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SHORT REPORT

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# Gestational weight gain and breastfeeding practices in relation to offspring body mass index among Amazonian young children

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**Abstract**

**Objective:** Excessive weight gain during childhood has been considered an early life risk factor for chronic disease in the long term. We examined the role of excessive gestational weight gain (GWG) and breastfeeding (BF) practices with the offspring's body mass index-for-age z-score (zBMI) at 2 years.

**Methods:** Data from 743 Amazonian young children of the MINA-Brazil population-based birth cohort study were used. Linear regression models were run to estimate the associations between excessive GWG and BF practices (exclusive breastfeeding, EBF <3 months of age and BF <1 year) with zBMI.

**Results:** Excessive GWG and BF <1 year were associated with an adjusted 0.24 units (95% CI: 0.08, 0.41) and 0.28 units (95% CI: 0.12, 0.44) higher zBMI at age 2 years, respectively.

**Conclusions:** Gain excessive weight during pregnancy and shorter BF duration (<1y) were associated with a higher body mass index at 2 years of age among Brazilian Amazonian children.

## 1 | INTRODUCTION

Childhood excessive weight gain, which predisposes to obesity and a higher risk of noncommunicable diseases in later life, is increasingly affecting low- and middle-income countries. The prevalence estimates of overweight worldwide, in Latin America, and among Brazilian children under 5 years in 2020 were 5.7%, 7.5%, and 7.3%, respectively, without considering the impact of the COVID-19 pandemic (United Nations Children's Fund & World Health Organization [WHO], 2021).

Evidence suggests that the origins of childhood excess weight start in the early stages of life (Woo Baidal et al., 2016). During pregnancy, excessive gestational weight gain (GWG) is related to greater childhood adiposity (Voerman et al., 2019), affecting a child's Body Mass Index (BMI) across three generations, indirectly through the grandmother and directly through the mother (Schneider et al., 2021). In the postnatal period, breastfeeding (BF) was suggested as a protective factor against noncommunicable diseases, including overweight and obesity later in life (Horta et al., 2015), despite controversies (Kramer et al., 2007; Zheng et al., 2020).

BMI reduction at an early age is a starting point toward lessening childhood excessive weight gain. Thus, a better insight of modifiable early nutrition factors is essential, particularly in low-income populations, with limited access to healthcare, and precarious environmental conditions. However, despite childhood overweight relevance in public health, information on nutritional status of Amazonian infants are scarce and data available

A full list of members of the MINA-Brazil Study Working Group is provided in the Acknowledgments section.

  

comes mainly from cross-sectional surveys (Cunha et al., 2017). Given the importance of perinatal factors for child health and the lack of longitudinal studies in remote areas, this study aimed to examine the role of excessive GWG and BF practices in BMI at 2 years of age in the first population-based birth cohort conducted in the Brazilian Amazon. We hypothesized that both adequate GWG and longer BF practices could inversely affect child BMI.

## 2 | METHODS

The MINA-Brazil study (Maternal and Child Health and Nutrition in Acre) design had been described previously (Cardoso et al., 2020). Between July 2015 and June 2016, all women who gave birth in the only maternity ward in Cruzeiro do Sul, Acre State, and agreed to participate in the study ($n = 1246$) were interviewed after delivery to obtain their baseline information. Follow-up assessment visits were performed at 6 months, 1 year, and 2 years to collect data on infant feeding practices and anthropometric status. In the present study, we analyzed data from 743 mother-infant dyads out of the 868 participants in the 2-year follow-up visit. Women with incomplete data on GWG ($n = 45$), children born preterm ($n = 64$), twins ($n = 14$), babies with contraindications to BF ($n = 1$, HIV-positive mother), and incomplete data on weight at 2 years ($n = 1$) were excluded. All the participants provided informed consent at enrollment. This study was approved by the ethical review board of the School of Public Health, University of São Paulo, Brazil (number 872.613, November 13, 2014).

The exposures of interest were the GWG and BF practices. The difference between maternal weight at delivery (collected from hospital records) and pre-pregnancy weight (obtained from prenatal cards) was used to estimate the GWG. Based on the pre-pregnancy BMI categories, the estimated GWG of women who gave birth at ≥37 weeks of gestational age was assessed according to the adherence of the Institute of Medicine GWG guidelines (IOM, 2009), as adopted by the Brazilian Ministry of Health, and further categorized as excessive or not. In the follow-up interviews, which were conducted by telephone in the first month and by in-person visits afterward, mothers were asked about their current BF status (yes or no), and the child's age when stopped BF. At 1- and 6-month assessments, using recall since birth, mothers reported the age of introduction of weaning foods. A list of foods commonly offered to infants (water, tea, fruit juice, cow milk, formula, other liquids, semi-solids, and solid foods) was provided. At 1- and 2-year assessments, a 24-h food recall based on the previous day consumption was administered. Children were considered exclusively breastfed if they received breast milk with no other food or drink. Feeding practices were categorized as exclusive breastfeeding (EBF, <3 and ≥3 months) and BF duration (<1 and ≥1 year).

The outcome of interest was the children's BMI at 2 years. Children's length and weight were determined using standardized procedures, and the age- and sex-specific z-scores for BMI (zBMI) were computed based on the WHO Child Growth Standards (WHO, 2006).

The participants' baseline characteristics at 2-year follow-up were similar to those lost to follow-up, although study families retained at 2 years were wealthier (Cardoso et al., 2020).

The independent predictors of the outcome were identified by comparing distributions (means and standard deviations, SD) using *t-test* or one-way ANOVA. Covariates were selected for multiple models if they were associated with the zBMI in the crude analysis at $P < .20$. Linear regression models were used to estimate the associations between excessive GWG and BF feeding practices with zBMI. The results were expressed as crude and adjusted mean differences with 95% confidence intervals (CI). Adjustment for covariates included maternal schooling, self-reported skin color, wealth index, primiparity, pre-pregnancy BMI, antenatal care visits, and child sex. The relation between BF practices and zBMI was adjusted for GWG and birth weight. All analyses were conducted using Stata 15.0 (StataCorp), with the significance level set at 5%.

## 3 | RESULTS

Overall, 36.5% of the women experienced excessive GWG. Although 63.6% exclusively breastfed their children for less than 3 months, 70% continued to breastfeed for up to 1 year or more. At the 1-year assessment, most children had consumed at least one processed food (90%). At the 2-year assessment, the infants' mean age was 23.8 (SD 1.4) months. The mean zBMI was 0.47 (SD 1.05), and 7.3% were overweight (zBMI for age ≥2). EBF and complementary food consumption were not significantly associated with child BMI (Table 1).

Offspring of women with excessive GWG or those who breastfed for less than 1 year had an adjusted mean zBMI 0.24 (95% CI: 0.08, 0.41) and 0.28 higher (95% CI: 0.12, 0.44), respectively, when compared with their counterparts (Table 2). These associations were not observed for overweight condition (data not shown).

**TABLE 1** Maternal and child characteristics by body mass index-for-age z score (zBMI)[a] at 2-year follow-up ($n = 743$). The MINA-Brazil birth cohort

| Exposures variables | Participants *n* (%) | zBMI mean (SD) | *p*[b] |
|---|---|---|---|
| *Maternal schooling* | | | 0.01 |
| ≤9 y | 205 (28.1) | 0.29 (1.03) | |
| 10–12 y | 381 (52.2) | 0.49 (1.06) | |
| >12 y | 144 (19.7) | 0.61 (1.05) | |
| *Self-report skin color* | | | 0.05 |
| White | 96 (13.2) | 0.26 (0.86) | |
| Black | 28 (3.8) | 0.24 (1.19) | |
| Mulatto | 567 (77.7) | 0.49 (1.05) | |
| Indigenous and yellow | 39 (5.3) | 0.72 (1.29) | |
| *Wealth index* | | | 0.07 |
| 1st lower | 143 (19.6) | 0.29 (0.91) | |
| 2nd | 274 (37.5) | 0.47 (1.12) | |
| 3rd higher | 313 (42.9) | 0.53 (1.04) | |
| *Primiparity* | | | 0.19 |
| No | 443 (60.7) | 0.42 (1.07) | |
| Yes | 287 (39.3) | 0.52 (1.02) | |
| *Pre-pregnancy BMI* | | | <0.01 |
| Underweight | 50 (6.7) | 0.24 (0.99) | |
| Normal weight | 418 (56.3) | 0.36 (1.01) | |
| Overweight | 202 (27.2) | 0.61 (1.10) | |
| Obesity | 73 (9.8) | 0.79 (1.06) | |
| *Antenatal care visits* | | | 0.02 |
| <6 visits | 126 (17.0) | 0.27 (1.04) | |
| ≥6 visits | 616 (83.0) | 0.50 (1.05) | |
| *Gestational weight gain*[c] | | | <0.01 |
| Not excessive | 486 (65.4) | 0.35 (1.04) | |
| Excessive | 257 (34.6) | 0.69 (1.02) | |
| *Child sex* | | | 0.92 |
| Female | 369 (49.7) | 0.46 (1.00) | |
| Male | 374 (50.3) | 0.47 (1.10) | |
| *Birthweight* | | | <0.01 |
| <2500 g | 19 (2.6) | 0.24 (0.63) | |
| ≥25 000–<4000 g | 669 (90.0) | 0.43 (1.06) | |
| >4000 g | 55 (7.4) | 1.01 (0.89) | |
| *Exclusive breastfeeding* | | | 0.47 |
| EBF ≥3 m | 245 (36.3) | 0.42 (1.13) | |
| EBF <3 m | 429 (63.7) | 0.49 (1.03) | |
| *Breastfeeding* | | | <0.01 |
| BF ≥1 y | 520 (70.0) | 0.39 (1.07) | |
| BF <1 y | 223 (30.0) | 0.64 (0.97) | |

(Continues)

TABLE 1 (Continued)

| Exposures variables | Participants *n* (%) | zBMI mean (SD) | *p*[b] |
|---|---|---|---|
| *Age at introduction of cow milk or solid food* | | | 0.30 |
| <4 m | 305 (56.1) | 0.50 (1.01) | |
| 4–6 m | 159 (29.2) | 0.35 (1.04) | |
| ≥ 6 m | 80 (14.7) | 0.39 (1.11) | |
| *Cow's milk consumption at the 1-year follow-up* | | | 0.36 |
| No | 542 (73.1) | 0.45 (1.06) | |
| Yes | 200 (26.9) | 0.53 (1.01) | |
| *Ultra-processed foods consumption in the 1-year follow-up*[d] | | | 0.89 |
| Not consumed | 75 (10.1) | 0.52 (1.28) | |
| 1 to 2 UPFs | 347 (46.7) | 0.46 (1.06) | |
| 3 or more UPFs | 321 (43.2) | 0.46 (0.98) | |

Abbreviations: GWG, gestational weight gain; BF, breastfeeding; BMI, body mass index; EBF, exclusive breastfeeding; m, months; UPFs, Ultra-processed foods; g, grams; y, year. Variation in n is due to missing data.

[a]According to the World Health Organization Growth Reference for children ages 0–5 years, 2006.

[b]From *t*-tests for dichotomous variables and ANOVA test for ordinal variables.

[c]According to the Institute of Medicine (2009).

[d]UPFs included industrialized yogurt, artificial fruit juice, soda, candies, cookies, packaged savory snacks, hotdogs and instant noodles, chocolate drinks, ice cream, jelly, cake, and industrialized soup.

TABLE 2 Crude and adjusted regression models for body mass index-for-age z-score (zBMI) at 2 years of age[a] in the MINA-Brazil birth cohort ($n = 743$)

| Dependent variable | Excessive GWG[b] | EBF < 3m[c] | BF < 1y[c] |
|---|---|---|---|
| *Child zBMI* | | | |
| Crude difference (95% CI) | 0.34 (0.18, 0.50) | 0.06 (−0.10, 0.23) | 0.24 (0.07, 0.40) |
| Adjusted difference (95% CI)[d] | 0.24 (0.08, 0.41) | 0.05 (−0.12, 0.21) | 0.28 (0.12, 0.44) |

*Note*: Complete case analyses (GWG, $n = 729$; EBF, $n = 662$; BF, $n = 729$). Totals differ due to missing values for covariates.

Abbreviations: BF, breast feeding; CI, confidence interval; EBF, exclusive breastfeeding; GWG, gestational weight gain; m, months; y, year.

[a]According to the WHO Growth Reference for children aged 0–5 years (WHO, 2006).

[b]According to the Institute of Medicine (2009). Not excessive GWG was considered the reference group.

[c]EBF ≥3 m and BF ≥1y were considered the reference groups.

[d]Models were adjusted for maternal schooling, self-report skin color, wealth index, primiparity, pre-pregnancy BMI, antenatal care visits, and child sex; the relationship between BF practices and zBMI was also adjusted for GWG and birthweight. Covariates were included in the multiple linear regression models if they were associated with the zBMI in the crude analysis at $P < .20$.

## 4 | DISCUSSION

Our results confirmed the predictive role of excessive GWG in offspring body weight. The transmission of excessive weight during pregnancy to the infant through intrauterine development conditions is hardly disengaged from cultural, environmental, and behavioral attributes (Skrypnik et al., 2019). However, a recent meta-analysis of cohort studies from developed countries showed that the proportions of the prevalence of overweight and obesity in children aged 2–5 years attributable to excessive GWG was 11.4% (Voerman et al., 2019). Conveniently, actions to prevent child excess weight should start at least during the fetal period.

Our results also showed that shorter BF duration (<1y) was associated with a higher zBMI at 2 years. Similarly, in a prospective cohort of Australian children, infants who were breastfed for more than 6 months had a significantly lower zBMI at all ages from 3 to 60 months, compared with those who were breastfed for a shorter period (Zheng et al., 2020). Yet, studies on the effect of BF promotion interventions on child growth observed a modest reduction in zBMI (Giugliani et al., 2015), or no effect (Kramer et al., 2007). Despite the mixed results, our findings support the potential influence of longer BF duration on lower adiposity in this population since household wealth index, maternal education, pre-pregnant BMI, and childbirth weight did not attenuate the magnitude of the association.

However, we did not observe a significant association of early introduction of cow milk or solid food and UPF consumption with child BMI. Similarly, Bell et al. (2018) found no association between timing of solid food and risk of childhood obesity at 24–36 months. Previous moderate evidence indicated no association between complementary feeding and body composition (English et al., 2019). Conversely, UPF high-rate intake in our population may have led to nonexistent association.

The strengths of our study include the use of data from a population-based birth cohort, which prevents reverse causation and recall biases; child anthropometric measurement by trained staff rather than self-reported; and prospective collection of BF information, which reduces misclassification. Limitations include possible selection bias due to losses to follow-up and uncertain generalizability to populations with different GWG and child BMI characteristics. Furthermore, we could not assess the associations with EBF at 6 months given the overall short duration of EBF; also, we cannot rule out residual confounding on the BF-BMI association by unmeasured factors such as child energy intake and physical activity.

Our estimates can guide public health policies by considering specific characteristics of Amazonian mother–child pairs for planning targeted interventions to prevent higher overweight rates in childhood.

## 5 | CONCLUSION

In this study, excessive GWG and shorter BF duration were related to increased zBMI at 2 years. Our findings emphasize that actions to prevent excessive weight gain in childhood should start during pregnancy. In view of the positive influence of BF on childhood weight, our results reinforce WHO recommendations for the promotion, support, and protection of EBF for 6 months and longer BF duration.

### AUTHOR CONTRIBUTIONS

Paola Soledad Mosquera participated in the data collection, performed data analyses and interpretation, and wrote the original draft of the manuscript; Eduardo Villamor performed data analyses and interpretation; Maíra Barreto Malta participated in the data collection; Marly Augusto Cardoso designed the research and revised initial draft of the manuscript. All authors revised and approved the final version of the manuscript.

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### CONFLICT OF INTEREST

None of the authors have conflicts of interest in relation to this manuscript.

### DATA AVAILABILITY STATEMENT

The data that support the findings of this study are openly available in Repository USP at http://repositorio.uspdigital.usp.br/handle/item/267, reference number 267.

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