Maternal Depression Trajectories and Child BMI in a Multi-ethnic Sample: A Latent Growth Modeling Analysis

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Abstract

Background: Perinatal (antenatal and postpartum) depression impacts approximately 12% of mothers. Perinatal depression can impact everyday functioning for mothers, and the relationship with, and development of, their children. The purpose of this study was to investigate depression trajectories from the antenatal period through 54-months postpartum and associations with child body mass index at 54-months postpartum.

Methods: This study applied latent growth modeling to the Growing Up in New Zealand study, which is a longitudinal pregnancy cohort study that provides nationally representative level data, to investigate associations between depression at three time points (antenatal, 9-months postpartum, 54-months postpartum) and child body mass index at 54-months (n=4897).

Results: The average slope of depression for this sample is low and decreases over time. When child BMI was added to the model as an outcome variable, both antenatal depression (B=.25, p<.01), and the rate of change of depression across the perinatal and postpartum periods (B=.09, p<.01) were associated with child BMI at 54-months postpartum. After controlling for sociodemographic characteristics, antenatal depression, but not postnatal depression, remained significantly associated with child BMI (B=.05, p<.05). When controlling for maternal pre-pregnancy BMI the effect of antenatal depression on child BMI at 54-months was entirely attenuated ($\chi^2 (9) = 39.60, p < .05, \text{SRMR = 0.01, CFI = .99, RMSEA = 0.03, BIC=53213}$).

Conclusions: Our findings align with the Developmental Origins of Health and Disease theory and imply that both the physical and mental health of mothers during pregnancy may be important indicators of child growth and development outcomes. Early intervention directed towards women who have even mild depression scores during pregnancy may promote healthy child development outcomes. Additionally, given the heterogeneity of depressive symptoms over time seen in this study, multiple assessment periods across the postpartum period may be valuable to adequately address and support maternal mental health.

Introduction

Perinatal depression (antenatal and postpartum) is defined symptomatically as exceeding a threshold on a screening measure, such as the Edinburgh Postnatal Depression Scale [1]. Studies vary in prevalence based on the timing and method of perinatal depression measurement, but estimates suggest that perinatal depression impacts approximately 12% of mothers [2]. In a recent systematic review, rates of depression appeared to be higher during pregnancy (17%) compared to the postpartum period (13%)[3]. Sixty-one percent (61%) of mothers with antenatal depression do not experience postpartum depression, and 53% of mothers with postpartum depression did not have depression during pregnancy [3]. Mothers who suffer from persistent depression (antenatal and postpartum) are at particular risk for negative maternal and child health outcomes [4].
Perinatal depression can impact everyday functioning for mothers, and the relationship with, and development of, their children [5]. For example, perinatal depression has been associated with an increased risk for early childhood depression, impaired or delayed language, cognitive development and behavioral problems [6]. Chronic perinatal depression has also been linked to poor social emotional development in early childhood [7]. For example, one study found that children whose mothers experienced perinatal depression had lower social skills at 5 years of age [8]. Poor development and depression early in life can lead to disparities in physical, emotional and mental health outcomes throughout the life course [9]. Given the importance of childhood wellbeing throughout the life course, it is imperative to investigate the relationship between perinatal depression and its impact on childhood development outcomes.

Maternal depression during these the perinatal periods has also been positively associated with obesity in early childhood; however, the findings vary by timing and duration of exposure [10–12]. Elevated body mass index (BMI) is a particularly important outcome of interest, since high BMI in childhood is a major risk factor underlying the development of many chronic diseases [13]. Identifying the determinants of obesity within a broader multi-level framework emphasizes the upstream influences of maternal mental health and modifiable factors beginning very early in the life course [14](Campbell, 2016). Promoting maternal mental health during the perinatal period, and beyond, may foster women's wellbeing and promote healthy childhood growth and development outcomes [15, 16].

Two different theoretical models describe the potential mechanistic pathways (or developmental trajectories) of maternal depression on childhood development outcomes: the Developmental Origins of Health and Disease (DOHaD) model [17, 18] and the Life Course Health Development (LCHD) model [19]. The DOHaD model explores the biological embedding of adversity (e.g., maternal depression) primarily during the antenatal period of development [20]. The LCHD framework incorporates multiple theories, including DOHaD, and contends that health is a consequence of cumulative factors that change as a person develops throughout the life course [21]. Studies have found that both antenatal and cumulative perinatal depression are associated with poor child outcomes [11]. However, the research is often cross-sectional, retrospective, relies on subjective or un-validated measures, and/or is limited to the first two years of life [10, 11].

Cross-sectional methods to investigate perinatal depression do not adequately address the timing and duration of maternal mood and resulting impacts on maternal and child wellbeing [3]. In contrast, the use of longitudinal data and latent growth modeling in particular, allows for the investigation of both the intercept and slope of maternal depression from the antenatal period through five-years postpartum and associations with early childhood outcomes. These methods allow better investigation of the DOHaD versus LCHD frameworks and can be used to explicate the ways in which adversities, such as depression, may aggregate over time and affect the intergenerational transmission of poor mental and physical health outcomes.
Additionally, a recent systematic review of perinatal depressive symptom trajectories emphasized the need for further research within larger and more diverse settings [22]. Specifically, there is a lack of evidence on maternal depression among minority groups within broader populations and those from a lower socioeconomic backgrounds [23]. To address this need, this study applied latent growth modeling to the Growing Up in New Zealand (GUiNZ) study, which is a longitudinal pregnancy cohort study that provides nationally representative level data. The GUiNZ study is unique in terms of the size and capacity to provide a comprehensive picture of maternal mental health and child development across multiple domains of influence, and for the inclusion of significant numbers of minorities, representative of this multicultural population. The purpose of this study was to investigate depression trajectories from the antenatal period through 54-months postpartum and their associations with child BMI at 54-months postpartum.

Methods

Participants

Participants for this study came from the GUiNZ study [24]. The GUiNZ study included pregnant persons with an expected delivery date between April 2009 and March 2010 resigning within a geographically defined region of New Zealand, chosen for its nationally representative ethnic and socioeconomic diversity. The cohort originally consisted of 6,853 children live-born to 6,822 women (11% of the national birth cohort over the recruitment period) and has been demonstrated to be representative of the broader current New Zealand birth population [24]. To date, there have been five waves of data collection (e.g. antenatal, 9-months, 24-months, 54-months, 8-years). Ethical approval for this study was obtained from the Colorado Institutional Review Board and the Ministry of Health Northern Y Regional Ethics Committee (NTY/08/06/055) in New Zealand. Three time points of data were used for the current study: T1 (pregnancy), T2 (9-months postpartum), and T3 (54-months postpartum).

Instruments

Outcome Variable: Child BMI z-score at 54-months

Child BMI was calculated as weight in kilograms divided by height in meters squared measured at the 54-months interview; children ranged in age from 48- to 60-months. The BMI scores were z-scored based on the continuous measure of gender- and age-specific BMI z-scores from the International Obesity Task Force (IOTF) Growth Standards [25].

Independent Variable: Antenatal and Postpartum Depression

Depression symptoms were measured during the antenatal and 9-month interviews using the Edinburgh Postnatal Depression Scale (EPDS) [1], a screening tool which consists of 10 self-report items focused on the cognitive and affective features of depression. Although the EPDS was originally designed to screen
for postnatal depression, it has been validated in populations of pregnant women [26]. Depression at 54-months postpartum was assessed using the Patient Health Questionnaire 9-item (PHQ-9) [27]. All depression scores were standardized using z-scores at each timepoint to allow for comparison between measures.

### Covariates

Socio-demographic variables were collected by self-report during the antenatal interview and included maternal age (years), education level (no secondary school qualification, secondary school degree, diploma or trade certificate, bachelor's degree, higher degree), total household income (<$20,000, $20,001-$30,000, $30,001-$50,000, $50,001-$70,000, $70,001-$100,000, $100,001-$150,000, >$150,001) and ethnicity (see below). Maternal age, education level, and total household income were modeled continuously. Ethnicity was defined as the woman's self-prioritized ethnicity (New Zealand European; Māori; Pacific Peoples; Asian; Middle Eastern, Latin American and African (MELAA); and other (Statistics New Zealand 2004). External prioritization was carried out (as utilized by Statistics New Zealand 2004) for mothers who identified with more than one ethnicity but who did not provide a self-prioritized main ethnicity[28]. In this study participants identifying as MELAA or other were grouped together as Other ethnicities (n = 141). Maternal ethnicity was coded as a categorical variable in all analyses and New Zealand European was used as the reference category (1 = New Zealand European, 2 = Māori, 3 = Pacifica, 4 = Asian, 5 = Other). Maternal pre-pregnancy BMI was collected via self-reported height and weight during the antenatal interview and was included in all analyses as a continuous variable.

### Analysis

GUiNZ data sets from three data collection waves, antenatal, 9-months and 54-months, were merged using the unique child identifier. Individuals who had non-missing data with respect to childhood BMI at 54 months variable were included (n = 5839). Within this sample, only mothers who completed an antenatal interview during pregnancy (depression data collected during pregnancy) were included for the final analytical sample (n = 4897). More than 5% of data were missing on key variables (range from 0–11.3%) so multiple imputation was used to create imputed values for missing data across all variables. The imputation model included all the variables in the final latent growth model. The observed cases and the imputed cases were analyzed separately to compare results; findings were not significantly different.

First, we ran univariate and bivariate statistics to explore all key variables. Next, we used latent growth curve modeling to investigate relationships between depression at three timepoints and child BMI, controlling for covariates. The following four models were run: 1) Unconditional two-factor (intercept, slope) linear growth model with varying fixed factor loadings; 2) exploratory models assessing for nonlinear quadratic trends in the trajectory; 3) analysis of outcomes (i.e., child BMI) of the intercept and slope; and 4) analysis of potential covariates (i.e. age, education, income, ethnicity, maternal pre-pregnancy BMI). Models were estimated and compared using well-established criteria for model fit to determine the best-fitting model including the chi square, Standardized Root Mean Square Residual (SRMR), Comparative fit index (CFI), Root Mean Square Approximation (RMSEA), and the Bayesian
Information Criteria (BIC). Models were inspected for convergence, replication of the best log likelihood, and entropy. Standardized coefficients, standard errors, and fit statistics are presented for all final models. All analyses were conducted with Mplus Version 8 [29] and analyses were considered significant at $p < .05$.

**Results**
| Variables                                      | Analytical Sample (n = 4897) |
|------------------------------------------------|-----------------------------|
|                                                | m   | sd  |
| Child Body Mass Index at 54-months             | 0.76| 1.1 |
| Antenatal Depression (EPDS)                    | 6.0 | 4.9 |
| 9-months Depression (EPDS)                     | 5.1 | 4.5 |
| 54-Months Depression (PHQ-9)                   | 3.5 | 3.7 |
| Maternal Age                                   | 30.4| 5.7 |
| Maternal Pre-Pregnancy BMI                     | 25.3| 5.7 |
| Maternal Self-Identified Ethnicity             |     |     |
| European                                       | 2949| 60.2|
| Māori                                          | 587 | 12.0|
| Pacifica                                       | 509 | 10.4|
| Asian                                          | 589 | 12.0|
| Other                                          | 263 | 5.4 |
| Education                                      |     |     |
| No sec school qualification                    | 267 | 5.5 |
| Sec school/NCEA 1–4                            | 1058| 21.9|
| Diploma/Trade cert/NCEA 5–6                    | 1469| 30.4|
| Bachelor’s degree                              | 1180| 24.5|
| Higher’s degree                                | 852 | 17.7|
| Household Income                               |     |     |
| <$20,001                                       | 145 | 3.5 |
| $21,001-$30,000                                | 196 | 4.7 |
| $30,001-$50,000                                | 524 | 12.5|
| $50,001-$70,000                                | 663 | 15.9|
| $70,001-$100,000                               | 978 | 23.4|
| $100,001-$150,000                              | 1010| 24.2|
Characteristics of the analytical sample are displayed in Table 1. The average child BMI IOTF z-score at 54 months was 0.76. The mean antenatal and 9-months postpartum depression score based on the EPDS were 6.0 and 5.1, respectively; the average 54-months postpartum depression score based on the PHQ-9 was 3.5. On average, mothers were 30 years of age with a BMI of 25. The ethnicity of the sample participants consisted of 60% New Zealand European, 12% Maori, 10% Pacika, 12% Asian, and 5% as other. Almost half of the sample had at least a bachelor’s degree (42%) and 40% reported an annual household income of at least $100,000 NZD.

Table 2
Correlations between continuous variables (n = 4897)

| Variables          | 1     | 2     | 3     | 4     | 5     | 6     | 7     | 8     |
|--------------------|-------|-------|-------|-------|-------|-------|-------|-------|
| Antenatal Depression | -    |       |       |       |       |       |       |       |
| 9-months Depression | 0.45** | -    |       |       |       |       |       |       |
| 54-months Depression | 0.30** | 0.33** | -    |       |       |       |       |       |
| Child BMI at 54-mos | 0.07** | 0.06** | 0.08** | -    |       |       |       |       |
| Household Income   | -0.19** | -0.18** | -0.17** | -0.13** | -    |       |       |       |
| Educational Attainment | -0.15** | -0.12** | -0.14** | -0.17** | 0.40** | -    |       |       |
| Maternal Age       | -0.19** | -0.13** | -0.16** | -0.09** | 0.38** | 0.33** | -    |       |
| Pre-pregnancy BMI  | 0.10** | 0.07** | 0.13** | 0.31** | -0.13** | -0.21** | -0.04 | -    |

*p < .05  
**p < .01

All variables included in the final model were significantly correlated. Antenatal depression scores were moderately correlated with postpartum depression scores at 9-months (r = .45, p < .01) and 54-months (r = .30, p < .01). Postpartum depression scores at 9-months and 54-months were also moderately correlated (r = .33, p < .01). Antenatal, 9-months and 54-months postpartum depression scores were inversely correlated with education level (r ranges from -.12 to -.15, p < .05), household income (r ranges from -.17 to -.19, p < .05), and maternal age (r ranges from -.13 to -.19, p < .05). There was a small, but significantly positive correlation between maternal pre-pregnancy BMI and depression scores at each of these three time points (r = .10, .07, .13; all p < .01). Child BMI at 54-months was significantly correlated
with antenatal and postpartum depression (range of \( r = .06-.08, p < .01 \)), household income (\( r = -.13, p < .01 \)), educational attainment (\( r = -.17, p < .01 \)), age (\( -.09, p < .01 \)), and pre-pregnancy BMI (\( r = .31, p < .01 \)).

### Table 3
Latent Growth Model Predicting Child BMI by Antenatal Depression (intercept) and the Trajectory of Depression (slope) among mothers from the Growing Up in New Zealand Data Set (n = 4879)

| Variables                          | Model 1     | Model 2     | Model 3     |
|------------------------------------|-------------|-------------|-------------|
|                                    | Beta        | SE          | Beta        | SE          | Beta        | SE          |
| Antenatal Depression (Intercept)   | 0.15**      | 0.02        | 0.05*       | 0.02        | 0.02        | 0.42        |
| Income                             | -0.14**     | 0.02        | -0.14**     | 0.02        |             |             |
| Education                          | -0.05**     | 0.02        | -0.05**     | 0.02        |             |             |
| Age                                | -0.14**     | 0.02        | -0.14**     | 0.02        |             |             |
| Maori                              | 0.07**      | 0.02        | 0.07**      | 0.02        |             |             |
| Pacifika                           | 0.15**      | 0.02        | 0.14**      | 0.02        |             |             |
| Asian                              | 0.03        | 0.02        | 0.04        | 0.02        |             |             |
| Other                              | 0.02        | 0.40        | 0.02        | 0.40        |             |             |
| Pre-Pregnancy BMI                  |             |             |             |             | 0.04*       | 0.02        |
| Depression Trajectory (Slope)      | 0.09**      | 0.04        | 0.05        | 0.17        | 0.02        | 0.62        |
| Income                             | -.00        | 0.88        | -.00        | 0.03        |             |             |
| Education                          | -0.01       | 0.03        | -0.01       | 0.03        |             |             |
| Age                                | 0.03        | 0.36        | 0.02        | 0.36        |             |             |
| Maori                              | -0.01       | 0.79        | -0.02       | 0.79        |             |             |
| Pacifika                           | -0.12**     | 0.00        | -0.13**     | 0.00        |             |             |
| Asian                              | -0.10**     | 0.03        | -0.08*      | 0.03        |             |             |
| Other                              | -0.05       | 0.06        | -0.05       | 0.06        |             |             |
| Pre-Pregnancy BMI                  |             |             |             |             | 0.08*       | 0.03        |
| BIC                                | 54429.63    | 53559.86    | 53330.81    |             |             |             |
| CFI                                | 1.00        | 0.99        | 0.99        |             |             |             |
| SRMR                               | .00         | 0.01        | 0.01        |             |             |             |
| RMSEA                              | .00         | .03         | .03         |             |             |             |
Table 3 presents results of growth models predicting the effect of baseline and growth of perinatal depression on child BMI at 54-months postpartum. The linear growth model with fixed factor loadings for the three timepoints at 0, 1, and 3, respectively, was deemed to be the best fit model compared to the no change models and nonlinear models based on model fit criteria ($\chi^2 (1) = .021, p > .05, \text{SRMR} = 0.001, \text{CFI} = 1.00, \text{RMSEA} = 0.00, \text{BIC} = 39546$). Consistent with life course research on depression trajectories, results from the linear growth models indicate that the average slope of depression for this sample is low and decreasing across time. When child BMI was added to the model as an outcome variable, both antenatal depression ($B = .25, p < .01$), and the rate of change of depression across the perinatal and postpartum periods ($B = .09, p < .01$) were associated with child BMI at 54-months postpartum (Model 1).

After controlling for sociodemographic characteristics (Model 2), antenatal depression, but not the slope of depression, remained significantly associated with child BMI ($B = .05, p < .05$). Having lower income, education, and age were associated with higher antenatal depression scores ($B = -.14, -.05, - .14$, respectively; all $p < .01$). Additionally, lower income and education were associated with higher levels of child BMI at 54-months postpartum ($B = -.05, -.06$, respectively; both $p < .01$). When controlling for maternal pre-pregnancy BMI (Model 3), the effect of antenatal depression on child BMI at 54-months was entirely attenuated ($\chi^2 (9) = 39.60, p < .05, \text{SRMR} = 0.01, \text{CFI} = .99, \text{RMSEA} = 0.03, \text{BIC} = 53213$). Maternal BMI was significantly and positively associated with antenatal depression scores ($B = .04, p < .05$), the slope of perinatal depression ($B = .08, p < .05$), and child BMI at 54-months postpartum ($B = .21, p < .01$).

Discussion

The purpose of this study was to apply a multivariate latent growth curve model to a large, longitudinal and representative data set in New Zealand to examine the relationships between perinatal depression and child BMI at 54-months postpartum. Though antenatal, 9-months, and 54-months postpartum depression scores were moderately correlated ($r$ ranged from $.30-.45$), the fit of the linear change model of depression was better than that of no change model, suggesting that on average, maternal depression scores are heterogeneous over time in this sample [30–32]. Our findings also suggest that depression scores generally decrease from the antenatal period through 54-months postpartum. These findings are supported by recent studies that have investigated changes in depression across these transitional periods [33, 34].

Prior to controlling for covariates, both the intercept and slope of maternal depression was associated with child BMI at 54-months postpartum. These data support the LCHD framework [19], suggesting that the cumulative effect of poor maternal health has detrimental impacts on child growth above and beyond exposure solely during the antenatal period. However, after controlling for sociodemographic factors, the association between the slope of depression and child BMI at 54-months was attenuated. In line with the DOHaD framework and past literature, a mother’s depression scores during pregnancy may detrimentally impact early childhood BMI, regardless of postpartum maternal mental health status [35–37]. Education, income and age were inversely associated with both antenatal depression and early childhood BMI; age and household income were the strongest predictors of antenatal depression scores in this sample.
These findings support previous literature on the impact of sociodemographic factors on antenatal depression scores and subsequent increases in the risk of adverse childhood outcomes [38]. Studies have found that education level and income are negatively associated with perinatal depression [39] and mothers having children at a younger age are at a higher risk for antenatal depression [40]. Sociodemographic factors were also significantly associated with child BMI; lower socioeconomic status was significantly associated with higher child BMI, potentially due to the structural factors (e.g., food access, affordability) that impact child growth and development outcomes [41]. Variations in depression and child BMI by ethnic group were identified as statistically significant. Pacifika, Maori, and Asian mothers reported significantly higher depression scores during the antenatal interview compared to New Zealand European mothers, with Pacifika women reporting the highest scores, which aligns with past studies with the GUiNZ data set [3]. Children of Pacifika and Maori mothers had higher BMI compared to New Zealand European children [42].

After controlling for all sociodemographic factors, only antenatal depression scores were associated with child BMI; the accumulation of depression throughout the postpartum period was no longer statistically significantly related to the outcome. A systematic review cited some studies that contradicted our findings and found a significant positive association between chronic perinatal and postpartum depression and risk factors for children being overweight in preschool, after controlling for covariates of socioeconomic status, maternal education status, marital status and ethnicity of the child [43]. However, the results were inconsistent across studies and depended on the time at which depression was measured (i.e., antenatal, postnatal, in isolation or longitudinally). In the GUiNZ sample, depression scores during the antenatal period appear to be most strongly associated with child BMI, while accumulated depression in the postpartum period did not contribute additional risk [37].

When maternal BMI was added into the final model, the association between depression and child BMI at 54-months of age was no longer statistically significant. Though this is supported by past studies [44], substantial heterogeneity in findings with respect to perinatal depression and child BMI z-scores exist [10]. For example, one recent study found that perinatal depression was associated with higher BMI for the child at three years, even after controlling for maternal BMI and childbirth weight [37]. These discrepancies may be partially explained by the interaction of mental and physical health during the antenatal period [45], which may amplify negative impacts on child growth and development outcomes. In the current sample, there was a small, though significant, correlation between antenatal depression and pre-pregnancy BMI. An earlier study found that mothers who were depressed and had a high BMI had infants with a higher birth weight compared to mothers who were not depressed and did not have a high BMI [46]. Collectively, these findings confirm that strong associations exist between physical and mental health outcomes and that physical health, and specifically maternal weight, may be the biggest predictor of early childhood BMI above and beyond the effects of depression on this outcome [47].

Despite the large sample size and longitudinal nature of the study, this study is not without limitations. Exposure to antenatal and postpartum depression is not necessarily causally related to early childhood BMI. In addition, many of the effect sizes were weak, but significant due to the large sample size. As such,
these significant findings may not be clinically significant. Future research is needed to continue exploring the biological and behavioral pathways that may create these associations. Both perinatal depression and early childhood obesity are complex health conditions. A variety of different risk and resilience factors may influence the observed associations. Finally, we assumed that baseline covariates in our analyses (e.g., income, education) were stable over time.

Previous research examined trajectories between antenatal depression and depression up to 1 to 2 years postpartum, but very few studies investigate trajectories in maternal depression through early childhood [34, 48]. Strengths of this research include the use of validated screening tools, the large sample size and ethnic and socioeconomic diversity of the GUiNZ sample, the low attrition rates, and the investigation of data from the antenatal period through 54-months postpartum. Our findings align with the DOHaD theory and imply that both the physical and mental health of mothers during pregnancy may be important indicators of child growth and development outcomes. Mental health supports and resources that start during pregnancy are critical to mitigate postpartum depression and promote the adoption of healthy coping behaviors. Early intervention directed towards women who have even mild depression scores during pregnancy may promote healthy child development outcomes. Additionally, given the heterogeneity of depressive symptoms over time seen in this study, multiple assessment periods across the postpartum period may be valuable to adequately address and support maternal mental health. Finally, there is a need to apply innovative modeling techniques, such as growth mixture modeling, to these types of data to investigate cohorts of women who may follow similar trajectories with respect to maternal mental health and allocate resources towards highest risk individuals. Differentiating public health and clinical health supports during these early sensitive periods may mitigate disparities between maternal and child mental and physical health outcomes.

**Abbreviations**

GUiNZ – Growing Up in New Zealand

BMI – Body Mass Index

IOTF - International Obesity Task Force

DOHaD - Developmental Origins of Health and Disease

LCHD – Life Course Health Development

EPDS – Edinburgh Postnatal Depression Scale

PHQ-9 – Patient Health Questionnaire

SRMR - Standardized Root Mean Square Residual

CFI - Comparative fit index
RMSEA - Root Mean Square Approximation

BIC - Bayesian Information Criteria

**Declarations**

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**Conflicts of interest/Competing interests**

The authors declare that they have no conflicts of interest.

**Availability of data and material (data transparency)**

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

**Authors’ contributions**

CF analyzed all data and was lead on the writing of this manuscript. RD is a student research assistant who helped with the literature review and writing. ZT, JP, and JN are mentors on this project and assisted in the analyses and interpretation of the findings as well as final review of the manuscript. CW and KW represented the GUiNZ team, supported interpretation of the analyses, and reviewed the manuscript. Finally, JL served as the primary mentor for this project, supported interpretation and framing of this manuscript, and reviewing the manuscript.

**Ethics approval**

Ethical approval for this study was obtained from the Colorado Institutional Review Board and the Ministry of Health Northern Y Regional Ethics Committee (NTY/08/06/055) in New Zealand. The study was performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

**Consent to participate (include appropriate statements)**

All participants were consented following the Ministry of Health Northern Y Regional Ethics Committee (NTY/08/06/055) in New Zealand protocol for the GUiNZ study.

**Consent for publication**

The authors affirm that human research participants provided informed consent for publication of all data included in this manuscript.
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Figures

A latent growth model highlighting significant associations between antenatal depression (intercept), the trajectory of depression from the antenatal period through 54-months postpartum (slope), and child BMI at 54-months, controlling for sociodemographic factors and maternal pre-pregnancy BMI.

* p<.05
** p<.01