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Social and ethnic-racial inequities of physical accessibility to street markets in Porto Alegre/RS, Brazil

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RESUMO

As feiras livres no Brasil são espaços importantes para a venda de frutas, verduras e legumes (FLV), considerados um dos aspectos-chave para “cidades saudáveis”. Este estudo adota uma abordagem ecológica com ênfase geográfico-espacial para descrever a acessibilidade às feiras livres em Porto Alegre, Brasil, por quatro modos de transporte (a pé, bicicleta, ônibus e carro). A distribuição das feiras pela cidade é mais equilibrada do que outros estabelecimentos de alimentos, embora a acessibilidade física seja altamente desigual entre os diferentes modos de transporte: a capacidade de alcançar uma feira a pé em 10 minutos ou menos é restrita a menos de 25% da população, enquanto quase 90% podem fazê-lo dirigindo um carro. Mais importante, o estudo encontrou uma associação direta e positiva entre os níveis de acessibilidade às feiras e a renda: as localidades mais ricas podem chegar às feiras em menos tempo usando qualquer modo de transporte do que as mais pobres ($p<0,001$). Além disso, regiões com maioria de habitantes brancos têm acessibilidade significativamente melhor às feiras a pé, de bicicleta e de ônibus ($p<0,01$) do que regiões com maioria de população negra, indígena ou amarela. Nosso estudo destaca a importância de abordar as desigualdades no acesso aos alimentos saudáveis.

Palavras-chave:

Iniquidades, acessibilidade urbana, raça/cor de pele, alimentos saudáveis, feiras livres.

ABSTRACT

Street markets in Brazil are important spaces for the commercialization of fruits and vegetables (FV), which access by the urban population is considered one of the key aspects for the so-called "healthy cities". This study adopts an ecological approach with geographic-spatial *emphasis to describe accessibility to street markets in Porto Alegre, Brazil, by four different modes of transport (walking, bicycle, bus and car). The distribution of markets across the city is more balanced than other food establishments, although physical accessibility is highly uneven across modes of transport: the ability to reach a market on foot in 10 minutes or less is restricted to no more than 25 % of the population, while almost 90% can do it by driving a car. More importantly, the study found a direct and positive association between levels of accessibility to street markets and income: wealthier areas can reach fairs in less time using any mode of transport than poorer ones (p<0.001). In addition, regions with a majority of white inhabitants have significantly better accessibility to the fairs on foot, by bicycle and by bus (p<0.01) than regions with a majority of Black, Indigenous or yellow populations. Our study highlights the importance of addressing inequalities in access to healthy foods.*

Keywords*: social inequities, urban accessibility, race/skin color, nutrition, farmers' market.*

INTRODUCTION

Eating fruits and vegetables (FV) is an important protective factor against the development of Chronic Noncommunicable Diseases (NCDs)[1]. The most consistent evidence[2,3] points to the importance of consuming these foods for the prevention of cardiovascular diseases, which are the main causes of death in the world, due to the presence of micronutrients, dietary fiber and photochemical compounds. Considering the importance of these foods, the World Health Organization recommends daily consumption of 400 grams of them, which is equivalent to five servings of FV[5]. However, the vast majority of the population does not meet these recommendations[6]. In Brazil, the consumption of FV is monitored by an annual telephone survey conducted by the Ministry of Health. Despite the study pointing to an increase in consumption in 2008 to 2016, in 2016 only 24.4% of the sample consumed FV in accordance with the WHO recommendation[7].

Several individual factors influence the consumption of fruits and vegetables, such as income, education, and race/skin color[8], combined with environmental factors such as the availability of establishments that sell these products and urban spatial accessibility. A study carried out in São Paulo, for example, suggests that the presence of stores that sell FV close to people’s residences is associated with more frequent consumption of these foods[9].

One of the locations where, traditionally, the Brazilian population buys fresh or minimally processed foods are street markets[10]. A study carried out in Porto Alegre[11] found that they are one of the main places to buy food among people who have a healthy eating pattern, mainly composed of FV. This suggests that these markets are indicators of healthier food environments, as their presence nearby can encourage the purchase of foods with higher nutritional value, generally at lower prices when compared to other traditional food establishments[12,13].

Street markets are part of short marketing circuits for foods, establishing more direct relationships between producers and consumers and ensuring the economic and social maintenance of small farmers. They integrate food and nutritional security systems in many Brazilian cities and regions and are seen as a sustainable strategy for urban food supply[14,15,16].

Physically, they are retail spaces with temporary stalls that occupy streets and public spaces at certain days and times[13] and which, usually, have their location defined by food supply decentralization policies. However, studies carried out in the Brazilian states of São Paulo[9], Minas Gerais[17] and Paraná [18] found that street markets are mostly installed in the more central regions of cities, and close to the higher-income populations, which may be one of the factors associated with the lower consumption FV by the most vulnerable populations. A review of national surveys on food consumption showed that men, people who are less educated and people of African descent had lower consumption of these foods[8].

Most studies on access to places selling fresh food [12,13,17] adopt “container” approaches to measure spatial accessibility, assessing the co-location of individuals and establishments, that is, the belonging of both to a same geographic area (neighborhoods, census tracts or buffers around the dwellings). An alternative, more realistic approach that has become the standard is the use of accessibility indicators that effectively calculate the possibility of people physically reaching certain destinations (whether they are places of supply, employment, study or leisure), located in any part of the city, using any actual mode of transport (walking, bicycle, bus and car) and moving through the streets of the city’s street network[19].

Employing this approach, our article sought to discuss the association between the sociodemographic characteristics of the inhabitants of Porto Alegre and their level of physical accessibility to the city’s street markets. Our aim is to reveal possible socio-spatial inequities that may hinder the consumption of healthy foods by vulnerable populations due to poverty and race/skin color.

METHODS

Study design and population

This study follows an ecological approach with emphasis on space, conducted from secondary data in the city of Porto Alegre, Rio Grande do Sul, Brazil. The city is the State capital, has an estimated population of 1,492,530 inhabitants and a Municipal Human Development Index of 0.805, classified as “very high” [20].

In Porto Alegre, the organization of street markets has been under the responsibility of the municipal government since the 1950s, when Municipal Decree n. 474 regulated the operation and designated locations for the markets, based on criteria such as the demographic density of the neighborhoods and accessibility to wholesale centers. Since then, several legislations have regulated aspects of these markets, together with other types of street commerce, without, however, significantly changing their quantity and locations[21].

Unit of analysis

Based on data from the 2010 Brazilian Census[22], the “Access to Opportunities”[19] project led by IPEA - the Brazilian Institute of Advanced Economic Research ['Instituto de Pesquisa Econômica Avançada'][19] - has re-aggregated the information originally collected and consolidated in census tracts into a spatial grid formed by hexagonal cells with a 357-meter diagonal called “H3 – Hexagonal hierarchical geospatial indexing system,” developed and made available by Uber company[23].

This homogeneous zoning and grouping system eliminate the so-called “Modifiable Areal Unit Problem” (MAUP) that emerges when using spatial units that have no homogeneity in shape and size and that present a lot of variability in relation to the existing physical elements, as is exactly the case of the Brazilian census tracts[24]. For an analysis fundamentally based on measuring real distances and travel times, this heterogeneity can introduce bias in the calculations, which justifies the adoption of a MAUP-free system such as the hexagonal grid. The Porto Alegre grid has 6,114 hexagonal cells and, for this work, only those with at least one inhabitant in 2010 were considered, totaling a sample of 3,232 cells (52.8%).

Sociodemographic data

From the data processed by IPEA, we took' the total population, the number and percentage of white, black, brown, indigenous or yellow residents, and the average per capita household income.

Race/skin color and income were transformed into binary variables: in the first case, every cell with more than 25.5% of the population (≥ 3rd quartile of the 2010 distribution) composed of ethnic-racial minorities (black, brown, indigenous, and yellow) was classified as 'high presence' of these population groups, and the others as 'low presence'. In the second case, every hexagon whose mean income value was below BRL 474.35 (≤ 1st quartile) was considered as 'lower income' and the others as 'higher income'.

Data on food markets

Data on the type, location, days and hours of operation of the markets were collected from the Porto Alegre City Hall webpage in August 2022 as a geospatial file, that is, containing addresses and geographic coordinates that allow locating them with precision within the city space. The location of each market was cross-referenced with the grid, enabling the construction of a matrix of origins (cells with population) and destinations (cells that contain one or more markets)[25].

We aggregated the three types of street markets that exist in the city – (I) conventional markets, known as 'model market' ['feiras modelo']; (II) farmers’ markets; and (III) ecological markets, which sell only organic and agroecological foods – into a single category, considering that they all sell fresh foods, mostly FV.

For comparison purposes, the location data of the other types of food establishments for 2020 in Porto Alegre were also analyzed. These data were provided by the State Treasury Department of Rio Grande do Sul and classified according to the nature of the products marketed, as proposed by the 2018 Technical Mapping of Food Deserts prepared by CAISAN (Interministerial Chamber for Food and Nutrition Security)? i) only or mainly unprocessed or minimally processed foods; ii) mixed products, usually with on-site food services (bakeries and restaurants); iii) only or mainly ultra-processed foods (sweet shops, snack bars, fast food places); and iv) grocery stores and supermarkets, analyzed separately by the diversity of products sold.

Analyses

The analysis of the distribution of food retail and street markets in geographic space started with the NNI – Nearest Neighborhood Index - which computes the average distances between each point and the nearest point and divides this number by the expected average distance in a hypothetical random distribution with the same number of points covering the same area. If the means are equal, the ratio is 1 (one) and the distribution can be considered random. If the expected mean is greater than what has been observed, then the ratio is less than 1 and the distribution can be considered concentrated. The closer to 0, the more concentrated[26].

To assess the physical accessibility of the population to markets (destination), the Minimum Travel Time (MTT) indicator was used. This is the minimum travel time (in minutes) from each cell with population (origin) by each mode of transport to the closest cell with markets available [27].

The IPEA *script package r5r*, prepared for the R software, was employed to calculate the path between each origin- destination pair, considering the real road network of Porto Alegre and four different modes of transport: walking, bicycle, public transport (bus) and car[28].

For the walking and cycling modes, the algorithm searches for the shortest path between the origin and the destination by any trafficable road, while for the car it considers the driving roadways, traffic lights and other restrictions present in the road network spatial model provided by the city of Porto Alegre (POA Dados Abertos https://dadosabertos.poa.br/)[29].

For bus trips, the code uses the same network as automobiles, but adds the itineraries of the lines, the location of the bus stops and the frequency of the vehicles, available in the GTFS – General Transit Feed Specification[28] – from Porto Alegre (POA Dados Abertos https://dadosabertos.poa.br/)[29]. The calculation considers the path (generally traveled on foot) between the centroid of the cell of origin and the nearest bus stop, the route of the bus line between this and the bus stop closest to the market(s), as well as the final path (on foot) between both. The final value of bus travel time, therefore, is the sum of walking times plus waiting times plus the bus trip itself.

The 2019 GTFS file was used to analyze the 'normal' condition of accessibility by city buses, as the 2020/2022 COVID-19 pandemic significantly altered the system – a problem that is not the focus of this article[30].

In the code specifications, the so-called 'off-peak' hours were adopted to calculate travel times by car and bus, considering that motorized trips to buy food at street markets are normally carried out between 9:00am and 12:00pm and between 2:00pm and 6:00pm, avoiding 7-9:00am, 12-1:00pm and 6-8:00pm periods. This simulates traffic conditions with less vehicles on the road, which, on the one hand, favors the car mode, but, on the other hand, can increase the travel time by bus, as the frequency of the service tends to be reduced at these times.

From the iteration of the search for routes and the calculation of the respective travel times between each point of origin and each of the markets for each of the travel modes, we classified the resulting times into 4 intervals: up to 10 minutes, 10 to 20 minutes, 20 to 30 minutes, and over 30 minutes.

Differences in accessibility between modes of transport and between cells with higher and lower income and with higher and lower presence of Black, Brown, Indigenous and yellow/Asian residents were described by absolute and relative frequency and their association was tested through Pearson's chi-square for heterogeneity and linear trend, adopting a significance level of 5%. The data were treated statistically in the R software (version 4.2.1) and GeoDa (version 1.20).

RESULTS

Population and street markets descriptives

Of the 3,232 cells with population, 808 (25%) were classified as 'lower income' and 812 (25.12%) as 'high presence' of ethnic-racial minorities. Of the latter, 425 (52.3%) were also classified as lower income, which indicates a somewhat expected relationship between race/skin color and poverty in Porto Alegre. These values are identical to those found in the census tract grid (the original unit of analysis of the 2010 Census): 25% in the first case and 25.12% in the second, which attests to the quality of the interpolation of data to the hexagonal grid prepared by IPEA.

Figure 1 shows that, of the 44 that exist in the city (6 farmers' markets, 6 agroecological markets, and 32 of the model market type), 59% are located in the central area of the city or on main avenues, which were included in the set of 'centralities' of Porto Alegre. Table 1 shows that this is the lowest value among all categories of food establishments in the city and that the level of concentration of markets (NNI = 0.91) is also the lowest.

Figure 2 shows the spatial distribution of the markets (green dots) superimposed on the distribution of binary cells of higher/lower income (2a) and race/skin color (2b). Of the 44 markets, only 5 (11%) are located in cells with high presence of minorities and zero in lower income cells. Consequently, no markets in Porto Alegre are located in an area with a simultaneous predominance of ethnic-racial minorities and lower income.

Accessibility

Table 2 shows the number and percentage of cells in each accessibility category for each mode of transportation, as well as the sum of the inhabitants of those exact cells. Looking at the extreme categories, we can see that 21.1% of the population can access a street market on foot within 10 minutes, 26.7% by bus, and 58% by bicycle, while 88.8% can access one by car. On the other hand, 26.5% of the city's total population resides in areas that are more than 30 minutes on foot from the nearest market, 14.3% are more than 30 minutes by bicycle, 13.8% by bus, and only 0.4% by car.

Table 3 shows that only 2.7% of the population living in cells classified as lower income can travel less than 10 minutes to reach the nearest market on foot, 36.4% by bicycle, 3.9% by bus, and 69.3% by car. On the other hand, 54.2% of the population residing in cells classified as lower income need to travel more than 30 minutes to reach the nearest market on foot, 32.3% by bicycle, 37.6% by bus and 1.2% by car, while only 21.6% of the higher income population take more than 30 minutes on foot, 11.2% by bicycle, 9.5% by bus, and a very low 0.3% by car. As for race/skin color, 11.2% of the population residing in cells classified as having a high presence of minorities can get to a market in less than 10 minutes by walking, 46.2% by bicycle, 15.2% by bus, and 78.4% by car, while in locations with low presence of minorities, 26.2% can arrive at a street market on foot in this time interval, 64% by bicycle, 32.5% by bus, and 94.1% by car.

On the other hand, 43.8% of the population in locations with high presence of minorities need to walk more than 30 minutes to the nearest market, 23.9% by bicycle, 25.9% by bus, and just over zero by car, while in the other locations, 17.7% walk more than 30 minutes, 9.3% by bicycle, 7.6% by bus, and 0.6% by car. All these differences are statistically significant in according to the chi-square tests for heterogeneity with $p <= 0.001$.

It is possible to infer a linear increase trend in the percentage of cells as walking travel time classes increase and, conversely, a decreasing trend for the automobile for both 'lower income' and 'high presence' of minorities groups. This trend was not observed in the 'higher income' and 'low presence' groups, as well as for the bicycle and bus modes for all groups.

DISCUSSION

The street markets in Porto Alegre showed a lower level of geographic concentration than other food stores, indicating a reasonably balanced distribution throughout the city and reflecting the fact that their location does not follow pure market logic like other businesses, as it is determined by public supply policies that seek, at least in theory, to bring producers closer to consumers throughout the city. However, about 1/4 of the markets are located in the central area of the city, indicating that there is still some concentration, and, in the case of Porto Alegre, whose main centrality ('centro expandido') is shifted to the west in relation to the geometric center, some imbalance in the distribution. This result is in line with works[10,11,12] that show that regions outside the central areas of cities do not usually have street markets, which can make it difficult for a large part of the population to access these resources. This is confirmed by our accessibility analysis, which showed that, even when located in areas with significant residential occupation, only a small portion – around 1/4 of the population – manages to reach a market in less than 10 minutes by walking or by bus, while using a car allows almost 90% of the population to reach one in this time interval.

Our results also show that there are enormous advantages in terms of accessibility to markets for high-income locations, which is in line with the literature, as studies carried out in

Brazil have found that higher-income areas have a greater presence of establishments that sell in natura and minimally processed foods [11,12,13,17]Also regarding the advantage of locations with a white majority, our results corroborate Brazilian studies such as the one by Honório et al., (2021) [31] which assessed racial inequities and concluded that areas with a lower presence of healthy foods had a higher percentage of Black, Brown or Indigenous peoples[32], as well as surveys conducted in the United States that suggest that neighborhoods with a higher predominance of black populations have lower availability of healthy foods [33,34].

The poorest population belonging to minority ethnic-racial groups can only balance their degree of accessibility to markets with the white and high-income strata by using a car as a mode of transport, confirming the privileges historically granted to this motorized and individual transportation in the structuring of Brazilian cities, both for the location of activities and the allocation of investments in transport system[35].

Even considering these differences, the bicycle proved to be an alternative for providing short trips to markets for more than half of the population, confirming its efficiency as a means of urban transportation[36]. However, it is still a very restricted mode of transportation in Brazil (about 1% of trips in cities with more than one million inhabitants in 2018 [37]) because, in addition to the small coverage and low quality of the cycling infrastructure in most cities, people who use bicycles face behavioral resistance from others, in addition to various types of prejudice.

Thus, there is little convergence between easy access to healthy food and the so-called 'active mobility', which requires physical activity while commuting and, therefore, is also a factor in the prevention of NCDs. Studies show that a daily walk of just over 10 minutes is enough to offer substantial protection, especially against cardiovascular disease and some types of cancer [38] and that the positive effects of cycling as a physical activity are greater than any problems caused by traffic accidents and exposure to air pollution [39,40].

Thus, with the difficulty in accessing street markets in a short period of time, the socially vulnerable population tends to purchase fresh food at the closest and most easily reached establishments, usually grocery stores and supermarkets where, in most cases, prices are higher and the quality of products is lower. This can make they buy less of these foods and prioritize ultra-processed foods.[41,42]. This is consistent with the reality of Brazil and Global South countries in general, where the spatial organization of cities and the mobility systems only reinforce spatial inequalities that add to inequalities in food, nutrition and health[43].

Strengths and limitations

The main strength of the present study is the pioneering nature of research on food environments in Brazil by bringing health sciences closer to city sciences and using a more realistic methodology to assess intra-urban accessibility, comparing different population strata, in addition to traditional proximity analyses. Most the cited studies use the 'container' approach to assess accessibility, and according to our best knowledge, there are still no studies that consider real accessibility to street markets by different modes of transport through the physical road network of the city.

The results, however, should be interpreted while considering some limitations: (1) its ecological approach makes causal inference impossible at the individual level, but it can generate hypotheses and indicate paths for other study designs; (2) in this sense, it was necessary to work by measuring the accessibility of locations and, only then, computing the resident population, which leads to differences between the percentage of cells and population in each category in each mode that reflect the fact that the more central hexagons have more inhabitants than the peripheral ones; (3) the use of data from the 2010 Brazilian Census, already quite outdated, can mask changes in socio-spatial distributions; and (4) street markets are occasional, as they occur at set days and times and, therefore, cannot be considered 'regular' commercial establishments like others can. Incorporating this seasonal aspect into the analyses, as well as breaking down the markets into their different types, in association with the use of more recent demographic data, can improve the investigation, adding complexity and providing new and better conclusions.

However, the current results are highly accurate and, therefore, allow to provide evidence for the improvement of healthy food supply policies with a focus on combating social inequalities. Since street markets are an important strategy for supplying healthy foods – with access to places that sell FV being one of the key aspects for the promotion of so-called "healthy cities", the present study indicates that an inclusive look at specific regions and populations is necessary, promoting adjustments in the mobility infrastructure and transport systems that allow the use of public and active transportation to access markets, or adopting fiscal policies such as, for example, financial incentives for traveling by bus.

In addition, urban planning policies can also help to guarantee the human right to adequate food and to face social inequalities in nutrition and health, such as, for example, the implementation of other food security devices such as community gardens in areas of greater social vulnerability or the adoption of more accurate and up-to-date criteria for defining locations for the street markets, taking into account the actual characteristics of the population and the available modes of transport.

CONCLUSION

This study assessed the physical accessibility of the population of the city of Porto Alegre/Brazil to street markets, seeking to understand the contrasts between different modes of transport and, especially, the inequality between socially vulnerable populations and the more favored layers of society.

The spatial distribution of the markets and the travel times to get to them were analyzed, and the results demonstrate that a large part of the city’s areas – inhabited predominantly by low-income populations and minority ethnic groups – have great difficulty to access these establishments, mainly by walking or by public transport (bus), which are, together with the bicycle, precisely the modes of transportation considered to be more healthy and sustainable. Only the car proved capable of considerably increasing accessibility to markets for these population strata, which does not seem to contribute to the reduction of urban inequalities.

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Figure 1. Location of the markets (green dots) in relation to the main center area and structural avenues (in gray) of the city of Porto Alegre.

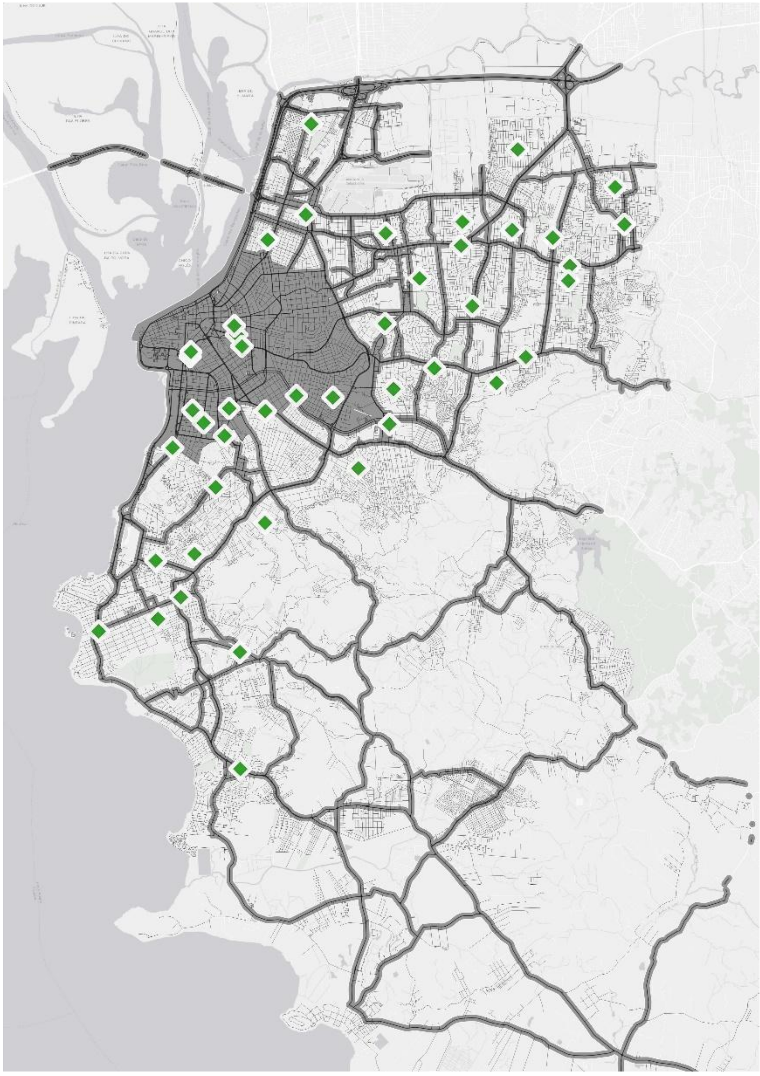


Table 1. Number, location and concentration of food establishments in Porto Alegre.

Type	N	% Center	% Avenues	% C + A	NNI
Street markets	44	25	34	59	0.91
Supermarkets	289	25	44	69	0.55
Minimally processed	445	24	41	65	0.49
Mixed	3,637	48	29	77	0.29
Ultra-processed	6,840	28	28	64	0.36

Figure 2. Location of street markets in Porto Alegre in relation to hexagons classified by income and race/skin color.

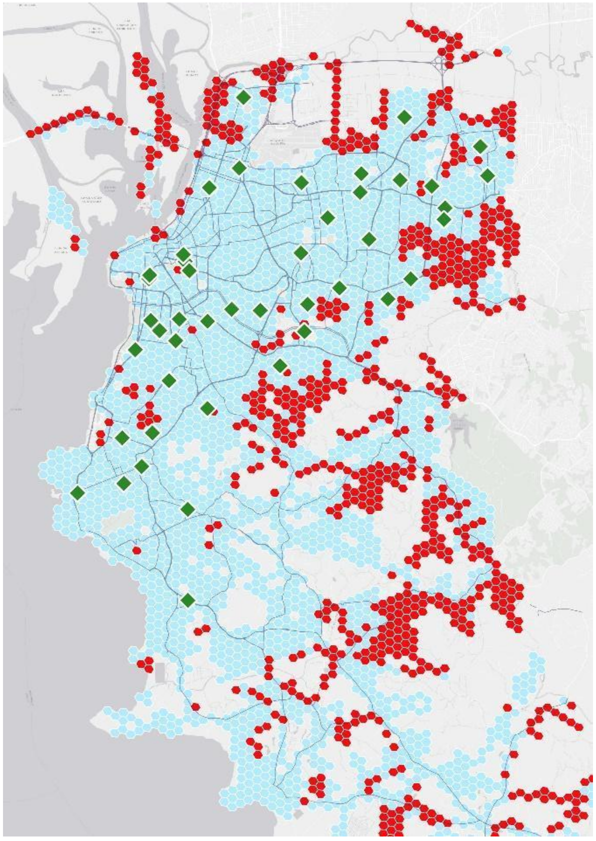
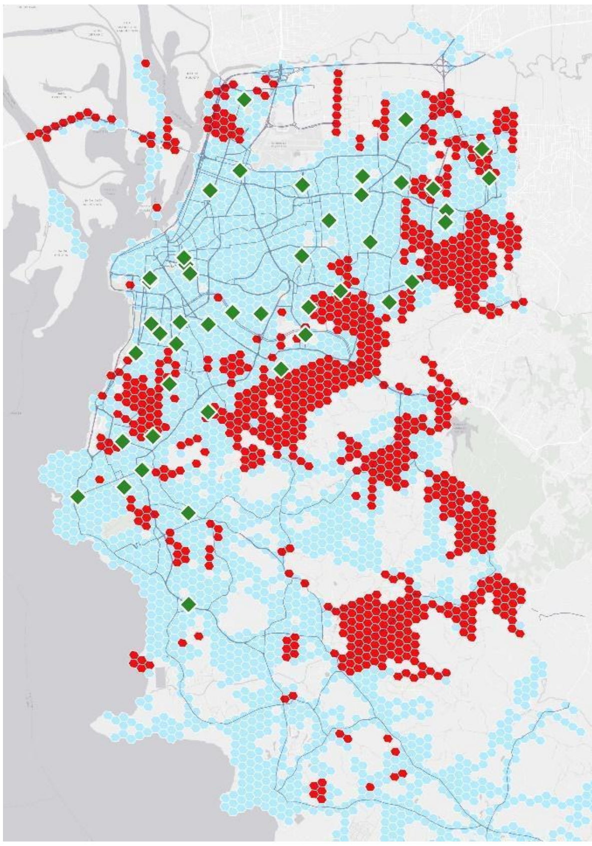
a) Red = Lower income	b) Red = High presence of racial minorities
	

Table 2. Minimum travel time in Porto Alegre to the nearest street markets by type of transport (walking, bicycle, bus and car)

Time class	Cells (%)	Population (%)
Walking		
<10min	320 (9.9)	293216 (21.1)
10-20min	624 (19.3)	447531 (32.2)
20-30min	464 (14.4)	280121 (20.2)
>30min	1824 (56.4)	368552 (26.5)
Total	*3232 (100)*	*1389420 (100)*
Bicycle		
<10min	1018 (31.5)	805735 (58)
10-20min	644 (19.9)	349516 (25.2)
20-30min	153 (4.7)	36132 (2.6)
>30min	1417 (43.8)	198037 (14.3)
total	*3232 (100)*	*1389420 (100)*
Public Transport		
<10min	421 (13)	370587 (26.7)
10-20min	958 (29.6)	628754 (45.3)
20-30min	447 (13.8)	198601 (14.3)
>30min	1406 (43.5)	191478 (13.8)
total	*3232 (100)*	*1389420 (100)*
Car		
<10min	2088 (64.6)	1233920 (88.8)
10-20min	692 (21.4)	140082 (10.1)
20-30min	271 (8.4)	9572 (0.7)
>30min	181 (5.6)	5846 (0.4)
total	*3232 (100)*	*1389420 (100)*

Table 3. Minimum travel time in Porto Alegre to the nearest street markets in association with income and race/skin color traits.

Time	**Lower income*** cells (%)	**Lower income*** pop (%)	**Higher income*** cells (%)	**Higher income*** pop (%)
Walking				
<10min	7 (0.9)	5,596 (2.7)	313 (12.9)	287,620 (24.4)
10-20min	58 (7.2)	45,258 (21.5)	566 (23.3)	402,251 (34.1)
20-30min	88 (10.9)	45,848 (21.7)	376 (15.5)	234,273 (19.9)
>30min	655 (81.1)	114,270 (54.2)	1,169 (48.2)	254,282 (21.6)
total	*808 (100)*	*210,972 (100)*	*2,424 (100)*	*1,178,426 (100)*
Bicycle				
<10min	96 (11.9)	74,980 (36.4)	922 (38)	730,755 (62)
10-20min	148 (18.3)	54,495 (26.5)	496 (20.5)	290,021 (24.6)
20-30min	55 (6.8)	9,898 (4.8)	98 (4)	26,234 (2.2)
>30min	509 (63)	66,621 (32.3)	908 (37.5)	131,416 (11.2)
total	*808 (100)*	*205,994 (100)*	*2,424 (100)*	*1,178,426 (100)*
Public Transport				
<10min	13 (1.6)	8,173 (3.9)	408 (16.8)	362,414 (30.8)
10-20min	123 (15.2)	80,074 (38)	835 (34.4)	548,680 (46.6)
20-30min	117 (14.2)	43,429 (20.6)	330 (13.6)	155,172 (13.2)
>30min	555 (68.7)	79,318 (37.6)	851 (35.1)	112,160 (9.5)
total	*808 (100)*	*210,972 (100)*	*2,424 (100)*	*1,178,426 (100)*
Car				
<10min	350 (43.3)	146,303 (69.3)	1,738 (71.7)	1,087,617 (92.3)
10-20min	258 (31.9)	58,132 (27.6)	434 (17.9)	81,950 (7)
20-30min	104 (12.9)	4,040 (1.9)	167 (6.9)	5,532 (0.5)
>30min	96 (11,9)	2,519 (1.2)	85 (3.5)	3,327 (0.3)
total	*808 (100)*	*210,972 (100)*	*2,424 (100)*	*1,178,426 (100)*

Time	**Higher minorities* cells (%)**	**Higher minorities* pop (%)**	**Lower minorities * cells (%)**	**Lower minorities* pop (%)**
Walking				
<10min	45 (5.5)	52,556 (11.2)	275 (11.4)	240,660 (26.2)
10-20min	115 (14.2)	108,697 (23.1)	509 (21)	338,834 (36.8)
20-30min	129 (15.9)	102,562 (21.8)	335 (13.8)	177,559 (19.3)
>30min	523 (64.4)	205,932 (43.8)	1,301 (53.8)	162,620 (17.7)
total	*812 (100)*	*469,747 (100)*	*2,420 (100)*	*919,673 (100)*
Bicycle				
<10min	229 (28.2)	217,027 (46.2)	789 (32.6)	588,708 (64)
10-20min	194 (23.9)	122,069 (26)	450 (18.6)	227,447 (24.7)

20-30min	60 (7.4)	18,559 (4)	93 (3.8)	17,573 (1.9)
>30min	329 (40.5)	112,092 (23.9)	1,088 (45)	85,945 (9.3)
total	*812 (100)*	*469,747 (100)*	*2,420 (100)*	*919,673 (100)*
Public Transport				
<10min	64 (7.9)	71,445 (15.2)	357 (14.8)	299,142 (32.5)
10-20min	221 (27.2)	190,330 (40.5)	737 (30.5)	438,424 (47.7)
20-30min	148 (18.2)	86,411 (18.4)	299 (12.4)	112,190 (12.2)
>30min	379 (46.7)	121,561 (25.9)	1,027 (42.4)	69,917 (7.6)
total	*812 (100)*	*469,747 (100)*	*2,420 (100)*	*919,673 (100)*
Car				
<10min	524 (64.5)	368,488 (78.4)	1,564 (64.6)	865,432 (94.1)
10-20min	241 (29.7)	97,611 (20.8)	451 (18.6)	42,471 (4.6)
20-30min	46 (5.7)	3,543 (0.8)	225 (9.3)	6,029 (0.7)
>30min	1 (0.1)	105 (0.0)	180 (7.4)	5,741 (0.6)
total	*812 (100)*	*469,747 (100)*	*2,420 (100)*	*919,673 (100)*

* Chi-square test with significance value <0.001 for all groups.

Lower income: Hexagons classified with income < BRL 474.35 (1st quartile)

Higher income: Hexagons classified with income > R$ 474.35 (2nd, 3rd, 4th quartiles)

Higher Minorities: Hexagons classified with percentage of black, brown, indigenous and yellow >=25%

Lower Minorities: Hexagons classified with percentage of black, brown, indigenous and yellow < 25%