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Household Food Insecurity And Obesity Risk In An Urban Slum In Brazil

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HOUSEHOLD FOOD INSECURITY AND OBESITY RISK IN AN URBAN SLUM IN BRAZIL

By

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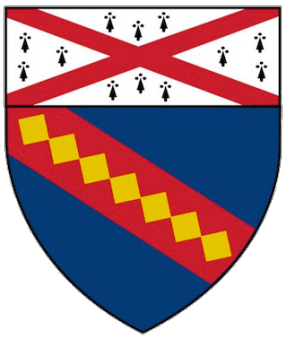

ABSTRACT

Background: The prevalence of obesity is growing among the poor. Household food insecurity (HFI) may partly explain this trend as individuals experiencing it may cope by consuming low-cost high calorie meals with little nutritive value. This study aimed to estimate the prevalence of HFI, identify its risk factors, and assess the relationship with obesity among adults in an urban slum community in Salvador, Brazil.

Design: This cross-sectional study interviewed participants at home to assess socioeconomic status, demographics, HFI (measured by the Brazilian Food Insecurity Scale (EBIA)), and health. Anthropometric measurements (height, weight, waist circumference) of each respondent were taken to assess obesity status. Per WHO guidelines, overweight/obesity was defined as BMI ≥ 25 kg/m^2, and abdominal obesity as > 88 cm for women and > 102 cm for men.

Participants/setting: A convenience sample of 171 adult respondents from a slum community in Salvador, Brazil, with ≥ 1 child < 18 years old were enrolled in the study. A total of 147 interviews were conducted with the individual responsible for food preparation.

Analysis: The association between HFI and obesity was examined after adjusting for demographic, socioeconomic and health variables. Logistic regression modeled the associations between severe HFI and overweight/obesity and abdominal obesity through adjusted odd ratios (aOR) with 95% confidence intervals (CI).

Results: The prevalence of HFI was 82.3%, with 38.1% of households experiencing mild, 23.8% moderate and 20.4% severe HFI. The odds of experiencing overweight/obesity were 2.31 times higher (95% CI 0.78-6.88) and the odds of abdominal obesity were 3.29 times higher (95% CI 1.02-10.51) among those severely HFI compared with less food insecure households.

Conclusions: Findings suggest the residents of households experiencing severe food insecurity, particularly women, are at an increased risk for both overweight/obesity and abdominal obesity.

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INTRODUCTION

When discussing food security, numerous and varied terms and facets are brought into the discussion in order to capture the complex nature of this multifaceted construct. The most commonly used definition was derived from the 1996 World Food Summit stating that "food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" [1]. The food security construct has four main dimensions: food availability, access, utilization and stability. Food availability refers to a food supply that is adequate for households to meet their dietary needs. It is driven by domestic production, imports and donations. Food access refers to the needs for households to have both physical and economic access to the food supply they need. Over the years, the food security field has shifted its attention from merely focusing on caloric adequacy to the importance of the quality of the overall diet. Food utilization refers to the consumption of a diet that supplies the energy and nutrient needs of the body. It is an important determinant of the individual's nutritional status. Adequate food utilization relies on proper food processing and consumption patterns. Finally, to achieve and sustain food security there must be stability in food availability, access and utilization across time [1-3].

Previous research has established a strong link between food insecurity and income level [4-6]. Low income is an important predictor for food insecurity, leaving poor families at high risk for poor health outcomes and potentially further jeopardizing the severity of the food insecurity they experience [7]. In addition to poverty, education level, race/ethnicity, participation in food assistance and social programs, household size and composition, maternal depression, and food availability, access and intake have all been shown to play a role in a household's risk of suffering food insecurity [7-11]. Like the vicious cycle of poverty and poor

health, food insecurity places individuals and households at risk for chronic diseases such as hypertension, diabetes, cardiovascular risk, child overweight status, dyslipidemia and developmental deficits, including both physical and cognitive detriments [7, 12-14]. These all affect social and mental well-being ultimately decreasing health status and quality of life of those experiencing food insecurity. Health is an economic asset of which poor and food insecure individuals are robbed, leading to poor economic development from the local to the national level [15].

Among Brazil's 190 million inhabitants, 21.4% lived in poverty in 2009 despite significant and somewhat successful efforts to reduce poverty in the country in recent years [16]. The number of food insecure among this 190 million exceeds the number living in poverty, indicating that food insecurity is not only the result of poverty, but of other factors as well. In 2009, 30.2% of Brazilian households, approximately 65.5 million people, lived in food insecure households. The northeastern region of Brazil, where the study community of Pau da Lima is located, is the region with the highest rates of HFI, with 46.1% of households suffering from food insecurity, compared to 23.3% and 18.7% in the wealthier southeastern and southern regions, respectively. In the state of Bahia, where Pau da Lima is located, 41.6% live in food insecure households, with 8.9% of these living in severely food insecure households [17].

Though food insecurity and insufficient dietary intake have been associated with malnutrition, traditionally it has been thought of as a risk factor for undernutrition rather than overnutrition. Over recent years, researchers have become increasingly interested in the food insecurity-obesity "paradox". This was first described by Dietz in 1995 when he posited the paradox that both obesity and food insecurity can coexist, as at the time the prevalence of both obesity and food insecurity was increasing within the same population. Obesity reflects

excessive energy intake and is a consequence of overconsumption while food insecurity reflects inadequate economic resources to obtain food resulting in diverse coping mechanisms that may range from sacrificing dietary quality to actually skipping meals and eventually going without food for a whole day. Thus, as Dietz stated, it seems paradoxical that both obesity and food insecurity can coexist within not only the same population but within a single household [18]. Since then, a number of studies have aimed to test this hypothesis and identify potential mechanisms to explain how food insecurity can lead to obesity [18-21]. Like food insecurity, overweight and obesity carry both health and economic consequences for both the individual and the nation. These effects include increased risk for poor cardiovascular health, diabetes, some cancers, dyslipidemia, stroke and gynecological problems, such as infertility, leading to premature death and substantial disability [22].

The prevalence of obesity in Brazil in 2009 was 14.8% for adults, 12.5% among men and 16.9% among women [23]. Although, these rates are not as high as those found in other middle income countries, the rate at which obesity has risen over the past 20 years is highly concerning. The prevalence of obesity for males has quadrupled and for females has doubled during the past two decades. If the obesity prevalence continues to increase at the current rate, by 2020 the obesity prevalence could match the current prevalence of the United States, where 1 in 3 adults are obese (35.7%) [24].

The current prevalence of overweight among adults in Brazil is alarming. In 2009, the prevalence of overweight among adults was 49%; 50.1% among men and 48% among women. Like obesity, overweight prevalence has risen dramatically over the past 20 years, tripling in men and rising from 28.7% to 48% among women [23].

Despite the coexistence of high rates of food insecurity and the rising rates of overweight/obesity in Brazil and other middle-income countries, the relationship between food insecurity and obesity risk remains understudied, particularly among urban slum dwellers. Pervious studies have documented an association between HFI and overweight/obesity among Brazilian adolescents and women [25-27]. However, those analyses were based on national data and not on studies specifically among urban slum dwellers. Addressing this population is key as rapid urbanization is resulting in a surge of urban slum populations in the context of the nutrition transition [28,29].

MATERIALS & METHODS

Study Population and Participant Sampling

This cross-sectional study took place from July 10th to August 20th, 2012 in the urban slum community of Pau da Lima/São Marcos, located on the periphery of the city of Salvador, the capital of the Brazilian northeastern state of Bahia. This community is a densely populated urban slum consisting of about 14,000 households, where approximately 55,000 individuals live. In 2011, the obesity rate in the city of Salvador was 11.1% [30]. However, to our knowledge no studies have examined the factors associated with obesity, including HFI, among Brazilian slum dwellers.

The community is made up of valleys and hills in an area spanning 0.46 km^2. A convenience sample was generated from a sample of households enrolled in an ongoing infectious disease cohort study in the community (Figure 1). The unit of study was the individual household respondent. Household respondents were included in the study if they met the following criteria based on demographic data obtained from the infectious disease cohort study: 1) participating in an ongoing infectious disease cohort study, 2) located in the urban slum valley

where this study was to be conducted, 3) contained at least one child less than 18 years of age living in the household during the study period. One adult per household who knew the most about the food situation in the home was selected as the intended survey respondent. A total of 171 respondents representing the same number of households were enrolled.

Each intended household respondents enrolled were visited at their homes a maximum of five times in attempts to locate them during the study period. Following five unsuccessful visits and attempts to locate the intended respondent the household was considered lost. If the intended household respondent no longer lived in the previously documented location, but was identified to have moved within the study valley, attempts were made to locate the new home. If the new location was not identified or had moved outside the study valley, it was considered lost.

The sample size was calculated based on a prevalence sample size calculation with a 95% confidence interval (CI), 7% precision margin, a 50% conservative prevalence estimate of household food insecurity (HFI) in the community (based on HFI data in the state of Bahia – 41.2% are household food insecure) [17], and a population of 482 (the total number of households in all community valleys with at least 1 child < 18 years of age). The calculation resulted in a target sample size of 140 households. In the actual sample, a total of 171 households were enrolled to account for expected attrition due to refusal of study participation as well as for losses due to inability to locate the intended survey respondent in the home during the study period.

Survey Measures

All data was collected through the administration of a survey during a home visit interview with the household respondent identified to be the main individual responsible for food preparation in the home. The survey consisted of four sections: respondent and household socio-

demographics, a food frequency questionnaire, family health and reporting of chronic diseases, and the Brazilian Household Food Insecurity Scale (EBIA). The demographics section obtained detailed information on household composition and characteristics of each member, including race/ethnicity, age, highest education level completed, and occupation, as well as socioeconomic data. Household socioeconomic status was determined through two measures: self-reported monthly household income and an indicator based on the Brazil's Economic Classification Criteria (CCEB). The total monthly income for each household was determined through the summation of the self-reported monthly income amount and the amount, if applicable, received from government assistance program Bolsa Família (a Brazilian conditional cash transfer program giving monetary assistance to low-income families who qualify and meet the conditions of participation ((i) a minimum school attendance of 85% of the monthly school hours for children 7-17 years old; (ii) a health and nutrition agenda for beneficiary families with pregnant women, nursing mothers or children under 7 years of age (pre-natal care, vaccination, health and nutrition surveillance))) [31]. CCEB is a 9-item instrument used to differentiate the population into 8 social classes by quantifying certain household characteristics and property, including, presence of a color television, radio, bathroom, automobile, housemaid, washing machine, video or DVD player, refrigerator and freezer (Appendix A). Each household material belonging or property was given a point value based on the quantity present in the home (for example: 1 car = 4 points, 2 cars = 7 points, 3 cars = 9 points and ≥ 4 cars = 9 points). To determine the household's final CCEB classification, first a score was given for the highest education level achieved by the head of household (for example: 'no education/up to 3rd grade complete = 0 points and '4th- 7th grade complete' = 1 point) and was added to the total 9-item summative score. Finally, based on the number of total points (9-item sum plus the education level point

value), each household was divided into one of 8 classes A1-E (A1 being the wealthiest and E being the poorest). Each of the 8 classes corresponds to an average household income in Brazil [32].

The family health section included a question on respondent's self-reported health status, and probed for the presence of eleven chronic diseases among household members: undernutrition, asthma, obesity, diabetes, hypertension, high cholesterol, depression, myocardial infarct/heart disease, stroke/cerebral vascular accident/cerebral hemorrhage, cancer, and chronic kidney disease. The previously validated Self-Rated Health Question (SRHQ) was used to evaluate the overall health status of the respondent. The SRHQ question asks, "In general, how would you considered your health status?" The respondents are presented with the following 5-item Likert scale response options: "very good", "good", "regular", "poor", and "very poor". The SRHQ has been applied extensively in national and global health surveys [33-35].

HFI was assessed using EBIA, an experience-based scale that is derived from the US Households Food Security Survey Module [36] and has previously been validated in Brazil [37-40]. EBIA is a 15-item survey, each with a dichotomous response (yes/no) questions that probes for various food insecurity experiences and behaviors during the previous 3-month period in response to economic constraints. Questions cover the gamut of the different levels of severity of the HFI experiences. These range from mere worry of running out of food to coping behaviors such as sacrificing dietary quality, diminishing and/or skipping meals and the gravest situation of going without food for a whole day. Questions are asked in reference to the respondent and any other adults in the household (9 items), as well as in reference to children in the home (6 items). A summative HFI score is computed for each EBIA item that is affirmed. Households are then

classified as either 'food secure' (score = 0), 'mild HFI' (score = 1-5); 'moderate HFI' (score = 6-10) or 'severe HFI' (score = 11-15) (Appendix B) [37].

Anthropometric Measurements

The outcome variables of overweight/obesity and abdominal obesity were quantified for each respondent through anthropometric measurements taken during the interview including height, weight and waist circumference. The weight and height of each respondent was assessed in duplicate and the average of the 2 measurements was used in the analyses. Body mass index (BMI) was then calculated using weight in kilograms and height in meters.

$$\text{BMI} = \frac{\text{weight (kg)}}{\text{height}^2\ (\text{m}^2)}$$

The BMI cut-off point for overweight/obese was ≥25 kg/m^2, as recommended by the World Health Organization (WHO) [41].

Waist circumference was measured to assess the risk of abdominal obesity. This variable was used in addition to BMI as abdominal adiposity predicts individual's risk for adverse chronic disease outcomes above and beyond the risk predicted by BMI alone [42]. Indeed, studies have shown that waist circumference is a convenient measure of central fat deposition [43] and potentially a better indicator than BMI for predicting risk of cardiovascular disease [44,45]. Those with high abdominal adiposity are at an increased risk for diabetes [46], hypertension [47], metabolic syndrome [48] and associated cardiovascular disease [43-45].

As with weight and height, the waist circumference of each respondent was evaluated through the average of 2 independent measurements. As recommended by WHO guidelines, the cut-off point for abdominal obesity based on waist circumference was >88 cm for females and >102 cm for males [49].

Data Collection and Management

A trained local research assistant administered and logged each survey electronically using the secure web-based research data capture application REDCap (Research Electronic Data Capture) hosted at the Gonçalo Moniz Center for Research, Oswaldo Cruz Foundation [50]. The data was entered into REDCap using a cellular telephone and saved to the protected Gonçalo Moniz Center for Research server via the cellular network. Paper surveys were used if the network was unavailable and when this occurred each was manually entered into the REDCap application by different two investigators for quality control. A second trained investigator accompanying the local research assistant obtained the anthropometric measurements of each respondent.

The study was approved by the Yale Human Investigation Committee and the Committee of Research Ethics of FIOCRUZ, Gonçalo Moniz Research Center, Brazil Ministry of Health. All subjects signed or fingerprinted an informed consent form upon agreement of study participation.

Statistical Analyses

Statistical analyses were performed using SAS version 9.2 (SAS Institute, Cary, NC). The final analytic sample was determined according to the enrollment and participation flow chart (Figure 2). Demographic, socioeconomic and health variables were examined to assess associations with HFI category in this community through analysis of variance for continuous variables and cross-tabulations for categorical variables. Chi-squared test or Fisher's exact test was used to determine statistical significance of cross-tabulations. P-values were reported for continuous variables and p for trends were reported for categorical variables. A p-value of ≤ 0.05 was considered statistically significant. Bivariate and multivariate analyses assessed the

association between the severest form of HFI, as it characteristically represents the presence of hunger, and the two outcome variables: overweight/obesity and abdominal obesity. Logistic regression using backward elimination was used to model the odds of overweight/obesity and abdominal obesity as a function of HFI. Logistic regression models were adjusted for age, race/ethnicity, education level, Bolsa Família enrollment, CCEB, smoking status, self-reported health status, total number of members living in the household, and number of children living in the household. These covariates were all initially included in the model from which backward elimination was run. Logistic regression results are expressed as adjusted odds ratio (aOR) and their corresponding 95% CI. Associations were deemed statistically significant if the 95% excluded the value of one.

RESULTS

Sample Characteristics

We were able to interview 147 out of the 171 households enrolled, yielding an 86.0% participation rate. Reasons for losses include study participation refusal (n = 2), the intended household respondent had moved out of the study valley (n = 17), the intended respondent was not found in the home during times of visit (n = 3), one respondent with mental incapacity, and one unreliable interview. Four out of five sampled households (82.3%) in the Pau da Lima/São Marcos community were food insecure with 56 households (38.1%) experiencing mild HFI, 35 households (23.8%) moderate HFI and 30 households (20.4%) severe HFI. Key characteristics of the sample are presented in Table 1 according to HFI level. A majority of the sample (79 respondents, 53.7%) identified themselves as black, followed by brown or of mixed race (63 respondents, 42.9%). Almost 60% (88 out of 147) of the respondents in the sample had less than an elementary education with only 23 respondents (15.7%) completing high school. Education

level was shown to be significantly associated with HFI (p=0.009), as among those with less than an elementary education, 24 respondents (27.3%) were severely food insecure compared to only 1 respondent (4.4%) among households where the respondent had a high school education. The mean daily per capita income (including any benefits from the social program Bolsa Família) among the community households was US$3.83. An inverse association was found between income and household food insecurity (p<.0001). Food secure households had almost triple the daily per capita income than those severely HFI, US$6.16 compared to $2.27 USD, respectively. On average, households were made up of an average of 1.9 individuals less than 18 years of age (SD = 1.3), with a significant association found between a greater number of children and a higher level of food insecurity severity (p=0.015).

Household Food Insecurity and Obesity

A majority of the sample was found to be overweight or obese (97 respondents, 67.8%). Figure 3 demonstrates the comparison of the prevalence of normal weight and overweight/obesity across food security levels in our community sample and Figure 4 demonstrates comparison in the prevalence of abdominal obesity across food security levels in our sample. In bivariate analysis, overweight/obese status was not statistically associated with HFI level, however a trend ($0.05 < p < 0.10$) was present between increasing overweight/obesity and increasing severity of HFI (p=0.065). Similar to overweight/obese status, the majority of the sample, 95 respondents, was classified as abdominally obese (66.4%). However, in contrast with overweight/obese status, the prevalence of abdominal obesity differed significantly across HFI severity levels (p=0.032).

Tables 2 and 3 list the bivariate ORs for the associations between HFI, covariates and the outcome variables overweight/obesity (Table 2) and abdominal obesity (Table 3). In bivariate

analyses, the odds of black respondents being overweight/obese were 2.27 times higher (95% CI 1.10-4.86) compared to their brown/mixed raced counterparts. Older age was a risk factor for both overweight/obese status and abdominal obesity. Among those ≥ 50 years of age, 85.2% were overweight/obese compared to 59.6% of those < 35 years of age (p=0.065); and 85.2% of those ≥ 50 years of age were abdominally obese compared to only 57.7% of those < 35 years of age (p=0.041). The odds of being overweight/obese were 3.90 times higher (95% CI 1.18-12.90) and the odds of being abdominally obese were 4.22 times higher (95% CI 1.28-13.94) among respondents ≥ 50 years. Twenty four out of twenty nine respondents (82.8%) living in severely food insecure households were overweight/obese compared to only 5 respondents (64.0%) not living in severely food insecure households (p=0.040). The odds of being overweight/obese were 2.70 times higher among those living in severely food insecure households (95% CI 0.96-7.60). The odds of being abdominally obese were 3.93 times higher (95% CI 1.28-13.94) among those living in severely food insecure households.

In the multivariate model, logistic regression was used to assess the independent association of HFI with overweight/obese status and abdominal obesity. The final model was adjusted for age, race/ethnicity, education level, Bolsa Família enrollment, CCEB, smoking status, self-reported health status, total number of members living in the household, and number of children living in the household (Tables 2 and 3, Figure 5 and 6). Even if HFI was not significantly associated with both outcome variables in the bivariate analyses, it was retained in both multivariate models as it is the key independent variable of interest. In the adjusted model for overweight/obese (Figure 5), the odds of black respondents being overweight/obese were 2.84 times higher (95% CI 1.31-6.17) compared to their brown/missed counterparts and the odds of those ≥ 50 years of age being overweight/obese were 4.65 times higher (95% CI 1.31-16.55)

compared to those < 35 years of age. The odds of being overweight/obese were 2.31 times higher (95% CI 0.78-6.88) among those living in severely food insecure households compared to living in households experiencing less than severe HFI.

Figure 6 shows the significant variables in the adjusted model for the risk of being abdominally obese. As with the overweight/obesity outcome, black race and older age of ≥ 50 years remained significantly correlated with the risk of abdominal obesity. The odds of black respondents being abdominally obese were 2.32 times higher (95% CI 1.08-5.02) compared to their brown/mixed counterparts and the odds of respondents ≥ 50 were 4.57 times higher (95% CI 1.29-16.14) than their younger counterparts aged < 35 years. In contrast to the overweight/obese outcome, severe HFI remained significant in the adjusted model. The odds of being abdominally obese were 3.29 times higher (95% CI 1.03-10.51) among those living in severely food insecure households compared to their counterparts living in less than severe food insecure households.

The Cronbach's alpha coefficient for EBIA was 0.92, supporting the internal validity of this food insecurity survey for future research use in the Pau da Lima/São Marcos community.

DISCUSSION

Historically in developing countries, obesity was considered a disease of the affluent, with studies demonstrating a higher prevalence among those of highest socioeconomic status (SES) [51] and lower SES being protective against obesity. However, this is has been shown to no longer be the case. As a country's gross national product increases, members of lower SES groups appear to increase their risk of obesity, with SES and obesity adopting an inverse relationship [52]. In addition to SES, higher levels of education appear to be protective against developing obesity [53]. No associations between SES or education and obesity were seen in our

study, perhaps due to the fact that in our sample there were no households in the top tiers of SES and there were almost no households where the respondent had a high level of education.

In Brazil between 1975 and 1989, obesity rates have increased across all socioeconomic groups and genders [54]. However, since 1989, Brazil's obesity rates follow an inverse relationship with SES, with this trend particularly evident among urban Brazilian women. Time trends have shown a larger increase in obesity among low SES women as compared to a stark decline in obesity rates among high-income women in Brazil. For numerous reasons, to be discussed further below, low-income women are considerably more exposed to factors associated with obesity risk and have now become at higher risk of developing obesity compared to their high-income counterparts [54-55]. Monteiro et al. showed the secular trends in age-adjusted obesity prevalence by income quintiles among men and women in Brazil between 1975 and 2003. The shifting of obesity burden from the affluent to the poor is clearly shown among Brazilian women during the 28-year period, as the linear relationship between SES and obesity evident in 1975 is no longer present in 2003 [56]. Santos demonstrated a similar pattern in obesity trends between 1975 and 2003 and showed the continuation of the SES-obesity inverse relationship through 2009 [57].

The rising obesity epidemic, particularly among low SES populations is positively linked to the global energy imbalance driven by the nutrition transition. The nutrition transition is a global shift in dietary and physical activity patterns lead by urbanization, modernization, economic development and demographic change in which diets rich in complex carbohydrates and fiber are replaced by more varied, energy-dense diets with a higher proportion of saturated fat, refined sugar, and meat products [58-59]. Throughout Brazil, ultra-processed food products containing large amounts of added sugars, saturated fat, sodium and less fiber and much higher

energy density now represents greater than one-quarter of a household's total energy consumption [60]. Among all Brazilian families, food purchases are the second most important expense for families, constituting 21% of their income. However, for low-income families particularly in Brazil's north and northeast areas, food becomes the single most important household expense, with families spending 33% of their income on food. Consequently, low-income families are dramatically affected by the inflation of food prices [61].

As the prices of energy-dense foods have dropped and the prices of fruits, vegetables and other healthy options have risen [62], families suffering from food insecurity may employ a coping strategy to prevent hunger by maintaining large intakes of energy-dense foods at the lowest cost possible. These low-cost sources of dietary energy may be one explanation for the rise in obesity rates among food insecure families. Food choices are based on a myriad of factors that include cost, taste, convenience and to a much lesser extent, health and variety [63]. The most energy-dense foods are typically the most palatable and the reverse is true for healthy foods as they are generally referred to as less appealing. Refined grains, potatoes, beans, fats and oils, and sweets have become a salient feature of the food supply among low-income families because they are palatable, energy dense, accessible and inexpensive [64-66]. As food costs diminish, the dietary energy density rises, and with this a potential escalation in the total energy intake and total fat intake leading to excessive weight. Consuming a diet primarily of energy dense foods results in higher monetary value as high energy density equates to low energy costs. The energy cost of cookies or potato chips is ~20 cents/MJ (1200 kcal/$), compared to ~95 cents/MJ (250 kcal/$) for carrots [67]. Brazilians consume more than 60% of the maximum limit of consumption of added sugars recommended by the WHO [68]. Consequently, the link to obesity may not be related to overconsumption, but rather the consumption of obesogenic foods that

offer the most dietary energy and higher sense of satiety at the lowest cost. The role of food choices in the obesity epidemic is a complex interaction of factors, driven by food purchases relying heavily on food cost and taste, as well as the "feast-famine" or adaptive response to episodic food insecurity in which during times of plenty, patterns of overconsumption ensue in preparation for times of food restriction [63,69-70].

Households experiencing any level of food insecurity go through periods of stress with regards to worrying about being able to provide a sufficient amount of food for their family or even when and where their next meal will be, in addition to the economic stress of episodic influx of financial resources. This stress may carry detrimental effects on health including posited associations with increased energy-dense foods intake, visceral body fat deposition and overall weight gain [71-72]. Various stress responses account for the increased risk of obesity among those living in food-impoverished environments. Various pathways have been proposed by which this stress promotes obesity, including one pathway involving the hypothalamus-pituitary-adrenal (HPA) axis. This axis has been shown to act as a reward pathway triggering the desire for increased food intake, particularly foods of high palatability, and high energy density, ultimately resulting in excess weight gain [72-74]. This drive to eat during times of chronic stress is typically for foods that are described as "comfort foods" – those that are nutrient dense with high fat, sugar and carbohydrate calorie content and minimal nutrient value that provide a sense of relief or contentment for the consumer [73]. Moreover, in response to the stress-activated HPA axis, the secretion of the steroid hormone cortisol increases leading to elevated abdominal fat mass accumulation. Central fat deposition that results from vulnerabilities of chronic stress has important health implications, in particular for cardiovascular disease as it has been shown to be a better indicator for cardiovascular risk than BMI [44,75-76]. Mediated through the stress

experienced by food insecure families, detrimental health risks are not only seen as a result of an increase in highly palatable, energy-dense foods, but also physiologically through the deposition of central fat mass. This implies the need for further characterization and understanding of the stress of food insecurity on a household, as well as striving to improve the state of food insecurity in Brazilian slums.

In response to poverty and the state of food insecurity in the country, Brazil combined four conditional cash transfer programs to form Programa Bolsa Família as part of the *Fome Zero* (Zero Hunger) strategy. This program aims to reduce hunger and food insecurity in Brazil stemming from the program's foundation that access to adequate food is a human right [77]. Under *Fome Zero*, Bolsa Família aims to invest in human capital through combating hunger and promoting food and nutrition security, fighting poverty, and stimulating sustained empowerment of families living in poverty and extreme poverty. The program is the largest conditional cash transfer program in the world reaching over 12 million families across all Brazilian municipalities, roughly 25% of the country's population. These direct cash transfers provided to families have shown to increase the amount of household spending on food annually, particularly among those who are experiencing some level of food insecurity compared to those who are food secure. Furthermore, Bolsa Família has seen an increase in food security by 52% per US$30 transferred to families, as well as increases in household food expenditure and aggregate consumption [78-80].

Among our sample, 52.4% of the households received Bolsa Família cash transfers. Among these 77 receiving households, 77.6% reported the benefits helping them to buy more food. However, despite the encouraging findings seen amongst our sample and within the literature, this increase in food expenditure cannot be directly translated to improvements in

nutrition among recipients. This outcome depends heavily on the quality of the household's diet and the foods they are obtaining with the Bolsa Família benefits. A study looking at Bolsa Família and food consumption observed an overall increase in consumption of all food groups, however the groups with the largest consumption increase were those of processed foods and high-density, energy-rich foods. For families dependent of Bolsa Família transfers and with high levels of food insecurity, criteria for food selection fell primarily on a combination of energy density with taste and availability, such as highly processed foods and sugars. Families desire to eat healthy but constraints, not only limited to economic resources but also to unhealthy food marketing and factors within the households, limit their ability to purchase and consume healthy foods. Amongst our study sample, 68.7% of families (and 72.7% amongst those receiving Bolsa Família) wish they could consume a larger amount of healthy foods.

While Bolsa Família has successfully impacted families in relieving poverty [81], improving food security among families, recovering nutritional deficits [78,82], decreasing under-five mortality due to malnutrition and diarrhea in children [83-84], and increasing the utilization of children's health services [85], the exact role and impact of these transfers related to nutritional health, overweight and obesity, among adults needs to be explored further. Overnutrition is quickly replacing undernutrition and merely improving overall food consumption isn't sufficient to improve health and, in fact, as described by the food-insecurity-obesity paradox, may be detrimental to health as families continue to purchase energy-dense, high calorie foods with little nutritive value along with minimal intake of nutrient-rich foods. Bolsa Família benefits are typically small (ranging from US$16 to $130.5 amongst our study households with 81% receiving < US$70), and coupled with the high cost of fruits, vegetables and meats, economic influx appears to be crucial in determining food purchasing amongst

families. Given the relationship between food energy density and food costs, the Bolsa Família program needs to ensure the benefit amount is adequate to purchase not only a sufficient amount of food but also food of high nutritional quality. Additionally, public policies urgently need to modify the food environment and facilitate food quality with the availability of healthy foods and the promotion of healthy eating habits. Interventions need to be targeted amongst families, communities, the media and within institutions such as schools, health systems and social programs, in order to halt this growing trend of overweight and obesity in Brazil.

Our findings have important potential implications for the Bolsa Família Program. First, it can be suggested that Bolsa Família surveillance is inadequate as among those severely food insecure, 30% are not receiving Bolsa Família benefits. These findings strongly imply the necessity for increased and improving surveillance and inclusion of qualified families in this impoverished slum community in order to improve their poverty condition, food insecurity situation in their households and ultimately their health.

Since Dietz first proposed the possible association between obesity and hunger in 1995, numerous studies have been conducted to test this hypothesis and ultimately have proven true the existence of this paradox. Despite the repeatedly shown association, the exact mechanism for how hunger and HFI are linked remains unclear and part of a highly charged debate. The natural mind would associate obesity with overconsumption, yet this paradox contradicts that thought, causing controversy over many mediators, including role of food assistance programs and their need if low-income individuals are in fact eating in excess. Townsend in 2011 presented a conceptual framework for food insecurity and its relationship to overweight and obesity that factors in known mediators of food insecurity and the effect of food insecurity on BMI. He theorized that factors such as demographic and socioeconomic variables, government assistance

programs, and environmental factors all played a role in determine food insecurity status. From there, food insecurity directly influenced lifestyle, including the choice for energy-dense foods, which ultimately resulted in a high BMI. In addition to this indirect impact of food insecurity on overweight/obesity mediated through lifestyle choices, Townsend also suggests a direct influence of food insecurity on elevated BMI status. This linear conceptual model appreciates the multifactorial nature of this paradox [86]. However, what is missing from this conceptual model is the consideration of stress, as a consequence of food insecurity and as a major risk factor for obesity.

In 2010, Seligman recognized the prospect of a cyclic nature between food insecurity and overweight and obesity status, as well as with other chronic diseases such as diabetes and hypertension [87]. In this model, the vicious cycle of food insecurity and obesity is appreciated as well as how each has the potential to perpetuate the other. Additionally, this model incorporates key influences that feast-famine and stress play in the relationship between food insecurity and obesity. Seligman posited that food insecurity results in constrained dietary options resulting in an increase total caloric intake from fats and refined carbohydrates and a decrease in dietary variety and fruits and vegetable intake as well as feast-famine compensatory strategies. With added stress, obesity and other chronic disease emerge, causing impaired self-management capacity, such as depression and decreased physical activity, as well as the introduction of competing demands such as medication and other healthcare costs, resulting in reduced ability to afford an appropriate diet. With more added stress, weight gain ensues as well as poor control of other risk factors, and further competing demands to round out the cycle causing exacerbation of food insecurity status. The Townsend and Seligman models are noticeably different, yet both contain important contributors and mediators in this paradox. But

which theory is right? As of right now, research can't say. These are theoretical models and though there is partial evidence supporting each of them, an overall conceptual model that explains the relationship between food insecurity and obesity has yet to be defined. As conditions and experiences across populations differ drastically, there may not be one single model capable of capturing all mediators or influences, explaining the food insecurity-obesity paradox. Research needs to characterize the determinants, influences and mediators of obesity risk within each population in order to implement change and alter the course of this epidemic amongst low-income communities.

Given the coexistence of household food insecurity and obesity among adult women, there is a high need to increase access to highly nutritious, low density diets rich in fresh fruits, vegetables, whole grains, and lean animal protein sources in communities such as Pau da Lima/São Marcos urban slum. The economics behind food insecurity and dietary choices also determines where a family is able to live, and thus, their food environment, including their proximity to food resources, restaurants, social services, public health services and nutrition assistance programs. If these things are not easily accessible to a community and its residents, a small increase in monetary assistance will not successfully alter their course along their path to obesity. The largest difference in consumption between social classes lies mainly in fruits and vegetables. With the supplementation of these food groups, families would be able to consume a varied and higher quality balanced diet that meets their nutritional needs with the ultimate goal of altering the food insecurity-obesity cycle and thus their health.

Some limitations of our study are due to the relatively small sample, despite our high participation rate of 86.0%. The HFI in our Pau da Lima/São Marcos community sample was 82.3%, significantly higher than the HFI rate for the state of Bahia (41.2%) [17]. This large

difference can be due to a number of reasons, one being bias as a result of our use of a convenience sample recruited from an ongoing community cohort study of infectious diseases. On the other hand, our study sample comes from a very impoverished community making the high HFI rates detected plausible. As EBIA is administered to the individual responsible for food preparation in the home, typically the mother of the children living in the home, these food insecurity-obesity findings therefore cannot be generalized to men. Additionally, one important limitation is that we may have lacked statistical power in the multivariate analyses to determine the true significance of severe food insecurity and overweight/obesity risk. Indeed, our findings suggested a sizeable association between overweight/obesity odds and severe food insecurity, but this association did not reach statistical significance. Furthermore, the lack of power may have restricted the identification of other significant obesity risk factors in this community sample. Our sample of convenience was limited to one valley of the community, potentially raising a question of the generalizability of these results to the community members living in other valleys as well as to other similar urban slums across Brazil. As a cross-sectional study and as EBIA only evaluates the presence of HFI within the 3 month period prior to the interview, the temporal sequence of the food insecurity-obesity association cannot be drawn from our study. It still remains a question of whether obesity is a result of HFI or if obesity has a role in determining the severity of HFI.

CONCLUSIONS

The results of our study indicate that the Pau da Lima/São Marcos residents among our sample suffering from severe food insecurity are at an increased odds of being overweight/obese, as well as at a significantly increased odds of being abdominally obese. In addition to those severely food insecure, sample residents older than 50 years of age and of black race are at a

significantly increased risk for both overweight/obesity (BMI) and abdominal obesity. This study represents the first research conducted with regards to both food insecurity and chronic disease in this urban slum population and has important public health implications for other urban slums similar to our slum community of Pau da Lima/São Marcos. Given the lack of research surrounding food insecurity and obesity in developing countries, as well as in this type of population in Brazil, these findings add important knowledge to the food insecurity-obesity paradox in Brazil.

Our study suggests answering several key questions through further prospective research. Some key questions include: Does food insecurity drive obesity? Does obesity drive food insecurity? Or is it a cyclical relationship? Future studies need to focus on identifying the healthy food behavior barriers and facilitators among food insecure families. Policy studies are needed in this regard to better understand if and how Bolsa Família could be strengthened to improve healthy food behaviors and corresponding health outcomes including the prevention of obesity amongst it's low-income participants.

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Table 1. Description of the study participants and distribution of household food (in)security level across characteristics (N=147).

		Food Insecurity Level				
Characteristic	**N (%)**	**Secure N=26 (17.7)**	**Mild N=56 (38.1)**	**Moderate N=35 (23.8)**	**Severe N=30 (20.4)**	**p**
Respondent Demographics						
Race/ethnicity						0.990
White	5 (3.4)	1 (20.0)	2 (40.0)	1 (20.0)	1 (20.0)	
Black	79 (53.7)	13 (16.5)	29 (36.7)	21 (26.9)	16 (20.3)	
Brown/Mixed	63 (43.9)	12 (19.1)	25 (39.7)	13 (20.6)	13 (20.6)	
Age (years) ± SD	39.8 ± 10.3	40.0 ± 10.6	37.3 ± 9.7	40.8 ± 9.0	43.4 ± 11.9	0.060
Sex						0.595
Male	3 (2.0)	1 (33.3)	1 (33.3)	0 (0.0)	1 (33.3)	
Female	144 (98.0)	25 (17.4)	55 (38.2)	35 (24.3)	29 (20.1)	
Education						0.009
None/elementary incomp.	88 (59.9)	10 (11.4)	30 (34.1)	24 (27.3)	24 (27.3)	
High school incomplete	36 (24.5)	7 (19.4)	15 (41.7)	9 (25.0)	5 (13.9)	
≥ High school	23 (15.7)	9 (39.1)	11 (47.8)	2 (8.7)	1 (4.4)	
Fixed employment						0.079
No	113 (77.4)	16 (14.2)	44 (38.9)	26 (23.0)	27 (23.9)	
Yes	33 (22.6)	10 (30.3)	11 (33.3)	9 (27.3)	3 (9.1)	
Overall health status						0.005
Very good/good/regular	130 (88.4)	26 (20.0)	53 (40.8)	28 (21.5)	23 (17.7)	
Poor/very poor	17 (11.6)	0 (0.0)	3 (17.7)	7 (41.2)	7 (41.2)	
Overweight/obese						0.065
No	46 (32.2)	6 (13.0)	19 (41.3)	16 (34.8)	5 (10.9)	
Yes	97 (67.8)	20 (20.6)	34 (35.1)	19 (19.6)	24 (24.7)	
Abdominal obesity						0.032
No	48 (33.6)	7 (14.6)	22 (45.8)	15 (31.3)	4 (8.3)	
Yes	95 (66.4)	19 (20.0)	31 (32.6)	20 (21.1)	25 (26.3)	
Depression						0.062
No	129 (87.8)	24 (18.6)	53 (41.1)	29 (22.5)	23 (17.8)	
Yes	18 (12.2)	2 (11.1)	3 (16.7)	6 (33.3)	7 (38.9)	
Household Demographics						
Household composition						
No. of members ± SD	4.2 ± 1.8	3.6 ± 1.1	4.2 ± 1.9	4.5 ± 2.1	4.4 ± 1.5	0.207
No. of children <18 ± SD	1.9 ± 1.3	1.3 ± 0.55	1.8 ± 1.4	2.3 ± 1.6	2.1±1.2	0.015
Daily income *per capita* (US$) ± SD	3.83 ± 2.95	6.16 ± 4.17	4.18 ± 2.50	2.46 ± 1.39	2.27 ± 1.51	<.0001
CCEB[a]						0.027
A1,A2,B1,B2,C1,C2	114 (77.6)	22 (19.3)	49 (43.0)	22 (19.3)	21 (18.4)	
D,E	33 (22.4)	4 (12.1)	7 (21.2)	13 (39.4)	9 (27.3)	
Bolsa Família						0.019
No	70 (47.6)	17 (24.3)	31 (44.3)	13 (18.6)	9 (12.9)	
Yes	77 (52.4)	9 (11.7)	25 (32.5)	22 (28.6)	21 (27.3)	

[a]CCEB classes A1,A2,B1,B2,C1,C2 = >US$25 median family income/day; D,E = <US$25 median family income/day equivalent

Table 2. Bivariate (unadjusted odds ratio (OR)) and multivariate (adjusted OR) associations between study variables and overweight/obese.

Characteristic	N	% Overweight/ Obese	Unadjusted OR (95% CI)	Adjusted OR (95% CI)[b]
Race/ethnicity				
Brown/mixed	61	59.1%	1.00	1.00
Black	77	75.3%	2.27 (1.10-4.68)	2.84 (1.31-6.17)
Age (years)				
< 35	52	59.6%	1.00	1.00
35-49	64	67.2%	1.39 (0.65-2.70)	1.69 (0.75-3.81)
≥ 50	27	85.2%	3.90 (1.18-12.90)	4.65 (1.31-16.55)
Educational level				
None/elementary incomp.	88	67.1%	1.00	--
High school incomplete	34	64.7%	0.90 (0.39-2.07)	
≥ High school	21	76.2%	1.57 (0.52-4.72)	
Severe HFI				
No	114	64.0%	1.00	1.00
Yes	29	82.8%	2.70 (0.96-7.60)	2.31 (0.78-6.88)
CCEB[a]				
A1,A2,B1,B2,C1,C2	110	67.3%	1.00	--
D,E	33	69.7%	1.12 (0.48-2.60)	
Bolsa Família				
No	69	62.3%	1.00	--
Yes	74	73.0%	1.63 (0.81-3.31)	
Overall health status				
Very good/good/regular	126	65.9%	1.00	--
Poor/Very poor	17	82.4%	2.42 (0.66-8.87)	
Smoking Status				
Never	102	66.7%	1.00	--
Ever	41	70.7%	1.21 (0.55-2.66)	
No. household members				
2 – 3 members	54	68.5%	1.00	--
4 – 5 members	65	66.2%	0.90 (0.42-1.94)	
≥ 6 members	24	70.8%	1.12 (0.39-3.19)	
No. children (<18 years)				--
1 child	67	62.7%	1.00	
≥ 2 children	76	72.4%	1.56 (0.77-3.16)	

[a]CCEB classes A1,A2,B1,B2,C1,C2 = >US$25 median family income/day; D,E = <US$25 median family income/day equivalent

[b]Final adjusted model was found using backward elimination logistic regression. Severe HFI, despite non-significance, was kept in the model because of the high increased risk shown and non-significance most likely due to lack of power from the study's smaller sample size.

Table 3. Bivariate (unadjusted odds ratio (OR)) and multivariate (adjusted OR) associations between study variables and abdominal obesity.

Characteristic	N	% Abdominally obese	Unadjusted OR (95% CI)	Adjusted OR (95% CI)
Race/ethnicity				
Brown/mixed	61	59.1%	1.00	1.00
Black	77	72.7%	1.85 (0.92-3.72)	2.32 (1.08-5.02)
Age (years)				
< 35	52	57.7%	1.00	1.00
35-49	64	65.6%	1.40 (0.66-2.98)	1.78 (0.79-3.99)
≥ 50	27	85.2%	4.22 (1.28-13.94)	4.57 (1.29-16.14)
Educational level				
None/elementary incomp.	88	65.9%	1.00	--
High school incomplete	34	67.7%	1.08 (0.47-2.51)	
≥ High school	21	66.7%	1.03 (0.38-2.84)	
Severe HFI				
No	114	61.4%	1.00	1.00
Yes	29	86.2%	3.93 (1.28-12.05)	3.29 (1.03-10.51)
CCEB[a]				
A1,A2,B1,B2,C1,C2	110	64.6%	1.00	--
D,E	33	72.7%	1.47 (0.62-3.46)	
Bolsa Família				
No	69	60.9%	1.00	--
Yes	74	71.6%	1.66 (0.81-3.27)	
Overall health status				
Very good/good/regular	126	64.3%	1.00	--
Poor/Very poor	17	82.4%	2.59 (0.71-9.50)	
Smoking Status				
Never	102	63.7%	1.00	--
Ever	41	73.2%	1.55 (0.70-3.46)	
No. household members				
2 – 3 members	54	64.8%	1.00	--
4 – 5 members	65	61.5%	0.87 (0.41-1.84)	
≥ 6 members	24	83.3%	2.71 (0.81-9.10)	
No. children (<18 years)				
1 child	67	61.2%	1.00	--
≥ 2 children	76	71.1%	1.56 (0.78-3.13)	

[a]CCEB classes A1,A2,B1,B2,C1,C2 = >US$25 median family income/day; D,E = <US$25 median family income/day equivalent

Figure 1. Arial view of the Pau da Lima/São Marcos community with the red outline demarcating the boundaries of the infectious disease cohort study from which our sample was derived. The red dots mark the households of the infectious disease cohort members where at least 1 household member had < 18 years of age. Our study included participants from the households located in the valley marked by the red arrow.

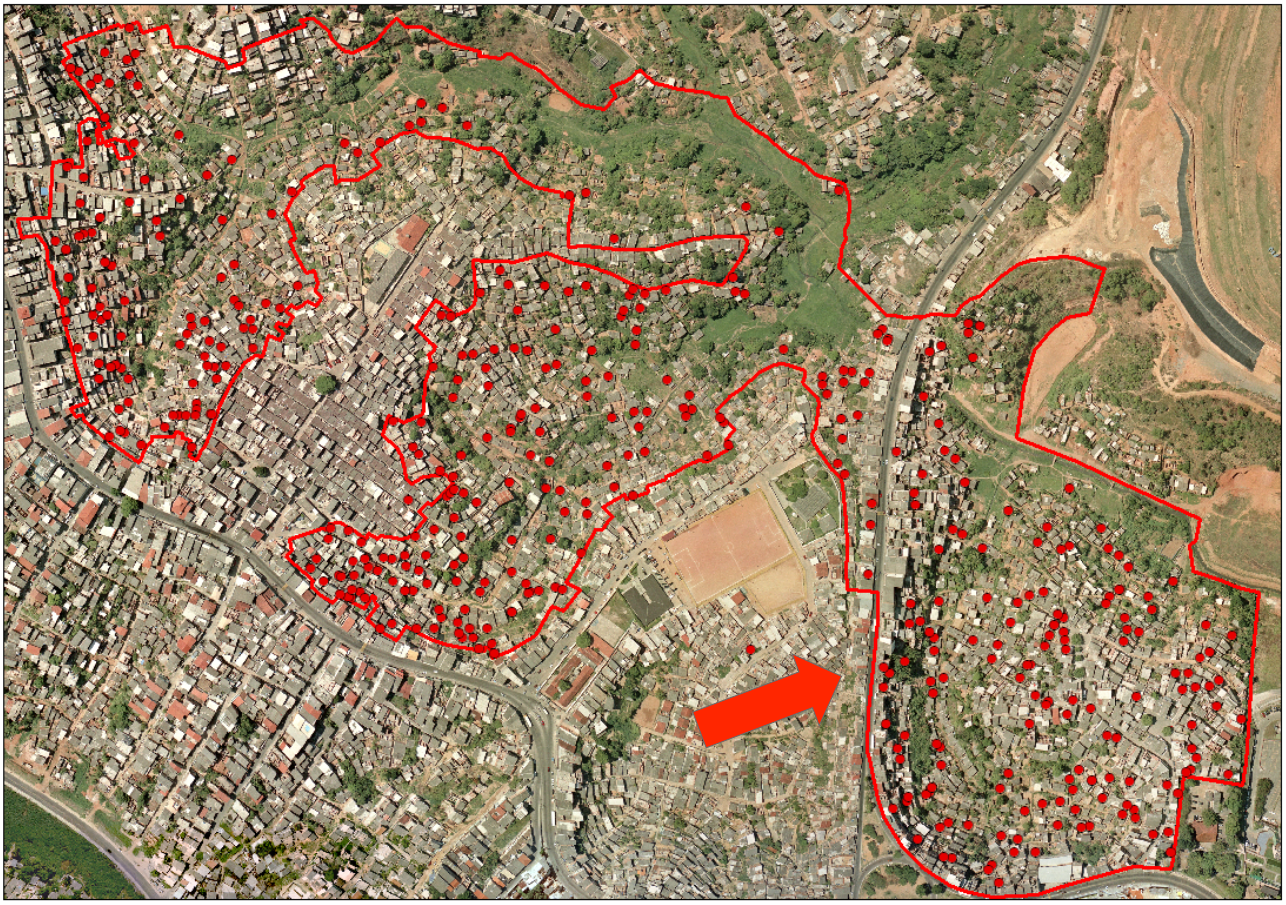


Figure 2. Study sampling, enrollment and participation flow chart (N=147).

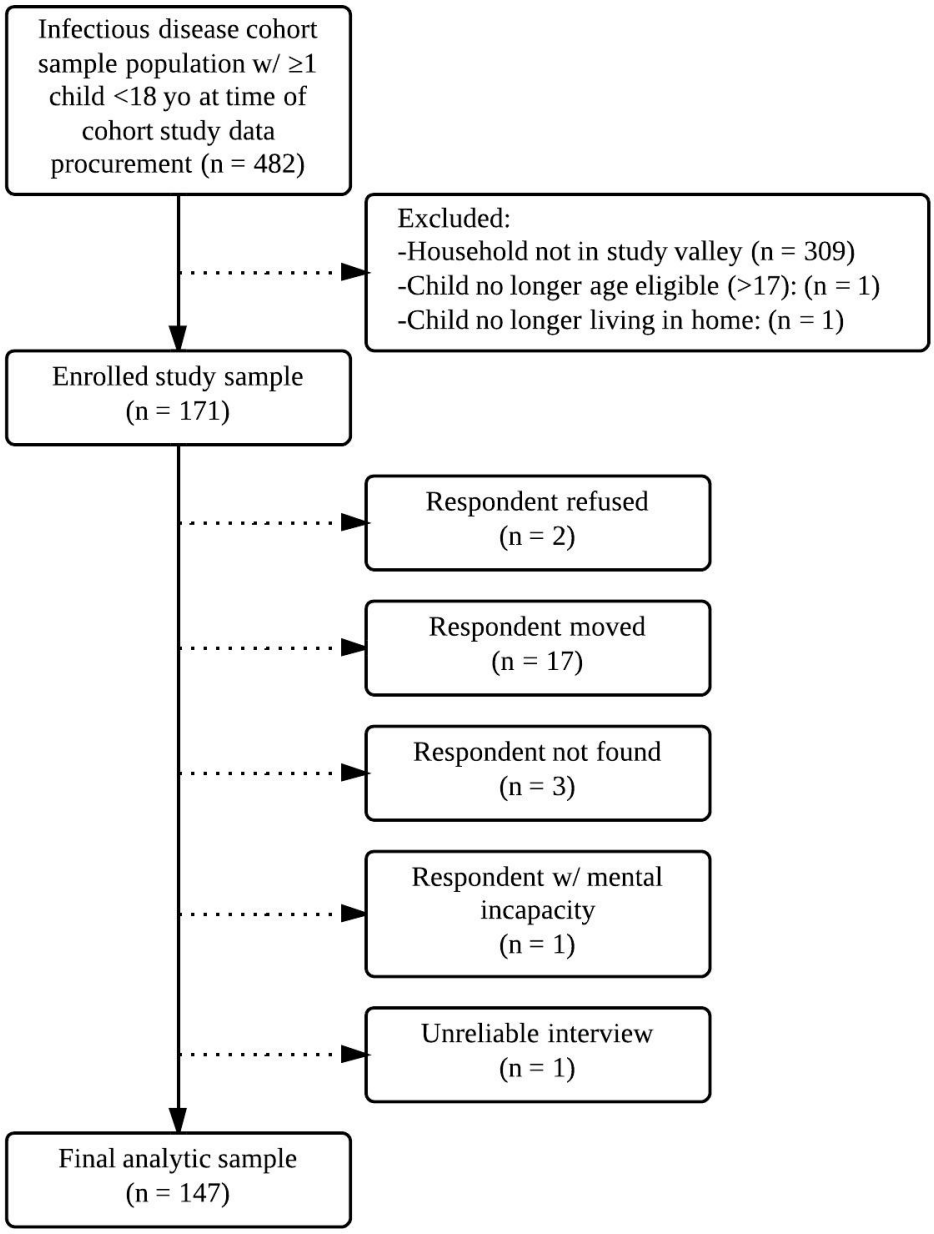


Figure 3. Comparison of the prevalence of normal weight individuals (BMI ≥ 18.5 - < 25 kg/m^2) and overweight/obese individuals (BMI ≥ 25 kg/m^2) across food security level in the community sample.

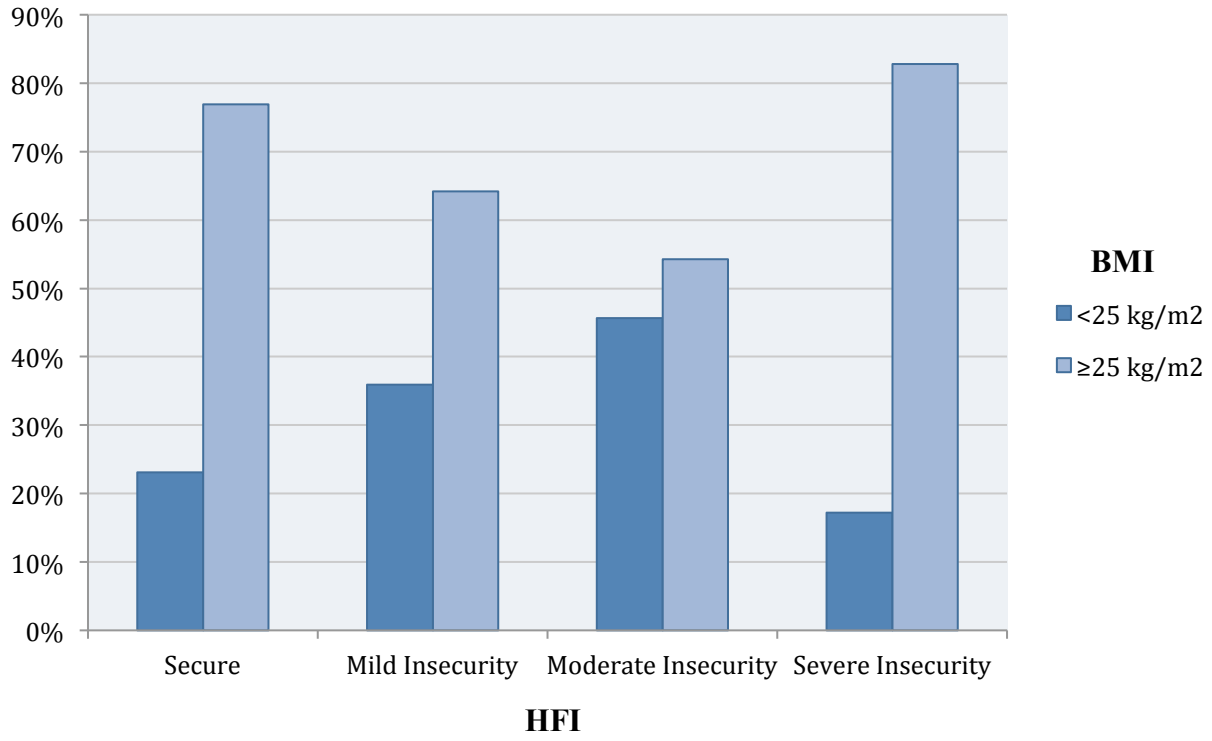


Figure 4. Comparison of the prevalence of abdominal obesity (>88cm, women, >102cm, men) across food security level in the community sample.

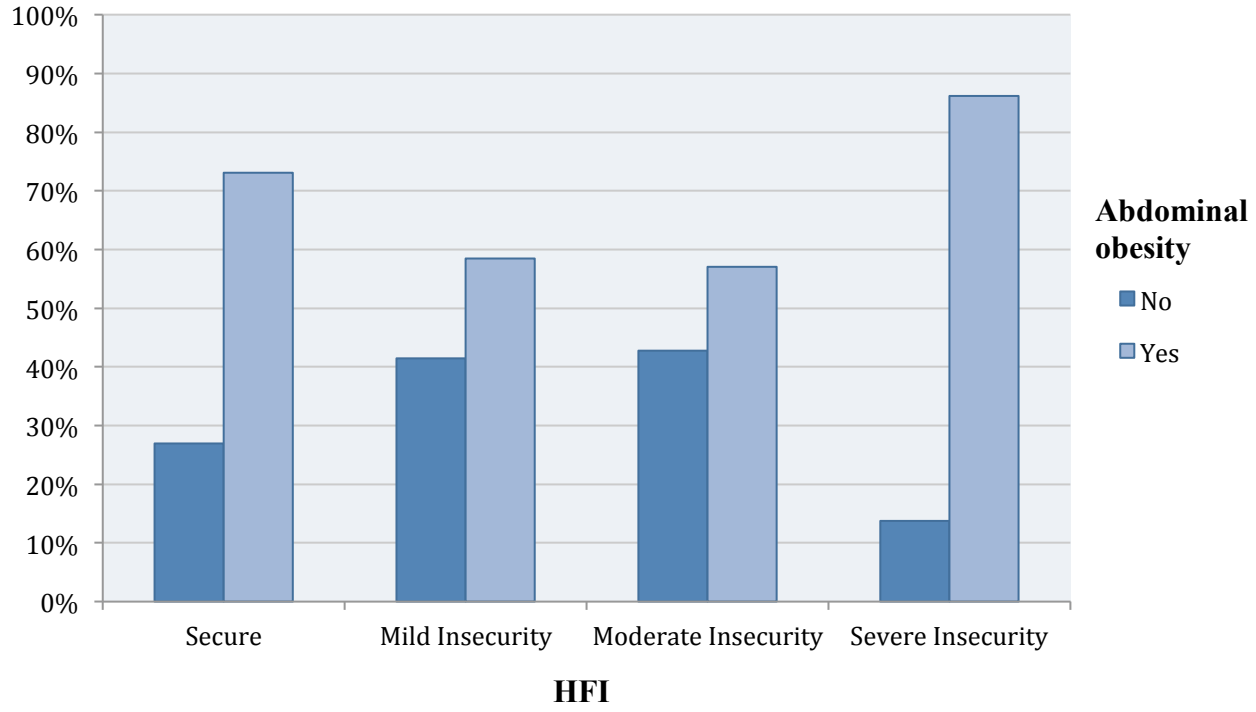


Figure 5. Prevalence and adjusted odds ratios (aOR) and 95% confidence intervals (CI) for factors associated with overweight/obesity.

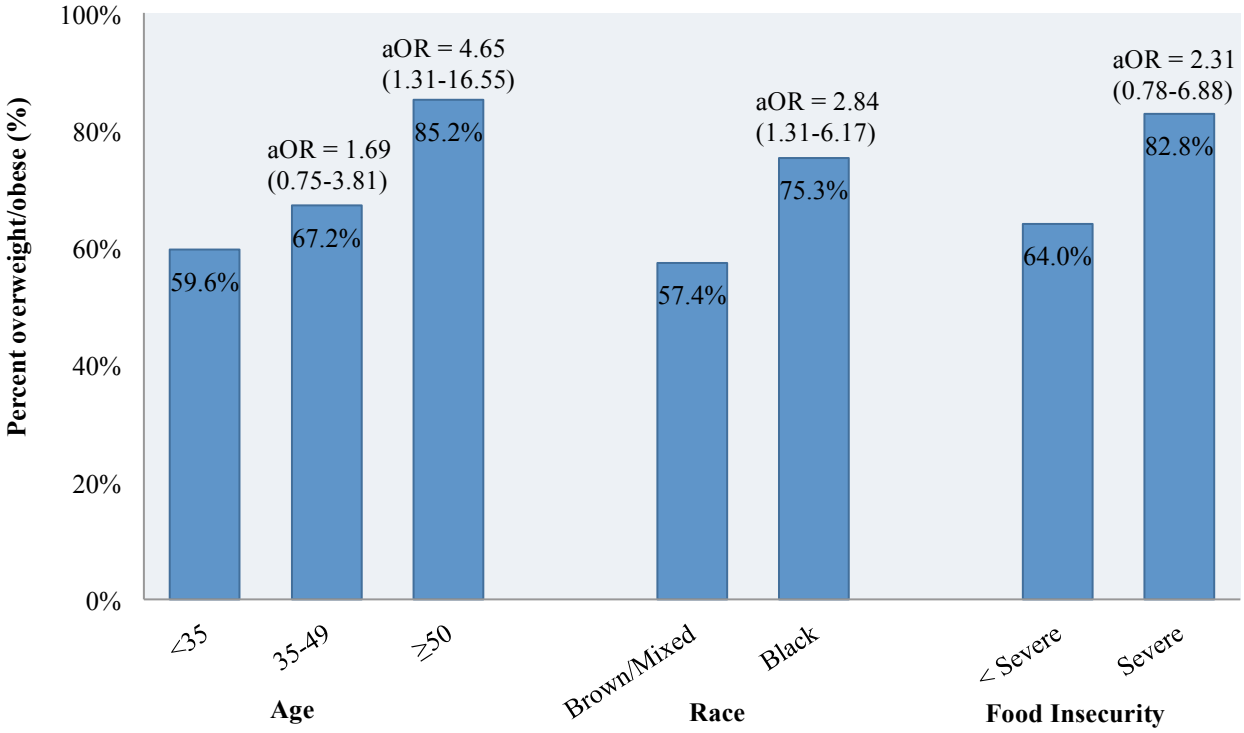
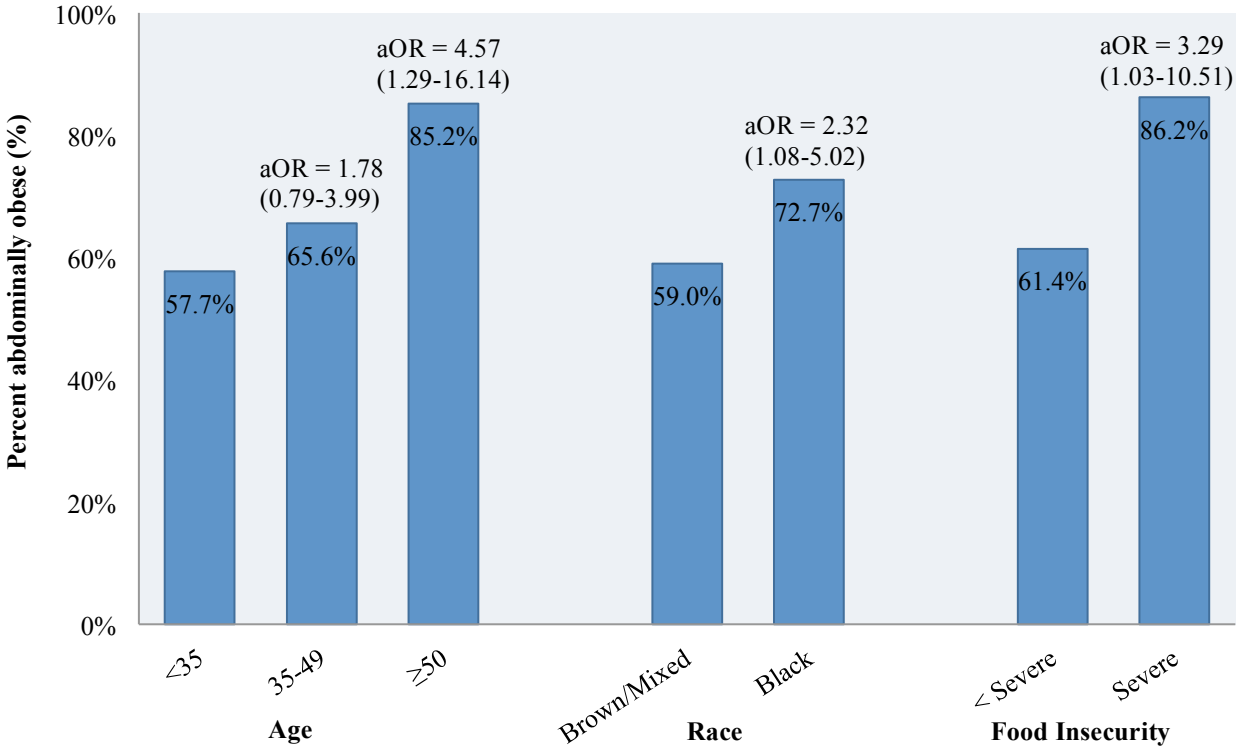


Figure 6. Prevalence and adjusted odds ratios (aOR) and 95% confidence intervals (CI) for factors associated with abdominal obesity.



Appendix A. Brazil Economic Classification Criteria 2012.

POINT SYSTEM

Possession of items

	Quantity of items				
	0	**1**	**2**	**3**	**4+**
Color television	0	1	2	3	4
Radio	0	1	2	3	4
Bathroom	0	4	5	6	7
Automobile	0	4	7	9	9
Housemaid	0	3	4	4	4
Washing machine	0	2	2	2	2
VCR/DVD	0	2	2	2	2
Refrigerator	0	4	4	4	4
Freezer (independent of the duplex unit or refrigerator)	0	2	2	2	2

Education of head of household

"No education/up to 3rd grade complete"	0
"4th - 7th grade complete"	1
"Elementary complete (8th grade)/High school incomplete"	2
"High school complete/Upper/graduate level incomplete"	4
"Upper/graduate complete"	8

HOUSEHOLD MONTHLY INCOME BY CLASS

Class	Points	Average household income (gross amount in Reis $) - 2010	US$
A1	42-46	12.926	6,463
A2	35-41	8.418	4,209
B1	29-34	4.418	2,209
B2	23-28	2.565	1,282.50
C1	18-22	1.541	770.50
C2	14-17	1.024	512
D	8-13	714	357
E	0-7	477	238.50

Appendix B. The 15-item Brazilian Food Insecurity Scale (EBIA); English back-translation from Portuguese [37]; cut-off points for HFI severity level.

Item	During the last 3 months…
1	Were you worried that you would run out of food before being able to buy or receive more?
2	Did you run out of food before having money to buy more?
3	Did you run out of money to have a health and varied diet?
4	Did you have to consume just a few foods because you ran out of money?
5	Were you unable to offer your children/adolescents a healthy and varied diet because you did not have enough money?
6	Did any of the children/adolescents not eat enough because there was not enough money to buy food?
7	Did you or any adult in your household ever reduce the size of meals or skip meals because there was not enough money to buy food?
8	Did you ever eat less than what you though you should because there was not enough money to buy food?
9	Did you ever feel hungry but did not eat because there was not enough money to buy food?
10	Did you lose weight because you did not have enough money to buy food?
11	Did you or any other adult in your household eve go without eating for a whole day or just have one meal in a whole day because there was not enough money to buy food?
12	Did you ever reduce the size of meals of your children/adolescents because there was not enough money to buy food?
13	Did your children/adolescents ever have to skip a meal because there was not enough money to buy food?
14	Were you children/adolescents ever hungry but you just could not buy more food?
15	Did your children go without food for a whole day because there was not enough money to buy food?

Food Insecurity Score (# 'yes' responses)	Household Food Insecurity Level
0	Food secure
1-5	Mild food insecurity
6-10	Moderate food insecurity
11-15	Severe food insecurity