

Multiple deprivation and other risk factors for maternal obesity in Portsmouth, UK

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ABSTRACT

Background

Maternal obesity is known to be associated with a range of adverse outcomes, both for the mothers and their children. It may be more prevalent in areas with higher deprivation as measured by the Index of Multiple Deprivation (IMD), but this has not been demonstrated consistently. This study focused primarily on the relationship between maternal obesity and deprivation in a setting where areas of significant deprivation are surrounded by the overall affluent South East England.

Methods

The study used the records of 3830 women who delivered under the care of a Portsmouth hospital from 1 April 2013 to 31 March 2014. Logistic regression was used to analyse the association between national IMD quintiles and maternal obesity, accounting for the potential confounders of age, ethnic origin, smoking status and parity.

Results

Following adjustment, women in the most deprived IMD quintile were 1.60 (95% CI 1.13, 2.26) times more likely to be obese compared to those in the least deprived quintile. Maternal obesity was also found to be associated with ethnicity and parity, but not with age or smoking status.

Conclusions

Maternal obesity increased with increasing deprivation. IMD may be a useful group-level indicator when planning interventions aimed at tackling maternal obesity.

INTRODUCTION

Maternal prepregnancy obesity (hereafter 'maternal obesity') is known to be associated with a range of adverse outcomes, both for the mothers and their children, and constitutes one of the leading risk factors for maternal mortality in high-income settings (1). Short-term outcomes include a range of pregnancy and delivery complications, including pre-eclampsia, gestational diabetes and large-for-gestational age infants (1-4). Long-term outcomes are predominantly linked to a worsened cardiovascular profile and increased risk of obesity in the children, with its metabolic, respiratory, gastrointestinal, musculoskeletal, reproductive, urological and psychosocial consequences (5-10).

Obesity presents a significant public health issue. It has been linked to lower socio-economic status and higher neighbourhood deprivation in high-income countries, and leads to a widening of health inequalities (11-14). Several mechanisms are thought to underlie the relationship between deprivation and obesity in developed countries. One of the key factors is education, both via its relationship with health literacy, and via its association with income and social class, which influence access to healthier food (15-17). Area deprivation can also mean less green space and fewer opportunities for active travel and physical activity, in addition to limited availability of healthy foods (18).

The English Index of Multiple Deprivation (IMD) is an official measure of small area deprivation, which is based on a composite score, and according to which all neighbourhoods in the country are ranked (19). Pregnant women with higher body mass index (BMI) may be more likely to reside in higher deprivation areas. The Centre for Maternal and Child Enquiries reported that women in the most deprived quintile constituted 28% of all maternities, but 34% of the maternities in women with a BMI ≥ 35 kg/m² (2). A study based on a nationally representative sample in England also showed that maternal obesity was associated with living in areas with higher levels of deprivation, and that women in all BMI categories outside of the normal range of 18.5-24.9 kg/m² had higher odds of living in the more deprived areas (20). Women from the most deprived IMD quintile were more likely to have a BMI in the obese category (≥ 30 kg/m²) compared with women in the least deprived quintile. However, a study in North West England failed to identify a correlation between the IMD and maternal obesity, which could be attributed in part to the fact that there was limited variability in the sample, with a significant proportion of the areas in the study being amongst the most deprived in the country (21).

Maternal obesity has also been found to be associated with multiple individual-level factors. Amongst these are age, ethnic origin and parity (2, 20-22), with the latter defined as the total

number of births at or over 24 weeks of gestation (23). There is a paucity of research into the association between smoking status and maternal obesity, but BMI has been shown to be lower amongst current smokers in the general population (24, 25).

Characterising populations of pregnant women is vital in enabling targeting of public health initiatives aimed at reducing maternal obesity, without which the existing health inequalities can worsen (26). Our study is based on a maternity dataset from a Portsmouth hospital, whose catchment area contains neighbourhoods with significant deprivation, but is surrounded by the relatively affluent South East England region. The study made use of prepregnancy weight and height reported by women at the booking appointment. This is the first antenatal appointment, usually with a midwife, which should take place by ten weeks of gestation. At this hospital maternal weight and height were measured at the dating ultrasound scan, 8 to 14 weeks of gestation, but we were unable to access and link these data, stored on an ultrasound reporting system, and proceeded with using BMI based on self-reported weight and height (hereafter 'self-reported BMI'). This study therefore will add to the evidence on the use of self-reported BMI when investigating maternal obesity associations. In addition, it will contribute to the knowledge on the use of IMD as a group-level indicator, as well as on the relationship between maternal obesity and ethnic origin, age, parity and smoking status.

METHODS

Study population and data source

The study population consisted of all women who gave birth under the care of Maternity Department at Queen Alexandra Hospital (QAH) in Portsmouth from 1 April 2013 to 31 March 2014. This included women in the city of Portsmouth and several adjoining boroughs of the county of Hampshire who gave birth in the main maternity unit in the hospital, in local midwifery-led maternity centres or at home, regardless of method of delivery. We used pseudonymised data, which had been collected and entered into a maternity records system by midwives and administrative staff as part of routine antenatal care.

Statistical analysis

Our outcome was maternal obesity. BMI values were calculated by dividing women's weight in kilograms by their height in metres squared. As per international classification of BMI status (27), continuous BMI was converted into a binary obesity variable, whereby women with a BMI of 29.9 kg/m² or less were classified as non-obese, and those with a BMI of 30 kg/m² or above as obese.

The Index of Multiple Deprivation (IMD) quintile constituted the primary exposure. IMD 2010 (28) was the latest available at the time of this study. It consists of 38 indicators under seven differentially weighted domains of deprivation. IMD scores are available for every Lower Layer Super Output Area (LSOA), which have a population between 1,000 and 3,000 residents (29). Women's postcodes were converted into LSOAs, and these were then converted into national IMD quintiles using a lookup table for allocating LSOAs to IMD2010 (30). The quintiles were named IMD1 to IMD5, from least to most deprived.

Other covariates were: age at booking in five-year age groups, self-reported ethnicity (White, Black, Asian, mixed, other, unknown), smoking status and parity. Chinese ethnic origin formed part of the Asian category, as per Office for National Statistics (ONS) guidance for presentation of ethnic group data (31). Mixed ethnicity category included all variations of mixed heritage. 'Smoking' referred to current smoking status self-reported at the booking appointment. Records with parity of three or greater were grouped due to small numbers.

Pearson's chi-squared test was carried out to assess crude relationships between each of the exposures and obesity. A multivariable model was then created with all the variables, and Wald test was carried out in relation to each of the exposures. All analyses were conducted using Stata[®] Data Analysis and Statistical Software, version 13.

RESULTS

Sample characteristics

A total of 5959 women delivered under QAH between 1 April 2013 and 31 March 2014. Of these, 448 records (7.52%) were missing IMD, mainly due to the absence of the LSOA in the lookup table, which could in part be explained by interval changes in postcodes and LSOA distribution. 4148 records (69.4%) included self-reported prepregnancy BMI. 3830 records (64.3%) contained both IMD and BMI. Baseline characteristics of the women with and without BMI and IMD are shown in Table 1. Women included were slightly more likely to be older, of White ethnic origin and multiparous, compared to those excluded. Statistical significance was reached for each variable, in part due to substantial numbers.

There were few age, smoking and parity observations missing in the remaining sample (0.3%, 2% and 0.1% respectively), and these were dropped from the multivariable model, yet a separate category was retained for the unknown ethnicity (9.3% of the sample). Women with missing ethnicity were less likely to report smoking (12% versus 20%), and more likely to be nulliparous (52% versus 30%), compared to those whose ethnicity was

recorded, with $p < 0.001$ for both relationships, but there was little evidence of an association with obesity, age or IMD quintile (data not shown).

Mean BMI in the sample was $25.7 \pm 5.8 \text{ kg/m}^2$, and mean age was 28.9 ± 5.6 years. Women in the most deprived quintile nationally (IMD5) constituted 42% of the sample, and only 8% of the women lived in LSOAs in the least deprived quintile (IMD1), indicating significant levels of deprivation in the sample compared to the national average of 20% of population in each IMD quintile. Just over half of the women in the sample had a BMI in the normal category. Women with BMI in the obese category were more likely to reside in areas with higher deprivation ($p\text{-value} < 0.001$) (Figure 1).

Table 2 represents women's characteristics by IMD quintile. In addition to higher prevalence of obesity, women in the more deprived quintiles tended to be younger, were more likely to report being a smoker and be multiparous. Women of Black or Asian ethnic origin were more likely to reside in areas with higher deprivation.

Results of both crude and multivariable analysis are presented in Table 3. The initial crude analysis suggested associations between in turn each of IMD quintile, ethnicity, smoking and parity, and the outcome of maternal obesity, with p -values indicating statistical significance of each of the associations. The relationship between age group and obesity was not statistically significant.

The association between deprivation and obesity remained similar after adjustment for potential confounders (Table 3). Women in the most deprived quintile were more likely to be obese compared to the least deprived quintile (OR: 1.60; 95% CI: 1.13, 2.26). There was strong evidence for an independent association between ethnic group and obesity in the multivariable model. Asian women were less likely to be obese compared to White women (OR: 0.37; 95% CI 0.20, 0.70). Women of Black or Mixed ethnicity were no more likely to be obese than White women. The association between obesity and smoking was attenuated in the multivariable model, from 1.30 (95% CI 1.07, 1.58) to 1.07 (95% CI 0.86, 1.32). The relationship between parity and obesity remained similar after adjustment. OR of obesity for women with three or more previous births was 1.65 (95% CI 1.26, 2.16), compared to nulliparous women.

DISCUSSION

Main findings of this study

Our study showed an association of maternal obesity with deprivation as measured by IMD, with the likelihood of obesity increasing with higher area deprivation. This association persisted after adjustment for age, ethnicity, smoking status and parity. Women in the most deprived quintile had higher odds of being obese (OR 1.60, 95%CI: 1.13, 2.26) compared to those in the least deprived quintile. We observed lower rates of obesity in our group of Asian women, but no significant association of maternal obesity with Black ethnicity. There was an association with parity of three or higher, but not with age or smoking status.

What is already known on this topic

Due to the key role of early life environment in influencing the long-term risk of obesity in the offspring, we may be witnessing an acceleration of the obesity epidemic through successive generations (32, 33). The topic of the influence of neighbourhood environment on lifestyle behaviours has been attracting increasing research interest in the recent years, as more understanding is needed in order to target public health interventions appropriately, without increasing existing health inequalities. Women in England in particular are known to experience greater health inequalities associated with obesity than those faced by men (12). 'One size fits all' public health programmes can increase such inequalities, with individuals from areas of higher deprivation likely to engage and benefit less (34, 35). Knowledge of maternal obesity associations can therefore aid planning of the weight management interventions.

In the only nationally representative England-based study of maternal obesity to date (20) an odds ratio of 2.2 was reported for the association between maternal obesity and deprivation, with confidence levels overlapping with those in our study. There is evidence to suggest that local environment and area deprivation have a greater effect on women compared to men, which may be due to the relatively smaller spheres of women's daily movements due to lower rates of full-time employment and greater childcare, domestic and caring responsibilities, and hence higher dependence on the neighbourhood environment (36, 37). In Southampton, a city with high levels of deprivation, which similarly to Portsmouth is set in the affluent South East England, the more deprived LSOAs have been shown to have a smaller variety of healthy food and worse quality fruit and vegetables compared to the less deprived LSOAs (38). A decrease in consumption of fruit and vegetables with worsening area deprivation, and higher density of fast food outlets in areas of higher deprivation have both been observed in England (39, 40).

Community-based weight management programmes may be one way of bringing interventions to those women most in need (41-43). Thinking more widely, changing the food environment of the higher deprivation areas can also have a role in weakening the link between deprivation and obesity. Examples include local authorities working with the food industry to make menus healthier and to control density and placement of fast food outlets. The importance of this work has been emphasised by Public Health England (39, 44). Much remains to be done, considering the complex nature of the relationship between food environment and obesity, which is set against the backdrop of the wider economy and politics.

Although area-level indicators have a role in studying complex public health issues, the danger of ecological fallacy should also be borne in mind. The extent of health inequalities may be underestimated without individual-level socio-economic data (45). Prevalence of obesity is known to fall with increasing social class in the UK, and this effect appears to be more marked in women compared to men (13). More research into the interactions between individual and area-level deprivation in relation to maternal obesity could also help inform interventions.

An association between Asian ethnicity and a decreased risk of obesity has been observed in England previously (2, 20, 21). In this ethnic group the risk of obesity complications starts to rise at a lower BMI, which may be due to a higher proportion of body fat at the same BMI (46). The BMI reference ranges are the same, but the World Health Organisation recommends additional, lower cut-offs for determining public health and clinical action in the normal and higher BMI categories in Asian people (46). It is essential to bear in mind this difference in order to avoid risk misclassification and increasing health inequalities already experienced by pregnant Asian women (47). Previous studies in the UK have shown an association between Black ethnicity and maternal obesity (2, 20), although one smaller study did not (21). Our study may have had insufficient numbers in this ethnic group to reveal an association, with only 1.5% of all maternities (whether or not leading to a delivery) being in women of Black ethnicity, compared with the national figure of 5% of mothers in all deliveries in England in 2013/2014 (2).

What this study adds

This study demonstrates that maternal obesity is significantly associated with neighbourhood deprivation in a relatively deprived area in an overall affluent region of England. This is a setting with a specific, but not atypical for the UK, distribution of deprivation levels. The study adds to the body of evidence on the wider determinants of maternal obesity, in particular as

our results differ to those reported for North West England, a region with deprivation being more uniformly widespread (21). Our findings should help inform local public health initiatives aimed at reducing obesity in women of reproductive age, as well as those in other parts of the country where there are urban pockets of deprivation surrounded by the much less deprived areas. This study confirms that IMD can be useful as a group-level indicator of the greatest need for health promotion interventions aimed at tackling maternal obesity, specifically in areas with a spectrum of deprivation levels.

Our study made use of self-reported BMI, revealing a clear underlying trend in the main association of interest. This adds to the knowledge on the use of self-reported BMI in population studies investigating obesity. Where there are barriers to measuring weight and height, the use of questionnaires or routine data which include self-reported values may be an acceptable substitute method for identifying associations and trends of obesity, as previously reported (48, 49). Correction equations may also be used in population studies to address misreporting tendencies (50-53).

The use of secondary data, routinely collected in the course of antenatal care, was cost-effective and allowed access to a relatively large dataset, reducing selection bias that can be associated with recruitment.

Limitations of this study

At the maternity unit in this study standard practice was for women to have their weight and height measured at their dating ultrasound scan, rather than booking appointment, at which self-reported values were collected initially. Ideally we would have liked to link our maternity dataset, containing self-reported BMI, to the ultrasound database with measured BMI, and conduct further analysis, but for a number of reasons this proved impossible. The use of self-reported BMI is a contentious area in public health and epidemiology research and it has been acknowledged that the overall prevalence of obesity may appear lower when using self-reported BMI (54-56). However, we were still able to observe a trend. In addition, the use of self-reported prepregnancy BMI removed the need for correction for length of gestation, with its potential for errors, and selection bias from having to exclude late bookings. This is due to the fact that late bookings are possibly more common in obese women (20, 57) and in women with complex social needs (58), who are more likely to reside in areas with higher deprivation.

Of note is the proportion of missing BMI data in the original sample. We also found that our study sample is likely to have proportionally more women who are older, white and

multiparous, compared to those excluded. The issue of missing data is frequently encountered in maternal obesity studies, and the percentage of missing BMI data can vary significantly, from negligible to sizeable. For example, in a UK study based on 23,668 deliveries, where both electronic records and clinical notes were used to collect BMI data, only 76% women had complete BMI data (59). In another UK study only 75% out of 6573 electronic maternity records had BMI (57). These figures are not dissimilar from the 70% of electronic records containing self-reported BMI in our study.

CONCLUSION

Maternal obesity as indicated by self-reported prepregnancy BMI was positively associated with multiple deprivation in an area with high levels of deprivation in an overall affluent region of England. There was also an inverse association with Asian ethnicity and an association with high parity, but not with age or smoking status. Further research is needed into the complex relationship between deprivation and maternal obesity, as well as into the most effective interventions to help address this link and lessen the overall burden of maternal obesity.

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Figure 1. Maternal obesity by IMD quintile in order of increasing deprivation

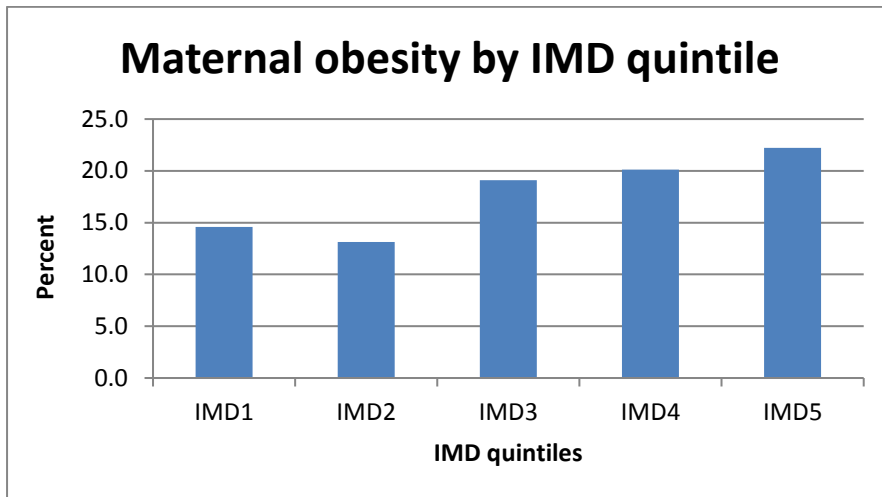


Table 1. Characteristics of the study sample and the women excluded on the basis of missing BMI or IMD

| Baseline characteristic | Included (3,830) n (% included) | Excluded (2,129) n (% excluded) | p-value* |
|--------------------------------|--|--|-----------------|
| <i>Age group, years</i> | | | |
| ≤19 | 154 (4.0) | 203 (9.5) | <0.001 |
| 20-24 | 740 (19.3) | 489 (23.0) | |
| 25-29 | 1,210 (31.6) | 616 (28.9) | |
| 30-34 | 1,104 (28.8) | 551 (25.9) | |
| ≥35 | 610 (15.9) | 256 (12.0) | |
| Unknown | 12 (0.3) | 14 (0.7) | |
| <i>Ethnicity</i> | | | |
| White | 3,224 (84.2) | 1,674 (78.6) | <0.001 |
| Black | 56 (1.5) | 26 (1.2) | |
| Asian | 114 (3.0) | 56 (2.6) | |
| Mixed | 22 (0.6) | 17 (0.8) | |
| Other | 57 (1.5) | 40 (1.9) | |
| Unknown | 357 (9.3) | 316 (14.8) | |
| <i>Smoking</i> | | | |
| yes | 3,039 (79.4) | 1,711 (80.4) | <0.001 |
| no | 715 (18.7) | 346 (16.3) | |
| Unknown | 76 (2) | 72 (3.4) | |
| <i>Parity</i> | | | |
| 0 | 1,209 (31.6) | 1,189 (55.9) | <0.001 |
| 1 | 1,409 (36.8) | 643 (30.2) | |
| 2 | 682 (17.8) | 183 (8.6) | |
| ≥3 | 526 (13.7) | 113 (5.3) | |
| Unknown | 4 (0.1) | 1 (0.0) | |

* χ^2 test

Table 2. Characteristics of the study sample by IMD quintile

| Variable | IMD quintile, n (%) | | | | | Total, n (%) | p-value* |
|---------------------------------|--------------------------|------------|------------|------------|-------------------------|--------------|----------|
| | IMD1 (least deprived) | IMD2 | IMD3 | IMD4 | IMD5 (most deprived) | | |
| <i>All women</i> | 315 (8) | 457 (12) | 639 (17) | 790 (21) | 1629 (42) | 3830 (100) | <0.001 |
| <i>Obesity</i> | | | | | | | |
| Non-obese | 269 (85.4) | 397 (86.9) | 517 (80.9) | 631 (79.9) | 1,267 (77.8) | 3,081 (80.4) | <0.001 |
| Obese | 46 (14.6) | 60 (13.1) | 122 (19.1) | 159 (20.1) | 362 (22.2) | 749 (19.6) | |
| <i>Age group, years</i> | | | | | | | |
| ≤19 | 5 (1.6) | 15 (3.3) | 26 (4.1) | 19 (2.4) | 89 (5.5) | 154 (4.0) | <0.001 |
| 20-24 | 33 (10.5) | 61 (13.4) | 88 (13.8) | 146 (18.5) | 412 (25.3) | 740 (19.3) | |
| 25-29 | 76 (24.1) | 125 (27.4) | 198 (31.0) | 275 (34.8) | 536 (32.9) | 1,210 (31.6) | |
| 30-34 | 119 (37.8) | 153 (33.5) | 212 (33.2) | 230 (29.1) | 390 (23.9) | 1,104 (28.8) | |
| ≥35 | 81 (25.7) | 102 (22.3) | 114 (17.8) | 118 (14.9) | 195 (12.0) | 610 (15.9) | |
| Unknown | 1 (0.3) | 1 (0.2) | 1 (0.2) | 2 (0.3) | 7 (0.4) | 12 (0.3) | |
| <i>Ethnicity</i> | | | | | | | |
| White | 268 (85.1) | 411 (89.9) | 539 (84.4) | 651 (82.4) | 1,355 (83.2) | 3,224 (84.2) | <0.001 |
| Black | 0 (0) | .. | 6 (1.0) | .. | 37 (2.3) | 56 (1.5) | |
| Asian | .. | .. | 14 (2.2) | 26 (3.3) | 66 (4.0) | 114 (3.0) | |
| Mixed | .. | 0 (0) | .. | .. | 16 (1.0) | 22 (0.6) | |
| Other | 5 (1.6) | .. | .. | 13 (1.7) | 30 (1.8) | 57 (1.5) | |
| Unknown | 38 (12.1) | 36 (7.9) | 73 (11.4) | 85 (10.8) | 125 (7.7) | 357 (9.3) | |
| <i>Smoking</i> | | | | | | | |
| Non-smoker | 291 (92.4) | 390 (85.3) | 557 (87.2) | 628 (79.5) | 1,173 (72.0) | 3,039 (79.4) | <0.001 |
| Smoker | 19 (6.0) | 54 (11.8) | 76 (11.9) | 140 (17.7) | 426 (26.2) | 715 (18.7) | |
| Unknown | 5 (1.6) | 13 (2.8) | 6 (0.9) | 22 (2.8) | 30 (1.8) | 76 (2.0) | |
| <i>Parity (previous births)</i> | | | | | | | |
| 0 | 108 (34.3) | 150 (32.8) | 218 (34.1) | 277 (35.1) | 456 (28.0) | 1,209 (31.6) | <0.001 |
| 1 | 140 (44.4) | 180 (39.4) | 252 (39.4) | 275 (34.8) | 564 (34.6) | 1,411 (36.8) | |
| 2 | 40 (12.7) | 78 (17.1) | 109 (17.1) | 142 (18.0) | 313 (19.2) | 682 (17.8) | |
| ≥3 | 27 (8.6) | 49 (10.7) | 60 (9.4) | 96 (12.2) | 296 (18.2) | 528 (13.8) | |

* χ^2 test

.. suppressed due to small numbers

Percentages total 100% vertically, except for 'All women'

Table 3. Associations of obesity with exposures

| Variable | unadjusted | | | adjusted | | |
|-------------------------|------------|------------|----------|----------|------------|----------|
| | OR | 95% CI | p-value* | OR | 95% CI | p-value† |
| <i>IMD quintile</i> | | | | | | |
| IMD1 (least deprived) | 1 | | <0.001 | | | <0.001 |
| IMD2 | 0.87 | 0.57, 1.31 | | 0.83 | 0.55, 1.28 | |
| IMD3 | 1.35 | 0.93, 1.95 | | 1.34 | 0.92, 1.94 | |
| IMD4 | 1.44 | 1.01, 2.07 | | 1.42 | 0.99, 2.05 | |
| IMD5 (most deprived) | 1.64 | 1.17, 2.30 | | 1.60 | 1.13, 2.26 | |
| <i>Age group, years</i> | | | | | | |
| ≤19 | 1 | | 0.294 | | | 0.246 |
| 20-24 | 1.22 | 0.75, 1.98 | | 1.17 | 0.72, 1.91 | |
| 25-29 | 1.48 | 0.93, 2.35 | | 1.47 | 0.91, 2.37 | |
| 30-34 | 1.42 | 0.89, 2.27 | | 1.44 | 0.88, 2.35 | |
| ≥35 | 1.31 | 0.80, 2.14 | | 1.33 | 0.79, 2.22 | |
| <i>Ethnicity</i> | | | | | | |
| White | 1 | | <0.001 | | | 0.001 |
| Black | 0.78 | 0.38, 1.61 | | 0.69 | 0.33, 1.43 | |
| Asian | 0.41 | 0.22, 0.77 | | 0.37 | 0.20, 0.70 | |
| Mixed | 0.60 | 0.18, 2.05 | | 0.55 | 0.16, 1.87 | |
| Other | 0.14 | 0.04, 0.60 | | 0.14 | 0.03, 0.57 | |
| Unknown | 0.71 | 0.52, 0.95 | | 0.77 | 0.57, 1.05 | |
| <i>Smoking</i> | | | | | | |
| Non-smoker | 1 | | 0.009 | | | 0.547 |
| Smoker | 1.30 | 1.07, 1.58 | | 1.07 | 0.86, 1.32 | |
| <i>Parity</i> | | | | | | |
| 0 | 1 | | <0.001 | | | <0.001 |
| 1 | 0.97 | 0.79, 1.19 | | 0.92 | 0.75, 1.14 | |
| 2 | 1.31 | 1.03, 1.66 | | 1.20 | 0.94, 1.55 | |
| ≥3 | 1.91 | 1.50, 2.44 | | 1.65 | 1.26, 2.16 | |

* χ^2 test

†Wald test

Adjustment for all the other variables in the model