Office for Health Improvement & Disparities

Small area associations between breastfeeding and obesity

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Contents

Executive summary

Purpose of this report

This report describes analyses of breastfeeding and child and maternal weight status, using routinely collected administrative data. This project aims to understand the direction and magnitude of any association at small area level between breastfeeding prevalence and children's weight status in the early years, and also between breastfeeding prevalence and mothers' weight status during subsequent pregnancy. The findings can inform policy and decision-makers looking at public health improvement and disease prevention.

Background

Obesity is a major public health issue and rates have increased in recent years. Obesity has a serious impact on morbidity, mortality and quality of life. However, the burden of obesity is unequally distributed, with the prevalence of overweight and obesity in adults, pregnant women and children is highest in the most deprived areas.

Breastfeeding makes an important contribution to the health of mother and baby. Breastfeeding boosts a baby’s ability to fight illness and infection; there is good evidence that not breastfeeding can increase the risk of chest and ear infections, diarrhoea and vomiting, and tooth decay. There is also growing evidence that not breastfeeding might increase the risk of obesity later in life.

It is recommended that babies are exclusively breastfed for around the first 6 months of life with continued breastfeeding for at least the first year of life once solid foods have been introduced. However, breastfeeding rates in the UK are low compared to other countries. Breastfeeding rates also vary between groups, with young mothers, mothers of white ethnicity, those living in more deprived areas of the country and those with lower levels of education the least likely to breastfeed.

Methodology

The relationships between breastfeeding and child weight at ages 4 to 5 and maternal weight later in life were measured at small geographical area level, using data from routinely collected administrative data sources. Statistical models were used to calculate the modelled proportions of mothers and children who were living with obesity and overweight at different levels of breastfeeding prevalence. Various other factors which may influence the relationships, such as deprivation and maternal health behaviours, were accounted for.

Results

There is a small inverse association between breastfeeding prevalence and the prevalence of children living with obesity and overweight at ages 4 to 5, which is independent of the role of other factors. This means that where breastfeeding prevalence is higher in the local area, the predicted prevalence of children living with obesity and overweight tends to be lower.

A similar (but smaller in magnitude) association exists between breastfeeding prevalence and the proportion of mothers who are living with obesity or overweight in a subsequent pregnancy; in areas where more mothers breastfeed, there tends to be fewer mothers who are living with obesity or overweight in a subsequent pregnancy.

These associations cannot be explained by other factors including maternal age, health behaviours during pregnancy and socioeconomic status.

Compared to areas with low levels of background risk factors for obesity and overweight and similar levels of breastfeeding, areas with high levels of these factors tend to have higher proportions of children and mothers living with obesity and overweight.

Conclusion

- Areas with higher levels of breastfeeding tend to have slightly lower proportions of mothers and children living with obesity and overweight. This association is independent of other factors such as deprivation. This is consistent with other studies and suggest breastfeeding may be relevant to preventing future ill health in mothers and children.

- Areas with high levels of risk factors for obesity and overweight are likely to have higher rates of children and mothers living with obesity and overweight than areas with similar levels of breastfeeding but lower levels of these risk factors. This shows the importance of deprivation and other factors in determining levels of obesity and overweight.

- There are significant limitations with these analyses, including the limitations of breastfeeding recording and the availability of suitable data. Investigating these research questions using data which links mother and baby is an important next step in understanding the associations between breastfeeding and weight status.

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1. Background

Obesity is a major public health issue in England. Obesity prevalence has risen substantially in recent decades, both in adults and children. The Health Survey for England 2019 found that 28% of adults were obese and a further 36% were overweight but not obese (1). The National Child Measurement Programme for 2020 to 2021 found that 14.4% of children in Reception (ages 4 to 5) and 25.5% of children in Year 6 (ages 10 to 11) were living with obesity (2). An additional 13.3% of children in Reception and 15.4% of children in Year 6 were living with overweight (2).

Obesity has a serious impact on morbidity, mortality and quality of life. It is a risk factor for type 2 diabetes, cardiovascular disease, liver and respiratory disease and many types of cancer, and can have an impact on mental health (3). Obesity in childhood is a major risk factor for obesity in adulthood and has implications for a child's physical and mental health, educational attainment and life expectancy (3). The burden of disease from obesity also has wide-reaching economic effects (3).

Obesity prevalence is associated with deprivation and is highest in the most deprived areas. The proportion of adults who were overweight or obese in England in 2019 to 2020 in the least deprived decile was 58.7% and in the most deprived decile it was 66.7% (4). Children in the most deprived parts of England are more than twice as likely to be living with obesity compared to their peers living in the least deprived areas (2). In the least deprived decile, the proportion of Reception aged children (ages 4 to 5) living with obesity was 7.8% and in the most deprived decile it was 20.3% (2). In Year 6 (ages 10 to 11), the prevalence of obesity was 14.3% for the least deprived decile and 33.8% for the most deprived decile. This is sowing the seeds of adult diseases and health inequalities in childhood.

Obesity in early pregnancy shows a clear gradient across deprivation deciles. In the least deprived decile 15.1% of women were living with obesity when they had their first antenatal appointment, compared to 28.5% in the most deprived decile. Mothers in their 20s and 40s are also more likely to be living with obesity in early pregnancy, as are mothers of black ethnicity (8).

Obesity in pregnancy presents risks for both mother and baby. Mothers who are living with obesity when they attend their first antenatal appointment ('booking' appointment) are at higher risk of pregnancy loss, complications during pregnancy such as gestational diabetes and preeclampsia, and complications at delivery (5,6,7). Babies whose mothers were living with obesity during pregnancy are more likely to be premature or stillborn and have a higher risk of birth defects (5,6,7).

Breastfeeding is known to have a range of health benefits for both mother and baby and supports bonding between them. There is evidence that babies who are not breastfed are at higher risk of developing respiratory, ear and gastrointestinal infections, (9,10). and at higher risk of hospitalisation for these conditions (9,11). There is evidence from one trial and a range of observational studies that not breastfeeding may be associated with disadvantages for certain neurodevelopmental outcomes (performance in intelligence tests) during childhood (12-15). Breastfeeding may also have an impact on the baby's future weight status through childhood and potentially into adulthood, though existing research gives conflicting evidence on this (9,16-18). Development in the first 1,001 days from conception to age 2 are therefore recognised to be a critical period in determining future health, wellbeing and opportunities (19).

The available evidence indicates that breastfeeding is associated with improved maternal health: lower risk of breast cancer and endometriosis, and greater postpartum weight loss and lower risk of obesity in the longer-term (9,20-22). If breastfeeding can help women to lose excess weight – either pre-pregnancy overweight or excess weight gained during pregnancy – this may offer both an important opportunity to impact maternal health.

It is recommended that babies are exclusively breastfed for the first 6 months of life, followed by breastfeeding alongside the introduction of nutritious complementary foods up to at least 2 years of age (23). However, breastfeeding rates are typically lower in high income countries compared to middle- and low-income countries, despite large increases since 2000 (24). Breastfeeding rates in the UK are also low compared to other similar countries (24). In 2020 to 2021 the proportion of infants in England who were exclusively or partially breastfed at 6 to 8 weeks of age was 47.6% (25) and this trend has been broadly stable in recent years. Data from 2010 indicates that only 1% of babies were exclusively breastfed for the first 6 months (26).

Many mothers who are not breastfeeding at 6 to 8 weeks report that more support and guidance from healthcare professionals would have helped them continue for longer and many mothers who stop report that they would have liked to continue for longer (26). Similarly, mothers also report breastfeeding and expressing milk being more difficult once they return to work (26), indicating that many mothers want to breastfeed but face challenges in doing so. Although the proportion of mothers who report there being facilities for them to breastfeed or express at work has increased since 2005, 8% of mothers reported being able to breastfeed at work in 2010 (26).

However, some mothers are more likely to breastfeed than others. Mothers living in more deprived parts of the country are less likely to breastfeed; in 2020 to 2021, there was almost a 2-fold difference between the proportion of infants who were breastfed at 6 to 8 weeks in the least deprived decile compared to the most deprived decile (27). Mothers who are young, have white ethnicity or who have a low level of education are least likely to breastfeed (26,27).

Given the disparities described above, many of the socioeconomic inequalities that can persist throughout life may therefore begin during pre-conception and pregnancy. Breastfeeding and obesity in pregnancy, among other factors, are recognised as specific drivers of health inequalities in the early years and therefore offer important opportunities to improve public health and reduce health inequalities.

In recognition of the importance of the early years for future health and wellbeing, in July 2020 the government commissioned Rt. Hon. Andrea Leadsom MP to conduct the Early Years' Healthy Development Review (19). The review looked into improving the health and development outcomes for babies in England and focused on the 1,001 critical days through pregnancy to the age of 2. The analysis described in this report was completed to improve understanding of obesity and inform future work, as part of government investment in weight management support.

The aims of this project are therefore to establish an understanding of the direction and magnitude of any association between breastfeeding prevalence and child weight status in the early years, and also between breastfeeding prevalence and mothers' subsequent weight status.

2. Methodology

This is a cross-sectional ecological study using routinely collected health data: a type of study that analyses data at a population or group level at a specific point in time.

Data was drawn from the following sources (full details in Appendix A):

- NHS Digital Maternity Services Data Set (MSDS), 2018 to 2019
- NHS Digital Community Services Data Set (CSDS), 2019 to 2020
- NHS Digital National Child Measurement Programme (NCMP) data, 2018 to 2019
- Office for National Statistics (ONS) Births data, 2018 to 2019
- mySociety Index of Multiple Deprivation (IMD) data, 2019

Two analyses were carried out:

- Analysis 1 - to identify any association between the proportion of babies receiving breastmilk and children who were living with obesity and overweight at ages 4 to 5

- Analysis 2 - to identify any association between the proportion of babies receiving breastmilk and mothers living with obesity and overweight

The analyses classified variables as 'exposure', 'confounder' or 'outcome' variable types, in order to pass these into the model and assess associations. Appendix B describes the populations of children and mothers included in each variable type.

For both analyses, the exposure variable was the proportion of children who were exclusively or partially breastfed at 6 to 8 weeks of age in 2019 to 2020.

The primary outcomes were

- Analysis 1 - the proportion of children who were living with obesity at ages 4 to 5

- Analysis 2 - the proportion of mothers who were living with obesity at the start of a subsequent pregnancy

The proportion of children and mothers who were living with overweight were also analysed as secondary outcomes. Appendix C describes the methods of exposure and outcome measurement, including definitions of obesity and overweight.

The analyses accounted for a range of confounders (other factors related to both the exposure and outcome variables independently and which may therefore influence associations in the analysis) which were identified in academic papers. The list of confounders and their definitions are available in Appendix F.

The analysis was conducted at the middle-layer super output area (MSOAs) level (Appendix D). MSOAs are small areas of around 10,000 people. The number of mothers or children in each area with each characteristic were counted and this number was divided by the total number of mothers or children as appropriate in that area to obtain the proportions of mothers or children with each characteristic for each MSOA.

Regression models were used to explore the associations. Regression is a statistical method used to model the relationship between 2 variables by fitting a straight line to the data. Here generalised linear regression models (GLM) were used to calculate the predicted prevalence of each outcome at different levels of breastfeeding prevalence, assuming all else remained equal. Checks for the impact of excluding some mothers and changing the levels of different variables in the models were completed. Appendix E gives additional information about the regression models used.

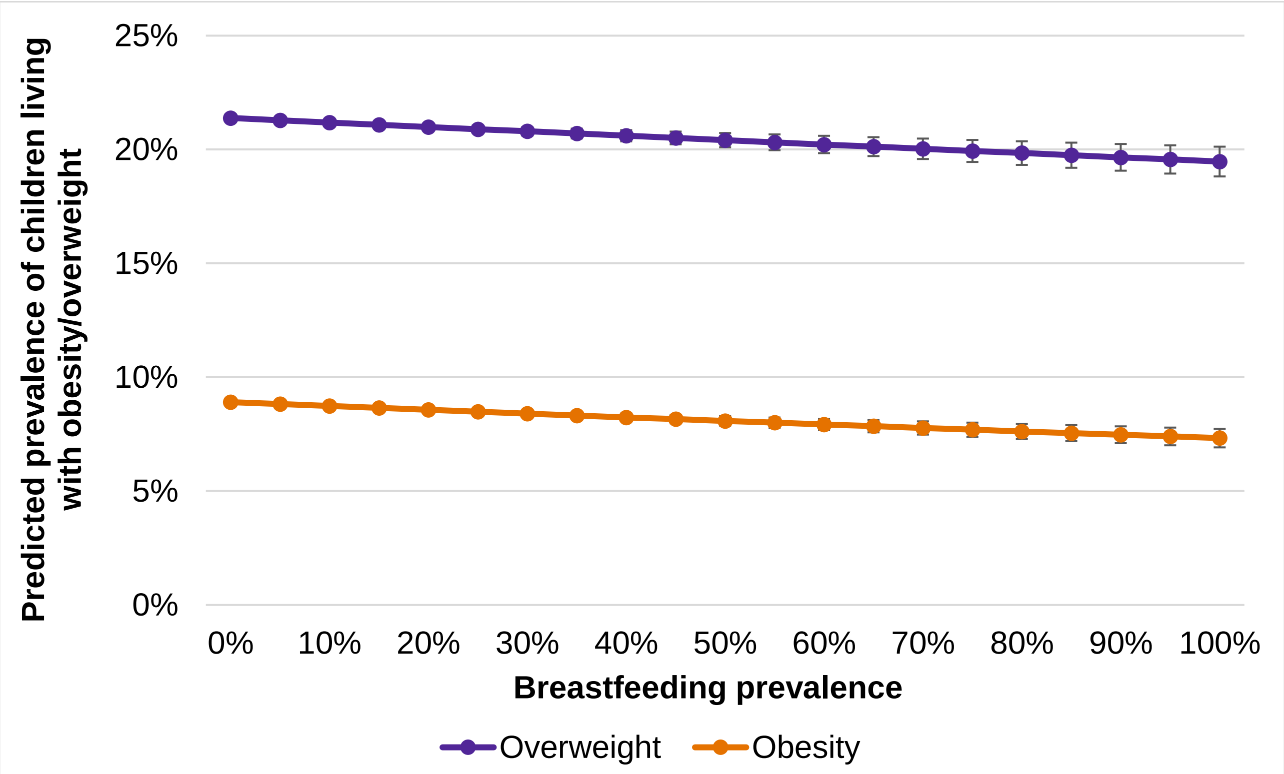
3. Results and discussion

Analysis 1: Child weight status

There is a small inverse association between breastfeeding prevalence and the prevalence of children living with obesity at ages 4 to 5, after accounting for a range of confounding variables. A similar association in the same direction exists between breastfeeding prevalence and the prevalence of children living with overweight. This means that, all else being equal, in MSOAs with higher proportions of children being breastfed at 6 to 8 weeks there tends to be lower proportions of children living with overweight and obesity.

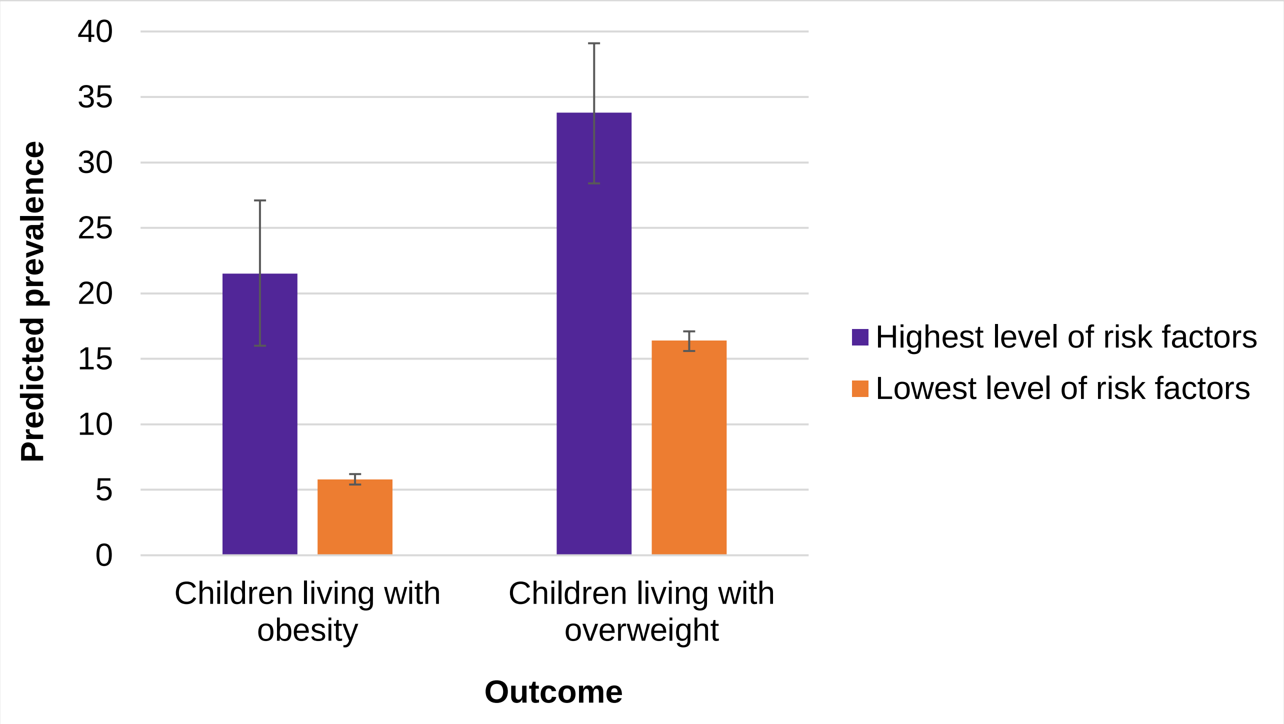
When each confounder is held at the level of its national average, the predicted prevalence of overweight and obesity decreases as breastfeeding prevalence increases (Figure 1). Where breastfeeding prevalence is modelled at 0%, 50% and 100%, the predicted prevalence of children living with obesity is 8.9% (95% confidence interval (CI) 8.8% to 9.0%), 8.1% (CI 7.9% to 8.3%) and 7.3% (CI 6.9% to 7.7%) respectively. Where breastfeeding prevalence is modelled at 0%, 50% and 100%, the predicted prevalence of children living with overweight is 21.4% (CI 21.2% to 21.6%), 20.4% (CI 20.1% to 20.7%) and 19.5% (CI 18.8% to 20.1%) respectively.

Figure 1: Predicted prevalence of children living with obesity and overweight for given rates of breastfeeding, holding all confounders at the national average



In a scenario where the level of risk factors for obesity and overweight (such as deprivation) are at their highest, the predicted prevalence of children living with obesity at the 2018 to 2019 national average breastfeeding prevalence (46.2%) (25) is 21.5% (CI 16.0% to 27.1%). This compares to a predicted prevalence of children living with obesity of 5.8% (CI 5.4% to 6.2%) in a scenario where the level of risk factors for obesity and overweight are at their lowest (Figure 2). The predicted proportions of children who are living with overweight in these 2 scenarios are 33.8% (CI 28.4% to 39.1%) and 16.4% (CI 15.6% to 17.1%) respectively.

Figure 2: Predicted prevalence of children living with obesity and overweight at the national average breastfeeding prevalence, in 2 alternative scenarios



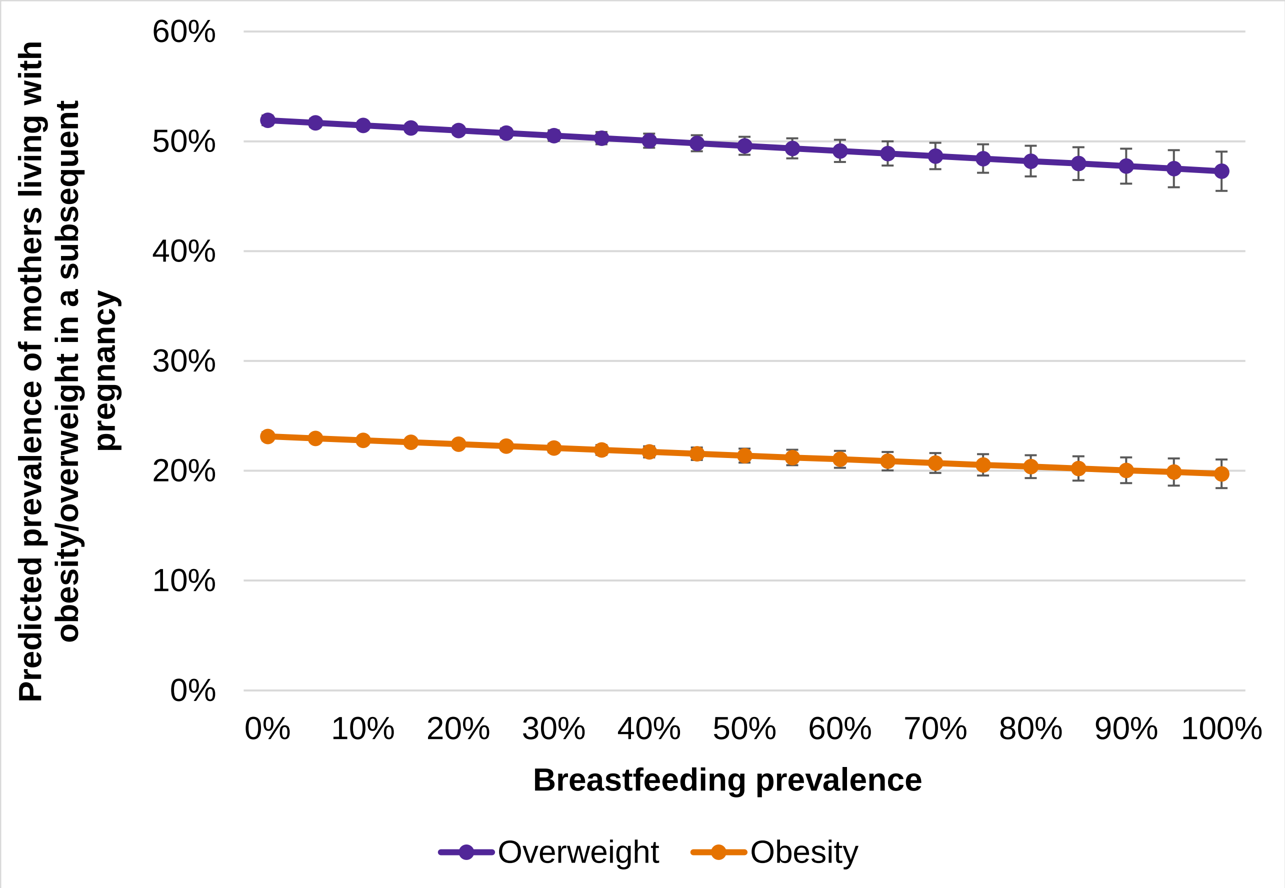
Analysis to consider the impact of including or removing some mothers from the model (sensitivity analysis) indicated that applying additional exclusions to the deliveries data (see Appendix E) did not substantially change the predicted prevalence of children living with obesity or overweight.

Analysis 2: Maternal weight status

After accounting for a range of confounding variables, there is a small inverse association between breastfeeding prevalence and the proportion of mothers who are living with obesity at the start of a subsequent pregnancy. An association in the same direction exists between breastfeeding prevalence and the proportion of mothers who are overweight at the start of a subsequent pregnancy. This means in MSOAs with higher proportions of children being breastfed at 6 to 8 weeks there tends to be lower proportions of mothers who are overweight or obese in a subsequent pregnancy. These associations are smaller than those identified for children's weight status. It is important to recognise these results are limited to mothers who have a subsequent pregnancy due to data availability so may not be representative of mothers overall (see Appendix C).

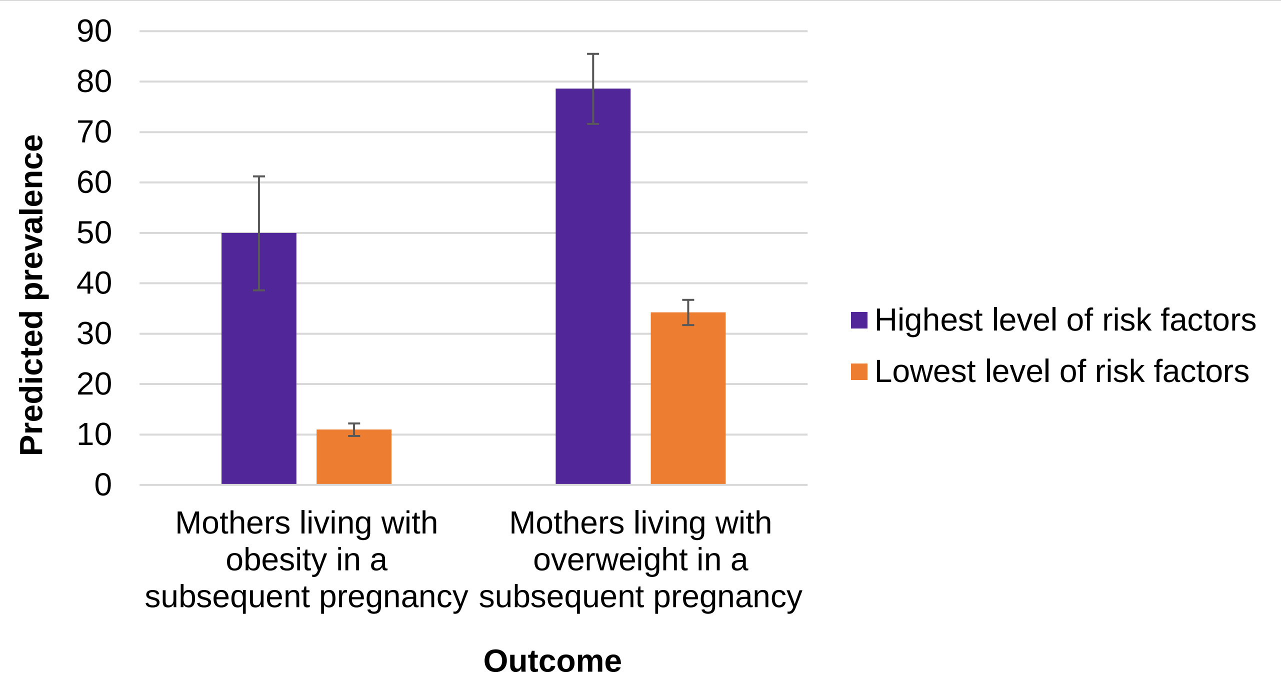
When each confounder is held at the level of its national average, the predicted prevalence of overweight and obesity decreases as breastfeeding prevalence increases (Figure 2). Where breastfeeding prevalence is modelled at 0%, 50% and 100%, the predicted prevalence of mothers living with obesity is 23.2% (CI 22.8% to 23.5%), 21.4% (CI 20.8% to 22.0%) and 19.7% (CI 18.4% to 21.0%) respectively. Where breastfeeding prevalence is modelled at 0%, 50% and 100%, the predicted prevalence of mothers living with overweight is 51.9% (CI 51.5% to 52.4%), 49.6% (CI 48.8% to 50.4%) and 47.3% (CI 45.5%to 49.1%) respectively.

Figure 3: Predicted prevalence of mothers living with obesity and overweight for given rates of breastfeeding, holding all confounders at the national average



In a scenario where the level of risk factors for obesity and overweight are at their highest, the predicted prevalence of mothers living with obesity in a subsequent pregnancy at the national average breastfeeding prevalence (46.2%) is 50.0% (CI 38.6% to 61.2%). This compares to a predicted prevalence of mothers living with obesity in a subsequent pregnancy of 11.0% (CI 9.7% to 12.2%) in a scenario where the level of risk factors for obesity and overweight are at their lowest (Figure 4). The predicted proportions of mothers living with overweight in a subsequent pregnancy in these 2 scenarios are 78.6 % (CI 71.6% to 85.5%) and 34.2% (CI 31.7% to 36.7%) respectively.

Figure 4: Predicted prevalence of mothers living with obesity and overweight at the national average breastfeeding prevalence, in 2 alternative scenarios



Unlike with the results for children, sensitivity analysis found that excluding certain mothers did slightly change the predicted prevalence of obesity or overweight for different levels of breastfeeding. When deliveries where the mother had any obstetric diagnosis or maternal critical incident were excluded, and all deliveries by caesarean section were excluded, the predicted proportion of mothers living with obesity at 0% breastfeeding prevalence was 52.5% and the predicted proportion at 100% breastfeeding prevalence was 46.7%. This is a difference of 5.8 percentage points. When these deliveries were included in the model, this difference was 4.6 percentage points. A slightly smaller impact of excluding these mothers was found for the proportion of mothers who were living with obesity in a subsequent pregnancy.

Discussion

The results indicate that there is a small association between breastfeeding prevalence and the prevalence of overweight and obesity which is independent of a wide range of confounding factors. This is consistent with other studies exploring the association between breastfeeding and obesity at the individual level using smaller populations, and with meta-analyses of such studies (9,12,14,16,17,28,29).

These results also emphasise the importance of the confounding factors in the prevalence of overweight and obesity. At the national average level of breastfeeding, areas with high levels of deprivation and other confounding factors have notably higher predicted levels of overweight and obesity in both mothers and children. The same level of breastfeeding is associated with much higher levels of obesity and overweight in areas with higher deprivation and other risk factors. This strengthens the evidence that the confounders assessed in this study have an important influence on the risk of overweight and obesity, therefore also lending weight to the study methods.

The sensitivity analyses indicate that the association between breastfeeding and child and maternal weight status persists across all kinds of deliveries. Obstetric diagnoses, maternal critical incidents and caesarean sections do not appear to modify or confound the relationships between breastfeeding prevalence and weight status in children. It is plausible that many mothers with these conditions were already excluded in the main data set or that at MSOA level there are very few deliveries with these characteristics, meaning excluding them has a minimal impact on the proportion of mothers with other characteristics in many MSOAs.

However, these exclusions do have an impact on the association between breastfeeding prevalence and the prevalence of mothers living with overweight or obesity in a subsequent pregnancy. When these deliveries are excluded from the model, there is a steeper gradient to the predicted prevalence of mothers living with overweight or obesity as breastfeeding prevalence increases, compared to when they are included in the model. This suggests that obstetric diagnoses, maternal critical incidents and caesarean sections may be important factors in determining a mother's breastfeeding choices and risk of subsequent maternal obesity or overweight.

Investigating these research questions using data which links mother and baby is an important next step in understanding the association between breastfeeding and weight. NCMP results from 2020 to 2021 show a large increase in the prevalence of obesity children in Reception between 2019 to 2020 and 2020 to 2021 (2). Breastfeeding rates may also have been affected by the coronavirus (COVID-19) pandemic. As the situation evolves and the longer-term effects of COVID-19 become more apparent, it will be important to repeat this analysis to assess the impact of the pandemic on the associations identified.

4. Conclusions

This study indicates that higher rates of breastfeeding are associated with lower rates of obesity and overweight in children and mothers. Areas which have higher rates of breastfeeding at 6 to 8 weeks of age tend to have slightly lower rates of children living with overweight and obesity at ages 4 to 5. This association exists when a range of confounding variables are taken into account. Areas with higher breastfeeding rates also tend to have slightly lower proportions of mothers living with overweight and obesity at the start of a subsequent pregnancy.

There is also evidence that other risk factors for obesity and overweight are important in determining the level of obesity and overweight in an area, regardless of breastfeeding status.

There are significant limitations to this study which should be considered when interpreting the findings. Further research using linked data is required to assess the nature of these associations at an individual level and explore the role of ethnicity and other confounders, as well as exploring the importance of breastfeeding intensity, method and duration beyond 6 to 8 weeks.

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Appendices

Appendix A: Data sources

Analysis of the association between breastfeeding and health outcomes including weight status would ideally use linked mother and baby datasets to analyse mother-child dyads, which would also enable analysis of the impact of prenatal characteristics and pregnancy behaviours on child health. A linked MSDS and CSDS dataset was sought for this study but could not be obtained.

Maternity Services Data Set (MSDS) (30)

MSDS captures information on women from their first antenatal appointment ('booking' appointment) with a midwife up until shortly after delivery. It includes some information about the baby or babies. It collects information on all pregnancies in England which reach the stage of a booking appointment. The data set is owned and managed by NHS Digital (NHSD) and Office for Health Improvement and Disparities (OHID) accesses an anonymised extract of the record-level MSDS data. Analysis previously published by the former Public Health England (PHE) has concluded that the data for 2018 to 2019 is of sufficient quality to be used for published analysis, including indicators of health in early pregnancy published in PHE Fingertips in 2020 (4).

National Child Measurement Programme (NCMP) (31)

Children are weighed and measured during their Reception year and Year 6 of school as part of the universal NCMP. The height, weight, and zBMI (body mass index) score are recorded in the NCMP dataset along with some basic demographic information and information about the school. zBMI is an age- and sex-standardised measure of body mass index used for studies of children (32). Children are assigned a weight status category of underweight, healthy weight, overweight or very overweight according to the 2nd, 85th and 95th centiles of the British 1990 growth reference (UK90) (33).

The NCMP dataset is owned by NHSD who collect data from each local authority. OHID receives an analysis data set directly from NHSD which does not include patient identifiable information.

Community Services Data Set (CSDS) (34)

CSDS records all publicly-funded healthcare and public health services delivered in the community in England. It includes information about activities and care contacts, demographics, diagnoses and observations. Data from local community IT systems flow each month to the national dataset, where it is processed and reported by NHSD. OHID accesses routine extracts for analysis in support of its child and maternal health analytical priorities.

Index of Multiple Deprivation score data (35)

The index of multiple deprivation (IMD) is a measure of relative deprivation of small areas in England. It is published by the Ministry of Housing, Communities and Local Government (MHCLG; now the Department of Levelling Up, Housing and Communities), with the most recent data published in 2019 (36). IMD is based on 7 domains of deprivation and is calculated at the lower-layer super output area (LSOA) level, but scores can also be calculated for higher geographies. Scores for a range of English geographies including middle-layer super output areas (MSOAs; Appendix D) have been calculated by the University of Sheffield, in collaboration with MHCLG and mySociety, and published by mySociety (35), using the population weighting method recommended by MHCLG (37). For this analysis, MSOA IMD scores were obtained from the mySociety Research website.

Office for National Statistics births data (38)

Birthweight variables used in this analysis (Appendix F) were calculated from Office for National Statistics (ONS) birth registrations data. These data cover all births registered in England and Wales and contain information about various birth characteristics, including the mother's LSOA of residence and the birthweight of the baby or babies. OHID has access to anonymised record-level births data.

Appendix B: Populations

Mothers at delivery

The population of mothers in the analyses differed between the maternal weight status outcome variables and the confounder variables.

To measure the proportion of mothers who were obese or overweight in a subsequent pregnancy, the population consisted of mothers in the MSDS with deliveries in 2018 to 2019 which were deemed to be a subsequent pregnancy. These were where the mother had a previous live birth, previous stillbirth or previous pregnancy loss recorded. No additional exclusions were applied to these outcome variables.

To measure the proportion of mothers with each of the confounder characteristics (see Appendix F), the population consisted of mothers in the MSDS with deliveries in 2018 to 2019 which resulted in a live, singleton birth at term (>=37 weeks gestation and <=42 weeks gestation) in England.

Some mothers were excluded from the confounder variables to prevent the data set being biased or including mothers who would be unable to breastfeed. Potential exclusion criteria were identified by a literature review and consultation with clinicians and academic experts. Premature babies (39) and multiple birth babies (40) show different growth patterns to term babies and both scenarios can also affect the likelihood of being breastfed (41). Postmature babies (those born after 42 weeks) are likely to have higher birthweight, which is associated with childhood obesity (42).

Additionally, mothers whose baby died shortly after birth or who themselves died shortly after birth were excluded. Deliveries where the baby was admitted to a neonatal unit were also excluded.

Since confounders were measured across all deliveries and the proportion of mothers who were overweight or obese in a subsequent pregnancy was taken from the same year of data, the same mothers will be included in the confounders and the outcome measure. This presents an issue for the statistical validity of the findings. Similarly, ideally multiple years of data would be used in the analysis to smooth variation between years. However, 2018 to 2019 is the only year of MSDS data available to OHID which is of sufficient quality for analysis.

Children

The population of children in the analyses consisted of children with a weight status in Reception (ages 4 to 5) recorded in the NCMP data set in 2018 to 2019.

The NCMP was conducted in 2019 to 2020 and 2020 to 2021 and record-level data are available to OHID. However, due to school closures resulting from the COVID-19 pandemic, there was significant disruption to these data collections (2). Although the national level data has been weighted to be representative and comparable with previous years, NHS Digital advise that there is significant variation in coverage of measurements between local authorities and in some the data aren't directly comparable to previous years. Therefore, the 2018 to 2019 data has been used for this study to maximise the size of the available data set.

As with mothers, ideally multiple years of data would be used in the analysis as advised in NCMP analysis guidance (33). Since the data from MSDS is limited to a single year, a single year of NCMP was also used.

Some children are not routinely measured as part of the NCMP. This includes children who were absent from school when measurement was completed, who opted out or whose parents or school opted out, who could not or refused to be measured due to cognitive impairment, or who were unsuitable for measurement due to physical impairment (43). The NCMP is also only delivered in state-maintained schools and some independent and special schools. Some children will therefore not be included who otherwise should be. These children may be more or less likely to have been breastfed and to be living with obesity/overweight, however this is unlikely to bias the results as this population is only a small fraction of the whole population.

Additionally, some children should be excluded from the NCMP and ONS Births data sets because of conditions and characteristics of their mothers during pregnancy and delivery. For example, deliveries with a neonatal admission have been excluded from the MSDS data set. Children who were admitted neonatally should therefore be excluded from the outcome measurement in the NCMP. However, relevant data items are not available in the NCMP and ONS Births data, and linkage between MSDS and these data sets is not possible. Therefore, these exclusions cannot be applied. This is also a limitation of the sensitivity analysis as the additional exclusions could only be applied to the MSDS data.

Ideally, NCMP data for the financial year 6 years after the MSDS data would be used, to increase the likelihood that the children in scope are those children with whom the mothers in scope were pregnant at the time of data collection. However, this is not possible with these data sets. It is assumed that this would have a limited impact on the results of this analysis because the nature of the 2 population groups is unlikely to undergo significant change over 5 years.

Appendix C: Exposure and outcome measurement

Exposure

In both analyses, the exposure variable is the prevalence of exclusive or partial breastfeeding at 6 to 8 weeks of age as recorded in the CSDS. The BFStatus variable indicates whether a baby is exclusively or partially breastfed at the time of the activity. This variable is derived from various fields included in an activity record, some of which use SNOMED codes (44) which indicate various types of infant feeding.

Some activities coded as new birth visits (ActivityCode= "08: Health Visitor New Birth Visit”) also have a breastfeeding status applied. For the purposes of this analysis, breastfeeding status records with the new birth visit activity code were excluded.

Breastfeeding prevalence was measured as the proportion of children aged 0 or 1 at the end of 2019 to 2020 who had BFStatus as “01: Wholly breastfed” or “02: Partially breastfed” in each MSOA. This was considered a suitable approximate measure of breastfeeding prevalence at 6 to 8 weeks. It is not possible to describe breastfeeding intensity more specifically. The denominator was all children aged 0 or 1 at the end of 2019 to 2020 in each MSOA as recorded in the CSDS.

Breastfeeding status is only routinely recorded at birth (first feed breastmilk) and at 6 to 8 weeks. Therefore, the role of breastfeeding duration cannot be assessed, though evidence indicates duration beyond 6 to 8 weeks is very important for future infant growth (45). Additionally, it is not possible to assess the extent to which breastfeeding is direct from the breast or through bottle feeding of expressed milk. There is a lack of consensus about the mechanism by which breastfeeding might influence obesity risk, however, one theory suggests that the infant may be better able to regulate milk intake when feeding directly at the breast and this encourages better regulation of food intake in childhood. Moreover, the role of responsive feeding as opposed to other approaches cannot be assessed but may be important in preventing subsequent weight gain. The limitations of the breastfeeding data used for this study prevent the analysis from investigating the potential importance of the mode of feeding breastmilk.

Data quality issues with the CSDS mean that the denominator will be an underestimate of the true number of children in each MSOA (46) and the sample of children included may be slightly biased if children with particular characteristics are more or less likely to be included in the CSDS.

Outcomes

There were 2 outcome variables for both analysis 1 and analysis 2 which are described below. Repeating statistical analyses with a secondary outcome variable is common practice to explore various possible associations. In this instance, differences in associations for overweight and obesity may have important policy implications. Also, a secondary outcome variable including all persons in that group who were overweight and obese has the potential to produce a more precise estimate of association because of the larger population in the analysis.

Analysis 1

The first outcome variable in analysis 1 was the proportion of children in Reception (ages 4 to 5) who were obese or severely obese, as measured in the NCMP pupil data table, in each MSOA in 2018 to 2019. All children in Reception (ages 4 to 5) who had a BmiPopulationCategory value of “very overweight” were included in the numerator. These are children whose BMI is at least at the 98th centile. The population classification of weight status was selected because this measures weight status against centiles of the UK90 growth reference (Appendix A), rather than clinical cut-offs. These thresholds are used by NHS Digital and OHID for reporting population prevalence (33). The denominator was the total number of children in Reception (ages 4 to 5) with a weight status recorded in the NCMP in each MSOA.

The second outcome was the proportion of children in Reception (ages 4 to 5) who were overweight (BmiPopulationCategory = “overweight”), obese or severely obese (BmiPopulationCategory = “very overweight”), as measured in the NCMP. These are children whose BMI is at least at the 91st centile.

Analysis 2

The first outcome was the proportion of mothers who were living with obesity at their antenatal booking appointment for a subsequent pregnancy, as measured in the MSDS and defined based on the mother's BMI. This is because it is only possible to assess the impact of breastfeeding on maternal weight status using maternal weight status at the booking appointment for a subsequent pregnancy.

Mothers were excluded if their booking appointment occurred at greater than 14 weeks gestation to minimise the effect of weight gained in the current pregnancy. BMI was calculated for all mothers included in the analysis using the height and weight measurements taken during the booking appointment. Mothers with implausible BMI values (those less than 13 or more than 80) were excluded.

Subsequent pregnancies were identified in the MSDS using the PreviousLiveBirths, PreviousStillBirths and PreviousLossesLessThan24Weeks variables. If any of these was greater than 0, the pregnancy was deemed a subsequent pregnancy.

Obesity in mothers was defined as a BMI at booking of greater than or equal to 30kg/m2, based on the PersonWeight and PersonHeight variables. The number of mothers with obesity in a subsequent pregnancy was calculated for each MSOA. This was then used to calculate the proportion of women with obesity in a subsequent pregnancy using the total number of pregnancies in the MSDS in 2018 to 2019 which are subsequent pregnancies as the denominator.

The second outcome was the proportion of mothers who were overweight or obese in a subsequent pregnancy, measured in the same way as described above but using a BMI threshold of greater than or equal to 25kg/m2 for inclusion in the numerator.

There is no routine measurement of weight status for mothers outside of the antenatal booking appointment setting. The population of mothers who have a subsequent pregnancy is different to the total population who have only one pregnancy, meaning the findings of these analyses cannot be generalised to the total population of mothers. For instance, mothers are more likely to smoke at booking for a subsequent pregnancy compared to a first pregnancy (8). They are also more likely to be drinking alcohol at booking and less likely to take folic acid supplements prior to conception (8). The associations identified here between breastfeeding and maternal weight status in a subsequent pregnancy may be different to the association between breastfeeding and maternal weight status in all mothers regardless of whether they go on to have further pregnancies.

Similarly, the association between breastfeeding and maternal weight status would ideally be measured by assessing whether mothers change weight status after pregnancy. Unfortunately, the MSDS cannot currently be linked to other data measuring weight status. It was also not possible to link multiple pregnancies to the same mother in the OHID extract of the MSDS data, meaning change in weight status between pregnancies could not be assessed.

Appendix D: Middle-layer super output areas (MSOAs)

Middle-layer super output areas (MSOAs) were used as the units of analysis. MSOAs are built from output areas used by the Office for National Statistics (ONS) for census data collection (47). MSOAs have between 5,000 and 15,000 total population in between 2,000 and 6,000 households. The current MSOA geographies were generated in 2011 and there are 6,791 MSOAs in England.

Testing was conducted to identify the most appropriate geographical level for analysis. At least 50% of areas were required to have at least 20 mothers with a delivery in 2018 to 2019 and 50 Reception age children with an NCMP measurement in 2018 to 2019. These criteria would prevent the risk of over-estimation of associations which can result from analysis with small numbers. MSOAs were identified as the most granular unit of analysis that met these criteria, therefore allowing robust statistical analysis and sufficiently precise effect estimates.

Larger geographical areas, such as lower tier local authorities, would allow for more robust analyses because they contain more mothers and children. However, using larger geographical areas would obscure variation at smaller area level.

Binary variables were generated at the individual record level for all variables except deprivation score, to identify whether each mother or child had each characteristic. These binary variables were then aggregated into MSOA-level counts and MSOA-level proportion variables were calculated using the appropriate denominators. Deprivation scores were directly measured at MSOA level.

Of the 6,791 MSOAs, 137 were excluded from the analysis because there were no live, term, single births recorded in the MSOA in 2018 to 2019.

Using MSOAs as the units of analysis provides a good indication of important associations at population level but cannot be extrapolated down to individual level. This type of error, where inferences about individuals made based on aggregate level information, is called the ecological fallacy.

Appendix E: Statistical methods

Linear regression models were iteratively developed and tested for model performance. Confounders were iteratively added and removed from the models and the assumptions of regression modelling tested to ensure statistical validity.

Scatter plots of outcome data and each confounder were used to identify outliers that could skew the data. Thresholds for valid data were defined and outlying MSOAs were excluded from the analysis.

Plots of residuals against fitted values of the dependent variables were used to identify heteroscedasticity and non-linearity. Normality of residuals was checked for by plotting kernel density estimates of residuals. Multicollinearity was identified using variance inflation factor testing. Variables were removed from the model if the variance inflation factor associated with them exceeded 1.5. Model specification error was tested for using a link test.

Once appropriate models had been identified, generalised linear models (GLM) were used to predict values of each outcome at varying levels of breastfeeding prevalence. This technique predicts the value of the outcome variable in a hypothetical additional area, for given levels of the primary exposure variable. The other independent variables are given a fixed value, meaning the predicted outcome values indicate the predicted level of the outcome for each level of the exposure independent of the influence of confounders.

This method was chosen because the dependent variables being assessed are proportions and because predicted levels of the outcome variables can be calculated for varying levels of the exposure at defined levels of confounders.

Predictions at 5% intervals of breastfeeding prevalence between 0% and 100% were generated with all confounders at the mean level for all MSOAs. The predicted values of the outcome variables were compared and assessed graphically.

Predictions at the national average breastfeeding prevalence in 2018/2019 (46.2%) (4) were made for 2 scenarios:

- Each modifiable confounder at its maximum risk level for the outcome for any MSOA (and non-modifiable risk factors at the mean value for all MSOAs the highest level of risk factors scenario)

- Each modifiable confounder at its minimum risk level for the outcome for any MSOA and non-modifiable risk factors at the mean value for all MSOAs the lowest level of risk factors scenario).

The predicted values of the outcomes in these 2 scenarios were tabulated.

Confounders were considered modifiable if it was judged that public health policy or interventions have the ability to influence the levels in the population. For example, the proportion of mothers aged under 25 in an area is considered to be modifiable, whereas the proportion of mothers whose pregnancies are first pregnancies is not.

Sensitivity analysis

Sensitivity analysis was used to determine the effect of excluding certain deliveries from the variables derived from MSDS. This allows for more confidence in the validity of the findings. Maternal obesity is a known risk factor for gestational diabetes and also affects birthweight (48). There is also evidence that the risk of intrahepatic cholestasis of pregnancy (ICP) increases with increasing BMI (49) and that it increases the risk of childhood obesity in the resulting children (50). Maternal obesity is also associated with an increased risk of preeclampsia (51) and incidents during delivery (maternal critical incidents), such as postpartum haemorrhage (5,6). Caesarean section has also been shown to present a higher risk of subsequent maternal and child obesity (52).

Table 1: Specification of data sets created for sensitivity analysis

Sensitivity analysis	Exclusions applied
Data set 1	Mothers with gestational diabetes Mothers with preeclampsia Mothers with intrahepatic cholestasis
Data set 2	1 plus Mothers who had a caesarean section
Data set 3	2 plus Mothers with any obstetric diagnosis Mothers with any maternal critical incident during delivery

These exclusions could not be applied to variables derived from other data sets because deliveries in the MSDS cannot be linked to babies in ONS Births data or children in the CSDS or NCMP (Appendix C).

Appendix F: Table of confounders considered for the analysis

Variable (including references for evidence supporting confounding)	Description	Data source	Analysis in which confounder was considered for inclusion in the model	Modifiability
Mothers with white ethnicity (12, FIND SOMETHING)	Proportion of mothers in each MSOA who had white ethnicity	MSDS	Analysis 1 Analysis 2	Not considered modifiable
Mothers with ethnicity other than white (26,53)	Proportion of mothers in each MSOA who had an ethnicity other than white	MSDS	Analysis 1 Analysis 2	Not considered modifiable
Children with white ethnicity (26,53)	Proportion of children in each MSOA who had white ethnicity	NCMP	Analysis 1	Not considered modifiable
Children with ethnicity other than white (26,53)	Proportion of children in each MSOA who had an ethnicity other than white	NCMP	Analysis 1	Not considered modifiable
Deprivation (4,26,53)	MSOA Index of Multiple Deprivation (IMD) score	mySociety IMD data	Analysis 1 Analysis 2	Considered modifiable
Smoking in early pregnancy (20,54,55)	Proportion of mothers in each MSOA who were smokers at the time of their booking appointment	MSDS	Analysis 1 Analysis 2	Considered modifiable
Smoking at the time of delivery (22,54,55)	Proportion of mothers in each MSOA who were smokers at the time of delivery	MSDS	Analysis 1 Analysis 2	Considered modifiable
Drinking in early	Proportion of	MSDS	Analysis 1	Considered

Variable (including references for evidence supporting confounding)	**Description**	**Data source**	**Analysis in which confounder was considered for inclusion in the model**	**Modifiability**
pregnancy (56)	mothers in each MSOA who were drinking at least 1 unit weekly at the time of booking appointment		Analysis 2	modifiable
Obesity in early pregnancy (any pregnancy) (5,6,7)	Proportion of mothers in each MSOA who were living with obesity at the time of their booking appointment	MSDS	Analysis 1	Considered modifiable
Obesity in a first pregnancy (5,6,7)	Proportion of mothers in each MSOA who were living with obesity at the time of their booking appointment for a first pregnancy	MSDS	Analysis 2	Considered modifiable
Overweight in a first pregnancy (5,6,7)	Proportion of mothers in each MSOA who were living with overweight at the time of their booking appointment for a first pregnancy	MSDS	Analysis 2	Considered modifiable
Maternal unemployment (26)	Proportion of mothers who were unemployed in each MSOA (not including students and retirees)	MSDS	Analysis 1 Analysis 2	Considered modifiable
Complex social factors (26,29,53,	Proportion of mothers in each	MSDS	Analysis 1 Analysis 2	Considered modifiable

Variable (including references for evidence supporting confounding)	Description	Data source	Analysis in which confounder was considered for inclusion in the model	Modifiability
56-59)	MSOA who had at least one complex social factor[1]			
Drug misuse in early pregnancy (58,59)	Proportion of mothers who were misusing non-medicinal drugs or other unauthorised substances at the time of booking appointment	MSDS	Analysis 1 Analysis 2	Considered modifiable
Previous drug misuse (58,59)	Proportion of mothers who reported having previously misused non-medicinal drugs or other unauthorised substances at the time of booking appointment	MSDS	Analysis 1 Analysis 2	Considered modifiable
Folic acid supplements before pregnancy (26)	Proportion of mothers in each MSOA who started taking folic acid prior to pregnancy as reported at time of booking appointment	MSDS	Analysis 1 Analysis 2	Considered modifiable

[1] Complex social factors are defined as the presence of at least one of the following: substance misuse (alcohol and/or drugs); status as a recent migrant, asylum seeker or refugee, or difficulty reading or speaking English; age under 20; experience of domestic abuse (National Institute for Health and Care Excellence. Pregnancy and complex social factors: a model for service provision for pregnant women with complex social factors. Clinical guideline [CG110]. 2010.)

Variable (including references for evidence supporting confounding)	Description	Data source	Analysis in which confounder was considered for inclusion in the model	Modifiability
Mothers aged under 20 (26,29,53)	Proportion of mothers in each MSOA who were aged under 20 at the time of booking appointment	MSDS	Analysis 1 Analysis 2	Considered modifiable
Mothers aged under 25 (26,29,53)	Proportion of mothers in each MSOA who were aged under 25 at the time of booking appointment	MSDS	Analysis 1 Analysis 2	Considered modifiable
Mothers aged under 40 or older (26,29,53)	Proportion of mothers in each MSOA who were aged 40 or older at the time of booking appointment	MSDS	Analysis 1 Analysis 2	Considered modifiable
Low birthweight (42,60)	Proportion of babies delivered in each MSOA with low birthweight (less than 2500g)	ONS Births	Analysis 1 Analysis 2	Considered modifiable
Very low birthweight (42,60)	Proportion of babies delivered in each MSOA with low birthweight (less than 1500g)	ONS Births	Analysis 1 Analysis 2	Considered modifiable
High birthweight (42,60)	Proportion of babies delivered in each MSOA with high birthweight (more than 4000g)	ONS Births	Analysis 1 Analysis 2	Considered modifiable

Variable (including references for evidence supporting confounding)	Description	Data source	Analysis in which confounder was considered for inclusion in the model	Modifiability
First time mothers (20,26)	Proportion of mothers in each MSOA whose babies were their first live-born child	MSDS	Analysis 1 Analysis 2	Not considered modifiable
Mothers with previous losses (20)	Proportion of mothers in each MSOA who had experienced previous pregnancy loss (miscarriage, termination or stillbirth)	MSDS	Analysis 1 Analysis 2	Not considered modifiable
First feed breastmilk (28,61)	Proportion of deliveries in each MSOA where the baby's first feed was maternal or donor breastmilk	MSDS	Analysis 1 Analysis 2	Considered modifiable

See Appendix E for details of how models were specified. See Appendix G for a list of the confounders included in each model.

Some likely confounders cannot be accounted for in this analysis. For instance, evidence indicates that the methods and timing of the introduction of complementary foods are important for determining weight status in childhood (62), and gestational weight gain is important for both mother and child's future weight status (17,20,62). Similarly, mothers whose pregnancies were planned may be more likely to breastfeed for longer and have a lower obesity risk, however pregnancy planning is not currently measured in routine data collection. Also, this study has also not been able to account for factors relating to fathers or to other household members. There may be additional confounders which have not been considered which may influence the associations identified. However, the confounders accounted for include many of those identified in literature as of greatest importance for breastfeeding and weight status.

Some confounders cannot be assessed in detail because of small numbers of observations. Ethnicity can only be assessed by aggregating all ethnic groups other than White into one category because there are very small numbers of mothers of some ethnicities in many MSOAs, meaning any more granular analysis would be statistically invalid. Therefore, variation between ethnicities is obscured. There is ample evidence that breastfeeding rates vary substantially by ethnicity, with significant differences between different non-white groups (26). Similarly, the analysis can only assess mothers with or without the presence of a complex social factors indicator, but different individual factors cannot be assessed. Lastly, the measure of deprivation is relatively crude. A more granular or individual-level measure would enable a more accurate assessment of the role of deprivation.

Appendix G: Model specifications

Model 1: Child weight status

Confounders
Proportion of children in each MSOA who had white ethnicity
Proportion of mothers in each MSOA who were smokers at the time of delivery
Proportion of mothers in each MSOA who were drinking at least 1 unit weekly at the time of booking appointment
Proportion of mothers in each MSOA who had at least one complex social factor
Proportion of mothers in each MSOA who were living with obesity at the time of their booking appointment for any pregnancy
Proportion of mothers who were unemployed in each MSOA (not including students and retirees)
Proportion of mothers who were misusing non-medicinal drugs or other unauthorised substances at the time of booking appointment
Proportion of mothers who reported having previously misused non-medicinal drugs or other unauthorised substances at the time of booking appointment
Proportion of mothers in each MSOA who started taking folic acid prior to pregnancy as reported at time of booking appointment
Proportion of mothers in each MSOA who were aged under 20 at the time of booking appointment
Proportion of mothers in each MSOA who were aged under 25 at the time of booking appointment
Proportion of mothers in each MSOA who were aged 40 or older at the time of booking appointment
Proportion of babies delivered in each MSOA with low birthweight (less than 2500g)
Proportion of babies delivered in each MSOA with very low birthweight (less than 1500g)
Proportion of babies delivered in each MSOA with high birthweight (more than 4000g)
Proportion of mothers in each MSOA whose babies were their first live-born child
Proportion of mothers in each MSOA who had experienced previous pregnancy loss (miscarriage, termination or stillbirth)
MSOA Index of Multiple Deprivation (IMD) score

Model 2: Child weight status

Confounders
Proportion of children in each MSOA who had white ethnicity
Proportion of mothers in each MSOA who had white ethnicity
Proportion of mothers in each MSOA who were smokers at the time of delivery
Proportion of mothers in each MSOA who were drinking at least 1 unit weekly at the time of booking appointment
Proportion of mothers in each MSOA who were living with obesity at the time of their booking appointment for a first pregnancy
Proportion of mothers in each MSOA who were living with overweight at the time of their booking appointment for a first pregnancy
Proportion of mothers in each MSOA who had at least one complex social factor
Proportion of mothers who were unemployed in each MSOA (not including students and retirees)
Proportion of mothers who were misusing non-medicinal drugs or other unauthorised substances at the time of booking appointment
Proportion of mothers who reported having previously misused non-medicinal drugs or other unauthorised substances at the time of booking appointment
Proportion of mothers in each MSOA who started taking folic acid prior to pregnancy as reported at time of booking appointment
Proportion of mothers in each MSOA who were aged under 20 at the time of booking appointment
Proportion of mothers in each MSOA who were aged 40 or older at the time of booking appointment
Proportion of babies delivered in each MSOA with low birthweight (less than 2500g)
Proportion of babies delivered in each MSOA with very low birthweight (less than 1500g)
Proportion of babies delivered in each MSOA with high birthweight (more than 4000g)
Proportion of mothers in each MSOA whose babies were their first live-born child
Proportion of mothers in each MSOA who had experienced previous pregnancy loss (miscarriage, termination or stillbirth)
MSOA Index of Multiple Deprivation (IMD) score

Appendix H: Tables of results

Table 1: Child weight status results

Breastfeeding prevalence	Predicted prevalence of children living with obesity at ages 4 to 5	Predicted prevalence of children living with overweight at ages 4 to 5
0%	8.91% (8.79%-9.02%)	21.39% (21.11%-21.55%)
5%	8.82% (8.72%-8.92%)	21.29% (21.14%-21.43%)
10%	8.73% (8.65%-8.82%)	21.19% (21.06%-21.32%)
15%	8.65% (8.56%-8.74%)	21.09% (20.96%-21.22%)
20%	8.57% (8.47%-8.66%)	20.99% (20.85%-21.14%)
25%	8.48% (8.38%-8.59%)	20.90% (20.73%-21.06%)
30%	8.40% (8.28%-8.53%)	20.80% (20.61%-20.99%)
35%	8.32% (8.18%-8.47%)	20.70% (20.49%-20.92%)
40%	8.24% (8.08%-8.40%)	20.60% (20.36%-20.85%)
45%	8.16% (7.98%-8.35%)	20.51% (20.23%-20.79%)
50%	8.08% (7.88%-8.29%)	20.41% (20.10%-20.73%)
55%	8.00% (7.78%-8.23%)	20.32% (19.97%-20.66%)
60%	7.93% (7.68%-8.17%)	20.22% (19.84%-20.60%)
65%	7.85% (7.58%-8.12%)	20.13% (19.71%-20.54%)
70%	7.77% (7.48%-8.06%)	20.03% (19.58%-20.48%)
75%	7.70% (7.39%-8.01%)	19.94% (19.45%-20.42%)
80%	7.62% (7.29%-7.95%)	19.84% (19.33%-20.36%)
85%	7.55% (7.20%-7.90%)	19.75% (19.20%-20.30%)
90%	7.47% (7.10%-7.84%)	19.66% (19.07%-20.24%)
95%	7.40% (7.01%-7.79%)	19.56% (18.94%-20.18%)
100%	7.33% (6.92%-7.74%)	19.47% (18.82%-20.13%)

Table 2: Maternal weight status results

Breastfeeding prevalence	Predicted prevalence of mothers who are obese in a subsequent pregnancy	Predicted prevalence of mothers who are overweight in a subsequent pregnancy
0%	23.14% (22.77%-23.51%)	51.91% (51.47%-52.35%)
5%	22.96% (22.63%-23.28%)	51.68% (51.30%-52.07%)
10%	22.78% (22.48%-23.08%)	51.45% (51.10%-51.80%)
15%	22.60% (22.31%-22.89%)	51.22% (50.87%-51.57%)
20%	22.42% (22.12%-22.73%)	50.99% (50.62%-51.36%)
25%	22.25% (21.91%-22.59%)	50.75% (50.34%-51.17%)
30%	22.07% (21.68%-22.46%)	50.52% (50.04%-51.01%)
35%	21.90% (21.46%-22.34%)	50.29% (49.73%-50.85%)
40%	21.73% (21.22%-22.23%)	50.06% (49.42%-50.70%)
45%	21.55% (20.99%-22.12%)	49.83% (49.10%-50.56%)
50%	21.38% (20.75%-22.02%)	49.59% (48.77%-50.41%)
55%	21.21% (20.51%-21.92%)	49.36% (48.45%-50.28%)
60%	21.04% (20.27%-21.82%)	49.13% (48.12%-50.14%)
65%	20.88% (20.04%-21.72%)	48.90% (47.79%-50.00%)
70%	20.71% (19.80%-21.62%)	48.67% (47.47%-49.87%)
75%	20.54% (19.57%-21.52%)	48.43% (47.14%-49.73%)
80%	20.38% (19.34%-21.42%)	48.20% (46.81%-49.60%)
85%	20.21% (19.11%-21.32%)	47.97% (46.48%-49.46%)
90%	20.05% (18.88%-21.22%)	47.74% (46.15%-49.33%)
95%	19.89% (18.65%-21.13%)	47.51% (45.82%-49.20%)
100%	19.73% (18.43%-21.03%)	47.28% (45.49%-49.06%)