

Obesity and Places Where People Living in Sao Paulo City, Brazil

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Abstract

Background The built environment characteristics and urban form can influence health outcomes like obesity in people living in high-income countries. However, there are few studies in megacities from middle-high income countries like Brazil in which the built environment has been modified and obesity has been growing slightly. Therefore, the objectives of this study were: 1) to describe the body mass index (BMI) and obesity in different health administrative areas in Sao Paulo; 2) to investigate the association between BMI and obesity with the places where people lived according to social and demographics variables, health variables, built environment, and family per capita income.

Methods This was a cross-sectional study that used the Sao Paulo Health Survey dataset (2015) with 3,145 individuals (18 years or older). The weight and height were self-reported and was calculated the BMI. Residential locations were geocoded, types and the mix of destinations were calculated in 500m buffers. We used multilevel models to examine the association between BMI and obesity with the places where the people lived.

Results The Midwest region showed the highest mean of the mix of destinations than other areas and the lowest prevalence of overweight and obesity. The BMI was higher for people that lived in North, Southeast, South, and East than Midwest after adjusted. Individuals that lived in North (OR=1.69 CI95% 1.18-2.43) and Southeast (OR=1.66 CI 95%1.17-2.37) had increased the likelihood for obesity compared with Midwest after adjusted by social and demographic variables, physical activity level, mix of destinations, and family per capita income.

Conclusion This study found that individuals that lived in the North, Southeast, South, and East had higher BMI than people who lived in Midwest, and people that lived in the North and Southeast had increased the likelihood of obesity compared with the Midwest area. The place where people living can influence BMI and obesity in megacities like Sao Paulo, Brazil. Key words: Body Mass Index, Obesity, Built Environment, Multilevel analysis.

Background

Obesity is characterized as abnormal or excessive fat accumulation that may decrease health. It is increasing in every region and was estimated to affect 650 million (13%) of people in the world [1]. This is a public health concern because obesity is an important risk factor and determinant for three of the four leading causes of non-communicable diseases (NCDs) worldwide, including cardiovascular diseases, type 2 diabetes, and certain cancers [2]. Nowadays, the major challenge faced relates to the fact that these arguments are multi-factorials problems related mainly to behavioral variables, such as level of physical activity and diet [3], and these variables are associated with health policies and the environmental variables [4].

Several studies have shown associations between built environment and obesity. Adults living in American metropolitan areas had higher BMI scores and were more likely to be obese than those living in brief areas [5]. However, another studies have shown that the association between built environment with obesity is not consensual [6–8].

Regarding the built environment at the neighborhood scale, Frank et al. [9, 10] found similar associations for adults living in metropolitan versus brief areas walkable. Several studies since 2004 have confirmed the inverse association between the land-use mix with obesity [11–14]. Some authors consider that the presence of walkable destinations are important for healthy weight [15, 16]. This assertion is reinforced by other studies that found

proximity to parks [17–19] and transit-stations [12, 20] to be associated with lower prevalence of obesity. Other built environment components may include of food access and types of food outlets. The proximity of grocery stores and supermarkets are associated with lower prevalence of obesity [21–23], while the presence of fast-food restaurants and convenience stores is associated with higher prevalence of obesity [24].

Nowadays, other important environment variable is the mix of destinations, defined as the sum of destinations diversity [25–27]. Recently, the mix of destinations in 500 m was associated with walking trips in adults living in Sao Paulo [28].

The most consistent evidence available for an association between built environment components and variations in obesity prevalence across different neighborhoods comes from high-income countries [12, 29]. However, it is not clear yet whether these variations and associations are also true in megacities from middle-income countries like Sao Paulo, Brazil [30–32]. Therefore, the objectives of this study were: 1) to describe the BMI and obesity in different health areas in Sao Paulo city, Brazil; 2) to investigate the association between BMI and obesity with the places where people lived according to social and demographics variables, health variables, built environment, and family per capita income.

Methods

Sao Paulo Health Survey

This was the cross-sectional study that used the Sao Paulo Health Survey (ISA) dataset (2015). The final face-to-face interviews were conducted with 4,043 study individuals (12 years or older). More details can be obtained in Alves et al. [33].

ISA: Physical Activity and Environment

This study is part of the longitudinal project to verify the relationship between built environment, physical activity, and nutritional status in adults that living in Sao Paulo city, Brazil.

Outcome variable

Weight and height variables were obtained by self-reported according to two questions: “What is your weight?”, whose response was given in kilograms and grams; and: “What is your height?”, with response options in meters and centimeters. There was calculated the body mass index (BMI) from the formula of weight in kilograms divided by the square of height in meters (Kg/m^2), in order to classify their nutritional status according to WHO standards [34]. Adults were considered as overweight ($\geq 25.0 \text{ Kg}/\text{m}^2$) and obese ($\geq 30.0 \text{ Kg}/\text{m}^2$) [34]. The self-report data was validated in a previous study with the same population and the study showed acceptable results [35].

Places of the City Where People Lived

We used the classification of the health administration areas of the municipality government of Sao Paulo city [36]. These areas are divided into five regions until 2015: East, South, Southeast, North, and Midwest [37].

Built Environment

The mix of destinations was characterized by the presence of the following items: a) bus stop; b) train and subway stations; c) parks; d) squares; e) public recreation centers; f) bike paths; g) primary health care units; h) supermarkets; i) bakeries; j) restaurants (food stores), and k) coffee-shops. These variables were calculated using a geographic information system (QGIS 2.14). We delineated radial buffers of 500 meters according to residential address. More details about the mix of destination score can be obtained in Florindo et al. [28].

Family Per Capita Income

The family per capita income using the total residence income divided by total the number of persons living in the same household was measured through the question “What was the average overall net household income last month?” and analyzed in quartiles: 1st quartile (lowest), second, third and fourth (highest).

Physical Activity

The physical activity was evaluated by International Physical Activity Questionnaire long version. The score was calculated in minutes per week by sum of minutes in each domain: occupational, leisure, transportation and household [38-40]. We used the cutoff point of 150 minutes per week (0-149 minutes/week, ≥ 150 minutes/week).

Social and Demographic Variables

Age groups (18–29, 30–39, 40–49, 50–59, and 60 years or older), sex (male, female), level of education (incomplete elementary school, complete elementary to incomplete high school, complete high school, undergraduate incomplete to complete) and, length of living in the same residence (up to one year, between one and five years, >five years).

Statistical Analysis

Chi-square test for overweight and obesity was calculated according to social and demographics variables, and health characteristics. Complex sample design according to the census tract (primary unit of the sample) in five health areas in Sao Paulo (strata), and the sample weight was used.

Two outcomes were used, 1) BMI in Kg/m^2 ; and 2) Obesity ($\text{BMI} \geq 30.0 \text{ Kg/m}^2$; yes or no). The place where people lived were the main independent variable and was based in five health administrative areas of the city: Midwest, North, Southeast, South, and East. Normality test was performed (Kolmogorov-Smirnov), since the data had no normal distribution, the mean was compared by the Kruskal-Wallis test and multiple post-hoc comparisons were performed using the Bonferroni test.

The modeling was undertaken took into account clustering by census tract and household in four stages: 1) Firstly, we conducted the analysis of BMI and obesity with places where people lived without adjust; 2) Secondly, we examined the analysis with adjustment for sex, age groups, education, length of living in the same residence and total physical activity; 3) Thirdly, we used all variables of the model 2 with mix of destinations 500 m buffers' size and 4) Finally, we used all variables of the model 3 with family per capita income. We used the `xtmixed` command for linear models and the results were presented as beta coefficients (β) with 95% confidence intervals, and the `xtmelogit` command for logistic models and the results were presented as odds ratios (OR) with 95% confidence intervals.

All analyses were conducted in Stata software (Stata version SE 12.1, StataCorp).

Ethical Committee

The Ethics Committee of the School of Arts, Sciences, and Humanities at the University of Sao Paulo approved this study (process number 55846116.6.0000.5390).

Results

The distribution of the adult population with BMI complete data regarding to five places was showed in Figure 1. Southeast area had a higher number of individuals (n=704) and the Midwest (n=502) was the smallest. The prevalence of overweight and obesity was high in adults who lived in the North (61.0% and 23.3%, respectively); in the other hand, Midwest area had a lower prevalence of both overweight (49.8%) and obesity (18.0%). There was no statistically significant difference between the five health administrative areas of both overweight ($p=0.07$) and obesity ($p=0.19$) (Table 1).

Insert Figure 1

Insert Table 1

The summary of a mix of destinations variables according to the five areas in Sao Paulo city was showed in Table 2. The Midwest region showed higher mean than other areas in 500 m buffers' size and the difference between areas was significant ($p<0.05$). Other differences were shown with family per capita income and total physical activity variables (Table 2).

Insert Table 2

Table 3 presents the results of the multilevel linear regression explaining the influence of BMI values in the health area administration where living according to social, demographics, environmental and health variables. After adjustment for all these variables, compared to the Midwest area, the North area had a greater increase in the BMI and all results were statistically significant to the other areas.

Insert Table 3

The people that lived in North area had increased the likelihood compared with people that lived in Midwest, independently of social and demographic variables, physical activity level, mix of destinations, and family per capita income (Table 4). For people lived in Southeast, the likelihood for obesity lost the significance after the adjustment by social and demographic variables, and for physical activity level, however, after the adjustment by mix of destinations, and family per capita income, the likelihood for obesity returned.

Insert Table 4

The people that lived in South had more likelihood compared with people that lived in Midwest only after the adjustment for social and demographic variables, for physical activity level, and for a mix of destinations, however, the significance was lost after the adjustment by family per capita income (Table 4).

Discussion

The main findings of the present study were: 1) The Midwest region showed the highest mean of mix of destinations than other areas and the lowest prevalence of overweight and obesity in Sao Paulo; 2) The BMI was high for people living in North, Southeast, South, and East than comparison with people from Midwest after adjusted for all variables; 3) Individuals that lived in North and Southeast had increased likelihood for overweight and obesity compared with Midwest.

Despite of the other study verified environmental determinants of diet, physical activity, and overweight among adults in Sao Paulo [41], this is the first study in a representative sample that investigated differences between BMI and obesity according to places where people lived.

In the Midwest area, we found the largest difference mean in the score of a mix of destinations compared to other areas, and lower prevalence for both overweight and obesity. This place presents an average income superior to other areas of the municipality, with a greater supply of public equipment, and jobs. A very diversified area with a great emphasis on green areas, with more than fifteen municipal parks, squares and shopping centers, restaurants, besides the main subway lines and bus stops [42], and this seems to explain our results. Differently, the North area in Sao Paulo, despite having extensive green areas and native forest and increased population density, in this area, 31.3% of the population total deaths in men and 34.2% in women are due to cardiovascular diseases. Overweight and obesity are risk factors that have contributed to the high of deaths due to this cause [43].

The male had a higher prevalence for overweight, and female had a higher prevalence for obesity. This pattern is detected in high-income countries over time [44, 45]. The observed differences across the cities suggest that environmental factors, and social contexts [46–49], can establish an important role regarding sex differences in overweight and obesity. It is important to note that the length of residence was associated with overweight and obesity and corroborated with other studies [50–52] showing that this variable is important for analyzing outcomes as overweight and obesity in upper-middle-income countries.

The socioeconomic status like the family per capita income is important to be considered and explains possible differences between places where people lived and the relationship with overweight and obesity. Despite family per capita income did not show association with overweight and obesity when analyzed by the chi-square test, in the hierarchical model, people that lived in North and Southeast areas had increased in the likelihood for overweight and obesity compared with people that lived in Midwest area. In addition, people that lived in South and East areas had lost significance for obesity after adjustment by family per capita income. The East area has a high population density, region with the lowest per capita income in the municipality, with the worst infrastructure, with the highest incidence of poverty and the lowest Human Development Index [42]. The South is a region that is observed economic distress, beyond social exclusion, with the presence of places of poverty and housing centers along brooks and watershed areas [53]. This shows that per capita household income is very important in these areas when we analyzed the nutritional status of the population.

In the city of Sao Paulo, those who earn more than one minimum wage per person per month in the household are 14% more likely to have obesity. And, these results may be associated specifically with other factors as food environment and food security [31, 46, 54]. These results were similar with other studies [55–58] that showed that disadvantage areas are associated with health problems in adults and support the need to focus on improving local environments to reduce socioeconomic and other inequalities.

The mix of destinations modified some results about the association between the places where people lived with obesity. A systematic review and meta-analysis of longitudinal studies about built environment and cardio-metabolic health showed no evidence was found, but this results were shown in high-income countries [59]. Other systematic review of the observational studies not found associations between walkability and obesity in longitudinal studies conducted with adults in high-income countries [60].

About the mix of destinations, Florindo et al. [28] showed that people that lived within 500 m with highest destinations had a greater likelihood of walking for transportation. The presence of destinations near of residences where people living are important for people walking, however, is important to investigate the different types to destinations, because the proximity of supermarkets is associated with lower rates of overweight and obesity [21–23], but the presence of fast-food restaurants and convenience stores is associated with higher rates of overweight and obesity [24]. In addition, should be considered that the rich access to healthy and affordable food and better local stores with no limited variety, higher quality and poorer prices, no compromising food security and potentially decrease inequities [61, 62].

Some limitations should be considered in interpreting the findings of the study. The caution should be exercised when extrapolating these results due to neighborhood self-selection bias, as people who are not obese and who live a healthier lifestyle that prevents obesity may choose to live in neighborhoods with better conditions [63, 64]. To obtain stronger causal inferences, further longitudinal and quasi-experimental studies must be conducted in addition to natural experimental studies [65]. The values for height and weight used to calculate the body mass index were self-reported by the individuals during the household interview. Although the self-reported data have been validated in a previous study with Sao Paulo Health Survey [35], they may be subject to inaccuracies. Moreover, the environment variable analyzed in our study does not fully represent the different aspects of the environment, since only the mix of destinations represents little to characterize the environment, and it is necessary to have other variables as walkability and the indicators that are part of the index as land-use mix, residential density, street connectivity. Family per capita income as a classification of socioeconomic status also has limitations due to the number of missing values, to avoid this it would be important to use other socioeconomic indicators. And, there was no evaluation of the eating pattern of the individuals.

Conclusions

Despite some limitations, this study showed that people lived in the Midwest had the lowest prevalence of overweight and obesity than in other regions. In addition, we found that individuals that lived in the North, Southeast, South, and East had higher BMI than people who lived in Midwest, and people that lived in the North and Southeast had increased the likelihood of obesity compared with the Midwest independent of social and demographic variables, physical activity, environmental variables, and socioeconomic status. Family per capita income modified the results for people living in East and South. The place where people living can influence health outcomes like BMI and obesity in megacities like Sao Paulo and these results may foster relevant information for decision-makers and researchers to discuss interventions to contribute to preventing this health problem in these places.

Abbreviations

IPAQ

International Physical Activity Questionnaire; CI–Confidence interval; OR–Odds Ratio; NCDs–Non-communicable diseases; BMI–Body Mass Index; SE–Standard error.

Declarations

Ethics approval and consent to participate

The Ethics Committee of the School of Arts, Sciences, and Humanities at the University of Sao Paulo approved the study (process number 55846116.6.0000.5390). The consent for participation in the study was written and obtained where individuals were children (under 16 years old) from their parents or guardian.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

JPASB and AAF had the idea of this study. JPASB and AAF contributed to data statistical analysis. JPASB, BSA, MAF, LVB, RMF and AAF contributed to interpretation and drafted the manuscript. JPASB, BSA, MAF and LVB contributed to georeferencing of built environment variables. All authors contributed to drafting, critically revising and approved the final manuscript.

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Tables

Table 1. Descriptive analysis of body mass index, overweight and obesity according to health administrative area where people lived, Sao Paulo Health Survey, 2015.

Exposure variables	Overweight			Obesity			BMI	
	BMI <25.0 Kg/m ²	BMI ≥25.0 Kg/m ²	p	BMI <30 Kg/m ²	BMI ≥30 Kg/m ²	p	Mean (SE)	p
<i>Overall (n=3145)</i>	43.6	56.4	-	79.2	20.8	-	26.3 (0.1)	-
<i>Health administrative areas (n=3077)</i>			0.07			0.19		0.01
Midwest	50.2	49.8		82.0	18.0		25.8 (0.3)	
North	39.0	61.0		76.7	23.3		26.7 (0.3)	
Southeast	42.9	57.1		77.5	22.5		26.4 (0.2)	
South	43.0	57.0		79.1	20.9		26.3 (0.3)	
East	45.0	55.0		82.0	18.0		26.1 (0.2)	

BMI - Body Mass Index; SE - Standard error.

Table 2. Descriptive variables for mix of destinations, family per capita income, and physical activity according to health administration area where people live Sao Paulo Health Survey, 2015.

Health administrative areas in Sao Paulo city, Brazil

		Midwest (I)		North (II)		Southeast (III)		South (IV)		East (V)		p
	Overall (n=3145)	(n=502)	%	(n=608)	%	(n=704)	%	(n=645)	%	(n=618)		
Exposure variables	% (95% CI); Mean (SE)	(95% CI); (SE)	Mean	(95% CI); (SE)	Mean	(95% CI); (SE)	Mean	(95% CI); (SE)	Mean	% (95% CI); (SE)	Mean	
Mix of destinations												<0.001
500 m buffers' size (n = 3077)												
Lowest	38.9 (32.6; 45.7)	16.2 (6.7; 34.2)		33.8 (21.3; 49.0)		35.4 (23.2; 49.9)		52.9 (38.3; 67.0)		50.9 (36.1; 65.5)		
Middle	22.9 (18.0; 28.7)	18.2 (6.8; 40.3)		19.8 (10.9; 33.2)		29.4 (19.4; 41.8)		19.3 (11.9; 29.8)		24.7 (14.3; 39.1)		
Highest	38.2 (31.1; 45.9)	65.7 (44.9; 81.7)		46.4 (28.5; 65.4)		35.1 (22.0; 50.9)		27.8 (15.1; 45.5)		24.5 (13.3; 40.7)		
Mean (SE) Mix of destinations 500 m buffers (score)	3.2 (0.1)	4.5 (0.4) °+##&		3.3 (0.3) *##&		3.3 (0.3) *##&		2.5 (0.2) *°+		2.5 (0.2) *°+		<0.001
Family per capita income (n = 2497)												<0.001
Lowest	23.1 (20.1; 26.3)	11.4 (5.5; 22.0)		26.2 (19.7; 34.0)		16.6 (12.1; 22.3)		30.9 (24.8; 37.8)		30.4 (24.1; 37.4)		
Second	23.8 (21.4; 26.4)	20.0 (13.9; 28.0)		23.3 (19.1; 28.0)		20.8 (16.1; 26.5)		28.2 (23.1; 33.8)		27.3 (22.4; 32.8)		
Third	25.0 (22.8; 27.4)	24.9 (19.1; 31.6)		23.4 (18.6; 29.0)		25.6 (21.6; 30.1)		21.9 (17.0; 27.7)		28.5 (23.7; 33.8)		
Highest	28.1 (24.3; 32.3)	43.7 (32.7; 55.4)		27.1 (18.6; 37.7)		37.1 (28.8; 46.2)		19.1 (12.5; 27.9)		13.8 (10.0; 18.8)		
Mean (SE)	1332.0 (70.8)	2089.3 (258.2) °+##&		1163.1 (104.1) *°&		1592.9 (182.8) *##&		1015.6 (95.0) *°+		874.2 (47.6) *°+		<0.001
Brazilian Currency												
Total physical activity (n = 3050)												
≥150 min/week	80.9 (78.8; 82.9)	77.3 (70.5; 83.0)		81.6 (76.0; 86.1)		82.7 (78.4; 86.3)		77.9 (72.8; 82.4)		83.5 (79.9; 86.5)		0.04
0-149 min/week	19.1 (17.1; 21.2)	22.7 (17.0; 29.5)		18.4 (13.9; 24.0)		17.3 (13.7; 21.6)		22.1 (17.6; 27.2)		16.5 (13.5; 20.1)		
Mean (SE) minutes per week	1150.3 (40.1)	1052.7 (98.6) #°&		1177.6 (94.9)		1016.4 (84.3) #°&		1196.2 (78.0) *°+		1325.3 (91.3) *°+		<0.001

Mean difference of mix of destinations 500 m buffers (score): *Significant difference between I with II, III, IV and V; ° Significant difference between II with I, IV and V; + Significant difference between III with I, IV and V; # Significant difference between IV with I, II and III; & Significant difference between V with I, II and III.

Mean difference of family per capita income (Brazilian Currency): *Significant difference between I with II, III, IV and V; ° Significant difference between II with I and V; + Significant difference between III with I, IV and V; # Significant difference between IV with I and III; & Significant difference between V with I, II and III.

Mean difference of total physical activity (minutes per week): *Significant difference between I with IV and V; ° No significant difference; + Significant difference between III with IV and V; # Significant difference between IV with I and III; & Significant difference between V with I and III.

Table 3. Multilevel linear regression results explaining the influence of BMI values in the health administration area where living according to sociodemographics, environmental and health variables, Sao Paulo Health Survey, 2015.

Exposure variable	BMI (Kg/m ²)			
	β (95% CI)	β (95% CI)	β (95% CI)	β (95% CI)
	Model 1*	Model 2**	Model 3***	Model 4****
<i>Health administration area where living</i>				
Midwest	Ref.	Ref.	Ref.	Ref
North	0.94 (0.33-1.55) #	0.97 (0.36-1.58) #	1.02 (0.41-1.63) #	1.35 (0.67-2.02) #
Southeast	0.62 (0.03-1.22) #	0.64 (0.51-1.23) #	0.73 (0.13-1.32) #	1.06 (0.41-1.72) #
South	0.63 (0.22-1.23) #	0.78 (0.17-1.39) #	0.89 (0.27-1.51) #	1.07 (0.36-1.78) #
East	0.38 (-0.23-0.99)	0.47 (-0.15-1.08)	0.57 (-0.05-1.20)	0.69 (0.01-1.37) #

*Model 1 without adjust; **Model 2 adjusted by sex, age groups, education, length of residence and total physical activity; *** Model 3 variables of the model 2 with mix of destinations 500 m buffers' size; **** Model 4 variables of the model 3 with family per capita income; # p<0.05.

Table 4. Association between health administration area where people lived and obesity according to social, demographics, environmental and health variable Sao Paulo Health Survey, 2015.

Exposure variable	Obesity BMI (≥30 Kg/m ² ; yes or no)	Obesity (BMI ≥30 Kg/m ² ; yes or no)	Obesity (BMI ≥30 Kg/m ² ; yes or no)	Obesity (BMI ≥30 Kg/m ² ; yes or no)
	Model 1* OR (95% CI)	Model 2** OR (95% CI)	Model 3*** OR (95% CI)	Model 4**** OR (95% CI)
<i>Health administration area where living</i>				
Midwest	1	1	1	1
North	1.46 (1.06-2.00) #	1.45 (1.04-2.02) #	1.50 (1.08-2.10) #	1.69 (1.18-2.43) #
Southeast	1.37 (1.00-1.87) #	1.38 (1.00-1.89)	1.46 (1.05-2.02) #	1.66 (1.17-2.37) #
South	1.36 (0.99-1.86)	1.34 (0.96-1.87)	1.46 (1.04-2.05) #	1.45 (0.99-2.13)
East	1.10 (0.79-1.53)	1.10 (0.78-1.55)	1.19 (0.84-1.68)	1.16 (0.80-1.70)

*Model 1 without adjust; **Model 2 adjusted by sex, age groups, education, length of residence and total physical activity; *** Model 3 variables of the model 2 with mix of destinations 500 m buffers' size; **** Model 4 variables of the model 3 with family per capita income; # p<0.05.

Figures

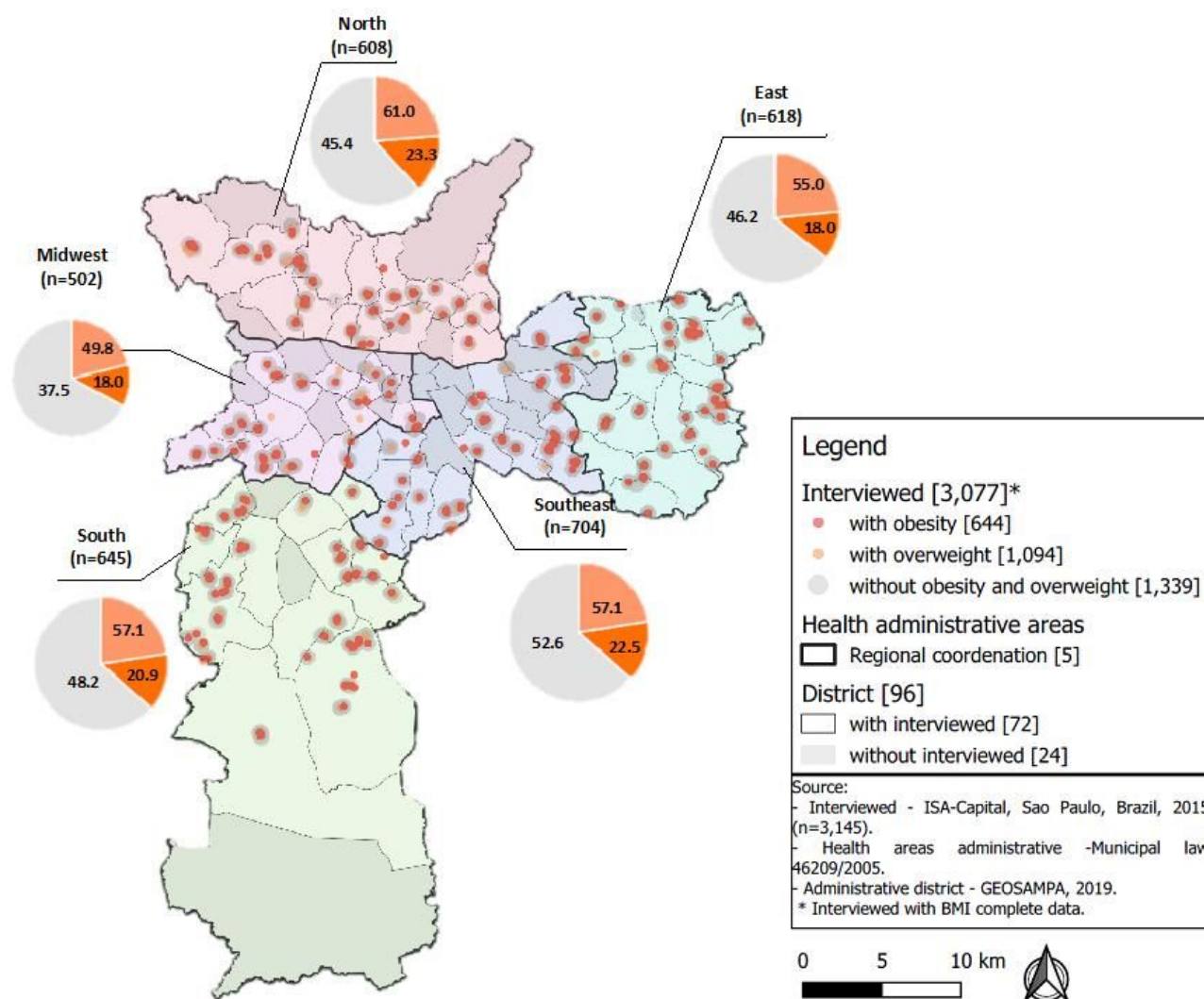


Figure 1

Descriptive of the adults with BMI complete data according to five health administrative areas in São Paulo city, Brazil, 2015.