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Racial and income inequalities in access to healthcare in Brazilian cities

Diego B. Tomasiello [*], João Pedro B. Vieira, João Pedro F.A. Parga,
Luciana M.S. Servo, Rafael H.M. Pereira [**]

Institute for Applied Economic Research, Setor de Ed. Públicos Sul 702/902, Bloco C Centro Empresarial Brasília 50, Torre B - Térreo, 70390-025, Asa Sul, Brasília, DF, Brazil

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ABSTRACT

Introduction: People's access to public healthcare can importantly contribute to reducing the prevalence of diseases and increasing life expectancy. Despite the advances of Brazil's Unified Health System (SUS), the country faces a permanent challenge in improving the coverage and equity of healthcare to reduce racial, spatial, and income inequalities in access to healthcare. Several studies have explored the spatial dimension of socioeconomic inequalities in access to healthcare in Brazil, but few analyze such inequalities within cities and bring evidence of racial inequalities.
Methods: This paper presents the first large-scale study in Brazil examining the social and racial inequalities of access to healthcare at a high spatial resolution. The analysis covers access to primary and high-complexity public healthcare by public transport, automobile, and walking for the 20 largest cities in Brazil in 2019.
Results: The results show that individuals with low income, regardless of race, have greater accessibility to primary healthcare in general. In contrast, individuals with high-income, mostly white, have substantially better accessibility to high-complexity healthcare. Yet, we find that racial inequalities in access to healthcare become much smaller when controlling for income.
Conclusions: The results contribute to a better understanding of the geographical dimension of inequalities in access to healthcare in major Brazilian cities, showing how access to healthcare is strongly conditioned by social, economic, and transport-related factors.

1. Introduction

The ease with which the population can access public healthcare has direct implications for reducing the prevalence of diseases and increasing life expectancy (World Health Organization, 2000). In Brazil, the Unified Health System (SUS) has universality and integrality as principles, ensuring attention to all health needs in an articulated and fair manner (Paim and Silva, 2010). Despite recent

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[*] Corresponding author. Institute for Applied Economic Research, Setor de Ed. Públicos Sul 702/902, Bloco C Centro Empresarial Brasília 50, Torre B - Térreo, 70390-025, Asa Sul, Brasília, DF, Brazil.

[**] Corresponding author. Institute for Applied Economic Research, Setor de Ed. Públicos Sul 702/902, Bloco C Centro Empresarial Brasília 50, Torre B - Térreo, Asa Sul, 70390-025, Brasília, DF, Brazil.

E-mail addresses: diego.tomasiello@ipea.gov.br (D.B. Tomasiello), joao.vieira@ipea.gov.br (J.P.B. Vieira), joao.parga@ipea.gov.br (J.P.F.A. Parga), luciana.servo@ipea.gov.br (L.M.S. Servo), rafael.pereira@ipea.gov.br (R.H.M. Pereira).

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advances of SUS, it faces a permanent challenge in planning the spatial distribution of medical procedures, equipment, and human resources to improve the coverage and equity of healthcare in the country (Castro et al., 2019; Lucchese, 2003; Servo et al., 2022).

The Covid-19 pandemic revealed a strong socioeconomic and racial gradient, disproportionately affecting black individuals and individuals with low income (de Ferreira de Souza, 2021; Li et al., 2021), with marked regional and spatial inequalities (Albuquerque and Ribeiro, 2020; Noronha et al., 2020). Even though SUS can help reduce racial and income inequalities (Lopes, 2021), Brazil faces historical and institutional racism (T. D. Silva and Silva, 2021) and chronic problems of underfunding (Piola et al., 2013; dos Santos, 2018).

Previous studies have analyzed the spatial dimension of socioeconomic inequalities in access to healthcare in Brazil (Albuquerque et al., 2017; Amaral et al., 2017; Andrade et al., 2013; Rocha et al., 2017; Travassos et al., 2006). However, most of these studies were conducted looking at healthcare access at the regional scale, comparing the geographical proximity to health equipment between municipalities, states, and regions (Amaral et al., 2021). Moreover, despite a growing literature on racial inequalities in access to health in Brazil (Bairros et al., 2011; Freitas et al., 2009; Goes and Nascimento, 2013; J. A. F. Santos, 2011; da Silva et al., 2020), few studies provide evidence on the spatial dimension of such inequalities, especially within urban areas.

This paper presents the first large-scale study in Brazil analyzing social and racial inequalities of access to healthcare in high spatial resolution. The analysis covers access to primary and high-complexity public healthcare (equivalent to specialty care) by public transport, automobile, and walking. It covers access to healthcare in the year 2019 in the 20 largest cities of the country - São Paulo, Rio de Janeiro, Salvador, Brasília, Fortaleza, Belo Horizonte, Goiânia, Manaus, Curitiba, Recife, Porto Alegre, Belém, Guarulhos, Campinas, São Luís, São Gonçalo, Maceió, Duque de Caxias, Natal e Campo Grande. The paper presents detailed descriptive analyses of the spatial inequalities of access to healthcare within cities and of social inequalities considering the intersectionality between income and race.

In the next section, we explain the methods, including databases and accessibility indicators used in the study. The results for different levels of accessibility of Brazilian cities are presented in section 3. In section 4, we discuss the research results, main findings, and potential implications for public policies.

2. Methods

The data used is detailed in the subsection below, while methods for estimating accessibility metrics and inequalities are described in the following subsection. The code for reproducing this paper's data analysis and visualizations is publicly available on a GitHub repository https://github.com/ipeaGIT/aop_saude_2022/releases/tag/v.1.1/.

2.1. Data

Data on healthcare facilities were obtained from the 2019 National Registry of Healthcare Facilities (CNES) of the Ministry of Health. The analysis considers only healthcare facilities financed by the Unified Health System (SUS). According to Brazilian health authorities, healthcare can be characterized according to their complexity level (Brasil, 2011; Ministério da Saúde, 2017). Low-complexity services (a.k.a primary care medical services) include, for example, basic dental treatment, general practice, and rehabilitation. Meanwhile, services such as hospitalizations, hemodialysis, intensive care, and cancer treatment (aka specialty care services) are considered of high-complexity. In this study, we focused on healthcare facilities that provide primary care and high-complexity healthcare services. Some healthcare facilities can simultaneously perform primary care and high-complexity services. In this case, the healthcare facility was considered in both categories. The healthcare facilities were then geolocated based on their address using proprietary ArcGIS Pro software (ESRI, Redlands, CA) and the Google Maps API (Pereira et al., 2022b; Google, 2023). Overall, it was possible to find the coordinates of 94% of the healthcare facilities.

The spatial distribution of the population was obtained from the statistical grid (IBGE, 2016), which has a resolution of 200 × 200 m in urban areas and 1 × 1 km in rural areas. Information on household income per capita and the racial composition of census tracts were obtained from the 2010 Demographic Census (IBGE, 2010) and imputed to each cell of the statistical grid using a dasymetric spatial interpolation operation (Comber and Zeng, 2019).

The healthcare facilities and the population data were spatially aggregated over a hexagon grid, which makes up our unit of analysis. We used the hierarchical index H3 (Brodsky, 2020) at resolution 9, where each hexagon has an area of 0.11 km^2. The hexagonal shape was chosen because it has topological properties that bring advantages to the study of spatial phenomena with important components of spatial mobility, neighborhood, and network connectivity (Birch et al., 2007). Furthermore, the use of hexagonal grids facilitates the interpretation and comprehension of results in spatial visualizations (Langton and Solymosi, 2021). Although we are using a single hexagon resolution to perform the analyses, which can result in issues related to the modifiable areal unit problem (MAUP), using such a high-resolution hexagon tends to produce robust results. The socioeconomic information from the statistical grid was interpolated onto the hexagonal grid based on the proportion of the intersection area between cells. Analyses were carried out to ensure that there were no variations, losses, or alterations in relation to the original census data. Thus, each hexagon has attributes of the resident population, average per capita household income, and racial composition. For this analysis, the Brazilian black population is the sum of self-declared black and brown individuals. The hexagons of each city were classified according to the quintile of income, following the local income distribution of each city. The per capita household income is aggregated at the census tract level, making it impossible to disaggregate it by race. Thus, we need to assume that black and white individuals in the same hexagon cell have the same income level.

For the modeling of accessibility on foot and by public transport, we used road network data from OpenStreetMap (OSM) available in November 2020, topography data from NASA's Shuttle Radar Topography Mission (SRTM) base for the year 2000 (NASA JPL, 2013), and data from public transport systems in the General Transit Feed Specification format (GTFS), obtained from the municipalities. The GTFS data were only available for Porto Alegre, Curitiba, São Paulo, Campinas, Rio de Janeiro, Belo Horizonte, Metropolitan Region of Goiânia, Recife, and Fortaleza. Thus, the analysis of access to healthcare by public transportation was conducted only for these nine municipalities, instead of the twenty. The analysis was conducted considering the calendars of services planned for between September and October 2019.

Finally, the accessibility analysis by car used historical traffic speed information on the roads obtained by the proprietary StreetMap Premium (ESRI, Redlands, CA). This database provides information about the average speed of vehicles captured by the Global Positioning System (GPS) data in each street segment every minute of the day over 2 years (first quarter of 2018 to the first quarter of 2020). The data is aggregated for each day of the week, allowing us to capture speed variations and optimal routes between days of the week and different departure times. Spatial and statistical analysis were carried out using R 4.1.2 (R Core Team, 2023) and the land use data and accessibility estimates used in the paper are available in the R package aopdata (*v1.0.2*; Pereira et al., 2022a).

2.2. Travel time and accessibility indicators

The first step to estimating the population's access to healthcare was to calculate, for each city, all-to-all travel time matrices between the centroids of every hexagon cell of the spatial grid. Next, we describe the methods used to calculate these matrices and estimate the levels of access to healthcare and the inequalities of accessibility by income and race.

2.2.1. Travel-time matrices

Travel-time matrices by public transport and walking were estimated using r5r (*v1.0.1*;Pereira et al., 2021), an R-package for routing analyses in multimodal transport networks. The following parameters were used for the routing model:

(1) Maximum travel time: 2 h for public transport
(2) Average walking Speed: 3.6 km/h
(3) Maximum walking distance to access and egress of public transport: 1000 m

In the case of public transport systems, the departure time of trips can have a large influence on travel times due to the variations in the frequency of services throughout the day(Conway et al., 2018; Stępniak et al., 2019). To deal with this, we calculate multiple matrices of travel time departing every minute in the morning peak period (06h–08h), and we considered the median travel time for each origin-destination pair.

The travel time matrices by private car were calculated using the Network Analyst extension of the ArcGIS Pro (ESRI, Redlands, CA). We estimated multiple travel time matrices departing every 15 min in the peak period and then extracted the median travel times for each origin-destination pair. These travel time estimates were used to calculate the accessibility levels of each hexagonal cell.

2.2.2. Accessibility indicators

First, we focus on access to primary healthcare. These healthcare facilities are planned to be more spatially distributed to increase service proximity because these services are meant to work as entry points for SUS (Brasil, 2017). For this reason, we have opted to calculate the minimum travel time (TMI) on foot for the population residing in each hexagon to the nearest healthcare facility (Eq. (1)).

$$TMI_{oP} = min(t_{odP}) \tag{Eq. 1}$$

Where:

TMI_{oP} is the minimum travel time from origin o to the closest healthcare facility P; and

t_{odP} is the travel time from the origin o to the destination d in which there is at least one healthcare facility $P > 0$.

Next, we focus on access to high-complexity healthcare. The more sophisticated the healthcare technology required, the greater the cost and scale needed to provide the service. Thus, the supply of high-complexity healthcare tends to be spatially restricted (Amaral, 2013). In addition, not all healthcare facilities offer the same types of services. For this reason, we have opted to calculate a cumulative accessibility metric (CMA) that measures the total number of healthcare facilities accessible within a given travel time (Eq. (2)). The accessibility to high-complexity healthcare facilities was calculated by public transport and car, with time cutoffs of 30 and 60 min for public transport and 15 and 30 min for car.

$$CMA_{oTPm} = \sum_{d=1}^{n} P_d \cdot f(t_{odm}) \tag{Eq. 2}$$

Where:

CMA_{oTPm} is the number of healthcare facilities P accessible from the origin o within the time cutoff T using the mode m;

P_d is the number of healthcare facilities per level of complexity at the destination d;

t_{odm} is the travel time from origin o to destination d using mode m; and

$f(t_{odm})$ is the time limit function, which indicates whether the travel time between the origin o and the destination d through the mode m is longer ($f(t) = 0$) or shorter ($f(t) = 1$) than T.

Table 1

Proportion of people according to income and race in the 20 largest cities of Brazil in 2010.

City	White Individuals with low incomes (%)	White Individuals with high income (%)	Black Individuals with low income (%)	Black Individuals with high income (%)	Region	Population (x 1000)
São Paulo	43.7	82.4	55.5	12.6	Southeast	11,163,678
Rio de Janeiro	34.0	81.0	64.9	18.2	Southeast	6,141,600
Salvador	11.1	40.0	87.1	58.6	Northeast	2,609,683
Brasília	28.6	66.6	69.4	31.8	Midwest	2,541,975
Fortaleza	27.4	53.1	71.0	45.8	Northeast	2,418,518
Belo Horizonte	29.2	77.0	69.2	22.2	Southeast	2,409,892
Goiânia	33.0	62.2	65.2	36.1	Midwest	2,121,815
Manaus	19.9	38.4	78.8	60.2	North	1,781,286
Curitiba	66.0	90.1	33.3	7.1	South	1,752,812
Recife	28.7	66.8	70.3	32.2	Northeast	1,528,300
Porto Alegre	64.4	93.9	34.9	5.6	South	1,399,322
Belém	20.4	41.4	78.7	57.3	North	1,377,243
Guarulhos	42.3	72.4	56.9	24.8	Southeast	1,216,984
Campinas	46.6	87.3	52.5	10.3	Southeast	1,077,147
São Luís	19.7	45.6	79.4	53.1	Northeast	994,059
São Gonçalo	34.4	54.7	65.0	44.8	Southeast	941,281
Maceió	28.6	54.0	70.0	44.8	Northeast	921,502
Duque de Caxias	28.9	43.7	69.9	55.3	Southeast	837,382
Natal	34.3	63.8	64.6	35.3	Northeast	793,605
Campo Grande	38.0	69.4	59.6	26.8	Midwest	783,418

Note. 1: Low income: individuals with per capita household income among the poorest 20%. High income: individuals with per capita household income among the richest 20%. Note. 2: The data for Goiânia reflect its entire metropolitan region. Information on indigenous individuals is not included in the table.

Source: 2010 Demographic Census.

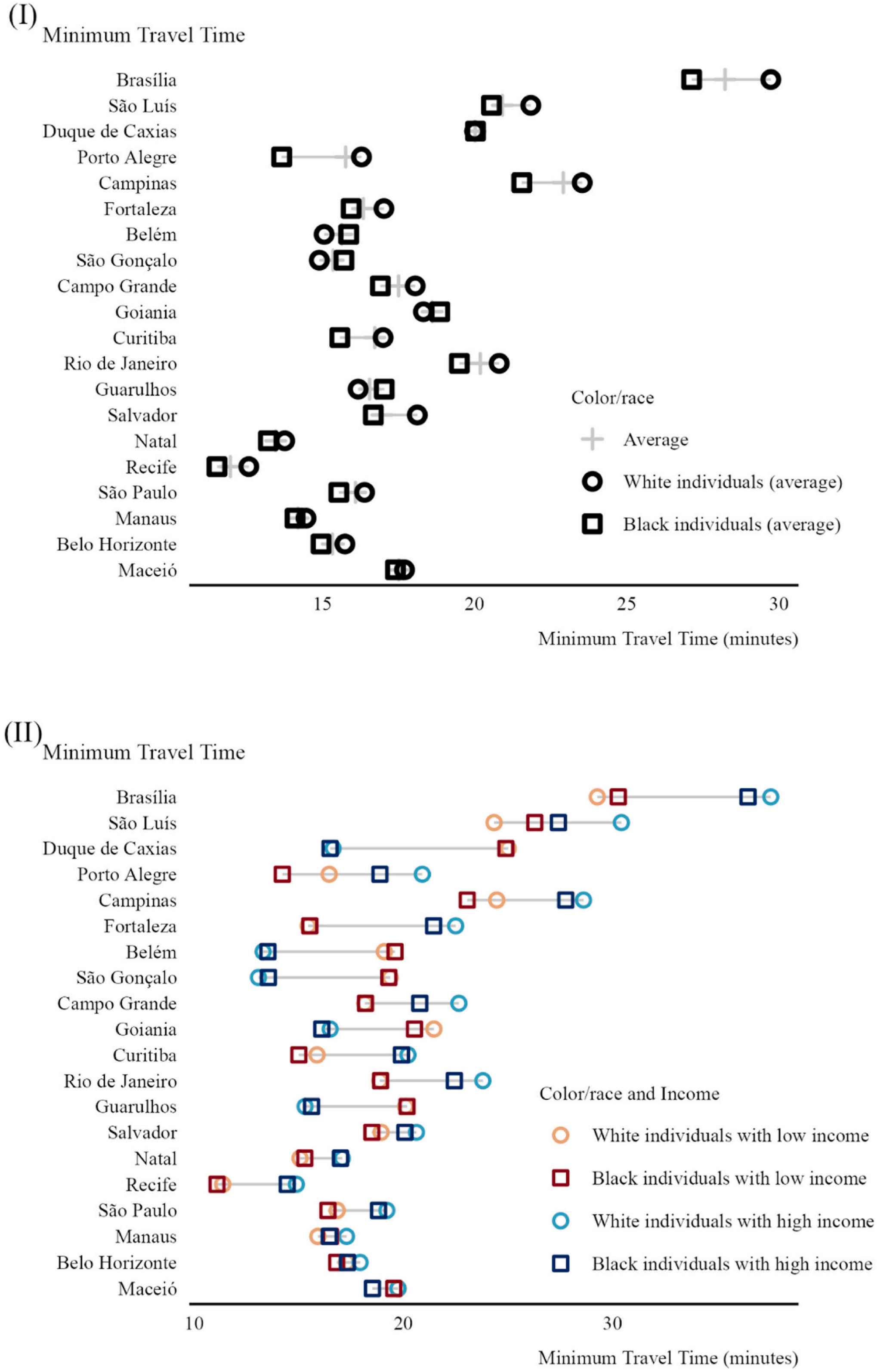

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Fig. 1. Average minimum walking times to the nearest primary healthcare facility according to income and race groups in Brazil in 2019. Note. 1: The vertical dash indicates the average travel time of the city. Low income: individuals with per capita household income among the poorest 20%. High income: individuals with per capita household income among the richest 20%. Note. 2: The data for Goiânia reflect its entire metropolitan region.

The TMI and CMA are widely used in analyses of access to healthcare (Neutens, 2015). We chose to use these indicators in this paper because, in addition to being simple to calculate and having low computational demand, they are also easy to interpret, which makes them simple to integrate into projects and evaluations of public policies.

In summary, at the end of data processing, we obtain for each cell of the spatial grid an estimate of the minimum walking time to primary healthcare facilities and the number of high-complexity healthcare facilities accessible by public transport in 30 and 60 min and by a car in 15 and 30 min.

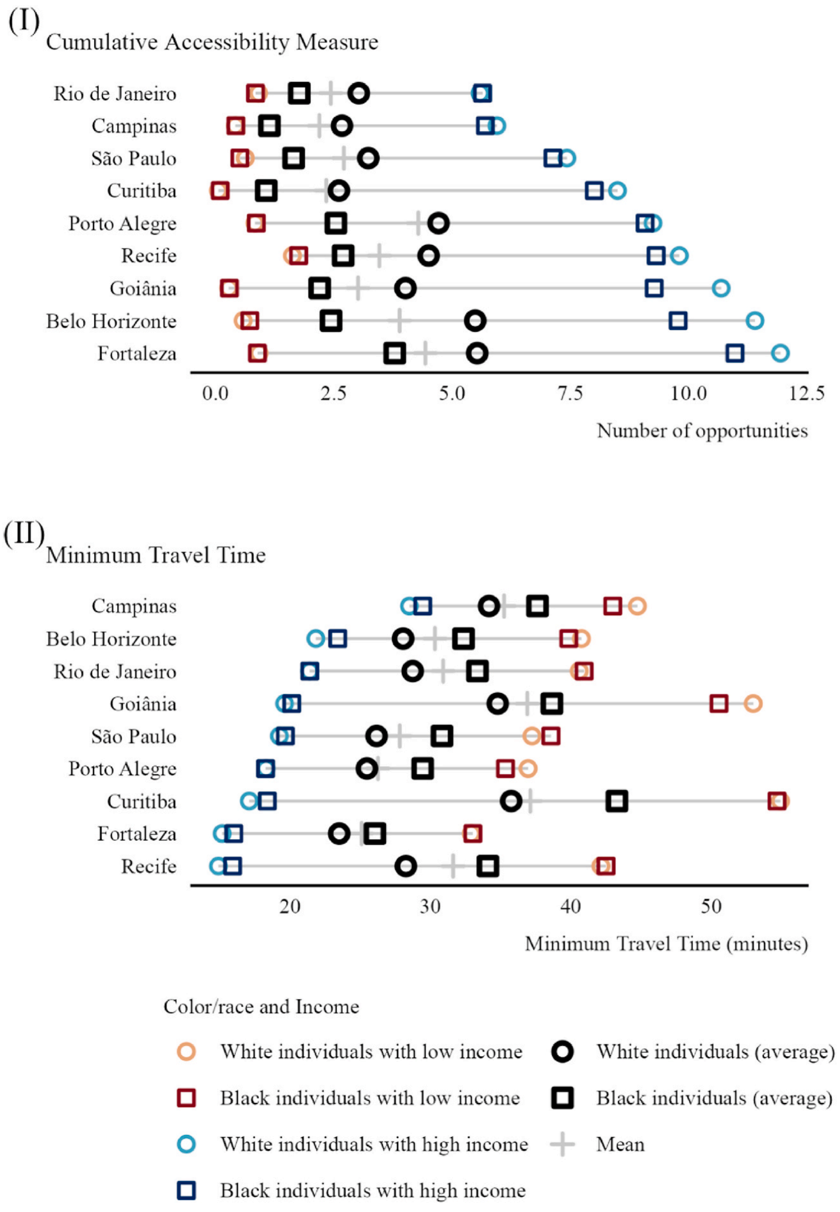

Fig. 2. Access by public transport to high-complexity healthcare facilities in Brazil in 2019 is represented by (I) the number of high-complexity healthcare facilities accessible within 30 min of travel, and (II) the minimum travel time to the nearest healthcare facility. Note. 1: The vertical dash indicates the average travel time in each city. Low income: individuals with per capita household income among the poorest 20%. High income: individuals with per capita household income among the richest 20%. Note. 2: The data for Goiânia reflect its entire metropolitan region.

3. Results

As a general context, black individuals in Brazilian cities tend to be more concentrated among those with low incomes (Table 1). Moreover, cities in the Midwest, North, and Northeast regions have higher proportions of black individuals in their population compared to municipalities in the South and Southeast regions due to enslaved peoples and colonial history in Brazil.

3.1. *Primary healthcare*

An essential question about the condition of access to healthcare is how long it would take a person to walk from home to the nearest primary healthcare facility. Fig. 1 shows the average minimum walking times for the 20% richer and 20% poorer population by race. The results show that, in most cities, black individuals live closer to primary healthcare facilities on average. Similarly, we also observed that individuals with low income have, on average, greater access to these facilities than individuals with high income in most cities.

We also find that racial inequalities in access to healthcare become much smaller when we compare black and white individuals

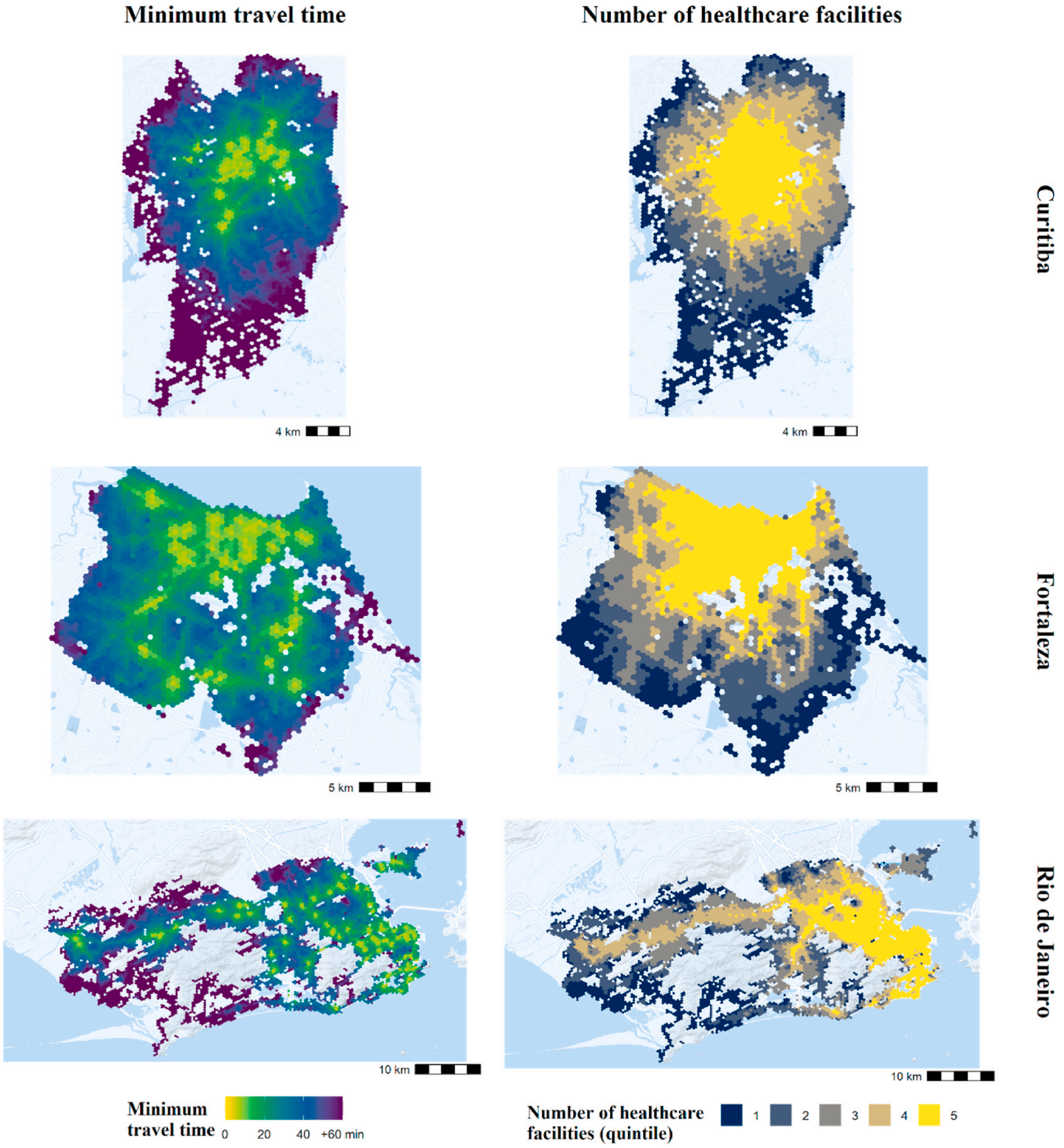

Fig. 3. Spatial distribution of access by public transport to high-complexity healthcare facilities represented by (I) minimum travel time to the nearest facility and (II) number of high-complexity healthcare facilities accessible within 60 min of travel. Curitiba, Fortaleza, and Rio de Janeiro, 2019.

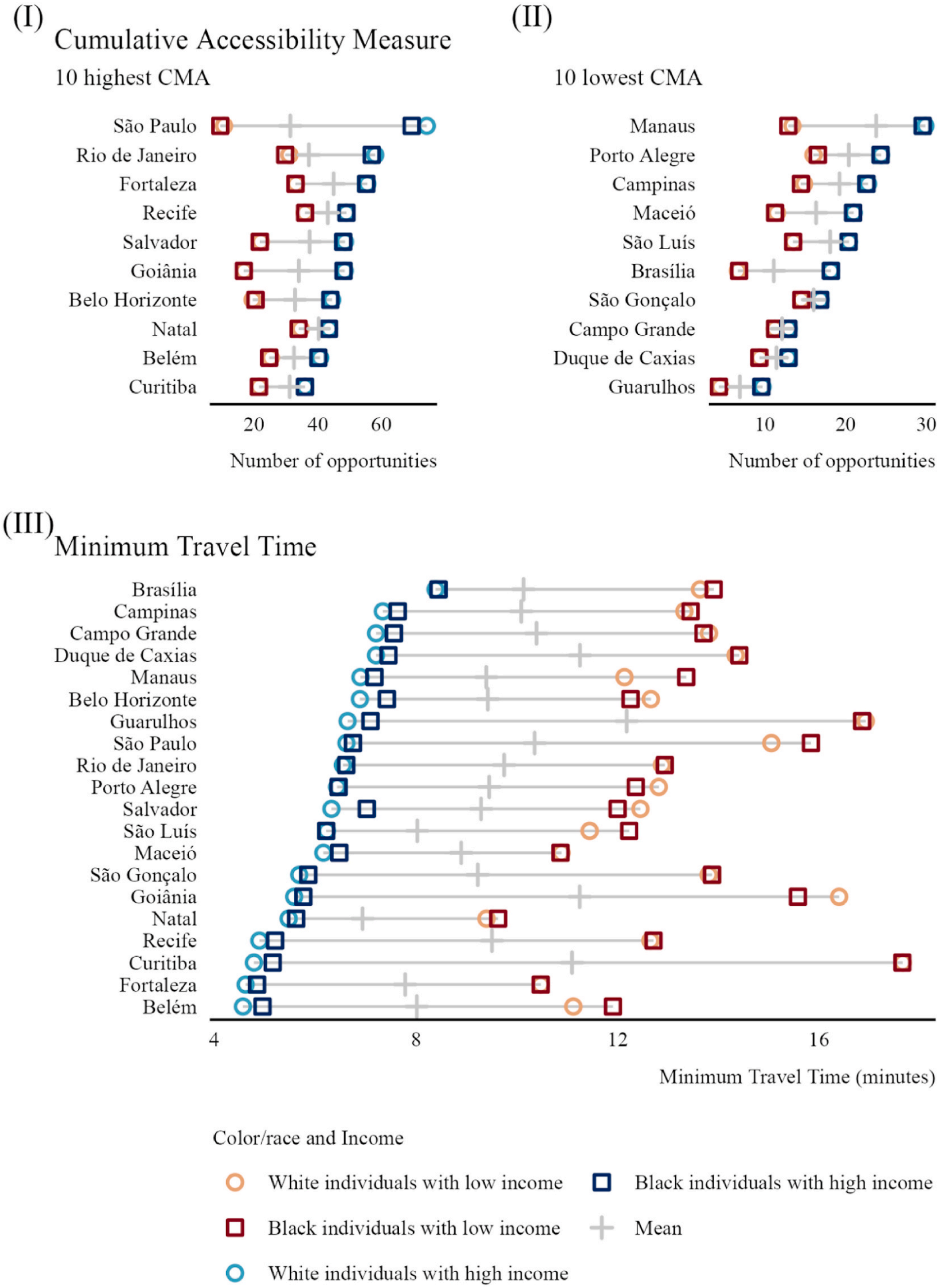

Fig. 4. Access by car to high-complexity healthcare facilities is represented by (I) the minimum travel time to the nearest facility and (II) the number of high-complexity healthcare facilities accessible within 30 min of travel. 2019.

Note. 1: The vertical dash indicates the average travel time of the city. Low income: individuals with per capita household income among the poorest 20%. High income: individuals with per capita household income among the richest 20%. Note. 2: The data for Goiânia reflect its entire metropolitan region.

within the same income level. Moreover, accessibility inequalities are more pronounced when we compare income (high income and low income) rather than racial groups (white and black individuals). Still, it is possible to observe that among individuals with high income, black individuals tend to have easier access to primary healthcare. Among the poorest, the situation varies between cities, but overall, the inequality between white and black individuals is small. On average, the municipalities of Brasília, Campinas, and São Luís have longer access times to primary healthcare, while Recife, Natal, and Manaus have shorter access times.

3.2. *High-complexity healthcare*

In contrast to primary healthcare, high-complexity healthcare facilities have a very distinct pattern of spatial distribution as they are more spatially concentrated. Fig. 2 shows the average minimum access time to the nearest high-complexity healthcare facility and the amount of these facilities accessible within 30 min by public transport. In all cities analyzed, white individuals can, on average, access more healthcare facilities and in shorter travel times than black individuals.

People with low income have the lowest accessibility. They are able to access on average approximately 1–2 high-complexity healthcare facilities within 30 min by public transport and take more than 30 min to access the nearest facility (Fig. 2). Again, racial inequalities almost disappear when we control for income, i.e. when comparing the average accessibility of black and white individuals with the same income level. This is particularly true among people with low income. However, among people with high-income, white individuals tend to have more access to high-complexity healthcare facilities than black individuals.

Fig. 3 shows the spatial distribution of minimum travel times and accessibility to high-complexity healthcare facilities by public transportation in Curitiba, Fortaleza, and Rio de Janeiro. For the sake of brevity, the maps presented throughout this article show the results for these municipalities, which were chosen for presenting markedly different population compositions, transport systems, and levels of inequality in access to healthcare. The areas near city centers and close to the main public transport corridors have considerably high levels of access to high-complexity healthcare facilities due to the spatial concentration of these facilities and the supply of public transport. While the number of high-complexity healthcare facilities accessible within 60 min of travel seems to be homogeneous in Curitiba city center, the minimum travel time indicator shows nuances in how easy it is to reach the closest facility, providing a complementary view of access to healthcare. In Fortaleza, the difference between both measures is more perceptible in the southern region. The minimum travel time indicator shows that from a few hexagons one can reach a high-complexity healthcare facility within 20 min in the southern region, but the cumulative indicator shows that this area presents low access to high-complexity healthcare facilities. A similar situation occurs in the western region of Rio de Janeiro, with the minimum travel time indicator showing easy access to high-complexity healthcare facilities, but the cumulative indicator showing low levels of access.

The automobile promotes a substantial increase in access to high-complexity healthcare facilities. Fig. 4 shows the number of healthcare facilities accessible by car in 30 min and the average minimum travel time by car to the nearest healthcare facility. The number of facilities accessible in up to 30 min is significantly higher by car than by public transport. Thus, there are substantial inequalities in access to these healthcare facilities between individuals with high and low incomes. However, there are no sharp discrepancies in accessibility between white and black individuals with the same income level, except for São Paulo, where white individuals with high income have greater accessibility than black individuals with high income.

In addition, access by car to the nearest high-complexity healthcare facility is below 16 min in all cities and for all income and racial groups. The municipalities of Guarulhos, Curitiba, and Duque de Caxias have, on average, the highest travel times. On the other hand, the municipalities of Natal, Fortaleza, and Belém have the shortest times (less than 8 min). Still, individuals with high income can access healthcare facilities much more easily than those with low incomes, especially black individuals with low incomes, who need, on average, to travel longer to access high-complexity healthcare facilities services.

4. Discussion

This paper examined the racial and income inequalities in access to primary healthcare and high-complexity healthcare facilities in the 20 largest cities in Brazil. The results show that, on average, Brasília, Campinas, São Luís, and Duque de Caxias have longer access times to primary healthcare facilities, while Recife, Natal, and Manaus have shorter access times. In terms of inequalities, Brasília, São Luís, and Duque de Caxias are the most unequal cities, while Maceió, Belo Horizonte, and Manaus are the most equal. Additionally, individuals with low income and black individuals have greater walking access to primary healthcare facilities than individuals with high income and white individuals. This is largely because these facilities are planned to be more spatially dispersed to reduce inequalities and universalize access to healthcare. However, we find marked inequality in access to high-complexity healthcare facilities.

Whether by public transport or by automobile, white individuals and individuals with high income tend to have greater accessibility to these healthcare facilities than black individuals and individuals with low income in almost all cities analyzed. This result largely reflects a combination of the spatial distribution patterns of socioeconomic groups. Black individuals and individuals with low income predominantly live in peripheral urban areas, while the provision of high-complexity healthcare facilities and public transport infrastructure tend to be spatially concentrated in central urban areas. The low supply of healthcare facilities in urban peripheries can be particularly problematic as it may imply an overload of service demand and long waiting lines for these services (Pereira et al., 2021). Our results also show how private cars convey substantially higher access to healthcare compared to public transport. Nevertheless, it is important to stress that monetary costs can impose relevant barriers to accessing opportunities (Herszenhut et al., 2022). The expenses of purchasing motorized private transport are likely to represent a major obstacle to accessing healthcare since car ownership is considerably lower among families with low income (Pereira et al., 2021).

The results should be analyzed considering some limitations. First, the population census does not allow one to explore income disparities within cells. This means that, although it is not possible to compare income inequalities within each cell, it is still possible to compare the income level between white and black individuals living in different hexagons in different regions of cities. Given the marked segregation patterns in the spatial distributions of racial and income groups in Brazilian cities, we are able to examine how access to healthcare varies by income and race. However, even though we would not expect huge income inequalities within hexagons of such small areas, this limitation may lead to higher levels of inequality in access to healthcare between individuals with high and low income compared to racial inequalities between white and black individuals. Second, the accessibility indicators used in this study are not able to capture travel costs, individual preferences, and competition over healthcare resources such as Intensive Care Unit (ICU) beds or medical teams, which may greatly vary across medical specialties. Moreover, this paper focuses specifically on the geographic conditions of access to healthcare facilities. However, there are several other barriers to healthcare access beyond the issues of geographic accessibility addressed here. When one tries to access particular services at a hospital, a patient may face several other types of barriers, for example, related to the availability of health professionals, medications, quality of care, etc. (Guimarães et al., 2019). Some of these barriers may be even more salient for black individuals with low income, and in particular women, due to structural aspects of racial discrimination in the healthcare system (Goes and Nascimento, 2013; N. N. da Silva et al., 2020).

The findings of this study show the importance of spatially explicit health planning policies to improve people’s access to healthcare and reduce accessibility inequalities. In contrast to the balanced spatial distribution of primary healthcare facilities, the spatial concentration of high-complexity healthcare facilities means that individuals with low income and mostly black individuals have considerably less access to high-complexity healthcare than individuals with high income. Policies to expand the provision of high-complexity healthcare to regions with higher population densities in urban peripheral areas could help reduce inequalities in geographic access to health without compromising the economies of scale of these services. Alternatively, the promotion of equity in access to healthcare could also be achieved with land use and housing policies that foster social housing for individuals with low income near city centers with greater healthcare and public transport infrastructure. In the short term, more effective policies could involve investing in the expansion of healthcare facilities supply and ensuring patients’ access through the referral system, together with holding the system accountable for the transportation of patients from disadvantaged communities with low accessibility.

Additionally, our findings suggest that local governments could also mobilize transportation policies to promote more equitable access to healthcare. To some extent, individuals with low income experience poor access to healthcare not only due to geographic distances but also because they are more dependent on public transportation systems with limited network coverage and connectivity. In this sense, it is essential to expand the provision of public transport networks in urban areas with low-income households and peripheral areas, allowing faster access to healthcare by people that are more dependent on this means of transport. This could be done, for example, with the construction of exclusive bus corridors, by increasing frequencies of services connecting peripheral areas to regions with higher concentrations of healthcare facilities and economic activities, and with the expansion of infrastructure and frequency of Bus Rapid Transit systems (BRTs), trains, and subways serving neighborhoods with low incomes.

The analysis presented in this paper illustrates how this type of accessibility analysis could support policies to expand the coverage and equity of healthcare systems and reduce socioeconomic and racial healthcare inequalities. Nonetheless, further research is necessary to investigate the extent to which healthcare access conditions can impact the health outcomes of the population. For instance, whether worse accessibility levels would be related to greater chances of people not scheduling or even missing appointments, medical procedures, and vaccination campaigns.

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I am submitting my manuscript titled “Racial and income inequalities in access to health in Brazilian cities” to be considered for publication in the Journal of Transport & Health. I am writing to disclose that I do not have any financial interests or financial support to declare in relation to this manuscript. I confirm that I have not received any financial support, research grants, honoraria, consulting fees, or other financial interests related to the research presented in the manuscript. There are no potential conflicts of interest or financial interests that could compromise the objectivity, integrity, and validity of the research reported in the manuscript. I want to emphasize that the research conducted and reported in the manuscript is free from any undue influence or bias resulting from financial interests. I am committed to upholding the highest standards of research integrity and providing accurate and comprehensive financial disclosure. Please note that this financial disclosure statement is true and complete to the best of my knowledge. I will promptly update the journal editor if any changes in my financial interests arise during the review or publication process. Thank you for considering my manuscript for publication in the Journal of Transport & Health. I appreciate your attention to this matter and remain committed to maintaining the highest standards of research integrity. Sincerely, Diego B. Tomasiello.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

R Scripts (Original data) (Cloud repository)

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