



REVIEW ARTICLE

Prevalence of childhood obesity in Brazil: systematic review and meta-analysis<sup>☆</sup>



Carolina Muller Ferreira <sup>a</sup>, Natália Dutra dos Reis <sup>a</sup>,  
Andresa de Oliveira Castro <sup>a</sup>, Dorotéia Aparecida Höfelmann <sup>b</sup>,  
Kátia Kodaira <sup>c</sup>, Marcus Tolentino Silva <sup>c</sup>, Tais Freire Galvao <sup>a,\*</sup>

<sup>a</sup> Universidade Estadual de Campinas, Faculdade de Ciências Farmacêuticas, Campinas, SP, Brazil

<sup>b</sup> Universidade Federal do Paraná, Departamento de Nutrição, Curitiba, PR, Brazil

<sup>c</sup> Universidade de Sorocaba, Programa de Pós-Graduação em Ciências Farmacêuticas, Sorocaba, SP, Brazil

Received 16 September 2020; accepted 9 December 2020

Available online 9 February 2021

KEYWORDS

Pediatric obesity;  
Child;  
Brazil;  
Prevalence;  
Systematic review;  
Meta-analysis

Abstract

**Objective:** To estimate the prevalence of childhood obesity in Brazil by means of a systematic review of representative studies.

**Sources:** We searched for population-based studies that assessed obesity in Brazilian children aged < 10 years in MEDLINE, EMBASE, Scopus and other sources up to September, 2019. Paired researchers selected studies, extracted data and assessed the quality of these studies. Meta-analysis of prevalence and confidence interval (95% CI) was calculated, weighted by the population sizes using Freeman-Tukey double-arccosine transformation. Heterogeneity ( $I^2$ ) and publication bias were investigated by meta-regression and Egger's test, respectively.

**Summary of the findings:** 53 studies were included (n = 122,395), which were held from 1986 to 2015 and limited mainly due to inadequate response rates. Prevalence of obesity in the three-decade period was of 8.2% [95% CI]: 8.1–8.4%,  $I^2 = 98.5%$ ). Higher prevalence was observed in boys (9.7% [9.4–9.9%],  $I^2 = 97.4%$ ) than girls (7.3% [7.1–7.5%],  $I^2 = 96.1%$ ). Prevalence increased according to the decade (1990: 6.5% [6.0–7.0 %],  $I^2 = 96.8%$ ; 2000: 7.9% [7.7–8.0 %],  $I^2 = 98.8%$ ; 2010: 12.0% [11.5–12.6 %],  $I^2 = 95.8%$ ), and Brazilian region (Northeast: 6.4% [6.2–6.7%],  $I^2 = 98.1%$ ; North: 6.7% [6.3–7.2%],  $I^2 = 98.8%$ ; Southeast: 10.6% [10.2–11.0%],  $I^2 = 98.2%$ ; South: 10.1 [9.7–10.4%],  $I^2 = 97.7%$ ). Heterogeneity was affected by age and region ( $p < 0.05$ ) and publication bias was discarded ( $p = 0.746$ ).

<sup>☆</sup> Study conducted at Universidade Estadual de Campinas, Faculdade de Ciências Farmacêuticas, Campinas, SP, Brazil.

\* Corresponding author.

E-mail: [taiscalvao@gmail.com](mailto:taiscalvao@gmail.com) (T.F. Galvao).

**Conclusion:** For every 100 Brazilian children, over eight had obesity in the three-decade period and 12 in each 100 had childhood obesity in more recent estimates. Higher prevalence occurred in boys, recent decades and more developed Brazilian regions.

© 2021 Sociedade Brasileira de Pediatria. Published by Elsevier Editora Ltda. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

## Introduction

Obesity affects 5% of children worldwide and increased by 20% from 1980 to 2015, with the highest prevalence in economically disadvantaged settings.<sup>1</sup> This health risk accounted for 4 million deaths in 2015, mainly due to cardiovascular disease, and presents a high rate of associated morbidity in adult life.<sup>1</sup> Measuring the prevalence of childhood obesity is crucial in tracking the trends of this health risk and establish public policies. <-- -->.

In Brazil - an emerging economy marked by high inequality -, nationwide surveys to assess obesity, especially in the pediatric population, have irregular frequency. Discrepancies between Brazilian regions as well as the effects of skin color and income were associated with the prevalence of childhood obesity in the most recent nationwide survey held in 2009.<sup>2</sup> Since then, local studies have been carried out in different Brazilian cities and states,<sup>3</sup> but no summarized representative estimates are available.

A systematic review with a meta-analysis is a valuable tool in this scenario. Although some reviews to summarize the obesity prevalence in Brazilian children by these methods have been conducted, the findings have limited validity, mainly due to the lack of representativeness,<sup>4-8</sup> absence of quality assessment of primary studies<sup>4,6,9</sup> and the use of an obsolete or irregular criteria for childhood obesity.<sup>4,9</sup> We aimed to assess the national prevalence of childhood obesity in Brazil by means of a systematic review and meta-analysis of representative studies.

## Methods

### Protocol and registration

The protocol containing the detailed methods of this systematic review was registered in the International prospective register of systematic reviews ([www.crd.york.ac.uk/prospero/display\\_record.php?ID=CRD42018091713](http://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42018091713)).

### Eligibility criteria

Observational or experimental representative studies that employed population or school-based sampling of children under 10 years old in Brazil were eligible. The prevalence of obesity in eligible studies relied on measured height and weight: studies with self-reported obesity were not eligible. Studies restricted to a particular ethnicity or social class were excluded.

## Information sources

We searched the MEDLINE, EMBASE, Scopus, Web of Science, CINAHL, LILACS, SciELO, and Brazilian nationwide theses and dissertations (Brazilian Coordination for the Improvement of Higher Education Personnel and repositories of Brazilian universities with a postgraduate program of collective health and nutrition) databases.

There were no language or publication status restrictions. We screened the references of relevant publications to identify additional potentially eligible studies.

## Search

The following search strategy was used for MEDLINE (via PubMed) and adapted for the other databases: (children OR child OR pediatric OR infant OR kid OR baby OR neonate OR childhood) AND (obesity OR overweight OR obese) AND (prevalence OR prevalencia) AND (Brazil OR Brasil), following the Peer Review of Electronic Search Strategies guidance.<sup>10</sup> The search results in compatible formats were imported into the Covidence platform ([www.covidence.org](http://www.covidence.org)), for removing duplications and further review's steps. Searches were held in January 2018 and updated in September 2019.

## Study selection

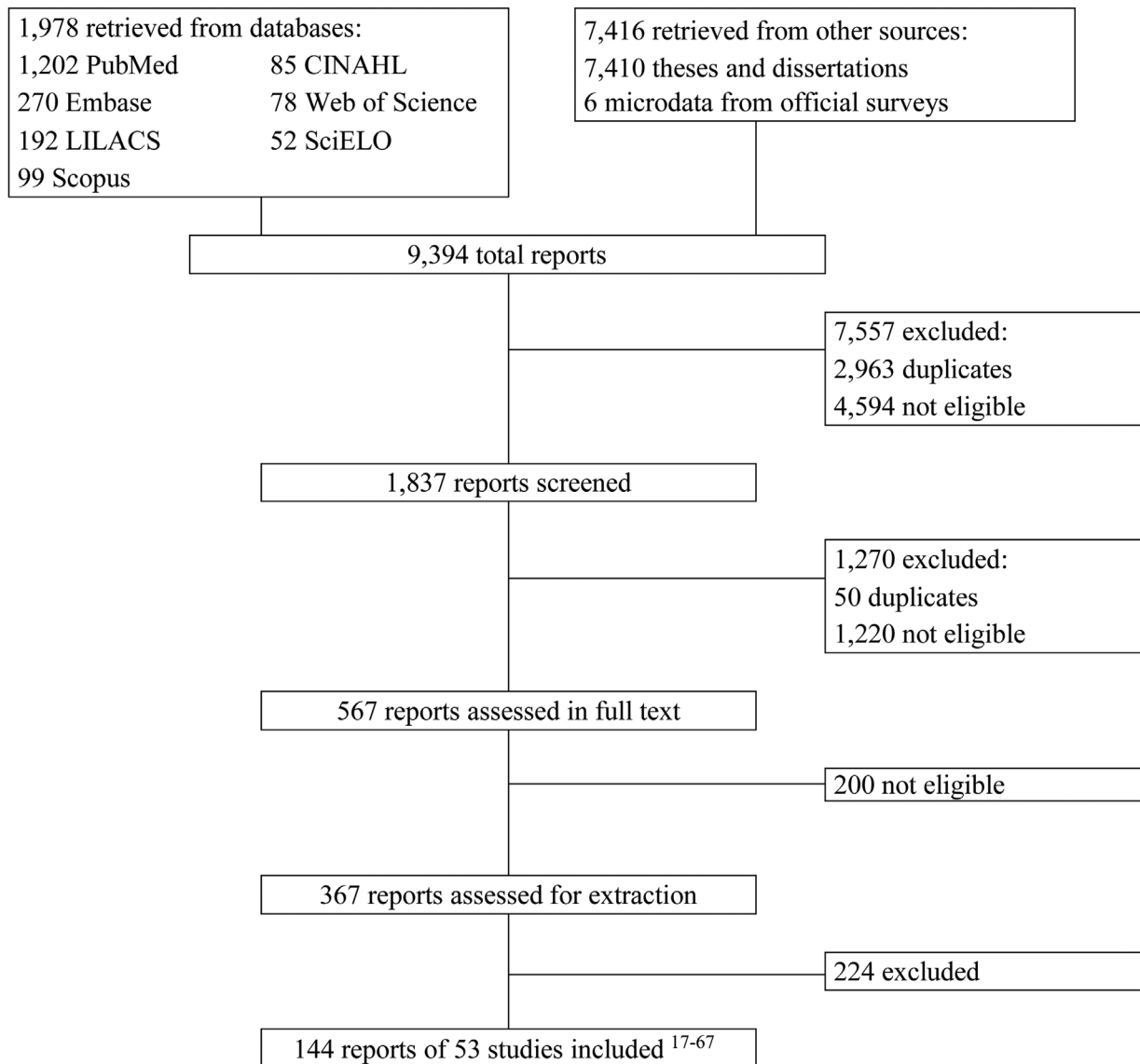
Independent paired researchers selected studies by screening titles and abstracts and then performing a full text assessment using the Covidence platform. A third reviewer arbitrated disagreements. For theses and dissertations, one reviewer screened the search results and eligibility was confirmed by a second researcher, using an Excel spreadsheet.

## Data collection process

Data were extracted by two reviewers and independently confirmed by another using a standardized spreadsheet. Disagreements were resolved by a third reviewer. Study authors were contacted to obtain additional data if relevant data were not available in the reports or to clarify conflicting information included in different reports on the same study.

## Data items

We extracted study data (author, data collection year, study design, sampling frame, publication type, and research location), population characteristics (age, sex, and number of children), and childhood obesity data of the total popu-



**Figure 1** Process of selection and inclusion of studies in the systematic review.

lation and in each group, according to the World Health Organization (WHO) criteria for obesity in children from 0 to less than 5 years old<sup>11</sup> and from 5 to less than 10 years old.<sup>12</sup> For eligible studies that assessed obesity by different criteria, we either recalculated the prevalence from the original studies' datasets using the WHO growth criteria<sup>11,12</sup> or obtained new estimates that were as supplied by the authors.

### Risk of bias in individual studies

Paired and independent researchers and confirmed by another, assessed the methodological quality of included studies using the checklist for prevalence data from the Joanna Briggs Institute,<sup>13</sup> consisting of the items: (i) sample frame (official source), (ii) sampling (probabilistic or universal sampling), (iii) sample size (statistically calculated), (iv) setting and participants description (appropriately

described), (v) coverage of data analysis (adequate coverage for different age and sex subgroups), (vi) methods for outcome measurement (WHO growth criteria),<sup>11,12</sup> (vii) standardization of outcome measurement (weight and height measured by validated instruments), (viii) statistical analysis (analysis adjusted or with sample weighting), and (ix) response rate (low rate of refusals and losses). Reviewers assigned 1 point for each item attended by the studies, with a maximum score of 9 per study.

### Summary measures

The primary outcome was the prevalence of childhood obesity and 95% confidence intervals (95% CIs). Secondary outcomes included the prevalence of childhood obesity in girls, boys, age groups, decade and Brazilian geographic regions (North, Northeast, Midwest, Southeast and South).

## Synthesis of results and additional analyses

We used Stata (version 14.2) for all statistical analysis. Meta-analysis of proportions were calculated with Freeman-Tukey double arcsine transformation<sup>14</sup> (metaprop command, ftt option) and weighted according to the official population size obtained from the Brazilian Institute of Geography and Statistics for each period and location of the primary studies ([www.ibge.gov.br](http://www.ibge.gov.br)). Heterogeneity was estimated by the assessment of inconsistency between studies ( $I^2$ ) and chi-squared tests, with a significance level of  $p < 0.10$ .

Publication bias was assessed by funnel plot asymmetry evaluation and Egger’s test (significance level of  $p < 0.05$ ).<sup>15</sup> Meta-regressions were calculated using the modified Knapp-Hartung method<sup>16</sup> to investigate the effects of independent variables (age, region, year, and quality score) on the variability of obesity prevalence between studies. To better explain the effect of contextual factors in the outcome, meta-regressions of prevalence of obesity by human development index and household income of the locality and decade that each study was held as available at the Brazilian Institute of Geography and Statistics.

## Results

### Study characteristics

Out of 9,394 retrieved records, 567 were assessed in full text, and 143 reports from 53 studies were included in the analysis (Fig. 1).<sup>17–67</sup> The references of all reports of included studies is listed in the Supplementary Material Appendix 1 and the reason for exclusion of the 222 studies assessed for data extraction is listed in Supplementary Material Appendix 2.

In total, 122,395 children were assessed in studies conducted between 1986 and 2015. Most of the studies were cross-sectional and school-based, conducted in the South and Southeast regions, and included children aged 6–9 years old (Table 1). Studies were limited mainly due to inadequate response rates, poor subject description and inappropriate statistical analyses. The quality assessment score ranged from 3 to 9 with a median of 7. The individual characteristics of each included study is depicted in the Supplementary Material Appendix 3. Upon our request from the authors, 36 studies sent additional data to allow proper quantitative synthesis.

### Childhood obesity prevalence

The overall prevalence of childhood obesity in this three-decade period was 8.2% ([95% CI]: 8.1–8.4%,  $I^2 = 98.5\%$ ), lower in girls (7.3% [7.1–7.5%],  $I^2 = 96.1\%$ ) than in boys (9.7% [9.4–9.9%],  $I^2 = 97.4\%$ ). Increasing trends in the obesity prevalence according to decade and age group were observed (Fig. 2). In the 2010s decade the prevalence was 12.0% ([11.5–12.6%],  $I^2 = 95.8\%$ ).

The highest prevalence rates of obesity were noted in the South (10.1% [9.7–10.4%],  $I^2 = 97.7\%$ ) and Southeast (10.6% [10.2–11.0%],  $I^2 = 98.2\%$ ) regions. Slightly lower obe-

**Table 1** Characteristics of included studies.

Characteristics	No. of studies	No. of children
Total	53	122,395
Age group (years)		
0–9	3	9,134
0–5	12	17,600
4–5	4	6,897
2–9	3	56,654
6–9	23	28,786
8–9	8	3,324
Study		
Cross-sectional	49	112,688
Cohort	4	9,707
Sample source		
School-based		
Public and private	26	27,530
Public	7	6,421
Population-based		
Household	15	78,505
Maternity	5	9,939
Region		
Brazil	5	69,713
North	2	577
Northeast	11	13,147
Southeast	14	10,711
South	19	26,985
Midwest	2	1,262
Decade		
1990s <sup>a</sup>	4	10,313
2000s	29	97,413
2010s	20	14,669
Limitations in methodological quality		
Sample frame	1	1,640
Sampling	11	10,390
Sample size	6	4,687
Setting and participants description	30	40,278
Coverage of data analysis	12	8,992
Method for outcome measurement	16	23,355
Standardization of outcome measurement	1	713
Statistical analysis	17	20,191
Response rate	42	112,279

<sup>a</sup> Includes one study held in 1986.

sity prevalence was observed in cross-sectional studies than in cohort studies, as well as in population-based studies rather than those in school-based studies (Table 2).

### Investigation of heterogeneity and publication bias

The variability in the obesity prevalence was significantly affected by the children’s age group ( $p < 0.001$ ; residual  $I^2 = 56.4\%$ ) and Brazilian region ( $p = 0.018$ ; residual  $I^2 = 63.4\%$ ), but not by the year of research ( $p = 0.051$ ; residual  $I^2 = 71.2\%$ ) and the methodological quality score of the studies ( $p = 0.256$ ; residual  $I^2 = 72.6\%$ ) (Fig. 3). Human devel-

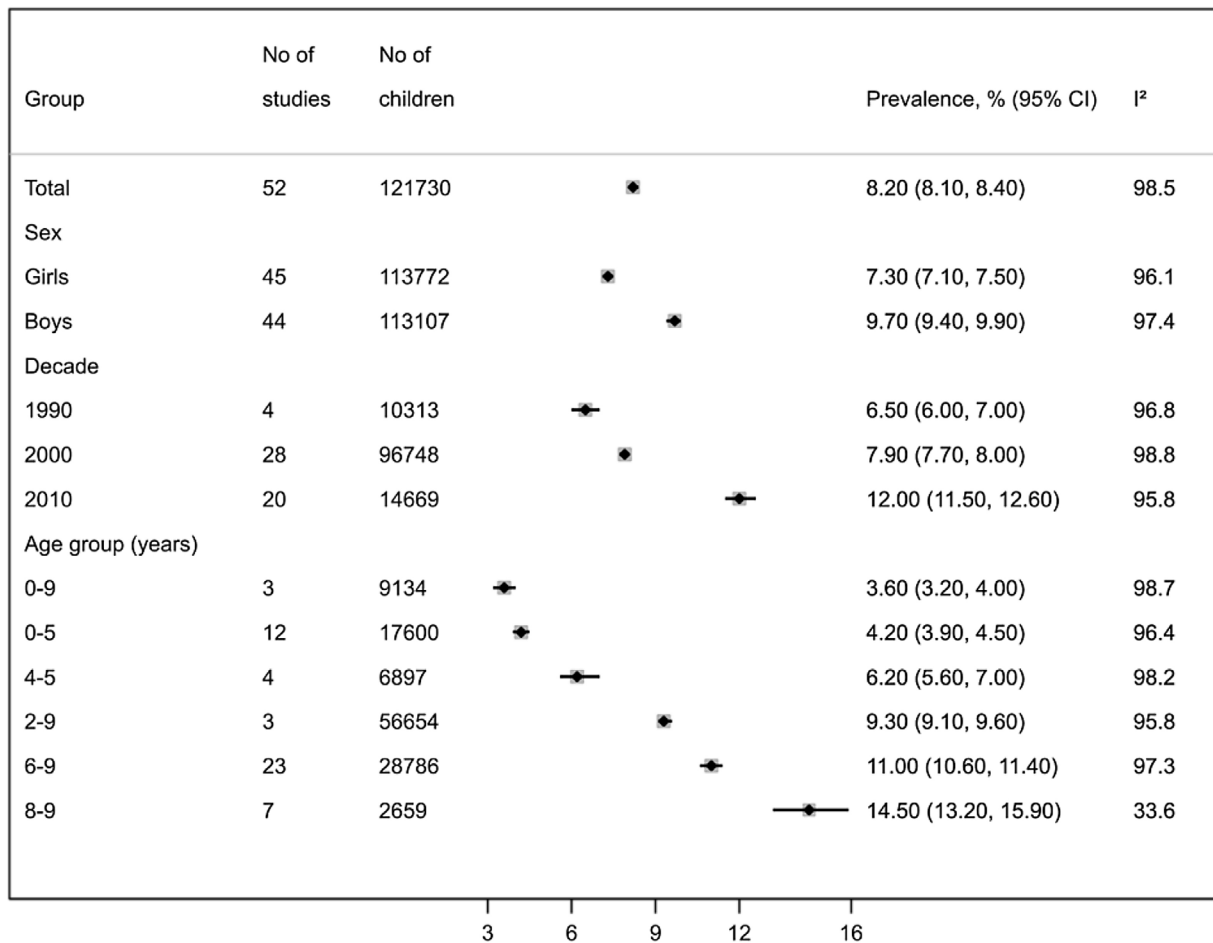


Figure 2 Prevalence of obesity in total and by sex, decade and age group.

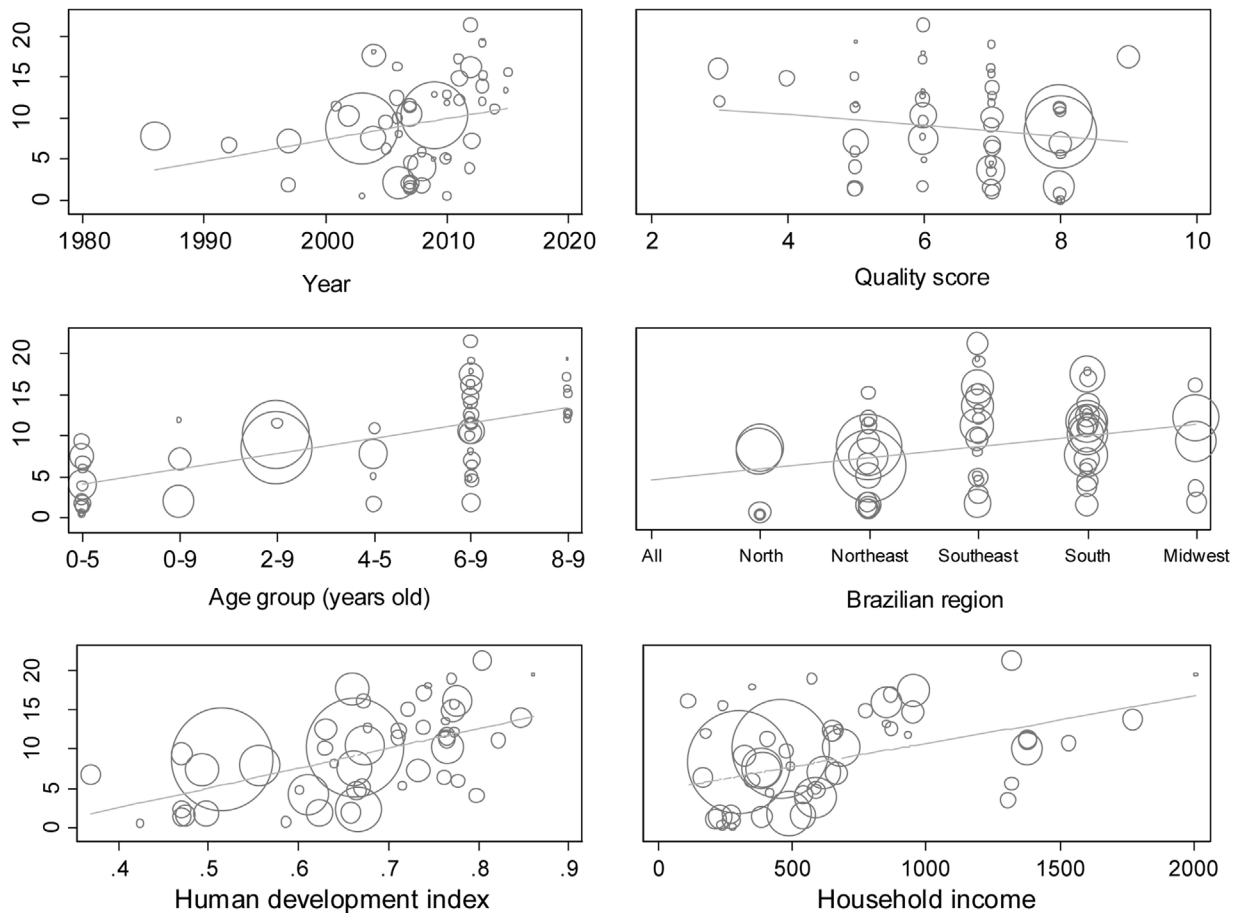
Table 2 Prevalence of childhood obesity, 95% confidence interval (CI) and heterogeneity (I<sup>2</sup>) according to the study design, sample source and region of studies.

Subgroup	No. of studies	No. of children	Prevalence, % [95% CI]	I <sup>2</sup> (%)
Study design				
Cross-sectional	48	112,023	8.1 [7.9–8.2]	98.3
Cohort	4	9,707	9.7 [8.9–10.6]	99.2
Sample source				
School-based				
Public and private schools	25	26,865	9.7 [9.3–10.1]	97.0
Public schools	7	6,421	12.6 [11.7–13.4]	93.0
Population-based				
Household	15	78,505	7.3 [7.1–7.5]	99.0
Maternity	5	9,939	9.5 [8.7–10.4]	99.0
Region <sup>a</sup>				
North	5	12,443	6.7 [6.3–7.2]	98.8
Northeast	15	38,193	6.4 [6.2–6.7]	98.1
Southeast	18	18,497	10.6 [10.2–11.0]	98.2
South	21	35,230	10.1 [9.7–10.4]	97.7
Midwest	5	11,805	9.7 [9.1–10.2]	98.1

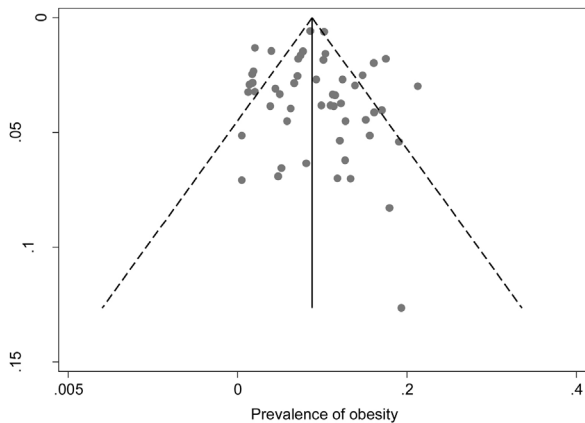
<sup>a</sup> The analysis included disaggregated data from each region if available in a nationwide study.

opment index ( $p < 0.001$ ; residual  $I^2 = 66.7\%$ ) and household income ( $p = 0.001$ ; residual  $I^2 = 66.1\%$ ) were positively associated to prevalence of obesity, also partially explaining the

heterogeneity. A symmetric distribution was noted in the funnel plot, without evidence of a small studies effect on childhood obesity ( $p = 0.746$ ) (Fig. 4).



**Figure 3** Prevalence of obesity in included studies by child age group, Brazilian region, year of research and quality score (study size is represented by the circle size).



**Figure 4** Prevalence of obesity in each study distributed according to the standard error of prevalence.

## Discussion

For every 100 Brazilian children assessed in this three-decade period, more than eight children had obesity and 12 in each 100 had obesity in the 2010s decade according to this systematic review and meta-analysis of representative studies. Obesity was slightly more frequent in boys than

in girls, and all estimates were heterogeneous. The prevalence increased with age, decade, and Brazilian regions, partially explaining the high variability across the conducted studies.

The results were highly inconsistent among the studies, which is a common limitation in meta-analysis of prevalence.<sup>68</sup> Subgroup analyses according to factors that significantly affected heterogeneity did not lead to more homogeneous estimates. Estimates were calculated from studies with population representativeness that used the same official criteria for assessing obesity in the Brazilian pediatric population.<sup>11,12</sup>

Boys had a slightly higher prevalence of obesity than girls in Brazil; this pattern was similar to those in Latin American and Caribbean regions in 2016, with 13% of obesity in boys and 10% in girls aged 5–19 years,<sup>69</sup> and in countries with a high-middle sociodemographic index according to the worldwide burden of obesity in 2015; however, this pattern was not observed in the overall childhood estimate.<sup>1</sup> An inverse association was observed in a systematic review of Australian studies conducted between 1967 and 2012, with a higher prevalence of combined overweight and obesity in girls (21%) than in boys (18%) aged 2–18 years.<sup>70</sup>

The age-standardized mean body mass index of children and adolescents increased globally from 1975 to 2016 (an

increase of 0.32 kg/m<sup>2</sup> per decade for girls and 0.40 kg/m<sup>2</sup> per decade for boys).<sup>71</sup> Projections of global childhood obesity estimated that 5.4% of the population aged 5–18 years will have obesity by 2025, a 0.5% increase in relation to 2013.<sup>72</sup> This trend seems to be influenced by human development in the region. Inverse associations between socioeconomic status and overweight and obesity were observed in a systematic review of 30 studies.<sup>73</sup> In Spain, a cohort study including 1.1 million children showed a slight reduction in childhood excess weight, from 42% in 2006 to 40% in 2016,<sup>74</sup> indicating the possible lower influence of time in highly developed regions.

The highest obesity prevalence was observed in more economically developed Brazilian regions, which also comprised the largest number of investigations. A bibliometric analysis of scientific obesity research studies from 1988 to 2007 revealed this tendency in few publications from Latin America in relation to more developed countries, with positive association between prevalence and the number of publications.<sup>75</sup> Investigation of contextual factors showed that prevalence of childhood obesity was higher in settings of higher human development index and household income, which may reveal more access to food but not adequate nutrition. The nutritional transition to the consumption of ultra-processed foods accounted for approximately 40% of the total daily intake in children aged 6 years in a birth cohort in southern Brazil,<sup>76</sup> compared to a cohort in the city of São Luís in the Northeast which is a less developed region, estimated in 26% of total calories of children up to 3 years old in 2007.<sup>77</sup>

Cohort studies reported a higher prevalence rate than cross-sectional studies, even though the latter were more frequent. Cohort studies are expensive due to the time required for follow-up and the large sample size, a possible explanation for the lower number of studies included, and are more prone to losses of follow-up than other types of studies.<sup>78</sup>

School-based studies had a higher prevalence and were more common than population-based studies, possibly due to more convenient logistic in recruiting and data collection of children. Absenteeism during data collection in school-based research studies may explain higher prevalence observed. An analysis of 1,069 students in fourth to sixth grade in nine public elementary schools in Philadelphia in a published 2007, reported that children with obesity were absent ( $12.2 \pm 11.7$  days) more frequently than healthy children ( $10.1 \pm 10.5$  days),<sup>79</sup> showing a possible difference in school attendance that could result in selection bias. In Brazil, absenteeism and the lack of universal education for children can be due to the effects of economic crises and increasing poverty, resulting in an increase in male child labor in 2015 compared to 2013 in both rural and urban areas.<sup>80</sup>

## Conclusion

Over eight out of every 100 Brazilian children up to 10 years old had obesity in the three-decade period of this comprehensive analysis of representative studies and 12 in each 100 children had obesity in the 2010s decade. Obesity was higher in boys than in girls and increased with age, decade,

and in more developed Brazilian regions. Further investigation should take into account underlying factors such as dietary patterns and inequalities across different Brazilian regions.

## Conflict of interest

The authors declare no conflicts of interest.

## Funding

This research was funded by the Brazilian National Council for Scientific and Technological Development (CNPq) [grant number: 440865/2017-4]. Galvao TF receives a productivity scholarship from CNPq [grant number: 3064482017-7].

## Acknowledgements

The authors thank Raisa Rafaela Santos de Gusmão for the contribution in piloting the selection and data extraction of studies, and the authors of eligible manuscripts for providing data or clarification upon our request: Adriana Paula Silva, Alanderson A. Ramalho, Alessandra Doumid Borges Pretto, Alessandra Vitorino Naghettini, Alynne Christian Ribeiro Andaki, Ana Flavia Granville-Garcia, Ana Mayra A. de Oliveira, Ana Paula Carlos Cândido Mendes, Anna Christina Barreto, Anne Jardim-Botelho, Barbara H. Lourenço, Carla de Oliveira Bernardo, Cassiano Ricardo Rech, Cézane Priscila Reuter, Denise Petrucci Gigante, Deysianne Costa das Chagas, Diego Moura Tanajura, Elenir Rose Jardim Cury Pontes, Elma Izze da Silva Magalhães, Emil Kupek, Fabian Calixto Fraiz, Felipe S. Neves, Gabriella Bettiol Feltrin, Gerson Luis de Moraes Ferrari, Haroldo da Silva Ferreira, Ida Helena Carvalho Francescantonio Menezes, Jéssica Pedroso, Julia Khede Dourado Vila, Juliane Berria, Lana do Monte Paula Brasil, Larissa da Cunha Feio Costa, Leonardo Pozza Santos, Lucia Yassue Tutui Nogueira, Luciana Neri Nobre, Marcela de França Verçosa, Marcos Britto Correa, Marcos Pascoal Pattussi, Maria Luiza Kraft, Maria Wany Louzada Strufaldi, Naruna Pereira Rocha, Nilton Rosini, Patrícia Casagrande Dias de Almeida, Paula Azevedo Aranha Crispim, Peter Katzmarzyk, Rosângela de Mattos Müller, Ruth Liane Henn, Samuel Carvalho Dumith, Sílvia Diez Castilho, Sílvia Letícia Alexius, Sílvia Nascimento de Freitas, Sílvia Regina Dias Medici Saldiva, Simone Augusta Ribas, Suélen Henriques da Cruz, Valter Cordeiro Barbosa Filho, Wendell Bila.

## Research dataset

The dataset of this research is fully available at: <https://osf.io/f2qnp>.

## Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at: <https://doi.org/10.1016/j.jpmed.2020.12.003>.

## References

1. Afshin A, Forouzanfar MH, Reitsma MB, Sur P, Estep K, Lee A, et al. Health effects of overweight and obesity in 195 countries over 25 years. *N Engl J Med*. 2017;377:13–27.
2. Pereira I, Andrade LM, Spyrides MH, Lyra CO. Nutritional status of children under 5 years of age in Brazil: evidence of nutritional epidemiological polarisation. *Cien Saude Colet*. 2017;22:3341–52.
3. Sperandio N, Priore SE. Inquéritos antropométricos e alimentares na população brasileira: importante fonte de dados para o desenvolvimento de pesquisas. *Cien Saude Colet*. 2017;22:499–508.
4. Guedes PF, Almeida KB, Moraes LP. The prevalence of childhood obesity among elementary school students in public schools: systematic literature review. *Revista Arquivos Científicos (IMMES)*. 2019;2:36–40.
5. Aiello AM, Marques de Mello L, Souza Nunes M, Soares da Silva A, Nunes A. Prevalence of obesity in children and adolescents in Brazil: a meta-analysis of cross-sectional studies. *Curr Pediatr Rev*. 2015;11:36–42.
6. Sousa CP, Olinda RA, Pedraza DF. Prevalence of stunting and overweight/obesity among Brazilian children according to different epidemiological scenarios: systematic review and meta-analysis. *Sao Paulo Med J*. 2016;134:251–62.
7. Niehues JR, Gonzales AI, Lemos RR, Bezerra PP, Haas P. Prevalence of overweight and obesity in children and adolescents from the age range of 2 to 19 years old in Brazil. *Int J Pediatr*. 2014;2014:583207.
8. Simões CF, Lopes WA, Remor JM, Locateli JC, Lima FB, Santos TL, et al. Prevalence of weight excess in Brazilian children and adolescents: a systematic review. *Rev Bras Cineantropom Desempenho Hum*. 2018;20:517–31.
9. Junior Md SG, Fraga AS, Araújo TB, Tenório MCC. Cardiovascular risk factor: obesity among children and adolescents in Brazilian macro-regions. *RBONE-Rev Bras Obes Nutr Emagr*. 2018;12:132–42.
10. McGowan J, Sampson M, Salzwedel DM, Cogo E, Foerster V, Lefebvre C. PRESS peer review of electronic search strategies: 2015 guideline statement. *J Clin Epidemiol*. 2016;75:40–6.
11. World Health Organization (WHO). WHO Child Growth Standards: Length/height-for-age, weight-for-age, weight-for-length, weight-for-height, and body mass index-for-age: Methods and development. Geneva: WHO; 2006.
12. de Onis M, Onyango AW, Borghi E, Siyam A, Nishida C, Siekmann J. Development of a WHO growth reference for school-aged children and adolescents. *Bull World Health Organ*. 2007;85:660–7.
13. Munn Z, Moola S, Lisy K, Riitano D, Tufanaru C. Methodological guidance for systematic reviews of observational epidemiological studies reporting prevalence and cumulative incidence data. *Int J Evid Based Healthc*. 2015;13:147–53.
14. Rücker G, Schwarzer G, Carpenter J. Arcsine test for publication bias in meta-analyses with binary outcomes. *Stat Med*. 2008;27:746–63.
15. Egger M, Davey Smith G, Schneider M, Minder C. Bias in meta-analysis detected by a simple, graphical test. *BMJ*. 1997;315:629–34.
16. Knapp G, Hartung J. Improved tests for a random effects meta-regression with a single covariate. *Stat Med*. 2003;22:2693–710.
17. Alexius SL, Olinto MT, Henn RL, Pattussi MP. The association between self-perceptions of psychological well-being and overweight in Brazilian children. *Matern Child Nutr*. 2012;8:267–74.
18. Andaki AC, Mendes EL, Tinoco AL, Santos A, Sousa B, Vale S, et al. Waist circumference percentile in children from municipalities of developed and developing countries. *Motriz: Rev Educ Fis*. 2017;23:e101733.
19. Ataíde Lima RP, de Carvalho Pereira D, Pordeus Luna RC, Gonçalves Mda C, de Lima RT, Filho MB, et al. BMI, overweight status and obesity adjusted by various factors in all age groups in the population of a city in Northeastern Brazil. *Int J Environ Res Public Health*. 2015;12:4422–38.
20. Barbosa L. Características gestacionais e de nascimento e alimentação no primeiro ano de vida e sua relação com displipidemias e excesso de peso em escolares [dissertation]. Viçosa, MG: Universidade Federal de Viçosa; 2009.
21. Barbosa Filho VC, Campos Wd, Fagundes RR, Lopes Ad S, Souza EAd. Presença isolada e combinada de indicadores antropométricos elevados em crianças: prevalência e fatores sociodemográficos associados. *Cien Saude Colet*. 2016;21:213–24.
22. Barreto AC, Brasil Ldo M, Maranhão Hde S. Prevalence of excess weight in preschoolers in the Northeast of Brazil. *Rev Assoc Med Bras (1992)*. 2007;53:311–6.
23. Bernardo Cde O, Vasconcelos Fde A. Association of parents' nutritional status, and sociodemographic and dietary factors with overweight/obesity in schoolchildren 7 to 14 years old. *Cad Saude Publica*. 2012;28:291–304.
24. Bertin RL, Malkowski J, Zutter LC, Ulbrich AZ. Estado nutricional, hábitos alimentares e conhecimentos de nutrição em escolares. *Rev Paul Pediatr*. 2010;28:303–8.
25. Berria J, Minatto G, Ribeiro RR, Santos KD, Petroski EL. Prevalência de obesidade abdominal e fatores associados em crianças e adolescentes de Cascavel-PR, Brasil. *Rev Educ Fis UEM*. 2013;24:269–77.
26. de Camargo AT, Borges CR, Köhler ML, de Lima Leite M, Fernandes AB, Kanunfre CC. Influência da televisão na prevalência de obesidade infantil em Ponta Grossa, Paraná. *Ciência, Cuidado e Saúde*. 2008;6:305–11.
27. Castilho SD, Nucci LB, Hansen LO, Assuino SR. Prevalence of weight excess according to age group in students from Campinas, SP, Brazil. *Rev Paul Pediatr*. 2014;32:200–6.
28. Chagas DC, Silva AA, Batista RF, Simões VM, Lamy ZC, Coimbra LC, et al. Prevalence and factors associated to malnutrition and excess weight among under five year-olds in the six largest cities of Maranhão. *Rev Bras Epidemiol*. 2013;16:146–56.
29. Coelho LG, Cândido AP, Machado-Coelho LG, Freitas SN. Association between nutritional status, food habits and physical activity level in schoolchildren. *J Pediatr (Rio J)*. 2012;88:406–12.
30. Costa Lda C, Silva DA, Almeida Sde S, de Vasconcelos Fde A. Association between inaccurate estimation of body size and obesity in schoolchildren. *Trends Psychiatry Psychother*. 2015;37:220–6.
31. Dallabona A, Cabral SC, Höfelman DA. Variáveis infantis e maternas associadas à presença de sobrepeso em crianças de creches. *Rev Paul Pediatr*. 2010;28:304–13.
32. Dumith SC, Farias Júnior JC. Overweight and obesity in children and adolescents: comparison of three classification criteria based on body mass index. *Rev Panam Salud Publica*. 2010;28:30–5.
33. Feltrin GB, Vasconcelos Fd A, Costa Ld C, Corso AC. Prevalence and factors associated with central obesity in schoolchildren in Santa Catarina, Brazil. *Rev Nutr*. 2015;28:43–54.
34. Fernández MR, Goettens ML, Demarco FF, Corrêa MB. Is obesity associated to dental caries in Brazilian schoolchildren? *Braz Oral Res*. 2017;31:e83.
35. Ferrari GL, Araújo TL, Oliveira LC, Matsudo V, Fisberg M. Association between electronic equipment in the bedroom and sedentary lifestyle, physical activity, and body mass index of children. *J Pediatr (Rio J)*. 2015;91:574–82.
36. Ferreira Hda S, Vieira ED, Cabral Junior CR, Queiroz MD. [Breastfeeding for at least thirty days is a protective factor against overweight in preschool children from the semiarid



- region of Alagoas]. *Rev Assoc Med Bras* (1992). 2010;56:74–80.
37. Ferreira Hda S, Cesar JA, Assunção ML, Horta BL. Time trends (1992-2005) in undernutrition and obesity among children under five years of age in Alagoas State, Brazil. *Cad Saude Publica*. 2013;29:793–800.
  38. Ferreira HS, Lúcio GM, Assunção ML, Silva BC, Oliveira JS, Florêncio TM, et al. High blood pressure among students in public and private schools in Maceió, Brazil. *PLoS One*. 2015;10:e0142982.
  39. Fraiz GM, Crispim SP, Montes GR, Gil GS, Morikava FS, Bonotto DV, et al. Excess body weight, snack limits and dental caries in Brazilian preschoolers: a population-based study. *Pesqui Bras Odontopediatria Clín Integr*. 2019;19:e4584.
  40. Freitas TP, Silva LL, Teles GS, Peixoto Md R, Menezes IH. Fatores associados à subestimação materna do peso da criança: um estudo de base populacional. *Rev Nutr*. 2015;28:397–407.
  41. Gigante DP, Victora CG, Matijasevich A, Horta BL, Barros FC. Association of family income with BMI from childhood to adult life: a birth cohort study. *Public Health Nutr*. 2013;16:233–9.
  42. Guedes DP, Rocha GD, Silva AJ, Carvalhal IM, Coelho EM. Effects of social and environmental determinants on overweight and obesity among Brazilian schoolchildren from a developing region. *Rev Panam Salud Publica*. 2011;30:295–302.
  43. Heleno P, Emerick L, Mourão N, Pereira D, Santos I, Oliveira AS, et al. Systemic arterial hypertension, blood pressure levels and associated factors in schoolchildren. *Rev Assoc Med Bras* (1992). 2017;63:869–75.
  44. Justo GF, Callo GQ, Carletti L, Molina MC. Nutritional extremes among school children in a rural Brazilian municipality. *Rural Remote Health*. 2012;12:2220.
  45. Kupek E, Lobo AS, Leal DB, Bellisle F, de Assis MA. Dietary patterns associated with overweight and obesity among Brazilian schoolchildren: an approach based on the time-of-day of eating events. *Br J Nutr*. 2016;116:1954–65.
  46. Trends in the prevalence of overweight and obesity among Brazilian school-children, 2002, 2007, and 2012/13. Leal D, Maria DAA, Lobo A, Hinnig P, Engel R, Soar C, editors. *Annals of Nutrition and Metabolism*. Basel, Switzerland: Karger Allschwilerstrasse 10; 2017. Ch-4009.
  47. Menezes AM, Hallal PC, Muiño A, Chatkin M, Araújo CL, Barros FC. Risk factors for wheezing in early adolescence: a prospective birth cohort study in Brazil. *Ann Allergy Asthma Immunol*. 2007;98:427–31.
  48. Moreira MA, Cabral PC, Ferreira HS, Lira PI. Overweight and associated factors in children from northeastern Brazil. *J Pediatr (Rio J)*. 2012;88:347–52.
  49. Müller Rde M, Tomasi E, Facchini LA, Piccini RX, da Silveira DS, Siqueira FV, et al. Prevalence of overweight and associated factors in under-five-year-old children in urban population in Brazil. *Rev Bras Epidemiol*. 2014;17:285–96.
  50. Nobre LN, Silva KC, de Castro Ferreira SE, Lopes Moreira L, Lessa Ado C, Lamounier JA, et al. Early determinants of overweight and obesity at 5 years old in preschoolers from inner of Minas Gerais, Brazil. *Nutr Hosp*. 2013;28:764–71.
  51. Nogueira LY. Estado nutricional e associação com variáveis comportamentais e socioeconômicas em escolares do município de Ourinhos-SP [dissertation]. Campinas: Universidade Estadual de Campinas, Faculdade de Odontologia de Piracicaba; 2014.
  52. Oliveira AM, Cerqueira EM, Souza Jd S, Oliveira AMC. Sobrepeso e obesidade infantil: influência de fatores biológicos e ambientais em Feira de Santana, BA. *Arq Bras Endocrinol Metabol*. 2003;47:144–50.
  53. A decade trend of childhood obesity in a developing country, 2001 to 2011. Oliveira AM, Veneza LM, Marques Da Silva CC, Cardoso De Oliveira AML, Santos ADS, Oliveira AM, et al., editors. *Diabetes*. Alexandria, VA 22311-1717 USA: Amer Diabetes Assoc 1701 N Beauregard ST; 2015.
  54. Oppitz IN, Cesar JA, Neumann NA. Overweight among children under five years of age in municipalities of the semiarid region. *Rev Bras Epidemiol*. 2014;17:860–72.
  55. Doumid Borges Pretto A, Correa Kaufmann C, Ferreira Dutra G, Pinto Albernaz E. Prevalence of factors related to the bone mass formation of children from a cohort in Southern Brazil. *Nutr Hosp*. 2014;31:1122–8.
  56. Ramalho AA, Mantovani SAS, Delfino BM, Pereira TM, Martins AC, Oliart-Guzmán H, et al. Nutritional status of children under 5 years of age in the Brazilian Western Amazon before and after the Interoceanic highway paving: a population-based study. *BMC Public Health*. 2013;13:1098.
  57. Salomons E, Rech CR, Loch MR. Nutritional status of six to ten-year-old schoolchildren in the municipal education system of Arapoti, Paraná, Brazil. *Rev Bras Cineantropom Desempenho Hum*. 2007;9:6.
  58. Santos LP, Santos IS, Matijasevich A, Barros AJ. Changes in overall and regional body fatness from childhood to early adolescence. *Sci Rep*. 2019;9:1888.
  59. Silva AP, Feilbelmann TC, Silva DC, Palhares HM, Scatena LM, Resende EA, et al. Prevalence of overweight and obesity and associated factors in school children and adolescents in a medium-sized Brazilian city. *Clinics (Sao Paulo)*. 2018;73:e438.
  60. Strufaldi MW, Silva EM, Puccini RF. Overweight and obesity in prepubertal schoolchildren: the association with low birth weight and family antecedents of cardiovascular disease. *Embu - metropolitan region of São Paulo, 2006*. *Cien Saude Colet*. 2011;16:4465–72.
  61. Travi MI, de Oliveira Bastos PRH, Pontes ER. Prevalência de sobrepeso, obesidade e circunferência abdominal alterada em escolares de 6 a 11 anos de idade em Campo Grande/MS. *Rev Bras Promoção Saúde*. 2012;24:54–62.
  62. Villa JK. Padrões alimentares e escore de síndrome metabólica em crianças de 8 e 9 anos do município de Viçosa, Minas Gerais [dissertation]. Viçosa, MG: Universidade Federal de Viçosa; 2014.
  63. Rocha NP, Milagres LC, Filgueiras MS, Suhett LG, Silva MA, Albuquerque FM, et al. Association of dietary patterns with excess weight and body adiposity in Brazilian children: the Pase-Brasil study. *Arq Bras Cardiol*. 2019;113:52–9. Erratum in: *Arq Bras Cardiol*. 2020;114:194.
  64. Instituto Brasileiro de Geografia e Estatística (IBGE). Departamento de População e Indicadores Sociais. Pesquisa sobre padrões de vida 1996-1997. 2nd ed. Rio de Janeiro: IBGE; 1999.
  65. Instituto Brasileiro de Geografia e Estatística (IBGE). Microdados da POF 2008-2009 (Pesquisa de Orçamentos Familiares). IBGE: Rio de Janeiro; 2010.
  66. Instituto Brasileiro de Geografia e Estatística (IBGE). Pesquisa de Orçamentos Familiares (POF) 2002/2003. IBGE: Rio de Janeiro; 2000.
  67. Brasil. Ministério da Saúde. Pesquisa Nacional de Demografia e Saúde da Criança e da Mulher-PNDS 2006: dimensões do processo reprodutivo e da saúde da criança. Brasília: Ministério da Saúde; 2009.
  68. Barendregt JJ, Doi SA, Lee YY, Norman RE, Vos T. Meta-analysis of prevalence. *J Epidemiol Community Health*. 2013;67:974–8.
  69. Di Cesare M, Sorić M, Bovet P, Miranda JJ, Bhutta Z, Stevens GA, et al. The epidemiological burden of obesity in childhood: a worldwide epidemic requiring urgent action. *BMC Med*. 2019;17:212.
  70. Ho NS, Olds T, Schranz N, Maher C. Secular trends in the prevalence of childhood overweight and obesity across Australian states: a meta-analysis. *J Sci Med Sport*. 2017;20:480–8.
  71. NCD Risk Factor Collaboration (NCD-RisC). Worldwide trends in body-mass index, underweight, overweight, and obesity from

- 1975 to 2016: a pooled analysis of 2416 population-based measurement studies in 128.9 million children, adolescents, and adults. *Lancet*. 2017;390:2627–42.
72. Lobstein T, Jackson-Leach R. Planning for the worst: estimates of obesity and comorbidities in school-age children in 2025. *Pediatr Obes*. 2016;11:321–5.
  73. Chung A, Backholer K, Wong E, Palermo C, Keating C, Peeters A. Trends in child and adolescent obesity prevalence in economically advanced countries according to socioeconomic position: a systematic review. *Obes Rev*. 2016;17:276–95.
  74. de Bont J, Díaz Y, Casas M, García-Gil M, Vrijheid M, Duarte-Salles T. Time trends and sociodemographic factors associated with overweight and obesity in children and adolescents in Spain. *JAMA Netw Open*. 2020;3:e201171.
  75. Vioque J, Ramos JM, Navarrete-Muñoz EM, García-de-la-Hera M. A bibliometric study of scientific literature on obesity research in PubMed (1988-2007). *Obes Rev*. 2010;11:603–11.
  76. Bielemann RM, Santos LP, Costa CD, Matijasevich A, Santos IS. Early feeding practices and consumption of ultraprocessed foods at 6 y of age: findings from the 2004 Pelotas (Brazil) Birth Cohort Study. *Nutrition*. 2018;47:27–32.
  77. Batalha MA, França AK, Conceição SI, Santos AM, Silva FS, Padilha LL, et al. Processed and ultra-processed food consumption among children aged 13 to 35 months and associated factors. *Cad Saude Publica*. 2017;33:e00152016.
  78. Camargo LM, Silva RP, de Oliveira Meneguetti DU. Research methodology topics: cohort studies or prospective and retrospective cohort studies. *J Hum Growth Dev*. 2019;29:433–6.
  79. Geier AB, Foster GD, Womble LG, McLaughlin J, Borradaile KE, Nachmani J, et al. The relationship between relative weight and school attendance among elementary schoolchildren. *Obesity*. 2007;15:2157–61.
  80. da Silva RO, Neto WP, Cassuce FC. Child labor and poverty: an analysis in the context of Brazilian economic recession. *Rev Desenvolv Econômico*. 2018;2:463–88.