# Predictors of inadequate gestational weight gain according to IOM recommendations and Intergrowth-21 st standards: The Araraquara Cohort Study

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## CRedIT Author Statement

Audêncio Victor: Conceptualization, Data curation, Formal Analysis, Methodology, Visualization, Writing – original draft, Writing – review & editing. Laísla Silva Teles de França da: Investigation, Methodology, Visualization, Writing – original draft. Leonardo Domingos Biagio: Investigation, Visualization, Writing – review & editing. Leticia Falcão de Carvalho: Investigation, Visualization, Writing – review & editing. Liania Alves Luzia: Investigation, Methodology, Visualization, Writing – review & editing. Perla Pizzi Argentato: Investigation, Methodology, Visualization, Writing – review & editing. Patricia H. C. Rondó: Conceptualization, Data curation, Funding acquisition, Investigation, Project administration, Resources, Supervision, Writing – review & editing.

## Keywords

gestational weight gain, predictors, cohort study, IOM recommendations, Intergrowth-21st standards



## Abstract

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Background: Gestational weight gain (GWG) is a critical factor for maternal and fetal health.Objective: To identify maternal predictors of GWG according to the 2009 Institute of Medicine (IOM) recommendations and Intergrowth-21 st standards.A prospective epidemiological cohort study conducted from 2017 to 2023 in southeastern Brazil assessed 1,557 women at three different stages of pregnancy (≤18, 20-26, and 30-36 weeks of gestation) and at delivery. Sociodemographic, obstetric, lifestyle, nutritional, and maternal morbidity characteristics were collected, along with biochemical parameters.Results: Among the participants, 38.7% had GWG above IOM recommendations, while 67.5% had GWG above the Intergrowth-21 st standards. Multinomial logistic regression analysis showed that women with pre-pregnancy obesity and women with the highest body fat percentage had, respectively, a 95% (OR=1.95; 95% CI: 1.08-3.51) and 1% (OR=1.01; 95% CI: 1.01-1.05) higher chance of GWG above IOM recommendations.Pregnant women in the lowest tertile of height, smokers, number of previous pregnancies, and women living in crowded homes had, respectively, a 57% (OR=0.57; 95% CI: 0.41-0.80), 36% (OR=0.64; 95% CI: 0.37-0.86), 35% (OR=0.65; 95% CI: 0.43-0.97), and 14% (OR=0.86; 95% CI: 0.59-0.86) lower chance of GWG above IOM recommendations.Women with diabetes were 2.53 times more likely (OR=2.53; 95% CI: 1.32-4.83) to have GWG below IOM recommendations. Using the Intergrowth-21 st standards, women with the highest body fat percentage had a 12% (OR=1.12; 95% CI: 1.02-1.24) higher chance of GWG above the 90 th percentile. Pregnant women in the lowest tertile of height were 2.82 times more likely (OR=2.82; 95% CI: 1.08-8.13) and women with the lowest hemoglobin concentrations had a 41% lower chance (OR = 0.59; 95% CI: 0.39-0.88) of having GWG below the 10 th percentile.The findings of this original study highlight the importance of comparing two instruments for assessing the adequacy of GWG and can help implement targeted interventions for specific groups of women based on their nutritional and socioeconomic status, lifestyle, and obstetric factors in order to prevent pregnancy-related complications.

## Contribution to the field

To the best of our knowledge, there are no studies assessing predictors of GWG using two different instruments, such as the IOM and Intergrowth-21st standards, in populations from low- or middle-income countries. This original study identified several predictors of inadequate GWG in a representative sample of Brazilian pregnant women. According to the IOM recommendations, the predictors of GWG were maternal height, pre-pregnancy BMI, body fat percentage, number of individuals per room, smoking, diabetes, and number of previous pregnancies. On the other hand, the main predictors of weight gain according to the Intergrowth-21st standards were maternal height, body fat percentage, and hemoglobin concentrations. These results expand our understanding of the maternal characteristics associated with inadequate GWG, providing valuable information for planning interventions and health policies designed to improve maternal-fetal outcomes.

## Funding information

This study was supported by the São Paulo Research Foundation (FAPESP) (grant number 2015/03333-6). AV, LFST, LFC and LDB had scholarships from the Coordination for the Improvement of Higher Education Personnel (CAPES). PPA had a scholarship from FAPESP (2018/17824-0).

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# Predictors of inadequate gestational weight gain according to IOM recommendations and Intergrowth-21st standards: The Araraquara Cohort Study

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## ABSTRACT

**Background:** Gestational weight gain (GWG) is a critical factor for maternal and fetal health.

**Objective:** To identify maternal predictors of GWG according to the 2009 Institute of Medicine (IOM) recommendations and Intergrowth-21$^{st}$ standards.

**Methods:** A prospective epidemiological cohort study conducted from 2017 to 2023 in southeastern Brazil assessed 1,557 women at three different stages of pregnancy (≤18, 20-26, and 30-36 weeks of gestation) and at delivery. Sociodemographic, obstetric, lifestyle, nutritional, and maternal morbidity characteristics were collected, along with biochemical parameters.

**Results:** Among the participants, 38.7% had GWG above IOM recommendations, while 67.5% had GWG above the Intergrowth-21$^{st}$ standards. Multinomial logistic regression analysis showed that women with pre-pregnancy obesity and women with the highest body fat percentage had, respectively, a 95% (OR=1.95; 95% CI: 1.08-3.51) and 1% (OR=1.01; 95% CI: 1.01-1.05) higher chance of GWG above IOM recommendations. Pregnant women in the lowest tertile of height, smokers, number of previous pregnancies, and women living in crowded homes had, respectively, a 57% (OR=0.57; 95% CI: 0.41-0.80), 36% (OR=0.64; 95% CI: 0.37-0.86), 35% (OR=0.65; 95% CI: 0.43-0.97), and 14% (OR=0.86; 95% CI: 0.59-0.86) lower chance of GWG above IOM recommendations. Women with diabetes were 2.53 times more likely (OR=2.53; 95% CI: 1.32-4.83) to have GWG below IOM recommendations. Using the Intergrowth-21$^{st}$ standards, women with the highest body fat percentage had a 12% (OR=1.12; 95% CI: 1.02-1.24) higher chance of GWG above the 90$^{th}$ percentile. Pregnant women in the lowest tertile of height were 2.82 times more likely (OR=2.82; 95% CI: 1.08-8.13) and women with the lowest hemoglobin concentrations had a 41% lower chance (OR = 0.59; 95% CI: 0.39-0.88) of having GWG below the 10$^{th}$ percentile.

**Conclusion:** The findings of this original study highlight the importance of comparing two instruments for assessing the adequacy of GWG and can help implement targeted interventions for specific groups of women based on their nutritional and socioeconomic status, lifestyle, and obstetric factors in order to prevent pregnancy-related complications.



**Keywords:** Gestational weight gain, predictors, cohort study, IOM recommendations, Intergrowth-21$^{st}$ standards

## INTRODUCTION

Pregnancy is a period characterized by significant changes that have direct implications for fetal health. Gestational weight gain (GWG) is essential to ensure the well-being of both the mother and the fetus; however, it still poses a challenge for many pregnant women because of the physical and psychological alterations that occur during this period of life (1). Additionally, in countries with persistent social inequalities like Brazil, socioeconomic disparities, for example in income and maternal education level, can affect GWG (2,3). In recent decades, obesity has become more prevalent worldwide and also affects women of reproductive age (1). It is estimated that over 21% of women worldwide will be obese by 2025 (4). Since they are a serious public health threat in low, middle- and high-income countries, obesity and overweight have become a growing concern for health authorities (5).

Inadequate GWG is associated with a range of complications for both the mother and the baby, including gestational diabetes, hypertension, and preeclampsia (6–8). Demographic, socioeconomic, biological, dietary, psychological, behavioral, and health-related factors can influence GWG (9–11). Therefore, understanding these factors can help identify women at risk and implement necessary intervention strategies and public policies designed to promote adequate GWG and to improve maternal and child health (12).

There are few large cohort studies in Brazil that have investigated the prevalence of and factors associated with GWG (11,13,14). In Pelotas, Rio Grande do Sul state, the prevalence of adequate GWG was 30.9%, while 47% of women had pre-pregnancy overweight or obesity. There was a rapid increase in GWG above the recommended level over a period of 30 years, particularly among lower-income women (13,14). In Rio de Janeiro, Rio de Janeiro state, 44% of pregnant women had insufficient GWG and 22% had excessive GWG. Risk factors included pre-pregnancy overweight, maternal age above 25 years, early menarche, and a history of smoking (11).

The recommendations of the Institute of Medicine (IOM) have been used to classify GWG since the 1990s; however, they have limitations since they were based on cross-sectional studies of pregnant women exclusively from a single country, the United States (15,16). It was only in 2016 that new international reference curves, the Intergrowth-21$^{st}$ standards, were developed using a multiethnic cohort of healthy, well-

nourished, and educated mothers from eight countries, including Brazil. These new standards provided a prescriptive reference chart for GWG (17).

There are still gaps in knowledge regarding predictors of GWG in low- and middle-income countries, particularly when a more representative curve such as Intergrowth-21$^{st}$ is used. Additionally, given the vast territory and existing socioeconomic, cultural, and dietary disparities in Brazil, conducting studies in different regions is crucial to better understand this issue. Therefore, the aim of this original study was to identify maternal predictors of GWG according to the 2009 IOM recommendations and Intergrowth-21$^{st}$ standards in Brazilian pregnant women enrolled in a large prospective cohort study.

## MATERIALS AND METHODS

### Study Design and Participants

This prospective population-based cohort study conducted from 2017 to 2023 was embedded in an ongoing larger study, called the "Araraquara Cohort Study". The sample included 1,557 women with gestational age ≤ 18 weeks who underwent prenatal care at the 34 Health Units in the city of Araraquara, São Paulo state, southeastern Brazil.

The pregnant women participating in the study were followed up at three different stages of pregnancy (≤ 18, 20-26, and 30-36 weeks of gestation) until the birth of their children. Women with twin pregnancies, miscarriages, fetal death, and stillbirths were excluded. Pregnant women with missing information on height, pre-pregnancy weight, and weight at the time of delivery were also excluded **(Figure 1)**. To permit adjustment to the Intergrowth-21$^{st}$ standards, only pregnant women with adequate body mass index (BMI) and without morbidity were included in the study **(Figure 2)**.

### Outcome Variables

GWG was calculated as the difference between weight at delivery and pre-pregnancy weight. Next, GWG was classified into three categories according to the recommendations of the IOM: (a) GWG below IOM recommendations; (b) GWG within IOM recommendations, and (c) GWG above IOM recommendations (15) **(Table 1)**. For the classification of GWG based on Intergrowth-21$^{st}$, the gestational age-specific GWG percentile of the international GWG standards for women with normal BMI was used, which defines a GWG between the 10$^{th}$ and 90$^{th}$ percentile as appropriate. Thus, pregnant

women below the 10th percentile and above the 90th percentile of the Intergrowth-21st standards were classified as having insufficient and excessive GWG, respectively (17–19).

Table 1 – IOM recommendations for gestational weight gain (15)

| Nutritional status | Pre-pregnancy BMI (kg/m²) | GWG (kg) | GWG rate in the 2nd and 3rd trimesters, mean (range) |
|---|---|---|---|
| **Underweight** | < 18.5 | 12.5-18 | 0.51 (0.44 -0.58) |
| **Normal weight** | 18.5-24.9 | 11.5-16 | 0.42 (0.35-0.50) |
| **Overweight** | 25-29.9 | 7-11.5 | 0.28 (0.23-0.33) |
| **Obesity** | ≥ 30.0 | 5-9 | 0.22 (0.17-0.27) |

BMI: body mass index; GWG: gestational weight gain.

## Maternal Predictors

Several factors were considered for the prediction of GWG. Socioeconomic and demographic factors included age (≤ 19, 20-35, or > 35 years), educational level (< 4, 5-11, or ≥12 years of schooling), per capita income in Brazilian Real (1 US$ = 4.9 R$), race (white or non-white), marital status (married/stable union or single/separated/widowed), and number of previous pregnancies (0, 1, or ≥ 2). Lifestyle included physical activity, smoking, and alcohol consumption. Morbidity included diabetes, hypertension, urinary tract infection, and cervicitis/vaginitis.

Anthropometry of the pregnant women was assessed based on height (cm) categorized into tertiles; BMI (kg/m²) categorized as underweight, normal weight, overweight, and obesity; arm circumference (cm) categorized as low weight (< 23 cm), adequate (25-28 cm), and overweight or obesity (≥ 28 cm), and body fat percentage. Other relevant data included gestational age at birth, glycemic profile (fasting blood glucose [mg/dL], insulin [µIU/mL], HOMA [µIU/mL], glycated hemoglobin [%]), high-sensitivity C-reactive protein (hs-CRP [ng/mL]), hemoglobin [g/dL], and lipid profile (total cholesterol, LDL-c, HDL-c, and triglycerides [mg/dL]). Additionally, the number of household members per room was categorized into tertiles and number of previous pregnancies was categorized as 0, 1, and ≥ 2.

## Statistical Analysis

Descriptive statistics was used for description of the sample. The Shapiro-Wilk test was applied to assess the normality of continuous variables. Continuous variables with a non-normal distribution were reported as median and interquartile range, while categorical variables were expressed as number (n) and percentage (%).

Bivariate analysis was performed to examine the associations between the independent variables and the dependent variable. The Kruskal-Wallis test was used for continuous variables, while the chi-square test or Fisher's exact test was applied to categorical variables. Data modeling was performed by multinomial logistic regression, which allows the analysis of associations between multiple independent variables and a dependent variable with three or more ordered categories, as is the case of the GWG adequacy categories according to IOM recommendations or Intergrowth-21$^{st}$ standards (18,20). The models were adjusted using a stepwise strategy, which is an iterative method that selects and removes independent variables based on statistical criteria. Variables with $p < 0.2$ were maintained in the model. For the adjustment process, variables predicted in the initial theoretical model were considered along with other potentially relevant variables identified in a literature review. The results were expressed as the following measures of association: odds ratio (OR) and 95% confidence interval (CI). All analyses were performed using R version 4.1.0 (R Foundation for Statistical Computing, Vienna, Austria).



## RESULTS

A total of 1,557 pregnant women were included in this study. Of these, 447 (28.7%), 506 (32.5%) and 604 (38.7%) had weight gain within, below and above the 2009 IOM recommendations, respectively. On the other hand, among 569 pregnant women with normal pre-pregnancy BMI, 81 (14.2%), 104 (18.3%) and 384 (67.5%) had weight gain within, below and above the Intergrowth-21$^{st}$ standards **(Tables 2 and 3)**.

### Maternal characteristics associated with GWG according to IOM recommendations

**Table 2** shows that maternal age did not significantly affect GWG (p=0.531). However, maternal height was significantly associated with GWG (p=0.003), with the highest weight gain being observed in the upper tertile (>66.6%) of height. Pre-pregnancy BMI was also significantly associated with GWG (p<0.001), with overweight and obese pregnant women showing the highest weight gain. Similarly, arm circumference, body

fat percentage, maternal education, number of individuals per room, and per capita income were all significantly associated with GWG ($p<0.001$).

Regarding lifestyle factors, smoking was significantly associated with GWG ($p<0.001$), while physical activity or alcohol consumption showed no significant association ($p=0.951$ and $p=0.885$, respectively). Pregnant women with diabetes had lower GWG compared to those without diabetes ($p<0.001$). However, no significant differences were observed for hypertension, urinary tract infection, cervicitis/vaginitis, or number of previous pregnancies. Finally, hemoglobin and HDL-c were significantly associated with GWG ($p=0.002$ and $p=0.012$, respectively), but no significant associations were found for hs-CRP, HOMA, glycated hemoglobin, fasting insulin, total cholesterol, LDL-c, or triglycerides.

**Maternal characteristics associated with GWG according to Intergrowth-21st standards**

**Table 3** shows that maternal age was not significantly associated with GWG ($p=0.292$). Similarly, no significant association with GWG was found for pre-pregnancy BMI, per capita income, race, marital status, physical activity, smoking, alcohol consumption, number of previous pregnancies, hs-CRP, HOMA, LDL-c, HDL-c or total cholesterol levels.

On the other hand, maternal height was found to be significantly associated with GWG ($p=0.034$), with the highest weight gain being observed in the lowest tertile (<33.3%) of height. The highest arm circumference ($p=0.007$) and body fat percentage ($p<0.001$) were also significantly associated with GWG.

**Predictors of GWG according to IOM recommendations**

Adjusted multinomial logistic regression analysis showed that women with a pre-pregnancy BMI indicating obesity and women with the highest body fat percentage had, respectively, a 95% (OR=1.95; 95% CI: 1.08-3.51) and 1% (OR=1.01; 95% CI: 1.01-1.05) higher chance of GWG above IOM recommendations **(Table 4)**. Pregnant women in the lowest tertile of height, smokers, women with ≥ 2 previous pregnancies, and women living in crowded homes had, respectively, a 57% (OR=0.57; 95% CI: 0.41-0.80), 36% (OR=0.64; 95% CI: 0.37-0.86), 35% (OR=0.65; 95% CI: 0.43-0.97) and 14% (OR=0.86; 95% CI: 0.59-0.86) lower chance of GWG above IOM recommendations. Women with

diabetes were 2.53 times more likely (OR=2.53; 95% CI: 1.32-4.83) to have GWG below IOM recommendations.

**Predictors of GWG according to Intergrowth-21$^{st}$ standards**

**Table 5** shows that women with the highest body fat percentage had a 12% (OR=1.12; 95% CI: 1.02-1.24) higher chance of GWG above the 90$^{th}$ percentile. Pregnant women in the lowest tertile of height were 2.82 times more likely (OR=2.82; 95% CI: 1.08-8.13) to have GWG below the 10$^{th}$ percentile. Additionally, women with the lowest hemoglobin concentrations had a 41% lower chance (OR=0.59; 95% CI: 0.39-0.88) of GWG below the 10$^{th}$ percentile.

## DISCUSSION

Adequate GWG is a crucial factor for maternal and fetal health. Since weight gain is a modifiable risk factor, it is possible to identify and prevent adverse consequences of insufficient or excessive GWG. Insufficient weight gain during pregnancy can lead to fetal developmental complications such as intrauterine growth restriction, low birth weight, preterm birth, and perinatal mortality. On the other hand, excessive weight gain in pregnancy is associated with maternal and infant metabolic disorders, hypertension, diabetes, cesarean delivery, and macrosomia (6,8,21–27).

According to the results of this study, 28.7%, 32.5% and 38.7% of the 1,557 pregnant women had GWG within, below and above the IOM recommendations, respectively. On the other hand, among 569 pregnant women with normal pre-pregnancy BMI, 14.2%, 18.3%, and 67.5% had weight gain within, below, and above the Intergrowth-21$^{st}$ standards, respectively. These findings corroborate those reported by Jin et al. (19) who compared the IOM recommendations, Intergrowth-21$^{st}$ standards and a local reference curve for GWG and their impact on the risk of gestational diabetes. The results showed that the use of Intergrowth-21$^{st}$ classified a higher proportion of women as having GWG above the 90$^{th}$ percentile (19).

The use of different instruments allows us to observe GWG in a more in-depth manner. For instance, the IOM recommendations have some limitations, including the fact that they are based on a specific population from the United States and rely on cross-sectional studies, limiting their applicability (15). The Intergrowth-21$^{st}$ standards uses a multiethnic cohort of healthy mothers from eight countries, including Brazil, and provide

a useful reference for assessing appropriate GWG (17). This highlights the importance of considering the differences between existing instruments when interpreting the results.

According to the IOM recommendations, the predictors of GWG were height, pre-pregnancy obesity, body fat percentage, diabetes, smoking, number of individuals per room, and number of previous pregnancies. The predictors of GWG based on the Intergrowth-21$^{st}$ standards were height, body fat percentage, and hemoglobin. Comparing the two instruments, both height and body fat percentage had an impact on GWG.

Our results are consistent with studies conducted in Brazil that used the IOM recommendations (11,13,14,28). A study with pregnant women from the Pelotas cohort showed a prevalence of adequate GWG of 30.9%, with 47% of women being overweight or obese before pregnancy (13). Another study involving the same cohort revealed a rapid increase in the prevalence of GWG above the recommended range among lower-income women over a period of 30 years (1982-2015). The prevalence of insufficient GWG ranged from 41% in 1982 to 30.8% in 2015, while the prevalence of excessive GWG ranged from 24.6% to 35.7% over the same period in a sample of 19,931 women (14). A study conducted in Maringá, Paraná state, Brazil, found a prevalence of excessive GWG of 38.3% among 462 pregnant women (28). Similar findings have been reported in the study by Rodrigues et al. (11) on 173 pregnant women from Rio de Janeiro, Brazil; 44% had insufficient GWG and 22% had excessive GWG. Deputy et al. (12) also found a high prevalence of inadequate GWG (68%) among 44,421 pregnant women living in Switzerland.

The height of the pregnant women was significantly associated with GWG. The tallest women had a higher risk of exceeding the IOM recommendations and Intergrowth-21$^{st}$ standard for GWG, while they were less likely to fall below these guidelines. This finding is consistent with the study by Chiavaroli et al. (29) that analyzed data from over 1 million pregnant women in the United States and found a positive association between maternal height and excessive GWG. Similarly, other studies also showed a positive relationship between maternal height and GWG (14,30) .Height can influence a woman's ability to accommodate fetal growth and the available space for weight gain during pregnancy (31,32). BMI showed significant associations with GWG. Obese women were more likely to exceed the IOM recommendations for GWG. These findings are consistent with Siega-Riz et al. (33) who found that obese women were more likely to exceed the IOM recommendations for GWG compared to women with normal BMI. Similarly, a systematic review and meta-analysis conducted by Voerman et al. (34), which

investigated the impact of maternal BMI and GWG on pregnancy complications in European, North American, and Australian cohorts, also reported that obese women had a higher risk of excessive GWG. The review included several studies and concluded that pre-pregnancy obesity was consistently associated with increased GWG. Other studies from low- and middle-income countries also found this relationship between BMI and GWG (30,31,35).The nutritional status of women before conception is reflected by their pre-pregnancy weight, which can affect their weight gain needs during pregnancy (36–38).

Women with two or more previous pregnancies had a lower risk of exceeding the IOM recommendations for GWG. These findings suggest that prior pregnancy experience may influence women's ability to control their weight gain during this period. One possible explanation is that women with previous pregnancies may be more aware of the importance of maintaining appropriate weight gain during pregnancy. They may have learned from their previous experiences and adopted healthier behaviors.

Pregnant women living in more crowded environments had a lower chance of GWG above the IOM recommendations compared to those living in less crowded homes. This finding may be attributed to the fact that crowded environments are an indicator of unfavorable socioeconomic conditions and limited access to healthcare resources. These factors can negatively affect the diet and lifestyle of pregnant women, resulting in lower GWG (39). Studies have shown that socioeconomic status is associated with GWG (30,40,41).

Among the other significant risk factors investigated, arm circumference and body fat percentage were positively associated with GWG, indicating that women with higher adiposity may have higher weight gain during pregnancy. These findings suggest that maternal nutritional status may be a determinant of GWG. Furthermore, hemoglobin concentrations may reflect maternal nutritional status and overall health, which can potentially affect GWG. These findings suggest a possible relationship between maternal health and appropriate GWG. However, further research is needed to better understand this association and its implications.

Lastly, the presence of diabetes was associated with a higher risk of falling below the GWG recommendations, contradicting previous studies that associated gestational diabetes with excessive weight gain during pregnancy (42–44). However, these findings are consistent with other studies that have shown a higher prevalence of diabetes or abnormal results in the oral glucose tolerance test among overweight and obese women

who gained less than 5 kg compared to those who gained more than 5 kg (45). Furthermore, a cohort study involving 2,842 pregnant women with diabetes found inadequate GWG to be common, with most participants (50.3%) experiencing insufficient weight gain, followed by adequate (31.6%) and excessive weight gain (18.1%) (46). This finding can be explained by the need for dietary restriction to control glucose levels, frequent weight monitoring, and the specialized support received by women with gestational diabetes (12,47,48). The risk of ketogenesis, especially in cases of evident hyperglycemia and/or weight loss, is negatively associated with neurocognitive development in children born to mothers with pre-existing diabetes or gestational diabetes (49).

In summary, the findings of this original study provide important insights into the factors associated with GWG and showed that several predictors of inadequate GWG in Brazil were similar to those of high-income countries. We highlight the need for further research on GWG in different populations and contexts, especially low- and middle-income countries, in order to determine the influence of specific factors in other regions of the world (36,37,50,51).

One limitation of the present study is that we did not assess the pregnant women's dietary intake, which could have provided valuable information on the impact of diet on GWG. However, the study has significant strengths. The prospective cohort approach permits to follow up pregnant women throughout the prenatal period until birth, providing more reliable and detailed data on GWG. The inclusion of a population-based sample also increases the representativeness of the results. Another strength of the study is that GWG is not based on data from the last prenatal visit, as is the case in most studies, but on weight data obtained in the maternity ward shortly before delivery.

Therefore, this original study provides important insights into maternal characteristics and predictors associated with GWG in a Brazilian population. The findings may help guide public health policies and intervention strategies aimed at promoting adequate GWG during pregnancy. However, the limitations mentioned must be considered when interpreting and generalizing the results of the study.

## CONCLUSION

To the best of our knowledge, there are no studies assessing predictors of GWG using two different instruments, such as the IOM and Intergrowth-21$^{st}$ standards, in populations from low- or middle-income countries. This original study identified several predictors of inadequate GWG in a representative sample of Brazilian pregnant women. According to the IOM recommendations, the predictors of GWG were maternal height, pre-pregnancy BMI, body fat percentage, number of individuals per room, smoking, diabetes, and number of previous pregnancies. On the other hand, the main predictors of weight gain according to the Intergrowth-21$^{st}$ standards were maternal height, body fat percentage, and hemoglobin concentrations.

These results expand our understanding of the maternal characteristics associated with inadequate GWG, providing valuable information for planning interventions and health policies designed to improve maternal-fetal outcomes.



## DATA AVAILABILITY STATEMENT

The data supporting the conclusions of this article will be made available by the authors, without undue reservation.

## ETHICS STATEMENT

The study was approved by the Research Ethics Committee with Human Subjects at the School of Public Health, University of São Paulo, prior to data collection, under protocol number CAEE: 59787216.2.0000.5421.

## AUTHOR CONTRIBUTIONS

AV and PHCR: conceptualization, methodology, formal analysis, and data curation. PHCR: funding acquisition and supervision. LAL, LFC, LDB, LT, PPA and PHCR: investigation. PHCR: project administration. AV and PHCR: visualization and writing - original draft. AV, LAL, LFC, LDB, PPA and PHCR: writing - review and editing. All authors contributed to the article and approved the submitted version.

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## CONFLICTS OF INTEREST

The authors declare no conflicts of interest to disclose.

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622 **Table 2. Maternal characteristics associated with gestational weight gain, in relation to IOM recommendations.**

| Variables | Overall | Gestational Weight Gain (IOM-2019) | | | P value |
|---|---|---|---|---|---|
| | | Within | Below | Above | |
| | | 447(28.7) | 506(32.5) | 604(38.7) | |
| **Age (years)** | | | | | |
| ≤ 19 | 154(9.9) | 47(3.02) | 51(3.28) | 56(3.6) | |
| 20-35 | 1189(76.4) | 346(22.22) | 389(25) | 454(29.16) | 0.531 |
| > 35 | 214(13.7) | 54(3.47) | 66(4.24) | 94(6.04) | |
| **Height(cm)** | | | | | |
| 1º tercil | 534(34.34) | 167(10.73) | 187(12.03) | 180(11.57) | |
| 2º tercil | 505(32.48) | 146(9.39) | 170(10.93) | 189(12.15) | 0.003 |
| 3º tercil | 516(33.18) | 134(8.62) | 147(9.45) | 235(15.11) | |
| **Pre-gestational BMI (kg /m²)** | 25.6(22.2-30.2) | 25(21.3-28.6) | 24.8(21.8-30.2) | 26.8(23.2-31.2) | <0.001 |
| **Pre-gestational BMI** | | | | | |
| Underweight | 89(5.7) | 29(1.86) | 38(2.44) | 22(1.41) | |
| Normal weight | 604(38.8) | 194(12.46) | 226(14.52) | 184(11.82) | <0.001 |
| Overweight | 456(29.3) | 139(8.93) | 109(7) | 208(13.36) | |
| Obesity | 408(26.2) | 85(5.46) | 133(8.54) | 190(12.2) | |
| **Arm circumference(cm)** | | | | | |
| < 23 | 67(4.37) | 23(1.50) | 29(1.90 | 15(0.89) | |
| 23-28 | 474(31) | 147(9.61) | 190(12.42) | 137(8.95) | <0.001 |
| > 28 | 989(64.64 | 264(17.25) | 283(18.50) | 442(28.89) | |
| **Body fat (%)** | 33.3(28.3-37.8) | 32.3(26.9-36.6) | 32.3(26.6-37) | 34.7(30.3-39.1) | <0.001 |
| **Gestational age (weeks)** | 39.4(38.5-40.3) | 39.4(38.7-40.3) | 39.2(38.1-40.1) | 39.7(38.9-40.4) | |
| **Maternal education (years)** | | | | | |
| ≤ 4 | 10(0.6) | 1(0.06) | 5(0.32) | 4(0.26) | |
| 5-11 | 1181(75.9) | 342(21.97) | 389(24.98) | 450(28.9) | <0.001 |
| ≥12 | 365(23.5) | 104(6.68) | 111(7.13) | 150(9.63) | |
| **Number of people per room** | | | | | |
| 1º tercil | 533(34.25) | 143(9.19) | 150(9.64) | 240(15.42) | |
| 2º tercil | 511(32.84) | 153(9.83) | 169(10.86) | 189(12.15) | 0.004 |
| 3º tercil | 512(33.90) | 151(9.70) | 187(12.02) | 174(11.18) | |
| **Per capita income (R$)** | 666.7(400-1000) | 665.9(400-970) | 600(382.4-1000) | 668(466.6-1000) | 0.002 |
| **Race** | | | | | |
| White | 722(46.3) | 208(13.36) | 223(14.32) | 291(18.69) | 0.392 |
| Non-white | 835(53.6) | 239(15.35) | 283(18.18) | 313(20.1) | |
| **Marital status** | | | | | |
| Married or in a stable relationship | 1359(87.3) | 388(24.93) | 441(28.32) | 530(34.04) | 0.896 |

| | | | | | |
|---|---|---|---|---|---|
| Single, separated, or widowed | 198(12.7) | 59(3.79) | 65(4.17) | 74(4.75) | |
| **Physical activity** | | | | | |
| Adequate | 175(11.2) | 50(3.21) | 59(3.794) | 66(4.24) | 0.951 |
| Inadequate | 524(33.7) | 156(10.02) | 172(11.05) | 196(12.59) | |
| **Smoking** | | | | | |
| No | 1434(92.1) | 409(26.27) | 449(28.84) | 576(36.99) | <0.001 |
| Yes | 123(7.9) | 38(2.44) | 57(3.66) | 28(1.8) | |
| **Alcohol consumption** | | | | | |
| No | 1238(79.5) | 353(22.67) | 401(25.75) | 482(30.96) | 0.885 |
| Yes | 319(20.5) | 94(6.04) | 105(6.74) | 120(7.71) | |
| **Diabetes** | | | | | |
| No | 1479(95,0) | 429(27.55) | 459(29.48) | 591(37.96) | <0.001 |
| Yes | 78(5) | 18(1.16) | 47(3.02) | 13(0.83) | |
| **Hypertension** | | | | | |
| No | 1448(93) | 420(26.97) | 470(30.19) | 558(35.84) | 0.608 |
| Yes | 109(7) | 27(1.73) | 36(2.31) | 46(2.95) | |
| **Urinary Tract Infection** | | | | | |
| No | 1378(88.5) | 400(25.69) | 448(28.77) | 530(34.04) | 0.682 |
| Yes | 179(11.5) | 47(3.02) | 58(3.73) | 74(4.75) | |
| **Cervicitis/Vaginitis** | | | | | |
| No | 1449(93.1) | 410(26.33) | 472(30.31) | 567(36.42) | 0.3873 |
| Yes | 108(7) | 37(2.38) | 34(2.18) | 37(2.38) | |
| **Number of previous pregnancies** | | | | | |
| 0 | 620(39.8) | 169(10.85) | 180(11.56) | 271(17.41) | |
| 1 | 439(28.2) | 136(8.73) | 145(9.31) | 158(10.15) | 0.025 |
| ≥ 2 | 498(32) | 142(9.12) | 181(11.62) | 175(11.24) | |
| **hs-CRP (ng/mL)** | 5.9(3.1-11.7) | 5.1(3-10) | 6.1(3.2-11.9) | 6.5(3.0-12.6) | 0.137 |
| **HOMA (uUI/mL)** | 1.36(0.9-2.1) | 1.4(0.9-2.1) | 1.3(0.99-2.1) | 1.42(1-2.2) | 0.094 |
| **Hemoglobin (g/dL)** | 12.5(12-13.1) | 12.6(11.9-13.1) | 12.4(11.8-13) | 12.6(121-13.2) | 0.002 |
| **Glycated hemoglobin %,** | 5.1(4.9-5.3) | 5.1(4.9-5.3) | 5.1(4.9-5.3) | 5(4.8-5.3) | 0.059 |
| **Fasting insulin (uUI/mL)** | 7(5-11) | 7(5-11) | 7(5-10) | 7(5-11) | 0.066 |
| **Cholesterol (mg/dL)** | 173(151-196) | 172(152-196) | 172(149-194) | 174(152-198) | 0.526 |
| **HDL-c (mg/dL)** | 56(48 -64) | 56(49-64) | 55(47 -62) | 56(49 -65) | 0.012 |
| **LDL-c(mg/dL)** | 95(77 -113) | 94(79 -111) | 94(76 -112) | 96(77 -115) | 0.639 |
| **Triglycerides (mg/dL)** | 104(81-133) | 104(80-134) | 106(85-137) | 100(80-129) | 0.13 |

Data are presented as number (percentage) and median and interquartile range (percentile 25 - percentile 75).
Statistical differences among gestational weight gain groups were tested with: Kruskal-Wallis test for continuous variables and $\chi 2$ test, Fisher's test for categorical variables.
Abbreviations: BMI: body mass index; LDL-c: low density lipoprotein cholesterol; HDL-c: high-density lipoprotein cholesterol. 1º tercil: < 33.3%, 2º tercil: ≥ 33.3%; ≤ 66.6% and 3º tercil: ≥ 66.6%
1 Brazilian Real (R$) = 4.9 US$

627 **Table 3. Crude and adjusted multinomial logistic regression models to assess predictors of GWG, according to the IOM recommendations.**

| Variables | Gestational Weight Gain (IOM-2019) | | | | | |
|---|---|---|---|---|---|---|
| | Below | Above | Below | Above | Below | Above |
| | Crude Model | | Adjusted Model A | | Final Adjusted Model | |
| | OR (IC95%) | OR (IC95%) | OR (IC95%) | OR (IC95%) | OR (IC95%) | OR (IC95%) |
| **Age (year)** | | | | | | |
| 20-35 | 1 | 1 | 1 | 1 | 1 | 1 |
| ≤19 | 0.97 (0.63 - 1.47) | 0.91(0.6 - 1.37) | 0.79 (0.32-1.90) | 1.14 (0.50-2.59) | 0.96 (0.57-1.63) | 1.09 (0.65-1.83) |
| > 35 | 1.09 (0.74 - 1.6) | 1.33(0.92 - 1.91) | 1.16 (0.58-2.33) | 1.21 (0.61-2.41) | 0.99 (0.63-1.55) | 1.22 (0.80-1.87) |
| **Height (cm)** | | | | | | |
| 3º tercil | 1 | 1 | 1 | 1 | 1 | 1 |
| 1º tercil | 1.02(0.75 - 1.4) | 0.61(0.46 - 0.83) | 1.65 (0.95-2.87) | 0.90 (0.53-1.53) | 0.97 (0.68-1.39) | 0.57 (0.41-0.80) |
| 2º tercil | 1.06(0.77 - 1.46) | 0.74(0.55 - 1) | 1.38 (0.79-2.40) | 1.01 (0.60-1.72) | 1.02 (0.71-1.47) | 0.78 (0.55-1.09) |
| **Pre-gestational BMI (kg /m²)** | | | | | | |
| Normal weight | 1 | 1 | 1 | 1 | 1 | 1 |
| Underweight | 1.12 (0.67-1.89) | 0.80 (0.44-1.44) | 1.91 (0.55-6.60) | 2.40 (0.61-9.41) | 0.86 (0.41-1.78) | 1.26 (0.57-2.80) |
| Overweight | 0.67 (0.49-0.92) | 1.58 (1.18-2.12) | 0.73 (0.36-1.49) | 1.42 (0.72-2.82) | 0.84 (0.52-1.36) | 1.26 (0.81-1.96) |
| Obesity | 1.34 (0.96-1.87) | 2.36 (1.70-3.26) | 1.34 (0.55-3.28) | 1.92 (0.80-4.57) | 1.94 (1.05-3.59) | 1.95 (1.08-3.51) |
| **Arm circumference (cm)** | | | | | | |
| 23-28 | 1 | 1 | 1 | 1 | 1 | 1 |
| <23 | 0.98(0.54 - 1.76) | 0.7(0.35 - 1.4) | 0.40 (0.10-1.64 | 0.39 (0.08-1.83) | 0.92 (0.41-2.07) | 0.54 (0.21-1.37) |
| > 28 | 1.8(1.36 - 2.37) | 0.83(0.63 - 1.09) | 0.72 (0.36-1.44) | 1.30 (0.63-2.66) | 0.79 (0.50-1.26) | 1.12 (0.70-1.78) |
| **Body fat %** | 1.00 (0.98-1.02) | 1.05 (1.03-1.07) | 1.00 (0.94-1.05) | 1.03 (1.01-1.09) | 0.98 (0.95-1.02) | 1.01 (1.01-1.05) |
| **Gestational age (weeks)** | 0.89 (0.84-0.95) | 1.05 (0.98-1.12) | 0.87 (0.80-0.94) | 1.11 (1.01-1.22) | 0.90 (0.84-0.96) | 1.06 (0.98-1.14) |
| **Maternal education (years)** | | | | | | |
| ≥12 | 1 | 1 | 1 | 1 | 1 | 1 |
| ≤4 | 4.68 (0.54-40.77) | 1.07 (0.79-1.44) | 1.63 (0.12-22.19) | 1.75 (0.13-23.46) | 3.47 (0.37-32.83) | 2.93 (0.30-28.74) |
| 5-11 | 2.77 (0.31-25.17) | 0.91 (0.68-1.22) | 0.62 (0.34-1.13) | 0.89 (0.49-1.63) | 0.88 (0.61-1.28) | 1.01 (0.71-1.45) |
| **Number of people per room** | | | | | | |
| 1º tercil | 1 | 1 | 1 | 1 | 1 | 1 |
| 2º tercil | 0.85(0.62 - 1.16) | 1.46(1.08 - 1.97) | 0.97 (0.54-1.74) | 1.08 (0.62-1.89) | 1.13 (0.78-1.64) | 0.88 (0.62-1.25) |
| 3º tercil | 0.89(0.66 - 1.21) | 1.07(0.79 - 1.45) | 1.13 (0.62-2.08) | 0.91 (0.50-1.65) | 1.31 (0.89-1.94) | 0.86 (0.59-0.86) |
| **Race** | | | | | | |
| White | 1 | 1 | 1 | 1 | | |
| Non-white | 1.10 (0.86-1.43) | 0.94 (0.73-1.20) | 0.92 (0.59-1.46) | 0.96 (0.61-1.50) | | |
| **Marital status** | | | | | | |
| Married or in a stable relationship | 1 | 1 | 1 | 1 | | |
| Single, separated, or widowed | 0.93 (0.61-1.44) | 0.95 (0.62-1.45) | 0.82 (0.41-1.66) | 0.72 (0.36-1.46) | | |
| **Physical activity** | | | | | | |
| Adequate | 1 | 1 | 1 | 1 | 1 | 1 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Inadequate | (0.60 - 1.44) | (0.623 - 1.454) | 0.86 (0.51-1.45) | 0.79 (0.48-1.32) | 0.94 (0.60-1.60) | 0.97 (0.56-1.34) |
| **Smoking** | 1.37 (0.89-2.10) | 0.52 (0.32-0.87) | 1.28 (0.63-2.59) | 0.55 (0.24-1.25) | 1.35 (0.83-2.20) | 0.64 (0.37-0.86) |
| **Alcohol consumption** | 0.98 (0.72-1.34) | 0.93 (0.69-1.26) | 0.92 (0.55-1.54) | 0.91 (0.54-1.52) | | |
| **Diabetes** | 2.44 (1.40-4.27) | 0.52 (0.25-1.08) | 2.80 (0.94-8.32) | 0.26 (0.05-1.45) | 2.53 (1.32-4.83) | 0.40 (0.16-1.99) |
| **Hypertension** | 1.19 (0.71-2.00) | 1.28 (0.78-2.10) | 0.67 (0.26-1.75) | 1.37 (0.56-3.36) | 0.72 (0.39-1.32) | 0.86 (0.48-1.54) |
| **Urinary Tract Infection** | 1.10 (0.73-1.66) | 1.19 (0.81-1.75) | 0.76 (0.39-1.48) | 1.33 (0.71-2.49) | | |
| **Cervicitis/Vaginitis** | 0.80 (0.49-1.30) | 0.72 (0.45-1.16) | 1.25 (0.47-3.38) | 1.43 (0.52-3.93 | | |
| **Number of previous pregnancies** | | | | | | |
| 0 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | 1.00 (0.73-1.37) | 0.72 (0.54-0.98) | 1.04 (0.58-1.87) | 0.70 (0.39-1.24) | 0.83 (0.55-1.25) | 0.69 (0.48-1.00) |
| ≥ 2 | 1.20 (0.88-1.62) | 0.77 (0.57-1.03) | 0.94 (0.49-1.81) | 0.60 (0.32-1.15) | 0.83 (0.57-1.25) | 0.65 (0.43-0.97) |
| **hs-CRP (ng/mL)** | 1.01 (0.99-1.02) | 1.01 (0.99-1.02) | 1.00 (0.98-1.03) | 1.00 (0.98-1.03) | | |
| **HOMA (uUI/mL)** | 1.02 (0.93-1.13) | 1.03 (0.94-1.13) | 0.88 (0.42-1.84) | 0.60 (0.25-1.40) | | |
| **Hemoglobin (mg/dL)** | 0.86 (0.75-0.99 | 1.12 (0.97-1.29) | 0.76 (0.62-0.94) | 1.01 (0.80-1.25) | 0.87 (0.75-1.01) | 1.05 (0.91-1.22) |
| **Glycated hemoglobin %** | 1.01 (0.74-1.40) | 0.88 (0.64-1.21) | 0.82 (0.50-1.35) | 1.22 (0.73-2.03) | | |
| **Fasting insulin (uUI/mL)** | 1.00 (0.98-1.03) | 1.01 (0.99-1.03) | 1.04 (0.87-1.23) | 1.12 (0.93-1.35) | 1.00 (0.97-1.02) | 0.99 (0.96-1.01) |
| **Cholesterol (mg/dL)** | 1.00 (0.99-1.00) | 1.00 (1.00-1.00) | 1.00 (0.97-1.03) | 0.97 (0.94-1.00) | | |
| **HDL-c (mg/dL)** | 0.99 (0.98-1.01) | 1.01 (1.00-1.02) | 0.99 (0.96-1.03) | 1.05 (1.01-1.08) | 1.00 (0.98-1.01) | 1.01 (1.00-1.02) |
| **LDL-c (mg/dL)** | 1.00 (0.99-1.00) | 1.00 (1.00-1.01) | 1.01 (0.97-1.04) | 1.03 (0.99-1.06) | 1.00 (0.99-1.00) | 1.00 (0.99-1.00) |

Abbreviations: GWG: gestational weight gain; BMI, body mass index; LDL-c, low density lipoprotein cholesterol; HDL-c, high-density lipoprotein cholesterol; CI, confidence interval; OR, odds ratio.
Crude Model: the association between each predictor variable and the outcome of interest (GWG).
Adjusted Model A: all predictor variables were adjusted for optimal prediction of GWG, considering their respective strengths.
Final Adjusted Model: significant and relevant variables were included based on the theoretical model.
1º tercil: < 33.3%, 2º tercil: ≥ 33.3%; ≤ 66.6% and 3º tercil: ≥ 66.6%

652 **Table 4. Maternal characteristics associated with gestational weight gain, according to Intergrowth-21st Standards.**
653

| Variables | Overall | Gestational Weight Gain-Intergrowth-21st Standards. | | | P value |
|---|---|---|---|---|---|
| | | Within | Below | Above | |
| | | 81(14.2) | 104 (18.3) | 384 (67.5) | |
| **Age (years)** | | | | | |
| ≤19 | 86(15.1) | 11(1.9) | 23 (4.0) | 52(9.1) | |
| 20-35 | 422(74.2) | 61(10.7) | 70(12.3) | 291 1.4) | 0.292 |
| >35 | 61(10.7) | 9(3.9) | 11(3.5) | 41(3.3) | |
| **Height(cm)** | | | | | |
| 1º tercil | 192(33.8) | 19(3.3) | 42(7.4) | 131 (23.0) | |
| 2º tercil | 197(34.7) | 29 (5.1) | 40(7.0) | 128(22.5) | 0.034 |
| 3º tercil | 179(31.5) | 33(5.8) | 22(3.9) | 124(21.8) | |
| **Pre-gestational BMI (kg /m²)** | 22.1(20.5-23.5) | 22.2(20.7-23.5) | 22.3(20.3-23.7) | 22.0(20.3-23.4) | 0.08 |
| **Arm circumference (cm)** | 26.5(20-28) | 26.5(25-28) | 26(24.5-27.5) | 27.2(25.7-28.5) | 0.007 |
| **Body fat (%)** | 28.4(25.3-31.3) | 29(26.4-32.2) | 27.70(25.5-30.3) | 28.4(25.2-31.1) | <0.001 |
| **Gestational age (weeks)** | 39.6(38.6-40.3) | 39.7(38.5-40.6) | 39.0(38.1-38.5) | 39.7(38.5-40.3) | <0.001 |
| **Maternal education (years)** | | | | | |
| <12 | 478 (74.8) | 67(11.8) | 88(15.5) | 323(56.8) | 0.935 |
| ≥12 | 91(25.6) | 14(2.5) | 16(2.8) | 61(10.7) | |
| **Number of people per room** | | | | | |
| 1º tercil | 217(38.2) | 35(6.1) | 40(7.04) | 142(25) | |
| 2º tercil | 171(30.1) | 24(4.2) | 27(4.8) | 120(25.1) | 0.649 |
| 3º tercil | 180(31.7) | 22(3.9) | 37(6.5) | 121(21.3) | |
| **Per capita income (R$)** | 666.7(425.3-1000) | 687.5(447.5-1200) | 625(400-1000) | 700(433.3-1000) | 0.125 |
| **Race** | | | | | |
| White | 245(43.1) | 34 (5.9) | 176 (8.3) | 161(28.8) | 0.42 |
| Non-white | 324(56.9) | 47(8.2) | 25(10.0) | 20(36.7) | |
| **Marital status** | | | | | |
| Married or in a stable relationship | 503(88.4) | 73(12.8) | 90(15.8) | 340(59.6) | 0.743 |
| Single, separated, or widowed | 66(11.6) | 8(1.4) | 14(2.5) | 44(7.7) | |
| **Physical activity** | | | | | |
| Adequate | 59(23.9) | 5(2.0) | 8(3.3) | 46(18.7) | 0.413 |
| Inadequate | 187(76.0) | 23(9.3) | 35(14.2) | 129(52.4) | |
| **Smoking** | | | | | |
| No | 529(92.9) | 77(13.5) | 97(17.0) | 355(62.4) | 0.698 |
| Yes | 40 (7.0) | 4(0.7) | 7(1.2) | 29(5.1) | |
| **Alcohol consumption** | | | | | |
| No | 456(80.2) | 69(12.1) | 83(146) | 304(53.4) | 0.465 |
| Yes | 113(19.8) | 12(2.1) | 21(3.7) | 80(14.1) | |
| **Number of previous pregnancies** | | | | | |
| 0 | 272(47.8) | 47(8.3) | 43(7.6) | 182(32.0) | 0.071 |

| | | | | | |
|---|---|---|---|---|---|
| 1 | 159(27.9) | 13(2.3) | 36(6.3) | 110(19.3) | |
| ≥ 2 | 138 (24.3) | 21(3.7) | 25(4.4) | 92(16.2) | |
| **hs-CRP (ng/mL)** | 4.2(2.3- 7.2) | 3.8(2.3- 8.2) | 4.5(2.8- 7.3) | 4.3 (2.1- 7.1) | 0.641 |
| **HOMA (uUI/mL)** | 1.0(0.8-1.4) | 1.1(0.8-1.4) | 1.0(0.8-1.5) | 1.1(0.7-1.4) | 0.918 |
| **Hemoglobin (g/dL)** | 12.4(11.8-13.0) | 12.5(12-13.3) | 12.1(11.6-12.8) | 12.5(11.8-13.0) | 0.01 |
| **Glycated hemoglobin %,** | 5(4.8-5.2) | 5.0(4.9-5.2) | 5.1(4.7-5.3) | 5.0 (4.8-5.2) | 0.25 |
| **Fasting insulin (uUI/mL)** | 5(4-7) | 6(4-8) | 5(4-8) | 5(4-7) | 0.703 |
| **Cholesterol (mg/dL)** | 170(150.8-191) | 169(154-187.5) | 169(148-192) | 172(149-194) | 0.645 |
| **HDL-c (mg/dL)** | 58(51-67) | 58(52-66) | 58.5(48-70) | 57.5(51-66) | 0.124 |
| **LDL-c (mg/dL)** | 91(76 -107) | 92(74 -106) | 88(73 -106) | 91(77 -107) | 0.852 |
| **Triglycerides (mg/dL)** | 99(80-118) | 95(82.5-115) | 102(82.3-116) | 98(77-119) | 0.654 |

Data are presented as number (percentage) and median and interquartile range (percentile 25 - percentile 75).
Statistical differences among gestational weight gain groups were tested with: Kruskal-Wallis test for continuous variables and $\chi 2$ test, Fisher's test for categorical variables.
Abbreviations: BMI: body mass index; LDL-c: low density lipoprotein cholesterol; HDL-c: high-density lipoprotein cholesterol. 1º tercil: < 33.3%, 2º tercil: ≥ 33.3%; ≤ 66.6% and 3º tercil: ≥ 66.6%
1 Brazilian Real (R$) = 4.9US$.

685 **Table 5. Crude and adjusted multinomial logistic regression models to assess predictors of GWG, according to Intergrowth-21st Standards.**
686

| Variables | Gestational Weight Gain- Intergrowth-21st Standards. | | | | | |
|---|---|---|---|---|---|---|
| | Below | Above | Below | Above | Below | Above |
| | Crude Model | | Adjusted Model A | | Final Adjusted Model | |
| | OR (IC95%) | OR (IC95%) | OR (IC95%) | OR (IC95%) | OR (IC95%) | OR (IC95%) |
| **Age (year)** | | | | | | |
| 20-35 | 1 | 1 | 1 | 1 | 1 | 1 |
| ≤ 19 | 1.82 (0.82 - 4.04) | 0.99 (0.49 - 2.01) | 1.78(0.82 - 3.04) | 1.40 (0.35-5.65) | 1.10 (0.30-4.12) | 1.44 (0.39-5.28) |
| >35 | 1.07 (0.41 - 2.74) | 0.95 (0.44 - 2.07) | 4.13 (0.60-28.24) | 0.43 (0.10-1.74) | 0.85 (0.28-2.62) | 0.52 (0.15-1.84) |
| **Height (cm)** | | | | | | |
| 3º tercil | 1 | 1 | 1 | 1 | 1 | 1 |
| 1º tercil | 3.32 (1.54 - 7.12) | 1.83 (0.99 - 3.4) | 3.12 (1.75-9.62) | 2.68 (0.73-9.90) | 2.82 (1.08-8.13) | 0.74 (0.26-2.12) |
| 2º tercil | 2.07 (1.01 - 4.25) | 1.17 (0.67 - 2.05) | 2.68 (0.49-14.57) | 1.96 (0.53-7.25) | 1.58 (0.63-3.97) | 0.90 (0.35-2.33) |
| **Arm Circumference (cm)** | | | | | | |
| 23-28 | 1 | 1 | 1 | 1 | 1 | 1 |
| <23 | 1.35 (0.24 - 7.66) | 1.16 (0.25 - 5.36) | 1.22 (0.82 - 6.0) | 0.84 (0.03-23.30) | 1.74 (0.11-2.19) | 0.95 (0.04-21.15) |
| > 28 | 0.58 (0.31 - 1.11) | 0.7 (0.42 - 1.17) | 1.01 (0.23-4.44) | 0.51 (0.15-1.68) | 1.20 (0.46-3.15 | 1.81 (0.69-4.77) |
| **Body fat (%)** | 0.81 (0.69-0.94) | 0.97 (0.84-1.12) | 0.88 (0.74-1.04) | 0.91 (0.79-1.05) | 0.99 (0.90-1.08) | 1.12 (1.02-1.24) |
| **Gestational age (weeks)** | 0.79 (0.70-0.89) | 1.07 (0.92-1.24) | 0.66 (0.51-0.86) | 0.81 (0.62-1.05) | 0.83 (0.68-1.02) | 1.26 (0.93-1.70) |
| **Maternal education (years)** | | | | | | |
| ≥12 | 1 | 1 | 1 | 1 | 1 | 1 |
| <12 | 1.15 (0.52-2.52) | 1.11 (0.59-2.09) | 0.78 (0.13-4.51) | 3.18 (0.72-14.04) | 0.85 (0.34-2.14) | 0.79 (0.30-2.06) |
| **Number of people per room** | | | | | | |
| 3º tercil | 1 | 1 | 1 | 1 | 1 | 1 |
| 1º tercil | 0.98 (0.48 - 2.01) | 1.23 (0.69 - 2.19) | 0.53 (0.10-2.83) | 0.41 (0.11-1.60) | 1.34 (0.50-3.62) | 1.38 (0.48-3.95) |
| 2º tercil | 1.47 (0.73 - 2.95) | 1.36 (0.75 - 2.44) | 1.34 (0.21-8.45) | 0.85 (0.19-3.77) | 1.31 (0.50-3.42) | 2.30 (0.85-6.23) |
| **Race** | | | | | | |
| White | 1 | 1 | 1 | 1 | | |
| Non-white | 0.88 (0.49-1.58) | 0.97 (0.60-1.58) | 0.73 (0.16-3.26) | 0.61 (0.17-2.16) | | |
| **Marital status** | | | | | | |
| Married or in a stable relationship | 1 | 1 | 1 | 1 | | |
| Single, separated, or widowed | 1.42 (0.56-3.57) | 1.18 (0.53-2.61) | 1.16 (0.26-5.14) | 1.90 (0.37-9.65) | | |
| **Physical activity** | | | | | | |
| Adequate | 1 | 1 | 1 | 1 | 1 | 1 |
| Inadequate | 0.95 (0.28-3.27) | 0.61 (0.22-1.70) | 0.80 (0.14-4.66) | 0.38 (0.09-1.70) | 1.63 (0.68-3.87) | 1.03 (0.43-2.47) |
| **Smoking** | 1.39 (0.39-4.92) | 1.57 (0.54-4.60) | 0.62 (0.03-10.97) | 0.47 (0.03-6.34) | 1.63 (0.68-3.87) | 2.19 (0.45-10.74) |
| **Alcohol consumption** | 1.45 (0.67-3.17) | 1.51 (0.78-2.93) | 1.47 (0.28-7.66) | 1.76 (0.44-6.96) | | |
| **Number of previous pregnancies** | | | | | | |
| 0 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | 3.03 (1.42-6.45) | 2.19 (1.13-4.22) | 0.81 (0.32-2.09) | 3.81 (0.92-5.79) | 0.78 (0.32-1.92) | 0.52 (0.20-1.31) |
| ≥ 2 | 1.30 (0.64-2.65) | 1.01 (0.91-1.12) | 3.61 (0.59-22.12) | 1.26 (0.32-4.98) | 1.72 (0.59-5.04) | 0.96 (0.31-3.00) |
| **hs-CRP (ng/mL)** | 1.01 (0.97-1.05) | 1.00 (0.97-1.04) | 1.02 (0.97-1.09) | 1.26 (0.32-4.98) | | |
| **HOMA (uUI/mL)** | 0.98 (0.67-1.44) | 1.07 (0.79-1.44) | 1.73 (0.06-51.17) | 1.26 (0.32-4.98) | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Hemoglobin (mg/dL)** | 0.64 (0.46-0.88) | 0.67 (0.35-1.29) | 0.55 (0.38-0.79) | 0.96 (0.54-1.71) | 0.59 (0.39-0.88) | 0.78 (0.51-1.20) |
| **Glycated hemoglobin %** | 1.45 (0.59-3.59) | 1.73 (0.82-3.66) | 0.41 (0.16-1.06) | 1.84 (0.42-8.08) | | |
| **Fasting insulin (uUI/mL)** | 0.98 (0.91-1.06) | 1.01 (0.95-1.06) | 0.93 (0.46-1.84) | 0.70 (0.21-2.31) | 0.59 (0.39-0.88) | 0.99 (0.90-1.08) |
| **Cholesterol (mg/dL)** | 1.00 (1.00-1.01) | 1.00 (1.00-1.01) | 1.07 (1.00-1.15) | 1.08 (0.97-1.20) | | |
| **HDL-c (mg/dL)** | 1.00 (0.99-1.01) | 1.00 (0.99-1.01) | 0.94 (0.87-1.01) | 0.90 (0.81-1.01) | 0.59 (0.39-0.88) | 1.01 (0.98-1.04) |
| **LDL-c (mg/dL)** | 1.00 (0.97-1.01) | 1.00 (0.97-1.0) | 0.93 (0.86-1.01) | 0.93 (0.83-1.04) | 1.01 (0.99-1.02) | 0.99 (0.97-1.01) |

Abbreviations: GWG: gestational weight gain; BMI: Body mass index; LDL-c: Low density lipoprotein cholesterol; HDL-c, high-density lipoprotein cholesterol; CI, confidence interval; OR, odds ratio.
Crude Model: the association between each predictor variable and the outcome of interest (GWG).
Adjusted Model A: all predictor variables were adjusted for optimal prediction of GWG, considering their respective strengths.
Final Adjusted Model: significant and relevant variables were included based on the theoretical model.
1º tercil: < 33.3%, 2º tercil: ≥ 33.3%; ≤ 66.6% and 3º tercil: ≥ 66.6%

Figure 1.JPEG

**Figure1 .** Selection of the study population according to IOM recommendations.

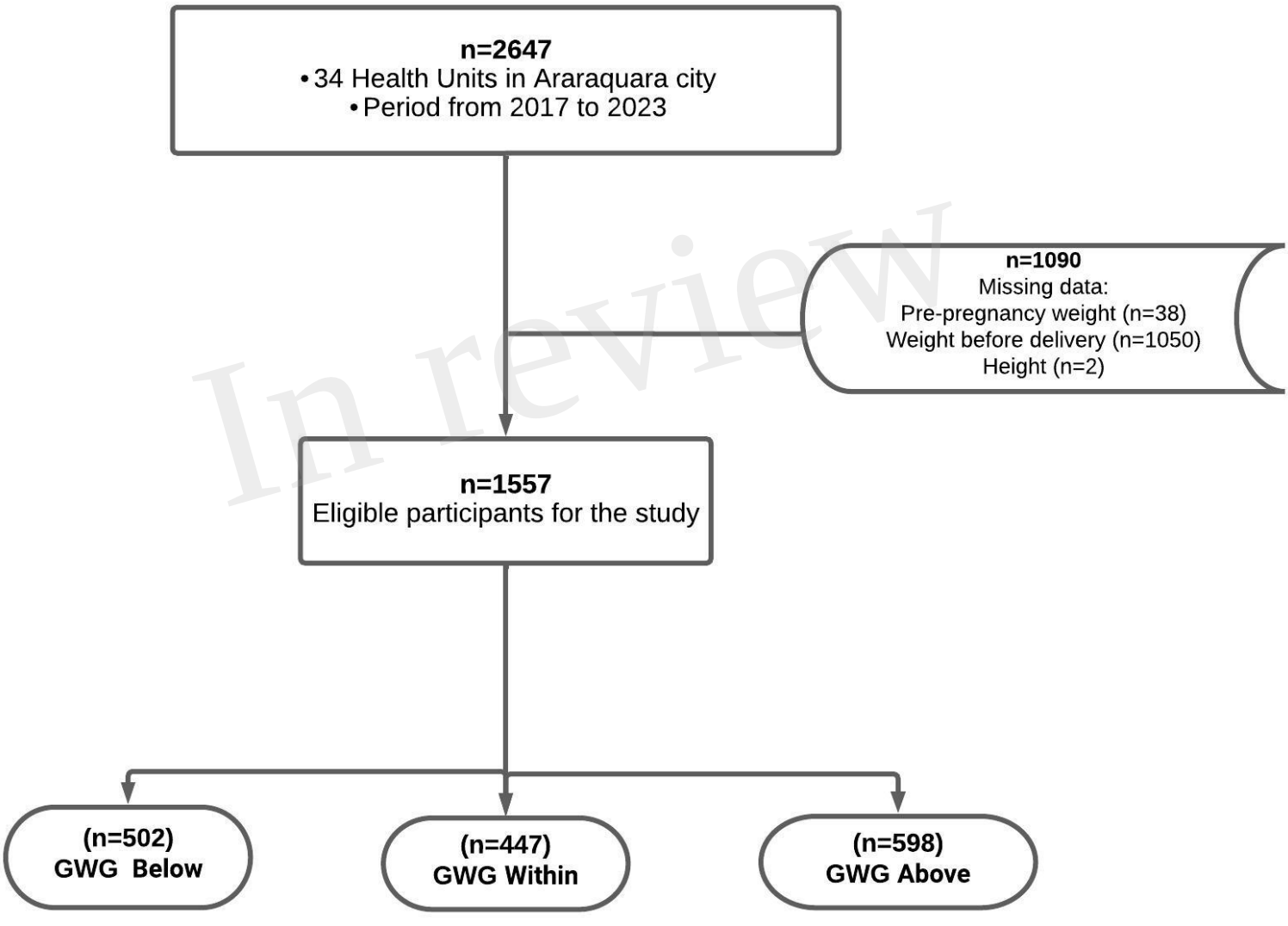

Figure 2.JPEG

**Figure 1. Selection of study population according to Intergrowth-21st standards.**

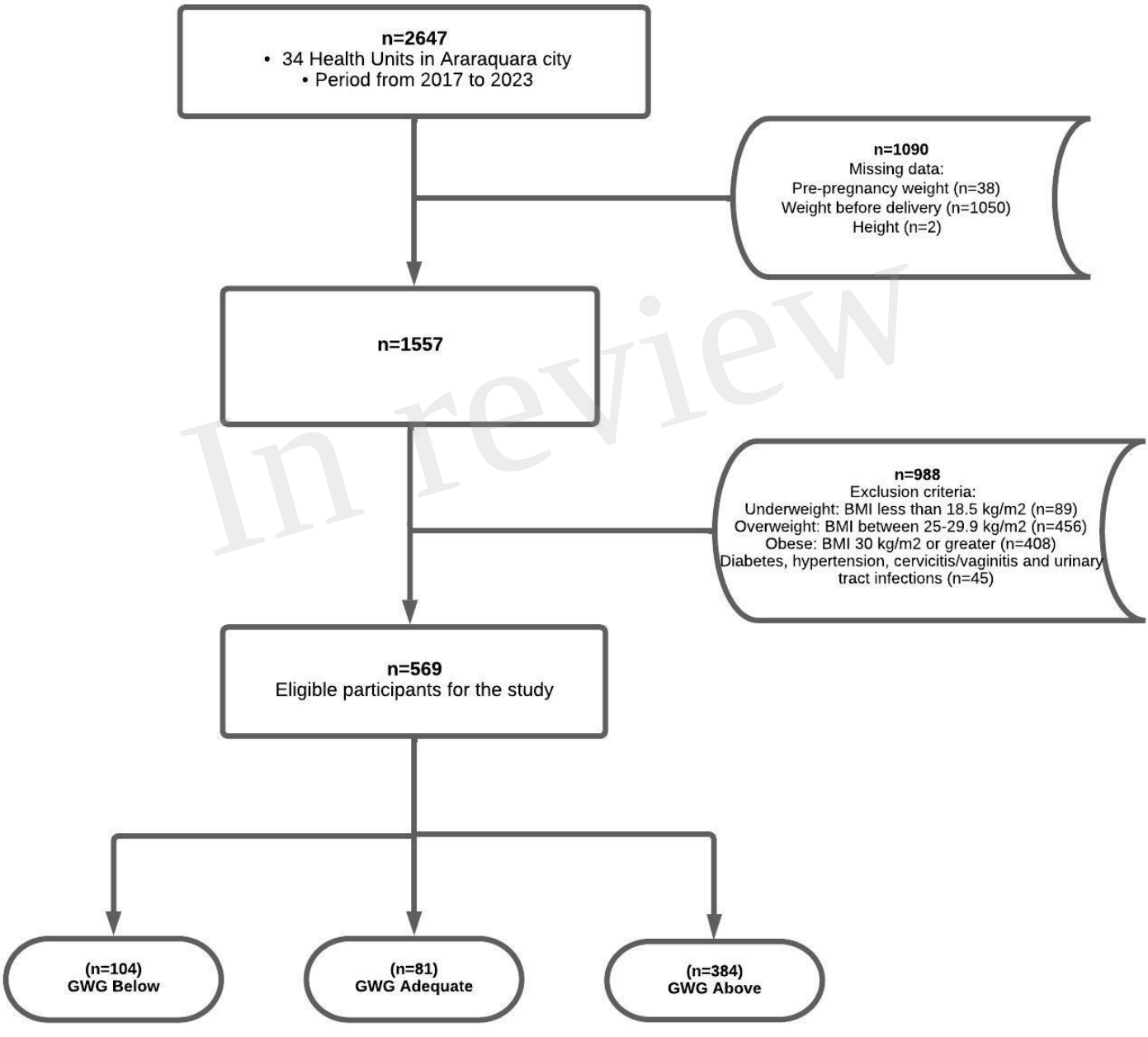

Figure 3.JPEG

**Figure 3.** Factors associated with GWG according to IOM recommendations – Araraquara Cohort Study.

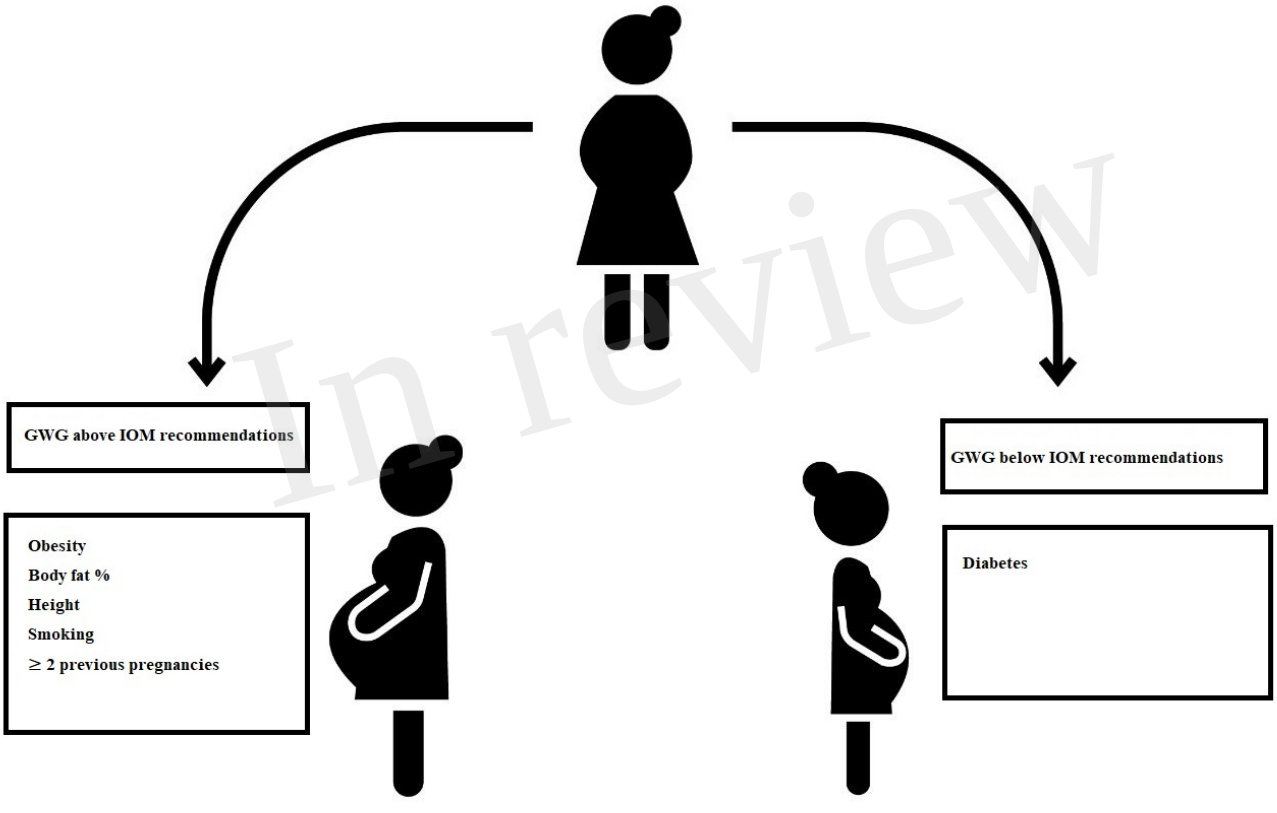

Figure 4.JPEG



**Figure 4.** Factors associated with GWG according to Intergrowth-21st standards – Araraquara Cohort Study.