REVISTA DE NUTRIÇÃO
Brazilian Journal of Nutrition

DOSSIER

Food Insecurity, Hunger and Obesity in contemporaneous Brazil

Editor
Francisco de Assis Guedes de Vasconcelos

Support
Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) (Edital Universal 2018, process nº 423174/2018-5); *Fundação Carlos Chagas de Apoio à Pesquisa do Estado do Rio de Janeiro* (FAPERJ) (Edital APQ1 2019 process in E-26/10.001596/2019). *Fundação Coordenação de Aperfeiçoamento de Pessoal de Nível Superior* (Capes) (Process n° 88887.363839/2019-00).

Conflict of interest
The authors declare that there are no conflicts of interest.

Received
June 7, 2023

Final version
November 1, 2023

Approved
November 14, 2023

Exploratory analysis of the association between stature, obesity, and food insecurity in adults of the National Dietary Survey 2017-2018

Análise exploratória da associação entre estatura, obesidade e insegurança alimentar em adultos no Inquérito Nacional de Alimentação 2017-2018

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Article elaborated from dissertation by TB DOMINGOS, entitled "*Análise do status de peso da população brasileira exposta a insegurança alimentar*". Universidade Federal do Rio de Janeiro; 2023.

How to cite this article: Domingos TB, Sichieri R, Salles-Costa R. Exploratory analysis of the association between stature, obesity and food insecurity in adults of the National Dietary Survey 2017-2018. Rev Nutr. 2024;37:e230113. https://doi.org/10.1590/1678-9865202437e230113

ABSTRACT

Objective
Evaluate short stature as a possible explanation for obesity, and identify if consumption of energy, protein, carbohydrate, and lipids were associated to higher risk for obesity in Brazilian adults (20-59 y) living in household food insecurity.

Methods
Cross-sectional study from 2017/2018 Household Budget Survey (N=28,112). Food insecurity was measured with the Brazilian Household Food Insecurity Measurement Scale. Short stature was used as an indicator of malnutrition at the beginning of life, which characterizes metabolic alterations resulting from the presence of food insecurity (cuts off women ≤149cm; men ≤160cm). Body mass index (kg/m^2) was estimated from self-reported weight and body height. The average food intake was estimated from a 24-hr recall. The weighted means and standard error of the food security/insecurity categories were assessed according to height, mean energy intake and protein(g), carbohydrate(g) and lipids(g) intake, stratified by gender and nutritional status.

Results
Both men and women with obesity and food insecurity had significantly lower average height in comparison with those in food security status (p-value <0.01). The prevalence of obesity 1 (BMI 30-34.9kg/m^2) increased significantly with the food insecurity among women. There was a trend towards short stature among obese women from families with food insecurity, as well as lower intake of energy. Among both men and women, the lowest intakes of protein and the highest intake of carbohydrates were observed in the underweight group (BMI <18.5kg/m^2).

Conclusion
In women, the risk of obesity may depend on the metabolic background, since who presents food insecurity and develop obesity have low stature and lower energy intake.

Keywords**:** Adult. Body height. Body mass index. Brazil. Food insecurity. Obesity.

RESUMO

Objetivo
Avaliar a baixa estatura como possível explicação para a obesidade, e identificar se o consumo de energia, proteína, carboidrato e lipídios esteve associado ao maior risco de obesidade em adultos brasileiros (20-59 anos) que vivem em domicílios em insegurança alimentar domiciliar.

Métodos
Estudo transversal realizado com dados da Pesquisa de Orçamentos Familiares 2017/2018 (N=28.112). A Insegurança alimentar domiciliar foi medida pela Escala Brasileira de Insegurança Alimentar. A baixa estatura (mulheres ≤149cm; homens ≤160cm) foi utilizada como indicador de alterações metabólicas decorrentes da presença de insegurança alimentar. O índice de massa corporal (kg/m²) foi estimado a partir do peso e altura autorreferidos. A média de ingestão alimentar foi estimada a partir do recordatório de 24 horas. As médias ponderadas e o erro padrão das categorias de segurança/insegurança alimentar foram avaliadas segundo estatura, médias de ingestão energéticas e de proteínas(g), carboidratos(g) e lipídios(g), estratificado por sexo e estado nutricional.

Resultados
Homens e mulheres com obesidade e insegurança alimentar apresentaram a média de estatura significativamente menor em comparação aqueles com segurança alimentar (p-valor <0,01). A prevalência de obesidade 1 (índice de massa corporal 30-34,9Kg/m²) aumentou significativamente com a insegurança alimentar entre as mulheres. Houve tendência de baixa estatura entre mulheres obesas de famílias com insegurança alimentar, bem como menor ingestão de energia. Entre homens e mulheres, a menor ingestão de proteína e a maior ingestão de carboidratos foram observadas no grupo de baixo peso (índice de massa corporal <18,5Kg/m²).

Conclusão
Nas mulheres, o risco de obesidade pode depender do metabolismo, pois quem apresenta insegurança alimentar e desenvolve obesidade possui baixa estatura e menor ingestão energética.

Palavras-chave**:** *Adulto. Estatura. Índice de massa corporal. Brasil. Insegurança alimentar. Obesidade.*

INTRODUCTION

In Brazil, data from the last National Health Survey showed the presence of high rates of obesity in the adult population (25.9%), with a higher prevalence of obesity among women (29,5%) than among men (21.8%) [1]. Additionally, studies demonstrate the increase of overweight and obesity in low-income populations [2], and among those living in household with Food Insecurity (FI) in Brazil [3,4].

The FI is defined as the lack of access to a sufficient nutritious food [5]. A direct estimative of FI reflects collective and individual hunger experiences, concern, or deprivation access to sufficient and quality food to maintain a healthy life, related to poor quality of the diet [6,7].

The FI is one of the most serious social and public health challenges to be faced [8]. In Brazil, according to the *II Inquérito Nacional sobre Insegurança Alimentar no Contexto da Pandemia da COVID-19 no Brasil* (VIGISAN, II National Survey on Food Insecurity in the Context of the COVID-19 Pandemic in Brazil) 125 million Brazilian men and women are living in an FI condition, with 33 million people experiencing hunger [9]. Impacts being more felt according to markers of gender, race and ethnicity, income, education, regional and territorial contexts [10,11].

The FI is, therefore, considered an important public health problem due to the link between undernutrition and obesity [12]. Some research reinforced that children living in households with severe levels of FI were more propensity of adverse effects on the health [13]. This is done due to the importance of adequate nutrition in the growth and development of early childhood, whether by offering energy or nutrients, a fact that does not occur in families that live with hunger and that has violated the human right to adequate food [14].

Undernutrition early in life may increase the risk of obesity, and short stature is a marker of inadequate development in the first years of life [15-17]. Stature acts as a proxy for metabolic capacity [18]. The intergenerational growth cycle, where children who suffered pregnancy malnutrition and/or in early childhood tend to have a shorter stature in adulthood, in other words, the malnutrition process can perpetuate [19].

Early malnutrition reduces energy requirements and nervous system changes that can facilitate fat accumulation [20,21]. Said-Mohamed et al. [22] and Hoffman et al. [23] indicate that individuals who suffered food deprivation in the first years of life had a reduction in the lipid oxidation rate, a risk factor for the accumulation of body fat, predisposing low body height individuals to obesity [24].

In Brazil, the coexistence of short stature and high Body Mass Index (BMI) has been described [16,25], especially in women [2,26]. Prevalence of FI in the Brazilian population has been increasing since 2018 and its consequences related to the poverty and impacts on the health are still underexplored [11,27]. The present study aimed to evaluate short stature as a possible explanation for obesity among adults living in FI households in Brazil, and identify if consumption of energy, protein, carbohydrate, and lipids was associated with a higher risk for obesity in this population.

METHODS

The present cross-sectional study was based on the National Dietary Survey (NDS), which was subsample of 2017-2018 Household Budget Survey by the *Instituto Brasileiro de Geografia e Estatística* (IBGE, Brazilian Office of Geography and Statistics) [28]. The study adopted a two-stage cluster sample design. In the first stage, census tracts were randomly selected; in the second stage, households were selected by simple random sampling within census tracts. Census tracts were grouped into household strata with geographical and socioeconomic homogeneity, and the number of tracts in each stratum was proportional to the number of households in the stratum. Household visits in each stratum were uniformly distributed throughout the 12 months to encompass seasonal food intake and prices variations. The sample represents five regions of the country (North, Northeast, Southeast, South, and Midwest), urban and rural areas, and different socioeconomic levels. The number of households selected was 20,112, and all individuals aged 10 years or older (46,164) were included in the dietary survey. This paper included only adults (20-59 years old) and excluded pregnant and lactating women. The final sample considered of 28,112 individuals (60.9% of the total sample).

For this research, data regarding body height, energy consumption, protein, carbohydrate, lipids, and nutritional status (BMI) were analyzed. The stature (m) was included as a 'proxy' for undernutrition early in life, being considered using the cutoff points described by Sichieri et al. [25], were short stature ≤149cm for women and ≤160cm for men.

Dietary Assessment

Dietary data were collected using 24-h recalls. Trained interviewers met residents face-to-face and used portable computers for registration and data entry. The database was subjected to data quality control to assess the coherence of the information by trained technical staff. Further details of the sample design, the total number of Primary Sampling Unit (PSUs) interviewed by states, data quality control, and the imputation of variables are described in the IBGE official report [28].

The residents selected for the subsample of the *Pesquisa de Orçamentos Familiares* (POF) 2017-2018 who answered the personal food consumption block were asked, in personal interviews, about all the food and drinks (including water) consumed on the previous day in each of the two interviews. The interviews were carried out on non-consecutive days chosen during the week when the interviewer was at home to capture all the modules of the POF 2017-2018. In this study, the authors considered only the first day of the interviews. The computerized data entry program for food records contains a database (food and beverage record) of 1,832 items. If the interviewee cited any item that was not on the list, the research agent could include it. For specific items, details of the method of preparation were requested, given that the method of preparation can change the nutritional composition of the food.

For analysis of the amount and nutritional composition of the additions, the options of oil, butter/margarine, mayonnaise, cheese and cream were considered as fat-based. When reported, they could add a maximum of 20% of the consumption, in grams, of the food to which they were added. The additions of sugar, honey, molasses, ketchup, mustard, and soy sauce represented a maximum of 10% of the consumption of the item. That is, if ketchup and mustard were added to a sandwich, each addition represents 5% of the sandwich weight. For sweeteners, only the frequency of consumption was recorded. At the end of the registration, the research agents were instructed to review the report of food consumed with the interviewee.

Based on this information, the consumed amount of each food item was estimated based on the participant's reports and by coding the quantities referred to in measures of mass and volume, based on standardized procedures as described by Bezerra et al. [29].

In this study, food intake was assessed using means of energy (kcal), protein (g), carbohydrate (g), lipids (g), among men and women of food security and all categories of food insecurity by nutritional status, estimated from the first 24-hr recall. To estimate the mean intake of a population, only a single 24-hr recall is necessary in populations study [30].

Nutritional Status

The participants body mass index (BMI, kg/m^2) was calculated based on their self-reported weight and body height. Prior studies have established the reliability and validity of self-reported body height and weight data among in Brazil and in other countries [31-33].

Using the World Health Organization cutoff points [34], BMI was classified into the following categories: underweight (BMI <18.5kg/m^2), normal weight (BMI 18.6–24.9kg/m^2), overweight (BMI 25–29.9kg/m^2), obesity grade 1 (BMI 30–34.9kg/m^2), obesity grade 2 (BMI 35– 39.9kg/m^2) and obesity grade 3 (BMI ≥40kg/m^2).

Assessment of Household Food Insecurity

The *Escala Brasileira de Insegurança Alimentar* (EBIA, Brazilian Household Food Insecurity Measurement Scale) was used to classify households into the following mutually exclusive Food Security (FS) or FI categories using recommended cutoff point for households: FS (when the family/household has regular and permanent access to quality food at adequate amount); mild FI (concern or uncertainty about access to food in the future); moderate FI (quantitative reduction of food among adults and/or disruption in eating patterns resulting from a lack of food among adults); and severe FI (quantitative reduction of food among adults and among those under 18 years of age, that is, disruption in eating patterns resulting from a lack of food among all residents; in this situation, hunger becomes a lived experience at home) [35]. The EBIA consists of 14 dichotomous questions ('yes' or 'no'), including eight items that apply only to households with adults (19 years old or more) and six items that apply to households with children and/or adolescents [35]. The scale was completed by the reference person in the family responsible for the purchasing and preparation of meals.

The analyses describe the population on sociodemographic characteristics, including information about self-reported sex (men; woman), age (20–29.9; 30–39.9; 40–49.9; 50–59.9), years of schooling (≤4, 5–8, ≥9) and geographical region (North, Northeast, Southeast, South, Midwest). These variables were selected and categorized based on a previous study using the same study population, which observed a significant relationship between education level and place of residence (geographical region and place of households) with overweight [3] and food intake [25].

Weighted point prevalence and standard error were estimated for socioeconomic variables characteristics (stature, age, years of schooling, and geographical regions) using the χ^2 test to compare the relationship according to FS/FI strata and nutritional status by sex. The expanded prevalence for nutritional status (underweight, normal weight, overweight and obesity) was also evaluated according to FS levels (mild FI, moderate FI, severe FI), stratified by sex. To assess whether there is a tendency for obesity to increase with increasing FI among men and women, we tested the tendency for increased prevalence in the FI categories (*p*-value of trend).

Further analysis was conducted to compare men and women of FS and all categories of FI. For this analysis, the FI categories were added (mild, moderate, and severe), being evaluated the weighted mean and Standard Error (SE) of stature, energy intake, and macronutrients intake (protein, carbohydrate, lipids) stratified by sex and nutritional status. The average consumption of macronutrients was related to the amount in grams ingested by the individuals. The percentage of intake that the mean in grams corresponded to the total calorie intake (%kcal) of the group was also analyzed.

Weighted estimates considered the complex sample design using 'svy' commands in Stata 16.

RESULTS

The prevalence of severe FI was highest among short-stature men, aged between 20 and 29.9 years old, with four or fewer years of education. Prevalence was also higher among those who lived in the North region of Brazil. The prevalence of severe FI was similar among men and women (15.8%). Regarding education, for both men and women, the lowest prevalence of FI, was among individuals who attended nine or more years of study. Southeast had the lowest prevalence of all forms of FI (Mild, Moderate and Severe), in both sex (Table 1).

Table 1 – Sample size, prevalence of household food insecurity[1] (%) according to sociodemographic characteristics and sex. National Dietary Survey (NDS). Brazil, 2017-2018.

Sociodemographic characteristics	Men				p^2	Woman				p^2
	Sample size	Food Insecurity				Sample size	Food Insecurity			
		Mild	Moderate	Severe			Mild	Moderate	Severe	
Stature										
Short stature[3]	1,143	32.6	14.8	11.7	<0.01	575	31.5	15.9	11.5	<0.01
Normal stature[4]	12,174	25.7	8.3	4.1		14,215	27.9	8.6	4.3	
Age										
20-29.9	3,402	26.3	10.2	5.4		3,249	30.0	8.5	3.9	
30-39.9	3,657	31.3	7.2	4.1	<0.01	3,927	31.4	7.2	3.8	<0.01
40-49.9	3,249	25.0	8.8	5.1		4,020	26.5	9.7	5.5	
50-59.9	3,009	20.8	8.8	4.0		3,599	24.2	9.9	4.8	
Years of schooling										
≤4	2,199	30.7	15.8	10.5	<0.01	1,941	30.5	17.2	12.4	<0.01
5-8	3,068	29.3	11.7	6.9		3,008	31.7	10.8	7.5	
≥9	8,050	24.4	6.5	2.8		9,846	26.7	7.0	2.3	
Geographical region										
North	2,031	30.1	16.3	13.6		2,090	35.7	18.2	10.3	
Northeast	4,494	30.9	13.9	7.5	<0.01	5,214	33.0	14.3	7.2	<0.01
South	3,319	25.4	6.3	2.3		3,697	27.4	6.0	2.5	
Southeast	1,753	18.3	2.9	1.6		1,940	17.9	3.2	2.3	
Midwest	1,720	24.7	7.4	4.1		1,854	25.8	6.5	4.9	

Note: [1] According to the Brazilian Household Food Insecurity Measurement Scale [35]; [2] *p*-values refer to the χ^2 test for differences in proportions; [3] ≤149 cm for women and ≤160 cm for men, according to Sichieri et al. [25]; [4] ≥150 cm for women and ≥161 cm for men, according to Sichieri et al. [25].

Table 2 shows the prevalence of the nutritional status categories according to the FS/FI strata and sex. The weighted prevalence of underweight was lower than 6%, and increased with the severity household FI, for both men and women. The prevalence of obesity increased significantly with the severity household FI among women but not among men.

Table 2 – Sample size, prevalence (%) and *p*-value of trend of underweight, overweight, obesity grade 1 and obesity grades 2+3, according to food security and food insecurity levels[1] by sex. National Dietary Survey (NDS). Brazil, 2017-2018.

Food security / insecurity levels	Sample size	Underweight	*p*-value of Trend	Normal weight	*p*-value of Trend	Overweight	*p*-value of Trend	Obesity[1]	*p*-value of Trend	Obesity 2+3	*p*-value of Trend
Men											
Food security	7,623	1.4		37.1		44.1		13.7		3.8	
Mild insecurity	3,593	1.3	<0.01	42.1	<0.01	41.4	<0.01	12.0	<0.01	3.2	<0.01
Moderate insecurity	1,309	2.3		46.6		37.4		10.7		3.2	
Severe insecurity	792	4.2		52.1		31.8		10.9		1.1	
Woman											
Food security	8,230	2.7		46.4		35.4		12.1		3.4	
Mild insecurity	4,238	2.4	<0.01	42.7	<0.01	35.5	<0.01	13.2	<0.01	6.2	<0.01
Moderate insecurity	1,462	4.2		39.5		37.1		12.9		6.3	
Severe insecurity	865	5.6		40.9		32.1		15.5		6.0	

Note: [1] According to the Brazilian Household Food Insecurity Measurement Scale [35].

To further explore the sex differences, the average stature and ingestion of some nutrients related to obesity were explored in men and women of food security and all categories of FI by nutritional status (Table 3). In men, the stature decreased with the increase in BMI categories, only for men from FI families. Among women, a trend towards lower average height was observed with the increase in BMI categories, but the trend towards lower average height was greater among those from FI families than those from FS. Comparing the trend for energy intake, it increased for males and decreased for females. Thus, women with obesity had the lowest energy intake. Among both men and women, the lowest intakes of protein and the highest intake of carbohydrates in

percentage of energy intake were observed in the underweight group, independently of the FS/FI status (Table 3).

Table 3 – Weighted mean and standard Error (SE) of stature, energy and nutrient intake (%kcal) among men and women of food security and all categories of food insecurity by nutritional status. National Dietary Survey (NDS). Brazil, 2017-2018.

Stature and ingestion of nutrients	Men						Woman					
	Underweight		Overweight		Obesity		Underweight		Overweight		Obesity	
	Means	SE	Means	SE	Means	SE	Means	SE	Means	SE	Means	SE
Food Security												
Stature (m)	1.73	0.0	1.73	0.0	1.73	0.0	1.65	0.0	1.62	0.0	1.60	0.0
Energy (kcal)	1,937	117.3	2,038	24.3	1,996	40.6	1,682	72.2	1,553	19.9	1,520	28.5
Protein (g) % kcal	82.1 17.0	6.4	95.2 18.7	1.3	97.1 19.5	2.1	74.0 17.6	4.4	69.8 18.0	1.0	69.9 18.4	1.4
Carbohydrate (g) % kcal	275.0 56.8	17.8	262.9 51.6	3.6	251.2 50.3	6.4	232.9 55.4	11.4	203.6 52.4	2.7	200.3 52.7	3.9
Lipids (g)%kcal	61.6 28.6	4.2	69.4 30.6	1.1	68.6 30.9	1.6	54.9 29.4	3.0	54.1 31.4	0.9	52.1 30.8	1.4
Food Insecurity												
Stature (m)	1.73	0.0	1.71	0.0	1.70	0.0	1.62	0.0	1.60	0.0	1.59	0.0
Energy (kcal)	1,777	83.8	1,976	28.8	1,996	45.3	1,537	60.1	1,520	24.5	1,480	29.6
Protein (g) % kcal	78.5 17.7	3.9	94.4 19.1	1.9	94.1 18.9	2.6	63.0 16.4	2.9	70.1 18.4	1.3	67.8 18.3	1.6
Carbohydrate (g) % kcal	253.1 57.0	12.9	261.1 52.8	3.9	264.4 53.0	6.1	220.8 57.4	9.5	202.3 53.2	3.3	201.9 53.1	4.7
Lipids (g) % kcal	53.1 26.8	3.3	65.2 29.7	1.1	65.3 29.4	1.8	48.1 28.2	2.7	51.2 30.3	1.0	47,3 28.0	1.0

DISCUSSION

The findings in the present study suggest, after exploratory analysis, that the risk of obesity among women with FI may be related to short stature. The mean stature was lower among women with obesity and from FI families, and these women also reported the lowest energy intake. Short stature is a marker for early-in-life undernutrition [15-17], and in a large Brazilian survey conducted in the urban areas of twenty-six state capitals and the federal district, Sichieri et al. [25] reported that the odds of being obese were strongly associated with short stature. Accordingly, the authors, among women with short stature, the odds of being obese was 3 times higher than among women with a stature greater than the 5th percentile after adjusting for diet, physical activity, and some environmental factors.

Another study, accomplished with woman in Quilombola communities in Brazil, shows results similar to the one seen by us, where short stature was significantly associated with excess body weight but not with a high energy intake [16]. Quilombola communities have high discrimination and exclusion, that impose socioeconomic conditions that place them at a risk of food insecurity [16], as well as our study population.

Reinhardt and Fanzo [36] also found that children who experienced stunting early in life and who remained stunted had a higher chance of developing overweight in adulthood. Among girls with stunting in Brazil, a low metabolic rate was observed by Hoffman et al. [23], suggesting a possible pathway to explain the association of household FI and obesity among women in the present study, since they had quite similar energy intake but a low average stature.

Comparing our data with previous analysis performed on the same sample (NDS), adults from households with FI reported lower energy intake than the overall adult population [37]. The overall mean energy intake, according to NDS, for men was 2,023 kcal, compared to 1,777 kcal among underweight men with FI and 1,996 kcal among men with obesity and FI. For women, the overall mean was 1,568 kcal, 1,537 kcal among underweight women, and 1,480 kcal among those with obesity and FI. We add that in our study, the energy intake of women with FI and obesity was even lower compared than women with obesity and FS. Therefore, data on short stature and energy intake, mainly among women, suggest that obesity is related to energy balance among individuals from disadvantaged and poor populations.

For the other dietary markers, there were no considerable differences between our participants and the overall adult population [37]. The percentage of energy from protein was 18.2% among women and 19.0% among men, in the overall adult population, and a greater difference was observed only among underweight women in our population, with a value of 16.4% energy from protein [37].

This study has some limitations. First, the data are cross-sectional, making it difficult to determine the temporality of some of the associations studied. Second, the EBIA evaluate FS score in the past 3 months, whereas nutritional outcomes, such as weight, and particularly, stature, accrue over much longer periods. However, the association of FS with all socio-economic indicators suggests that individuals classified as having FI are at chronic risk of scarcity. Other factors, within the causal network were also left unassessed.

Measurement error may result from using self-reported body height and weight to calculate BMI for the weight classification. However, prior studies have established the reliability and validity of self-reported body height and weight data in Brazil and in other countries [31-33].

Another limitation was considered in relation to the food intake report. In fact, it is also necessary to consider that overweight individuals who are dissatisfied with their body weight may be more likely to underreport their usual food intake when compared to those without excess weight and those satisfied with their body weight, respectively [38].

Additionally, the associations between body height and obesity can be confounded by other variables that we did not consider and may be involved in the causal network, such as genetics, one of the determinants of an individual having tall or short stature, and postpartum weight retention in women, which could be the reason for being overweight [39]. For this type of analysis, studies dealing with the subject are specific and were not addressed in this work.

CONCLUSION

Food insecure men and women who develop obesity have lower average stature. Still, in women the risk of developing obesity is possibly related to the metabolic background, since women with FI who develop obesity have a lower average stature and lower energy intake. In addition, stature decreases significantly as the FI severity increases in these women. Considering the limitation of national studies dealing with possible factors relating to the effects of FI on obesity among Brazilian women, this study presents results that attempt to explore the relationship of short stature in the debate on the causality of social inequalities related to FI identified by the EBIA.

More detailed studies should compare metabolic differences among men and women living in scarcity scenarios to understand the underlying mechanisms and moderators that contribute differently to the sex nutritional status.

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CONTRIBUTORS

TB DOMINGOS participated in data analysis, the manuscript concept and writing; R SICHIERI participated in the manuscript concept, supervision and revising; R SALLES-COSTA participated in the manuscript concept, supervision and revising. All authors: read and approved the final manuscript.