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Iniquities in the built environment related to physical activity in public school neighborhoods in Curitiba, Paraná State, Brazil

Iniquidades do ambiente construído relacionado à atividade física no entorno de escolas públicas de Curitiba, Paraná, Brasil

Inequidades del ambiente construido, relacionado con la actividad física, en el entorno de escuelas públicas de Curitiba, Paraná, Brasil

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Abstract

This study aimed to investigate the association between the characteristics of the environment related to physical activity and income in areas around schools in Curitiba, Paraná State, Brazil. A total of 888 street segments were audited with a systematic observation instrument in three sections (Routes, Segments, and Crossings) in a radius of 500 meters around 30 public schools. The total score was the sum of the sections. Data on income in the school neighborhood were obtained from the 2010 Population Census*, and the linear distance from each school to the city center was calculated. Multilevel models (level one = segment; level two = school) were applied to the analysis, with estimates of weighted means and intraclass correlation coefficients (ICC). In the crude analysis, the highest variability between schools was observed in the Segments section (ICC = 0.41) and the lowest in the Routes section (ICC = 0.19). The street segments located around schools in the lowest income tertile reach an adjusted mean total score of 15.6 (95%CI: 13.0-18.3), nearly half of that in those with the highest income, which reached 30.7 points (95%CI; 28.0-33.5), with a significant difference between the tertiles (p < 0.001). The score for the more central areas of the city was 30.1 (95%CI: 26.9-33.4), significantly higher (p < 0.001) than for the more peripheral areas, where the score was 16.3 (95%CI: 12.8-19.8). The characteristics of the environment assessed by the Routes and Segments sections, in addition to the total score, were associated with the lowest income. An environment with worse quality in lower income areas is one of the iniquities that needs to be faced in Brazil's metropolises in order to help improve the people's health.*

Environmental Design; Socieconomic Factors; Urban Health

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Introduction

City planning has a strong impact on the population's living conditions [1]. Worldwide, the occupation of urban areas is expected to increase from 55% in 2015 to 66% by 2050, pointing to the decisive role of cities in dealing with the most critical global development issues [2].

The urban design has an effect on health, and one of its primary objectives should be the promotion of quality of life [3]. Understanding the role of the social and physical context on health and the impact of these variables on different social gradients can be a way to combat iniquities in health [4].

Although "iniquities" and "inequalities" are often used as synonyms, they are actually distinct concepts. Inequalities in health refer to the observable differences between subgroups within a population [5]. Meanwhile, iniquities are inequalities that are considered unfair and amenable to being avoided [5], the effort at which is the focus of public policies in health [6]. One global topic that underlines initiatives to fight health iniquities in cities is the need to deal with situations where, even in cities with abundant resources, the opportunities are concentrated in a small and select group of individuals [2].

Low-income areas tend to have worse environmental conditions [7]. Obstructions on sidewalks, greater social disorder [7], lower green cover area, fewer trash bins and speed bumps [8], and less recreational areas [9] are characteristics found in these areas. Thus, people living in lower-income areas are potentially more sensitive to action by public policies [3].

An example of an intervention that influences people's lives is the implementation of urban equipment such as schools and health units in a given territory. The existence of such structures is a determining factor for economic development, in addition to the potential for territorial organization and structuring of human clusters [10]. The relationship between human behavior and the school's surroundings, for example, impacts the neighborhood and should be considered when planning such urban equipment [10].

Public schools are considered traffic hubs, so that properly adjusting the circulation around them is important for good traffic performance and the well-being of the communities they serve [10]. Adequate planning for the implementation of such equipment should consider measures that provide safe commuting to and from home and school.

Urban planning and mobility policies are also examples of interventions capable of promoting health, since they can mediate access to services (e.g. medical care, education, jobs, etc.) that directly affect quality of life [11,12]. Equitable distribution of transportation equipment in neighborhoods with different socioeconomic levels can help reduce social and health iniquities and should be a priority in government policies [13]. Characteristics of the built environment can thus be a focus of intervention capable of improving access to essential services that help reduce iniquities between neighborhoods with different income levels [13], with the potential of reaching a large share of the population.

The evidence for the relationship between the built environment and health is mostly based on secondary data, and these elements are not capable of reflecting people's experience when interacting with the neighborhood [14,15]. To understand this link to the attributes closest to pedestrians, it is important to reduce the scale of assessment, seeking information on a microscale [15,16].

Details of the built environment's microscale such as quality of sidewalks, tree cover, adequate traffic signals at crossings, and aesthetics, as well as the social environment (e.g. presence of graffiti, garbage, waste, rubble) appear to affect people's trust, comfort, and safety when circulating in their neighborhoods, but they have received less attention [15,17,18]. In addition to these characteristics being assessed less frequently, the relationship between the built environment and iniquities in health has not been explored in sufficient depth [3,13].

Several studies in Curitiba, Paraná State, Brazil, in recent years have focused on the built environment [19,20,21]. However, the relationship with health iniquities has been explored largely according to the difference in prevalence of physical activity among residents of areas with high versus low income [22], more than the disparities in the presence of environmental attributes. The current study thus aimed to investigate the association in the distribution of characteristics of the built environment's microscale in relation to physical activity and income in school neighborhoods in Curitiba.

Methods

This cross-sectional study is part of the project *Excess Weight in Students and Characteristics of the School Environment in Curitiba, Paraná* at the Federal University of Paraná. This analytical study assessed the surroundings of 30 state public schools in the Paraná state capital that offered daytime classes from the 6th grade of primary school to the 3rd year of secondary school.

Curitiba is the largest city in the state of Paraná, with an estimated population of 1,864,416 in 2014 and a human development index of 0.823, considered high. However, in 2010, 8.1% of the permanent private households were classified as belonging to substandard clusters [23]. Data from the 2014 *School Census* indicated a total enrollment of 129,333 in the city's state schools, of which 72,848 in primary school (final years) and 56,485 in secondary school [24].

Selection of areas in the school neighborhood

The research project of which the current study is a part had its sampling parameters defined to represent students from the 6th year of primary school to the 3rd year of secondary school for daytime state schools in Curitiba. The following parameters were thus used: 50% prevalence of the outcome, margin of error 4 percentage points, 95% confidence interval (95%CI), design effect of 2, and 20% predicted non-response rate, resulting in a sample of 1,437 students.

Having defined the total sample size, we opted to perform the sampling with the same size for each school (n = 48), resulting in 30 school units. The establishments were selected from the list of state schools in the city in 2014 (n = 167), excluding those that exclusively work with special education or indigenous children (n = 3). The number of schools (30) determined for the study is consistent with the rule of 30 school units at each level suggested by Kreft & De Leeuw [25], considered adequate for estimating regression coefficients in multilevel analyses, although numbers close to 50 are desirable for reducing biases in estimating some parameters [26]. The distribution covered ten regional school administrative areas with at least two and at most six schools selected from each. One school refused to participate, which required a new selection to complete the estimated number.

Definition of the radius around schools and selection of street segments

An area with a radius of 500 meters around each school was assessed. The lack of available addresses for the students prevented determining the routes from home to school. We thus assessed the school neighborhoods for them to reflect this environment's characteristics, a situation that has been applied to previous studies [27,28,29]. The radius was consistent with the literature as adequate for measuring attributes of the pedestrian microscale, approximately 400 meters around the person's destination [15,17,18].

Street segment was defined as the stretch between two street intersections. In the total of 30 areas, 3,517 street segments were eligible. Due to the amount of locations in the current study, the assessment of all the segments would entail complex and costly operational logistics, so for this study we opted to use a sample of the school neighborhoods. The study thus considered a sample of 25% of the total segments in an area, as proposed by McMillan et al. [30]. To represent this amount, 879 street segments would be needed, but to guarantee the representativeness according to school unit, 888 segments were selected. For purposes of comparison, a sample calculation for a prevalence study, considering parameters that would maximize its size (50% prevalence of the outcome, 4% margin of error, and 5% level of significance) would result in fewer segments (513).

The schools were georeferenced based on their addresses, using the open-access geographic information system package QGIS (v.2.14.0) (http://qgisbrasil.org/). Based on a file with the layout of the city's streets provided by the Curitiba City Institute for Urban Research and Planning (IPPUC), the street segments located within a radius of 500 meters were systematically selected.

Auditing the segments

Assessment of the built environment's attributes used the *Microscale Audit of Pedestrian Streetscapes* (MAPS), complete version [15], translated and applied to the Brazilian context [31]. MAPS was developed from accumulated experiences with various systematic social observation tools and provides a detailed assessment of information at the closest level to pedestrians (microscale), consisting of four sections: Routes, Street Segments, Crossings, and Dead-End Streets [15].

In the current study, only the first three sections were applied, since recreational equipment on dead-end streets is quite uncommon in Brazil. The Routes sections assessed the presence of target destinations, mixed land use, presence of urban equipment, transportation options, and characteristics of the streets, beside social attributes, street maintenance, and aesthetics. Audit of the Segments section aimed to capture the number of vehicle lanes; continuity, quality, and width of sidewalks; presence of obstacles; presence and coverage of trees; building height and recessed frontage; visibility of pedestrians from the window level; cycling infrastructure; and public lighting. In the Crossings section, we assessed the intersection controls (signs, stoplights, turnarounds); pedestrian signage (pedestrian lanes, elevated crosswalks); accessibility (recessed guides, tactile paving, refuge islands); number of crossing lanes; and waiting areas for bicycles.

For familiarity with the data collection tool, the researchers used the tool's manual available on the developers' website (http://sallis.ucsd.edu/measure_maps.html). The principal investigator also participated in face-to-face data collection sessions in a study under way using the same tool [31], besides maintaining permanent contact with researchers accustomed to using it in other studies. The pilot study in this stage was done in the area of a school not selected for the study.

The systematic social observation method (audit) was virtual, using the Google Street View platform (https://www.google.com.br/intl/pt/streetview/#!/). The street audit stage was done from February to September 2017. The time between data collection and the date on the photograph on the platform varied from 6.0 to 75.0 months, with a median of 25.5. This assessment modality has been described in the literature as valid and reproducible for measuring attributes of the built environment on a large scale while saving time and financial resources and providing greater safety in areas with more serious social disorder [32,33,34].

For this study, each street segment was defined as a route to be measured. Creation of the route used the itinerary definition tool from Google Maps (https://www.google.com/maps), with the starting and finishing points using the addresses on the segment, going from the lowest to the highest number on the street.

To adjust the location defined for the segment, all the addresses were verified with the georeferenced data using the GIS tool, and when the addresses were not the same as those provided by Google Maps, the route was corrected manually.

Data collected in the audit stage were keyed into an electronic form, created and stored using the free-access Epi Info software (v.7.2.1.0) (https://www.cdc.gov/epiinfo/index.html).

Built environment variable

MAPS, in the version and format used here, has 186 items distributed between the street segment identification and audit tool sections. Data were grouped according to the Routes, Segments, and Crossings sections as proposed in the tool's validation and reproducibility studies [15,17,27,31] The scoring system consists of levels that consider positive and negative attributes according to their expected effect on physical activity [17,31].

Complete details on the scoring system are available on the tool's website (http://sallis.ucsd.edu/measure_maps.html). The possible score on each section varied according to the following distribution: Routes (-11 to 61), Segments (-6 to 21), and Crossings (-4 to 44). The total score for the street segment was obtained as the sum of the MAPS sections. The final score for the school neighborhoods used the mean of the scores of the segments comprising each area.

To identify the differences in the quality of the pedestrian microscale between the city's central and peripheral areas, we calculated the linear distance from the school's address to the city center (ground zero). This measurement was obtained with the GIS tool and recorded in kilometers.

Income in the school neighborhoods

Using the GIS intersection tool, the census tracts contained in the buffer areas were selected (n = 375), and the income data were obtained from the database of the Brazilian Institute of Geography and Statistics (IBGE; http://www.ibge.gov.br). Income in the school neighborhoods was calculated as the mean nominal income of heads-of-households in the set of census tracts comprising each area, obtained from the 2010 *Brazilian Demographic Census*. The school surroundings had a mean of 12.5 (±4.5) tracts that were intercepted inside the defined radius.

Data analysis

The descriptive stage for the data from the built environment (microscale), income, and distance from the city center to the school neighborhoods used measures of central tendency (means and medians) and dispersion (standard deviations and minimum and maximum values). Next, they were grouped in tertiles for income (1T [BRL 857.96-BRL 1,506.68]; 2T [BRL 1,506,69-BRL 2,709.91]; 3T [BRL 2,709.92-BRL 7,181.06]) and distance from city center (1T [1.60km-5.20km]; 2T [5.21km-8.37km]; 3T [8.38km-20.26km]).

The variability in the MAPS scores between schools and segments was estimated by two-level mixed multilevel models (level 1 = segment and level 2 = school), which allowed estimating grand means and intraclass correlations (ICC = area level variance/ total variance) [33].

We began by identifying the parameters for the null model for each section (Routes, Segments, and Crossings) and the total MAPS score (model 1). Next, we included one-by-one the variables for the buffer zone's income and the distance from the school to ground zero. The last model considered the income and distance variables simultaneously. The adjusted predicted mean MAPS scores and respective 95%CI were generated with the margins command. Cronbach's alpha was calculated to assess the internal consistency of the items that comprised each scale of MAPS and the total score. The analyses used the Stata software (https://www.stata.com) with significance set at 5%.

Ethical aspects

All stages of the research and publication of the data complied with the provisions of *Resolution 466/2012* of the Brazilian National Health Council. The research project was submitted to the Institutional Review Board of the Federal University of Paraná, study protocol 46085215.1.0000.0102, and approved under case review 1.426.615 on February 26, 2016.

Results

A total of 908 street segments were assessed, of which 20 were excluded for various reasons (irregular occupation, absence of streets, access blocked by gates, or lack of images), leaving 888 for analysis.

Mean nominal monthly income in the census tracts included in the areas was BRL 2,526.26, ranging from BRL 429.96 to BRL 13,807.53. The distance from the schools to the city's ground zero ranged from 1.6km to 20.3km, with a mean of 7.7km.

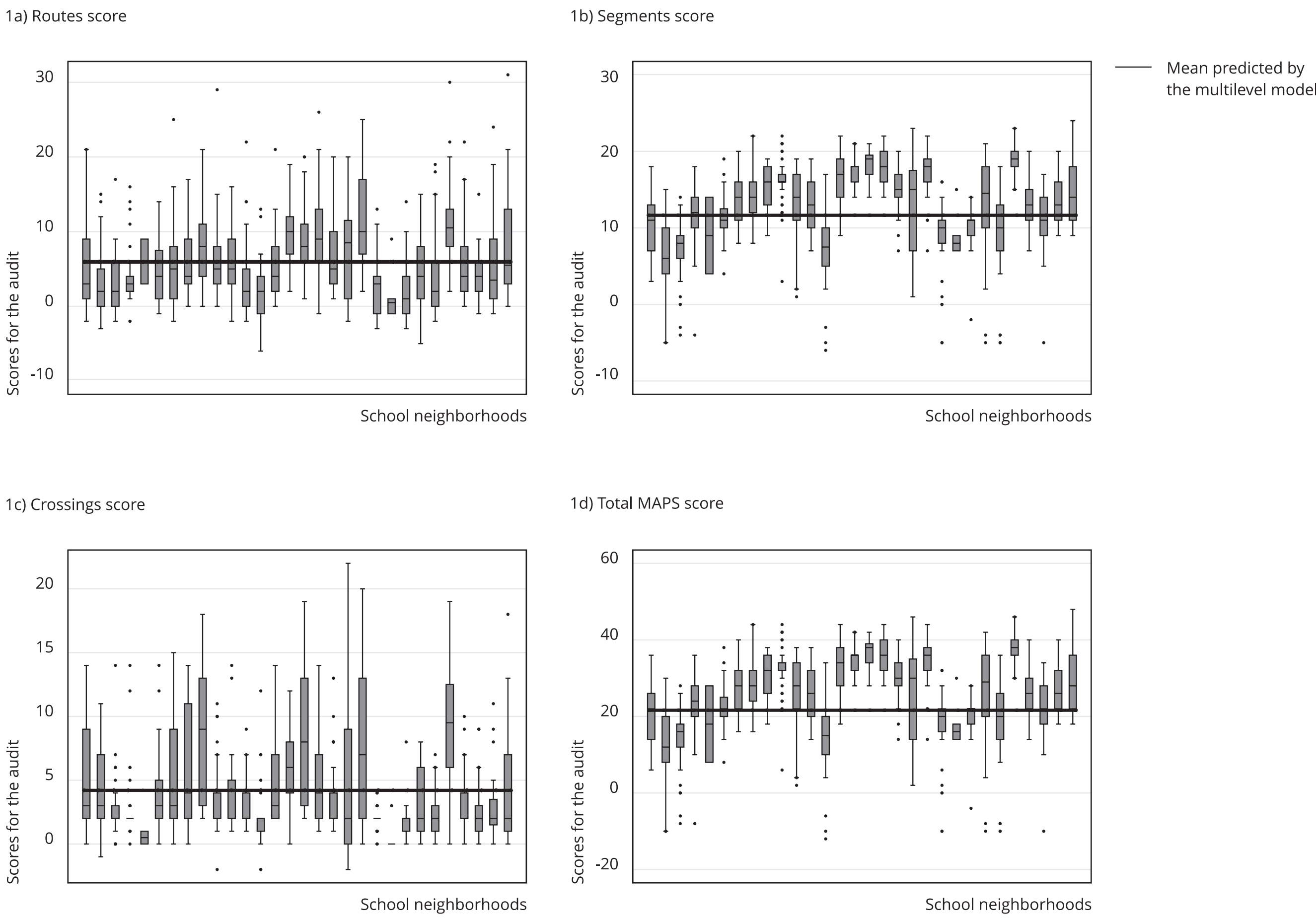
Mean total MAPS score was 21.4 points (95%CI: 20.6-21.7). After grouping the segments by school neighborhood (n = 30), the mean total score ranged from 11.0 to 39.9 points.

Figure 1 illustrates the variation in the microscale score in each section of the audit tool and allows comparing the mean predicted MAPS score generated with the mixed multilevel model to the score obtained from assessment of the 30 school neighborhoods. The total MAPS score showed an ICC of 0.35 and internal consistency, assessed by Cronbach's alpha, of 0.87. The widest variation at the school level was seen in Segments (ICC = 0.41) and the lowest in Routes (ICC = 0.19). More than one-third of the schools showed lower median values for the Segments section than the predicted mean, while for ten schools, even the 25th percentile was higher than the predicted mean value.

Table 1 shows the comparison of the mean scores for the street audit by section and total MAPS with the null model (intercept) and after inclusion of the income and distance variables. Schools in the

Figure 1

Comparison of the total MAPS score and section scores and the mean predicted by the multilevel model in the school neighborhoods. Curitiba, Paraná State, Brazil, 2017.2017.



CA: Cronbach's alpha; ICC: intraclass correlation; MAPS: *Microscale Audit of Pedestrian Streetscapes*; PM: predicted mean.
Note: Mean predicted by the mixed multilevel model. Level 1, street segments (n = 888). Level 2 school neighborhoods (n = 30); (1a) PM = 5.9, ICC = 0.19, CA = 0.68; (1b) PM = 12.9, ICC = 0.41, CA = 0.83; (1c) PM = 4.2, ICC = 0.22, CA = 0.80; (1d) PM = 23.0, ICC = 0.35, CA = 0.87, p < 0.001.

upper income tertile showed a total score 93.6% higher than those in the lower tertile. In the grouping by distance, schools closest to the city center (1st tertile) scored 84.7% higher than those in the most peripheral areas (3rd tertile).

ICC decreased when income and distance were incorporated into the analyses (Table 1). In the tool's Segments section, in which the variability was higher (ICC = 0.41), the ICC decreased to 0.13 with the inclusion of income and to 0.19 with the inclusion of distance from the city center.

Figure 2 illustrates the total audit score and scores by sections after adjusting for income and distance to ground zero. School neighborhoods located in the lowest income tertile reached 15.6 points (95%CI: 13.0-18.3), 96.8% less than those with the highest income, where the score was 30.7 (95%CI: 28.0-33.5), with a statistically significant between tertiles (p < 0.001). In the model adjusted for income and distance from ground zero, school neighborhoods farther from ground zero scored a total of 15.8 points (95%CI: 12.9-18.6) versus 29.9 for the more central schools (95%CI: 27.3-32.6) (p = 0.038).

Table 1

Mean total MAPS score and section scores around state schools in Curitiba, Paraná State, Brazil, 2017.

	Routes score		Segments score		Crossings score		Total MAPS score	
	Mean (95%CI)	p-value	Mean (95%CI)	p-value	Mean (95%CI)	p-value	Mean (95%CI)	p-value
Null model (intercept)	5.9 (4.9; 6.8)	< 0.001	12.9 (11.6; 14.1)	< 0.001	4.2 (3.5; 5.0)	< 0.001	23.0 (20.2; 25.8)	< 0.001
ICC	0.19		0.41		0.22		0.35	
Income in school neighborhood *								
1st tertile	3.6 (2.5; 4.7)	< 0.001	9.2 (8.1; 10.2)	< 0.001	2.9 (1.8; 4.0)	0.001	15.7 (12.6; 18.6)	< 0.001
2nd tertile	5.8 (4.6; 6.9)		13.3 (12.3; 14.4)		4.3 (3.2; 5.4)		23.5 (20.6; 26.4)	
3rd tertile	8.4 (7.3; 9.6)		16.5 (15.4; 17.6)		5.6 (4.5; 6.7)		30.4 (27.5; 33.4)	
ICC	0.08		0.13		0.16		0.15	
Distance from city center **								
1st tertile	8.2 (7.0; 9.4)	< 0.001	16.3 (15.0; 17.6)	< 0.001	5.6 (4.5; 6.7)	0.005	30.1 (26.9; 33.4)	< 0.001
2nd tertile	5.5 (4.3; 6.6)		12.5 (11.2; 13.8)		3.8 (2.7; 4.9)		21.8 (18.6; 25.0)	
3rd tertile	3.6 (2.3; 4.9)		9.5 (8.1; 10.9)		3.2 (2.0; 4.4)		16.3 (12.8; 19.8)	
ICC	0.19		0.19		0.18		0.19	

95%CI: 95% confidence interval; ICC: intraclass correlation; MAPS: *Microscale Audit of Pedestrian Streetscapes*.

Note: p-value obtained by the Wald test in the mixed multilevel model;

* Defined as the mean income of the census tracts, obtained in the 2010 Brazilian Demographic Census, contained within a radius of 500 meters around the school; Income tertiles: 1T (BRL 857.96-BRL 1,506.68); 2T (BRL 1,506.69-BRL 2,709.91); 3T (BRL 2,709.92-BRL 7,181.06);

** Defined as the distance in kilometers between the school's location and the city's ground zero; Distance tertiles: 1T (1.60km-5.20km); 2T (5.21km-8.37km); 3T (8.38km-20.26km).

In the assessment of the pedestrian microscale by MAPS sections in this model, the differences between scores at the extremes of income remained significant, except for Crossings (p = 0.086). For distance, the difference was only statistically significant in the Segments section (p = 0.002).

The variability of the model adjusted simultaneously for income and distance, defined by the ICC, showed differences for both total MAPS score (ICC = 0.13) and Crossings (ICC = 0.16), Routes (ICC = 0.07), and Segments (ICC = 0.08) when compared to the models considering the variables singly (Table 1).

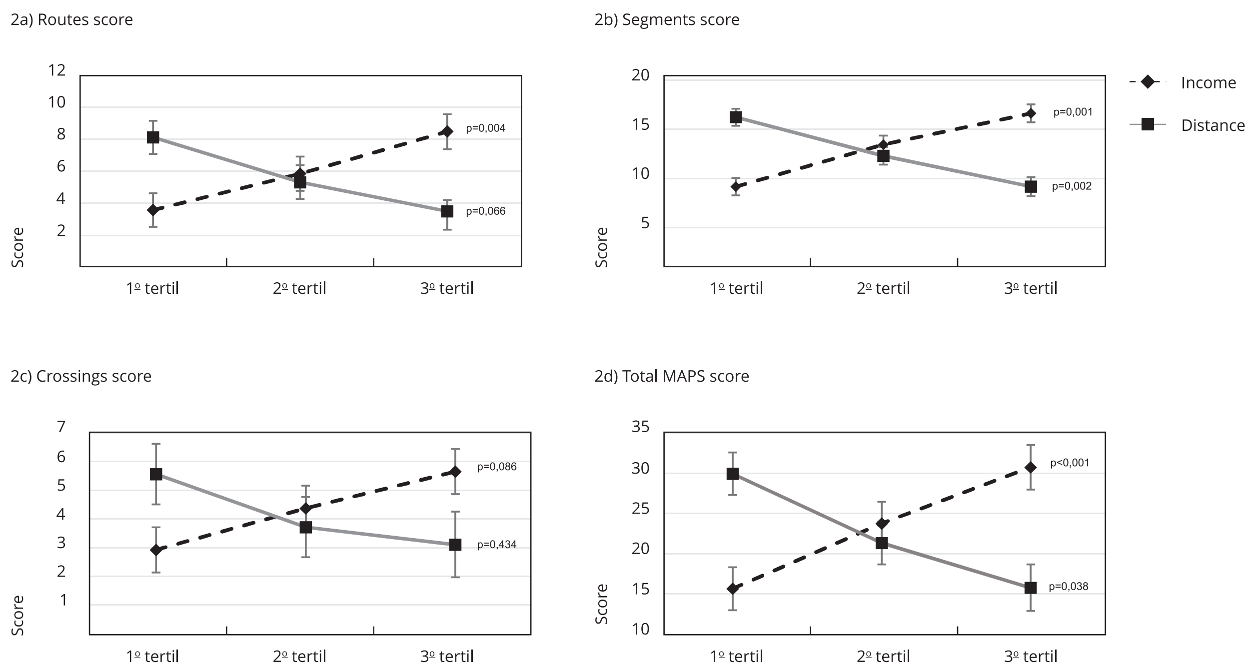
Discussion

The current study pointed to important iniquities in the distribution of characteristics of the environment around schools, partially explained by income and distance from the city center. Areas with lower income and located on the periphery of Curitiba showed worse quality of the pedestrian microscale.

After adjusting for income and distance, school neighborhoods with better economic status showed better conditions in the pedestrian microscale, independently of the distance from the city center, when compared to those with lower income. In areas in the lowest income tertile, total MAPS score was roughly half that of the school neighborhoods located in the highest income tertile. This substantial difference points to iniquity in the distribution of characteristics of the built environment, influenced by the economic status of school neighborhoods and with potential impact on the community's conditions for commuting. The differences between income strata in the current study are consistent with studies in high-income countries like the United States [35] and Australia[36].

Figure 2

Total MAPS score and section scores after adjusting for income and distance. Curitiba, Paraná State, Brazil, 2017.



95%CI: 95% confidence interval; ICC: intraclass correlation; MAPS: *Microscale Audit of Pedestrian Streetscapes*;
Note: p-value obtained by the Wald test in the mixed multilevel model; Bars indicated values within the 95% confidence interval; income tertiles: 1T (BRL 857.96-BRL 1,506.68); 2T (BRL 1,506.69-BRL 2,709.91); 3T (BRL 2,709.92-BRL 7,181.06); distance tertiles: 1T (1.60km-5.20km); 2T (5.21km-8.37km); 3T (8.38km-20.26km); ICC: (2a) Routes (ICC = 0.07); (2b) Segments (ICC = 0.08); (2c) Crossings (ICC = 0.16); (2d) Total MAPS (ICC = 0.13).

Studies comparing areas with different income levels in U.S. cities, such as Austin [37], New York [8], Baltimore, San Diego, and Seattle [35], found opposing results when assessing attributes related to quality of sidewalks (Segments section) and pedestrian safety (Crossings section). Urban planning in these cities appears to be concerned with offering greater pedestrian safety in more vulnerable areas [35].

In addition to income, distance from the city center was also associated statistically with scores in the microscale. The score in the central areas was almost double that of peripheral areas, even after adjusting for income. Areas located farther from the city center tend to concentrate groups with higher risk of vulnerability [36] and worse quality of the urban environment, especially as regards access to essential services [38].

Total MAPS score was similar in the division of the assessment tool by sections. Positive attributes in the Routes section such as presence of trees or objects of art were less common in areas located farther from the city center and with lower income. These aesthetic characteristics have been described as less frequent in areas with adverse social conditions [35,39]. In addition, elements reported in the literature as associated with greater feeling of insecurity (graffiti and accumulated garbage) [40] were more common in the school neighborhoods located on the periphery of Curitiba.

The difference in the distribution of urban environmental attributes according to income and the relationship to distance from the city center merits analysis. There is a tendency of low-income groups to live in areas with poor urban planning and sanitary conditions [41]. The more generic explanation is that these are the only areas that are accessible to the poor population, whether because they are public areas and or preservation areas (invaded, squatted), they are devalued on the real estate market, or are more available for occupation due to their risky characteristics and lack of urban infrastructure [41].

In Curitiba, the neighborhoods farthest from the city center concentrate the areas with the highest social and environmental vulnerability [42], a pattern also seen in other Brazilian cities like São Paulo [41]. The concentration of urban infrastructure in higher-income areas, which may or may not be in the city center, generates patterns of spatial segregation that place a greater burden on residents of the periphery in their commuting and access to essential and recreational services, which influence people's quality of life [43].

The public space is where people can exercise their rights and duties. It expresses the ways people use or have access to social resources [44,45] The availability of green areas, spaces for leisure-time activities, and access to health services, schools, and public transportation offer citizens opportunities to enjoy the city, fostering well-being and human development [3]. Residing in areas with worse social conditions and less access to resources affects people's health and result in higher prevalence of health problems, especially chronic noncommunicable diseases [46].

One of the health-related behaviors influenced by access to resources and social and environmental factors is physical activity [47]. The lack of functional and safe public spaces, which is more common in areas with worse social status [9], is just one of the obstacles that needs to be overcome in order to contain the pandemic of physical inactivity and the related adverse health outcomes [48].

It is thus necessary to understand how the school, social, community, and work environment and transportation systems provide or deny opportunities for incorporating physical activity into people's daily lives [48,49]. The inequalities in the environment of Brazilian cities reflect the iniquities in the country's social organization. This is also manifested in the access to physical activity by different social groups, providing poor Brazilians with fewer opportunities to be physically active [49].

Brazilian students with lower socioeconomic status and enrolled in public schools have lower odds of engaging in physical activity [49]. Thus, worse quality in the pedestrian microscale in lower-income school neighborhoods highlights the need to expand studies on the influence of these attributes on the different domains of physical activity for students circulating in these spaces.

The presence of urban equipment in a neighborhood influences the behavior of those residing around it [10]. In the case of elementary and secondary schools, concern with the organization of the surrounding environment is important for understanding its influence on schoolchildren's health. Urban planning manuals [50,51] indicate the need to offer opportunities for community engagement and interaction based on the relationship between the school and the surrounding neighborhood, in addition to promoting students' health in an environment that favors and encourages active commuting to and from school.

In order for these urban planning concepts to materialize, it is important to know the conditions students face in order to reach the educational, social, and leisure-time equipment. The quality of the pedestrian microscale, the hierarchy of the street system, and the availability of byways for pedestrians and cyclists are factors that can help minimize accidents around schools and their impacts on students' health [10]. Thus, using tools that allow learning about the attributes of the environment around such equipment on a wide scale, such as virtual audit, can be a promising area for research.

One limitation to the current study may be the use of virtual auditing, although it contributed to speed, scale, and safety in the assessment of the built environment [32]. The microscale is more sensitive to modifications in shorter time intervals, besides entailing lower costs [15], and it can thus undergo alterations in the time between date of the image capture and the assessment. The time difference between the audit and collection of the images in the platform is a limitation to the use of this type of technology in health research [52], and it can influence the study's results. As with the microscale's characteristics, the areas farthest from the city center also showed older photographs, repeating the gradient of income and distance in the quality and age of the photographs.

In the current study, the coverage of the images in the selected segments was 97.8%. The application of this audit technique to other locations, including cities farther from the state capitals, can be limited by a series of factors, including the topography of the spaces, and can also influence the availability of images on the platform. However, its use has been explored extensively in international studies [33,34] and can provide an opportunity for the expansion of research in the urban environment, with future possibilities for automation of this type of assessment [52] at lower costs, a necessary factor in scenarios with scarce research funds, as in the Brazilian case.

Another limitation is that the study was designed to be representative of the city's students, not its schools per se. Still, the selection of the school establishments and their distribution across all the municipality's administrative regions and in scenarios with different socioeconomic conditions allowed identifying important gradients in the quality of the built environment according to income in the surrounding area.

The disparity in the urban spaces between wealthier and poorer areas, whether in the assessment of income distribution or distance from the city center, raises new prospects for understanding the city's development model. The association found by the study between the characteristics of the built environment related to physical activity and income, even in one of the Brazilian cities with the highest human development index [53], pointed to the need for further understanding of the specificities of social and economic segregation that characterize Brazilian cities [43] and their impact on the residents' health.

The data's discrepancy, when compared to studies in cities in high-income counties, reinforces the need to expand research assessing the environment directly in low and middle-income countries, such as Brazil. In addition, the use of virtual audit can be a possibility for expansion of the area of research in the surroundings of other social equipment, such as parks, city squares, and health units.

Environments with worse quality in lower-income areas is one of the iniquities that needs to be confronted in Brazilian metropolises. This can potentially help improve people's quality of life, emphasizing the need for policies to improve the urban layout, especially in peripheral and lower-income areas.

Contributors

D. S. Santos and D. A. Höfelmann participated in the study project's conception and design, data analysis and interpretation, writing of the article, and approval of the final version for publication. A. A. F. Hino participated in the data analysis and interpretation, critical revision of the content, and approval of the final version for publication.

Additional informations

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References

1. Barton H, Grant M. Urban planning for healthy cities a review of the progress of the european healthy cities programme. J Urban Health 2013; 90 Suppl 1:129-41.
2. World Health Organization. Global Report on Urban Health: equitable, healthier cities for sustainable development. Geneva: World Health Organization; 2016.
3. Gelormino E, Melis G, Marietta C, Costa G. From built environment to health inequalities: an explanatory framework based on evidence. Prev Med Rep 2015; 2:737-45.
4. Wei C, Cabrera-Barona P, Blaschke T. Local geographic variation of public services inequality: does the neighborhood scale matter? Int J Environ Res Public Health 2016; 13:981.
5. Arcaya MC, Arcaya AL, Subramanian SV. Inequalities in health: definitions, concepts, and theories. Glob Health Action 2015; 8:27106.
6. da Silva ICM, Costa JC, Ewerling F, Hellwig F, Ferreira LZ, Ruas LP, et al. Mensuração de desigualdades sociais em saúde: conceitos e abordagens metodológicas no contexto brasileiro. Epidemiol Serv Saúde 2018; 27:e000100017.
7. Kelly CM, Schootman M, Baker EA, Barnidge EK, Lemes A, Kelly CM. The association of sidewalk walkability and physical disorder with area-level race and poverty. J Epidemiol Community Health 2007; 61:978-83.

8. Neckerman KM, Lovasi GS, Davies S, Purciel M, Quinn J, Feder E, et al. Disparities in urban neighborhood conditions: evidence from gis measures and field observation in New York City. J Public Health Policy 2009; 30 Suppl 1:S264-85.
9. Moore LV, Diez Roux AV, Evenson KR, McGinn AP, Brines SJ. Availability of recreational resources in minority and low socioeconomic status areas. Am J Prev Med 2008; 34:16-22.
10. Neves FH. Planejamento de equipamentos urbanos comunitários de educação: algumas reflexões. Cadernos Metrópole 2015; 17:503-16.
11. Spinney JEL, Scott DM, Newbold KB. Transport mobility benefits and quality of life: a time-use perspective of elderly Canadians. Transp Policy (Oxf) 2009; 16:1-11.
12. Marmot M, Friel S, Bell R, Houweling TAJ. Closing the gap in a generation: health equity through action on the social determinants of health. Lancet 2008; 372:1661-9.
13. Rachele JN, Learnihan V, Badland HM, Mavoa S, Turrell G, Giles-Corti B. Neighbourhood socioeconomic and transport disadvantage: the potential to reduce social inequities in health through transport. Journal of Transport & Health 2017; 7 (Pt B):256-63.
14. Hino AAF, Reis RS, Florindo AA. Ambiente construído e atividade física: uma breve revisão dos métodos de avaliação. Rev Bras Cineantropom Desempenho Hum 2010; 12:387-94.
15. Millstein RA, Cain KL, Sallis JF, Conway TL, Geremia C, Frank LD, et al. Development, scoring, and reliability of the Microscale Audit of Pedestrian Streetscapes (MAPS). BMC Public Health 2013; 13:403.
16. Freitas ED, Camargos VP, Xavier CC, Caiaffa WT, Proietti FA. Instrumento para condução de observação social sistemática: métodos e resultados da concordância interobservadores. Cad Saúde Pública 2013; 29:2093-104.
17. Cain KL, Millstein RA, Sallis JF, Conway TL, Gavand KA, Frank LD, et al. Contribution of streetscape audits to explanation of physical activity in four age groups based on the Microscale Audit of Pedestrian Streetscapes (MAPS). Soc Sci Med 2014; 116:82-92.
18. Sallis JF, Cain KL, Conway TL, Gavand KA, Millstein RA, Geremia CM, et al. Is your neighborhood designed to support physical activity? A brief streetscape audit tool. Prev Chronic Dis 2015; 12:E141.
19. Hino AAF, Reis RS, Sarmiento OL, Parra DC, Brownson RC. Built environment and physical activity for transportation in adults from Curitiba, Brazil. J Urban Health 2013; 91:446-62.
20. Hino AAF, Reis RS, Sarmiento OL, Parra DC, Brownson RC. The built environment and recreational physical activity among adults in Curitiba, Brazil. Prev Med 2011; 52:419-22.
21. Sallis JF, Cerin E, Conway TL, Adams MA, Frank LD, Pratt M, et al. Physical activity in relation to urban environments in 14 cities worldwide: a cross-sectional study. Lancet 2016; 387:2207-17.
22. Reis RS, Akira A, Hino F, Rech CR, Kerr J, Hallal PC. Walkability and Physical activity: findings from Curitiba, Brazil. Am J Prev Med 2013; 45:269-75.
23. Atlas de Desenvolvimento Humano no Brasil. http://atlasbrasil.org.br (accessed on 01/Feb/2018).
24. Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira. Resultados do Censo Escolar 2014. http://portal.inep.gov.br/resultados-e-resumos (accessed on 02/Jun/2018).
25. Kreft I, De Leeuw J. Introducing multilevel modeling. Thousand Oaks: Sage Publications; 1998.
26. HoxJJ, Moerbeek M, Schoot RVD. Multilevel analysis: techniques and applications. 3rd Ed. Mahwah: Lawrence Erlbaum Associates; 2017.
27. Frank LD, Fox EH, Ulmer JM, Chapman JE, Kershaw SE, Sallis JF, et al. International comparison of observation-specific spatial buffers: maximizing the ability to estimate physical activity. Int J Health Geogr 2017; 16:4.
28. Arvidsson D, Kawakami N, Ohlsson H, Sundquist K. Physical activity and concordance between objective and perceived walkability. Med Sci Sports Exerc 2012; 44:280-7.
29. Nelson MC, Gordon-Larsen P, Song Y, Popkin BM. Built and social environments. Associations with adolescent overweight and activity. Am J Prev Med 2006; 31:109-17.
30. McMillan TE, Cubbin C, Parmenter B, Medina AV, Lee RE. Neighborhood sampling: how many streets must an auditor walk? Int J Behav Nutr Phys Act 2010; 7:20.
31. Cain KL, Geremia CM, Conway TL, Frank LD, Chapman JE, Fox EH, et al. Development and reliability of a streetscape observation instrument for international use: MAPS-global. Int J Behav Nutr Phys Act 2018; 15:47.
32. Phillips CB, Engelberg JK, Geremia CM, Zhu W, Kurka JM, Cain KL, et al. Online versus in person comparison of Microscale Audit of Pedestrian Streetscapes (MAPS) assessments: reliability of alternate methods. Int J Health Geogr 2017; 16:27.
33. Schootman M, Nelson EJ, Werner K, Shacham E, Elliott M, Ratnapradipa K, et al. Emerging technologies to measure neighborhood conditions in public health: implications for interventions and next steps. Int J Health Geogr 2016; 15:20.
34. Odgers CL, Caspi A, Bates CJ, Sampson RJ, Moffitt TE. Systematic social observation of children's neighborhoods using Google Street View: a reliable and cost-effective method. J Child Psychol Psychiatry 2012; 53:1009-17.
35. Thornton CM, Conway TL, Cain KL, Gavand KA, Saelens BE, Frank LD, et al. Disparities in pedestrian streetscape environments by income and race/ethnicity. SSM Popul Health 2016; 2:206-16.

36. Currie G, Richardson T, Smyth P, Vella-Brodrick D, Hine J, Lucas K, et al. Investigating links between transport disadvantage, social exclusion and well-being in Melbourne – updated results. Research in Transportation Economics 2010; 29:287-95.
37. Zhu X, Lee C. Walkability and safety around elementary schools. economic and ethnic disparities. Am J Prev Med 2008; 34:282-90.
38. Delbosc A, Currie G. The spatial context of transport disadvantage, social exclusion and well-being. J Transp Geogr 2011; 19:1130-7.
39. Landry SM, Chakraborty J. Street trees and equity: evaluating the spatial distribution of an urban amenity. Environ Plan A 2009; 41:2651-70.
40. Mason P, Kearns A, Livingston M. "Safe Going": the influence of crime rates and perceived crime and safety on walking in deprived neighbourhoods. Soc Sci Med 2013; 91:15-24.
41. Alves HPF. Vulnerabilidade socioambiental na metrópole paulistana: uma análise sociodemográfica das situações de sobreposição espacial de problemas e riscos sociais e ambientais. Rev Bras Estud Popul 2006; 23:43-59.
42. Cunico C, Lohmann M. Vulnerabilidade socioambiental de Curitiba: correlação com os eventos de alagamentos registrados entre 2005 e 2010 pela Defesa Civil Municipal. Geografia, Ensino e Pesquisa 2017; 21:165-85.
43. Villaça F. São Paulo: segregação urbana e desigualdade. Estudos Av 2011; 25:37-58.
44. Kuri PR. Espacio público ¿Espacio de todos? Reflexiones desde laciudad de México. Revista Mexicana de Sociología 2015; 77:7-36.
45. Borja J, Muxi Z. El espacio público, ciudad y ciudadanía. Barcelona: Electa; 2000.
46. Rachele JN, Giles-Corti B, Turrell G. Neighbourhood disadvantage and self-reported type 2 diabetes, heart disease and comorbidity: a cross-sectional multilevel study. Ann Epidemiol 2016; 26:146-50.
47. Bauman AE, Reis RS, Sallis JF, Wells JC, Loos RJF, Martin BW. Physical activity 2: correlates of physical activity: why are some people physically active and others not? Lancet. 2012; 380:258-71.
48. World Health Organization. Physical activity strategy for the WHO European Region 2016-2025. Copenhagen: WHO Regional Office for Europe; 2015.
49. Programa das Nações Unidas para o Desenvolvimento. Relatório de desenvolvimento humano nacional – movimento é vida: atividades físicas e esportivas para todas as pessoas. Brasília: Programa das Nações Unidas para o Desenvolvimento; 2017.
50. US Green Building Council. LEED v4 for Neighborhood development. https://goo.gl/xusZkj (accessed on 15/May/2018).
51. U.S. Green Building Council, Land Use Law Center. Technical guidance manual for sustainable neighborhoods. s.l.: Land Use Law Center; 2013.
52. Rzotkiewicz A, Pearson AL, Dougherty B V., Shortridge A, Wilson N. Systematic review of the use of Google Street View in health research: major themes, strengths, weaknesses and possibilities for future research. Health Place 2018; 52:240-6.
53. Ribeiro LCQ, Ribeiro MG, organizadores. IBEU – índice de bem-estar urbano. Rio de Janeiro: Letra Capital; 2013.

Resumo

O objetivo do estudo foi investigar a associação entre as características do ambiente relacionado à atividade física com a renda em áreas de entorno escolar em Curitiba, Paraná. Foram auditados 888 segmentos de rua com um instrumento de observação sistemática em três seções (Rotas, Segmentos e Cruzamentos) no raio de 500 metros ao redor de 30 escolas públicas. O escore total foi a soma das seções. Dados de renda do entorno escolar foram obtidos do Censo Demográfico *de 2010, e a distância linear de cada escola até o centro da cidade foi calculada. Modelos multiníveis (nível um segmento e nível dois escola) foram aplicados na análise, com estimativas de médias ponderadas e correlações intraclasse (ICC). Na análise bruta, a maior variabilidade entre as escolas foi observada na seção Segmentos (ICC = 0,41), e a menor, na seção Rotas (ICC = 0,19). Os segmentos de rua localizados no entorno de escolas do primeiro tercil de renda alcançaram uma média ajustada de 15,6 (IC95%: 13,0-18,3) no escore total, quase metade daqueles de renda maior, que atingiram 30,7 (IC95%: 28,0-33,5) pontos, com diferença significativa entre os tercis (p < 0,001). O escore das áreas mais centrais foi 30,1 (IC95%: 26,9-33,4), significativamente maior (p < 0,001) se comparado àquelas mais periféricas em que a pontuação foi 16,3 (IC95%: 12,8-19,8). As características do ambiente avaliadas nas seções Rotas e Segmentos, além do escore total, mostraram-se associadas com a menor renda. Ambiente de pior qualidade em áreas de menor renda é uma das iniquidades que precisa ser enfrentada nas metrópoles brasileiras e que pode contribuir para a melhoria da saúde das pessoas.*

Planejamento Ambiental; Fatores Socioeconômicos; Saúde da População Urbana

Resumen

El objetivo del estudio fue investigar la asociación entre las características del ambiente relacionado con la actividad física, con la renta en áreas del entorno escolar en Curitiba, Paraná. Se auditaron 888 segmentos de calle con un instrumento de observación sistemática en tres secciones (Rutas, Segmentos y Cruces) en un radio de 500 metros alrededor de 30 escuelas públicas. El marcador total fue la suma de las secciones. Los datos de renta del entorno escolar se obtuvieron del Censo Demográfico *de 2010, y se calculó la distancia lineal de cada escuela hasta el centro de la ciudad. Modelos multiniveles (nivel uno segmento y nivel dos escuela) se aplicaron en el análisis, con estimativas de medias ponderadas y correlaciones intraclase (ICC). En el análisis bruto, la mayor variabilidad entre las escuelas se observó en la sección Segmentos (ICC = 0,41), y la menor, en la sección Rutas (ICC = 0,19). Los segmentos de calle, localizados en el entorno de escuelas del primer tercil de renta, alcanzaron una media ajustada de 15,6 (IC95%: 13,0-18,3) en el marcador total, casi la mitad de aquellos de renta mayor, que alcanzaron 30,7 (IC95%: 28,0-33,5) puntos, con diferencia significativa entre los terciles (p < 0,001). El marcador de las áreas más centrales fue 30,1 (IC95%: 26,9-33,4), significativamente mayor (p < 0,001), si se compara a aquellas más periféricas, donde la puntuación fue 16,3 (IC95%: 12,8-19,8). Las características del ambiente evaluadas en las secciones Rutas y Segmentos, además del marcador total, se mostraron asociadas con una menor renta. Un ambiente de peor calidad en áreas de menor renta es una de las inequidades contra las que se necesita luchar en las metrópolis brasileñas y que puede contribuir a la mejora de la salud de las personas.*

Planificación Ambiental; Factores Socioeconómicos; Salud Urbana

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