

## Environmental factors associated with excessive gestational weight gain: a meta-analysis and systematic review

Fatores ambientais associados ao ganho de peso gestacional excessivo: uma meta-análise e revisão sistemática

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**Abstract** *The aim is, systematically examine the scientific evidences that associated environmental factors (environment, social environment, environmental planning and spatial population distribution) with the excessive gestational weight gain. A meta-analysis and systematic review carried out as per the Cochrane Handbook recommendations and following the steps recommended by the Preferred Reporting Items for Systematic Reviews and Meta-Analyzes. The inclusion studies were done with the following PECO criteria: P-pregnant women, E-environmental factors, O-weight gain. The search procedure was conducted on the databases EMBASE, Web of Science, Cinahl, LILACS and MEDLINE (PubMed). The relationship between the socioeconomic factors of the micro-region of residence and gestational weight gain was evidenced by the linkage between residing in high-poverty neighborhoods and inadequate gestational weight gain. This study revealed the higher prevalence of excessive gestational weight gain in pregnant women those lives in urban areas. Environmental factors of the pregnant women's residence area implicated in the excessive gestational weight gain. Our findings can therefore contribute to the development of public policies to prevent inadequate gestational weight gain.*

**Key words** *Pregnant Women, Gestational weight gain, Obesity, Social environment*

**Resumo** *O objetivo é examinar sistematicamente as evidências científicas que associam fatores ambientais (meio ambiente, meio ambiente social, planejamento ambiental e distribuição espacial da população) com o excessivo ganho de peso gestacional. Trata-se de uma revisão sistemática e meta-análise realizada seguindo os passos recomendados pelo Preferred Reporting Items for Systematic Reviews and Meta-Analyzes. Os estudos de incluídos basearam-se nos seguintes critérios PECO: P-gestantes, E-fatores ambientais, O-ganho de peso gestacional. O procedimento de pesquisa foi conduzido nas bases de dados EMBASE, Web of Science, Cinahl, LILACS e MEDLINE (PubMed). A relação entre os fatores socioeconômicos da microrregião de residência e o ganho de peso gestacional foi evidenciada pela ligação entre a residência em bairros de alta pobreza e o ganho de peso gestacional inadequado. Este estudo revelou a maior prevalência de ganho de peso gestacional excessivo em gestantes que vivem em áreas urbanas. Fatores ambientais da área de residência das gestantes implicados no ganho de peso gestacional excessivo. As descobertas desse estudo podem, portanto, contribuir para o desenvolvimento de políticas públicas para evitar o ganho de peso gestacional inadequado.*

**Palavras-chave** *Gestantes, Ganho de peso gestacional, Obesidade, Ambiente social*

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## Introduction

The gestation period comprises several psychobiological changes in pregnant women. One of the main alterations in pregnant women is the relative weight gain<sup>1</sup>. Gestational weight gain is a complex and unique biological process that is important for the growth and development of the fetus. Nevertheless, there is a proper weight gain per trimester that is considered healthy during pregnancy<sup>2</sup>.

Currently, overweight and obesity are major public health issues worldwide. The growing prevalence of overweight and obesity in women has resulted in an excessive weight gain during pregnancy<sup>3</sup>. In this context, studies conducted in different countries revealed a high prevalence of excessive weight gain during pregnancy<sup>1,4-6</sup>. A study carried out in 2008 in different states of the United States showed that 41.8% of the gestational weight gains exceeded the recommended healthy levels<sup>6</sup>. These findings point out the need for control measures on the weight gain during the gestational period<sup>1</sup>.

Excessive gestational weight gain typically brings negative consequences to the maternal and neonatal health. Reports indicate adverse outcomes, such as increased risk of low birth weight, premature birth, gestational diabetes and preeclampsia due to gestational weight gain above the recommended rates<sup>6,7</sup>.

In 2009, the Institute of Medicine (IOM) developed guidelines for preventing unsuitable weight gain during pregnancy. Inadequate gestational weight gain is the one outside of the recommended IOM range, which includes both insufficient and excessive gains. These guidelines highlight the importance of knowing and acting on the risk factors that determine the nutritional status and pregestational body mass index (BMI) of pregnant women, thereby influencing on the weight gain over this period. Individual risk factors, including unhealthy diet and physical inactivity, play a role in the gestational weight gain, especially on the excessive one, as already established in the literature<sup>6,8,9</sup>.

However, environmental factors could also induce excessive gestational weight gain<sup>10</sup>. In general, environmental factors can be divided into physical built environment and social environment<sup>11,12</sup>. In this sense, the built environment is understood as factors that encompass the neighborhood, mixed land use, density, aesthetic attributes, availability and access to facilities<sup>12</sup>, the social environment, in turn, is constituted

by feelings of personal safety to policies and media that promote healthy lifestyles or not. It can also include elements related to individual living conditions, such as income, education, criminal background, social support networks, and level of confidence, which are associated with greater or lesser social disorder and social deprivation in the neighborhood<sup>13,14</sup>.

Reports have shown that environmental factors are associated with the prevalence of overweight and obesity in the general population because they influence on personal habits, such as diet and physical activity preferences<sup>14,15</sup>. These findings reveal that individual's health status is also affected by the environmental context<sup>14</sup>.

Considering the environmental influence on obesity, we hypothesized that the inadequate weight gain during pregnancy could also be influenced by the environment. Hence, this review aimed to examine the scientific evidence that correlated environmental factors with excessive weight gain in pregnant women.

## Methods

### Protocol and registration

This systematic review was carried out as per the Cochrane Handbook recommendations for Systematic Intervention Reviews<sup>16</sup>, and prepared according to the steps recommended by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA Statement)<sup>17,18</sup>. The study protocol was registered in the International Prospect Register of Systematic Reviews (PROSPERO) under the identification CRD42020203988.

### Search procedure and selection criteria

The search procedure was conducted on the databases EMBASE, Web of Science, Cinahl, LILACS and MEDLINE (PubMed). The lists of publications included in the review and previous systematic reviews were also reviewed. The search terms included "Pregnant Women", "Pregnancy", "Weight Gain", "Obesity", "Overweight", "Environmental Health", "Environment and Public Health", "Social Environment", "Environment Design", "Residence Characteristics". The included search terms were separated by Boolean operators 'OR' or 'AND'. In addition, we searched the reference lists of the included studies to identify studies missed by the search strategy (Chart 1).

### Criteria of Eligibility

The inclusion studies were done with the following PECO criteria (Chart 2): (1) pregnant women; (2) observational studies (cross-sectional or cohort studies); (3) studies with data on overweight and obesity in pregnant women, and related risk factors.

The exclusion criteria were: (1) clinical trials, (2) experimental studies, (3) case-control studies, (4) systematic reviews and meta-analysis, and (5) letters to the editor.

### Selection of studies and data extraction

Two independent reviewers (TGFV and TPRS) examined the titles and abstracts, as well as extracted and recorded the data from each eligible report. The divergences were solved by consensus decision-making or consulting the opinion of a third and fourth reviewers (FPM and CKD).

The following information were extracted from all the selected reports: general data (title and authors, year of publication, geographical location); methods (study design, measures of

association); participant characteristics (age, race/ethnicity, parity) and outcomes (excessive gestational weight gain rate and individual and environmental risk factors for the excessive weight gain during pregnancy). Regarding the analogous reports, the most recent one or that providing more information about the outcomes was taken for analysis.

### Bias risk assessment

All chosen reports were evaluated for their methodological quality using the Newcastle-Ottawa scale (Ottawa Hospital Research Institute)<sup>19</sup>. This tool assesses 7 study aspects subdivided into 3 domains: selection (sample representativeness, sample size, non-respondents and exposure assessment), comparability (control of confounding), and outcome (outcome assessment and statistical test).

The Newcastle-Ottawa scale for cohort studies was adjusted to allow the quality assessment of the transverse studies included in the systematic review<sup>20</sup>.

**Chart 1.** Search strategy.

Search strategy
(((("Environmental Health"[MeSH] OR "Environmental Healths" OR "Healths, Environmental" OR "Environmental Health Science" OR "Environmental Health Sciences" OR "Health Science, Environmental" OR "Health Sciences, Environmental" OR "Science, Environmental Health" OR "Sciences, Environmental Health" OR "Health, Environmental" OR "Environment and Public Health"[MeSH] OR "Social Environment"[MeSH] OR "Environments, Social" OR "Social Environments" OR "Environment, Social" OR "Environment Design"[MeSH] OR "Design, Environment" OR "Designs, Environment" OR "Environment Designs" OR "Healthy Places" OR "Healthy Place" OR "Residence Characteristics"[MeSH] OR "Characteristic, Residence" OR "Characteristics, Residence" OR "Residence Characteristic" OR "Domicile" OR "Domiciles" OR "Neighborhood" OR "Neighborhoods")))) AND (((("Weight Gain"[MeSH]) OR "Gain, Weight" OR "Gains, Weight" OR "Weight Gains" OR "Obesity"[MeSH]) OR "Overweight"[MeSH])))) AND (((("Pregnant Women"[MeSH] OR "Pregnant Women" OR "Women, Pregnant" OR "Pregnant Woman" OR "Woman, Pregnant" OR "Pregnancy"[MeSH] OR "Pregnancy" OR "Pregnancies" OR "Gestation"))))

Source: Authors.

**Chart 2.** Descriptors of terms defined with the PECO strategy.

PECO strategy	Descriptors
P (population) - pregnant women	Pregant women, pregnancy, gestation
E (exposition) - environmental factors	Environmental health, environment and public health, social environment, environmental planning, spatial population distribution
C (control)	Not applicable
O (outcome) - weight gain	Weight gain, obesity, overweight

Source: Authors.

### Statistical analysis

The data were eventually grouped using the meta-analysis of prevalence, which was performed using the free software Rstudio (version 3.4.4). For the statistical analyses, the packages “*meta*” and “*metafor*” in versions 4.9-4 and 2.0, respectively, were used. Within the “*metafor*” package, the *metaprop* function was used to calculate proportions. The gestational weight gain was classified as adequate (gestational weight gain within the recommended BMI range) and inadequate (gestational weight gain outside of the recommended BMI range, considering the excessive gain. Insufficient gestational weight gain was considered only for the descriptive analysis and discussion).

The fixed effects and random effects models were applied using the model for methodological heterogeneity between studies, which was evaluated using the I-square test and Q statistics. The heterogeneity between the studies was assessed by Cochran. The Q test and a P test for a trend <0.10 were considered to be statistically significant. The I<sup>2</sup> test was performed to assess the magnitude of the heterogeneity, considered moderate if I<sup>2</sup>>25.0% and high if I<sup>2</sup>>75.0%. The test assesses the null hypothesis, that the studies evaluate the same effect, as there was heterogeneity between them (I<sup>2</sup>=96%), using the random effect model. The heterogeneity can refer to differences in participants, type of study, and so on.

### Results

Initially, 3,936 articles suitable to meet the goal of this review were retrieved using the search method. After duplicate exclusion (144), 3,792 articles were selected for title and abstract analysis by two independent reviewers. Among this total, 27 articles were carefully chosen for full reading.

After the full reading step, 17 articles were excluded due to some of the following reasons: lack of environmental data and non-availability of the full text even after contacting the original authors via email. After an additional search, one more article<sup>1</sup> that met the criteria was found and included in this review.

Finally, 11 articles<sup>1,4,5,7,10,21-26</sup> met all the inclusion criteria and 3 articles<sup>1,7,24</sup> contained data relevant for inclusion in the meta-analysis of the environmental factors (Figure 1). Details of the selected articles are summarized in Table 1.

The excessive gestational weight gain ranged from 23.2% to 82.4% in studies conducted in Iran

and Florida, respectively. Most of the retrieved studies were conducted in the United States. Only 3 studies were conducted in other countries, namely, Brazil, Iran and Bangladesh.

Most of the researches<sup>1,5,7,21,22,24-26</sup> investigated personal and environmental factors related both to insufficient gestational weight gain and excessive gain. However, to meet the goals of this study, the pooled analysis considered only the excessive gestational weight gain to examine the associated environmental factors.

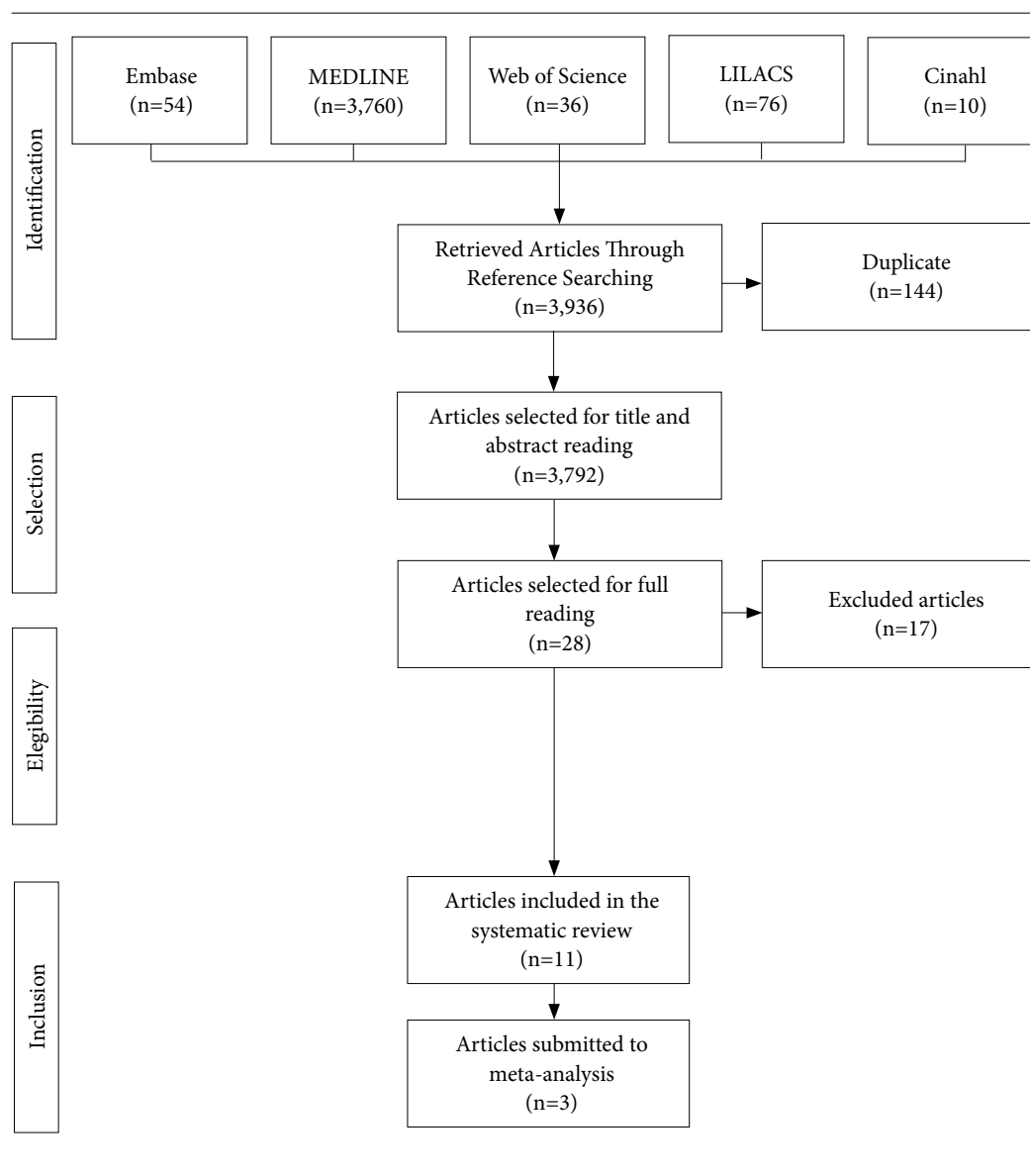
### Environmental factors associated with excessive gestational weight gain

The relationship between the socioeconomic factors of the micro-region of residence and gestational weight gain was investigated using 5 articles, which indicates that there is an association between residence in high poverty-rated neighborhoods and inadequate gestational weight gain<sup>5,7,22,23,25</sup>. A study conducted in the United States revealed that the relative risk of excessive gestational weight gain is 1.11 (95%CI 1.02-1.21) times higher for white pregnant women residing in high poverty-rated neighborhoods rather than in richer neighborhoods<sup>7</sup>.

Galín *et al.*<sup>22</sup> associated the statistics of pregnant women residing in neighborhoods with high violence rates with excessive gestational weight gain (RR 1.04, 95%CI 1.03-1.05). Bandreldin *et al.*<sup>5</sup>, Mendez *et al.*<sup>23</sup> and Mendez *et al.*<sup>25</sup> reported on the difference in the inadequate gestational weight gains by neighborhood racial composition and economic vulnerability of the pregnant woman's residence neighborhood. It was shown that black or Hispanic women residing in poor neighborhoods were more prone to inadequate gestational weight gain, tending particularly to insufficient gain. Mendez *et al.*<sup>25</sup> showed that this relationship was significant only for the insufficient gestational weight gain.

Galín *et al.*<sup>22</sup> investigated the possible correlations between the neighborhood violence rate and excessive gestational weight gain. The results showed that pregnant women residing in neighborhoods with high violence levels showed excessive weight gain compared to those residing in safer neighborhoods (RR 1.04, 95%CI 1.03-1.05).

The neighborhood's area, violence and poverty indexes, and the distance from the pregnant woman's residence to the supermarket were found to have a positive correlation with the excessive gestational weight gain<sup>10</sup>. Other authors also showed a correlation between the excessive gestational weight gain and US nationality<sup>26</sup>, and



**Figure 1.** Flowchart of the study selection.

Source: Authors.

between the inadequate gain and arsenic-contaminated water consumption and Hindu religious community<sup>4</sup>.

From the selected studies, 3 articles were included in the meta-analysis of prevalence because they brought relationships between excessive gestational weight gain and the pregnant woman's home environment, considering both the urban and rural contexts. The pooled analysis revealed that the highest prevalence of pregnant women with excessive weight gain residing in ur-

ban areas, although with no statistical differences (P 51%, 95%CI 44.34-57.84, p-value=0.363) (Figure 2). It is noteworthy that few studies generate more imprecision of the measure and great heterogeneity.

#### **Individual characteristics associated with excessive gestational weight gain**

Regarding the skin color, it was found that non-white women residing in poor neighbor-

**Table 1.** Characteristics of the articles included in the systematic review (n=11).

First author, year	City, Country	Sample size	Excessive weight gain rate (%)	Risk factors for the excessive gestational weight gain	Methodological quality
Mendez <i>et al.</i> , 2014 <sup>25</sup>	Allegheny County, US	55,608	55	Black race/ethnicity, residence in neighborhoods with high poverty rates	6
Laraia <i>et al.</i> , 2007 <sup>10</sup>	North Carolina, US	703	58	Physical incivility and precarious social spaces	6
Headen <i>et al.</i> , 2018 <sup>7</sup>	United States	5,690	43	Residence in neighborhood with limited socioeconomic aspects	5
Badreldin <i>et al.</i> , 2018 <sup>5</sup>	Chicago, US	29,380	41.8	Neighborhood with high poverty rates, black or Hispanic race	4
Gallagher <i>et al.</i> , 2013 <sup>24</sup>	South Carolina, US	132,795	47.9	Living in rural areas with normal BMI	5
Galín <i>et al.</i> , 2017 <sup>22</sup>	California, US	2,364,793	49.8	Residence in neighborhoods with high violence rates	5
Farhangi, 2016 <sup>21</sup>	Northwest Iran	481	23.2	High education level, prenatal care at public health centers, nulliparity	5
Hasan <i>et al.</i> , 2018 <sup>4</sup>	Matlab, Bangladesh	1,883	54	Short stature, previous BMI - overweight and obesity, advanced age, multiparity, low socioeconomic status, low education level, belonging to the Hindu religious community, consumption of arsenic-contaminated water and giving birth during the monsoon or dry season compared to summer.	6
Mendez <i>et al.</i> , 2016 <sup>23</sup>	Allegheny County, US	73,061	59	Black race/ethnicity; residence in poor neighborhoods	5
Tabet <i>et al.</i> , 2017 <sup>26</sup>	Florida, US	1,385,574	82.4	Born in United States, excessive weight pregestational obesity, and hypertension	5
Silva <i>et al.</i> , 2019 <sup>31</sup>	Ceará, Brazil	189	51.3	No partner and not having paid work were associated with insufficient weight gain	3

Source: Authors.

hoods were more likely to be overweight and pre-gestational obesity and had a higher prevalence of inadequate gestational weight. These data were statistically significant only for the weight gain below the recommended IOM levels. This relationship was found when the neighborhood composition and its socioeconomic index were analyzed<sup>5,23,25</sup>.

Galín *et al.*<sup>22</sup> and Tabet *et al.*<sup>26</sup> showed that the excessive weight gain prevails in pregnant women with higher education level rather than with low education level. The influence of the number of previous pregnancies on the excessive gestational weight gain was analyzed by Hasan *et al.*<sup>4</sup>

and Farhangi<sup>21</sup>. However, the results were controversial: Hasan *et al.*<sup>4</sup> found an increased probability of inadequate gestational weight gain for multiparous women compared to the nulliparous ones (OR=1.5, 95%CI 1.2-1.9), whereas Farhangi<sup>21</sup> found that the weight gain was significantly higher in nulliparous women.

The pre-gestational BMI conditions also had a significant effect on the excessive gestational weight gain, revealing that women becoming overweight and obese prior to pregnancy had a higher probability of showing excessive gestational weight gain<sup>4,24,26</sup>.

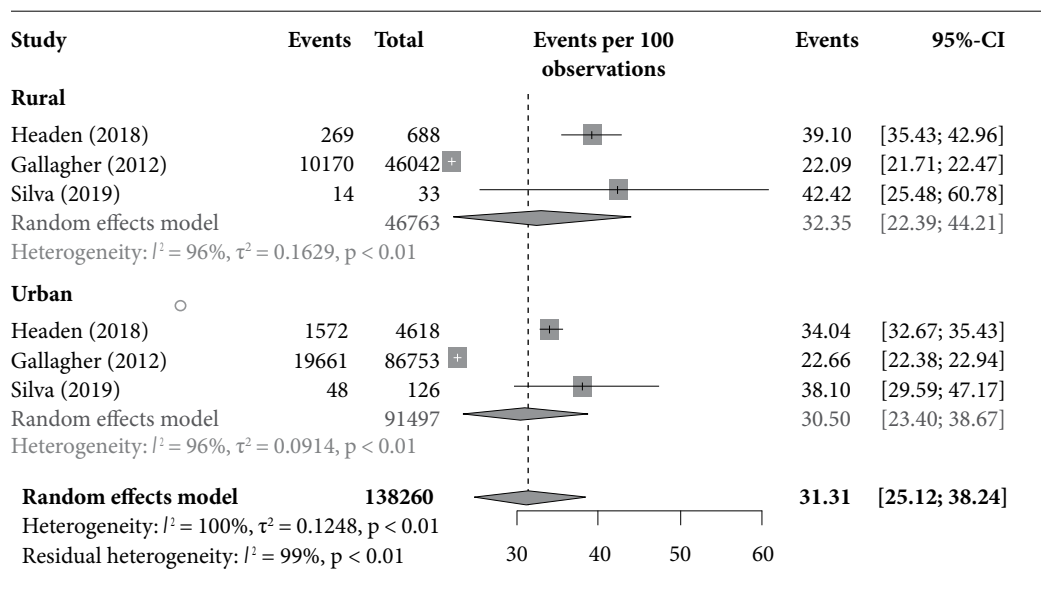


Figure 2A. Adequate weight gain by place of residence.

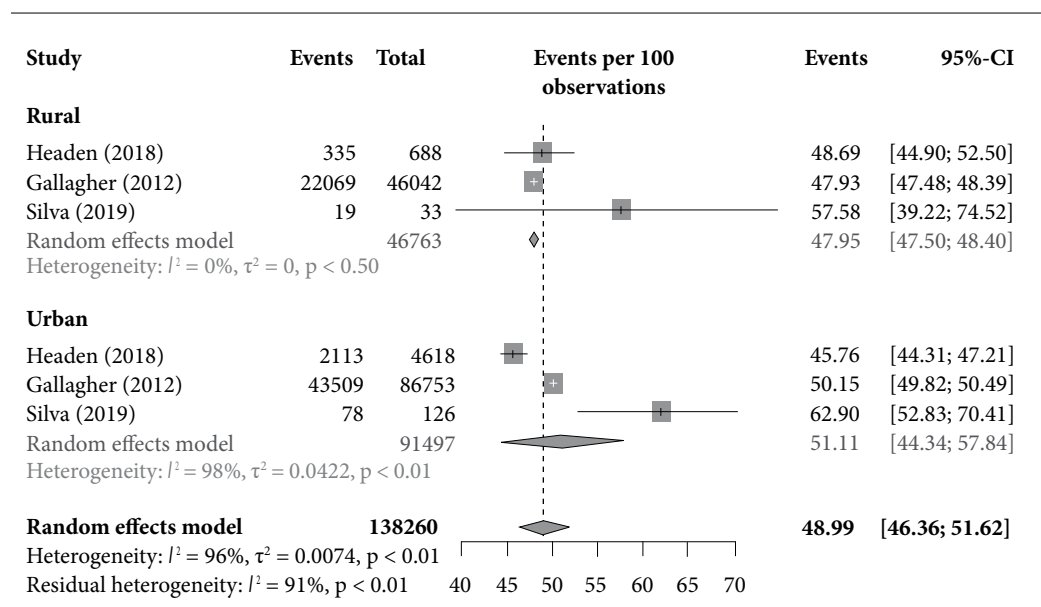


Figure 2B. Excessive weight gain by place of residence.

Figure 2. Forest Plot (meta-analysis of prevalence) of excessive and adequate gestational weight gain per micro-region of residence.

Source: Authors.

## Discussion

The results of this study evidenced from the selected articles that environmental factors related to the pregnant women, such as socioeconomic

level/poverty index of the pregnant woman's microregion of residence, neighborhood composition, violence level, and the distance from the pregnant woman's house to supermarket, may play a role on the excessive gestational weight

gain. In the general population, such associations have been examined in several reports<sup>14,15,27</sup>.

The importance of describing the environmental factors that implicate in the excessive gestational weight gain is unveiled by the consolidated evidences on how excessive weight gain is linked to several negative outcomes – both for the maternal and neonatal health. Studies describe adverse results, such as increased risk of low birth weight, premature birth, gestational diabetes and preeclampsia<sup>1,6,7</sup>. Nevertheless, it is observed that the debate on the influence of the environmental factors is still recent in the gestation context – the first study was published in 2007 by Laraia *et al.*<sup>10</sup>, with the aim to correlate the directly measured neighborhood their suburbs characteristics with smoking, diet quality, vigorous leisure activity before and during pregnancy, and gestational weight gain.

Chaparro *et al.*<sup>28</sup> investigated temporal trends of overweight and obesity in pregnant women in Sweden. They found substantial differences in the prevalence of overweight and pre-gestational obesity for region<sup>28</sup>. However, they did not discuss which regional characteristics could explain these prevalence differences, demonstrating the need for further research to elucidate the mechanisms related to the environment.

In this review, the selected articles showed that the pre-gestational BMI conditions are predictors of excessive weight gain during pregnancy and may be influenced by the environmental context. These results agree with the findings evidenced by Headen *et al.*<sup>7</sup> and Galin *et al.*<sup>22</sup>, confirming that social and economic differences in the pregnant women' living context, such as the poverty and violence indexes of the neighborhood, can influence on the weight gain during pregnancy<sup>7,22</sup>.

The pooled analysis results of the urban and rural environment influences on the excessive gestational weight gain showed that the higher prevalence of excessive gestational weight gain occurred in women that live in urban areas. In this review, studies carried out in four countries with different levels of urbanization were identified. While the US and Brazil have more than 80% of their inhabitants residing in urban areas<sup>27</sup>. Research conducted in the general population showed a relationship between the overweight/obesity and urban environment, among other factors, due to the eased access to foods considered unhealthy, ultra-processed and of low nutritional quality<sup>29</sup>.

Another result of this review was the relationship found by Galin *et al.*<sup>22</sup> between the neigh-

borhood violence index and excessive gestational weight gain. For Cohen *et al.*<sup>30</sup>, violence and fear can influence on healthy diet and active lifestyle, two main factors related to weight gain and obesity. People who live in violent micro-regions are less likely to be physically active, have less access to healthy foods, and are more likely to suffer from psychological effects, such as stress, depression and anxiety, which lead to poor diet and physical inactivity<sup>29</sup>.

The relationship between the built environment, including areas for physical activity and proximity to supermarkets, and excessive gestational weight gain described by Laraia *et al.*<sup>10</sup> has not been properly examined yet. These environmental factors have been more examined in the general population to investigate obesity<sup>14,15</sup>. A study conducted in a medium-sized city in Brazil in 2019 demonstrated that the accessibility to public and private areas for physical activity is linked to obesity in the adult population<sup>31</sup>.

The present review becomes relevant due to the extensive bibliographic search, without restricting language and year of publication. All steps of this systematic review were conducted according to the PRISMA criteria, including the peer review at all screening stages. However, we highlight some limitations mainly associated with the features of the included articles, such as their transverse design, whose results only reflect on associations, and not on cause-effect relationships.

It is also worth mentioning that it was possible to perform a meta-analysis with only 3 of the included articles because they presented analysis of common variables. Nevertheless, the sample size differences must be considered critically in the result analysis. It is also noteworthy that the fact that few studies were included in the prevalence meta-analysis limits the assessment of heterogeneity, although the random effects model was employed. The other reports show a large variation of design, which generated different measures of association, thereby hindering the pooled analysis.

## Conclusion

This study revealed the higher prevalence of excessive gestational weight gain in pregnant women that lives in urban areas, evidencing the influence of the environment on the gestational weight gain. This study also demonstrated that the environmental factors related to the living context



of pregnant women influenced on the excessive gestational weight gain rates, which, in turn, may implicate in several maternal and neonatal out-

comes. Our findings can therefore contribute to the development of public policies for the magnitude of inadequate gestational weight gain.

## Collaborations

TPR Silva, TGF Viana and CK Duarte conducted the literature research, extracted the data and evaluated the quality of studies. CK Duarte performed the statistical analysis. TPR Silva, TGF Viana, G Velasquez-Melendez, MC Pessoa, LL Mendes, FP Matozinhos, MLC Inácio and CK Duarte drafted/revised the manuscript. TPR Silva, TGF Viana and FP Matozinhos designed the study and interpreted the results. All authors made substantial contributions and approved the final version.

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