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# Adverse pregnancy outcomes attributable to socioeconomic and ethnic inequalities in England: a national cohort study

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## ABSTRACT

**Background** Socioeconomic deprivation and an ethnic minority background are known risk factors for adverse pregnancy outcomes. We quantified the magnitude of these socioeconomic and ethnic inequalities at population level in England.

**Methods** We used administrative hospital data to evaluate stillbirth, preterm birth (<37 weeks gestation), and fetal growth restriction (FGR; liveborn with birthweight <3$^{rd}$ centile) in England between 1$^{st}$ April 2015 and 31$^{st}$ March 2017 by socioeconomic deprivation quintiles and ethnic group. Attributable fractions (AF) for the entire population and specific groups compared to least deprived and/or White women were calculated without and with adjustment for smoking and body mass index (BMI).

**Findings** 1 155 981 women with a singleton birth were included. 4 505 births were stillbirths (0·4%). Of the 1 151 476 liveborn babies, 69 175 (6·0%) were preterm births and 22 679 (2·0%) births with FGR. 24% of stillbirths, 19% of preterm births, and 31% of FGR could be attributed to socioeconomic inequality. These population AFs were substantially reduced with adjustment for ethnic group, smoking and BMI (12%, 12% and 16%, respectively). 12% of stillbirths, 1.2% of preterm births and 17% of FGR could be attributed to ethnic inequality. Adjustment for socioeconomic deprivation, smoking and BMI only had a small impact on these ethnic group AFs (13%, 2.6% and 19%, respectively). Group-specific AFs were especially high in the most socioeconomically deprived South-Asian women and Black women for stillbirth (54% and 64%, respectively) and FGR (72% and 55%, respectively).

**Interpretation** Socioeconomic inequalities account for a quarter of stillbirths, a fifth of preterm births, and a third of births with FGR. The largest inequalities were seen in the most deprived Black and South-Asian women. Prevention should target the entire population as well as particular high-risk ethnic minority groups, addressing specific risk factors and wider determinants of health.



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## Research in context

*Evidence before this study*

Socioeconomic deprivation and a minority ethnic background are associated with adverse perinatal outcomes. However, there is a lack of evidence on the strength of these risk factors and on the scale of their impact at population level. We searched MEDLINE 2000 until 1 January 2021 for reviews of studies carried out in the United Kingdom using the following search terms: ("inequality", "disparity", "socioeconomic", "ethnicity", or "race") and ("stillbirth", "preterm", or "fetal growth restriction"). A systematic literature review of the relationship between socioeconomic deprivation and adverse pregnancy outcomes, published in 2012, reported that risks of adverse pregnancy outcomes in women in the most deprived group were between 1.5 times (for stillbirth) and 1.8 times (for low birth weight) higher than in women in the most affluent group. A review on inequalities and stillbirth, published in 2019, concluded that research investigating inequalities and stillbirth was underdeveloped and that consequently it is not possible to estimate the potential stillbirth reduction if inequalities were reduced.

*What this study adds*

This study of more than 1 million births in the English National Health Service found that a quarter of stillbirths, a fifth of preterm births, and a third of births with fetal growth restriction would not have occurred if all women had the same risk as women in the least deprived socioeconomic group. Adjustment for ethnicity, maternal smoking and obesity at the start of pregnancy reduced these attributable fractions considerably.

The starkest increases in risk were found in Black and South-Asian women. For example, about two thirds of stillbirths in the most deprived Black women and three quarters of births with fetal growth restriction in the most deprived South-Asian women would not have occurred if they had the same risk as White women in the most affluent group.

*Implications of all available evidence*

Concerted action is needed, involving not only midwives and obstetricians, but also public health professionals and politicians, that aims to reduce socioeconomic and ethnic inequalities in pregnancy outcomes, targeting the entire population as well as Black and South-Asian women in deprived socioeconomic groups. Prevention should address the wider determinants of health as well as specific risk factors, including maternal smoking and obesity.

## INTRODUCTION

In many high-income countries, including the United States (US) and the United Kingdom (UK), women from more deprived socioeconomic backgrounds and ethnic minority groups are known to experience poorer outcomes in pregnancy and birth, with higher rates of stillbirth, preterm births, fetal growth restriction (FGR), and neonatal and infant mortality.[1–3] These outcomes have long term ramifications for children and families, the healthcare system and the economy.[4,5]

Reducing socioeconomic and ethnic inequalities in pregnancy outcomes has been a key objective of health policies in many countries.[6] For example, the English National Health Service (NHS) has set as a target that between 2019 and 2025 the overall rates of stillbirth and neonatal mortality should be reduced by 50% and preterm birth by 25%.[7] However, efforts to improve pregnancy outcomes and to mitigate inequalities are impeded by a lack of information about how differences in pregnancy outcomes are related to women's societal circumstances and pre-existing health, and which groups are most strongly affected. It has been recognised that research investigating inequalities in pregnancy outcomes is underdeveloped in the UK as in many other high-income countries.[8]

The aim of this study was to quantify socioeconomic and ethnic inequalities in stillbirth, preterm birth and FGR in England whilst also taking account of health at the onset of pregnancy and complications which arise during pregnancy. Clear measures are needed to communicate the size of these inequalities in pregnancy outcomes to clinicians and women and their families as well as to public health professionals and policymakers.[9]

First, we used population attributable fractions, which represent the proportions of adverse pregnancy outcomes that would not have occurred if all women had the same pregnancy risk as women in the least deprived socioeconomic group or as those from a White ethnic background.[9,10] We also estimated these population attributable fractions with adjustment for smoking status and body mass index (BMI) at the onset of pregnancy, to explore to what extent these prominent modifiable risk factors mediate socioeconomic and ethnic inequalities.

Second, we estimated group-specific attributable fractions, which represent the proportions of adverse pregnancy outcomes that would not have occurred if women in a particular group would have had the same risk as White women in the least deprived socioeconomic group.

## METHODS

### Data sources

This study used a dataset compiled by the National Maternity and Perinatal Audit, based on records of each birth from maternity information systems used by NHS maternity services in England to record care throughout pregnancy and birth,[11] that includes births between 1st April 2015 and 31st March 2017. These records were linked to the Hospital Episode Statistics, an administrative database with records of all hospital episodes in the English NHS. The resulting dataset captures approximately 94% of births that occurred in England during the study period.[11]

### Definition of the study population

Women were included in the study if they gave birth to a singleton baby with a recorded gestation between 24 and 42 completed weeks and if information was available on whether the baby was born alive or stillborn. Terminations of pregnancy were excluded.

### Definition of outcomes

Three pregnancy outcomes were evaluated. Stillbirth was defined as any recorded birth of a stillborn baby of at least 24 completed weeks (24+0 weeks or more) of gestation. Preterm birth was defined as the recorded birth of a liveborn baby between 24 and 37 completed weeks. FGR was defined as the birth of a liveborn baby of at least 24 completed weeks with a birthweight below the 3rd centile for gestational age, according to UK-WHO growth charts.[12]

## Definition of socioeconomic deprivation and ethnicity

We used the Index of Multiple Deprivation (IMD) as a measure of a woman's socioeconomic status (Supplementary Table 2). The IMD provides an area-level measure of deprivation derived from information about income, education, employment, crime, and the living environment. We categorised women into five socioeconomic groups according to national quintiles of IMD rankings of 32,844 "Lower Super Output Areas" with typically 1 500 inhabitants.[13]

Maternal ethnicity was coded using the Office for National Statistics categorisation system from the 2001 Census.[14] Ethnicity was considered missing if it was coded as "not stated" (Supplementary Table 2). Ethnic origin was collapsed into five groups: White, South-Asian, Black, Mixed, and Other (including Chinese).

Coding of all included variables is described in Supplementary Table 1.

## Calculation of the attributable fractions

Numbers of outcomes between quintiles of deprivation and ethnic groups were compared using Chi squared tests. For each pregnancy outcome, we used the rate of adverse outcome observed for women in the least deprived quintile and/or from a White ethnic background as the reference rate. These reference rates were then applied to the women in the entire population or in a specific group to estimate the expected number of women with an adverse pregnancy outcome. Attributable fractions (AFs) were calculated as the difference in the observed and expected number of women with an adverse pregnancy outcome divided by the observed number or ($O - E) / O$. The AF described the proportion of adverse outcome that would not have occurred were the rates of the outcome the same as in the women in the reference group. The attributable fraction compares the reference group either with the entire population, producing a "population attributable fraction", or with a specific group, producing a group-specific attributable fraction, also known as "attributable fraction in the exposed".[10]

We used logistic regression models to estimate expected numbers of women with adverse pregnancy outcomes, adjusting for ethnicity or deprivation, maternal smoking and BMI at the onset of pregnancy. We also adjusted for a number of other maternal risk factors, including maternal age, maternal parity, previous caesarean section, preexisting medical conditions, previous obstetric complications or complications in the current pregnancy defined according to the National Institute for Health and Care Excellence (Supplementary Table 2).[15] An interaction term between parity and previous caesarean birth was included in all models where both these terms were included. We included in the supplementary material a full description of the models as well as a graphical representation of their goodness of fit (Supplementary Table 6, Supplementary Figure 2).

The adjusted attributable fractions were calculated as described earlier but now using the expected numbers of adverse outcomes predicted by the logistic regression models. Confidence intervals for the attributable fractions were calculated after using logarithmic transformation to normalise the distribution and stabilise the variance.[16]

## Handling of missing data

Unadjusted attributable fractions were calculated only including women with complete information about socioeconomic deprivation or ethnicity. All regression analyses were restricted to women who had complete information about the outcome under consideration (100% of women for stillbirth and preterm birth and 99.6% for FGR). When estimating adjusted results, we imputed missing maternal risk factors, including socioeconomic deprivation and ethnicity, using chained equations creating 10 data sets. The results for each of these data sets were pooled using Rubin's rules.[17]

## Sensitivity analysis

To examine the robustness of our results to different population definitions, we carried out sensitivity analyses of stillbirth and FGR only including babies born at term (at or after 37 weeks of gestation). A second sensitivity analysis was carried out with preterm birth defined as a birth before 34 weeks of gestation. A third sensitivity analysis was a complete-case analysis (in other words, excluding records with missing values for maternal risk factors rather than imputing missing data).

All analyses were performed using Stata version 14.1, StataCorp, USA.

### Ethical approval

This study used data collected to evaluate service provision and performance and therefore was exempt from ethical review by the NHS Health Research Authority. The use of personal data without patients' consent was approved by the NHS Health Research Authority (16/CAG/0058).

## RESULTS

We identified 1 233 184 women who gave birth to a singleton baby with a gestational age between 24 and 43 weeks in the English NHS between 1st April 2015 and 31st March 2017 (Figure 1). 1 155 981 women with singleton births were included in the study, of whom 4 505 had a stillbirth (0·4%). Of the 1 151 476 women who had a live birth, 69 175 (6·0%) had a preterm birth and 22 679 (2·0%) had a birth with FGR (Table 1).

### Socioeconomic deprivation

1 087 776 women had complete information about their socioeconomic status. The stillbirth risk increased according to socioeconomic deprivation from 0·29% in the least deprived group to 0·47% in the most deprived group (Figure 2, Supplementary Table 3, p<0·001). The population attributable fraction can be calculated as the excess number of stillbirths (4 150 - 3 173) divided by the observed number of stillbirths in women with complete data about socioeconomic group (4 150) which gives 24% (95%CI: 17% - 30%).

For stillbirth, the population attributable fraction related to socioeconomic deprivation decreased to 19% with adjustment for ethnic group and to 12% with adjustment for ethnic group, smoking, and BMI (Table 2). The population attributable fraction remained 12% (95%CI: 4% - 20%) with further adjustment for other maternal risk factors.

The risk of a preterm birth in liveborn babies increased with socioeconomic deprivation from 4·9% in the least deprived group to 7·2% in the most deprived group (Figure 2, Supplementary Table 3, p<0·001) which corresponds to a population attributable fraction of 19% ([64 926 - 52 892] / 64 926; 95%CI: 17% - 20%). For preterm birth, the population attributable fraction related to socioeconomic deprivation decreased to 18% with adjustment for ethnic group and reduced to 12% with adjustment for ethnic group, smoking, and BMI (Table 2). The additional effect of adjustment for other maternal risk factors reduced the population attributable fraction to 10% (95%CI: 8% - 12%).

The risk of FGR increased from 1·2% in the least deprived group to 2·2% in the most deprived group (Figure 2, p<0·001). The attributable fraction was 31% ([17 529 - 12 014] / 17 529; 95%CI: 28% - 34%). The population attributable fraction related to FGR decreased to 25% with adjustment for ethnic group and to 16% with adjustment for ethnic group, smoking, and BMI. Additional adjustment for other risk factors had very little effect and the population attributable fraction remained close to the same level at 17% (95%CI: 13% - 20%).

### Ethnicity

Stillbirth risk varied according to maternal ethnicity and ranged from 0·34% in women with a White ethnic background to 0·70% in women with a Black ethnic background (Figure 2, p<0·001). The population attributable fraction (the proportion of stillbirths that would not have occurred if all women had the same stillbirth risk as women with a White ethnic background) was 12% ([4 118 - 3 638] / 4 118, among 1 061 417 women with complete information about ethnic group; 95%CI: 10% - 13%). Adjustment for socioeconomic deprivation, smoking, BMI, and other maternal risk factors had little effect and with full adjustment the population attributable fraction was 13% (95%CI: 10% - 15%).

The variation in the risk of preterm birth according to ethnicity was relatively small and ranged from 6·0% in women with a White ethnic background to 6·5% in South-Asian women and 6·6% in Black women (Figure 2, p<0·001). The corresponding population attributable fraction was 1·2% ([63 898 – 63 139] / 63 898; 95%CI: 0.8% - 1.6%) and it remained 1.2% (95%CI: 0.7% - 1.7%) with adjustment for socioeconomic deprivation, smoking, BMI, and the other maternal risk factors.

The risk of FGR varied according to ethnicity from 1.4% in women with a White ethnic background to 3.5% in women with a South-Asian background (Figure 2, p<0.001) with a corresponding population attributable fraction of 17% ([17 035- 14 074]/17 035; 95%CI: 16% - 18%). Adjustment for socioeconomic deprivation, smoking, BMI, and the other risk factors had little impact and produced a population attributable fraction of 20% (95%CI: 19% - 20%).

### Specific risk groups

The attributable fractions for specific groups defined according to socioeconomic deprivation and ethnicity, presented in Figure 3, demonstrate that the proportion of stillbirths that would not have occurred if all women had the same stillbirth risk as the least deprived White women was substantially increased in women from more deprived socioeconomic backgrounds and ethnic minority groups. More detailed descriptive information about the distribution of maternal risk factors according to ethnicity and socioeconomic deprivation is available in Supplementary Table 7. Attributable fractions for stillbirth were especially high in women in the most deprived socioeconomic group if they were from a Black (64%; 95%CI: 58% - 69%), South-Asian (54%; 95%CI 47% - 59%), or Mixed and Other ethnic background (39%; 95%CI 28% - 48%). Similarly, high attributable fractions were found for FGR in women in the most deprived socioeconomic group with a South Asian (72%; 95%CI 70% - 73%), Black (55%; 95%CI 52% - 58%), or Mixed and Other ethnic background (48%; 95%CI 44% - 51%).

### Sensitivity analyses

Very similar results were demonstrated in analyses of stillbirth and FGR risk in term babies only, in analyses where a preterm birth was defined as a birth before 34 completed weeks of gestation (Supplementary Table 4 and Supplementary Figure 1), and in analyses that excluded births with missing data on maternal risk factors (Supplementary Table 5).

## DISCUSSION

### Summary of results

In this study of more than 1 million recent births in England, we demonstrated that 24% of stillbirths, 19% of live preterm births and 31% of livebirths with FGR would not have occurred if all women had the same risk of adverse pregnancy outcomes as women in the least deprived socioeconomic group. These population attributable fractions were considerably lower – especially the population attributable fraction for stillbirth – if we adjusted for ethnicity, maternal smoking and BMI at the onset of pregnancy, which suggests that a considerable part of the socioeconomic inequalities in pregnancy outcomes can be explained by the combined influences of these maternal characteristics.

We also found that 12% of stillbirths, 1% of preterm births and 17% of births with FGR would not have occurred if all women had the same risks as women from a White ethnic background. Adjustment for socioeconomic deprivation, maternal smoking and BMI had little impact on these population attributable fractions.

Considering socioeconomic deprivation and ethnic background together, we found the starkest increases in the risks of stillbirth and FGR. About half of stillbirths and about three quarters of births with FGR in the most deprived South Asian women could be attributed to socioeconomic and ethnic inequalities. Similarly, about two thirds of stillbirths and about half of births with FGR in the most deprived Black women could be attributed to socioeconomic and ethnic inequalities.

## Methodological considerations

We used a large routinely collected dataset including 94% of births that occurred in England during the study period. A small number of NHS hospitals were unable to contribute to the National Maternity and Perinatal Audit, primarily because of limitations of their local clinical information systems.[11] This provides strong support for the representativeness of our findings.

We used an aggregate area-based measure to capture the level of socioeconomic deprivation. The socioeconomic status of people living in a particular area can vary and range from lowest to highest level of socioeconomic deprivation. This will have led to non-differential misclassification of the socioeconomic status of some women, which is likely to have led to "regression dilution", so that our results may underestimate the true extent of socioeconomic differences in pregnancy outcomes.[18] Deprivation measures covering smaller areas – or ideally individual households – are needed to quantify more accurately the impact of socioeconomic deprivation on adverse pregnancy outcomes and overall health.

There are ongoing concerns about the accuracy of the coding of ethnic groups in the Hospital Episode Statistics database. However, a comparison of ethnicity codes in 59,000 patients recorded in this database against self-reported ethnicity information indicated a high level of agreement, especially for the distinction between patients with a White and those with another ethnic background (agreement level 98%). The level of agreement was worse for distinguishing specific ethnic minority groups, such as Indian, Pakistani, and Bangladeshi or Black-Caribbean and Black African and therefore we used the higher-level ethnic categories, such as South-Asian and Black.[19]

The interpretation of the attributable fraction as the percentage of adverse outcomes that would not have occurred if women were not "exposed" to a different background, depends on the assumption that biases are absent and that there is not effect modification.[10] It is unlikely that this assumption is fully met in the context of our study, because "exposures" such as socioeconomic deprivation and ethnicity are linked to many other circumstances, including overall health, health-related behaviour, nutrition, lifestyles factors, and wider aspects of "adversity" that are all recognised risk factors of poor pregnancy outcomes.[20]

## Interpretation

Evidence of socioeconomic and ethnic inequality in outcomes for babies born in the UK and many other high-income countries is widely reported.[21] There are many possible reasons for these inequalities and causal pathways are long and complex.[22] Both socioeconomic deprivation and an ethnic minority background are typically linked to a wider pattern of adverse circumstances, including increased rates of maternal smoking, obesity, and mental illness. Other recognised pathways through which socioeconomic and ethnic inequalities can influence pregnancy outcomes are environmental exposure, for example related to pollution related to traffic and industrial activity and poor housing, social isolation and lack of social cohesion, poor access to maternity care and health care in general, and increased level of chronic stress as a result of economic strain, insecure employment, and more frequent stressful life events.[23]

We found that the increases in the stillbirth and FGR birth rates in women from an ethnic minority background do not seem to be explained by socioeconomic deprivation. Other factors related to ethnicity, religion and culture may contribute to a societal disadvantage in such a way that it increases the risk of poor pregnancy outcomes.[24] In addition, there are physiological differences between ethnic groups that may lead to differences in maternal immunological, vascular and endocrine response to pregnancy.[25] All this indicates that more detailed causal mediation analysis is a research priority.

Current policy initiatives to reduce stillbirth, preterm birth and FGR in England should take these causal complexities into account. Currently, most initiatives aiming to reduce adverse pregnancy outcomes recommend that maternity services focus on individual risk factors and specific high risk-groups.[26,27] Our results suggest that initiatives focusing on individual women's choices and behaviour and the antenatal care that they receive will have limited effects. First, this focus puts the onus on individual women expecting them to control risk factors that are at least partly due to social context and societal attitudes. Second, the clinical interventions available to maternity services to mitigate the risk of adverse perinatal outcomes – monitoring of fetal growth more precisely and frequently,[28] and considering elective birth at term[29] – tackle the consequences of socioeconomic and ethnic inequalities.

Our results demonstrate the potential impact of public health approaches in reducing the risk of adverse pregnancy outcomes. For example, we found that the population attributable fraction of socioeconomic inequalities for stillbirth and FGR reduced considerably if we took maternal smoking and obesity at the onset of pregnancy into account. Initiatives to reduce smoking and improve dietary habits in the community, as part of wider public health initiatives addressing a broader range of lifestyle factors and adverse maternal circumstances, provide important opportunities to improve the health of mothers and their babies.

Every attempt to address inequalities in pregnancy outcomes or wider inequalities in health will have to tackle the fundamental causes and will have to move from addressing the “downstream factors”, including specific clinical conditions as well as lifestyle factors, to the conditions that ultimately influence the choices that individuals can make about their own lives.[30] These “upstream factors” include access to high-quality education, employment and fairness in terms of income and welfare support.[30] As risk is spread across the whole population with the exception of the most affluent White women, such interventions need to address the whole population, in order to achieve their maximum benefit.[31]

The largest increases in excess risk of stillbirth and birth with FGR occurred in women from a South Asian and Black ethnic background in the more deprived socioeconomic groups. Our estimates suggest that two thirds of stillbirths in Black women in the most deprived socioeconomic group would not have occurred if they had the same risk as White women in the least deprived socioeconomic group. Similarly, about three quarters of birth with FGR would not have occurred in the most deprived South Asian women if they had same risk as the least deprived white women. These observations underscore the relevance of the complementary nature of the “population” and “high-risk” approaches to prevention of adverse births outcomes.[31]

Our findings demonstrate that national programmes to make pregnancy safer, including those in England which set specific targets of reducing stillbirth and preterm birth rates by 2025,[7,27] can only be realistically achieved through concerted action including not only midwives and obstetricians, but also public health professionals and politicians. First, clinical interventions should target high-risk groups during pregnancy, for example with programmes for smoking cessation and adoption of healthy dietary habits, as well as ensuring enhanced access to high-quality antenatal care, including improved continuity of the clinical team, adequate monitoring of fetal growth, and offering induction of labour when stillbirth risk is considered to be increased. High-quality audits of maternity care and pregnancy outcomes linked to quality improvement initiatives are key to monitoring the outcome of these clinical interventions.[32]

Second, public health interventions are needed to reduce inequalities in women’s health before pregnancy, not only focusing on smoking and dietary habits, but also considering the wider aspects of maternal adversity, such as mental health issues, substance abuse and stress related to social disadvantage.

Third, wider political initiatives are needed to address the key domains of inequality, such as income, education and employment because these upstream factors are the key determinants of the downstream factors that act as indirect pathways that influence pregnancy outcomes.[23]

Finally, progress in reducing inequalities should be monitored, for example using a type of score card that is currently being implemented in Australia,[33] not only focusing on indicators of antenatal and intrapartum care but also on social marginalisation and disadvantage.[3]

## Conclusions

Inequalities between socioeconomic and ethnic groups account for a substantial proportion of stillbirths, preterm births and births of babies with fetal growth restriction. Our results, observed in England, provide lessons for other high-income countries, although specific circumstances may differ.

Concerted action is needed to reduce inequalities in pregnancy outcomes. Maternity services and public health professionals should work closely with politicians to address the full complexity of the pathways contributing to the socioeconomic and ethnic differences in pregnancy outcomes, targeting the entire population as well as those groups recognised to be at the highest risk.

**Table 1. Characteristics of 1 155 981 women who gave birth to a singleton infant in England between the 1$^{st}$ April 2015 and 31$^{st}$ March 2017***

| Characteristic | Number of women (%) | Characteristic | Number of women (%) |
|---|---|---|---|
| *All* | *1 155 981* | | |
| | | | |
| **Socioeconomic and ethnic groups** | | | |
| *Decile of socioeconomic deprivation* | | *Maternal BMI (kg/m$^2$)* | |
| Least deprived 20% | 158 401 (14·6) | Underweight (<18.5) | 28 200 (2·9) |
| Less deprived 21-40% | 178 676 (16·4) | Ideal weight (18.5-24.9) | 457 385 (47·3) |
| Median deprived 41 -60% | 203 698 (17·6) | Overweight (25.0-29.9) | 274 338 (28·4) |
| More deprived 61-80% | 246 266 (68·1) | Grade I obese (30·0-34.9) | 126 644 (13·1) |
| Most deprived 81-100% | 300 735 (26·0) | Grade II obese (35.0-39.9) | 52 496 (5·4) |
| *Missing* | *68 205 (5·9)* | Grade II obese (≥40·0) | 27 261 (2·8) |
| | | *Missing* | *189 657 (16·4)* |
| *Maternal ethnic group* | | | |
| White | 818 982 (77·2) | | |
| South Asian | 126 262 (11·9) | **Presence of conditions considered high risk by NICE** | |
| Black | 52 361 (4·9) | *Conditions* | |
| Mixed | 19 561 (1·8) | Preexisting medical conditions | 140 980 (15·2) |
| Other stated | 44 251 (4·2) | Previous birth complication | 67 946 (7·3) |
| *Missing* | *94 564 (8·2)* | Conditions in current pregnancy | 248 781 (26·9) |
| | | *Missing* | *229 985 (19·9)* |
| **Maternal characteristics at onset of pregnancy** | | | |
| *Maternal age (years)* | | | |
| <20 | 37 394 (3·3) | **Pregnancy outcomes** | |
| 20-34 | 857 074 (75·0) | *Baby's outcome* | |
| 35-39 | 201 336 (17·6) | Liveborn | 1 151 476 (99·61) |
| ≥40 | 46 423 (4·1) | Stillborn | 4 505 (0·39) |
| *Missing* | *13 754 (1·2)* | *Among term babies* | |
| | | Liveborn | 1 082 301 (99·84) |
| *Maternal parity* | | Stillborn | 1 683 (0·16) |
| 0 | 485 555 (42·3) | | |
| 1 | 414 993 (36·1) | *Gestational age* | |
| 2 | 150 518 (13·1) | Preterm (< 37 completed weeks) | 71 997 (6·2) |
| 3 or more | 97 676 (8·5) | Term | 1 083 984 (93·8) |
| *Missing* | *7 239 (0·6)* | *Among liveborn babies* | |
| | | Preterm (< 37 completed weeks) | 69 175 (6·0) |
| *Previous caesarean section* | | Term | 1 082 301 (94·0) |
| Previous caesarean section | 163 267 (14·4) | | |
| No previous caesarean | 968 279 (85·6) | *Birthweight centile (among liveborn babies)* | |
| *Missing* | *24 435 (2·1)* | | |
| | | Less than 3$^{rd}$ centile | 22 679 (2·0) |
| *Maternal smoking status* | | 3-9$^{th}$ | 66 049 (5·7) |
| Non-smoker | 821 549 (86·5) | 10-89$^{th}$ | 955 177 (83·0) |
| Smoker | 128 684 (13·5) | 90$^{th}$ or more | 103 004 (9·0) |
| *Missing* | *205 748 (17·8)* | *Missing* | *4 567 (0·4)* |

* Percentages are presented for women with available data only, except for the percentage of missing data.

**Table 2. Population attributable fractions (95% confidence interval) of stillbirth, preterm birth and birth with FGR for socioeconomic deprivation and ethnicity among 1 155 981 women**

| | Stillbirth | Preterm birth | Birth with FGR |
|---|---|---|---|
| ***Socioeconomic deprivation†*** | | | |
| No adjustment | 24% (17%, 30%) | 19% (17%, 20%) | 31% (28%, 34%) |
| Adjusted for: | | | |
| Ethnic group | 19% (12%, 26%) | 18% (17%, 20%) | 25% (22%, 28%) |
| Ethnic group, smoking, BMI | 12% (4%, 19%) | 12% (10%, 14%) | 16% (13%, 20%) |
| Ethnic group, smoking, BMI, all maternal factors* | 12% (4%, 20%) | 10% (8%, 12%) | 17% (13%, 20%) |
| | | | |
| ***Ethnic group‡*** | | | |
| No adjustment | 12% (10%, 13%) | 1·2% (0.8%, 1.6%) | 17% (16%, 18%) |
| Adjusted for: | | | |
| Socioeconomic group | 11% (9%, 13%) | 0·1% (-0·3%, 0·5%) | 15% (14%, 16%) |
| Socioeconomic group, smoking, BMI | 13% (11%, 15%) | 2·6% (2·2%, 3·0%) | 19% (18%, 20%) |
| Socioeconomic group, smoking, BMI, all maternal factors* | 13% (10%, 15%) | 1·2% (0·7%, 1·7%) | 20% (19%, 20%) |

†Compared to those in the least deprived quintile.

‡Compared to women from a White ethnic background.

*These include age, parity, pre-existing medical conditions, previous obstetric complications and conditions in the current pregnancy sufficient to recommend that the woman gives birth in an obstetric-led setting.

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**Figure 1. Data flow diagram**

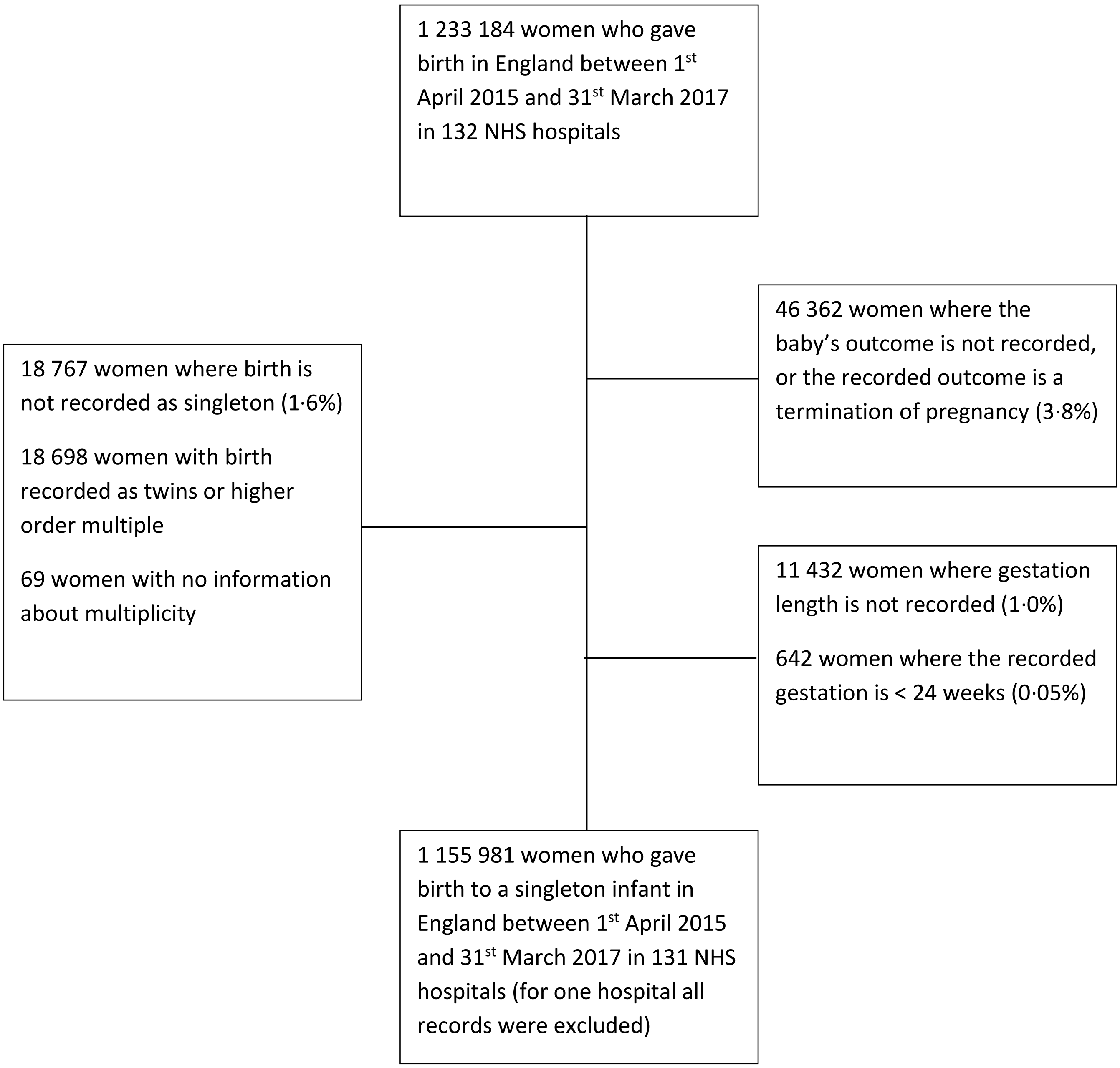
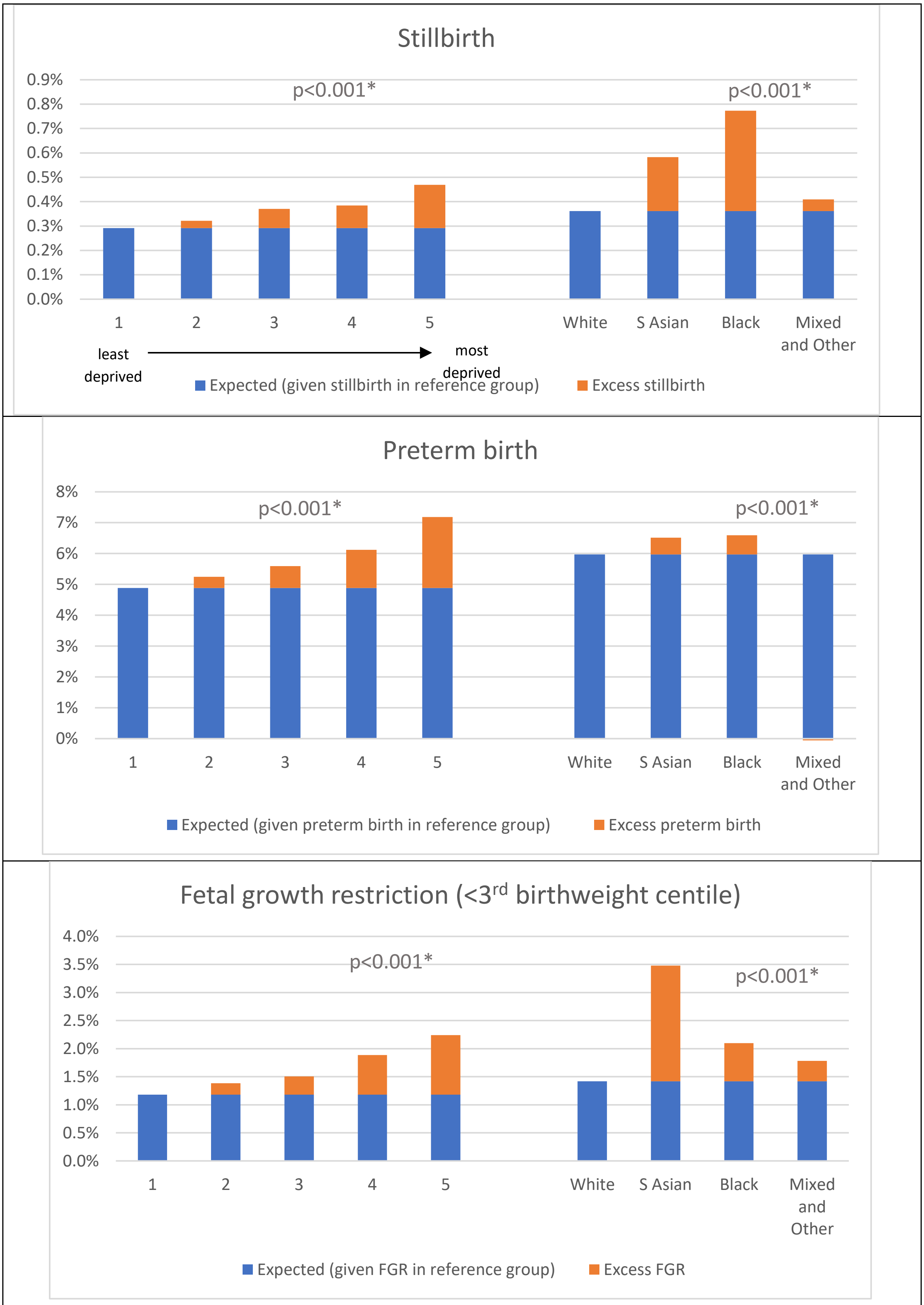


**Figure 2. Stillbirth, preterm birth and fetal growth restriction rates by socioeconomic deprivation (national quintiles: 1 least and 5 most deprived) and ethnicity (as defined in Methods section).**




*p values are calculated using chi2 tests

**Figure 3. Attributable fractions† (95% confidence interval) of stillbirth, preterm birth and birth with FGR for groups according to socioeconomic deprivation and ethnicity**

| | Ethnic background | | | |
|---|---|---|---|---|
| | White | South Asian | Black | Mixed and Other |
| **Stillbirth** | | | | |
| **Socioeconomic deprivation** (national quintiles) | | | | |
| 1 (least deprived) | Reference | 33% (27%, 39%) | 48% (41%, 54%) | 12% (0%, 23%) |
| 2 | -9% (-21%, 4%) | 39% (29%, 47%) | 52% (44%, 60%) | 19% (4%, 32%) |
| 3 | 19% (9%, 27%) | 46% (37%, 53%) | 58% (50%, 64%) | 28% (15%, 40%) |
| 4 | 18% (8%, 26%) | 45% (37%, 52%) | 57% (50%, 63%) | 28% (14%, 39%) |
| 5 (most deprived) | 30% (23%, 37%) | 54% (47%, 59%) | 64% (58%, 69%) | 39% (28%, 48%) |
| **Preterm** | | | | |
| **Socioeconomic deprivation** (national quintiles) | | | | |
| 1 (least deprived) | Reference | 5% (3%, 7%) | 1% (-3%, 4%) | -9% (-13%, -6%) |
| 2 | -9% (-21%, 4%) | 12% (8%, 15%) | 7% (3%, 12%) | -2% (-6%, 3%) |
| 3 | 13% (10%, 15%) | 17% (14%, 20%) | 13% (9%, 17%) | 5% (0%, 9%) |
| 4 | 20% (18%, 22%) | 24% (22%, 27%) | 20% (17%, 24%) | 13% (9%, 16%) |
| 5 (most deprived) | 32% (30%, 34%) | 35% (33%, 37%) | 32% (29%, 35%) | 26% (23%, 29%) |
| **Fetal growth restriction** | | | | |
| **Socioeconomic deprivation** (national quintiles) | | | | |
| 1 (least deprived) | Reference | 54% (52%, 55%) | 26% (22%, 31%) | 15% (9%, 19%) |
| 2 | 13% (8%, 18%) | 60% (57%, 62%) | 36% (30%, 41%) | 25% (19%, 31%) |
| 3 | 18% (14%, 23%) | 62% (60%, 65%) | 40% (35%, 44%) | 30% (25%, 35%) |
| 4 | 29% (26%, 33%) | 67% (65%, 69%) | 48% (44%, 52%) | 40% (35%, 44%) |
| 5 (most deprived) | 39% (36%, 42%) | 72% (70%, 73%) | 55% (52%, 58%) | 48% (44%, 51%) |

†Compared to White women in the least deprived quintile.

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**Author contributions**
JJ, KW, JH, AK, TH, JvdM conceived the study. All authors were involved in the design. JJ and JvdM analysed the data. All authors interpreted the results. JJ and JvdM wrote the report with contributions from all other authors. JH, AK, TH and JvdM are joint senior authors. JJ and IGU have accessed and verified the underlying data.

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