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OPRU Briefing Paper - Modelling the potential impact on inequalities of population interventions on maternal smoking in pregnancy: Evidence from the Born in Bradford cohort (December 2023)

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Key message

- Inequalities in childhood obesity are marked and have widened in recent years. Maternal smoking in pregnancy has been identified as an early life risk factor linked to subsequent obesity. The social patterning of smoking in pregnancy (being more prevalent in disadvantaged groups) is likely to be a driver of inequalities in childhood obesity. However, we do not know how policy interventions seeking to address this modifiable behaviour might affect inequalities in childhood obesity.

- This research used a novel causal mediation framework with longitudinal data from a socioeconomically disadvantaged and ethnically diverse regional cohort (Born in Bradford, BiB), to simulate the impact on obesity inequalities at age 7 years of a hypothetical population intervention targeting smoking in pregnancy. The hypothetical intervention changed levels of maternal smoking in pregnancy across the population to match the level reported by the most advantaged households (in effect, reducing levels of smoking in pregnancy). These changes reduced inequalities in later childhood obesity, suggesting that interventions focusing on early life risk factors such as smoking in pregnancy hold promise for policy initiatives to tackle obesity inequalities. Despite differences in sociodemographic composition between samples, these findings echo the results of earlier analyses of national (UK Millennium Cohort Study, MCS) and regional (Southampton Women's Survey, SWS) cohorts.

Executive summary

Background

Inequalities in childhood obesity are marked and have widened in recent years. Smoking in pregnancy is an early life risk factor for childhood obesity. It is also socially patterned, with higher levels of smoking reported in disadvantaged groups. Smoking in pregnancy is therefore likely to be a risk factor implicated in inequalities in childhood obesity. However, we do not know how policy interventions seeking to reduce smoking in pregnancy might affect inequalities in childhood obesity.

This research used a novel causal mediation framework in a socioeconomically disadvantaged and ethnically diverse regional cohort (Born in Bradford, BiB) to simulate the impact on obesity inequalities at age 7 years of hypothetical population interventions targeting smoking in pregnancy. The hypothetical intervention changed levels of maternal smoking in pregnancy across the population to match levels reported by the most advantaged households (in effect, reducing levels of smoking in pregnancy).

Aim

- To simulate using longitudinal data the potential impact on childhood obesity inequalities at age 7 years (an age at which inequalities are becoming more apparent) of interventions that reduce smoking in pregnancy across the population to levels reported by the most advantaged social households.

Executive summary

What we did

An intervention targeting maternal smoking in pregnancy was simulated in the BiB cohort study. A causal mediation framework was used to model the relationships between socioeconomic circumstances at birth (maternal highest educational qualification achieved), smoking in pregnancy and obesity at age 7 years, accounting for confounders. The adjusted association between socioeconomic circumstances and obesity (accounting for baseline confounders), was compared to the association between socioeconomic circumstances and obesity after simulating an intervention that changed the levels of smoking in pregnancy in the sample to match that of the most advantaged households (highest maternal education – degree level or higher). This comparison allows for an estimation of the change in the relationship between socioeconomic circumstances and obesity that would follow such population interventions.

Key findings

- ✓ Obesity was more common among children from disadvantaged households.
- ✓ Simulating an intervention that changed levels of smoking in pregnancy in the whole population to match levels reported in the most advantaged households, reduced inequalities in childhood obesity.
- ✓ Childhood obesity prevalence at age 7 years was 17% where the mother was a graduate and 19.5% where they had no educational qualifications. The difference in childhood obesity prevalence for the no educational qualification group compared to the degree or higher group narrowed after simulating an intervention on smoking in pregnancy from 2.5% to 0.9% (a relative reduction of 36%).
- ✓ Given the challenges of conducting population interventions, modelling simulated interventions can provide useful insights for policy-makers. In particular, the level of smoking in pregnancy modelled was realistic, reflecting the level observed in advantaged households in this cohort.

Background

Research context

Enhancing our understanding of the causes and intersectionality of inequalities is a cross-cutting theme of Policy Research Units and a high priority for the Department of Health and Social Care and the National Institute for Health and Care Research. In Autumn 2021, the Institute for Child Health workstream of OPRU proposed a long-term project that sought to investigate the origins of inequalities in childhood obesity and the known risk factors that may act to widen (or narrow) disparities in obesity.

This project has several key areas of focus:

- A detailed description of the social patterning of obesity and its key risk factors, and the development and persistence of inequalities in obesity across childhood.
- An assessment of how sources of disadvantage or risk factors may accumulate and how this accumulation may impact on obesity.
- The intersectionality of inequalities in obesity i.e., the extent to which some groups have greater (or lesser) rates of obesity compared to what you might expect.
- Disparity analysis which assesses the extent to which policy interventions addressing early years risk factors may decrease population inequalities in childhood obesity.

This briefing paper reports the results of a disparity analysis, which considers the impact of modifying an early life risk factor (smoking in pregnancy) and observing the impacts on inequalities in childhood obesity using data from a socioeconomically disadvantaged and ethnically diverse regional cohort, the BiB study. In doing so, it replicates work carried out earlier in the project using a national cohort (the UK Millennium Cohort Study, MCS) and another regional cohort (the Southampton Women's Survey, SWS).

Background

Inequalities in childhood obesity

Childhood obesity is socially patterned, with lower levels of obesity found in advantaged groups compared to the most disadvantaged groups.[1] These inequalities have widened in recent years.[2] Since childhood obesity tracks into later life[3] and obesity is associated with subsequent morbidity and mortality,[4] it is likely that inequalities in childhood obesity will result in inequalities in both adult obesity and wider health outcomes. In this context, it is important to identify modifiable risk factors for obesity that may provide a focus for public health interventions. One potential early life risk factor is smoking in pregnancy[5,6], which is socially patterned and contributes to the development of obesity inequalities.[7]

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Background

Although smoking in pregnancy is modifiable, the extent to which policy interventions targeting these risk factors would decrease obesity inequalities is unknown. Population-level interventions are difficult to conduct and evaluate. An alternative approach is to simulate interventions using longitudinal population cohort data. In this research, we apply a novel causal mediation framework,[8,9] to estimate the impact on obesity inequalities of a hypothetical intervention that changes the levels of smoking in pregnancy in all households to match that observed in the most advantaged households. These simulation has real-world, policy relevance, since the level of smoking in pregnancy being modelled has been achieved by the most advantaged households in this cohort. A similar analysis has previously been carried out using national (MCS) and a regional (SWS) cohorts, which, despite sample differences, showed that socioeconomic inequalities in obesity reduced following a simulated intervention on smoking in pregnancy[10].

Research question

- Would, and to what extent, the socioeconomic gradient in obesity at age 7 years reduce if a hypothetical intervention could change the level of maternal smoking in pregnancy across all households to match that reported in the most advantaged households?

AIM. To explore the potential of intervening on an early life risk factor (smoking in pregnancy) to reduce socioeconomic inequalities in childhood obesity in the BiB cohort study.

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Methods

Overview

- We investigated socioeconomic inequalities in obesity at age 7 years in the BiB cohort study. Socioeconomic status was represented by a marker of the mother's highest educational achievement; obesity was assessed using the UK90[11] cut off based on z-scores for BMI.
- A causal mediation framework was used to model the impact on inequalities in obesity at 7 years of a hypothetical population intervention that resulted in the levels of maternal smoking in pregnancy in all households matching those observed in the most advantaged households in the cohort.

Data source

- The BiB cohort is a longitudinal study investigating child health and development launched in 2007, consisting of over 13,000 children and their families in Bradford. The city has a high population of ethnic minorities, and about 45% of the families recruited are of Pakistani origin. The study also includes a significant proportion of families living in economic deprivation. The first wave of data was collected from mothers during pregnancy, and subsequent waves have collected data on children into adolescence.

Obesity inequalities

- A measure of maternal highest educational qualification was used to assess socioeconomic circumstances (recorded at the baseline wave).
- BMI was calculated from measured heights and weights at age 7 years, with obesity defined using the UK90 age and sex-specific cut off. The highest 5th centile of BMI was adopted as it is policy-relevant and comparable to other data sets.

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Methods

Simulating a population intervention within a causal mediation framework

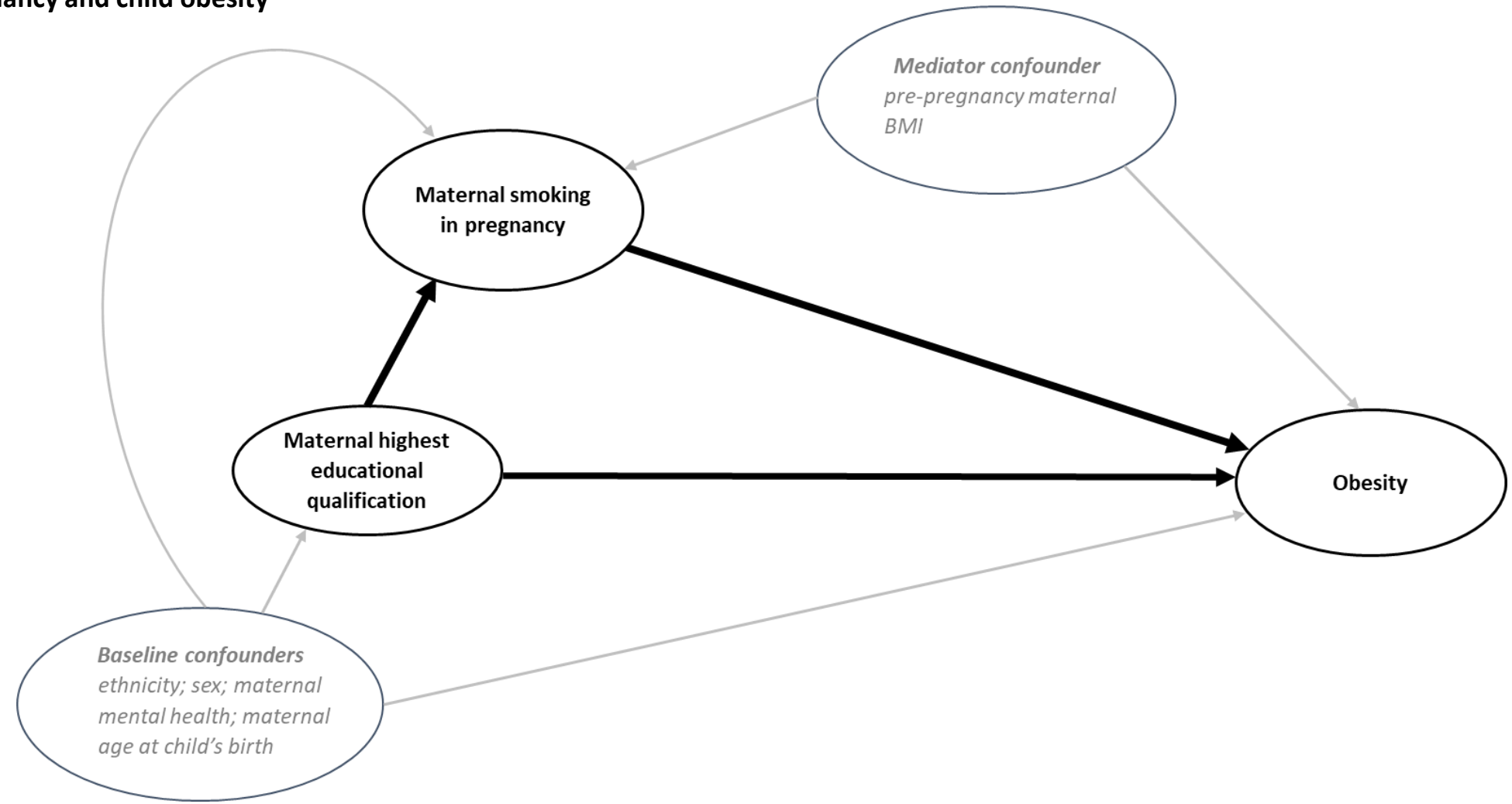
- A causal diagram (Figure 1) shows the hypothesised relationships between variables in the mediation analysis.
- This mediation framework indicates that the causal pathway between socioeconomic circumstances (the exposure) and obesity (the outcome) is partially the consequence of smoking in pregnancy (mediator), which is more common in socially disadvantaged groups and is on the pathway between exposure and outcome.
- By reducing levels of smoking in pregnancy in the disadvantaged groups, inequalities in obesity should also reduce. The diagram also includes theory-informed confounding variables, temporally positioned as either baseline or mediator confounders, which is accounted for to provide more accurate estimates of the relationship between socioeconomic circumstances and obesity.
- The BiB cohort study was analysed using a complete case sample with no missing data on any of the variables (n=3,373).

Modelling the impact of hypothetical interventions (2 stages)

1. The relationship between socioeconomic circumstances (maternal highest level of education) and obesity (UK90 cut-off) was estimated, accounting for baseline confounders. This provided an adjusted population average prevalence of obesity at each level of socioeconomic circumstances. BMI was calculated from measured heights and weights, with obesity defined using the UK90 age and sex-specific cut off. The highest 5th centile of BMI was adopted as it is policy-relevant and comparable to other data sets.
2. A hypothetical intervention was simulated by setting the smoking in pregnancy (mediator) distribution for the cohort sample (representing the population) to match that observed in the most advantaged households (where the mother was educated to Degree level or higher). The relationship between socioeconomic circumstances and obesity was then re-estimated, accounting for the new mediator distribution and baseline and mediator confounders.

Methods

Figure 1. Causal diagram of the hypothesised relationships between maternal highest educational qualification, maternal smoking in pregnancy and child obesity



Methods

Modelling the impact of hypothetical interventions

- In both stages, inequalities were expressed as differences in obesity prevalence (risk differences) for each level of socioeconomic circumstances (maternal education) compared to the baseline obesity prevalence in the most advantaged households. This mediation framework indicates that the causal pathway between socioeconomic circumstances (the exposure) and obesity (the outcome) is partially the consequence of smoking in pregnancy (mediator), which is more common in socially disadvantaged groups and is on the pathway between exposure and outcome.
- The change in obesity inequalities between the two stages reflected the impact of the hypothetical intervention at each level of socioeconomic circumstances in comparison to the obesity prevalence among children in most advantaged households. This is expressed in terms of absolute change following the hypothetical intervention and as a percentage of the original difference in obesity prevalence between each socioeconomic group versus the most advantaged households.

What we found

Mediation modelling

- The adjusted population average prevalence of obesity was elevated for children whose mothers were educated below degree level (Table 1). For example, the adjusted prevalence of obesity was 17% in the degree/higher group and 19.5% in the no qualifications group (a risk difference between these groups of 2.5%). Following the hypothetical intervention, the risk difference between the two groups fell to 0.9%; a 36% relative change. A similar pattern was observed for the A level and O level/GCSE groups.

Table 1. Smoking in pregnancy simulated intervention impact on inequalities in obesity at 7 years in BiB

	Population prevalence	Observed risk difference (A)	Intervention risk difference (B)	A – B	A – B (% change)
Degree/Higher	17.0 (14.6-19.5)	-	-	-	-
A level	18.5 (16.3-20.7)	1.5 (-1.8-4.7)	1.0 (-2.2-4.2)	0.5 (0.1-0.8)	33.3%
O level/GCSE	18.5 (16.9-20.1)	1.5 (-1.5-4.4)	0.8 (-2.2-3.7)	0.7 (0.2-1.2)	46.7%
None	19.5 (17.3-21.7)	2.5 (-0.8-5.8)	1.6 (-1.6-4.8)	0.9 (0.2-1.5)	36.0%

Discussion

Summary:

- Socioeconomic inequalities in childhood obesity were shown in the BiB cohort study. An intervention simulation was modelled within a causal mediation framework, focusing on smoking in pregnancy, an early years risk factor associated with childhood obesity and more prevalent in disadvantaged households. Levels of smoking in pregnancy across the entire sample were reduced to that reported in the most socioeconomically advantaged group. This had a sizeable impact on obesity inequalities, although they were not eliminated.
- The pattern of results in this socioeconomically disadvantaged and ethnically diverse regional cohort is similar to findings from a national cohort (MCS) and another regional cohort (SWS), suggesting results are robust across populations.

Strengths of the work:

- The potential impact on inequalities in child obesity of a hypothetical intervention for maternal smoking in pregnancy was modelled based on changing patterns of smoking to match realistic levels, as reported by the most advantaged groups in the cohort.
- Longitudinal data allowed exposure, mediator and outcome variables to be measured temporally.
- Height and weight data were objectively measured, and rich mediator and confounder data were available.
- Findings are in line with earlier work in other cohort studies, despite the BiB study being particularly ethnically diverse and socioeconomically disadvantaged.

Discussion

Limitations of the work:

- Most variables were reported by the child's mother, and many were reported retrospectively, and therefore the possibility of bias cannot be discounted.
- While mediation analyses used longitudinal data and accounted for plausible confounding variables, data were observational and results may have been affected by unmeasured confounding and causality cannot be assumed.
- The simulation modelled the potential impact of a hypothetical intervention on the mediating risk factor (smoking in pregnancy). These analyses did not require specification of the details of any real-world intervention that would lead to these changes.

Implications for policy:

- Childhood obesity inequalities were demonstrated in BiB, a regional UK cohort study that is socioeconomically disadvantaged and ethnically diverse.
- Mediation analyses, simulating the effects of a hypothetical intervention targeting smoking in pregnancy, reduced inequalities in mid-childhood.
- These results suggest that interventions on early life risk factors (such as on smoking in pregnancy) have the potential to contribute to a reduction in social inequalities in childhood obesity.
- A separate challenge will be the identification and implementation of effective interventions at scale.

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