

## **Title**

Is socioeconomic inequality in postnatal depression an early-life root of disadvantage for children?

## **Abstract**

This paper investigates the role that socioeconomic inequality in postnatal depression might play in intergenerational transmission of inequality. Infants' development is thought to be particularly sensitive to mothers' mental health at this time, suggesting that greater early life exposure to maternal depression among disadvantaged groups might be a root of later socioeconomic inequalities. Heightened contact with health services during this period presents opportunities for intervention, but higher unmet need for treatment of postnatal depression among the disadvantaged might be widening inequalities. The aim of this study is to quantify the potential contribution of postnatal depression to socioeconomic inequalities in adverse childhood health and development outcomes.

Regression-based decomposition of the concentration index is used to explore the association between income inequality in postnatal depressive symptoms and income inequality in children's outcomes. Four problems of early adolescence are explored: emotional and conduct problems, special educational needs, and low self-assessed health. Data are taken from the UK Millennium Cohort Study, with a sample of 4,359 mothers and children with complete data on outcomes and covariates, and a second sample of 5,441 when missing covariates are filled using multiple imputation.

The key finding is that socioeconomic inequality in maternal postnatal depression is a significant contributor to inequalities in special educational needs, emotional problems, and low self-assessed health for children at age 11, even after accounting for a range of other factors that might explain such associations. These findings highlight the importance of understanding the impact of postnatal depression interventions on inequalities, and the downstream influence on children's outcomes. Addressing inequalities in mothers' postnatal depression might be an avenue for reducing early life disadvantage for children.

**Keywords**

- UK
- Socioeconomic inequality
- Postnatal depression
- Childhood difficulties
- Decomposition of the concentration index

## **Introduction**

It is well-known that being born into a socioeconomically disadvantaged family carries a heightened risk of physical and mental health problems [1,2]. Such early life health inequalities would usually be considered unfair, or inequitable, being unrelated to the child's own choices nor attributable to their personal responsibility [3]. These problems may have important consequences for the whole life course [4], with some health inequalities in adult life likely to have their origins in childhood [5,6]. Finding ways to reduce avoidable socioeconomic inequalities in health is a priority for public policymaking worldwide, alongside improving population health [7]. Reducing socioeconomic inequalities in children's health offers the opportunity to act at the root of adult problems, but these are increasing over time rather than decreasing [8].

Maternal postnatal depression, which occurs in 10-20% of mothers in high-income countries [9], could be an influential early life factor that mediates such inequalities, since it displays a socioeconomic gradient and is linked to children's outcomes [10]. At the individual level, both prevalence and severity of postnatal depression are higher among mothers with lower socioeconomic status [11-15]. Risk factors for postnatal depression, such as single parenthood, low maternal age, and poor social support [12,16], are also associated with lower income. At the national level, countries with higher levels of income inequality have higher prevalence of postnatal depression [17].

Maternal postnatal depression has been associated with a range of problems in children. The first years of life are seen as a key period of vulnerability to the influence of maternal mental health problems, a time when foundations are laid in the child's neurodevelopment, cognitive pathways, behavioural and emotional patterning, and physical development [18]. Postnatal depression is posited to influence children's emotional, behavioural and cognitive outcomes [16,19] through mechanisms such as maternal-infant bonding, parenting behaviours, exposure to negative maternal cognitions or family stress, reduced maternal stimulation of the infant, and/or effects on the home learning environment [20]. It is also associated with longer-term or recurrent maternal depression [21], of particular concern since duration of exposure to maternal depression may mediate the association between postnatal depression

and child outcomes [22-24]. Depression during pregnancy (antenatal depression) is correlated with postnatal depression, and also associated with adverse infant and child outcomes, although there may be distinct mechanisms linking depression with children's development at these different periods, with more biological emphasis during pregnancy and behavioural or parenting pathways in the postnatal period [18,25]. The relationship between postnatal depression and children's outcomes is complex, with multiple mechanisms confounding and mediating the association [26]. This may explain why, even where postnatal depression is successfully treated, it is not clear from interventional studies that this is adequate to ameliorate the risk of adverse children's outcomes [27,26].

Frequent contact between mothers and health services during the perinatal period presents opportunities to intervene. However, interventions aiming to address postnatal depression may actually be exacerbating inequalities. Lower socioeconomic status is associated with lower access to and utilisation of mental health interventions [28]. In the postnatal context, for women of similar clinical eligibility, uptake and adherence tend to be lower among the more disadvantaged [29-31]. Many policies and interventions target postnatal depression, but distributional effects of these interventions are not often addressed. This might be an important omission if inequalities in postnatal depression lead to intergenerational transmission of disadvantage. In the UK, the setting for this study, political attention has recently been focussed on perinatal mental health with increased investment in universal services and attempts to improve access to specialist mental health services [32]. However, apart from geographic differences in access the focus has largely been on improving perinatal mental health overall without much attention paid to its socioeconomic distribution.

Understanding the relationship between postnatal depression and childhood inequalities will inform policies that target early life inequalities. While previous research has demonstrated the socioeconomic gradient in maternal postnatal depression, and links between postnatal depression and children's outcomes, we still need to know what reduction in childhood inequalities might be achieved by intervening in postnatal depression. A study comparing UK and US data found cumulative exposure to maternal depression partly accounted for socioeconomic patterning of children's cognitive development and health, and that patterns of association were similar in the two countries [33]. However, it did not

directly examine the influence of maternal depression on the socioeconomic distribution of children's outcomes, nor did it allow for the influence of maternal depression to differ at critical junctures such as the postnatal period.

This study uses longitudinal cohort data to quantify the potential contribution of inequality in postnatal depression to childhood inequalities. The postulated influence of maternal postnatal depression is not limited to early childhood, with consequences often attributed into late adolescence [19]. These include academic and cognitive problems, emotional difficulties such as depression or anxiety, behavioural problems including conduct disorder, and physical health problems such as infections or asthma [34,35], with the most consistent evidence across studies being for an association with cognitive problems [36]. I explore inequality in four problems of early adolescence: special educational needs; emotional and conduct problems; and poor self-assessed health. The findings could inform the priority placed on reducing inequalities in postnatal depression rather than simply addressing postnatal depression without considering distribution of the benefits, with a view to reducing unfair differences in children's outcomes.

## **Methods**

The concentration index (CI) is a bivariate measure of socioeconomic inequality in health, which quantifies the correlation between a person's rank on a measure of socioeconomic status (such as ranking poorest to richest on income) and their level of health. Unlike some other metrics of socioeconomic inequality in health, which measure the difference in health between people at the extremes of the socioeconomic range, it incorporates the full range of the income distribution [37]. Decomposition of the CI is used to describe the possible contribution of various factors to the observed inequality of health (or ill-health) over income [38]. In this study, four different ill-health variables represent children's problems: special educational needs, emotional problems, conduct problems, and low self-assessed health. Income inequality in each (as captured by the CI) is decomposed, with postnatal depressive symptoms as an explanatory variable, to investigate links between income inequality in postnatal depression and income inequality in children's outcomes.

Data are taken from the Millennium Cohort Study (MCS) [39], a nationally representative longitudinal study of families in England, Scotland, Wales and Northern Ireland that includes a rich array of individual, family and neighbourhood characteristics. From these survey data, variables were taken which captured postnatal depressive symptoms, later children's outcomes, and a range of child, mother, and family characteristics which are relevant to children's health and development. No formal ethics approval was sought for this research because it makes use of only publicly available anonymised survey data.

## **Data**

The MCS began in 2000, when the families had a baby of around 9 months of age. Five subsequent waves of data were collected when the child was aged 3, 5, 7, 11, and 14 years. Details of the study design and methods have been published previously [40].

### *Measures of maternal depression*

The key explanatory variable is a measure of maternal postnatal depressive symptoms. The baseline wave of the MCS was in the late postnatal period, when the study children were around nine months of age. At this wave mothers were asked whether they had felt low or sad for a period of two weeks or more since the baby was born, consistent with low-threshold questions that are sometimes used in screening for postnatal depression [41], and which has been used as a measure of postnatal depression [42]. Mothers also completed a modified version of the Rutter Malaise Inventory on which a score of more than 4 indicated depressive symptoms [43].

Most women with postnatal depression recover within the first few months; after this, prevalence of depressive symptoms remains steady from 3-4 months until up to 2 years [21]. The first, low-threshold question could therefore capture earlier (possibly resolved) postnatal depressive symptoms and/or later symptoms. The Malaise Inventory could only capture ongoing or (less commonly) later onset symptoms. Neither tool is diagnostic of postnatal depression. The present study terms either a positive

response to the first question and/or a score of more than 4 on the Malaise Inventory “postnatal depressive symptoms”, avoiding the term “postnatal depression” as this is a clinical diagnosis.

The analysis also includes measures of maternal depression at other periods. At baseline, mothers were also asked if they had ever been diagnosed with depression and, if so, whether they were currently treated for depression. This did not differentiate historical depression from postnatal depression, and could not identify undiagnosed depression, but would have captured at least some cases of antenatal (during pregnancy) depression. The variable ‘later depression’ indicates that the mother reported treatment for depression and/or new diagnosis of depression after the postnatal period. The survey did not identify the type of treatment for depression, so the treatment variables may have captured both pharmacological and psychological therapies.

#### *Measures of children’s outcomes.*

Teachers reported on the presence of special educational needs (SEN) when the children were 11 years of age. This label indicates the presence of learning difficulties requiring additional or alternative resourcing [44], including cognitive, behavioural, or emotional problems.

The Strengths and Difficulties Questionnaire (SDQ) is a 25-item set of questions used to assess the behaviour and mental health of children aged 4-16 years [45]. It can be completed by parents, teachers, and children themselves (from 11 years of age). Combining results from all three respondents can improve the sensitivity of the instrument, with parents and teachers providing the most reliable results, but children’s responses particularly helpful for the detection of emotional problems [46]. The questions are grouped into five sub-scales addressing emotional, behavioural and peer problems, hyperactivity, and prosocial behaviour. When reported by any one of parent, teacher or child, the emotional subscale is a significant predictor of clinical diagnosis of emotional problems, as is the behavioural subscale a predictor of clinical diagnosis of behavioural problems [47].

Children did not self-report the SDQ until wave 6 (age 14 years), while teacher’s SDQ scores were collected at wave 5 (age 11 years) and parents’ scores at each wave. Therefore, the emotional subscale

from teachers at wave 5, children at wave 6, and parents at both waves 5 and 6 were combined to give a picture of emotional problems in early adolescence. A single variable was created for emotional problems, which indicated if any of the relevant parent, child or teacher SDQ subscales at wave 5 or 6 was above the threshold to indicate a high risk of disorder [45,46]. The same approach was taken with the behavioural subscale to construct a conduct problems variable.

At wave 6, children were asked to rate their own health generally as ‘excellent’, ‘very good’, ‘good’, ‘fair’, or ‘poor’. Lower self-reported health at 14 years [48] and lower mother-reported child health at 5 years [35] have been associated with maternal postnatal depression. Adolescents are reliable reporters of their own general health, and may provide the most consistent reports over time as they move beyond early adolescence [49], providing an indicator of later health risks. Here, children reporting ‘poor’ or ‘fair’ health are considered to have low self-assessed health (SAH).

#### *Maternal and family characteristics.*

Along with maternal mental health, the MCS collects data on a range of factors that could be relevant to inequalities in children’s outcomes. Family income at wave 1, inclusive of wages and self-employment earnings of both partners, plus other relevant payments and tax credits, was formulated into equivalised weekly family income. This equivalisation adjusts for differences in family size and composition, relative to a couple with no children, weighted used modified OECD scales [50]. Neighbourhood socioeconomic status at wave 1 was captured using the Index of Multiple Deprivation (IMD), which measures several dimensions of the local population in the area of residence (including income, employment, health, education, housing, and crime) [51]. Country-specific deciles of the index identify how a family’s area of residence compares to the rest of that country. Both family income and neighbourhood socioeconomic status were measured at wave 1 to cast light on the influence of family socioeconomic status in the postnatal period, rather than over the course of the childhood, because the focus was on inequalities in the postnatal period.

Maternal characteristics taken from wave 1 of the survey included: whether the mother had more than high school education; whether she reported being married or living with her partner (not specifically

the child's father); whether she was a teenager (age less than 20 years) at the child's birth; and whether or not she had other children living with her. Mothers and children were identified as of white ethnicity or as one of Indian, Pakistani, Bangladeshi, Black, Black British, mixed ethnicity or another unspecified ethnicity, which were grouped together under 'ethnic minority'. At wave 1 mothers also stated whether they had any problems that required medical attention during the pregnancy, whether they smoked during the pregnancy, and their weight during pregnancy. Throughout the survey mothers were asked whether their partner had ever used force towards them.

At wave 2 of the survey (when the child was aged 3), parents reported the frequency of the following activities: reading to the child, taking him/her to the library, and teaching the alphabet, numbers or counting, songs, poems or nursery rhymes, and painting or drawing. This was formulated into a variable indicating the quality of the early home learning environment, which has been shown to be associated with the risk of educational difficulties [52].

## **Sample**

The survey sample was stratified by country but also at the electoral ward level to ensure sufficient representation of disadvantaged and ethnic minority families [53]. Analyses were conducted in Stata (V.14) using survey sampling weights to account for the resulting disproportionate representation of disadvantaged and ethnic minority groups, and for the non-independence of observations due to clustering in the sample design. The baseline wave of the MCS included data from interviews with 18,552 families, 11,332 of whom were interviewed at the sixth wave (when the child was aged 14). The sample was limited to those families in which the natural mother was interviewed at baseline (N=18,504), since the focus was on maternal postnatal depression, and further restricted to families with singleton children (N=18,248). Missing data on outcome and covariates reduced the sample size for children's outcomes to 4,359 (80% of those with child outcome data). Key sample characteristics are provided in Table 1, with the mean values displayed for each income quintile, grouped according to whether the mother had postnatal depressive symptoms.

## Decomposition of the concentration index (CI)

In this study the CI quantifies the degree of income inequality in children's problems (broadly termed ill-health here), comparing families over the spectrum of income at the time of the child's birth. The standard CI can be calculated by regression of a transformed ill-health variable on the fractional rank of income ( $r$ ) [54], and is given by  $\hat{\gamma}$  in (1):

$$2\sigma_r^2 \left( \frac{h_i}{\mu_h} \right) = \alpha + \gamma r_i + \varepsilon_i \quad (1)$$

where  $h$ =ill-health,  $\mu_h$ =mean ill-health and  $\sigma_r^2$  is the variance of the rank

This standard CI measures relative inequality; multiplying by  $\mu_h$  generates the generalised CI, measuring absolute inequality, which was applied in this study. The CI was further modified to accommodate binary ill-health variables [55], using the modified CI proposed by Erreygers [56].

Decomposition of the CI following Wagstaff et al. [38] breaks down the observed income inequality of ill-health into components associated with potential contributors to inequality. This approach takes the estimated coefficients ( $\beta_k$ ) from regression of the health variable upon the range of potential contributors,  $x_k$ , as follows:

$$CI_{ill-health} = \sum \theta_k GC_\varepsilon / \mu_h \quad (2)$$

where  $\theta_k = \left( \frac{\beta_k \bar{x}_k}{\mu_h} \right) CI_k$ , incorporating the mean ( $\bar{x}_k$ ) and the CI ( $CI_k$ ) for each potential contributor  $k$

The term  $\theta_k$  in (2) comprises the contribution of each factor to inequality in each of the four children's problems. The results can also be expressed as a proportion of the overall inequality by dividing by  $CI_{ill-health}$ . This approach assumes that factors can contribute to observed inequality if they are both associated with the health variable (captured by  $\beta_k$ ) and are unequal across income (captured by  $CI_k$ ). The key estimand in this analysis is  $\theta_k$  for postnatal depressive symptoms, indicating the contribution of income inequality in postnatal depressive symptoms to income inequality in children's problems. Additional factors included in each decomposition were the other maternal depression variables

(diagnosis of depression up to baseline, treatment for depression at baseline, and later depression), and those suggested in the literature to be associated with the health outcome, provided that similar factors were observed in the survey. As the health outcome variables were binary, logit models were used to regress ill-health on the range of potential contributory factors, with marginal effects calculated at the mean [57,54]). Standard errors for each factor's contribution were obtained by bootstrapping, with 2000 replications.

The ranking variable in each analysis was the log of equivalised family income at baseline. This and other socioeconomic variables were taken from the baseline survey to capture inequalities relating to the family situation at birth and to avoid the possibility that maternal postnatal depression would influence those variables at later waves.

Selection of other explanatory variables was informed by previous studies of factors associated with children's outcomes, particularly those factors thought to contribute to inequalities [52,58,59,1,60-64]. Common to all children's models were family composition at baseline, maternal age and education, neighbourhood socioeconomic status (IMD) at baseline, whether there had been medical problems during the pregnancy or at the birth, whether the mother had ever reported her partner using force toward her, whether the child was from an ethnic minority, and the child's gender. The model for special educational needs additionally included the season of birth and the quality of the early home learning environment, which have both been associated with the likelihood of teachers reporting educational difficulties [65,52]. The model for self-assessed health included factors with possible biological impact on the developing foetus: whether the mother smoked during the pregnancy, and whether she was underweight (body mass index less than 18) or very obese (body mass index over 35) during the pregnancy.

### *Sensitivity tests*

Those with missing covariates due to item non-response were more likely to be single, younger, from an ethnic minority, living in a more deprived neighbourhood or in poverty, or have less education than those with complete data (see Supplementary Table 1). Analyses were therefore repeated with missing

values of covariates (but not outcome or maternal mental health variables) filled by multiple imputation using the `mi impute chained` command in Stata, with 30 imputed datasets. The imputation model included all variables from the regression models used for analysis, and applied predictive mean matching for continuous variables, and logit regression for binary variables. The imputed datasets were combined using Rubin's method [66], with a resultant sample of 5,441 for children's outcomes. Results of both complete case (CC) and missing imputed (MI) analyses are presented.

In the main analysis, income was excluded from the explanatory models, following the argument of Erreygers, Kessels [67] that, while income may be a relevant explanatory variable in a model of health, including income in the descriptive model of inequality over income is inappropriate, and could give a false impression of a well-specified model that explains close to 100% of observed inequality. On the other hand, if income plays a direct role in health inequalities, excluding it from the regression could miss such an effect and lead to artificially inflated estimates for other variables. Therefore, the analysis was repeated with income included in the decomposition model. Where it is included, the contribution of income can be interpreted as any direct association between health and income, confounded with unexplained inequality [67].

The marginal effects from the logit models used to regress ill-health are non-unique as they depend on the value of the explanatory variables at which marginal effects are calculated; therefore, the results were compared with those obtained using linear models.

## **Results**

### **Inequality in postnatal depressive symptoms**

There were marked differences in postnatal depressive symptoms over the income gradient, as shown in Table 1. While a third (33%) of women in the sample overall experienced postnatal depressive symptoms, this included half (50%) of those in the lowest income quintile, and only a quarter (25%) of those in the highest income quintile. Indicators of later maternal depression also displayed socioeconomic inequality. Overall, 25% of women reported either being treated for depression or diagnosed with depression after the postnatal period, and this was higher among those who had

experienced postnatal depressive symptoms (38%) than those who had not (18%), with an income gradient in both groups. Taking into account that poorer women were also more likely to have experienced postnatal depressive symptoms demonstrates the compounded risk of depression in this group. Of those in the lowest income quintile at baseline, 21% had both postnatal depressive symptoms and later treatment for or diagnosis of depression, and 38% had neither. In contrast, only 7% of those in the highest income quintile had both depression indicators, while 64% had neither.

### **Inequality in children's outcomes**

As shown in Table 1, all four outcome measures were more common in children whose mothers had experienced postnatal depressive symptoms. Each type of problem also displayed a gradient over income, although the nature of the gradient and the gap associated with maternal postnatal depressive symptoms varied between outcomes, as seen in Figure 1. In the lowest income quintile, prevalence of special educational needs was similar between those whose mothers did and did not have postnatal depressive symptoms, and this diverged at the higher end of the income spectrum, while the opposite was true for conduct problems. Prevalence of low self-assessed health differed conditional on maternal postnatal depressive symptoms at the extremes of income, but was more similar in the mid-range of income. Emotional problems showed a more consistent gap between the two groups over the full range of income. The most commonly reported reasons for special educational needs (see Supplementary Table 2) included outcomes associated with postnatal depression, such as learning difficulties and behavioural problems [68].

The concentration curves in Figure 2 (and associated statistically significant CIs in Supplementary Table 3) confirm the presence of socioeconomic inequality in children's outcomes to the disadvantage of the poor. For each outcome, but particularly for conduct problems, the results show slightly higher levels of inequality when the missing data were filled using multiple imputation (see online appendix).

Association between income inequality in postnatal depressive symptoms and income inequality in children's outcomes The results of the decomposition of inequality in each of the four outcomes, as displayed in Figures 3-6, show that even after accounting for a range of other factors, income inequality

in maternal postnatal depressive symptoms was significantly associated with the observed income inequality in special educational needs, emotional problems, and low self-assessed health in early adolescence. The greatest percentagewise contribution of postnatal depressive symptoms was to inequality in special educational needs, at 8.4% of the CI in that outcome, followed by a contribution of 6.9% for emotional problems, and 4.5% for low self-assessed health. Inequality in postnatal depressive symptoms was not found to be a statistically significant contributor to inequality in children's conduct problems. (See Supplementary Tables 4-7 for detailed decomposition results)

Inequality in depression diagnosed up to baseline, which would have included some diagnoses of antenatal and postnatal depression, was also a significant contributor to inequality in emotional problems in early adolescence. Inequality in depression diagnosed or treated after the postnatal period was a statistically significant contributor to inequality in special educational needs, emotional problems, and conduct problems. Of the maternal depression variables, only postnatal depressive symptoms were significant in the decomposition of inequality in low self-assessed health at 14 years. Treatment for depression at baseline was not significant in any of the decompositions.

Neighbourhood deprivation and maternal education were significant contributors for most outcomes. Family composition was also a contributor: inequality in family size, as indicated by whether the child had older siblings, was significant for inequalities in self-assessed health, conduct problems and special educational needs, while maternal marital status was significant for conduct problems. The quality of the home learning environment was significant in the decomposition of inequality in special educational needs.

Results of sensitivity testing are shown in Supplementary Tables 8-11. The association of inequality in postnatal depressive symptoms and each of the outcomes was slightly larger with imputation of missing covariate data. The findings were also similar when linear models were used in place of logit models, and when income was included in the decomposition model [67], although other results did change substantially in such a model. In particular, the apparent contributions of neighbourhood deprivation,

maternal marital status, and the number of siblings were smaller when income was included in the decomposition model.

## **Discussion**

This study highlights a potential link between socioeconomic inequality in postnatal depression and socioeconomic inequality in children's outcomes. The key finding is that inequality in maternal postnatal depressive symptoms is a significant contributor to inequalities in special educational needs, emotional problems, and low self-reported health, even after accounting for a wide range of factors that might have been thought to explain the association. There was no association between income inequality in postnatal depressive symptoms and income inequality in children's conduct problems. While the question of whether postnatal depression causes problems for children has been addressed before, this study contributes evidence on a related but distinct question: whether socioeconomic inequalities in postnatal depression are an early-life mediator of disadvantage for children. The results support this hypothesis, without allowing for a causal interpretation.

While it did not address the same childhood outcomes as this study, and a study based in China used decomposition of the concentration index to examine contributors to socioeconomic inequality in children's developmental delay, and found that socioeconomic inequality in caregiver depression was one of the major contributors [69]. A previous study using the same dataset but applying different methods found that maternal mental health problems partly explained socioeconomic inequality in children's outcomes at age 11 [70]. The authors suggested that research should focus on critical periods of exposure, as the current study does.

The finding of significant socioeconomic inequality in mothers' postnatal depressive symptoms is consistent with that found in earlier studies, but shows that this inequality exists over the range of income. Previous studies have shown a socioeconomic gradient in postnatal depression, but have used methods which group women into two or more categories based on a measure of socioeconomic status (such as income, poverty, subjective financial wellbeing) and examine differences in postnatal depression across those groups [e.g. 71,72,11].

### *Strengths and limitations of the study*

A strength of this study was the rich set of explanatory variables included, which addressed explanations for the association through alternate pathways. Some have suggested that postnatal depression is only associated with children's outcomes through its association with depression at other points in the life course. Studies examining the causal pathways between maternal perinatal mental health and children's emotional problems in adolescence have found that both earlier (antenatal) and later depression to be significant along with, and sometimes instead of, postnatal depression [73-75]. The present study examined this by including both earlier and later diagnoses of maternal depression in the decomposition models and found inequality in maternal depression at all three time points to be associated with inequality in emotional problems in early adolescence. It was not possible to explicitly address the question of antenatal depression since this was not captured in the survey but the variable for earlier depression would have captured at least some women diagnosed with depression during pregnancy. No association was found between inequality in postnatal depressive symptoms and inequality in children's conduct problems, but the association was present for later depression. Previous studies have shown mixed results on whether children's conduct or externalising problems are associated with postnatal depression, particularly when other depressive periods are considered [36].

Another strength of the study was the range of child outcome domains assessed, including self-assessed health in early adolescence. There has been limited previous exploration of the association between postnatal depression and children's self-assessed health [48,35]. This outcome measure showed a statistically significant association with postnatal depressive symptoms but not with either of the variables indicating earlier or later diagnosis of depression in the mother. The interpretation of adolescents' self-assessed health may differ from that in adults, which has been shown to predict outcomes such as mortality. Self-assessed health in adolescents is considered more of a useful measure of longer-standing health, or self-concept of health [76], in a group who have comparatively low incidence of health problems. It may function as an intermediate marker of the association between early life experiences and later adult health outcomes [77]. As such, the association of inequality in self-assessed health and inequality in postnatal depressive symptoms may be another indicator that early

life exposure to maternal depression could be a root of inequality that casts a long shadow into adulthood.

An important limitation of this study is that the analysis did not allow for a causal interpretation. The presence of associations between inequality in postnatal depressive symptoms and inequality in children's outcomes is consistent with the hypothesis that exposure to maternal depression during the postnatal period is influential in children's development. Such a finding warrants further investigation into postnatal depression as a root of childhood inequalities, to investigate other credible explanations for this association and address sources of endogeneity. This study could not capture factors unobserved in the survey, such as adverse life events, genetics, and social or community-level influences, that might predispose both the mother to depression and the child to this range of problems. Reverse causality might also explain the association between later maternal depression and children's problems, but not the association with postnatal depression unless the child's problems have onset in infancy. The use of teacher-reported outcomes reduced the potential for reporting bias, as maternal reporting of child outcomes can be influenced by her mood and SES [78,79], but teachers' reporting may also be affected by the SES of the child [80]. The use of three reporters (parents, teachers and children themselves) improved the sensitivity to capture emotional and conduct problems in early adolescence, but may have led to lower specificity.

The measure of postnatal depressive symptoms used here was not validated against clinical diagnoses of depression. The low-threshold question may be vulnerable to recall bias, and the Malaise Inventory only captured a snapshot of symptoms at nine months after the birth. However, the study measure has advantages over diagnosis-based measures in that it does not ignore undiagnosed depression, and is able to capture a spectrum of symptom severity. It may be particularly important to capture undiagnosed depression, since inequalities in access to health services or help-seeking behaviour may lead to hidden inequalities if only diagnosed depression is explored. A major emphasis of research and intervention in this field is depression, particularly postnatal depression. However, the term 'depression' in this context has often been used to encompass an array of problems rather than representing an homogenous set of symptoms consistent with a single diagnosis, with symptom overlap between syndromes such as

depression, anxiety, adjustment disorders, and maternal-infant bonding problems [81]. The measure used here may have captured some of these other clinical conditions.

The survey data did not allow unmet need for treatment to be captured, which may have been important to understanding how socioeconomic inequalities are transmitted to children. Here, poorer mothers had higher rates of treatment, reflecting their higher rates of reported depression, but a measure of unmet need for treatment may have portrayed a different socioeconomic distribution. However, treatment at baseline was not a statistically significant explanatory variable in any of the children's outcome models, so (by definition) the models did not find inequality in treatment to be a significant contributor to inequality in children's problems.

Previous evidence from the MCS has shown a stronger association of children's cognitive development with persistent poverty rather than poverty at a single wave of the survey as used in this study [82]. Here, the intention was to explore inequalities at birth, and so the income variable captured household income at the baseline wave of the survey, but did not take later family income into account.

While paternal postnatal depression is increasingly recognised as an important issue in its own right, and in combination with maternal depression [83-85], only mothers were asked the first question regarding postnatal depressive symptoms, and so inequalities in paternal postnatal depression are not considered in this study. This could be an important area for further research given the growing evidence on the relevance of paternal mental health to children's outcomes. Socioeconomic patterns of marital status would also be relevant to such an analysis. While paternal depression may influence children's outcomes, there is a marked socioeconomic gradient in maternal marital status, and this was associated particularly with inequality in conduct problems. It would be important to consider the influence of both the presence of fathers in the home and fathers' mental health, rather than limiting any analysis to just families inclusive of fathers.

### *Implications*

Taken together, the presence of significant socioeconomic inequality in postnatal depressive symptoms and the possibility that this inequality contributes to later childhood inequalities, suggest that reduction of inequalities could be a priority in postnatal mental health policy. For health to depend on socioeconomic status is considered unjust, at least to the extent that health discrepancies are not a result of individuals' free choices. Such inequalities may be particularly unpalatable, and considered unfair or inequitable, where they are amenable to public policy intervention [86,3]. Policymakers need to balance the priorities of improving postnatal mental health overall, and of reducing inequalities in postnatal depression. Health sector resources are limited, and unless strategies can accomplish both together, they may have to prioritise one over the other [87,86]. Broader impacts of inequalities in postnatal depression, such as the potential for intergenerational transmission of disadvantage, might be an important factor in such decisions.

Identifying which types of perinatal mental health interventions reduce inequalities for mothers and children is an important area for future research. Some existing interventions for the prevention or treatment of postnatal depression have been targeted at groups based on characteristics such as poverty or social isolation [e.g. 88,89]. Others have taken a universal approach [e.g. 90,91]. Targeting those at greatest disadvantage could reduce inequalities, but the presence of inequality across the income spectrum might also encourage efforts in the broader population [92]. Measuring the impact of treatment on the socioeconomic distribution of health in mothers and children is essential, since socioeconomic inequalities in treatment of mothers' depression may lead to greater socioeconomic inequalities in children's outcomes if treating maternal depression has a spillover benefit to children.

The substantial apparent contribution of income in each model when it was included in the sensitivity analysis might suggest that important factors have not been captured in this study, but may also suggest that income could play a direct role in driving inequalities in health. The latter interpretation would support interventions that increase families' income as a way of reducing inequalities in postnatal depression and children's outcomes.

Future research might be able to exploit some form of exogenous variation in maternal postnatal depression, such as successful prevention or treatment. An advantage of such an approach would be that it would not only allow for a causal interpretation of the association between inequality in maternal postnatal depression and children's inequalities, it would also demonstrate the feasibility of intervening to reduce early-life roots of inequality, which is the end goal of such research. However, differences in uptake or adherence to the intervention by socioeconomic status would be an important consideration for such research. Another dataset may allow for the application of instrumental variable approaches, which could include a structural equation modelling approach to the simultaneous decomposition of inequality in health and socioeconomic status as suggested by Kessels, Erreygers [93].

## **Conclusions**

This paper has presented descriptive evidence supportive of the hypothesis that inequalities in maternal postnatal depression may be contributing to a lifetime of inequality for children. The question of whether this is a causal relationship warrants further exploration. The findings support a policy focus on reducing inequalities in postnatal depression alongside improving postnatal mental health overall, with the dual goals of reducing inequalities in women's mental health and in acting on the roots of inequality in childhood. In order to inform decision-making, we need to understand the effect of interventions on socioeconomic gradients in both postnatal depression and downstream outcomes.

### **Figure captions**

Figure 1. Gradient over income in children's outcomes, by maternal postnatal depressive status

Figure 2. Concentration curves in children's outcomes

Figure 3. Percentagewise contributions to income inequality in special educational needs at age 11

Figure 4. Percentagewise contributions to income inequality in emotional problems in early adolescence

Figure 5. Percentagewise contributions to income inequality in conduct problems in early adolescence

Figure 6. Percentagewise contributions to income inequality in self-assessed health in early adolescence

Table 1. Distribution of outcomes and covariates over baseline income quintiles and maternal postnatal depressive symptoms (PND) (%) (N=4,359)

Characteristic	Overall	By PND status		Distribution over baseline income quintiles <sup>#</sup>				
				1 (low)	2	3	4	5 (high)
<i>Maternal depression variables</i>								
Postnatal depressive symptoms (PND)	33.2			50.4	40.4	39.1	28.1	25.0
Ever diagnosed with depression up to 9mo	23.1	PND	45.6	54.6	54.4	52.2	40.5	31.2
		No PND	11.9	14.9	18.5	15.5	10.7	7.9
Currently treated for depression at 9mo	7.1	PND	19.9	23.6	26.9	22.2	18.8	10.8
		No PND	0.8	2.0	1.6	1.5	0.5	0.2
Treatment for depression or diagnosis of depression reported at a later wave	24.1	PND	38.3	44.5	48.1	40.0	37.2	26.1
		No PND	17.1	25.0	22.6	20.8	14.7	13.2
<i>Children's problems</i>								
Special educational needs reported by teacher at 11 years of age	16.1	PND	19.6	26.0	24.0	19.2	16.5	16.1
		No PND	14.3	24.3	19.9	15.2	13.3	11.0
Emotional problems in early adolescence (parent, teacher and child at 11-14 years)	14.2	PND	20.8	31.7	27.7	20.2	17.4	13.2
		No PND	10.9	21.4	17.3	10.6	10.1	7.6
Conduct problems in early adolescence (parent, teacher and child at 11-14 years)	10.1	PND	13.3	27.7	18.7	12.7	7.9	6.8
		No PND	8.6	22.7	13.9	8.7	6.6	5.7
Low self-assessed health at 14 years of age	11.6	PND	15.8	27.9	19.6	11.0	14.3	12.6
		No PND	9.5	18.7	18.6	11.2	7.3	5.5

<sup>#</sup>Quintiles are country-specific, so that families are ranked against those within each country rather than the UK overall

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