans, or considered clinically significant enough to modify care recommendations and thus warrant coding.[42] Further investigation is required to understand whether there are biological considerations regarding effectiveness of medications commonly used to control PPH. [42]

It is also possible that prophylactic treatment and observational measures are not equally considered and offered between ethnic groups. Women from ethnic minority groups in the UK report poorer experiences of antenatal and intrapartum care which may be reflected in less attention to risk factors, antenatal symptoms of anaemia or concerns and symptoms indicative of PPH.[43,44] Investigating this hypothesis requires further detail regarding care pathways, which is not possible in this analysis of routinely collected electronic health data. A case-control study could be used to assess treatment differences by ethnic group.

However, while further investigations are ongoing, it would be prudent for healthcare professionals to be aware of the increased observed risk in women from ethnic minority groups, with the aim of being particularly attentive in monitoring for early identification and treatment of PPH.

Conclusion

Women from an ethnic minority background, and particularly women from a black ethnic group, are at increased risk of PPH. This association persists following adjustment for maternal, fetal and birth characteristics. Further investigation is needed to understand the unexplained increase in risk, including possible mechanisms and the effectiveness of medications to control bleeding in women from different ethnic groups. While the results of further investigations are awaited, clinical and policy action should focus on the prediction, early identification and management of severe illness and postpartum haemorrhage in women from ethnic minority groups, in order to reduce observed inequalities. Healthcare professionals should be aware of this increased observed risk of postpartum haemorrhage in ethnic minority groups, and, as with all women, be enabled to identify and treat PPH rapidly, to mitigate risk of maternal morbidity and mortality.

Supporting statements

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Author contribution: JJ, JvdM, DP and KW conceived the study. All authors planned the analysis. JJ conducted the analysis and wrote the first draft of the paper. All authors reviewed and redrafted the study. KW supervised the study.

Ethical approval: This study used data routinely collected in clinical care to evaluate service provision and performance and therefore individual consent was not sought. Institutional consent to access the data was provided by the NHS Health Research Authority Confidentiality Advisory Group, approval number 16/CAG/0058. This study was approved by the LSHTM Ethics Committee, approval number 14544, on 4th April 2018.

Patient and Public Involvement: The questions addressed by this study were informed by discussions from the NMPA's Inequalities Sprint Audit reference group, which includes women with lived experience of pregnancy and birth in the UK from diverse ethnic and socioeconomic groups.

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Table 1. Summary characteristics of 906 961 births in England with complete recorded information about maternal ethnic group between 1st April 2015 and 31st March 2017

	*Births with complete information about each characteristic (%)***	*White*	*S Asian*	*Black*	*Mixed*	*Other*
Number of women	906 961	705 948	107 382	42 170	16 456	35 005
Postpartum haemorrhage >=1500ml	28 268 (2.9%)	19 633 (2.8%)	2 806 (2.6%)	1 652 (3.9%)	479 (2.9%)	1 225 (3.5%)
Maternal characteristics (n, %)*						
Most deprived socioeconomic quintile†	800 047 (88.2%)	160 437 (23.9%)	38 290 (38.5%)	18 641 (48.5%)	5 418 (35.2%)	10 652(33.3%)
Maternal age at birth 35 or over†	900 440 (99.3%)	146 832 (21.0%)	23 928 (22.3%)	12 510 (29.7%)	3 505 (21.4%)	9 423 (27.0%)
Maternal BMI 30 or over (obesity) †	762 767 (84.1%)	130 197 (21.8%)	16 000 (18.2%)	11 571 (33.7%)	3 141 (22.7%)	4 557 (15.6%)
Fibroids	880 534 (97.1%)	893 (0.1%)	271 (0.3%)	455 (1.1%)	60 (0.4%)	90 (0.3%)
Bleeding disorders	880 534 (97.1%)	3 795 (0.6%)	307 (0.3%)	100 (0.3%)	50 (0.3%)	117 (0.4%)
Diabetes	880 534 (97.1%)	32 096 (4.7%)	15 012 (14.3%)	3 492 (8.6%)	1 027 (6.5%)	2 802 (8.3%)
Hypertensive disease	880 534 (97.1%)	39 701 (5.8%)	5 683 (5.4%)	3 847 (9.5%)	875 (5.5%)	1 683 (5.0%)
Placental conditions	880 534 (97.1%)	8 451 (1.2%)	1 330 (1.3%)	545 (1.3%)	191 (1.2%)	451 (1.3%)
Nulliparous	902 245 (99.5%)	292 232 (41.6%)	36 285 (34.0%)	12 647 (30.2%)	6 496 (39.7%)	14 952(43.0%)
Previous caesarean section	902 474 (99.5%)	93 792 (13.4%)	20 161 (18.8%)	9 448 (22.5%)	2 411 (14.7%)	5 039 (14.5%)

Fetal characteristics (n, %)*						
Multiple birth	906 961 (100%)	11 267 (1.6%)	1 288 (1.2%)	807 (1.9%)	252 (1.5%)	501 (1.4%)
Stillbirth	906 961 (100%)	2 416 (0.3%)	587 (0.5%)	307 (0.7%)	82 (0.5%)	151 (0.4%)
Preterm birth†	906 961 (100%)	49 183 (7.0%)	8 046 (7.5%)	3 360 (8.0%)	1 189 (7.2%)	2 187 (6.2%)
Birthweight of 4500g or more†	904 377 (99.7%)	12 427 (1.8%)	603 (0.6%)	495 (1.2%)	198 (1.2%)	418 (1.2%)
Birth characteristics (n, %)*						
Induction	896 024 (98.8%)	206 201 (29.6%)	28 091 (26.3%)	10 556 (25.2%)	4 398 (26.9%)	8 417 (24.2%)
Birth assisted by instrument	904 603 (99.7%)	85 370 (12.1%)	13 366 (12.5%)	2 678 (6.4%)	1 624 (9.9%)	4 675 (13.4%)
Birth by caesarean section	904 603 (99.7%)	181 101 (25.7%)	30 775 (28.7%)	14 398 (34.2%)	4 449 (27.1%)	9 455 (27.1%)
Episiotomy	893 819 (98.6%)	106 252 (15.3%)	17 923 (16.9%)	3 655 (8.8%)	1 990 (12.3%)	5 858 (17.0%)
Manual removal of placenta	880 534 (97.1%)	13 061 (1.9%)	1 320 (1.3%)	484 (1.2%)	231 (1.5%)	502 (1.5%)

**percentages of women of each ethnicity with each characteristic are given among records with complete data for that characteristic only*

***percentages of all births with complete data about the characteristic. †these variables are split into more categories for analysis; details in Suppl. Tables 1, 3*

$p<0.001$ for all characteristics using the χ^2 test to evaluate distribution between ethnic groups.

Table 2. Risks of postpartum haemorrhage of 500, 1000, 1500 and 2000ml by ethnic group among 981 801 women who gave birth in England between 1st April 2015 and 31st March 2017

	Recorded blood loss in millilitres*				
	500ml or more	1000ml or more	1500ml or more	2000ml or more	3000ml or more

Number of women	981 801	322 606	75 674	28 268	11 964	2 469
Risk of PPH		32.9%	7.7%	2.9%	1.2%	0.3%
Risk by ethnic group (n, %)						
White	705 948	223 641 (31.7%)	52 427 (7.4%)	19 633 (2.8%)	8 347 (1.2%)	1 723 (0.2%)
South Asian	107 382	37 123 (34.6%)	7 896 (7.4%)	2 806 (2.6%)	1 165 (1.1%)	258 (0.2%)
Black	42 170	16 331 (38.7%)	4 322 (10.2%)	1 652 (3.9%)	737 (1.7%)	165 (0.4%)
Mixed	16 456	5 241 (31.8%)	1 258 (7.6%)	479 (2.9%)	200 (1.2%)	38 (0.2%)
Other	35 005	13 027 (37.2%)	3 205 (9.2%)	1 225 (3.5%)	548 (1.6%)	122 (0.3%)
Missing	74 840	27 243 (36.4%)	6 566 (8.8%)	2 473 (3.3%)	967 (1.3%)	163 (0.2%)

*p<0.001 in Chi squared tests comparing distributions by ethnic group for all levels of blood loss

Table 3. Associations between postpartum haemorrhage of 1500ml or more and characteristics available at booking and at birth among 981 801 women who gave birth in England between 1st April 2015 and 31st March 2017

Characteristics	Risk	Crude OR (95% CI)	p value*	Model 1 (maternal characteristics)†	p value*	Model 2 (maternal and fetal characteristics)‡	P value*	Model 3 (maternal, fetal and birth characteristics)§	p value*
Maternal ethnic group**									
White	2.8%	Ref	<0.001	Ref	<0.001	Ref	<0.001	Ref	<0.001
South Asian /Asian British	2.6%	0.94 (0.90, 0.97)		0.98 (0.94, 1.02)		1.18 (1.13, 1.26)		1.14 (1.09, 1.19)	
Black / Black British	3.9%	1.42 (1.35, 1.50)		1.36 (1.29, 1.44)		1.49 (1.41, 1.58)		1.54 (1.45, 1.63)	
Mixed	2.9%	1.06 (0.97, 1.16)		1.09 (0.99, 1.19)		1.17 (1.07, 1.28)		1.20 (1.09, 1.32)	
Other	3.5%	1.27 (1.20, 1.35)		1.27 (1.19, 1.35)		1.34 (1.26, 1.43)		1.37 (1.29, 1.46)	

*Wald test **ethnic group was imputed where it was missing

†maternal characteristics: maternal age, BMI, socioeconomic status, parity, previous caesarean section, medical conditions (diabetes, hypertension, bleeding disorders, fibroids, placental disorders)

‡maternal characteristics and additional fetal characteristics: gestational age, birthweight, livebirth/stillbirth, multiplicity

§maternal characteristics, fetal characteristics and additional birth characteristics: induction of labour, mode of birth, episiotomy, manual removal of placenta

Figure 1. Data flow diagram