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Challenges for sustainable urban mobility in small cities: study in Piratininga/SP

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Desafios para a mobilidade urbana sustentável em cidades pequenas: estudo em Piratininga/SP

RESUMO

Objetivo - O presente artigo busca identificar e analisar as barreiras existentes para a adoção de modos ativos de transporte nos deslocamentos urbanos de uma cidade pequena paulista om população inferior a 20 mil habitantes, Piratininga-SP.

Metodologia - A metodologia adotada consiste em revisão bibliográfica, visita a campo e aplicação de questionário a uma amostra da população selecionada de acordo com o perfil demográfico revelado pelos dados do Censo/IBGE.

Originalidade/relevância - O artigo apresenta informações sobre as condições de mobilidade e o perfil dos deslocamentos urbanos em uma cidade com população inferior a 20 mil habitantes (de pequeno porte), que representa a maioria dos municípios brasileiros. Grande parte dos estudos nesta temática envolve cidades com população acima de 60 mil habitantes, cidades médias e grandes centros, urbanos o que revela uma lacuna nos estudos urbanos sobre mobilidade urbana sustentável em pequenas cidades brasileiras.

Resultados - Os resultados revelaram a predominância da utilização do automóvel no município e evidenciaram alguns dos fatores que influenciam essa escolha do modo de transporte utilizado, que está relacionada à flexibilidade de horário, rapidez, fácil acesso, segurança (assalto), facilidade no deslocamento e conforto ambiental.

Contribuições teóricas/metodológicas – A revisão da literatura busca atender à necessidade de aprofundamento conceitual dos temas relacionados às cidades de pequeno porte e de adaptação de um questionário sobre mobilidade urbana para esse contexto específico. Essa revisão não apenas fundamentou teórico-conceitualmente a pesquisa, mas também evidenciou lacunas no campo dos estudos urbanos e planejamento urbano e regional sobre essa temática, mobilidade em cidades pequenas brasileiras. A adaptação do questionário apresenta-se como uma etapa crucial, pois considera as particularidades e desafios enfrentados por essas cidades, garantindo que as questões formuladas sejam relevantes e adequadas às suas realidades locais. Dessa forma, as contribuições teóricas e metodológicas se entrelaçam, proporcionando uma melhor compreensão do padrão de mobilidade presente em pequenos centros urbanos brasileiros.

Contribuições sociais e ambientais A pesquisa exploratória de abordagem quantitativa e qualitativa evidenciou que o governo local de Piratininga-SP não tem suficientemente promovido a mobilidade urbana sustentável, estando, assim, em desacordo com as diretrizes da atual política nacional de mobilidade urbana. Os resultados desta pesquisa podem contribuir para o debate público sobre políticas de mobilidade urbana em cidades de pequeno porte na perspectiva da sustentabilidade urbana, com vistas a estimular o uso de modos ativos de transporte, especialmente para deslocamentos curtos, e, assim, contribuir para o desenvolvimento de uma cidade mais sustentável e saudável.

PALAVRAS-CHAVE: Mobilidade urbana sustentável. Cidade de pequeno porte. Cidade saudável.

Challenges for sustainable urban mobility in small cities: study in Piratininga/SP

ABSTRACT

Objective - This article seeks to identify and understand the barriers to the adoption of active modes of transport in urban travel in a small city with a population of less than 20,000 inhabitants.

Methodology - The methodology adopted consists of a bibliographic review and the application of a questionnaire to a sample of the population according to the IBGE Census.

Originality/relevance - The article also presents information on the profile of urban travel in a city with a population of less than 20,000 inhabitants (small-sized), which represents the majority of Brazilian municipalities. Most studies on this topic involve cities with a population of over 60,000 inhabitants, medium-sized cities and large centers, therefore, there is a gap in studies of sustainable urban mobility in small cities.

Results - The results showed the predominance of automobile use in the municipality and some of the factors that influence this choice of mode of transport are related to flexibility of schedules, speed, easy access, safety (robbery), ease of travel and environmental comfort. Theoretical/methodological contributions – The literature review meets the conceptual needs of topics related to small cities and the adaptation of a specific questionnaire for this context. This review not only grounds the research in relevant theories, but also identifies gaps in existing knowledge, allowing for the development of more robust approaches. Adapting the questionnaire is a crucial step, as it considers the

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particularities and challenges faced by these cities, ensuring that the questions formulated are relevant and appropriate to the local reality. In this way, the theoretical and methodological contributions are intertwined, providing a solid framework for the analysis and interpretation of data, in addition to enabling a better understanding of the social and economic phenomena that permeate small urban centers.

Social and environmental contributions – These data indicate that the local government has not effectively promoted the concept of sustainable urban mobility, thus being at odds with the guidelines of the country's current urban mobility policy. The results of this research can be used by municipal public managers to encourage the use of active modes of transport, especially for short journeys, and contribute to the development of a healthier city.

KEYWORDS: Sustainable urban mobility. Small city. Healthy city.

Retos para la movilidad urbana sostenible en ciudades pequeñas: estudio en Piratininga/SP

RESUMEN

Objetivo – Este artículo busca identificar y comprender las barreras para la adopción de modos de transporte activos en los desplazamientos urbanos en una ciudad pequeña con una población menor a 20 mil habitantes.

Metodología - La metodología adoptada consiste en una revisión bibliográfica y la aplicación de un cuestionario a una muestra de la población según el Censo del IBGE.

Originalidad/relevancia - El artículo también presenta información sobre el perfil del transporte urbano en una ciudad con población menor a 20 mil habitantes (pequeño tamaño), que representa la mayoría de los municipios brasileños. La mayoría de los estudios sobre este tema involucran ciudades con una población mayor a 60.000 habitantes, ciudades medianas y grandes centros, por lo que existe un vacío en estudios sobre movilidad urbana sustentable en ciudades pequeñas.

Resultados - Los resultados mostraron el predominio del uso del automóvil en el municipio y algunos de los factores que influyen en esta elección del modo de transporte están relacionados con la flexibilidad horaria, velocidad, fácil acceso, seguridad (robos), facilidad de desplazamiento y confort ambiental.

Aportes teóricos/metodológicos – La revisión de la literatura responde a la necesidad conceptual de temas relacionados con las ciudades pequeñas y la adaptación de un cuestionario específico para este contexto. Esta revisión no sólo fundamenta la investigación en teorías relevantes, sino que también identifica lagunas en el conocimiento existente, lo que permite el desarrollo de enfoques más sólidos. Adaptar el cuestionario es un paso crucial, ya que considera las particularidades y desafíos que enfrentan estas ciudades, asegurando que las preguntas formuladas sean relevantes y adecuadas a la realidad local. De esta manera, se entrelazan los aportes teóricos y metodológicos, proporcionando un marco sólido para el análisis e interpretación de los datos, además de posibilitar una mejor comprensión de los fenómenos sociales y económicos que permean a los pequeños centros urbanos.

Contribuciones sociales y ambientales - Estos datos indican que el gobierno local no ha promovido de manera efectiva el concepto de movilidad urbana sustentable, entrando así en conflicto con los lineamientos de la actual política de movilidad urbana del país. Los resultados de esta investigación pueden ser utilizados por los gestores públicos municipales para fomentar el uso de modos de transporte activos, especialmente para trayectos cortos, y contribuir al desarrollo de una ciudad más saludable.

PALABRAS CLAVE: Movilidad urbana sostenible. Villa. Ciudad saludable.

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1 INTRODUCTION

Population concentration in global urban spaces has intensified in recent decades, rising from 29.5% in 1950 to 56.2% in 2020, and this percentage is estimated to increase to 68.4% in 2050 (UN, 2018).

In Brazil, this shift from a predominantly rural to an urban country has resulted in transformations in many cities, including in terms of urban mobility.

The urbanization process in most Brazilian cities has not been accompanied by the development of an urban mobility infrastructure that supports all modes of transportation, with active transportation and motorized public transport being neglected in particular (Magagnin, 2008). Population concentration in global urban spaces has intensified in recent decades, rising from 29.5% in 1950 to 56.2% in 2020, and this percentage is estimated to increase to 68.4% by 2050 (UN, 2018).

In Brazil, this shift from a predominantly rural to an urban country has resulted in transformations in many cities, including in terms of urban mobility.

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In the last two decades, many cities have adopted the concept of urban mobility to address issues related to the movement of people and goods within the city. It is characterized by the articulation of integrated actions involving urban planning and transportation plans, based on studies and proposals on infrastructure, circulation systems, public transportation, land use and occupation, and the environment, among other aspects (Bergman; Rabi, 2005; Brasil, 2006; Magagnin, 2008, Meotti; Silva, 2016; Pinto et. al. 2024).

According to Litman and Burwell (2006), the concepts of sustainability and sustainable development are progressively advancing on issues of urban mobility, with the aim of foreseeing actions in the present that do not compromise the travel conditions of future generations (Gudmundsson, 2004; Richardson, 2005; Oliveira; Rodrigues da Silva, 2015).

Sustainable urban mobility can be defined as the result of a set of transportation and circulation policies that aim to provide broad and democratic access to urban space, by prioritizing non-motorized and collective motorized modes of transportation effectively, through integrated, inclusive, and sustainable actions that do not generate socio-spatial segregation (ANTP, 2003).

In Brazil, this vision is still recent and has been gradually incorporated into discussions of master plans and urban mobility (Rodrigues da Silva; Costa; Macedo, 2007; Magagnin, 2008).

Sustainable urban mobility is based on the following principles: discouraging the intensive use of individual motorized transportation, integrating urban planning and land use and occupation with issues related to mobility and transportation, reducing the consumption of non-renewable energy (fossil fuels), diversifying transportation options through the adoption of intermodality, and reducing the environmental impacts of urban travel (Brasil, 2004). This concept encourages a shift in transportation modes toward more sustainable ones by encouraging the use of active modes of transportation, such as cycling and walking (Winters et

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al., 2013), in addition to public transportation, with priority given to the adoption of non-polluting vehicles.

Research (Vasconcellos, 1996; Magagnin, 2008; Rabelo, 2019; Silva 2021) indicates that many Brazilian cities have faced various urban mobility problems on various scales. Notable among these are the increase in the number of traffic accidents with fatalities, congestion or slowdowns, the increase in non-renewable energy consumption and, therefore, pollutant emissions, and slow travel times, among others (Brasil, 2006; Magagnin, 2008; Magagnin; Rodrigues da Silva, 2008; IPEA, 2010; 2016).

Several of these urban mobility problems are linked to urban growth, which prioritized land use in favor of real estate speculation. This approach resulted in numerous urban voids and contributed to increased commuting and the excessive use of automobiles and motorcycles.

The lack of urban infrastructure for the safe and comfortable use of active transportation modes is a major problem in several Brazilian cities (Brasil, 2006; Magagnin, 2008; Magagnin; Rodrigues da Silva, 2008). According to Forsyth and Southworth (2008), these problems stem from urban planning that prioritized the implementation of infrastructure for automobiles over pedestrians and cyclists.

The characteristics of urban morphology have a direct impact on urban mobility, as they affect travel conditions and, consequently, the modes of transportation used by people (Milakis; Cervero; Van Wee, 2015; Song et al., 2017).

Mobility conditions are also directly associated with the characteristics of the urban fabric and the physical treatment of roads and sidewalks, the existence of regular public transportation networks, the quality of these services and their fares, signage, road system usage control systems, and the presence or absence of bike paths or lanes. These are just some of the factors that influence mobility conditions and patterns in urban centers (Brasil, 2006; 2007; Magagnin, 2008).

To incorporate sustainability concepts into a city, a compact land use pattern must be adopted, with high population density, mixed land use, and easily accessible facilities. These factors favor the use of active modes of transportation, such as walking and cycling, or collective motorized modes, such as public transportation. The impacts of adopting these measures can be observed in reduced trip volume, shorter distances traveled, and shorter travel times (Cervero; Kockelman, 1997; Song et al., 2017).

2 BARRIERS TO THE ADOPTION OF SUSTAINABLE URBAN MOBILITY

In addition to the aforementioned aspects, social and cultural barriers can interfere with the use of more sustainable modes of transportation. Studies by Lavery, Páez, and Kanaroglou (2013) and Escobar; Flórez; and Portugal (2017) show that the choice of transportation mode can be associated with socioeconomic and spatial factors, available modes, trip attributes, and previous experiences related to the trip.

Schwanen and Lucas (2011) and Escobar, Flórez, and Portugal (2017) reveal that trips made by higher-income groups tend to be by motorized individual transportation, especially when there are access restrictions or intermodal connections, and when parking is available at the destination, regardless of the fee (De Witte et al., 2013). Long distances are also associated

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with the use of motorized individual transportation, especially when there is no adequate public transportation system. In this case, walking and cycling are not justified. Factors such as personal experience with previous trips and the advantages offered by a particular mode of transportation are other justifications for adopting motorized individual transportation. Escobar, Flórez, and Portugal (2017) also list aspects related to trip quality, such as speed, comfort, safety, convenience, flexibility, and accessibility, as well as others related to externalities, such as cost, climate protection, and health benefits.

Some research has identified another set of reasons associated with symbolic-affective or psychological elements that may be associated with the choice to use a car. These factors are linked to feelings of freedom, enjoyment or stress associated with its use, power, status, and self-control (Anable; Gatersleben, 2005; Steg, 2005; De Witte et al., 2013).

Nations that adopt a policy of encouraging the acquisition of motorized individual modes of transportation, as is the case in Brazil, coupled with historical and cultural factors that view the availability or ownership of automobiles as a symbol of status and freedom, have negatively impacted the adoption of more sustainable modes of transportation for daily commutes (Ramis; Santos, 2012).

Banister (2008) states that the population should use automobiles very little for urban travel. He believes this would enable greater accessibility and quality of urban spaces. He adds that cities should combine urban planning strategies with service innovation and the use of active modes or public transportation. The solution to urban mobility problems, according to Banister (2008), is not to prohibit or eliminate automobile use, but to design cities that offer quality infrastructure for different modes of transportation, including the possibility of non-car use.

2.1 Urban mobility in cities with populations of less than 20,000 inhabitants in Brazil

The current Brazilian National Urban Mobility Policy, established by Law No. 12,587 of 2012 (Brazil, 2012), determines which municipalities in the federation must develop an urban mobility plan. This requirement includes municipalities with a population of over 20,000; those in metropolitan regions, economically developed regions, and urban agglomerations with a total population of over one million; and those in areas of tourist interest, including coastal cities whose mobility dynamics typically change on weekends, holidays, and vacation periods due to the large influx of tourists (Brazil, 2012).

The Ministry of Cities, responsible for initially defining Brazil's urban mobility policy, classified municipalities by population to determine which elements should be incorporated into the assessment of urban mobility standards. Five classes were defined: (i) municipalities with a population of 60,000 to 100,000; (ii) municipalities with populations between 100,000 and 250,000 inhabitants; (iii) municipalities with populations between 250,000 and 500,000; (iv) municipalities with populations between 500,000 and one million inhabitants; and (v) municipalities with populations over one million inhabitants (Brasil, 2015).

This division incorporated the identification of "relatively homogeneous mobility patterns that vary directly with population growth, which does not always correspond to local

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reality" (Brasil, 2015, p. 156). Therefore, it is important to understand the reality of each city to develop appropriate planning for each one.

According to data from the 2010 Census/IBGE, 84.40% of Brazilians lived in urban areas, with 45.3% of this population distributed among 5,232 cities with populations under 100,000 inhabitants, corresponding to 95% of Brazil's municipalities. and 17% of the population lives in cities with fewer than 20,000 inhabitants. In 2022, this figure increased to 84.72%, according to the 2022 Census/IBGE. 44.8% of Brazilian municipalities have up to 10,000 inhabitants, representing 6.3% of the country's population, and 70.6% of Brazilian municipalities have up to 20,000 inhabitants, representing 14.8% of the country's population. Due to their significant representation, small cities deserve special attention from their planners and government officials (Melo; Soares, 2009; Sudário, 2017).

Despite regional specificities regarding urban mobility, many cities have not incorporated urban sustainability perspectives into their growth. The adoption of an urbanization pattern based on the expansion of the urban fabric has contributed to increasing urban vacancies for competition in the real estate market. This generates unequal access to land. Thus, many areas, especially those located in the city's most peripheral regions, lack infrastructure, not only related to motorized and non-motorized transportation, but also to basic sanitation, security, and public lighting (Maricato, 2003; Brasil, 2015; Silva, 2015).

Little data is available on urban mobility in municipalities with populations under 60,000. However, by familiarizing yourself with many of these municipalities, it is possible to identify some recurring problems. Furthermore, the lack of a classification or definition of small cities creates significant inaccuracy in research and public policy.

According to ANTP data (2020), non-motorized modes of transportation—walking and cycling—are the most common in all municipalities in the country, regardless of population (Table 1). In cities with 60,000 to 100,000 inhabitants, non-motorized travel is proportionally higher compared to public transportation and individual motorized transportation. Furthermore, it is noteworthy that bicycle use is extremely low compared to walking. However, the use of individual motorized transportation is higher than that of public transportation in these cities.

Table 1 - Division of trips by mode of transport and size of municipality (%)

MODES OF TRANSPORTATION		Population range (inhabitants)				
		Over 1 million	500,000 to 1 million	250,000 to 500,000	100,000 to 250,000	60,000 to 100,000
Public Transportation	Bus (municipal + metropolitan)	26	25	24	22	19
	Rails	10	0	0	0	0
	Subtotal	36	25	24	22	19
Motorized individual transportation	Auto	26	27	27	26	24
	Motorcycle	2	5	5	6	7
	Subtotal	28	31	32	32	32
Non-motorized transport	Bicycle	1	2	3	4	6
	On foot	35	41	41	42	44
	Subtotal	36	43	44	46	50
TOTAL (%)		100	100	100	100	100

Fonte: ANTP (2020).

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One explanation for these data may lie in the morphological and urban characteristics of cities, which "can condition their infrastructure and significantly influence urban and regional mobility and circulation" (Brasil, 2015, p. 59).

The elements that can contribute to the use of active and more sustainable modes of transportation in small cities are: the road network or the type of road layout (orthogonal or winding), the available infrastructure, the topography, and the presence of natural and urban barriers (Brasil, 2015).

Data provided by the National Association of Public Transport (ANTP, 2003, 2020) show that walking or cycling in cities with populations under 60,000 exceeds 40.20% and can reach up to half of the total (Brazil, 2015); however, data on the mobility patterns of municipalities with populations under 60,000 are rarely published. According to the survey, in cities with populations over 60,000, the percentage of trips using active modes rose from 40.2% to 50% between 2003 and 2020 (Brazil, 2015). In cities with populations under 60,000, which often lack municipal public transport, these non-motorized trips are even higher.

Municipalities with populations between 20,000 and 60,000 share some common characteristics that can determine the predominance of active transportation modes. These include: small size (reduced urban area); walking is the predominant mode of travel; significant use of bicycles; lack of regular public transportation service; rural public transportation system; minimal public participation in transportation management; and low or medium motorization rates (Brazil, 2015). Data from the IBGE (2017) on the topic (transportation) show that the presence of public bike paths and bike racks in municipalities with up to 20,000 inhabitants, although limited, is higher than in larger cities.

According to the Census/IBGE (2022), approximately 70% of municipalities in Brazil have populations of fewer than 20,000.

Due to this significant representation, it is important for local authorities to have up-to-date data on the commuting patterns and urban mobility conditions of their residents to propose effective measures from the perspective of urban sustainability.

This article aims to fill a gap in research on the profile of urban commuting in cities with populations of less than 20,000 inhabitants, by identifying and analyzing the factors that lead to the high use of automobiles in these cities, a major challenge for the implementation of a municipal policy for sustainable urban mobility.

3 METHODOLOGIES

This is exploratory research with a quantitative-qualitative approach. The data collection technique identifies barriers that may influence individuals' choice of motorized transportation, particularly personal transportation, over active modes in a small city, Piratininga, São Paulo. This research was conducted through a field visit, on-site observation, and a questionnaire administered to a group of city residents.

The questionnaire's structure was based on research developed by Brazilian researchers (Bertazzo, 2008, 2016; Stein, 2013; Samios, 2018). The use of the questionnaires and methodologies proposed by the authors is justified not only by the academic quality of their

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work, but also by the suitability of their approaches to the specific needs of our research, ensuring an effective and relevant data collection instrument.

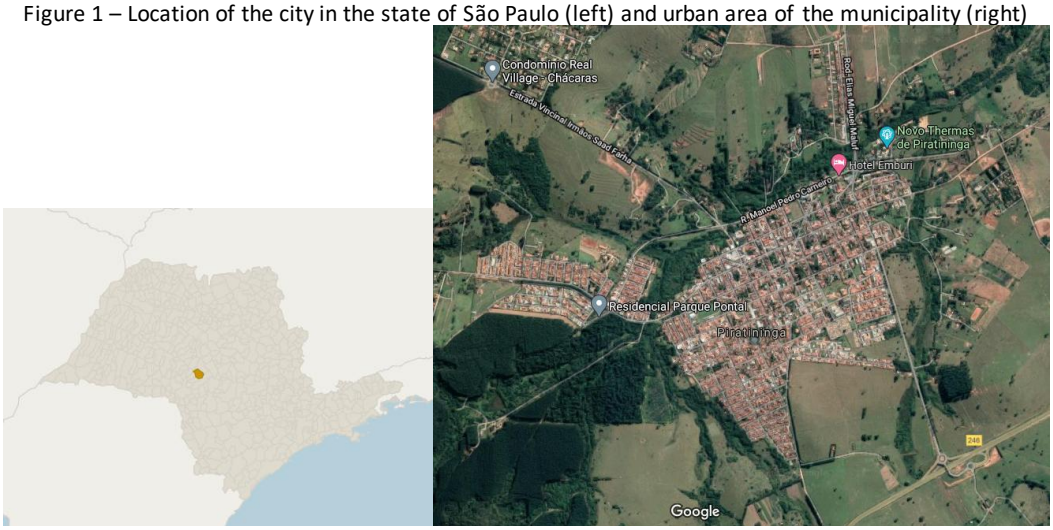
The questionnaire consisted of open-ended and closed-ended questions (dichotomous and multiple-choice), grouped into two parts. The first part presents a characterization of the respondents, and the second part consists of questions related to the barriers perceived by the interviewees that compromise the use of active transportation modes.

The sample for administering the questionnaires was defined based on the population estimate calculated by the IBGE for 2020, which was 13,765 inhabitants. To ensure adequate representativeness, a 95% confidence level and a 10% sampling error were adopted, assuming a heterogeneous distribution (50/50). Furthermore, care was taken to ensure that the questionnaires were administered to individuals over 18 years of age, covering all genders, thus ensuring that the sample reflected the diversity of the population.

4 CHARACTERIZATIONS OF URBAN MOBILITY IN PIRATININGA/SP

Piratininga is located in the central-west region of the state of São Paulo, Brazil, with a population of 15,108 inhabitants. According to the 2022 Census, the population growth rate between 2010 and 2022 was 25.14%, higher than the national average of 6.5% and the São Paulo state average of 7.65%, as well as that of a neighboring medium-sized city, Bauru/SP, of 10.24%. Due to its number of inhabitants, it can be classified as small-sized I, with less than 20,000 inhabitants (Figure 1).

Figure 1 – Location of the city in the state of São Paulo (left) and urban area of the municipality (right)



Fonte: IBGE (2021) e Google Maps (2021) adapted by Silva (2021).

The municipality, which covers an area of 402.409 km², has an urban core structured similarly to other cities in west-central São Paulo, where the urban fabric begins at the railway station, from which the city originated. It follows an orthogonal layout, resembling a "checkerboard" with some urban voids resulting from real estate speculation, retained awaiting better conditions for urban expansion (Figure 2).

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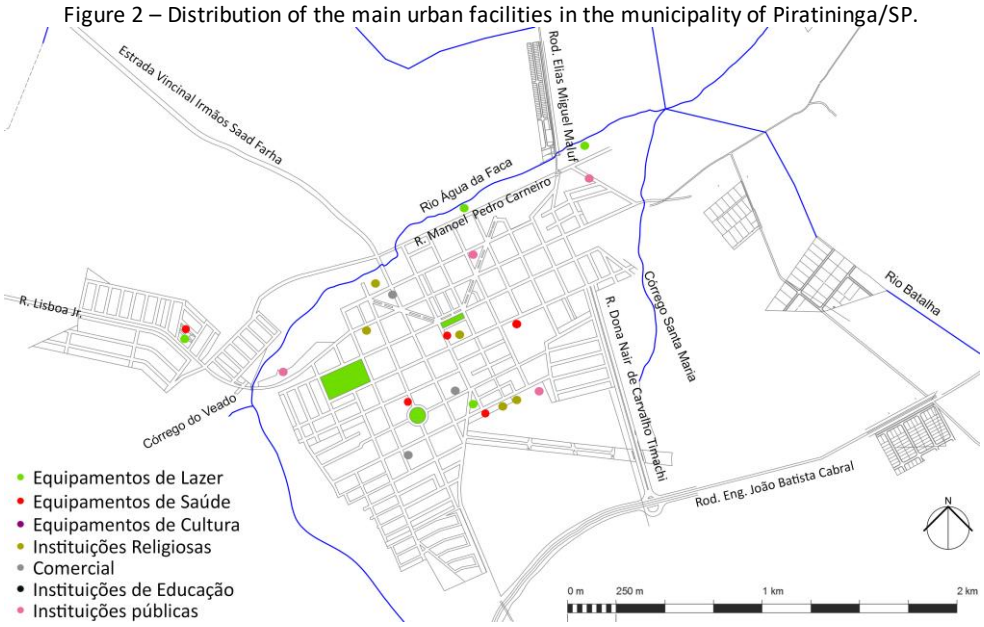
Figure 2 – Distribution of the main urban facilities in the municipality of Piratininga/SP.



Fonte: Piratininga City Hall (2021). Prepared by Silva (2021).

The urban expansion of the city of Bauru (a neighboring municipality to Piratininga), coupled with the city's land values, were factors that boosted Piratininga's real estate market. The influx of local residents into the city contributed to the development of numerous neighborhoods and mid- and high-income housing complexes along the city's main entrances, to the south (Eng. João Batista Cabral Highway), north (Elias Miguel Maluf Highway), and northwest (Estrada Vicinal Irmãos Saad Farha), which contributed to the expansion of the urban fabric and significantly altered the city's landscape.

The main urban amenities identified in the city are: health clinics, schools, churches, plazas, and commercial and service establishments, located in the city center. Commercial and service-related activities predominate in this area, as shown in Figure 2.

There are two main road axes that cross the city's traditional layout diagonally, starting from the lower area and converging at the main church square (Figure 2).

In addition to the highways, another significant route for urban mobility is Manoel Pedro Carneiro Street, which provides access to new real estate developments. This street becomes Otávio Bertone Street. Alternatively, Lisboa Júnior Street also serves as an important access point, crossing the central region and connecting the entire city.

In the city center, many cars can be seen traveling on narrow streets. However, the main avenues and streets (arterial and collector) are adequately sized, according to the parameters presented in the Traffic Calming Measures Guide (SENATRAN, 2024), ranging from 16 to 18 meters in width. However, there is free street parking, which encourages the use of cars for all types of travel and hinders traffic. On the other hand, there is little pedestrian traffic during the week (Figures 3a and 3b).

Accessibility issues are also noted on the city's sidewalks. In much of the city, problems related to pavement maintenance, uneven surfaces, narrow sidewalks, few wheelchair ramps, and the absence of tactile paving near the city's main urban facilities are observed (Figure 3c).

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Bicycle use as a mode of transportation is uncommon in people's daily activities. No bicycle users were observed during our visits to the city. The current size of the roads, suitable for motorized transport, however, does not allow the insertion of cycle paths or cycle lanes, as suggested by the Brazilian accessibility standard (NBR nº 9050/2021).

Figure 3 – Traffic and mobility infrastructure situation in the municipality of Piratininga/SP.

Fonte: Silva (2021).

Over the past 10 years, the vehicle fleet has grown significantly, approximately 156%, according to the 2022 Census. In Piratininga, São Paulo, according to data from the National Department of Transit (DENATRAN) (2022), from 2006 to 2022, the municipal fleet increased by 320%. The number of automobiles (cars, pickup trucks, and utility vehicles) grew by 279%, and the number of motorcycles (motorcycles and scooters) grew by 567%, exceeding the national growth rate. Figure 4 shows the evolution of the automobile and motorcycle fleets between 2006 and 2022.

In 2001, the municipal fleet consisted of 2,856 vehicles, of which 2,014 were automobiles and 229 were motorcycles. In that year, the motorization rate was 3.76 inhabitants per vehicle. Regarding the automobile fleet, the calculated ratio was 5.33 inhabitants per automobile and for motorcycles, it was 46.90 inhabitants per motorcycle (Figure 4). In 2009, there was significant growth in the municipal fleet, which reached 4,671 vehicles, of which 3,038 were automobiles and 673 were motorcycles. That year, the motorization ratio was 2.55 inhabitants per vehicle. Regarding the automobile fleet, the calculated ratio was 3.92 inhabitants per automobile and the motorcycle index was 17.70 inhabitants per motorcycle.

In 2022, there was significant population growth, and the municipal fleet grew to 5,974 automobiles and 1,356 motorcycles. That year, the motorization ratio in the city increased to 1.53 inhabitants per vehicle. Regarding the automobile fleet, the calculated ratio was 2.52 inhabitants per automobile and the motorcycle index was 11.14 inhabitants per motorcycle.

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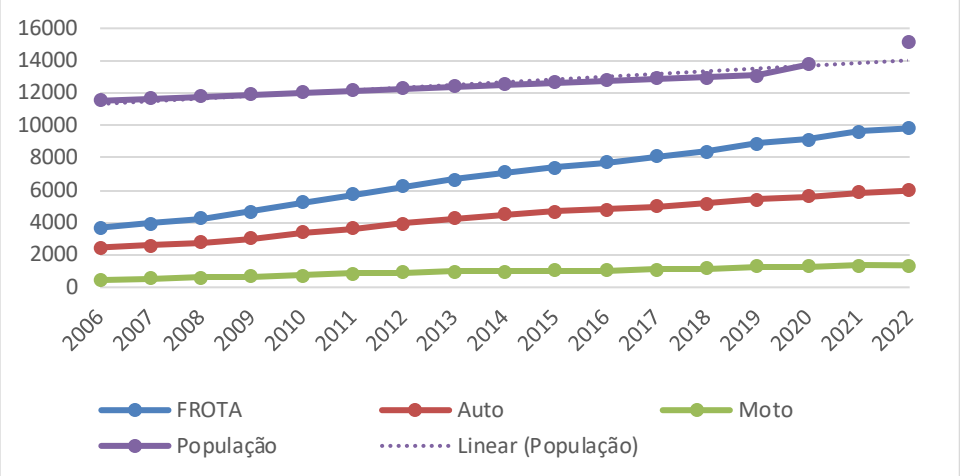
Figure 4 – Piratininga's vehicle fleet for the period 2001 to 2020



Fonte: IBGE (2020), DENATRAN (2020) e Silva (2021).

The current Participatory Master Plan dates back to 2008 and has not been recently updated, as provided for in the City Statute, LF No. 10,257, of July 10, 2001. The law establishes parameters for territorial expansion, helps identify priorities for infrastructure investments such as transportation, sanitation, and housing, and ensures social inclusion, allowing all population groups, especially the vulnerable, to have a voice in decision-making. Finally, it stimulates local economic growth by enhancing commercial areas and promoting income-generating and employment activities, with a view to local economic development, resulting in a more equitable and pleasant city for all.

The city's Master Plan contains some urban planning guidelines related to mobility (Section IV - Specific Guidelines, Articles 15 and 16). These articles indicate that the city should promote the expansion of commercial, service, residential, and mixed-use areas in a sustainable manner. Therefore, green corridors should be created to support the transportation system, aiding urban mobility and connecting different destinations. This will allow for integration with cycle paths and the creation of alternative routes for citizens. (Piratininga, 2008).

Specifically, regarding urban mobility, the Master Plan (Law No. 1,825, of December 9, 2008) mentions the need to prioritize pedestrians, cyclists, people with special needs and reduced mobility (universal accessibility), public transportation over private transportation, and to improve the urban environment of public transportation corridors, with the goal of reducing the need for daily commutes. Although the legislation is based on the principles of sustainable urban mobility, the motorization index data and the results of the questionnaires did not identify this impact on daily commutes in the city.

4.1 Barriers to the adoption of sustainable transport modes

To identify the barriers that influence transportation mode choice in the city, a questionnaire was administered to 117 people of both genders and different age groups. The age groups were defined proportionally to the age pyramid estimated by the 2020 Census for the municipality.

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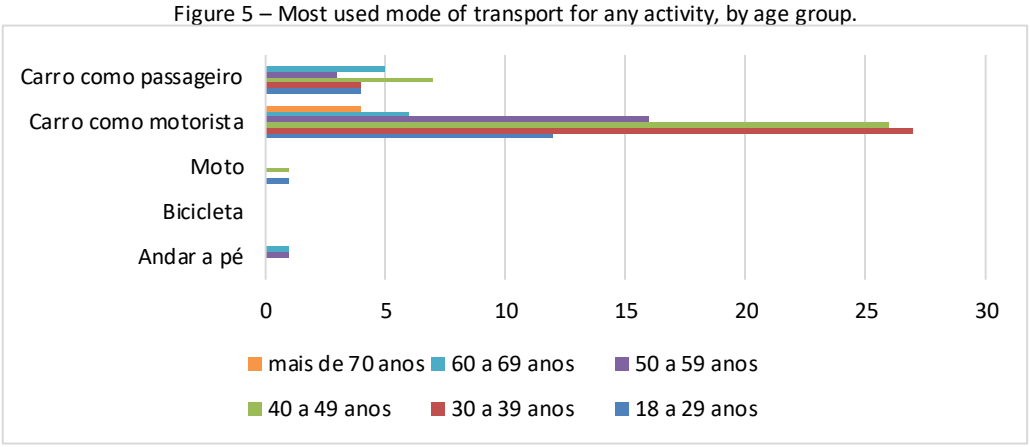
The majority of respondents, 68%, were men. The predominant age group in the sample was adults, aged 40 to 49 (29.06%), followed by those aged 30 to 39 (26.50%).

The data reveal a high rate of motorization in the city, with 78.63% of the sample owning at least one car at home. This trend was observed across all age groups, but was most pronounced among adults aged 18 to 59. On the other hand, the 60+ age group showed a predominance of individuals without a car. The data show that the mode of transportation most frequently used by respondents during the week, for any activity, was predominantly the automobile - 96.58% of responses, a condition observed across all age groups. The majority of respondents (77.8%) drive their cars. Walking or riding a motorcycle corresponds to 1.71% of responses. No person interviewed mentioned using a bicycle as a mode of transportation, although the municipality has a relatively flat terrain and is considered a small territorial area (Figure 2).

Regarding data on the most used mode of transportation, by age group, it is observed that in the age group between 30 and 39 years, the majority - 29.67% of people - use the car as a driver, followed by the age group of 40 to 49 years - 28.57%, 50 to 59 years - 17.58%, 18 to 29 years - 13.19%, 60 to 69 years - 6.59% and over 70 years - 4.40%. The use of the car as a passenger is predominant in the age group between 40 and 49 years, 31.82%, followed by respondents from 50 to 59 years, 22.73%, and tied for the age groups of 18 to 29 years and 30 to 39 years, both with 18.18% (Figure 5).

Figure 5 – Most used mode of transport for any activity, by age group.



Fonte: Silva (2021).

According to the interview results, the reasons justifying the use of the automobile as the main mode of transportation in the city of Piratininga were mainly associated with three factors: flexible hours for use (76.07% of responses), speed (57.26%), and easy access to the car (55.56%) (Table 2). Reasons that had little influence on automobile use were related to inadequate infrastructure (0.85%), long distances (1.71%), and economic issues (3.42%). It was observed that in the age group over 70 years, all reasons were considered relevant (1st or 2nd place in the ranking) for the use of the automobile in daily activities.

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Table 2 - Ranking of reasons for frequent car use, by age group.

MOTIVES	AGE RANGE (years)						TOTAL	
	18 a 29	30 a 39	40 a 49	50 a 59	60 a 69	+ de 70		
Speed	2º	2º	3º	3º	3º	1º	**67**	**57,26%**
Economy (Financial)	5º	6º	6º	7º	5º	2º	**4**	**3,42%**
Flexible schedule	1º	1º	1º	1º	1º	1º	**89**	**76,07%**
Ease of travel	4º	5º	5º	5º	4º	1º	**29**	**24,79%**
Long distance	5º	6º	6º	7º	6º	2º	**2**	**1,71%**
Easy access	2º	3º	2º	2º	2º	1º	**65**	**55,56%**
Comfort	4º	5º	5º	5º	4º	1º	**29**	**24,79%**
Security (robbery)	3º	4º	4º	4º	3º	1º	**44**	**37,61%**
Inadequate infrastructure	5º	6º	6º	8º	6º	2º	**1**	**0,85%**
Weather conditions	4º	5º	5º	6º	4º	1º	**28**	**23,93%**
Pick-up/drop-off	4º	5º	5º	6º	4º	1º	**28**	**23,93%**

Fonte: Silva (2021).

Table 3 - Ranking of reasons for frequent use of walking, by age group.

MOTIVES	AGE RANGE (years)						TOTAL	
	18 a 29	30 a 39	40 a 49	50 a 59	60 a 69	+ de 70		
Speed	3º	3º	3º	5º	2º	2º	**63**	**23,93%**
Economy (Financial)	2º	1º	2º	1º	1º	2º	**91**	**77,78%**
Preserve the environment	1º	2º	1º	2º	1º	1º	**93**	**79,49%**
Exercise	6º	7º	7º	6º	5º	4º	**35**	**29,91%**
Improve health	5º	4º	6º	6º	3º	3º	**46**	**39,32%**
Short distance	7º	8º	8º	7º	5º	4º	**17**	**14,53%**
Easy access	4º	6º	5º	4º	4º	3º	**47**	**40,17%**
REASONS	4º	5º	4º	5º	4º	3º	**48**	**41,03%**
Comfort	6º	6º	7º	3º	4º	4º	**42**	**35,90%**
Safety (robbery)	9º	9º	9º	8º	7º	5º	**2**	**1,71%**
Inadequate infrastructure	8º	10º	9º	8º	6º	5º	**3**	**2,56%**
Weather conditions	9º	10º	9º	8º	6º	5º	**2**	**1,71%**

Fonte: Silva (2021).

The reasons that would justify using walking as the main mode of transportation in the city were associated with: environmental preservation (79.49% of responses – 1st place in the ranking), followed by economic considerations (77.78% – 2nd place in the ranking), which, while relevant, is not sufficient to replace the use of cars, as revealed by the comparison with the data in the previous table; and comfort (41.03% – 3rd place in the ranking). Factors such as inadequate infrastructure (1.71%), lack of a license (1.71%), and weather conditions (2.56%) were not considered barriers to adopting walking (Table 3).

The reasons that would justify not using cycling as the main mode of transportation were associated with: physical exhaustion (94.02%), a unanimous response across all age groups; followed by the lack of availability or ownership of bicycles (82.05%) and lack of safety (53.85%) (Table 4). Inadequate infrastructure was not considered a barrier to bicycle use,

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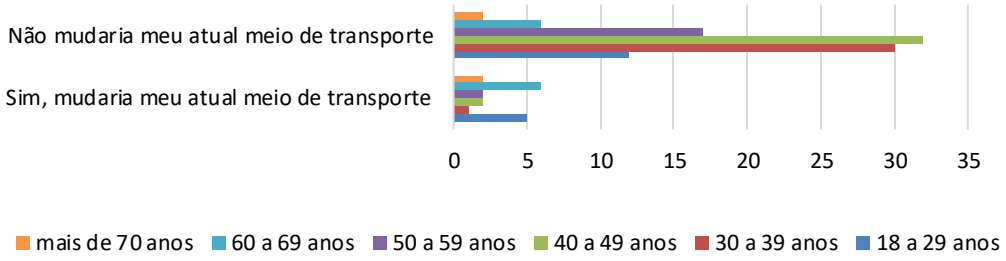
however, when analyzing the city's infrastructure, it was found that there is no system of cycle paths, cycle lanes or cycle routes that allows the use of bicycles comfortably and safely in the city.

Table 4 - Ranking of reasons for NOT using a bicycle frequently, by age group.

MOTIVES	AGE RANGE (years)						TOTAL	
	18 a 29	30 a 39	40 a 49	50 a 59	60 a 69	+ de 70		
Slowness	4º	5º	4º	3º	3º	2º	**50**	**42,74%**
Physical wear and tear	1º	1º	1º	1º	1º	1º	**110**	**94,02%**
Long distance	4º	6º	5º	4º	4º	2º	**44**	**37,61%**
Uncomfortable	4º	6º	5º	4	4º	2º	**44**	**37,61%**
Security (robbery)	3º	3º	3º	2º	4º	1º	**63**	**53,85%**
Inadequate infrastructure	4º	6º	6º	4º	5º	2º	**42**	**35,90%**
Weather conditions	4º	4º	4º	3º	4º	2º	**50**	**42,74%**
Relief	4º	5º	4º	2º	3º	2º	**52**	**44,44%**
No bicycles	2º	2º	2º	1º	2º	1º	**96**	**82,05%**

Fonte: Silva (2021).

Figura 6 – Distribution of results of changing the current mode of transport.



Fonte: Silva (2021).

Regarding the possibility of changing their current mode of transportation for urban travel—whether for work, study, leisure, or shopping—84.62% of respondents stated that they do not intend to replace their car. This response is predominant in the 18-60 age group (Figure 6). Among those who would consider this change are seniors aged 60-69 and young people aged 18-29.

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Table 5 - Data regarding changes in the current mode of transport, by age group.

ACTIVITIES		Walking	Bicycle	Motorcycle	Car as driver	Car as a passenger
WORK	N. respondents	17	13	9	1	3
	% of line total	39,53%	30,23%	20,93%	2,33%	6,98%
ESTUDY	N. respondents	17	14	8	0	3
	% of line total	40,48%	33,33%	19,05%	0,00%	7,14%
LEISURE	N. respondents	17	14	8	0	3
	% of line total	40,48%	33,33%	19,05%	0,00%	7,14%
SHOPPING	N. respondents	17	14	8	0	0
	% of line total	43,59%	35,90%	20,51%	0,00%	0,00%

Fonte: Silva (2021).

Regarding this change, 39.53% of respondents would switch to walking to work, followed by cycling (30.23%), and motorcycle (20.93%). Regarding study and recreational activities, 40.48% of respondents would switch to walking, 33.33% to cycling, and 19.05% to motorcycle. For shopping, 43.59% would switch to walking, 35.90% to cycling, and motorcycle (20.51%).

The existing urban configuration also directly influences the modes of transportation used in cities with limited urban areas. Factors such as terrain and traffic can contribute positively or negatively to the use of walking or driving for these urban trips.

The results in Piratininga, São Paulo, highlight the predominant use of cars for most urban trips, regardless of the user's age group. These data reveal that the city has not contributed to effectively implementing the concept of sustainable urban mobility, which is to say, it is going against the guidelines of the country's current urban mobility policy. These data demonstrate a high number of urban trips using individual motorized transportation, as is the case in many larger cities.

Active modes are capable of meeting people's short-distance travel needs. Distances of up to 1 km can be covered on foot, and up to 2 km can be covered by bicycle for daily activities (Forsyth; Southworth, 2008; Escobar, Flórez, Portugal, 2017; Pires, Magagnin, 2021; Silva 2021). However, to encourage the adoption of these modes, the mobility infrastructure must offer quality and safety to its users.

Data from Piratininga, São Paulo, showed that the main factors contributing to car use are flexible schedules, speed, easy access, safety (avoiding robberies), ease of travel, and comfort. Factors that could be detrimental to walking, such as length of the route, inadequate infrastructure, and adverse weather conditions, were cited by a minority of respondents, with the exception of those over 60.

5 CONCLUSION

Recent national and international research has encouraged sustainable urban mobility and highlighted its benefits, directly linked to population health and environmental preservation, due to the use of active and, therefore, more sustainable modes of transportation.

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In the case of Piratininga, São Paulo, significant growth in its vehicle fleet has been observed in recent years, surpassing the national and state average, as well as that of Bauru, São Paulo, a neighboring mid-sized city. It can be considered that the pandemic has led the population to increase car ownership.

The survey results showed that 96.58% of respondents use cars for their daily activities, with 77.78% as drivers and 18.80% as passengers; these data primarily refer to the 30- to 39-year-old age group.

The reasons for choosing the automobile as the main mode of transportation in the city are primarily associated with three factors: flexible travel times, speed, and easy access to a car. This last factor is associated with the high rate of motorization observed in the city.

The main factors that become barriers and influence the non-use of active and more sustainable modes of transportation are: physical exhaustion, lack of safety (robbery), inadequate infrastructure, unfavorable environmental conditions, and the lack of availability or ownership of bicycles. Regarding environmental conditions, it is important to highlight the increasingly frequent extreme weather conditions in the current context of the climate emergency, and how this situation is exacerbated by the prioritization of individual motorized transportation.

The research presented contributes to the debate on mobility conditions in small Brazilian cities by analyzing a municipality with a population of less than 20,000, Piratininga, São Paulo, in the country's wealthiest state, São Paulo. This is a municipality profile that has been little investigated in urban mobility research. It is important to conduct similar studies in other small cities with the same demographic profile to identify whether Piratininga, São Paulo, follows more general or specific trends regarding urban mobility and the commuting conditions of its residents. These studies can assist public administrators in making decisions on public policies and investments to improve urban mobility in small cities, from the perspective of sustainable development, which involves increasing the use of active transportation modes.

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STATEMENTS

CONTRIBUTION OF EACH AUTHOR

When describing each author's involvement in the manuscript, use the following criteria:

Vinicius Luis Arcangelo Silva: Study Design and Development, Data Curation, Formal Analysis, Investigation, Methodology, Writing - Initial Draft, Writing - Critical Review, Final Review and Editing, Supervision.

Leticia Moreira Sigolo: Methodology, Critical Review, Supervision.

DECLARATION OF CONFLICTS OF INTEREST

We, **Vinicius Luis Arcangelo Silva** and **Leticia Moreira Sigolo**, declare that the manuscript entitled **CHALLENGES FOR SUSTAINABLE URBAN MOBILITY IN SMALL CITIES: STUDY IN PIRATININGA/SP**:

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