



National overview of infrastructure for active commuting: a territorial analysis of Brazil's 5,570 municipalities

Infraestrutura para o deslocamento ativo: uma análise territorial nos 5.570 municípios brasileiros

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ABSTRACT

Objective: This study presents a territorial analysis of urban infrastructure aimed at active commuting -sidewalks, sidewalk obstacles, wheelchair ramps, lighting, trees, and bike-signalized roads -across Brazil's 5,570 municipalities, based on data from the 2022 Urban Survey of Household Surroundings conducted by the Brazilian Institute of Geography and Statistics. **Methods:** Descriptive statistical analyses of these elements were performed for all municipalities, further stratified by municipality size, region of Brazil, population growth, per capita Gross Domestic Product (GDP), and urban hierarchy, as well as specifically for each of the 27 Brazilian capitals. **Results:** The results reveal significant territorial disparities. Cities with larger populations, capital status, and higher per capita GDP displayed better indicators such as the presence of wheelchair ramps, tree coverage, and sidewalks. Bike-signalized roads were consistently low across most Brazilian municipalities, while street lighting showed consistently high coverage nationwide. **Conclusion:** These findings also support the planning of cities that are more equitable, resilient, and sustainable. These results, disaggregated for all 5,570 municipalities and aggregated for comparison groups, provide valuable input for the development and revision of master plans, urban mobility strategies, and initiatives focused on territorial equity, aligning with the targets of Sustainable Development Goal 11 and the principles of the Brazilian City Statute.

Keywords: Infrastructure; Walking; Cycling; Census; City planning.

RESUMO

Objetivo: Este estudo apresenta uma análise territorial da infraestrutura urbana voltada ao deslocamento ativo - calçadas, obstáculos nas calçadas, rampa para cadeirantes, iluminação, arborização e vias com sinalização para bicicletas - nos 5.570 municípios brasileiros, a partir dos dados da Pesquisa Urbanística do Entorno dos Domicílios 2022, realizada pelo Instituto Brasileiro de Geografia e Estatística. **Métodos:** Foram realizadas análises estatísticas descritivas desses elementos, para todos os municípios brasileiros e estratificadas por porte populacional, região do Brasil, crescimento populacional, produto interno bruto (PIB) per capita e hierarquia urbana e, especificamente, para cada uma das 27 capitais brasileiras. **Resultados:** Revelam um cenário de grandes desigualdades territoriais. Cidades com maior porte populacional, capitais e com maior PIB per capita apresentaram melhores indicadores, como a presença de rampas para cadeirantes, arborização e calçadas. Vias sinalizadas para bicicletas apresentaram valores consistentemente baixos na grande parte dos municípios brasileiros, enquanto a iluminação foi consistentemente alta em todo o país. **Conclusão:** Esses achados contribuem ainda para embasar o planejamento de cidades mais equitativas, resilientes e sustentáveis. Esses resultados, desagregados para os 5.570 e agregados para os grupos de comparação, oferecem subsídios valiosos para formulação e revisão de planos diretores, estratégias de mobilidade urbana e ações voltadas à equidade territorial, alinhando-se às metas dos Objetivos de Desenvolvimento Sustentável 11 e aos princípios do Estatuto da Cidade.

Palavras-chave: Infraestrutura; Caminhada; Ciclismo; Censo; Planejamento de cidades.

Introduction

Cities are spaces of intense social, economic, and environmental transformations, concentrating opportunities and challenges that directly affect the lives and health of urban populations^{1,2}. Accelerated urban-

ization has generated environments that, although dynamic, often reproduce territorial inequalities and compromise collective well-being^{1,2}.

In 2018, the World Health Organization published the Global Action Plan on Physical Activity 2018–2030, one of whose main objectives is to create active

environments as an effective strategy to promote physical activity³. These environments include well-planned cities that encourage the use of public transportation, walking, and cycling, contributing to the reduction of non-communicable diseases, improvements in mental health, strengthening of social cohesion, and mitigation of environmental impacts, thereby promoting population health and well-being^{4,5}. In addition, there are growing efforts to reduce environmental inequalities in access to and opportunities for physical activity^{3,6,7}.

The way that urban centers are planned and managed directly influences physical activity levels, exposure to environmental risks, access to essential services, and overall quality of life^{8,9}. In this context, active commuting, especially walking and cycling, has been recognized as an effective strategy to promote health, social inclusion, and urban sustainability¹⁰. However, there is an ongoing debate about active commuting, particularly in low- and middle-income countries such as Brazil, where walking and cycling often do not result from free choice but rather from the absence of alternatives, characterizing situations of “mobility by necessity”¹¹. In such cases, more favorable environments could offer greater safety and comfort, while for those who can choose whether or not to commute actively, better environments could make this choice more likely and increase the time dedicated to these activities, also enhancing safety and comfort.

Urban infrastructure, such as accessible sidewalks, trees, public lighting, and cycling facilities, plays a central role in promoting healthy and equitable cities^{12,13}. Numerous national and international studies have sought to map and evaluate these urban and socioeconomic conditions, aligning with the Sustainable Development Goals (SDGs), particularly SDG 11, which aims to “make cities and human settlements inclusive, safe, resilient, and sustainable”¹⁴⁻¹⁹.

In this context, however, an important conceptual challenge remains. Recent literature shows that, although there is a growing body of scientific work dedicated to measuring urban inequalities, there is still a lack of clarity in the definition and use of spatial indicators related to inequity in urban health. As highlighted by Leão et al.²⁰, many studies show a misalignment between the concept of inequity they intend to analyze and the indicators or methods actually applied, which limits the ability to adequately interpret structural territorial inequalities. These authors argue for the need for more robust analytical methods and for expanding

these approaches in low- and middle-income settings, where inequalities tend to be more pronounced and empirical evidence remains scarce.

In Brazil, the Urban Survey of Household Surroundings conducted by the Brazilian Institute of Geography and Statistics (*Instituto Brasileiro de Geografia e Estatística* – IBGE) as part of the 2022 Census represents a major methodological advance by incorporating observational attributes of urban infrastructure, providing an unprecedented and robust basis for analyzing active commuting and territorial equity across all Brazilian municipalities²¹. In this sense, quantifying and understanding the distribution of attributes such as sidewalks, sidewalk obstacles, wheelchair ramps, lighting, trees, and bicycle-designated roads at the national level can support evidence-based urban planning, promoting healthier, more accessible, and more sustainable cities.

Thus, the present study aims to analyze the distribution of urban attributes that favor active commuting, such as sidewalks, sidewalk obstacles, wheelchair ramps, lighting, trees, and bicycle-designated roads, across Brazil’s 5,570 municipalities, based on the Urban Survey of Household Surroundings²¹. The study also seeks to compare these attributes by municipality size, region of Brazil, population growth, per capita Gross Domestic Product (GDP), and urban hierarchy, identifying the most critical and the most favorable scenarios for active commuting.

The results of this study may have multiple applications. They can support diagnoses of urban and regional inequalities, guide public policies aimed at sustainable mobility, inform the development and revision of municipal master plans, and foster investments in inclusive urban infrastructure, in accordance with the principles of Brazil’s City Statute for more equitable and sustainable urban development²². In addition, the data can be integrated into intersectoral strategies in public health, education, environmental policy, and road safety.

Methods

The Urban Survey of Household Surroundings, conducted by IBGE during the 2022 Census, goes beyond traditional household data collection. It aims to characterize urban conditions surrounding Brazilian dwellings using a standardized observational approach focused on visible elements of urban infrastructure. The survey was carried out during the reconnaissance

phase of the 340,965 census tracts by Census Supervisory Agents prior to the main 2022 Census data collection²³. Because each census tract contains multiple blocks and each block has several sides (street faces), the total number of evaluated faces is much larger than the number of census tracts.

Therefore, using the face of the blocks (each side of the block/city block, whether or not it contains buildings) as the unit of observation, eleven attributes were evaluated by the Urban Survey of Household Surroundings, with 3 different categorization methods applied depending on the attribute. These are:

- 1) Minimum existence criterion - whether specific elements are present:
 - Public lighting;
 - Road paving;
 - Sidewalk;
 - Curb;
 - Storm drain;
 - Wheelchair ramp;
 - Presence of open sewage;
 - Accumulated garbage in public spaces;
- 2) Predominance criterion - what is most common in the observed area:
 - Road circulation capacity (whether it allows vehicle and pedestrian traffic);
 - Type and quality of paving;
- 3) Counting criterion - quantifies elements:
 - Number of trees on block faces (degree of tree coverage).

For this study, only attributes most directly related to active commuting, especially walking and cycling, were used. Their definitions follow the IBGE manual²⁴:

- **Presence of sidewalk** - identify if there is available space for the circulation of at least one pedestrian – approximately 80 cm – separated from the area intended for vehicle circulation, using the curb as an indicator of the presence of a sidewalk;
- **Obstacles on the sidewalk** - identify the existence of obstacles and fixed unevenness that compromise circulation, especially for people with disabilities, the elderly, or people with some degree of impairment in walking;
- **Wheelchair ramp** - identify the existence of a wheelchair ramp on the sidewalk. A wheelchair ramp is considered a lowered sidewalk or curb/

guide. Generally, the ramp is located near corners, specifically intended to provide access for people who use wheelchairs;

- **Tree** - identify the existence of tree(s) on the sidewalk being traversed and/or in the central median. Only vegetation taller than the average height of a person, approximately 1.70m, is considered;
- **Lighting** - identify at least one fixed point that provides lighting for the public space, which must be located in a public area. Even broken lighting points are considered to exist;
- **Bicycle-designated roads** - identify the lanes designated for bicycle traffic. These include cycle lanes, bike paths, or shared lane markings.

According to IBGE, during the data acquisition and processing phase, two data quality control procedures were applied: 1: Pre-checking, which generated alerts for missing mandatory fields or for inconsistent or potentially erroneous entries (e.g., completion time longer than 10 minutes; unpaved street with a storm drain; street allowing pedestrian/motorcycle circulation and a bus stop); and 2: Consistency checking, which involved comparison with the 2010 survey results (only for items that were comparable between surveys, namely lighting, storm drains, sidewalks, and road capacity), comparison with satellite images and Google Street View, identification of municipalities with outlying values when compared with municipalities of the same region and municipality size, detection of municipalities with zero values for specific items, and comparison of opposite street faces (e.g., both sides of the same street segment should have the same value for “bicycle-designated road,” for example)²³.

The attributes described above were compiled for each of Brazil's 5,570 municipalities and were subsequently grouped into five comparison categories: 1) Municipality size (Small – up to 50,000 inhabitants; Medium – 50,001 to 100,000 inhabitants; Large – more than 100,000 inhabitants); 2) Region of Brazil (Central-West, Northeast, North, Southeast, South); 3) Population growth between 2010 and 2022 (Negative growth: -45.6% to -0.01%; 1st growth tertile: 0% to 4.730%; 2nd growth tertile: 4.731% to 12.20%; 3rd growth tertile: 12.21% to 188.5%); 4) Per capita GDP quartiles (1st quartile: R\$ 5,407.70 to R\$ 12,820.40; 2nd quartile: R\$ 12,820.41 to R\$ 24,441.00; 3rd quartile: R\$ 24,441.01 to R\$ 40,772.30; 4th quartile: R\$ 40,772.31 to R\$ 920,834.00); and 5) Urban hierarchy

(state capital vs. non-capital municipalities).

To compare the magnitude of differences in attribute percentages across the city groupings, the Equiplot graphical method, developed by the International Center for Equity in Health (www.equidade.org) was used. To enable future analyses, comparisons, and ecological studies involving Surveillance System for Risk and Protective Factors for Chronic Diseases by Telephone Survey (*Vigilância de Fatores de Risco ou Proteção para Doenças Crônicas por Inquérito Telefônico* – VIGITEL) data, a stratified analysis was also conducted for each of the 27 Brazilian state capitals. In the supplementary material (Tables S1 and S2), in addition to mean values, standard deviations, minimum values, and maximum values are reported for each attribute within each grouping of municipalities. Furthermore, a map showing the percentage values for each of Brazil's 5,570 municipalities was produced using QGIS software, version 3.30.0.

Results

The map shown in Figure 1 displays the percentages of sidewalk presence, sidewalk obstacles, wheelchair ramps, bicycle-designated roads, trees, and lighting on all block faces assessed in the Urban Survey of Household Surroundings for each of Brazil's 5,570 municipalities. Marked territorial disparities are evident across municipalities, except for bicycle-designated roads and wheelchair ramps (which are consistently low) and lighting (which is consistently high). Higher percentages of sidewalks are observed in the Southeast and Central-West regions, while higher tree coverage is found in the Central-West and South. For a more detailed view, the same dataset shown in Figure 1 can be accessed for each of the 5,570 municipalities at the provided link.

Considering all 5,570 Brazilian municipalities, on average 63.3% (SD = 19.2%) of block faces have sidewalks. However, some municipalities have 0% sidewalk coverage, such as Chaves in the North region, while two municipalities, Santa Cruz do Xingu/Mato Grosso and Godoy Moreira/Paraná, have 100% of their block faces with sidewalks. Regarding sidewalk obstacles, the mean value was 46.8% (SD = 18.4%), with nine municipalities reporting no block faces with obstacles (Rio Fortuna/Santa Catarina; Santa Rosa de Lima/Santa Catarina; Gouvelândia/Goiás; Urupema/Santa Catarina; Paial/Santa Catarina; Centenário/Rio Grande do Sul; Mampituba/Rio Grande do Sul; Itan-

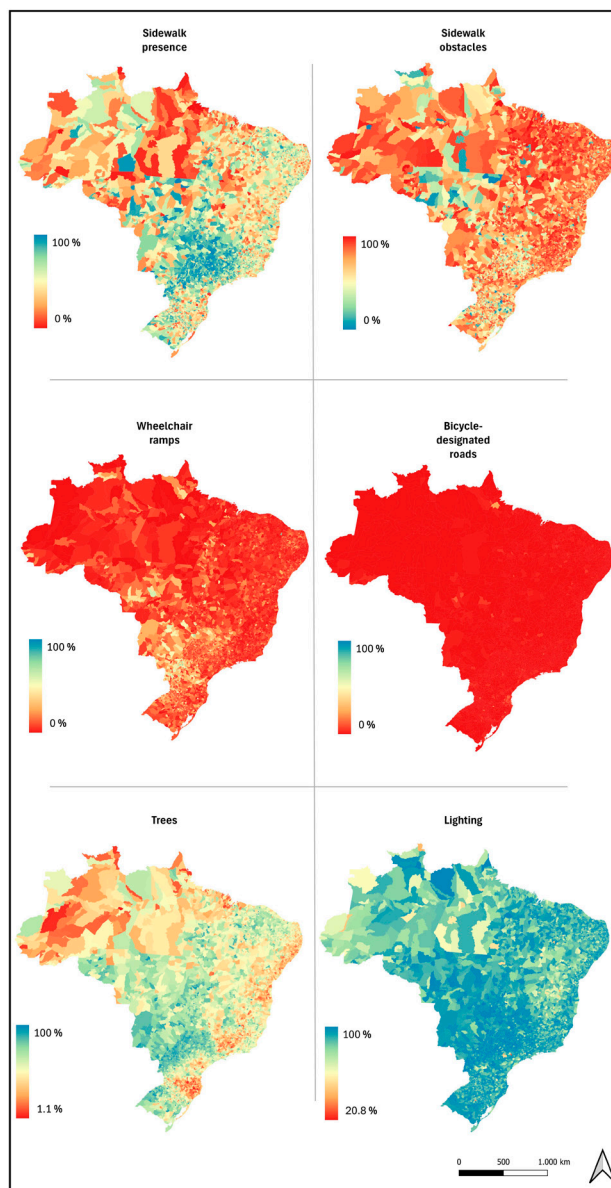


Figure 1 – Percentage presence of sidewalks, sidewalk obstacles, wheelchair ramps, bicycle-designated roads, trees, and lighting on all block faces evaluated in the Urban Survey of Household Surroundings in each of Brazil's 5,570 municipalities (Brazilian Institute of Geography and Statistics, 2022).

hangá/Mato Grosso; Amaturá/Amazonas). The three municipalities with the worst conditions were Lunar-delli/Paraná, where 98.3% of sidewalks presented obstacles, followed by Borrazópolis/Paraná and Aspásia/São Paulo, with 96.5% and 95.2%, respectively.

With respect to wheelchair ramps, the situation remains highly critical. On average, only 11.2% (SD = 11.2%) of block faces have this structure, and in 91 municipalities (1.6%) no ramps exist at all. In contrast, the three best-performing municipalities were Jaguaribara/Ceará, Maringá/Paraná, and Boa Esperança do Iguacu/

Paraná, with 78.2%, 71.8%, and 69.6% of block faces, respectively, having sidewalks with wheelchair ramps.

Another important factor for pedestrian safety is street and sidewalk lighting, which was the most prevalent of the six attributes analyzed. On average, 89.5% (SD = 8.1%) of block faces have lighting. The three municipalities with the lowest values were Quadra/São Paulo (20.8%), Passa Sete/Rio Grande do Sul (34.8%), and Porangaba/São Paulo (39.5%), while 23 municipalities reported 100% lighting coverage (Rio do Oeste/Santa Catarina; Pedra Mole/Sergipe; Salgado/Pernambuco; Novo Tiradentes/Rio Grande do Sul; Belo Monte/Alagoas; Rosário da Limeira/Minas Gerais; Oivedos/Paraíba; João Dias/Rio Grande do Norte; Pinhal/Rio Grande do Sul; Pedras Altas/Rio Grande do Sul; Riachão/Paraíba; Canudos do Vale/Rio Grande do Sul; Platina/São Paulo; Santa Clara d'Oeste/São Paulo; Novo Itacolomi/Paraná; Santa Rita d'Oeste/São Paulo; Ribeirão dos Índios/São Paulo; Cachoeira Dourada/Minas Gerais; Nova Castilho/São Paulo; Jaborandi/São Paulo; Trabiçu/São Paulo; Oscar Bressane/São Paulo; Aspásia/São Paulo).

Trees are another important attribute for comfort, particularly thermal comfort, and for pedestrian attractiveness. On average, 53.8% (SD = 20.1%) of block faces in Brazilian municipalities have at least one tree. The three municipalities with the lowest values were Paial/Santa Catarina (1.1%), Careiro da Várzea/Amazons (2%), and Arapeí/São Paulo (2.7%), while the three highest were São Pedro das Missões/Rio Grande do Sul, União Paulista/São Paulo, and Garruchos/Rio Grande do Sul, with 99%, 98.3%, and 97.3%, respectively.

Among all attributes, bicycle-designated roads were the least prevalent. On average, only 0.7% (SD = 1.5%) of block faces have this type of infrastructure. In 2,734 municipalities (49.1%), no bicycle-designated roads exist; 278 municipalities (5%) have only 0.1%, and 290 municipalities (5.2%) only 0.2%. The municipalities with the highest values were Abdon Batista/Santa Catarina (28.1%), Afuá/Pará (24.7%), Lauro Müller/Santa Catarina (20.4%), Balneário Camboriú/Santa Catarina (20.4%), and São Lourenço do Oeste/Santa Catarina (16.7%). In absolute terms, however, the municipalities with the largest number of block faces with bicycle-designated roads were the capitals São Paulo ($n = 247,393$), Rio de Janeiro ($n = 155,636$), Salvador ($n = 92,859$), Fortaleza ($n = 80,192$), and Goiânia ($n = 74,693$).

When the six attributes were analyzed across the

five municipal groupings, wide variation was observed. For example, sidewalk presence averaged 72.4% in the Southeast compared with 49.9% in the North (Figure 2). Figure 2 also shows that for sidewalks, sidewalk obstacles, and wheelchair ramps, the highest values were observed in capitals, large cities, and municipalities with high per capita GDP. Notably, per capita GDP was the only stratification in which the best-performing municipalities simultaneously had higher proportions of sidewalks and wheelchair ramps and lower levels of sidewalk obstacles, thus representing the most favorable scenario for pedestrians and wheelchair users.

Regarding tree coverage, the results reveal a counterintuitive pattern: capitals and large cities showed higher values than non-capital, small, and medium-sized municipalities (Figure 3). Another counterintuitive finding concerns the North region, home to the Amazon Forest, the largest, most diverse, and densest forest on the planet, yet only 50.7% of block faces in northern cities had one or more trees. Conversely, cities with negative population growth showed a higher proportion of block faces with trees compared with all municipalities experiencing positive growth (1st, 2nd, and 3rd growth quartiles). For lighting, variation across city groups was small regardless of the metric used, with high mean values such as 84.5% in the North and 92.6% in the Central-West (a difference of 8.1 percentage points).

In contrast, for bicycle-designated roads, the mean values across comparison groups were extremely low, ranging, for example, from 0.36% of block faces in low-GDP municipalities to 1.02% in high-GDP municipalities (Figure 4). Capitals, municipalities with high population growth, high per capita GDP, large municipality size, and those in the South region exhibited the highest proportions of this type of cycling infrastructure (Figure 4).

Table 1 presents the percentage of block faces with the six attributes for each of the 27 Brazilian capitals. For sidewalk presence, the lowest proportions were observed in Salvador (40%), Macapá (52.8%), and Vitória (56.7%), whereas the highest were in Curitiba (88.1%), Brasília (87.7%), and Goiânia (87.3%). Salvador also performed poorly for wheelchair ramps, with only 3.2% of block faces having this structure. The best-performing capitals were Campo Grande (49%), Curitiba (33.8%), and Brasília, which not only ranked among the top three for sidewalk presence but also had 27.4% of sidewalks equipped with wheelchair ramps.

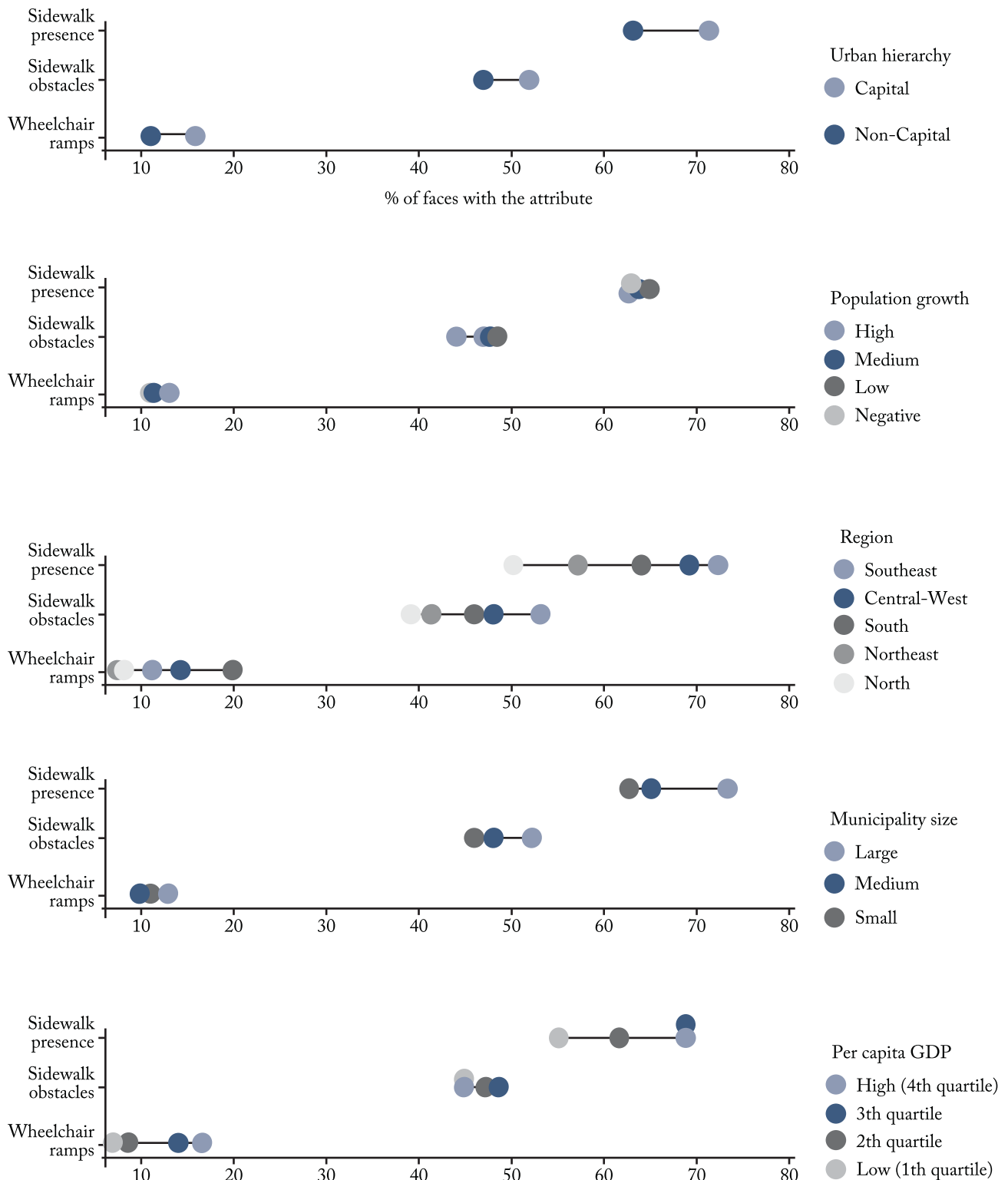


Figure 2 – Differences in the percentage of block faces evaluated in the Urban Survey of Household Surroundings with sidewalks, sidewalk obstacles, and wheelchair ramps, stratified by municipality size, Brazilian region, population growth profile, per capita income, and urban hierarchy (Brazilian Institute of Geography and Statistics, 2022).

For sidewalk obstacles, 90.8% of sidewalk faces in São Luís had at least one obstacle, with Teresina (88.6%) and Manaus (86.8%) also showing very high values.

The lowest, though still high, levels of sidewalk obstacles were observed in Porto Alegre (47.8%), Vitória (51.8%), and Campo Grande (57.1%).

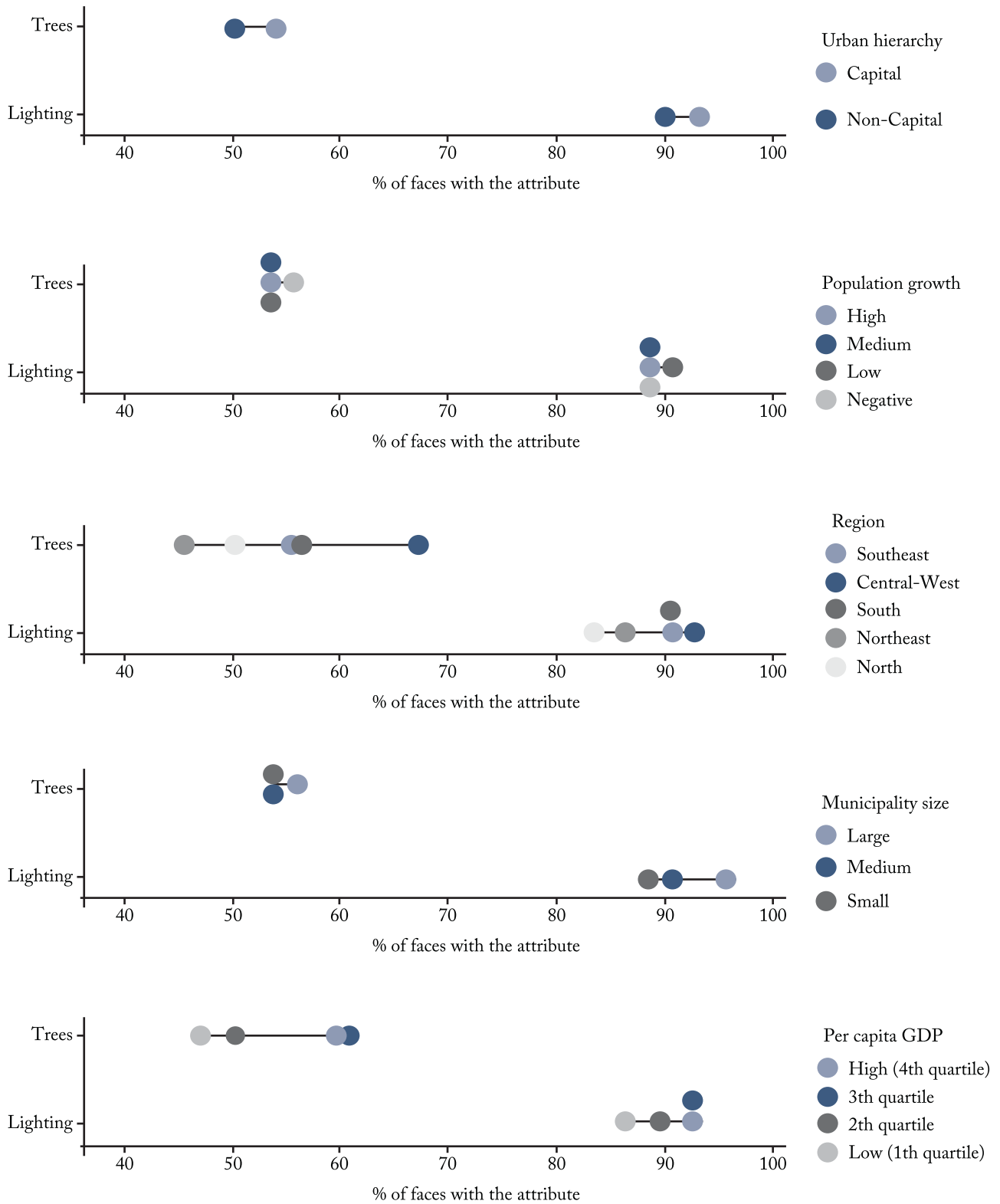


Figure 3 – Differences in the percentage of block faces evaluated in the Urban Survey of Household Surroundings with trees and lighting, stratified by municipality size, Brazilian region, population growth profile, per capita income, and urban hierarchy (Brazilian Institute of Geography and Statistics, 2022).

Regarding tree coverage, the worst-performing capitals were Salvador (24.7%), São Luís (32.1%), and Rio Branco (32.2%), while the best were Brasília (81.8%), Campo Grande (80.5%), and Curitiba (76.8%).

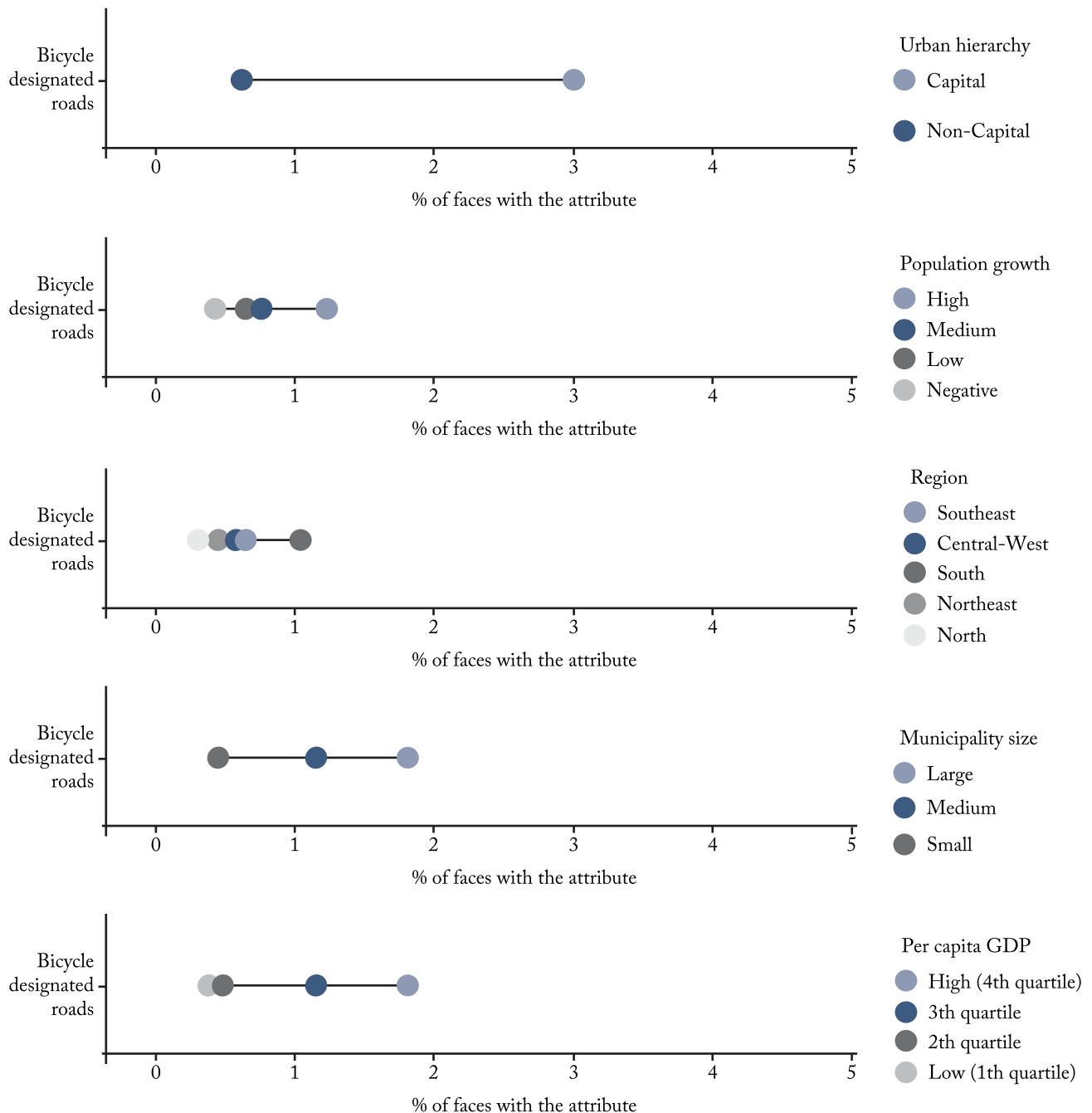


Figure 4 – Differences in the percentage of block faces evaluated in the Urban Survey of Household Surroundings with bicycle-designated roads, stratified by municipality size, Brazilian region, population growth profile, per capita income, and urban hierarchy (Brazilian Institute of Geography and Statistics, 2022).

For lighting, the lowest values were in Porto Alegre (84.5%), Macapá (84.8%), and Rio Branco (86.7%), and the highest in Vitória (98%), Goiânia (97.6%), and Campo Grande (96.8%). For bicycle-designated roads, capital city values were low, ranging from 0.87% in Porto Velho to 7.92% in Fortaleza. São Paulo and Rio de Janeiro, which have the highest absolute numbers of such streets (247,393 and 155,636, respectively), showed intermediate relative values of 4.17% and

2.53%, respectively.

Discussion

The analysis of urban attributes that support active commuting across all Brazilian municipalities revealed a scenario of substantial territorial inequalities, directly reflecting the challenges faced by the population in terms of accessibility, road safety, and pedestrian and cycling infrastructure. These findings reinforce evidence

Table 1 – Percentage values of the presence of sidewalks, sidewalk obstacles, wheelchair ramps, bicycle-designated roads, trees, and lighting on all block faces evaluated in the Urban Survey of Household Surroundings for each of the 27 Brazilian state capitals (Brazilian Institute of Geography and Statistics, 2022).

	Sidewalk presence (%)	Sidewalk obstacles (%)	Wheelchair ramp (%)	Bicycle-designated road (%)	Tree (%)	Lighting (%)
Aracaju	80.3	78.8	19.7	3.81	37.5	94.7
Belém	57.6	80.3	6.6	5.02	35.5	92.6
Belo Horizonte	83.6	73.0	22.7	1.72	60.5	95.3
Boa Vista	58.4	68.5	15.5	2.20	41.4	95.3
Brasília	87.7	75.5	27.4	4.17	81.8	90.2
Campo Grande	78.1	57.2	49.0	1.45	80.5	96.8
Cuiabá	78.7	76.5	22.1	1.08	58.3	94.0
Curitiba	88.1	64.0	33.8	3.90	76.8	96.8
Florianópolis	66.3	57.3	14.6	7.18	39.7	96.0
Fortaleza	79.5	81.0	10.1	7.92	51.0	96.3
Goiânia	87.3	63.6	25.1	1.86	73.6	97.6
João Pessoa	75.3	77.2	8.4	2.88	42.7	94.7
Macapá	52.8	81.3	11.8	1.83	53.4	84.8
Maceió	71.1	72.2	11.4	1.76	36.3	93.7
Manaus	72.4	86.8	5.2	1.03	39.7	90.2
Natal	73.4	80.6	11.7	1.70	44.8	93.8
Palmas	69.5	81.2	11.8	1.55	76.5	90.9
Porto Alegre	63.3	47.8	20.2	2.29	60.2	84.5
Porto Velho	57.3	78.8	13.2	0.87	49.2	91.7
Recife	58.4	78.2	7.6	3.93	38.4	94.9
Rio Branco	62.7	82.7	13.5	4.86	32.2	86.7
Rio de Janeiro	68.0	68.9	8.7	2.53	49.9	92.0
Salvador	40.0	68.0	3.2	2.64	24.7	94.2
São Luís	75.4	90.8	6.1	1.13	32.1	95.5
São Paulo	81.5	72.7	15.2	3.95	55.3	93.7
Teresina	80.2	88.6	11.1	2.51	49.4	95.9
Vitória	56.7	51.8	21.5	4.64	40.0	98.0

* Greener cells indicate higher percentage values, whereas redder cells indicate lower values for each column, except for “Sidewalk obstacles”, for which higher values represent worse conditions.

previously reported in the national and international literature on the importance of the built environment for promoting physical activity^{9,10}. Cities with larger populations, capital status, and higher per capita GDP showed better indicators, such as the presence of wheelchair ramps, trees, and sidewalks, suggesting a concentration of investments in more developed areas.

The low prevalence of wheelchair ramps, with an average of only 11.2% of block faces having this structure and the alarming situation of 91 municipalities (1.6%) with none at all, highlights a critical weakness in urban accessibility policies. Although 1.6% represents a small proportion of Brazilian municipalities, this corresponds to 91 municipalities in which all sidewalks are unsuitable for wheelchair users. This gap compromises not only the right to mobility for people

with disabilities but also their opportunity to engage in physical activity. Florindo et al.¹⁰ emphasize that the promotion of active commuting through walking requires high-quality sidewalks that allow all individuals, regardless of their personal condition, to use them fully. The presence of sidewalk obstacles, which exceeds 90% in some capitals, constitutes a direct barrier to active commuting and exposes pedestrians to accident risks. These findings corroborate the urban safety literature, which stresses the need for infrastructure that goes beyond lighting alone, including adequate paving, universal accessibility, and horizontal signage for pedestrians and cyclists⁹.

Although public lighting was the most prevalent attribute identified in this study, it may not be sufficient to ensure truly active environments. This is because the

surroundings survey evaluates the existence of lighting points, not their actual functioning (e.g., whether bulbs are present or operational). Therefore, these data must be interpreted with caution, as there are no national estimates of the proportion of non-functioning lighting points, and the data produced and disseminated by IBGE may not fully reflect the reality of well-lit and safe environments. As a mitigating factor, Brazil has robust legislation on public lighting that establishes: a) municipal responsibility for providing public lighting services, as defined in Articles 30(I) and 149-A of the 1988 Federal Constitution; b) mandatory technical standards issued by the Brazilian Association of Technical Standards, with specific parameters for illuminance, uniformity, and energy efficiency (Brazilian standards - NBR 5101/2012); and c) mechanisms for funding the implementation and maintenance of public lighting services²⁵.

Bicycle-designated roads showed the worst indicators, with a national average of only 0.7% of streets designated for bicycles and nearly half of municipalities lacking any cycling infrastructure. This absence runs counter to the World Health Organization Global Action Plan on Physical Activity (2018–2030), which identifies cycling infrastructure as a central element for promoting health, reducing chronic diseases, and combating physical inactivity. Moreover, the limited expansion of cycling facilities in smaller or less developed cities reinforces a pattern of infrastructural inequality, also documented in a longitudinal study using ISA-SP data, which showed that in São Paulo, most bicycle lanes were installed in central areas with higher income and education levels¹⁵. Beyond their low prevalence and unequal spatial distribution, the type of cycling facility also matters. Although the Urban Survey of Household Surroundings groups cycle paths, bike lanes, and shared routes, these facilities differ substantially: cycle paths are physically separated from motor traffic; bike lanes share the same level as traffic lanes and are usually painted red; and shared routes (bike routes) share the roadway with motor vehicles and are identified only by horizontal and vertical signage. These differences affect not only cyclists' level of protection but also the level of stress experienced during travel, which can influence the attractiveness of cycling as a mode of commuting or leisure activity²⁶.

The relationship between population growth and attributes such as tree coverage displayed counter-intuitive patterns, suggesting that cities with negative population growth retain a higher proportion of

tree-covered areas. This may reflect less intensive land-use dynamics, preserving green spaces due to lower real estate pressure. Although tree cover is essential for thermal comfort and street attractiveness, it must be accompanied by integrated urban mobility policies and incentives for active use of public spaces. According to Rocha et al.²⁷, tree-lined cities offer better thermal comfort, improve individual well-being, and enhance visual quality. In addition, trees increase humidity levels, vegetated areas can raise local atmospheric humidity by up to 50%, and help regulate solar radiation²⁸. However, given the survey's threshold (at least one tree 1.7 m tall), it is not possible to guarantee that all these benefits are present on the 53.8% of block faces that have at least one tree. More alarmingly, 46.2% of block faces have no trees at all.

Despite its national scope and the unprecedented nature of the Urban Survey of Household Surroundings²³, this study has some limitations. Observational data may be subject to variation in census agents' interpretation, and the lack of information on actual use of infrastructure (e.g., walking or cycling frequency) prevents direct correlation with physical activity levels. Moreover, analyses at the aggregated municipal scale may mask important intra-city inequalities. Nevertheless, as a nationwide study in a developing country, it has strong transformative potential by providing an unprecedented empirical basis for intersectoral policymaking, master plan revisions, and investments in inclusive infrastructure, aligned with Sustainable Development Goal 11 and the principles of Brazil's City Statute.

This study revealed important territorial inequalities in the distribution of urban attributes that support active commuting across Brazilian municipalities. Data from the Urban Survey of Household Surroundings showed that larger, wealthier, and capital cities have better urban infrastructure, whereas smaller, lower-income, and demographically declining municipalities face serious limitations, especially in Bicycle-designated roads. These findings reinforce the need for intersectoral public policies and evidence-based urban planning aimed at promoting health, social inclusion, and sustainable mobility. Ultimately, the results provide valuable input for the formulation and revision of master plans, urban mobility strategies, and actions focused on territorial equity, aligning with the targets of Sustainable Development Goal 11 and the principles of the City Statute, and contributing to the planning of more equitable, resilient, and sustainable cities.

Conflict of interest

The author declares no conflict of interest.

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Author's contributions

Teixeira IP: Conceptualization; Methodology; Software; Validation; Formal analysis; Investigation; Resources; Data curation; Supervision; Project administration; Visualization; Funding acquisition; Writing – original draft; Writing – review & editing; Approval of the final version.

Declaration regarding the use of artificial intelligence tools in the article writing process

The author used the Artificial Intelligence (AI) tools Chat GPT 5.2 and Grammarly Edu exclusively to assist in the verification and linguistic improvement of the English text of the manuscript.

Availability of research data and other materials

The contents underlying the research text are contained in the manuscript.

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Supplementary Material

Table S1 – Percentage values of sidewalk presence, sidewalk obstacles, and wheelchair ramps on all block faces evaluated in the Urban Survey of Household Surroundings, stratified by city size, region of Brazil, population growth profile, per capita income, and urban hierarchy (Brazilian Institute of Geography and Statistics, 2022).

	Sidewalk presence (%)				Sidewalk obstacles (%)				Wheelchair ramps (%)			
	Min	Max	Mean	Standard deviation	Min	Max	Mean	Standard deviation	Min	Max	Mean	Standard deviation
Municipality size												
Large	29.9	98.5	72.8	15.0	22.9	77.5	51.6	11.9	1.0	71.8	13.0	12.0
Medium	11.7	98.3	65.0	17.9	5.1	81.5	47.7	14.4	0.1	64.8	9.6	9.8
Small	0.0	100.0	62.6	19.4	0.0	98.3	46.4	18.9	0.0	78.2	11.2	11.2
Region												
Central-West	4.1	100.0	68.8	20.0	0.0	90.1	48.3	21.6	0.0	59.9	13.5	11.9
Northeast	3.6	95.6	56.5	15.6	0.2	87.9	46.4	15.3	0.0	78.2	6.5	5.9
North	0.0	94.5	49.9	21.3	0.0	91.4	38.7	20.4	0.0	56.9	7.8	8.9
Southeast	10.7	99.4	72.4	17.4	0.3	95.2	52.9	17.0	0.0	67.8	10.6	9.1
South	4.4	100.0	63.7	18.8	0.0	98.3	41.3	19.4	0.0	71.8	19.7	14.7
Population growth												
High (3rd positive tertile)	1.1	100.0	62.7	20.9	0.0	94.1	44.0	18.7	0.0	71.8	12.4	12.5
Medium (2nd positive tertile)	0.9	98.5	64.3	19.1	0.0	93.5	47.5	17.7	0.0	67.8	11.1	10.7
Low (1st positive tertile)	13.2	99.4	64.7	17.9	0.0	95.2	48.6	17.5	0.0	68.4	10.8	10.7
Negative	0.0	100.0	62.5	19.1	0.0	98.3	46.9	18.8	0.0	78.2	10.9	10.9
Per capita Gross Domestic Product												
High (4th quartile)	6.8	100.0	68.5	18.9	0.0	93.9	44.9	19.2	0.0	71.8	16.5	13.5
3rd quartile	4.4	100.0	68.6	19.1	0.0	98.3	48.8	19.3	0.0	68.4	14.1	12.0
2nd quartile	2.3	99.4	61.7	18.9	0.0	95.2	48.3	18.2	0.0	78.2	8.3	8.6
Low (1st quartile)	0.0	96.8	54.9	16.7	0.0	91.1	45.2	16.4	0.0	42.0	6.3	5.9
Urban hierarchy												
Capital	40.0	88.1	70.5	12.2	27.2	71.0	51.9	12.1	3.2	49.0	15.8	9.9
Non-capital	0.0	100.0	63.3	19.3	0.0	98.3	46.8	18.4	0.0	78.2	11.2	11.2

Tabela S2 – Percentage values of bicycle-designated roads, trees, and lighting on all block faces evaluated in the Urban Survey of Household Surroundings, stratified by city size, region of Brazil, population growth profile, per capita income, and urban hierarchy (Brazilian Institute of Geography and Statistics, 2022).

	Bicycle-designated roads (%)				Trees (%)				Lighting (%)			
	Min	Max	Mean	Standard deviation	Min	Max	Mean	Standard deviation	Min	Max	Mean	Standard deviation
Municipality size												
Large	0.0	20.4	1.93	2.1	15.0	91.5	55.7	16.2	76.2	99.9	93.5	4.1
Medium	0.0	12.8	1.20	1.7	15.3	92.4	54.1	18.0	60.1	99.1	90.8	6.8
Small	0.0	28.1	0.54	1.4	1.1	99.0	53.6	20.5	20.8	100.0	89.2	8.3
Region												
Central-West	0.0	12.8	0.56	1.2	23.2	94.5	68.0	12.9	57.9	99.8	92.6	5.4
Northeast	0.0	7.9	0.45	0.9	6.3	95.3	46.3	15.8	43.0	100.0	87.5	8.0
North	0.0	24.7	0.53	1.6	2.0	93.1	50.7	20.4	44.0	99.6	84.5	9.5
Southeast	0.0	13.0	0.65	1.2	2.7	98.3	56.5	20.6	20.8	100.0	90.9	8.2
South	0.0	28.1	1.06	2.3	1.1	99.0	56.7	22.8	34.8	100.0	91.4	6.7
Population growth												
High (3rd positive tertile)	0.0	20.4	1.21	2.1	4.6	93.8	52.9	19.9	39.5	100.0	89.4	8.7
Medium (2nd positive tertile)	0.0	24.7	0.68	1.4	1.1	93.1	53.3	19.9	20.8	100.0	89.5	8.3
Low (1st positive tertile)	0.0	20.4	0.60	1.3	3.0	98.3	53.3	19.7	47.4	100.0	90.1	7.5
Negative	0.0	28.1	0.42	1.1	2.0	99.0	54.5	20.4	34.8	100.0	89.3	8.0
Per capita Gross Domestic Product												
High (4th quartile)	0.0	20.4	1.02	1.9	3.0	99.0	59.1	20.1	51.3	100.0	92.1	6.3
3rd quartile	0.0	28.1	0.78	1.7	1.1	98.3	59.6	21.0	20.8	100.0	91.6	7.1
2nd quartile	0.0	12.5	0.48	1.0	2.0	96.9	49.6	19.7	34.8	100.0	88.7	8.4
Low (1st quartile)	0.0	24.7	0.36	1.0	3.8	95.3	47.5	16.4	47.2	100.0	85.9	8.9
Urban hierarchy												
Capital	0.9	7.9	2.98	1.8	24.7	81.8	50.4	16.0	84.5	98.0	93.4	3.6
Non-capital	0.0	28.1	0.64	1.5	1.1	99.0	53.8	20.1	20.8	100.0	89.5	8.1

Reviewers' assessment

The reviews of this article were originally conducted in Portuguese. This version has been translated using ChatGPT and subsequently reviewed by the Chief Editors.

Reviewer A

Anonymous

Format

- Does the article comply with the manuscript preparation rules for submission to the *Revista Brasileira de Atividade Física e Saúde*?
Yes

- Regarding formal aspects, is the manuscript well structured, containing the sections: introduction, methods, results, and discussion (with the conclusion as part of the discussion)?
Yes

- Is the language appropriate, and is the text clear, precise, and objective?
Yes

- Was any indication of plagiarism observed in the manuscript?
No

Suggestions/Comments:

- The article is well structured and clearly organized. The language is appropriate, and no writing corrections are necessary.

Abstract

- Are the abstract and the abstract in English adequate (containing: objective, information about the study participants, variables studied, main results, and a conclusion) and do they reflect the content of the manuscript?
Yes

Suggestions/Comments:

- The abstract and the English abstract are adequate.

Introduction

- Was the research problem clearly stated and delimited?
Partly

- Is the research problem adequately contextualized in relation to the existing knowledge, moving from the general to the specific?
Partly

- Are the reasons justifying the need for the study (including the authors' assumptions about the

problem) well established in the writing?

Yes

- Are the references used to support the presentation of the research problem current and relevant to the topic?
Partly

- Was the objective clearly presented?
Yes

Suggestions/Comments:

- This article makes an important contribution to the topic of active mobility in the Brazilian context. The theme and the problem are partially explored in depth, although they are highly relevant. I present some suggestions so that the authors can further deepen the themes in the national context and in light of the current scientific literature:

- The importance of active mobility is presented as a strategy for promoting human and planetary health. However, there is an important ethical issue under debate in the field. People move actively either out of necessity or by choice, depending on structural and social conditions. Therefore, it must be considered that not all active travel occurs under favorable and safe conditions—for example, walking, cycling, or using public transportation in areas exposed to crime, traffic accidents, and environmental pollution. By proposing the topic in a context of environmental inequality, the authors seem to neglect this issue. Thus, this problematization should be further developed. To this end, I suggest the article:

- Salvo D, Jáuregui A, Adlakha D, Sarmiento OL, Reis RS. When Moving Is the Only Option: The Role of Necessity Versus Choice for Understanding and Promoting Physical Activity in Low- and Middle-Income Countries. *Annu Rev Public Health.* 2023;44:151–169. doi:10.1146/annurev-publhealth-071321-042211.

- Another aspect that appears to be insufficiently contextualized is the theme of inequity and spatial inequality. The topic does not seem to be well positioned or clearly defined. There are important gaps regarding these themes and how they are measured. Here is a suggested reading to support the context:
- Avarão Leão, A.L., Gierbolini-Rivera, R.D., Franco

Silva, M. et al. Spatial indicators of inequity in urban health research: a scoping review. *Discov Public Health* 22, 27 (2025). <https://doi.org/10.1186/s12982-025-00421-z>.

- The intersection between active mobility and cities is intrinsically related to urban design and policies that promote changes to facilitate this mode of transportation. This theme is also largely absent from the introduction. Here is a reading on the topic that may be useful:
- Nice KA, Thompson J, Zhao H, et al. Effects of city design on transport mode choice and exposure to health risks during and after a crisis: a retrospective observational analysis. *Lancet Planet Health*. 2025;9(6):e467–e479. doi:10.1016/S2542-5196(25)00088-9.
- Finally, a minor detail: the authors use the terms active mobility and active travel throughout the title and the text. These terms should be standardized, and it should be clearly defined which term will be used.

Methods

- Are the methodological procedures, in general, appropriate for studying the research problem?
Yes
- Are the methodological procedures adopted for conducting the study sufficiently detailed?
Yes
- Was the procedure adopted for selecting or recruiting participants appropriate to the problem studied and described in a sufficient, clear, and objective manner?
Not applicable
- Were information provided about the instruments used for data collection, their psychometric properties (e.g., reproducibility, internal consistency, and validity), and, when relevant, about the operational definition of variables?
Partly
- Is the data analysis plan appropriate and adequately described?
Yes
- Were the inclusion and/or exclusion criteria for sample participants described and appropriate for the study?
Not applicable
- Did the authors provide clarification about the ethical procedures adopted for conducting the research?

Partly

Suggestions/Comments:

- The methods are well detailed. However, there is a lack of information about the quality of the instrument used by IBGE. There is abundant literature on street-segment audits that consistently reports acceptable reliability of the method; however, this information is not included in the methods, nor is information about the instrument used. Likewise, the procedures adopted by IBGE observers when recording data, controlling quality, and other related aspects are not described.

Results

- Is the use of tables and figures appropriate and does it facilitate adequate presentation of the study results?
Partly
- Is the number of illustrations in the article in accordance with the journal's manuscript submission guidelines?
Yes
- Are the number of participants at each stage of the study, as well as the number and reasons for losses and refusals, presented in the manuscript?
Not applicable
- Are the characteristics of the participants presented and sufficient?
Not applicable
- Are the results presented appropriately, highlighting the main findings and avoiding unnecessary repetition?
Yes

Suggestions/Comments:

- Some details may help improve the readability of the figures:
 - a) The color palette makes it difficult to clearly distinguish some points. Greater contrast should be created to allow visual distinction.
 - b) Figures 2–4 do not facilitate natural reading and visualization of the results. I suggest reorganizing them so that all study variables are represented within each category of analysis—for example, sidewalks, ramps, roads, lighting, bicycle signage according to urban hierarchy, and so on.

Discussion

- Are the main findings of the study presented?
Partly

- Are the study limitations and strengths presented and discussed?

Partly

- Are the results discussed in light of the study limitations and the existing knowledge on the topic?

Partly

- Are the potential contributions of the main study findings to scientific development, innovation, or real-world intervention discussed by the authors?

Partly

Suggestions/Comments:

- The discussion overlooks the issues raised for reflection in the introduction (necessity versus choice, inequity and spatial inequalities, urban design and active mobility), and it also fails to reflect on limitations in light of the quality of the study instrument and the implications for policy and practice. I feel that the discussion in these aspects falls considerably short.

Conclusion

- Was the study conclusion presented appropriately and is it consistent with the study objective?

Yes

- Is the study conclusion original?

Yes

Suggestions/Comments:

- No comments.

References

- Are the references up to date and sufficient?

Partly

- Is most of the reference list composed of original research articles?

Partly

- Do the references comply with the journal's standards (quantity and format)?

Yes

- Is citation in the text adequate, that is, do the statements in the text cite references that actually substantiate such statements?

Yes

Suggestions/Comments:

- The references presented do not reflect the most recent discussions on the topic.

Comments to the authors

- I congratulate the authors on an excellent study. The topic is relevant and the analysis is original. How-

ever, the findings could be even more relevant if there were greater scientific and thematic depth in the introduction and discussion.

Final recommendation (decision)

- Major revisions required

Reviewer B

Anonymous

Format

- Does the article comply with the manuscript preparation rules for submission to the Revista Brasileira de Atividade Física e Saúde?

Yes

- Regarding formal aspects, is the manuscript well structured, containing the sections: introduction, methods, results, and discussion (with the conclusion as part of the discussion)?

Yes

- Is the language appropriate, and is the text clear, precise, and objective?

Yes

- Was any indication of plagiarism observed in the manuscript?

- No

Suggestions/Comments:

- First, I would like to congratulate the authors. This is a very well-written article, with fluent and engaging reading. Some points could be expanded, especially in the discussion section, which will be addressed in this review.

Abstract

- Are the abstract and the abstract in English adequate (containing: objective, information about the study participants, variables studied, main results, and a conclusion) and do they reflect the content of the manuscript?

Yes

Suggestions/Comments:

- Once again, congratulations to the authors. The abstract and the English abstract are adequate, direct, and concise, and provide the necessary information about the study.

Introduction

- Was the research problem clearly stated and delimited?

Yes

- Is the research problem adequately contextualized in relation to the existing knowledge, moving from the general to the specific?

Yes

- Are the reasons justifying the need for the study (including the authors' assumptions about the problem) well established in the writing?

Yes

- Are the references used to support the presentation of the research problem current and relevant to the topic?

Yes

- Was the objective clearly presented?

Yes

Suggestions/Comments:

- The introduction is well written and clearly presents the research problem. The paragraph on page 4, lines 6–9, and the paragraph on lines 17–23 seem to complement each other; I believe they could be merged into a single paragraph to improve text flow, which would also allow for expanding some discussions later.

Methods

- Are the methodological procedures, in general, appropriate for studying the research problem?

Yes

- Are the methodological procedures adopted for conducting the study sufficiently detailed?

Partly

- Was the procedure adopted for selecting or recruiting participants appropriate for the problem studied and described in a sufficient, clear, and objective manner?

Yes

- Were information provided about the instruments used for data collection, their psychometric properties (e.g., reproducibility, internal consistency, and validity), and, when relevant, about the operational definition of variables?

Yes

- Is the data analysis plan appropriate and adequately described?

Yes

- Were the inclusion and/or exclusion criteria for sample participants described and appropriate for the study?

Yes

- Did the authors provide clarification about the ethical procedures adopted for conducting the research?
Not applicable

Suggestions/Comments:

- The methods are well described; however, I have a few questions:
- Regarding the classification of municipality size, what was this criterion based on? I ask because the classification of large municipalities is very broad, since those with more than 100,000 inhabitants include very diverse municipalities, such as São Paulo and many others with around 100,000 inhabitants that differ substantially. It may be helpful to explain the basis for this classification and why it is sufficient, or alternatively to adopt a less broad classification.
- In the supplementary tables, were any tests performed in addition to reporting means to assess possible differences? If not, why?
- In the supplementary tables, there are columns containing only zeros; these should be removed.
- In the results, there is a table presenting data from capital cities; however, I did not find in the methods what was done regarding this analysis, nor any reference to it.

Results

- Is the use of tables and figures appropriate and does it facilitate adequate presentation of the study results?

Yes

- Is the number of illustrations in the article in accordance with the journal's manuscript submission guidelines?

Yes

- Are the number of participants at each stage of the study, as well as the number and reasons for losses and refusals, presented in the manuscript?

Not applicable

- Are the characteristics of the participants presented and sufficient?

Not applicable

- Are the results presented appropriately, highlighting the main findings and avoiding unnecessary repetition?

Yes

Suggestions/Comments:

- The results are very well described; the figures and tables are well prepared and easy to visualize. I be-

lieve this is the best-written and most detailed section of the article, with no major additional contributions needed.

- On line 10 of page 11, correct “baixo” to “baixos.”

Discussion

- Are the main findings of the study presented?
Yes
- Are the study limitations and strengths presented and discussed?
Yes
- Are the results discussed in light of the study limitations and the existing knowledge on the topic?
Yes
- Are the potential contributions of the main study findings to scientific development, innovation, or real-world intervention discussed by the authors?
Yes

Suggestions/Comments:

- The discussion is well presented and well written; once again, congratulations to the authors.
- Only a few suggestions and reflections:
- In the strengths section, explicitly state that this is a very large study conducted in a developing country; check the literature to see whether there is something similar elsewhere, as this is likely a major strength given the size and diversity of Brazil.
- One reflection regarding Table 1 is that, considering the data found in Vigitel, it may be possible to draw some relationships and propose hypotheses about their impact. Expanding this discussion could be interesting.
- Based on national and international studies, it may be possible to further emphasize the importance of studying and implementing public policies that improve these structures—for example, how improved walkability increases physical activity levels, or studies in São Paulo showing that living near bike lanes and cycle paths is important for protection against arterial hypertension, and so on.
- On line 9 of page 13, there is a minor Portuguese error: “.. a existência calçadas ...”; add the word “de.”

Conclusion

- Was the study conclusion presented appropriately

and is it consistent with the study objective?

Yes

- Is the study conclusion original?

Yes

Suggestions/Comments:

- Once again, congratulations to the authors. This section is well presented and well written.

References

- Are the references up to date and sufficient?
Yes
- Is most of the reference list composed of original research articles?
Yes
- Do the references comply with the journal’s standards (quantity and format)?
Yes
- Is citation in the text adequate, that is, do the statements in the text cite references that actually substantiate such statements?
Yes

Suggestions/Comments:

- With the suggestions I have made, the authors could consider expanding the reference list slightly, since the journal’s guidelines have not yet reached the maximum limit.

Comments to the authors

- First, I would like to congratulate the authors on this work—a very well-written study addressing a relevant topic, with timely research and extremely reliable and important data. The writing is clear and makes the manuscript easy to read. However, some sections could be improved, such as the introduction and a slight expansion of the discussion, bringing more reflection on the topic and on the impact of these facilities on physical activity. I recommend a few minor corrections and suggestions as outlined above.

Final recommendation (decision)

- Minor revisions required