Acta Scientiarum

http://periodicos.uem.br/ojs
ISSN on-line: 1807-8664
Doi: 10.4025/actascitechnol.v45i1.61329

Citizens' perception analysis of public transport and smart technologies in the Brazilian capitals during the SARS-CoV-2 pandemic

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ABSTRACT. Amidst the consequences of the SARS-CoV-2 pandemic, the overall trip decrease and public transport modal share contraction pose a critical dilemma towards urban mobility. Through a questionnaire in Brazilian capitals, the present article considered (1) the citizens' safety perception of urban mobility and public transport before and during the pandemic, (2) an estimated perception of the post-pandemic, (3) perception of safety regarding both traditional and smart measures, and (4) the concern about data use and privacy. Findings indicated an increase in private cars (41%) and ride-sourcing services (442%) use and a decrease in public transport modes during the pandemic, with an expectation of a post-pandemic modal split following the same pattern. According to respondents, most measures implemented resumes to traditional individual ones, without a systemic approach or smart initiatives. About the latter, a contrasting result was obtained, where there is a high safety perception if implemented with a low security perception over data use and privacy. In this sense, operators, public authorities, city planners and users must observe systemic sanitary measures, regulatory laws and transparency over data use and privacy, democratic and inclusive decision-making processes to address urban vulnerabilities and ensure safe public transport during and after the pandemic.

Keywords: COVID-19; data privacy; global south; smart cities; transit; urban mobility.

Received on October 27, 2021.
Accepted on October 13, 2022.

Introduction

SARS-CoV-2 shocked the world in 2019 and stopped it in 2020. On February 26, 2021, one year after the first notified case in Brazil, there were 10,455,630 accumulated cases and 252,835 deaths. On April 26, the coronavirus deaths in 2021 (195,848) exceed those of 2020 (194,949), and a few days later the total number of deaths reached 401,186 with 14,590,678 confirmed cases (Brazil, 2021). This reflects the critical scenario on which data was collected for this article, in a country with one of the highest number of infections and the lowest number of studies (Benita, 2021), which was a scenario that required crucial interventions and political effort to reduce the rate of mortality and contamination, enabling better social and economic recovery.

Social distancing, as one of the main and most effective measures to contain the spread of the virus, presents an almost diametrical opposition to the nature of public transport. As a result, one of the initial recommendations was to avoid using public transport systems if possible or at least avert crowded vehicles. Even in an ideal situation with individual protection measures and companies following the safety recommendations, passengers in close proximity within overcrowded vehicles are potentially exposed to contamination (De Vos, 2020; Musselwhite, Avineri, & Susilo, 2020; Pardo et al., 2021).

The use of individual motorised vehicles, although a safer option, maintains the same issues as before the pandemic and cannot be considered as a sustainable alternative due to noise, air pollution, congestion and accidents. Additionally, these modes of transport contribute to perpetuate social inequalities in the urban environment (Davison & Knowles, 2006). Therefore, it is necessary to provide high quality and safe public transport, regarding the propagation of SARS-CoV-2 and possible new pandemic scenarios. For these reasons, during the pandemic, smart measures and technologies have been adopted to improve virus containment strategies (Söderström, 2020).

Following the above-mentioned context, the present article aimed to encourage and foster the sociotechnical study of control mechanisms, since the technologies addressed are not commonly present in the Brazilian capitals, but represent a global trend of surveillance technologies, with an imperative and universal modulator nature. Hence, the proposed study sought to analyse the perception that public transport had during the pandemic and what are the perspectives and challenges for the post-pandemic, as well as the perception about smart measures and technologies and their potential use to enable a ubiquitous pandemic vectors containment. In this sense, the contributions of the present article are: (1) analysis of the impacts of COVID-19 in Brazilian capitals' modal splits, composing the set of worldwide studies with a Global South perspective, (2) perception of public transport systems in Brazil in the pandemic context, (3) analysis of Brazilians' expectations regarding mobility in a post-pandemic scenario, (4) perception of surveillance technologies, related to smart cities initiatives, in Brazilian capitals, (5) perception of data privacy and protection, and (6) relation between health safety perception and data privacy concerns.

The remainder of the article is organised as follows. The next section presents the methodology, highlighting the data collected from questionnaires and the statistical tests performed. The section after describes the background review, addressing the context of public transport during the pandemic, measures against the pandemic in the public transport, smart city conceptualisation, narratives and modes of existence, and questionnaire results, followed by discussions and conclusions.

Material and methods

The first stage of the methodology consisted of a review of the impacts on urban mobility patterns, especially on public transport systems, due to the COVID-19 pandemic. Topics covered include modal split changes, traditional and smart measures adopted to contain the spread of the new coronavirus and post-pandemic perspectives. The next stage is composed of a survey on Brazilian capitals about commuting and public transport perception. Data collection occurred from January 18, 2021 to April 06, 2021, through a questionnaire available on Google Forms and distributed on social media and email lists. The questionnaire had five parts: (1) demographics; (2) commuting before and during the COVID-19 pandemic; (3) public transport perception during the COVID-19 pandemic; (4) commuting and public transport perception after the COVID-19 pandemic; and (5) safety perception related to traditional and smart measures on public transport. For this questionnaire, it was also considered three scenarios: before, during and after the COVID-19 pandemic.

In the first part, individuals provided demographic information such as gender, age, ethnicity, education level, employment status, city of residence, and if they had received Emergency Aid[1].

The second part had questions related to mode choice before and during the COVID-19 pandemic. From this part, individuals were addressed to the next parts according to their responses for mode choice. Thus, individuals who answered that commuted by public transport (bus, train or metro) during the COVID-19 pandemic were addressed to part three before answering the questions of part four, while the individuals who commuted by other modes were directly addressed to part four.

In the third part, the individuals answered questions related to which measures were adopted to contain the virus dissemination and their safety perception using bus, train or metro during the pandemic. In the fourth part, the individuals were enquired about how they intended to commute after the pandemic. To answer the fourth part, a post-pandemic scenario was described as: population receives one of the available vaccines against the SARS-CoV-2 and the incidence of COVID-19 decreases, but it is still necessary to adopt sanitary measures such as the mandatory use of masks, social distancing to contain the crowds and constant sanitisation.

The last part comprised safety perception about the use of traditional and smart measures on public transport. It was used Likert type scale to enquire how safe the individuals felt about a given measure and presented traditional and smart initiatives adopted to face the spread of the SARS-CoV-2, admitted only those recommended by the World Health Organization (WHO) or contained in published academic articles. In addition, a question about data privacy and safety was also presented. Figure1 presents a flowchart of the questionnaire and the path respondents were addressed according to their answers to the question of commuting mode during the pandemic.

[1] Emergency Aid was a monetary assistance provided by the Brazilian Government due to the pandemic.

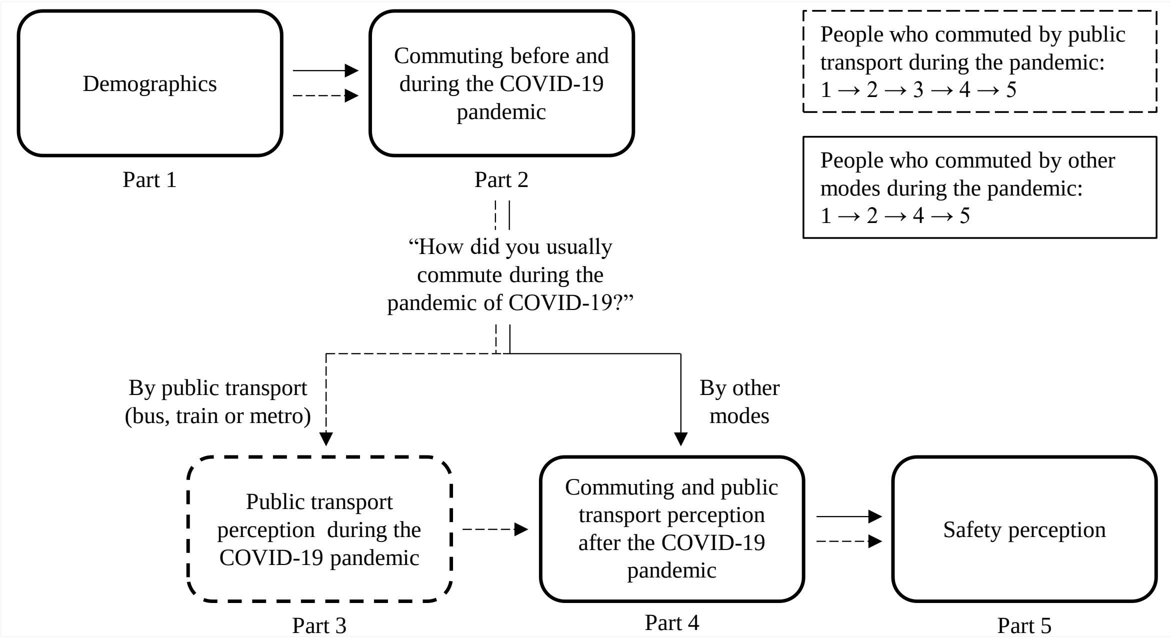

Figure 1. Flowchart of the questionnaire.

Sample size was calculated for simple random sampling using Equation (1) and Equation (2) (Oliveira & Grácio, 2005):

$$n_0 = \frac{1}{E_0^2} \quad (1)$$

$$n = \frac{N * n_0}{N + n_0} \quad (2)$$

where n_0 is the first approximation of the sample size; E_0 is the tolerable sampling error; n is the sample size and N is the population size. It is important to mention that was considered a confidence level of 95% and a tolerable sampling error of 5%, being necessary at least 400 responses.

Descriptive and statistical analyses were conducted on the collected data. Chi-square test was applied to changes in modal split in the three scenarios, such as also performed by Abdullah, Dias, Muley, and Shahin (2020) and Anke, Francke, Schaefer, and Petzoldt (2021). After verifying internal consistency of the Likert type scales through Cronbach alpha (Cronbach, 1951), the Kruskal–Wallis test was used to compare the answers of measure's perception according to mode choice before, during and after the pandemic. Variables that showed a significant difference in Kruskal–Wallis test were further investigated through Dunn's test, used in this study as a post-hoc test; the Bonferroni correction was applied to reduce type I errors (Abdullah et al., 2020; Corder & Foreman, 2011). For all the statistical analyses, p-values lower than 0.05 ($p < 0.05$) were considered statistically significant. The analyses were performed within RStudio software, version 2022.7.1.554. The Chi-square and Kruskal–Wallis are R built-in functions, while Cronbach alpha test was performed through the "ltm" package and Dunn's test through "rstatix" package (RStudio, 2022).

Results and discussion

In this section, there was an effort to approximate an international perspective to the Brazilian reality regarding public transport and smart city concepts in the context of the SARS-CoV-2 pandemic. Besides that, the questionnaire results provided comprehensive insights into the changes in modal split and public transport commuters' perception of these systems during the pandemic, as well as analyses of safety perception regarding traditional and smart measures.

Public transport during the SARS-CoV-2 pandemic

Social distancing, as a crucial aspect of the COVID-19 containment effort, presented a challenge to urban mobility, in particular to public transport (De Vos, 2020; Musselwhite et al., 2020). Abdullah et al. (2020) in a worldwide research found an overall reduction in mobility with shorter travel times, with similar results presented by Aloi et al. (2020), Bucsky (2020) and De Haas, Faber, and Hamersma (2020).

However, this reduction did not occur equally among all modes of transport. Abdullah et al. (2020) showed that the public transport modal share decreased and private motorised and non-motorised modes increased, with a contraction of 36 to 13% for public transport, and an increase of 32 to 39% for private cars, and by 8 to 15% for walking. Aloi et al. (2020) found a significant increase in car use (from 48 to 77%) during the pandemic in Santander, Spain. On the other hand, public transport and walking decreased from 8 to 2% and 42 to 19%, respectively. Bucsky (2020) verified a reduction from 43 to 18% in the use of public transport in Budapest, Hungary. Moreover, the car usage in the modal share increased by 22%, while the use of bicycle increased by 2%.

The process of public transport losing passengers drastically increased during the pandemic in Brazilian capitals, although it did not start in the pandemic. The reduction on bus demand reached 80% in March 2020 and, even with flexibilization in social isolation in the following months, there was still a reduction of approximately 40% since November 2020 (NTU, 2021). In the rail systems, at the end of 2020, there was a reduction in demand of 46.7%, reaching a total yearly loss of 1.6 billion passengers (ANPTrilhos, 2021). Since, in most Brazilian capitals, public transport is financed by charging fares, in 2020 there was a sharp drop in revenue, being BRL 11.8 billion for buses and BRL 8 billion for rail systems (ANPTrilhos, 2021; NTU, 2021).

Measures against the pandemic on public transport

The emergency of the pandemic caused a response in the operation of transport services worldwide. However, despite the need to adapt to the pandemic, it was clear the importance of public transport to ensure access and continuity of basic services. Several agencies claimed that, once adopted sanitary measures, these systems could be safe (UITP, 2020). Pardo et al. (2021) argued that it is possible to reduce contagion risk in a public transport vehicle considering five factors: (1) user behaviour - people should stay in silence, with masks adjusted properly and with eye protection during all trips; (2) type of ventilation system - frequent air renewal reduces probability of contagion; (3) distance between people; (4) duration of the trip - short trips generate less exposure; and (5) frequent cleaning of surfaces. Benita (2021) also presented among several others: (1) providing information on congestion inside public transport platforms or vehicles to potential users; and (2) association of transit and land use policies, such as different opening hours to distribute the demand for public transport.

In Brazil, the National Association of Urban Transport Companies (NTU, 2021) pointed out that the most used measures on buses were nebulisation disinfection, end of fare payment in cash, social distance signalling, limitation of number of passengers, tunnels for body disinfection and body temperature measurements. According to the National Association of Passenger Railway Carriers (ANPTrilhos, 2021), in rail systems there were the cleaning of stations and trains, adoption of sanitation technologies (spraying of disinfectant products, the use of ultraviolet-based equipment and temperature measurement through cameras), passenger orientation campaigns, installation of specific visual communication to indicate physical distancing, supply of trains at levels above demand and training of employees to serve the public in the face of the pandemic.

Concomitantly, smart measures and technologies have been used to improve the containment actions of the virus spread and contamination (Benita, 2021; Chang, 2021). The use of traditional and smart measures is more effective, as shown in Budd and Ison (2020), Chen and Pan (2020), Lyons (2020), Nam (2020) and Söderström (2020). Among the smart measures and technologies, it can be highlighted the following: (1) smart security cameras providing detection or not of the use of masks on public transport vehicles and at their stations (Rahman, Manik, Islam, Mahmud, & Kim, 2020); (2) tracking of COVID-19 patients to create a map of contamination risk zones and to identify potentially contaminated people (Chang, 2021; Das & Zhang, 2020; Silva et al., 2021; Sonn & Lee, 2020); and (3) classification system of exposure level (via mobile phone or transport card) to automatically prevent individuals from using public transport services (Chen & Pan, 2020).

Despite the significant contribution that can be obtained through the use of smart measures and technologies on public transport systems, the Brazilian capitals, until this research was carried out, have failed to effectively implement such technologies (ANPTrilhos, 2021; NTU, 2021).

Smart narratives and post-pandemic perspectives on public transport

In a scenario where multiple smart city definitions exist and are simultaneously promoted, and actively implemented in urban realities, the adopted definition in this study needs to be clearly defined, as the struggles for this definition is a conflict between diverse technopolitical agendas (McFarlane & Söderström, 2017; Reia & Cruz, 2021). Beforehand, let's move away the smart cities concepts or characteristics this study does not adhere to, leaving the subsequent definition clearer. The smart city must not be a refurbished and high-tech urban entrepreneurial enterprise that deepen social and economic exploitation (Hollands, 2008, 2015); it must not be an enhancement of a specific territory marketability above others through empty labelling (Theodore, Peck, & Brenner, 2011; Wiig, 2015a, 2015b); nor should it be a hegemonic agenda that suffocates and undermines communities and localities' needs, culture or urban experience to promote a more digitally embedded urbanity without any regard for the particularities of where it is implemented and enforced (Grossi & Pianezzi, 2017; Hollands, 2008; Hollands, 2015; Krüger & Pellicer-Sifres, 2020; Wiig, 2015a, 2015b). Finally, what the smart city should be? A technopolitical agenda, that applies technology to solve communities and localities' real issues, it must represent a conjunction of initiatives, strategies and measures to promote a social and structural change, achieving better quality of life, economic and social equity while respecting the particularities of each urban environment (Grossi & Pianezzi, 2017; Hollands, 2008; McFarlane & Söderström, 2017; Reia & Cruz, 2021).

Thus, the term "smart technologies" refers to all of IoT (Internet of Things) and ICT (Information Communication Technology) devices and systems that aim for a ubiquitous digital integration of people, spaces and environments (virtual and physical). As for the term "smart measures" it corresponds to the institutional (public and private) and organised implementation, use, regulation and management of smart technologies. Therefore, the unified term "smart measures and technologies" encompasses both definitions. The choice of these terms was to differentiate them from "technology measures" (Florida, 2005; 2010; 2014). The inclusion of the "smart" adjective links these measures and technologies to the smart city concepts, development strategies, policies and technopolitical agendas, dispelling the depoliticised notion of purely technical and impartial implementation of ICT and IoT tech-driven urban initiatives.

Hence, this study understands that innovations should not be hollowed, i.e., that they do not result in the aggravation of inequalities and gentrification but have a meaningful positive and equitable impact on society (Grossi & Pianezzi, 2017; Hollands, 2015). Also, it does not adhere to initiatives and technologies that foment a creative class (Florida, 2005; 2010; 2014) that reap and harvest the benefits of high-tech urban interventions while relegating to the underdeveloped urban spaces the "uncreative", those with less human capital that cannot contribute to the smart city. Nor endorses exonovation (Krüger & Pellicer-Sifres, 2020) or creative destruction (Harvey, 2006) practises that are inconsequential to urban and economic reality. Thus, the smart label should not be an instrument to shroud underlying city changes that deepen social division and inequalities (Grossi & Pianezzi, 2017; Hollands, 2008).

Regarding this study, to better understand the impacts of the COVID-19 pandemic to public transport policies, especially those regarding surveillance technologies, there is a need to understand how these technologies come to fruition within a city transport system. As mobility plays a key role in social exclusion and inclusion, such technologies and policies may indeed decrease social exclusion for a percentage of the population, albeit not changing or increasing it for another part (Chang, 2021; Giannotti et al., 2021; Hendl, Chung, & Wild, 2020; Kenyon, Rafferty, & Lyons, 2003; Ranisch et al., 2020). The differences in the social realities of the Global South and the Global North change the nature of the smart cities' strategies and initiatives, as shown by de-colonial studies, and empirical analysis from India, South Africa and Singapore (Das & Zhang, 2020; Datta, Aditi, Ghoshal, Thomas, & Mishra, 2021; Odendaal, 2020; Söderström, 2020). Although with distinct realities, all present existing smart city (and quasi) experiences that serve as a parameter to dwell upon when researching technology-based initiatives in Brazil.

Söderström (2020) classified the smart city into three modes of existence: (1) state-led strategies of urban development, (2) the platform urbanism, i.e., corporate-led, and (3) citizen-driven or civil society-led. State-led strategies of urban development may present more comprehensive social inclusion aspects, as for citizen-driven society-led initiatives. In opposition to those, a corporate-led initiative or a platform urbanism, for its own nature, may contribute to aggravating social exclusion and therefore inequalities, especially in a Global South context (Giannotti et al., 2021; McFarlane & Söderström, 2017; Söderström & Mermet, 2020). However, the dominance of the corporate-led smart city is not an impediment for the existence of different modes and initiatives, but to disregard this mode prevalence is a riddance of all obstacles and forces that can promote a real struggle for more socially conscious smart development and initiatives (Hollands, 2008; Söderström, 2020).

The public sector has regained unexpected power and trust through the loss of significance of privacy as a human right for surveillance, control and decision-making processes during the pandemic. This may change afterwards, but citizens will be more inclined to accept urban digitalisation processes, thus enabling an acceleration of smart urban development (Brem, Viardot, & Nylund, 2021; Echegaray, 2021; Kunzmann, 2020). These affirmations are reasonable to where the State and governments took control of the pandemic. However, this is not the case for Brazil, where reigned an estate of political disarray resolving in a distrust towards government officials and policies (Datafolha, 2021).

Kunzmann (2020) predicted that car mobility may overrun and undermine the efforts to more sustainable mobility policies with public transport and individual non-motorised modes at the centre. Works published by Abdullah et al. (2020), Aloi et al. (2020) and Bucsky (2020) corroborate with this assertion, showing a decrease of public transport and private cars increase during the pandemic. As Ceder (2020) argued, the future of urban mobility must be through public transport, since individual motorised modes are not sustainable, especially private cars. Platform-based transport systems, i.e., ride-sourcing services provided by transportation network companies, do not address sustainability issues solved by public transport and can be directly responsible for public transport demand decrease (Beojone & Geroliminis, 2021; Ngo, Götschi, & Clark, 2021; Oviedo, Granada, & Perez-Jaramillo, 2020). Public transport users appreciate the value of time, fare and convenience. Therefore, such transportation modes need to lure and captivate customers by the use of innovative planning, operational strategies and seamless integration that render public transport system as a more attractive and viable option (Ceder, 2020). This fact can also be considered to a post-pandemic scenario, since traditional and smart measures must appeal to commuters and pass an overall sense of safety.

Following a trend of smart urban development acceptance, digital-driven social interactions, creative industries, culture and city-centric modes of development that already exist may adapt to this post-pandemic reality. Therefore, companies and States will seek to boost revenue and to employ technologies, initiatives and policies to make cities smarter (Kunzmann, 2020). This implies a deepening of the datafication and digitalisation of society, economy and culture, an increase in disparity and socioeconomic inequality between central and peripheral countries, as well as within countries themselves (Chang, 2021). It is worth mentioning that several authors claimed these technologies could be a way to enable an economic recovery, as occurred after the 2008 crisis (Florida, 2010; Grossi & Pianezzi, 2017; Hollands, 2008; Hollands, 2015; Wiig, 2015a, 2015b), as it may be the case of the post-pandemic economic reality (Brem et al., 2021). In this sense, it can be noticed a convergence between smart policies for economic recovery and the still incipient Brazilian laws and regulations regarding data protection and privacy (Brasil, 2018, 2020a, 2020b; Reia & Cruz, 2021), because the lack of control and safeguard over citizens and city data raises issues regarding the vulnerability of, among other aspects, platform-based transport systems (Acheampong, 2021; Brem et al., 2021; Chang, 2021; Oviedo et al., 2020; Ranisch et al., 2020).

State-led urban development strategies with social participation and citizen-led initiatives are, therefore, essential to enable more sustainable public transport modes to reverse demand loss. Another issue regarding tech-driven initiates must be accounted for: one in four Brazilians do not use the internet, representing a total of 47 million people; and within low-income classes, only 50% of household have internet access (CETIC.BR, 2020). Thus, tech-driven initiatives may represent a barrier and an aggravating factor for an already inequality impaired mobility (Chang, 2021).

For these reasons, any smart technology applied to public transport systems in the Brazilian near future, as well as in other Global South countries, need not only to take heed of the pre-pandemic tendencies (e.g., demand decrease, individual motorised modes prevalence, inadequate infrastructures, overcrowded vehicles and others), but to account for a way to improve the attractiveness of public transportation modes to the users, while preventing inequalities, data protection vulnerabilities and revenue boosting policies and initiatives.

Questionnaire results

In the subsequent topics, the data obtained from the questionnaire are presented and commented in the following order: (1) data characterisation; (2) impacts of COVID-19 pandemic in overall commuting behaviour; (3) public transport perception during the pandemic; and (4) safety perception of public transport.

Data characterisation

From January 18, 2021 to April 06, 2021, a total of 641 answers were collected, exceeding the minimum of 400 answers to obtain a confidence level of 95% and tolerable sampling error of 5%. Since Brazil is a country of continental dimensions, it is difficult to carry out research on a national level. However, an effort was made in this study to ensure that the regional representation of the responses followed the population distribution pattern of the five regions (Central West, North, Northeast, South and Southeast), as presented in Table 1. The cities with the highest number of answers within each region were Brasília (28; Central West), Palmas (29; North), Recife (47; Northeast), Curitiba (45; South), and São Paulo (129; Southeast). On the other hand, no answers were obtained in the city of Cuiabá (Mato Grosso State), located in the Central West region.

Table 1. Distribution of the sample per Brazilian region.

Region	Capitals' population (IBGE 2020)	% of resident population	Responses collected	% of responses collected
Central West	6,115,462	12.10%	59	9.20%
North	5,910,843	11.70%	83	12.95%
Northeast	12,602,080	24.94%	196	30.58%
South	3,945,704	7.81%	84	13.10%
Southeast	21,960,466	43.46%	219	34.17%
Total	50,534,555	100%	641	100%

The demographic information is provided in Table 2. All classifications referring to race and ethnicity were based on the definitions of the Brazilian Institute of Geography and Statistics (IBGE, 2019). Data was collected only from adults.

Table 2. Demographic information.

Items	Category	Frequency	Percentage
Gender	Female	399	62.25%
	Male	239	37.29%
	Prefer not to say	3	0.47%
Age	< 20	25	3.90%
	21-30	294	45.87%
	31-40	182	28.39%
	41-50	77	12.01%
	51-60	49	7.64%
	> 60	14	2.18%
Ethnicity	Asian[2] (Japanese, Chinese, Korean, etc.)	5	0.78%
	White	338	52.73%
	Indigenous / native Brazilians	5	0.78%
	Black	75	11.70%
	Pardo[3]	197	30.73%
	Prefer not to say	16	2.50%
	Other	4	0.62%
Education level	Undergraduate degree and below	199	31.05%
	Graduate degree (incomplete)	178	27.77%
	Graduate degree (concluded)	258	40.25%
	Other	6	0.9%
Employment	Student	235	36.66%
	Employed (informal, formal, self-employed, public)	360	56.16%
	Unemployed	25	3.90%
	Other occupation	21	3.28%
Emergency Aid	Yes	79	19.08%
	No	335	80.92%

Impacts of COVID-19 pandemic on overall commuting behaviour

In parts 2 and 4 of the questionnaire, it was presented three questions regarding mode choice, "How did you usually commute before the pandemic of COVID-19?", "How did you usually commute during the pandemic of COVID-19?" and "How do you intend to commute after the pandemic of COVID-19?". Figure 2 presents the modal split based on these questions. The applied Chi-square test showed that there was a significant difference between the modal split distribution in the three compared scenarios (Before/During: χ^2= 222.18, df = 7, p-value < 0.000; Before/After: χ^2 = 23.992, df = 7, *p*-value = 0.001143; During/After: χ^2= 154.13, df = 7, *p*-value < 0.000). As an overall analysis, there is a notable decrease of the public transport share and an increase of the use of private cars and ride-sourcing services.

Although walking showed an increase of 59% during the pandemic, in the post-pandemic (after) scenario it tends to remain relatively the same as before. The opposite happens in cycling, which did not show any significant changes during the pandemic, but showed an increase of 142% in the after-pandemic scenario. It is worth mentioning that Brazilian cities lack in cycling infrastructure and, even under these conditions, individuals revealed an intention to commute in this mode. Public transport lost 64% of participation on bus mode and 85% on trains and metros. There is an expectation of recovering participation on trains and metros

[2] In Brazil, IBGE classifies people of Asian descent as "yellow".
[3] Pardo is a Brazilian classification for mixed-race people with multiple descent.

after the pandemic, but for buses, participation recovery is only partial, since before the pandemic 43% of individuals commuted by this mode and only 34% intend to use it after. Private cars increased 41% of their participation during and 8% after the pandemic. Ride-sourcing services, which represented only 4% of the modal split before, showed the highest growth (442%) and represented 22% of the modal split during the pandemic. In the post-pandemic scenario, there was a reduction in ride-sourcing services share when compared to during the pandemic, but it is still 54% higher than before the pandemic.

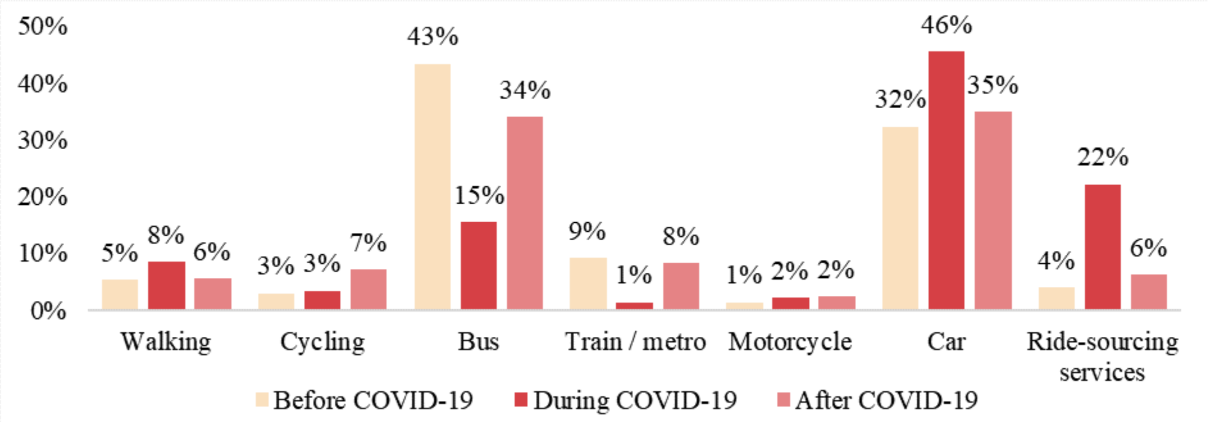

Figure 2. Modal split before, during and after (expected) the pandemic of COVID-19.

Analysing individuals who used only public transport before the pandemic (a total of 337 individuals), it can be noticed the behaviour presented in Figure 3. The applied Chi-square test showed that there was a significant difference between the modal split distribution during and after the pandemic ($\chi^2 = 171.32$, df = 7, p-value < 0.000). During the pandemic, a significant migration to private cars was observed, which held 23% of individuals, while the ride-sourcing services held 32% of them. Only 27% of individuals remained using bus and 2% using train or metro. Shifting to walking was the choice of 10% of this sub-sample. In the post-pandemic scenario, public transport is expected to partially recover its participation, with less significant shifts to private cars (10%), cycling (7%) and ride-sourcing services (6%).

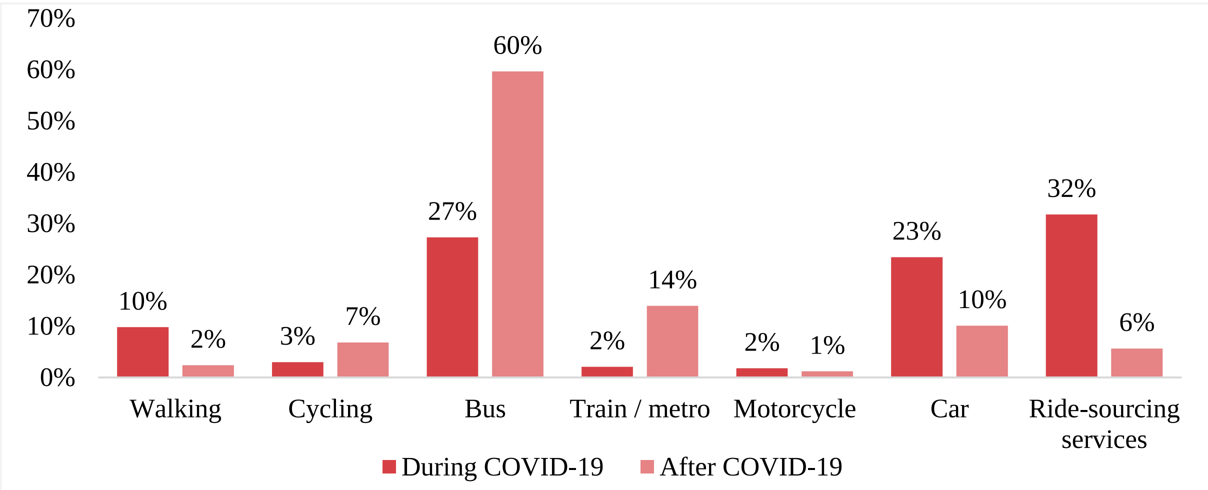

Figure 3. Modal split during and after (expected) the pandemic of COVID-19 for people who answered that used to commute by public transport before the pandemic.

Public transport perception during the pandemic

In the third part of the questionnaire, it was investigated the public transport perception during the pandemic. Only individuals that commuted by bus, train or metro answered the questions, resulting in a sample size of 108 individuals (16.8% of the dataset). Table 3 shows the main measures adopted on public transport to contain the SARS-CoV-2 dissemination. A list of implemented measures, based on the literature review shown in this study, was presented to the individuals that could select multiple answers. Mandatory use of masks at terminals, stations or stops and inside vehicles was the most frequent answer, followed by publicity of the necessary precautions to reduce the risk of infection. These measures represent individual solutions to contain the pandemic and, despite being important, they do not represent a systematic approach from operators. This affirmation is supported by lower numbers of answers of measures for which operators were responsible, such as installation of equipment with hand sanitizers, disinfection of vehicles, reducing the number of passengers per vehicle, journeys with seated passengers only, and increase of the fleet.

Table 3. Number of occurrences of answers to which measures were implemented on public transport.

Measure	Number of occurrences
Mandatory use of masks at terminals, stations or stops and inside vehicles	102
Publicity of the necessary precautions to reduce the risk of infection (posters with information on the form of infection, symptoms, distance from crowds)	74
Installation of equipment with hand sanitizers at terminals, stations or stops and inside the vehicles	45
Disinfection of vehicles	36
Establishment of safe distances in queues at terminals, stations or stops	28
Physical barriers (plastic curtains) at the workstations of drivers and fare collectors	13
Reducing the number of passengers per vehicle	12
Journeys with seated passengers only	8
End of fare payment in cash	7
Measurement of people's temperature at terminals, stations or stops and inside the vehicles	5
Increase of the fleet	4

Finally, the individuals were questioned regarding their perception about public transport on a Likert type scale. Cronbach's alpha coefficients were applied to the responses of this section to determine internal consistency. The value of Cronbach's alpha coefficient was 0.828, within the range of 0.8–0.9, ensuring good reliability (Nunnally, 1994). Figure 4 shows that 75.9% of individuals believed the implemented measures were not sufficient to contain SARS-CoV-2 spread, 57.4% believed that measures that should be implemented by companies were not complied with, 78.7% believed that measures were not properly monitored, and 85.2% affirmed that they did not feel safe on public transport during the pandemic. The fewer negative results were obtained to the questions about publicity of measures (38.9%) and individual measures being complied with (47.2%).

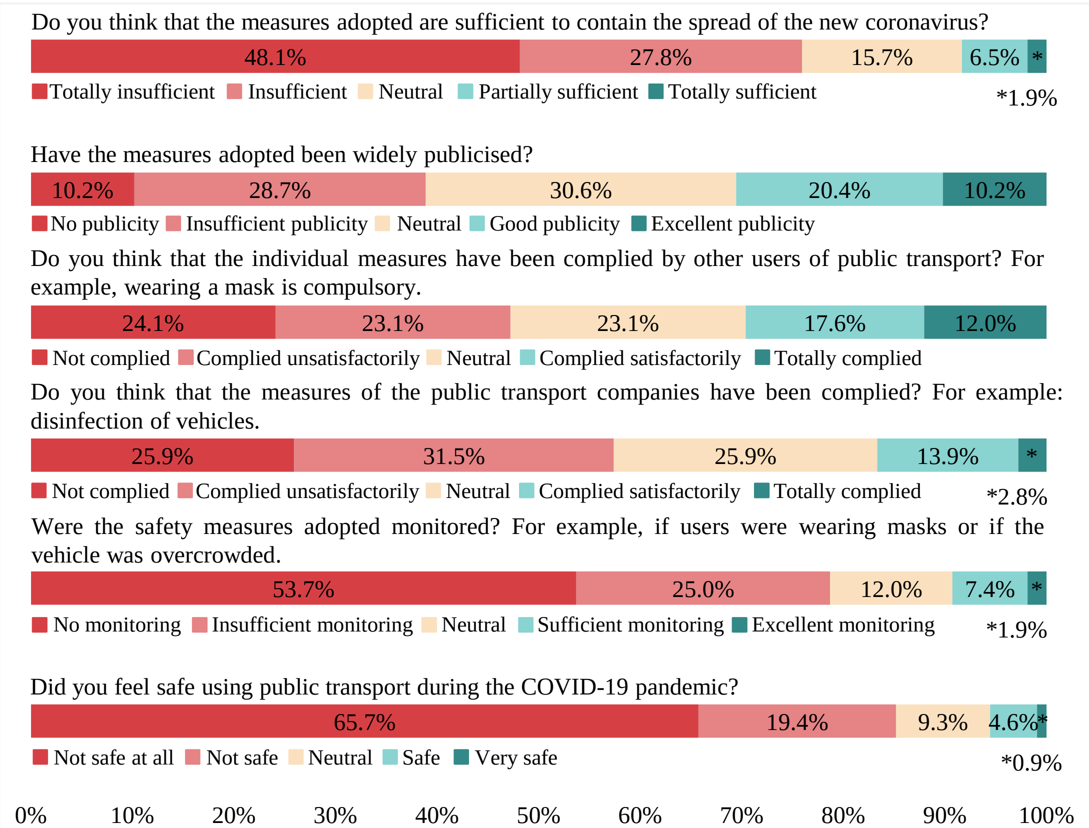

Figure 4. Safety perception of public transport users during the COVID-19 pandemic.

Safety perception of public transport

In this part of the questionnaire, it was firstly presented the following question: "How safe would you feel if the following measures were adopted on public transport in your city after the COVID-19 pandemic?". This question referred to the traditional measures. Again, the Cronbach's alpha coefficient was applied to the responses of this section's questions to determine internal consistency. It is readily observed in Figure 5 that monitoring of the security measures resulted in an overwhelming perception of safety, with 82.2% of individuals declaring it as very safe or safe, closely followed by disinfection of vehicles (with 81.4%) and the reduction of the number of passengers by vehicle (with 80.8%). On the negative side of the spectrum, fare payment in cash had the highest percentage, with 19.7%.

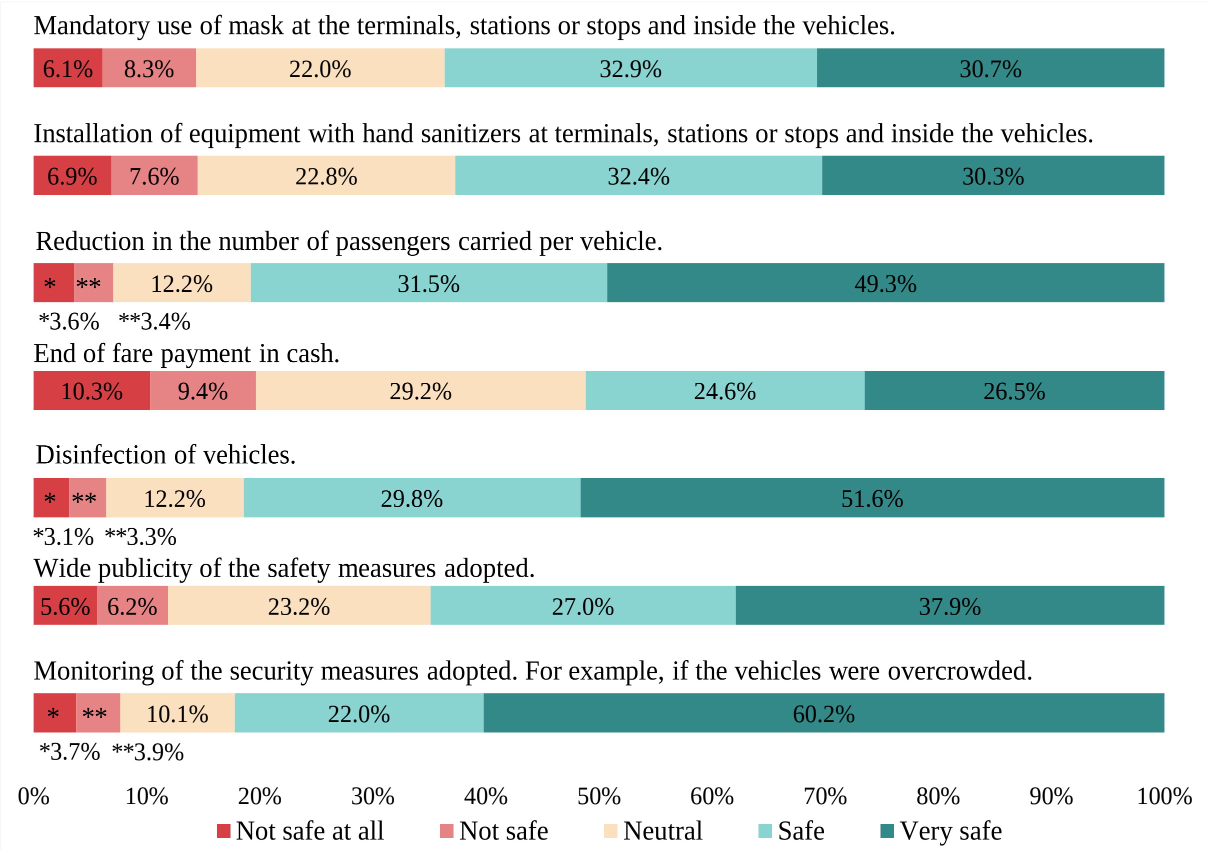

Figure 5. Safety perception of traditional measures on public transport to contain the spread of SARS-CoV-2.

The value of Cronbach's alpha coefficient was 0.901, within the range of $\alpha \geqslant 0.9$, ensuring excellent reliability (Nunnally, 1994). Kruskal–Wallis test results showed that the traditional measure "End of fare payment in cash" was the only one that had no significant difference according to mode choice in the three scenarios. During the pandemic, "Reduction in the number of passengers carried per vehicle" also had no significant difference. Other than that, all traditional measures had significant differences according to mode choice of before, during and after the pandemic. Further Dunn's tests performed on these variables showed that perception changed mainly between people who commuted by walking, ride-sourcing services, car and public transport. Detailed results of both Kruskal–Wallis and Dunn's tests are presented in Tables 4, 5, 6, 7 and 8.

After a detailed description of the smart measures and technologies previously presented in this article, other two questions were asked. As presented in Figure 6, the limitation of access to public transport according to exposure levels and risk classification was the measure which provided the greatest sense of safety, with 68% of positive responses. Security cameras to compel the use of masks appears with 65.3% and real-time mapping of people's movement with 64.7%. On the other hand, the one which gave the least sense of safety was the anonymous tracking of mobile phones for the creation of interaction maps, with 27% of negative responses, surpassing by 9.2% the classification of individuals according to different levels of exposure, the second with the least perception of safety. These results showed a greater sense of safety around smart measures and technologies that have a more systemic approach, i.e., those which do not merely provide an isolated action with no effective results but have a high social value. For example, what is the point of creating a map of interactions of COVID-19 patients or classifying individuals with different levels of risk and exposure if no practical, organised and systemic measures are being implemented?

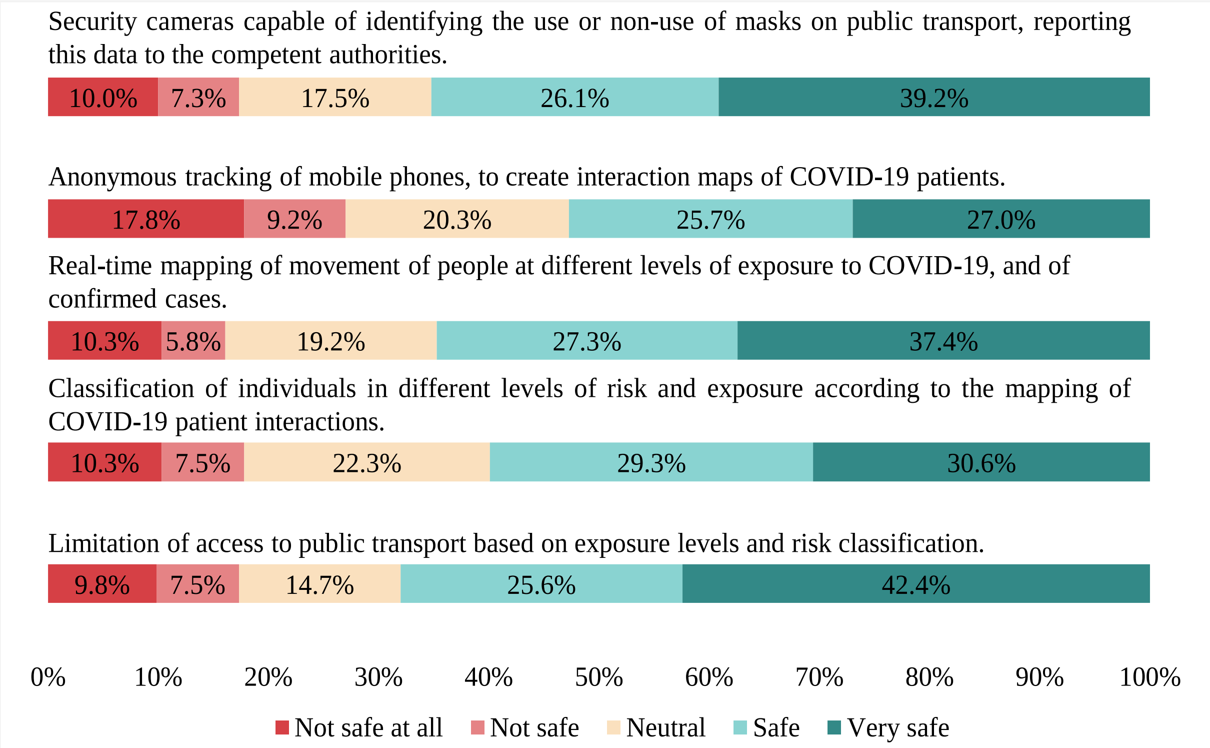

Figure 6. Safety perception of smart measures and technologies on public transport to contain the spread of SARS-CoV-2.

The value of Cronbach's alpha coefficient for this set of questions was 0.905, within the range of $\alpha \geqslant 0.9$, ensuring excellent reliability (Nunnally, 1994). Kruskal-Wallis test results showed that overall perception of smart measures and technologies did not have a significant difference according to mode choice. Only the measure "Classification of individuals in different levels of risk and exposure according to the mapping of COVID-19 patient interactions" had a significant difference according to mode choice in the scenarios before and after the pandemic. However, the further investigation through Dunn's test was inconclusive, as *p*-value was not significant in the post-hoc test.

At last, in Figure 7, the perception related to data security and privacy is presented. The anonymous tracking of mobile devices for the creation of COVID-19 patient interaction maps generated the greatest concern among all measures, with a total of 57.4% negative responses, of which 39% were very concerned. In addition, the real-time mapping received 50.5% of negative responses. The use of cameras to identify the use of masks had the lowest percentage of rejection, since 24.8% of individuals were not worried at all with this kind of measure. This corroborates with the findings of Grekousis and Liu (2021), that personal data privacy should not be violated for the collection of epidemiological information, and trustworthy legal frameworks are essential to higher population uptake of smart measures and technologies, thus ensuring their effectiveness.

The value of Cronbach's alpha coefficient for this set of questions was 0.910, within the range of $\alpha \geqslant 0.9$, ensuring excellent reliability (Nunnally, 1994). Kruskal-Wallis test results showed that overall perception of smart measures and technologies regarding data privacy did not have a significant difference according to mode choice. Only the measure "Security cameras capable of identifying the use or non-use of masks on public transport, reporting this data to the competent authorities" had a significant difference according to mode choice during the pandemic. Dunn's test results, however, were inconclusive, as *p*-value was not significant in the post-hoc test.

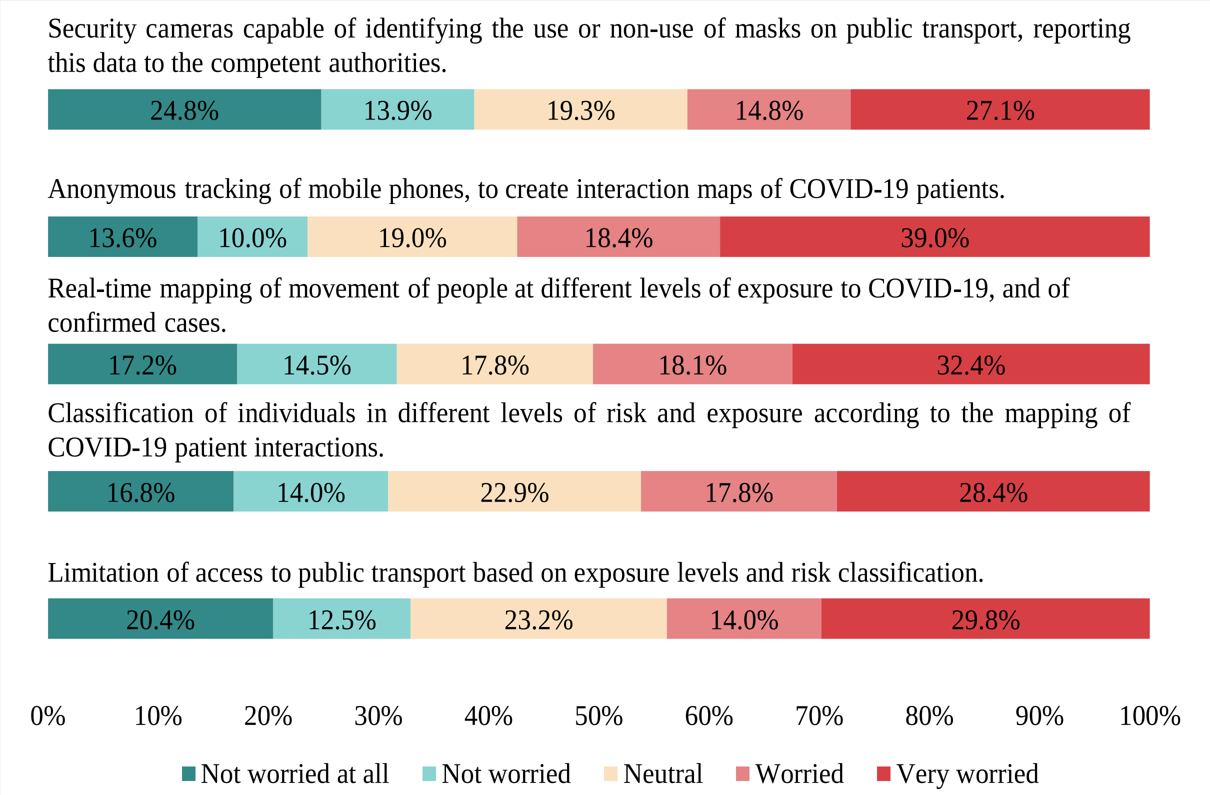

Figure 7. Safety perception of smart measures and technologies on public transport in relation to data privacy and safety.

Table 4. Kruskal-Wallis and Dunn's test results for all measures explained by commuting mode in the three analysed scenarios (before, during and after the pandemic).

Measure	Measure type	Explained by	Kruskal-Wallis test				Post-hoc (Dunn's test)
			Chi-squared	df	p-value	Decision*	
Mandatory use of mask at the terminals, stations or stops and inside the vehicles	Traditional	Commuting mode before the pandemic	16	6	0.010	Reject H_0	Not significant
Installation of equipment with hand sanitizers at terminals, stations or stops and inside the vehicles			13	6	0.040	Reject H_0	Not significant
Reduction in the number of passengers carried per vehicle			22	6	0.001	Reject H_0	Significant difference between car and public transport
End of fare payment in cash			8	6	0.300	Accept H_0	-
Disinfection of vehicles			22	6	0.001	Reject H_0	Significant difference between car and public transport
Wide publicity of the safety measures adopted			24	6	0.001	Reject H_0	Significant difference between ride-sourcing and walking and between car and walking
Monitoring of the security measures adopted. For example, if the vehicle was overcrowded			17	6	0.009	Reject H_0	Significant difference between car and public transport

Mandatory use of mask at the terminals, stations or stops and inside the vehicles	Traditional	Commuting mode during the pandemic	22	6	0.001	Reject H_0	Significant difference between car and public transport
Installation of equipment with hand sanitizers at terminals, stations or stops and inside the vehicles			15	6	0.020	Reject H_0	Not significant
Reduction in the number of passengers carried per vehicle			12	6	0.070	Accept H_0	-
End of fare payment in cash			8	6	0.200	Accept H_0	-
Disinfection of vehicles			13	6	0.040	Reject H_0	Not significant
Wide publicity of the safety measures adopted			16	6	0.020	Reject H_0	Significant difference between car and public transport
Monitoring of the security measures adopted. For example, if the vehicle was overcrowded			18	6	0.006	Reject H_0	Significant difference between ride-sourcing and car
Mandatory use of mask at the terminals, stations or stops and inside the vehicles	Traditional	Commuting mode after the pandemic (excepted)	28	6	$p < 0.000$	Reject H_0	Significant difference between car and public transport
Installation of equipment with hand sanitizers at terminals, stations or stops and inside the vehicles			29	6	$p < 0.000$	Reject H_0	Significant difference between car and walking and between car and public transport
Reduction in the number of passengers carried per vehicle			33	6	$p < 0.000$	Reject H_0	Significant difference between ride-sourcing and public transport and between car and public transport
End of fare payment in cash			11	6	0.090	Accept H_0	-
Disinfection of vehicles			33	6	$p < 0.000$	Reject H_0	Significant difference between car and public transport
Wide publicity of the safety measures adopted			37	6	$p < 0.000$	Reject H_0	Significant difference between car and walking and between car and public transport
Monitoring of the security measures adopted. For example, if the vehicle was overcrowded			31	6	$p < 0.000$	Reject H_0	Significant difference between car and walking and between car and public transport
Security cameras capable of identifying the use or non-use of masks on public transport, reporting this data	Smart (regarding risk of infection)	Commuting mode before the pandemic	9	6	0.200	Accept H_0	-

to the competent authorities							
Anonymous tracking of mobile phones, to create interaction maps of COVID-19 patients			6	6	0.400	Accept H_0	-
Real-time mapping of movement of people at different levels of exposure to COVID-19, and of confirmed cases			12	6	0.070	Accept H_0	-
Classification of individuals in different levels of risk and exposure according to the mapping of COVID-19 patient interactions			13	6	0.040	Reject H_0	Not significant
Limitation of access to public transport based on exposure levels and risk classification			10	6	0.100	Accept H_0	-
Security cameras capable of identifying the use or non-use of masks on public transport, reporting this data to the competent authorities			7	6	0.400	Accept H_0	-
Anonymous tracking of mobile phones, to create interaction maps of COVID-19 patients			4	6	0.700	Accept H_0	-
Real-time mapping of movement of people at different levels of exposure to COVID-19, and of confirmed cases	Smart (regarding risk of infection)	Commuting mode during the pandemic	8	6	0.300	Accept H_0	-
Classification of individuals in different levels of risk and exposure according to the mapping of COVID-19 patient interactions			10	6	0.100	Accept H_0	-
Limitation of access to public transport based on exposure levels and risk classification			5	6	0.500	Accept H_0	-
Security cameras capable of identifying the use or non-use of masks on public transport, reporting this data to the competent authorities	Smart (regarding risk of infection)	Commuting mode after the pandemic (excepted)	13	6	0.050	Accept H_0	-

Anonymous tracking of mobile phones, to create interaction maps of COVID-19 patients			9	6	0.200	Accept H_0	-
Real-time mapping of movement of people at different levels of exposure to COVID-19, and of confirmed cases			10	6	0.100	Accept H_0	-
Classification of individuals in different levels of risk and exposure according to the mapping of COVID-19 patient interactions			18	6	0.006	Reject H_0	Not significant
Limitation of access to public transport based on exposure levels and risk classification			9	6	0.200	Accept H_0	-
Security cameras capable of identifying the use or non-use of masks on public transport, reporting this data to the competent authorities			3	6	0.800	Accept H_0	-
Anonymous tracking of mobile phones, to create interaction maps of COVID-19 patients			1	6	1.000	Accept H_0	-
Real-time mapping of movement of people at different levels of exposure to COVID-19, and of confirmed cases.	Smart (regarding data privacy and protection)	Commuting mode before the pandemic	0.8	6	1.000	Accept H_0	-
Classification of individuals in different levels of risk and exposure according to the mapping of COVID-19 patient interactions			4	6	0.700	Accept H_0	-
Limitation of access to public transport based on exposure levels and risk classification			3	6	0.900	Accept H_0	-
Security cameras capable of identifying the use or non-use of masks on public transport, reporting this data to the competent authorities	Smart (regarding data privacy and protection)	Commuting mode during the pandemic	13	6	0.040	Reject H_0	Not significant
Anonymous tracking of mobile phones, to create interaction			11	6	0.090	Accept H_0	-

maps of COVID-19 patients							
Real-time mapping of movement of people at different levels of exposure to COVID-19, and of confirmed cases			10	6	0.100	Accept H_0	-
Classification of individuals in different levels of risk and exposure according to the mapping of COVID-19 patient interactions			10	6	0.100	Accept H_0	-
Limitation of access to public transport based on exposure levels and risk classification			7	6	0.300	Accept H_0	-
Security cameras capable of identifying the use or non-use of masks on public transport, reporting this data to the competent authorities	Smart (regarding data privacy and protection)	Commuting mode after the pandemic (excepted)	6	6	0.400	Accept H_0	-
Anonymous tracking of mobile phones, to create interaction maps of COVID-19 patients			5	6	0.500	Accept H_0	-
Real-time mapping of movement of people at different levels of exposure to COVID-19, and of confirmed cases			3	6	0.600	Accept H_0	-
Classification of individuals in different levels of risk and exposure according to the mapping of COVID-19 patient interactions			5	6	0.600	Accept H_0	-
Limitation of access to public transport based on exposure levels and risk classification			4	6	0.700	Accept H_0	-

Table 5. Dunn's test results for measures that had H_0 rejected in Kruskal-Wallis test (only variables with significant difference were included in the table).

Measure	Explained by	Group 1	Group 2	n1	n2	Statistic	*p*-value adjusted
Reduction in the number of passengers carried per vehicle	Travel mode before the pandemic	Car	Public transport	207	337	4.399	$p < 0.000$
Disinfection of vehicles	Travel mode before the pandemic	Car	Public transport	207	337	4.280	$p < 0.000$
Wide publicity of the safety measures adopted	Travel mode before the	Ride-sourcing	Walking	26	34	3.040	0.0497

	pandemic	services					
Monitoring of the security measures adopted. For example, if users were wearing masks or if the vehicle was overcrowded	Travel mode before the pandemic	Car	Walking	207	34	3.332	0.018
	Travel mode before the pandemic	Car	Public transport	207	337	3.437	0.012
Mandatory use of mask at the terminals, stations or stops and inside the vehicles	Travel mode during the pandemic	Car	Public transport	292	108	3.744	0.004
Wide publicity of the safety measures adopted	Travel mode during the pandemic	Car	Public transport	292	108	3.199	0.029
Monitoring of the security measures adopted. For example, if users were wearing masks or if the vehicle was overcrowded	Travel mode during the pandemic	Ride-sourcing services	Car	142	292	-3.300	0.0203
Mandatory use of mask at the terminals, stations or stops and inside the vehicles	Travel mode after the pandemic (excepted)	Car	Public transport	224	271	4.543	p < 0.000
Installation of equipment with hand sanitizers at terminals, stations or stops and inside the vehicles	Travel mode after the pandemic (excepted)	Car	Walking	224	36	3.255	0.024
	Travel mode after the pandemic (excepted)	Car	Public transport	224	271	4.437	p < 0.000
Reduction in the number of passengers carried per vehicle	Travel mode after the pandemic (excepted)	Ride-sourcing services	Public transport	40	271	3.390	0.015
	Travel mode after the pandemic (excepted)	Car	Public transport	224	271	5.046	p < 0.000
Disinfection of vehicles	Travel mode after the pandemic (excepted)	Car	Public transport	224	271	5.440	p < 0.000
Wide publicity of the safety measures adopted	Travel mode after the pandemic (excepted)	Car	Walking	224	36	3.768	0.003
	Travel mode after the pandemic (excepted)	Car	Public transport	224	271	4.867	p < 0.000
Monitoring of the security measures adopted. For example, if users were wearing masks or if the vehicle was overcrowded	Travel mode after the pandemic (excepted)	Car	Walking	224	36	3.247	0.024
	Travel mode after the pandemic (excepted)	Car	Public transport	224	271	4.944	p < 0.000

Table 6. Safety perception of measures with significant difference in Dunn's test (according to commuting mode of before the pandemic).

Measure	Commuting mode before the pandemic	Not safe at all	Not safe	Neutral	Safe	Very safe
Reduction in the number of passengers carried per vehicle	Car	4.3%	4.3%	14.5%	40.1%	36.7%
	Public Transport	3.0%	3.0%	9.2%	27.6%	57.3%

Disinfection of vehicles	Car	3.4%	5.3%	15.0%	36.2%	40.1%
	Public Transport	2.1%	2.1%	9.5%	27.9%	58.5%
Wide publicity of the safety measures adopted	Car	7.2%	8.7%	21.7%	33.3%	29.0%
	Ride-sourcing services	3.8%	3.8%	42.3%	30.8%	19.2%
	Walking	5.9%	0.0%	8.8%	26.5%	58.8%
Monitoring of the security measures adopted. For example, if users were wearing masks or if the vehicle was overcrowded.	Car	3.9%	7.2%	11.6%	25.6%	51.7%
	Public Transport	3.0%	1.8%	8.6%	21.1%	65.6%

Table 7. Safety perception of measures with significant difference in Dunn's test (according to commuting mode of during the pandemic).

Measure	Commuting mode during the pandemic	Not safe at all	Not safe	Neutral	Safe	Very safe
Mandatory use of mask at the terminals, stations or stops and inside the vehicles	Car	6.5%	11.6%	22.6%	34.2%	25.0%
	Public Transport	2.8%	0.9%	19.4%	38.0%	38.9%
Wide publicity of the safety measures adopted	Car	7.2%	8.9%	23.3%	30.1%	30.5%
	Public Transport	1.9%	5.6%	20.4%	25.0%	47.2%
Monitoring of the security measures adopted. For example, if users were wearing masks or if the vehicle was overcrowded.	Car	2.7%	6.8%	12.0%	26.4%	52.1%
	Ride-sourcing services	4.2%	0.7%	8.5%	17.6%	69.0%

Table 8. Safety perception of measures with significant difference in Dunn's test (according to commuting mode of after the pandemic (expected))

Measure	Commuting mode after the pandemic (expected)	Not safe at all	Not safe	Neutral	Safe	Very safe
Mandatory use of mask at the terminals, stations or stops and inside the vehicles	Car	8.0%	12.5%	24.6%	31.7%	23.2%
	Public Transport	3.0%	4.4%	20.7%	35.1%	36.9%
Installation of equipment with hand sanitizers at terminals, stations or stops and inside the vehicles	Car	8.9%	10.7%	25.9%	32.6%	21.9%
	Public Transport	3.3%	4.8%	20.3%	36.2%	35.4%
	Walking	5.6%	2.8%	11.1%	36.1%	44.4%
Reduction in the number of passengers carried per vehicle	Car	4.0%	4.9%	14.3%	39.7%	37.1%
	Public Transport	3.3%	2.6%	8.5%	24.0%	61.6%
	Ride-sourcing services	0.0%	7.5%	27.5%	30.0%	35.0%
Disinfection of vehicles	Car	3.1%	6.3%	15.2%	36.2%	39.3%
	Public Transport	1.5%	1.8%	9.6%	23.2%	63.8%
Wide publicity of the safety measures adopted	Car	7.6%	8.9%	25.4%	31.7%	26.3%
	Public Transport	2.6%	4.8%	20.3%	24.7%	47.6%
	Walking	5.6%	0.0%	13.9%	19.4%	61.1%
Monitoring of the security measures adopted. For example, if users were wearing masks or if the vehicle was overcrowded.	Car	3.6%	7.1%	13.4%	27.7%	48.2%
	Public Transport	3.3%	1.8%	7.0%	17.7%	70.1%
	Walking	5.6%	2.8%	0.0%	13.9%	77.8%

Discussions and policy implications

In countries where there is a deeper and more widespread smartification of the urban environment, laws, policies and measures provide the State greater power of data control and management, as well as sociocultural acceptance of surveillance initiatives (Chen & Pan, 2020; Das & Zhang, 2020; Kasdan & Campbell, 2020; Kim, 2020; Nam, 2020; Oh, 2020; Söderström, 2020; Sonn & Lee, 2020). Additionally, in these countries, traditional measures (such as the use of masks, isolation and social distancing, sanitisation of public places and others) are enforced and applied in conjunction to the smart measures and technologies, both embedded in a local, regional and national systems and policies (Budd & Ison, 2020; Chen & Pan, 2020; Gkiotsalitis & Cats, 2020; Sonn & Lee, 2020). It is also important to mention that robust smart city policies, previous experiences with epidemics, transparency of the adopted systems, an interventionist state culture (Sonn & Lee, 2020) and other aspects render the acceptance of surveillance technologies by the population somewhat easier (Kasdan & Campbell, 2020; Kim, 2020; Nam, 2020; Oh, 2020).

Although smart city policies and efforts towards greater ubiquity and digitalisation of the urban environment exist in Brazilian capitals, the density of such initiatives is far behind other countries, even those from the Global South[4]. Brazil also has negative points in other aspects that influence smart development strategies acceptance in the current global scenario, such as government transparency and accountability, publicity and wide integrated use of initiatives, incipient law and regulations for protecting the data use and privacy (Brasil, 2020a; Grekousis & Liu, 2021; Reia & Cruz, 2021; Silva & Fernandes, 2020). Laws on protection and regulation of data usage must constantly struggle with new and unprecedented forms of exploitation of the current data-centric format of neoliberalism (Anand, 2021; Arsel, Adaman, & Saad-Filho, 2021; Grossi & Pianezzi, 2017; McFarlane & Söderström, 2017; Reia & Cruz, 2021). In Brazil, as a Global South country in dependant political and economic relations with the Global North, this struggle is far more considerable (Giannotti et al., 2021; McFarlane & Söderström, 2017; Reia & Cruz, 2021; Söderström & Mermet, 2020). In this scenario, it was verified in literature a dominance of platform-based initiatives over the other modes of smart cities' existence (Grossi & Pianezzi, 2017; McFarlane & Söderström, 2017; Söderström, 2020); aligned with that, this study found that ride-sourcing services participation in modal split increased by 442% during the pandemic.

This highlights some aspects that the urban planner will have to deal with in relation to smart urban development in a post-pandemic scenario: (1) inclusion on the decision-making process regarding smart city policies and strategies, i.e., the implementation of smart measures and technologies; (2) anticipate negative aspects of such strategies; (3) take heed of other urban necessities and vulnerabilities of spatial, social, cultural, economic and political nature; (4) differences between the Global South and Global North must be accounted for, especially to urban planners in the South; and (5) carefully choose what mode of existence or strategy must prevail over others and consequences of such choice (Chang, 2021; Kunzmann, 2020; Reia & Cruz, 2021; Söderström, 2020).

Therefore, some considerations can be made relating to the Brazilian public transport in a post-pandemic scenario regarding the questionnaire results: (1) smart solutions, in the form of surveillance technologies, have effectiveness in preventing the society from pandemic vectors; (2) smart and traditional measures can be successfully used in an attempt to enhance safety perception regarding the use of public transport; (3) smart measures and technologies alone are not sufficient; (4) along with the use of smart measures, in the form of surveillance technologies, comes the need for a system composed of laws, institutions and mechanisms to protect personal data and privacy; and (5) the use of surveillance technologies without proper smart policy regulation and non-concomitance with health and traditional measures may only represent an unnecessary expense to the public coffers and have the opposite effect to the intended one, representing another reason to avoid public transport.

Public transport can be a safe place as stated by companies and agencies related to operators, once safety measures are adopted to contain the spread of the new coronavirus. In fact, the participants of this research reported significant percentages of safety perception if measures were implemented. However, this is not the perception of those who commuted by public transport during the pandemic, being expressed by the high percentages of negative perceptions regarding the measures adopted, mainly in terms of monitoring and the compliance of individual and companies' measures. High quality and safe public transport against the transmission of the new coronavirus remains the best alternative to mitigate the externalities of individual motorised modes, including to curb a possible increase in the number of trips by such in the post-pandemic period.

Surveillance technologies already exist and are extensively used, which does not mean that the struggle and arguments against them are not valid and do not deserve to be discussed. This study sheds light on some of the aspects of existing and future technologies, mainly in relation to public transport. Regulations and data protection initiatives must be expanded and enhanced to promote control and disposition over data to the citizens, specifically public transport passengers. Democratic, transparent and participatory control must be an essential element of future public policies and laws addressing these issues.

Conclusion

Some key point of this article must be emphasised: (1) during the pandemic public transport lost a significant percentage of passenger demand while travel by individual car (own or ride-sourced) increased significantly with an expectation of a post-pandemic modal split following the same pattern, (2) most

[4] The multiplicity of realities from different Brazilian capitals, of diverse regions and socio-economic realities is a fact that must not be undermined. However, even those that have an urban space more attractive and susceptible for smart initiatives to take place, or that have their own creative/smart city policies, measures and initiatives, are mostly behind in various ways to other Global South experiences due to international political and economic reasons and structures that transcend the scope of this study (Anand, 2021; Arsel, Adaman, & Saad-Filho, 2021; Giannotti et al., 2021; Krüger & Pellicer-Sifres, 2020; Reia & Cruz, 2021; Silva & Fernandes, 2020; Söderström, 2020; Theodore et al., 2011).

measures implemented during the pandemic resumes to traditional individual ones, without a systemic approach or smart initiatives, (3) about smart measures, there is a high safety perception contrasted with a low security perception over data use and privacy, and (4) systemic regulated sanitary measures (traditional and smart) enhance safety perception of public transport.

Acknowledgements

This study was financed in part by the *Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil* (CAPES) – Finance Code 001. The authors would like to thank CAPES and the Federal University of São Carlos (UFSCar), Brazil, for the facilities, as well as the financial support provided; all people who answered the questionnaire; the anonymous reviewers for their valuable comments that greatly contributed to improving the final version of the paper; and Maria Dolores Dalpasquale for revising the manuscript and for providing language assistance. And last but not least, this study is dedicated to all of those who lost their lives to this pandemic, their relatives, friends and close ones.

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