ORIGINAL ARTICLE

Mapping and projections of obesity in the Brazilian adult population assisted in Primary Health Care: impact of the COVID-19 pandemic

Mapeamento e projeções da obesidade na população adulta brasileira atendida na Atenção Primária à Saúde: impacto da pandemia de COVID-19

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ABSTRACT

Objective: To map the temporal evolution of overweight and obesity in Brazilian adults and estimate the prevalence of obesity for 2025 and 2030, evaluating the potential impact of the COVID-19 pandemic. **Method:** Data were collected on the nutritional status of adults from 2008 to 2021 from the Food and Nutrition Surveillance System (SISVAN), from which we calculated the prevalence and average annual rates of the variation of overweight and obesity. The projection of obesity, using linear regression, was analyzed in three scenarios: PP: with data from the pre-pandemic period (2008-2019); outlier: with adjustment of the data trend (2008-2021), including the pandemic period, considering a return of scenario PP for projections from 2022; P: adjustment of pandemic data (2019-2021) to estimate the projection. **Result:** In the period 2008–2021, we observed an average annual rate of overweight increase of 0.48 %/year. The prevalence of obesity more than doubled during this period, from 14.5% in 2008 to 32.9% in 2021 (i.e., an increase of 1.42). In the outlier scenario, the prevalence projections for obesity are 38.8% and 45.5% for 2015 and 2030, respectively. In the PP scenario (without the pandemic), the expected prevalence for the same period would be approximately 36.8% and 43.4%, respectively. **Conclusion:** Obesity and overweight follow an increasing trend. The COVID-19 pandemic accelerated the increase in the prevalence of obesity in Brazil and impacted its projections for the coming years.

RESUMO

Objetivo: Mapear a evolução temporal de sobrepeso e obesidade de adultos brasileiros e estimar as prevalências de obesidade para 2025 e 2030, avaliando o potencial impacto da pandemia de COVID-19. **Método:** Foram coletados dados do estado nutricional de adultos de 2008 a 2021 do Sistema de Vigilância Alimentar e Nutricional (SISVAN), a partir dos quais foram calculadas as prevalências e taxas médias anuais da variação de sobrepeso e obesidade. A projeção da obesidade, utilizando regressão linear, foi analisada em três cenários: PP: com dados do período pré-pandemia (2008-2019); outlier: com ajuste da

tendência de dados (2008-2021), incluindo o período da pandemia, considerando um retorno do cenário PP para projeções a partir de 2022; P: ajuste dos dados da pandemia (2019-2021) para estimativa da projeção. **Resultado:** No período de 2008 e 2021, observamos uma taxa anual média de aumento de sobrepeso de 0,48 %/ano. A prevalência de obesidade mais que dobrou nesse período, passando de 14,5% em 2008 para 32,9% em 2021 (i.e., um aumento de 1,42). No cenário outlier, as projeções das prevalências de obesidade são de 38,8% e 45,5% para os anos de 2015 e 2030, respectivamente. No cenário PP (sem a pandemia), a prevalência esperada para o mesmo período estaria em torno de 36,8% e 43,4%, respectivamente. **Conclusão:** A obesidade e o sobrepeso seguem uma tendência de aumento crescente. A pandemia de COVID-19 acelerou o aumento da prevalência de obesidade no Brasil e impactou a sua projeção para os próximos anos.

INTRODUCTION

Obesity is a chronic condition characterized by excess body fat and has increased significantly in recent years[1]. In addition, obesity is associated with the development of other chronic conditions, such as diabetes, hypertension, cardiovascular diseases, and cancer, and is considered an important public health problem[2-5]. In Brazil, 25.9% of individuals over 18 years of age had obesity in 2019 and 60.3% were overweight, according to data from the National Health Survey[6]. In the same year, more than 5 million people worldwide died as a result of obesity, placing obesity as the fifth leading cause of death in the world and reinforcing its relevance in the current scenario[7].

In Brazil, obesity has a high cost to the Brazilian Unified Health System (SUS). In 2018, SUS had a cost of R$ 3.45 billion for outpatient services, hospitalization, and the People's Pharmacy program to treat obesity, arterial hypertension, and diabetes mellitus, with 11% of this amount attributable solely to obesity[8]. In addition to direct costs, obesity also has indirect economic and social impacts. In this sense, obesity also results in higher expenditure on early retirement related to health, in addition to increased absenteeism, unproductivity at work, and morbidity and mortality[5].

In the context of public health, the Food and Nutrition Surveillance System (SISVAN) was implemented as a health policy to describe and analyze dietary and nutritional trends in Brazilians attending primary health care (PHC). From SISVAN data, health professionals and managers can diagnose nutritional status, identify nutritional problems, and measure their size in the territories. Thus, the organization of strategies for health promotion, prevention, and control of diseases related to nutrition, such as overweight and obesity, can become more precise and efficient when considering the specific characteristics of the territories[9].

In 2020, with the onset of the COVID-19 pandemic, an infectious disease caused by the coronavirus of SARS-CoV-2, obesity was recognized as an important risk factor for the complications of this infection, including the increased risk of developing the disease in its severe form, higher hospitalization rates, higher risk of mechanical ventilatory support, and mortality[10]. In turn, the COVID-19 pandemic may have influenced the worsening of obesity because the SARS-CoV-2 containment policies (lockdowns, social distancing, etc.) led to changes in the population's habits, such as reducing the level of physical activity, increased sedentary behavior, and changes in eating habits, such as higher consumption of high calories from sugars and fat. These factors are commonly associated with weight gain[11].

Given the above, the present study aimed to map the temporal evolution of the prevalence of overweight and obesity in the Brazilian adult population assisted in PHC between 2008 and 2021 and estimate the prevalence of obesity for 2025 and 2030, evaluating the possible impact of the pandemic years (2020 and 2021). As a secondary objective, we analyzed the coverage rate of nutritional status data records in the PHC in each Federative Unit (FU) to better understand the scope of SISVAN in Brazilian territories.

METHODS

The record of nutritional status of adult individuals (20 and 59 years), male and female, assisted at PHC in the period between 2008 and 2021 was collected from the consolidated reports of SISVAN Web[12], using the web scraping technique, with the rvest package in the statistical environment of the R software. SISVAN adopts the recommendations established by the World Health Organization[13] for the classification of the nutritional status of the adult population: underweight (< 18.5 kg/m²); eutrophy (18.5 kg/m² to 24.9 kg/m²); overweight (25.0 kg/m² to 29.9 kg/m²); obesity class I (30.0 kg/m² to 34.9 kg/m²), obesity class II (35.0 kg/m² to 39.9 kg/m²) and obesity class III (≥40 kg/m²). Subsequently, we classified overweight (≥25 kg/m²) and general obesity (≥30 kg/m²), by categorizing the aforementioned groups.

Data processing and analysis were performed through the libraries of scientific computing and data visualization Geopandas, Matplotlib, and Seaborn from Python 3.9 using the territorial divisions of the Brazilian Institute of Geography and Statistics (IBGE) available in digital shapefile[14-17]. Coverage maps of nutritional status data by FU and prevalence of overweight and obesity by FUs and geographic regions (North, Northeast, Midwest, Southeast, and South) of Brazil were constructed.

The average annual rate of change in the prevalence of overweight and obesity from 2008 to 2021 was calculated using the following formula:

$$Annual\ Average\ Rate \left(T_{2008-2021} \right) =$$
$$\frac{\Delta prevalence\ [\%]}{time\ interval\ [years]} = \tag{1}$$
$$\frac{prevalence_{2021} - prevalence_{2008}}{(2021 - 2008)}.$$

The coverage of nutritional status records in Brazil was evaluated by calculating the total number of adults with nutritional status data recorded in SISVAN by the number of adult population in Brazil projected for the same year[18]. Similarly, the same evaluation was performed for each FU. This calculation was performed for the years 2008 and 2021.

The projection of obesity prevalence for 2025 and 2030 was estimated using linear regression analysis as follows:

$$f(x) = a_0 \cdot x + a_1, \qquad (2)$$

where a_0 is the angular coefficient of regression, a measure of the rate of variation of the dependent variable $f(x)$, in relation to the independent variable x. The a_1 coefficient is the value of the function $f(0)$. In the present study, we consider x as the time (in years) and $f(x)$ as the prevalence of obesity.

The regression model allows the extraction of important information from time series, in addition to enabling analysis of projections for subsequent years. To analyze the impact of the COVID-19 pandemic, we consider three scenarios:

1. Scenario PP: pre-pandemic scenario (2008-2019), in which a linear regression analysis of the data from 2008 to 2019 was performed to project the prevalence of obesity, assuming that the growth that occurred in the pre-pandemic period would be maintained. This scenario was defined as a "control group" to assess the impact of the COVID-19 pandemic.

2. Outlier scenario: in this "outlier" scenario there is a special situation that considers the years of the pandemic (2020 and 2021) as an anomaly in the general trend of the data, which changed the trend observed in previous years. However, from 2022, in this scenario, it is expected that the behavior of the data will return to be similar to that in the pre-pandemic scenario. To adjust the projection, the prevalence of obesity in 2021 serves as a starting point, reflecting the impact of the pandemic on obesity. And the a_0 parameter, on the other hand, is the estimated constant based on the pre-pandemic scenario. This is used to adjust the projection

and ensure that it is aligned with the trend observed before the pandemic. Therefore, the combination of these two parameters allows the projection to consider both the impact of the pandemic and the overall trend of the data before the pandemic.

3. Scenario P: pandemic scenario, in which a linear regression model was applied to data from the period 2019-2021, and used for obesity projection. In this scenario, it is assumed that the changes caused by the pandemic will continue indefinitely.

The SciPy optimization library of Python 3.9 was used to obtain the a_0 coefficients with respective confidence intervals for the three scenarios using the linear least squares method[14]. Finally, we estimated the future prevalence of obesity by projecting the adjusted curves until 2030.

RESULTS

The prevalence of overweight in the adult population assisted at PHC in 2008 was 28.4%, while in 2021, this prevalence was 34.6%. From these data, we observed that the average annual variation rate of this condition was 0.48 %/year. Regarding obesity, in 2021 the prevalence was more than double that observed in 2008, starting from 14.5% and reaching 32.9%, with an average annual variation rate of 1.42 %/year (Figure 1A).

When analyzing the different degrees of obesity (Figure 1B), obesity class I in 2008 presented a prevalence of 10.2% and 20.3% in 2021, with an average annual variation rate of 0.78 %/year. Obesity class II increased from 3.0% to 8.1% in the same period, resulting in an average annual rate of 0.39 %/year. Finally, obesity class III followed the same trend, with prevalences of 0.3% and 4.6% for 2008 and 2021, respectively, with an average annual variation rate of 0.33 %/year.

Federative Units (FU)

In relation to the FU, in 2021, Amapá presented the highest prevalence of overweight (37.9%), followed by Pará (37.3%) and Roraima (37.3%). The states with the lowest prevalence of overweight in the same year were Espírito Santo (31.8%), Rio Grande do Sul (32.0%), and
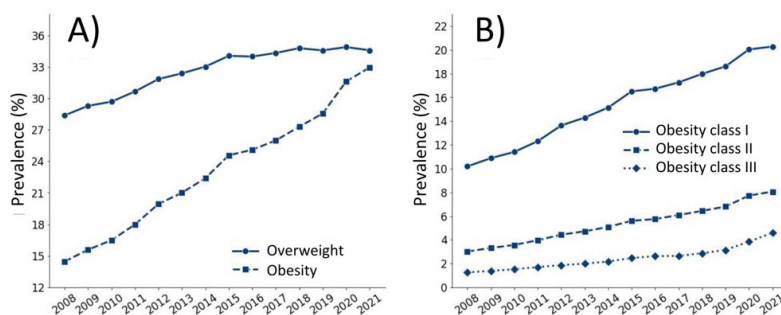
Figure 1 – Temporal evolution of overweight and obesity in the adult population assisted in the Primary Health Care, Brazil, 2008-2021. (A) Temporal evolution of overweight (BMI ≥ 25 kg/m^2) and general obesity (BMI ≥ 30 kg/m^2); (B) Temporal evolution of obesity class I (BMI = 30 to 34.9 kg/m^2), obesity class II (BMI = 35.0 to 39.9 kg/m^2), obesity class III (BMI ≥ 40 kg/m^2). Source: SISVAN-WEB[12].

Mato Grosso do Sul (32.3%). Overall obesity in 2021 had the highest prevalence in Rio Grande do Sul (43.2%), followed by São Paulo (40.6%) and Mato Grosso do Sul (40.3%). In addition to being the states with the highest prevalence of general obesity in 2021, they also presented the highest average annual rate of variation ($T_{2008-2021}$) (Table 1; Supplementary Figure 1).

In addition to the increased prevalence of general obesity, the severity of this condition is increasing. The states that had the highest prevalence of obesity class III were also those that recorded the highest rates of average annual variation: Rio Grande do Sul (prevalence = 8.3%; $T_{2008-2021}$ = 0.41 %/year), Espírito Santo (prevalence = 7.4%; $T_{2008-2021}$ = 0.44 %/year) and São Paulo (prevalence = 7.3%; $T_{2008-2021}$ = 0.34 %/year). An important point to be highlighted is the relationship between the prevalence of this condition in Rio Grande do Sul and Brazil, considering that this FU presented almost twice the prevalence of the country (prevalence = 4.6%; $T_{2008-2021}$ = 0.26 %/year). On the other hand, FU Maranhão (prevalence = 1.5%; $T_{2008-2021}$ = 0.07 %/year), Piauí (prevalence = 2.4%; $T_{2008-2021}$ = 0.15 %/year), and Pará (prevalence = 2.0%; $T_{2008-2021}$ = 0.10 %/year) had the lowest prevalence of severe obesity (Figure 2; Supplementary Table 2).

Table 1 – Prevalence and Annual Average Rate of Overweight, General Obesity, and Severe Obesity in the Federative Units of Brazil between 2008 and 2021.

FU/year	Overweight (25.0-29.9 kg/m²)			General obesity (≥ 30.0 kg/m²)			Obesity class III (≥ 40.0 kg/m²)		
	Prevalence (%)		$T_{2008-2021}$ (%/year)	Prevalence (%)		$T_{2008-2021}$ (%/year)	Prevalence (%)		$T_{2008-2021}$ (%/year)
	2008	2021	-	2008	2021	-	2008	2021	-
Acre	30.4	35.0	0.35	14.7	27.3	0.97	1.1	2.6	0.12
Alagoas	28.9	34.7	0.45	12.9	32.8	1.53	0.9	3.8	0.22
Amazonas	31.5	37.0	0.42	15.6	31.0	1.18	1.1	3.1	0.15
Amapá	32.3	37.9	0.43	16.9	30.5	1.05	1.5	3.1	0.12
Bahia	26.4	35.2	0.68	11.3	27.6	1.25	0.9	2.8	0.15
Ceará	29.9	36.4	0.50	12.5	33.3	1.60	0.7	3.8	0.24
Distrito Federal	30.6	33.4	0.22	18.4	36.9	1.42	1.6	5.8	0.32
Espírito Santo	29.5	31.8	0.18	19.0	38.3	1.48	1.7	7.4	0.44
Goiás	27.5	33.7	0.48	14.0	34.0	1.54	1.3	5.5	0.32
Maranhão	24.5	37.0	0.96	8.5	21.4	0.99	0.5	1.5	0.08
Minas Gerais	27.9	33.6	0.44	15.7	32.3	1.28	1.6	5.0	0.26
Mato Grosso do Sul	29.6	32.3	0.21	21.7	40.3	1.43	2.4	6.5	0.32
Mato Grosso	30.4	33.8	0.26	17.2	35.6	1.42	1.7	5.4	0.28
Pará	27.8	37.3	0.73	10.9	25.4	1.12	0.7	2.0	0.10
Paraíba	30.1	35.4	0.41	13.7	32.0	1.41	0.9	3.8	0.22
Pernambuco	28.4	35.2	0.52	12.0	30.8	1.45	0.9	4.2	0.25
Piauí	25.2	36.4	0.86	9.1	26.4	1.33	0.5	2.4	0.15
Paraná	30.1	33.7	0.28	18.9	36.8	1.38	1.8	5.4	0.28
Rio de Janeiro	28.8	32.6	0.29	21.1	36.6	1.19	2.5	6.5	0.31
Rio Grande do Norte	30.8	34.9	0.32	15.2	36.3	1.62	1.1	4.8	0.28
Rondônia	26.5	34.2	0.59	14.6	31.6	1.31	1.2	4.1	0.22
Roraima	31.7	37.3	0.43	15.5	32.3	1.29	1.2	3.2	0.15
Rio Grande do Sul	31.8	32.0	0.02	24.6	43.2	1.43	2.9	8.3	0.42
Santa Catarina	30.6	34.4	0.29	21.4	34.6	1.02	2.5	5.0	0.19
Sergipe	26.5	34.5	0.62	11.4	31.2	1.52	0.9	3.9	0.23
São Paulo	30.3	32.6	0.18	23.1	40.6	1.35	2.8	7.3	0.35
Tocantins	27.7	35.7	0.62	13.4	28.4	1.15	1.1	3.4	0.18

FU: Federative Unit. $T_{2008-2021}$: Annual Average Rate between 2008 and 2021. Source: SISVAN-WEB[12].

Geographical regions

When comparing the geographic regions of Brazil in 2021, the North region has the highest prevalence of overweight, with 36.9%, followed by the Northeast with 35.7%, the South with 33.6%, the Midwest with 33.4%, and the Southeast with the lowest prevalence, 33.0%. Regarding the prevalence of general obesity, the South region presented a higher prevalence (37.3%), followed by the Southeast (36.4%), Midwest (36.0%), Northeast (29.1%), and North (28.3%) (Supplementary Figure 2).

Linear regressions

Figure 3 shows the prevalence of obesity (BMI ≥ 30 kg/m^2), considering the three previously defined
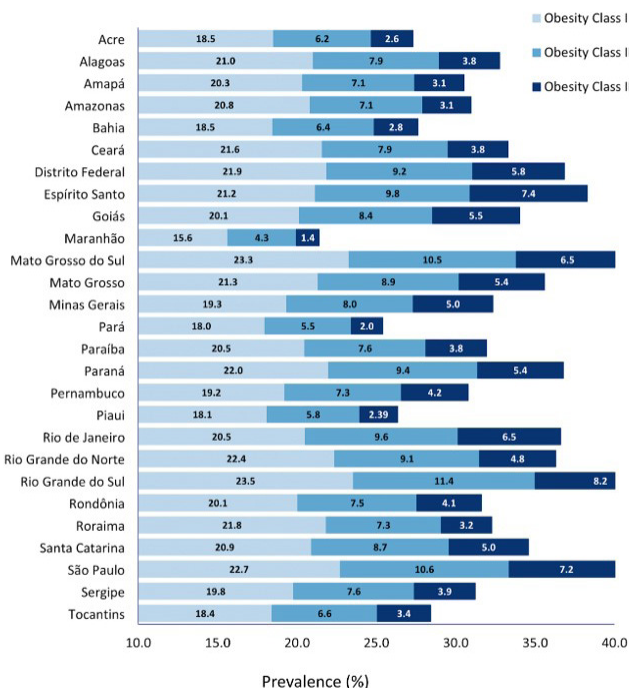
Figure 2 – Prevalence of obesity in the adult population assisted in Primary Health Care according to Federative Unit, Brazil, 2021. Source: SISVAN-WEB[12].
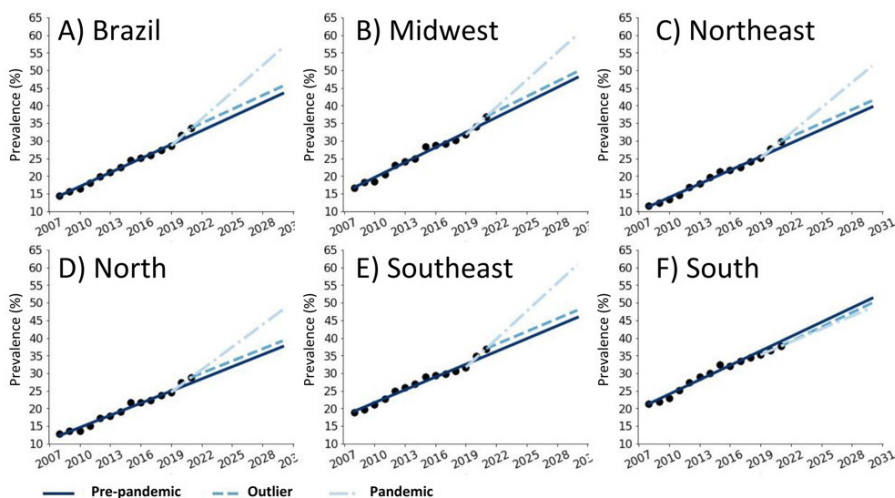
Figure 3 – Prevalence of obesity (BMI ≥ 30 kg/m^2) for three different scenarios according to the COVID-19 pandemic, in Brazil and in the geographical regions, 2008-2030.
Source: SISVAN-WEB[12].

scenarios in Brazil and geographic regions. Obesity showed a linear increase between 2008 and 2019, a behavior correctly captured by the PP scenario. However, during the years 2020 and 2021, there was a greater increase in these prevalences, as shown by the increased slope of the curves referring to scenario P. The outlier scenario, which estimates the increasing trend of obesity post-pandemic, considering the increase that had already occurred in the pre-pandemic years, is in the middle, showing that the impact of the pandemic for subsequent years will be lower than scenario P and higher than PP. It is interesting to note that the prevalence of obesity in the South region was the least impacted by the pandemic (Figure 3F), with all scenarios showing similar regressions.

Regarding the projections (Figure 4 and Supplementary Table 2), the South and Central-West regions are those with the most alarming estimates in the PP scenario, 44.4% (95% CI: 41.1-47.8%) and 40.8 % (95% CI: 37.7-43.9%), respectively, for the year 2025 and 51.2 % (95% CI: 47.2-55.3%) and 47.9 % (95% CI: 44.2 - 51.7%) for 2030. In scenario P, the South region does not present significant changes in the PP scenario, and the Southeast region appears as one of the most alarming. Figure 4C shows the angular coefficients of regressions, which represent the annual growth in the prevalence of obesity. Again, it is possible to observe the impact of the pandemic years 2020 and 2021 on the

progression of obesity. This impact is evidenced by the increase in the coefficient, which jumped from 1.32 %/year (95% CI: 1.25-1.39 %/year) to 2.58 %/year (95% CI: 2.28-2.88 %/year) in Brazil. This increase was also observed in the other Brazilian regions, except for the South region (Figure 4C and Supplementary Table 2).
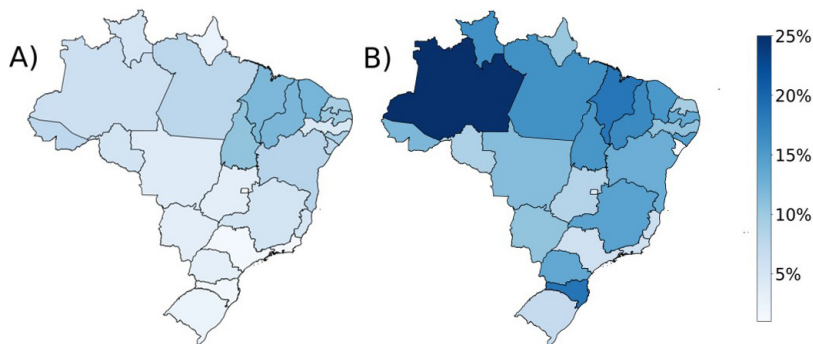
Coverage of nutritional status records

The coverage of the population's nutritional status record is still low compared with the total population of the country (Figure 5). In 2008, anthropometric data were recorded for 5,247,693 adults, and in 2021 this number increased to 14,086,458 adults. This data represents a coverage of 4.7% of the Brazilian population in 2008, with a variation of 0.6%–12.3% among the states. In 2021, coverage increased to 10.9%, with a variation of 0.3%–25.8% among FU. All 27 FU had an increase in coverage of the nutritional status record from 2008 to 2021, except Sergipe, which showed a sharp reduction (from 7.7% to 0.3%).

DISCUSSION

In the present study, when analyzing SISVAN data from 2008 to 2021, more than half of the adult population assisted at PHC had excess weight (covering both overweight and obesity), and the geographical distribution of these
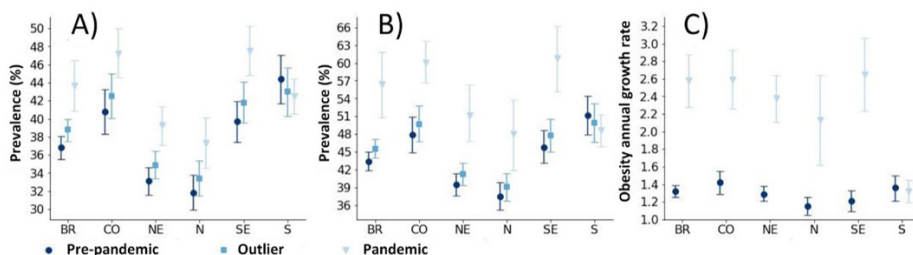
Figure 4 – Projections of prevalence and annual growth of obesity (BMI ≥ 30 kg/m²) in different scenarios, in Brazil and in Brazilian geographical regions. Data presented on mean and 95% confidence interval. (A) Projection of obesity prevalence's for 2025; (B) Projection of obesity prevalence's for 2030; (C) Obesity annual growth rate given by angular coefficient of linear adjustments. BR: Brazil; CO: Midwest; NE: Northeast; N: North; SE: Southeast; S: South.
Source: SISVAN-WEB[12].

Figure 5 – Coverage of the nutritional status record in adults from Primary Health Care, Brazil, 2008 (A) and 2021 (B).
Source: SISVAN-WEB[12].

conditions was not homogeneous in the national territory. The highest prevalence of overweight was found in the North region: Amapá (37.9%), Pará (37.3%), and Roraima (37.3%), while obesity had the highest prevalence in the South, Southeast, and Midwest regions, with emphasis on Rio Grande do Sul (43.2%), São Paulo (40%), and Mato Grosso do Sul (40.3%).In addition, the prevalence of obesity more than doubled between 2008 and 2021, from 14.5% to 32.9%, with an average annual variation rate of 1.42 %/year. Not only obesity but also its severity has increased significantly over the years, with an average annual increase of more than 25% in the prevalence of obesity class III. Currently, obesity class III is observed in 4.6% of the Brazilian population, but its distribution is uneven in the states, ranging from 1.5% in Maranhão to 8.3% in Rio Grande do Sul.

Considered a public health problem, obesity has reached epidemic proportions throughout the world. Currently, 39% of the world population is overweight and 13% is obese[18]. According to the World Obesity Atlas 2022[19], published by the World Obesity Federation, by 2035, one in four adults will have obesity in the world. In addition, recognizing that obesity is an urgent public health problem, the World Health Organization set the goal of no increase in the prevalence of obesity and adult diabetes between 2010 and 2025. However, according to the World Obesity Federation, no country is on track to achieve this goal[20]. In Brazil, according to data from the National Health Survey (PNS), the prevalence of obesity increased from 20.8% to 25.9% between 2013 and 2019[6]. Taken together, these data show the increasing trend of obesity and the need to implement strategies to prevent and control obesity in the country considering the particularities of each territory.

As far as we can see, our work is the first to analyze the impact of the COVID-19 pandemic on the prevalence of obesity in Brazil in the short and long term. During the pandemic period (2020 and 2021), we observed a significant increase in obesity, except in the South region, compared with the years before the pandemic. The NutriNet Brazil cohort evaluated changes in body weight of more than 14,000 Brazilian adults during the COVID-19 pandemic and showed that 19.7% of them had a weight gain of at least 2 kg in 6 months. The authors also highlighted the predominance of weight gain over weight loss during the same period[21]. Similarly, a cross-sectional population study conducted in two cities in southern Brazil (Rio Grande, Rio Grande do Sul state and Criciúma, Santa Catarina state) showed that the prevalence of weight gain during the pandemic was 38.4% among adults[22]. Lee et al.[23] also noted in the Korean population that the prevalence of obesity and severe obesity increased significantly from 2019 to 2020. In the United States, there was also a significant increase in BMI and the prevalence rate of obesity among adults from 2019 to 2020[24]. A systematic review and meta-analysis study that included data from 36 observational studies observed a significant increase in body weight in the post-lockdown period in adults and adolescents (>16 years)[25]. These data reinforce the influence of the COVID-19 pandemic on obesity not only in Brazil but also worldwide.

Among the factors related to the increase in obesity, we can highlight the behavior and quality of life changes generated by the pandemic. Among them, the pandemic significantly reduced our mobility and physical activity, leading to an increase in sedentary behavior[26,27]. In a population-based cross-sectional study conducted in the southern region of Brazil, it was demonstrated that remote work was associated with a 23% higher likelihood of weight gain during the pandemic compared with those who did not work remotely[22]. A study conducted in Brazil showed that overweight people were more likely to practice less physical activity during the pandemic. Thus, overweight people were more susceptible to developing obesity during this period[28]. Furthermore, chronic stress resulting from distancing and/or social isolation during the pandemic period led to a deterioration in emotional health. This, in turn, contributed to changes in eating behaviors, such as increased consumption of ultra-processed and fast foods and reduced consumption of fresh foods, which negatively impacted obesity rates[29-31].

Research by the Brazilian Institute of Consumer Protection (IDEC) in partnership with Datafolha showed that the consumption of ultra-processed foods by adults aged 45–55 years increased from 9% to 16% between 2019 and 2020[30,31]. Menezes et al.[32] found a reduction in sleep quality, an increase in consumption of ultra-processed foods, and a decrease in fresh and minimally processed foods in adult individuals in Minas Gerais, Brazil, at the end of 2020. The Brazilian survey "ConVid, Behavior Research" also showed a reduction in physical activity, increased screen time, intake of ultra-processed food, and consumption of cigarets and alcoholic beverages during the lockdown period[33]. A study conducted in the United States showed an association between increased fast-food consumption and obesity during the COVID-19 pandemic. The hypotheses raised to explain this association were related to stress and anxiety during this period, which led to the emotional intake of unhealthy foods. In addition, the pandemic significantly impacted the food system by disrupting local food environments and exacerbating problems of access and accessibility to food, which consequently drove fast-food consumption by convenience and accessibility[34]. Thus, the increase in health risk behaviors and the worsening of lifestyle in the pandemic period seem to have contributed to the increase in obesity in this period[35].

Brazil is a country in continental proportions, with great variability between its geographic regions concerning climate, culture, and economic activities[36]. Despite this, the increase in the prevalence of obesity followed a linear trend in all regions of the Brazilian territory. Except for the Southern region, we observe an important impact of the pandemic on the increase in obesity. However, although the pandemic accelerated the increase in the prevalence of obesity, the rate of increase in obesity in scenario P seems unlikely. The context experienced during the pandemic is no longer our reality. Recently, the WHO decreed the end of the COVID-19 pandemic[37]. Thus, the outlier scenario projections seem more viable considering the current reality. In the outlier scenario, unfortunately, the projections for the prevalence of obesity are 38.8% and 45.5% for the years 2015 and 2030, respectively. What we would expect

if the pandemic had not existed (scenario PP), would be a prevalence of around 36.8% and 43.4%, respectively, for the same period. Thus, the outlier scenario indicates that obesity projections should follow an increasing trend, impacted by the COVID-19 pandemic, which accelerated the growing trend of obesity prevalence among Brazilian adults who use the SUS.

Primary Health Care (PHC) stands out for being close to the community and being the preferred gateway to the Health Care and Surveillance Network. Thus, PHC plays a strategic role in the prevention of obesity. However, adequate management of obesity in the country still presents significant challenges and disparities between regions[38]. In this context, SISVAN is an essential tool because the assessment of nutritional status can be an important strategy for assessing and monitoring obesity.

In our study, we observed a low coverage concerning anthropometric data of SISVAN, despite the increase over the years. This result meets the data reported in the literature. Several factors appear to contribute to the inadequacy of this coverage, including insufficient planning, monitoring, and information management, which lead to issues such as unregistered data and irregularities in data registration for DATASUS; centralization and verticalization of social policies; difficulty in implementing a unified system; operational problems; and lack of political commitment on the part of managers in the nutritional area. Hence, the challenge confronting national-level nutritional surveillance becomes apparent, emphasizing the need for concerted efforts to uphold the quality of data collection and recording, thereby enhancing the reliability of generated data.

Among the strengths of this study, we highlight the use of consolidated data from SISVAN from 2008 to 2021, which allowed us to perform an analysis of the temporal evolution of overweight and obesity in adults assisted at PHC in Brazil and its FU, including the impact the COVID-19 pandemic had on them. We emphasize that even with the pandemic, the registration coverage rate in SISVAN did not present a sudden reduction during the pandemic period, which allowed a better quality of the data analyzed. In addition, linear regressions provided projections of the prevalence of obesity for 2025 and 2030, serving as a stimulus for the development of public policies for the management of obesity. Among the limitations of this study, we highlight that the evaluated population is not representative of the Brazilian territory because the data used comes from anthropometric records of adults assisted at PHC. Thus, it is not possible to extrapolate the results to the entire Brazilian population. In addition, the model used for linear regressions has some limitations because mathematically, $f(x)$ can increase or decrease indefinitely while the prevalence is restricted to 0% and 100%. Therefore, extreme predictions need to be considered sparingly. Finally, the performance of linear regressions is directly related to data quality. For smaller geographic groupings (municipalities) or with lower coverage of the nutritional status record (such as UF Sergipe), fluctuations found in the data may be responsible for generating distorted and spurious predictions and extrapolations. Thus, we chose to perform these analyses only for Brazil and regions. In an addendum, the importance of expanding the coverage of

the SISVAN data record is added as a way to strengthen and improve the data on smaller scales so that models can be applied locally and meet the peculiarities and particularities of the municipality, for example.

The low coverage of the SISVAN registry also directly affects the quality of the data, making a robust diagnosis of the territory difficult. For instance, Sergipe experienced a significant decline in coverage in 2020, starting from 16.8% in 2019 and reaching only 0.34% in 2021. Some studies report that this underutilization of the system can be due to several factors such as high turnover of professionals, complexity of the system, and problems with the equipment, which makes it difficult to use data for planning new health policies[39]. From this, the necessity of instituting public policies for obesity management is discerned, with SISVAN emerging as a prominent tool for this objective[9]. However, it's noteworthy that SISVAN is currently underexploited. Despite its immense potential for strategic planning, efficient management, and comprehensive evaluation of nutritional status.

CONCLUSION

The prevalence of overweight and obesity increased across all Brazilian states from 2008 to 2021, with the North exhibiting the highest prevalence of overweight and the South exhibiting the highest prevalence of obesity. Moreover, not only did obesity rates escalate but also the severity of obesity witnessed a substantial increase during this timeframe. These results reinforce the need for the development of effective public policies for the management of obesity given its impact on the quality of life of the population and the public health system. In addition, the COVID-19 pandemic accelerated the increase in the prevalence of obesity in Brazil, except in the South, for the years 2025 and 2030. Finally, the coverage of the nutritional status registry increased from 2008 to 2021, but remains below 30% in all States of the country, indicating the need to implement measures to improve the adherence of professionals to SISVAN, both in the collection and use of your data.

REFERENCES

1. WHO: World Health Organization. Obesity: preventing and managing the global epidemic. Geneva: WHO; 2000. (WHO Technical Report Series).

2. Guh DP, Zhang W, Bansback N, Amarsi Z, Birmingham CL, Anis AH. The incidence of co-morbidities related to obesity and overweight: a systematic review and meta-analysis. BMC Public Health. 2009;9(1):88. http://doi.org/10.1186/1471-2458-9-88. PMid:19320986.

3. Guo Y, Yue XJ, Li HH, Song ZX, Yan HQ, Zhang P, et al. Overweight and obesity in young adulthood and the risk of stroke: a meta-analysis. J Stroke Cerebrovasc Dis. 2016;25(12):2995-3004. http://doi.org/10.1016/j.jstrokecerebrovasdis.2016.08.018. PMid:27618195.

4. Bendor CD, Bardugo A, Pinhas-Hamiel O, Afek A, Twig G. Cardiovascular morbidity, diabetes and cancer risk among children and adolescents with severe obesity. Cardiovasc Diabetol. 2020;19(1):79. http://doi.org/10.1186/s12933-020-01052-1.

5. d'Errico M, Pavlova M, Spandonaro F. The economic burden of obesity in Italy: a cost-of-illness study. Eur J Health Econ. 2022;23(2):177-92. http://doi.org/10.1007/s10198-021-01358-1. PMid:34347176.

6. IBGE: Instituto Brasileiro de Geografia e Estatística. Coordenação de Trabalho e Rendimento. Pesquisa Nacional de Saúde: 2019: atenção primária à saúde e informações antropométricas. Rio de Janeiro: IBGE; 2020.

7. Global Burden of Disease Collaborative Network. Global Burden of Disease study 2019 (GBD 2019). Seattle: Institute for Health Metrics and Evaluation (IHME); 2021.

8. Nilson EAF, Santin Andrade RC, Brito DA, Oliveira ML. Costs attributable to obesity, hypertension, and diabetes in the Unified Health System, Brazil. Rev Panam Salud Publica. 2018;44:e32. http://doi.org/10.26633/RPSP.2020.32.

9. Mrejen M, Cruz MV, Rosa L. O Sistema de Vigilância Alimentar e Nutricional (SISVAN) como ferramenta de monitoramento do estado nutricional de crianças e adolescentes no Brasil. Cad Saude Publica. 2023;39(1):e00169622. http://doi.org/10.1590/0102-311xpt169622. PMid:36856228.

10. Boutari C, Mantzoros CSA. A 2022 update on the epidemiology of obesity and a call to action: as its twin COVID-19 pandemic appears to be receding, the obesity and dysmetabolism pandemic continues to rage on. Metabolism. 2022;133:155217. PMid:35584732.

11. Ammar A, Brach M, Trabelsi K, Chtourou H, Boukhris O, Masmoudi L, et al. Effects of COVID-19 home confinement on eating behaviour and physical activity: Results of the ECLB-COVID19 international online survey. Nutrients. 2020;12(6):1583. http://doi.org/10.3390/nu12061583. PMid:32481594.

12. Brasil. Ministério da Saúde. Sistema de Vigilância Alimentar e Nutricional – SISVAN. SISVAN-WEB [Internet]. Brasília: Ministério da Saúde; 2022 [cited 2022 Oct 20]. Available from: https://sisaps.saude.gov.br/sisvan/relatoriopublico/index

13. WHO: World Health Organization. WHO Expert Committee. Physical status: the use and interpretation of anthropometry. Geneva: WHO; 1995.

14. McKinney W. Data structures for statistical computing in Python. In: Proceedings of the 9th Python in Science Conference (SciPy 2010); 2010; local. Austin, Texas. Proceedings. SciPy; 2010. vol. 445.

15. Hunter JD. Matplotlib: a 2D graphics environvent. Comput Sci Eng. 2007;9(3):90-5. http://doi.org/10.1109/MCSE.2007.55.

16. Waskom ML. Seaborn: statistical data visualization. J Open Source Softw. 2021;6(60):3021. http://doi.org/10.21105/joss.03021.

17. IBGE: Instituto Brasileiro de Geografia e Estatística. Malha municipal. Rio de Janeiro: IBGE; 2021.

18. WHO: World Health Organization. Obesity and overweight [Internet]. 2021 [cited 2023 May 25]. Available from: https://www.who.int/en/news-room/fact-sheets/detail/obesity-and-overweight

19. WOF: World Obesity Federation. World obesity atlas 2023 [Internet]. London: WOF; 2023 [cited 2023 May 25]. Available from: www.johnclarksondesign.co.uk

20. WOF: World Obesity Federation. Obesity: missing the 2025 global targets. London: WOF; 2020. 242 p. [cited 2023 May 25]. Available from: https://data.worldobesity.org/publications/WOF-Missing-the-2025-Global-Targets-Report-FINAL-WEB.pdf

21. Costa CS, Steele EM, Leite MA, Rauber F, Levy RB, Monteiro CA. Body weight changes in the NutriNet Brasil cohort during the COVID-19 pandemic. Rev Saude Publica. 2021;55:1. http://doi.org/10.11606/s1518-8787.2021055003457.

22. Meller FO, Schäfer AA, Bianca LV, Viero VSF, Saes-Silva E, Quadra MR, et al. Home office is associated with weight gain during the Covid-19 pandemic: Brazilian population-based studies [Internet]. Ciência e Saúde Coletiva; 2023 [cited 2023 May 25]. Available from: http://cienciaesaudecoletiva.com.br/artigos/home-office-is-associated-with-weight-gain-during-the-covid19-pandemic-brazilian-populationbased-studies/18978?id=18978

23. Lee MN, Choi YS, Kim SD. The leading factors of obesity and severe obesity in Korean adults during the COVID-19 pandemic. Int J Environ Res Public Health. 2022;19(19):12214. http://doi.org/10.3390/ijerph191912214. PMid:36231516.

24. Restrepo BJ. Obesity prevalence among U.S. adults during the COVID-19 pandemic. Am J Prev Med. 2022;63(1):102-6. http://doi.org/10.1016/j.amepre.2022.01.012. PMid:35725124.

25. Bakaloudi DR, Barazzoni R, Bischoff SC, Breda J, Wickramasinghe K, Chourdakis M. Impact of the first COVID-19 lockdown on body weight: a combined systematic review and a meta-analysis. Clin Nutr. 2022;41(12):3046-54. http://doi.org/10.1016/j.clnu.2021.04.015. PMid:34049749.

26. Park AH, Zhong S, Yang H, Jeong J, Lee C. Impact of COVID-19 on physical activity: a rapid review. J Glob Health. 2022;12:05003. http://doi.org/10.7189/jogh.12.05003. PMid:35493780.

27. Faria TMTR, Silva AG, Claro RM, Malta DC. Time trends and COVID-19 post-pandemic changes in physical activity and sedentary behavior prevalence among Brazilian adults between 2006 and 2021. Rev Bras Epidemiol. 2023;26(Suppl 1):e230011. http://doi.org/10.1590/1980-549720230011.supl.1.

28. Prado WL, Lofrano-Prado MC, Christofaro DGD, Santana CCA, Cucato GG, Jackson M, et al. The effects of COVID-19 stay-at-home orders on physical activity of people with obesity. Einstein. 2022;20:eAO6727. http://doi.org/10.31744/einstein_journal/2022AO6727. PMid:35476088.

29. Clemmensen C, Petersen MB, Sørensen TIA. Will the COVID-19 pandemic worsen the obesity epidemic? Nat Rev Endocrinol. 2020;16(9):469-70. http://doi.org/10.1038/s41574-020-0387-z. PMid:32641837.

30. ACT Promoção da Saúde. Na pandemia, consumo de ultraprocessados quase dobra em faixa etária com maior risco [Internet]. 2020 [cited 2023 May 25]. Available from: https://actbr.org.br/post/na-pandemia-consumo-de-ultraprocessados-quase-dobra-em-faixa-etaria-com-maior-risco/18691/

31. IDEC: Instituto de Defesa do Consumidor. Pandemia: aumento de consumo de ultraprocessados pelo Brasil [Internet]. 2021 [cited 2023 May 25]. Available from: https://idec.org.br/noticia/pandemia-aumento-de-consumo-de-ultraprocessados-pelo-brasil

32. Menezes-Júnior LAA, Andrade ACS, Coletro HN, Mendonça RD, Menezes MC, Machado-Coelho GLL, et al. Food consumption according to the level of processing and sleep quality during the COVID-19 pandemic. Clin Nutr ESPEN. 2022;49:348-56. http://doi.org/10.1016/j.clnesp.2022.03.023. PMid:35623836.

33. Malta DC, Szwarcwald CL, Barros MBA, Gomes CS, Machado IE, Souza PRB Jr, et al. A pandemia da COVID-19 e as mudanças no estilo de vida dos brasileiros adultos: um estudo transversal, 2020. Epidemiol Serv Saude. 2020;29(4):e2020407. http://doi.org/10.1590/s1679-49742020000400026. PMid:32997069.

34. Myers CA, Broyles ST. Fast food patronage and obesity prevalence during the COVID-19 pandemic: an alternative explanation. Obesity. 2020;28(10):1796-7. http://doi.org/10.1002/oby.22993. PMid:32741130.

35. Oliveira LV, Rolim ACP, Silva GF, Araújo LC, Braga VAL, Coura AGL. Modificações dos hábitos alimentares relacionadas à

pandemia do COVID-19: uma revisão de literatura. Braz J Health Rev. 2021;4(2):8464-77. http://doi.org/10.34119/bjhrv4n2-367.

36. Costa DVP, Lopes MS, Mendonça RD, Malta DC, Freitas PP, Lopes ACS. Food consumption differences in Brazilian urban and rural areas: the National Health Survey. Cien Saude Colet. 2021;26(Suppl 2):3805-13. PMid:34468674.

37. WHO: World Health Organization. Statement on the fifteenth meeting of the IHR (2005) Emergency Committee on the COVID-19 pandemic [Internet]. Geneva: WHO; 2023 [cited 2023 May 25]. Available from: https://www.who.int/news/item/05-05-2023-statement-on-the-fifteenth-meeting-of-the-international-health-regulations-(2005)-emergency-committee-regarding-the-coronavirus-disease-(covid-19)-pandemic

38. Lopes MS, Freitas PP, Carvalho MCR, Ferreira NL, Menezes MC, Lopes ACS. Is the management of obesity in primary health care appropriate in Brazil? Cad Saude Publica. 2021;37(Suppl 1):e00051620. http://doi.org/10.1590/0102-311x00051620. PMid:34932618.

39. Magalhães IF, Teixeira RA. Avaliação da implantação do SISVAN em municípios da jurisdição da superintendência regional de saúde de Diamantina/MG. Diamantina: Universidade Federal dos Vales do Jequitinhonha e Mucuri; 2019.

Supplementary Material

Supplementary Table 1. Prevalence of obesity in the adult population assisted in Primary Health Care according to the Federative Unit, Brazil, 2021.

Supplementary Table 2. Projections of prevalence and annual growth of obesity (BMI ≥ 30 kg/m^2) in different scenarios, in Brazil and Brazilian geographical regions. Data presented in mean and 95% confidence interval.

Supplementary Figure 1. Prevalence of A) overweight (BMI ≥ 25 kg/m^2) and B) obesity (BMI ≥ 30 kg/m^2) in the adult population assisted in primary health care by federative unit, Brazil, 2021.

Supplementary Figure 2. Prevalence of A) overweight (BMI ≥ 25 kg/m^2) and B) obesity (BMI ≥ 30 kg/m^2) in the adult population assisted in primary health care by geographical region, Brazil, 2021.

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