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A brief study of public transportation and sustainable cities management during COVID-19 pandemic

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SUMMARY

This paper aims to analyse the measures adopted in Brazilian State Capitals and the Federal District, since the beginning of the pandemic, to ensure safety conditions in public transport against the possible contagion of COVID-19, suggesting sustainable actions aligned to SDG 11 - Sustainable Cities and Communities for the post-COVID future. Based on relevant data from March to July 2020, acquired from journals, newspapers, and municipal and governmental decrees, it was possible to identify measures adopted for public transportation during the first COVID-19 wave in Brazil. The results demonstrate that it is necessary to create a strategy and map the extent of population mobility in public transport. These information is essential for predicting risk areas, making decisions, and establishing effective control mechanisms. Innovative and sustainable urban mobility requires clear policies and cooperation between public authorities and private transportation companies and investment in public roads and infrastructure and sustainable actions aligned with SDG 11 - Sustainable Cities and Communities for the post-COVID future.

KEYWORDS: Public Transportation. Urban Mobility. Urban Management.

1 INTRODUCTION

The emergence of a new strain of coronavirus in 2019 in Wuhan (China) changed the world. As the virus spread around countries, crossing borders and affecting different populations, the virus had become another critical factor for urban public transportation management (Morawska et al., 2020). Thus, representing a considerable challenge in managing large cities and ensuring urban mobility (Sohrabi et al., 2020). Due to agglomeration and overcrowding, there is a potential risk of contamination and virus dissemination in public transportation, especially in large cities (Ghosh et al., 2020).

Van Wee & Ettema (2016) argue that public transportation leaves people more exposed to health incidents and uncertainties. Thus, it is undeniable to see that pandemics severely impact transportation and human mobility, considering the immediate effects of lockdowns, social distancing rules, home isolation, and total or partial suspension of transportation services (Hasselwander et al., 2021). These measures are necessary because closed and crowded environments can increase the risk of COVID-19 transmission (Mesgarpour et al., 2021).

When analysing the spread of the virus, it is evident how it grew strength in China during the Spring Festival, where thousands of people travelled, contributing to the outbreak going beyond Chinese borders (LI et al., 2020). In addition, China's megacity's public transportation infrastructure facilitated the disease spread through long-distance buses, subways, express railroads, and air transport (Ratcliffe, 2020). In this period, public transportation experienced a significant drop in passenger numbers to avoid social contact and mitigate the impacts of the pandemic (Shakibaei et al., 2021). However, many reasons drive people to use public transportation, even during public health crises. Means of transportation are chosen because of the utility they provide for performing activities at the destination that cannot be avoided (Souche-Le Corvec & Zhao, 2020).

Against a backdrop of so many uncertainties, the COVID-19 pandemic calls into question the ability of cities, especially large ones, to ensure proper management and sustainability, i.e., to implement the 2030 Agenda and the Sustainable Development Goals (SDGs) by 2030 (ONU, 2015). The SDG 11 - Sustainable Cities and Communities is specifically

concerned with making cities and human settlements inclusive, safe, resilient, and sustainable, stands out in this matter (ONU, 2015). This SDG consists of seven goals. Among these, 11.2 aims to provide access to safe, accessible, sustainable, and affordable transport systems for all by improving road safety through the expansion of public transport, with particular attention to the needs of people in vulnerable situations, women, children, people with disabilities and the elderly by 2030. To be implemented efficiently, it is essential to promote effective action in urban public management. This includes proper management of cities and transport to ensure that users can feel safe and healthy, providing access for all, including the socially and financially vulnerable, and ensuring balance with the environment (Souza & Soares, 2017; UN, 2015). Since the SDGs are interconnected, meeting one contributes to the implementation and positive outcomes of the other SDGs.

According to Wang et al. (2019) the extent of population mobility constitutes essential information for predicting risk areas and decision-making to establish control measures, especially when it comes to transport modes and city management. The central objective of strategic planning of public transport should be to ensure an adequate, comfortable, integrated, safe, efficient, accessible, and affordable transport system and correlating socioeconomic development policy guidelines to achieve urban environmental sustainability (PINHEIRO; FARIAS, 2018). Therefore, Hasselwander et al. (2021) e Squaiella; Righi; Marchelli (2018) reinforce that creating policies supporting evidence-based technologies is necessary to ensure that transportation systems are resilient to future pandemic outbreaks and manage to remain sustainable, especially in large cities. Moreover, Nicotra et al. (2020) point out that when social distancing measures are introduced in public transportation for the same number of passengers, i.e., when there is no lockdown, the capacity of buses, trains, and subways needs to increase and not decrease as adopted by many countries and also by Brazilian states. Hence, public transportation is important and fundamental for locomotion, especially for low-income populations in larger cities like capitals (NICOTRA et al., 2020).

Therefore, this paper aims to analyse the measures adopted by urban management to improve safety conditions in public transport in Brazilian State

Brazilian State Capitals and the Federal District against the possible contagion of COVID-19 and suggest actions aligned to SDG 11 to support the management of cities. After this introduction, the paper is structured in five additional sections. Section 2 presents this research's theoretical concepts. Section 3 presents the research method. Section 4 presents the results. Section 5 presents the discussion and suggestions for sustainable mobility actions and finally the Section 5 outlines this study's final considerations.

2 PUBLIC TRANSPORTATION WORLDWIDE PANORAMA

For Lazari (2020); John Hopkins (2020) the catastrophe brought by the new coronavirus, generate a collapse in the globalized world , infecting more than 4 million people by may 2020 worldwide. The crisis caused by the COVID-19 pandemic forced governments around the world to seek and develop comprehensive recovery measures (Hoffmann, 2020). China ended its public transportation services, especially to high-risk areas, to prevent the spread of the virus (PHELAN; KATZ; GOSTIN, 2020). Even after the suspension of COVID-19 health restrictions, demand for public transportation decreased significantly, as much of the

population understood that public transport could increase the chances of contagion (IPSOS, 2020). Zhao et al. (2020) corroborate this statement and comment that there was a strong relationship between the number of train trips and the increase in COVID-19 cases in the country.

In Italy, the second country with the highest first wave contagion outside of China, Coppola; De Fabiis (2021) points out that the introduction and effectiveness of interpersonal distancing on public transport has been one of the most effective measures to prevent contagion. According to Coppola; De Fabiis (2021), the demand for public transportation in Italy recorded an unprecedented reduction in overall usage, with decreases of 90% up to 95% of passengers, while in the reopening phases, demand gradually returned to pre-crisis levels, which demonstrates structural changes in travel behaviour. In the Netherlands, de Haas, Faber, and Hamersma (2020) point out that restrictive measures and public transport options reduced trips by more than 90% compared to the same period in 2019.

Germany recorded significant changes in the public from public transport as people increased their use of cars, walking, and cycling (ANKE et al., 2021). In Greece, measures included distributing passengers more evenly throughout the day, with the greatest concentration occurring among low-income users who maintained frequency with daily trips (POLITIS et al., 2021). In addition, trips on foot and by car increased (POLITIS et al., 2021). Even the United Kingdom, initially resistant to adopt commuting restrictions, quickly changed its overall position. More specifically, the UK started to adopt new measures, among them the so-called Responsible Transport, such as avoiding crowded public transport and travelling only if necessary, as a way to break the chain and if possible, walking and cycling as an alternative means of transport (BUDD; ISON, 2020). Besides cooperating to mitigate the virus, the use of bicycle paths during the pandemic opens doors for the strengthening of sustainable urban mobility (PRATELLI et al., 2020).

In the United States, responses to the COVID-19 pandemic concerning public transportation have been challenging to coordinate due to the size of the country, which interferes with and prevents coordinated actions from being organised by the federal government (PARR et al., 2020). The Philippines has introduced one of the most severe blockages in the world. According to Hasselwander et al. (2021), who conducted a study in Manila, those most dependent on public transport were disproportionately affected by the blockades as public transport was unable to fulfill its public service role ensure sustainable mobility for citizens. Zhang et al. (2021) compared the behaviour of public transport users in Hong Kong before and during the first wave of the pandemic. The authors found that the most significant reduction occurred among children and students due to increased awareness about the pandemic, which led people to reduce unnecessary travel.

In general, the overall strategies imposed by public management, such as regional blockades, stay-at-home orders, travel restrictions, and sanitisation of vehicles, had positive effects in reducing the use of public transportation and making demand schedules more flexible (PAPPALARDO et al., 2020). However, it is clear that the poorest and most vulnerable population is the most significant portion of society that has to continue working during a pandemic, this fact can lead to a higher risk of infection and consequently negative socioeconomic impacts regarding the cities management (ZHANG et al., 2021). Fraiberger et al. (2020) corroborate by pointing out that the percentage of the wealthiest population reduced

twice as much as the poorest in public transport, which shows that the strategies adopted do not guarantee sustainable actions.

3 RESEARCH METHOD

The analysis consisted of collecting information in journalistic news, media, technical guidelines and municipal and governmental decrees regarding the measures adopted for public transport during the first wave (March to July 2020) of COVID-19 in Brazilian State Capitals and the Federal District, as well as the support of scientific literature with previous studies. The progressive implementation of the Internet and the massive use of social networks contribute to the growth of journalistic information and the transmission of data (DE LA PISCINA et al., 2014; SQUAIELLA; RIGHI; MARCHELLI, 2018). The impact of each action on pandemic containment was interpreted using a conceptual framework.

4 RESULTS

Coppola and De Fabiis (2021) stress that interpersonal distancing is considered highly effective in containing SARS-COVID 19 contamination but can also be highly unsustainable for transportation systems. According to Tirachini & Cats (2020b), public transport lines were already running at total capacity before the pandemic (e.g. during peak periods). There was no infrastructure capacity available for increased travel frequency, redistribution of lines and schedules. According to the new travel demand, there was a lack of additional vehicles and drivers to organise adequate supply (NICOTRA et al., 2020).

In Brazil, public transportation in capital cities is provided mainly by bus lines and rail (metro) systems (SAHRAEI; KUŞKAPAN; ÇODUR, 2021). The country was already experiencing significant crowding in public transportation before the pandemic and the inability to meet the demand in a balanced way. According to Johns Hopkins (2020), Brazil is the first wave reach the top five countries with the most cases and deaths from the disease, having reached second place in June 2020, mainly due to the failed attempts to implement successful social distancing and isolation across the country (MARSON, 2020). Considering the measures applied by Brazilian State Capitals and the Federal District to public transportation during the first wave of COVID-19 in the country, Table 1 summarises the actions used.

Table 1 – Public Transportation Measures Applied by the Brazilian States and the Federal District

Brazilian Region	Public Transportation Measures Applied
North Region comprised by the States of: Acre; Amapá; Amazonas; Pará; Rondônia; Roraima; Tocantins	Circulation maintained between 30% and 40% of the fleet and reduced availability of schedules and lines, but with seating restricted to both urban and rural buses (DIÁRIO DO AMAPÁ, 2020). Closure of bus stations and a ban on intercity and interstate travel, except only for health workers and essential services. To ensure compliance with the decrees, the application of health barriers in the bus stations and highways were done (G1 AC, 2020a). Suspension of the senior citizen and student cards for the duration of the state of public calamity (G1 RO, 2020). Reinforcement of cleaning on buses (RIOS, 2020a). Daily washing with 70% alcohol or bleach solution every trip cycle, especially at points of contact with the hands of users such as

	seats, floors, and handrails. The turnstiles at the entrance and exit of the central terminal were also sanitised, and the windows, roof hatches were always open (G1 AC, 2020c). Distribution of alcohol gel and masks for all passengers (AGÊNCIA BRASIL, 2020). River transport was closed between March and April (SANTOS, 2020). The waterway transport of passengers was suspended until July. When the service was reestablished, new rules were adopted, such as the determination of a social distance of 2 meters between nets, a capacity limit of 40% for ferry boats, motorboats and 60% of the capacity in fast boats, in addition to the demarcation of seats and the mandatory use of masks by all (MOREIRA, 2020a). Awareness actions with stickers on buses and vans, distribution of masks, pamphlets with guidelines and information on care against COVID-19 (RIOS, 2020a).
Northeast Region comprised by the States of: Alagoas; Bahia; Ceará; Maranhão; Paraíba; Pernambuco; Piauí; Rio Grande do Norte; Sergipe	Suspension of intercity public transportation with surveillance through blitz located at strategic points in the states that connect the capitals (MENDONÇA, 2020). Reduction of bus trips, maintenance around 35% of the total fleet, with full suspension or reduction of up to 50% on Saturdays and Sundays (G1 PE, 2020). Buses could circulate with all seated passengers according to the vehicle's capacity. For standing passengers, a limit was established. All should stand on the markings with a distance of 1 meter, in addition, open windows, no use of air conditioning, mandatory use of masks (Rodrigues 2020). In public transport, there was a reduction of bus stops and reduction of the public transport route in commercial or non-essential service areas, as well as the determination of strategies to avoid crowding on buses and at passenger terminals (MURILO, 2020). Inspections at significant bus terminals to ensure compliance with sanitary measures and maintenance of the distance and prohibition of crowding at Integrated Terminals (TI) (PELEGI, 2020b). Cleaning at the final stops and at the end of each shift, in addition to cleaning during rest periods at the integration terminals. Specific cleaning products were used (CRISTINNE, 2020). The temperature was checked, alcohol gel was made available, and the use of masks was mandatory (STRANS, 2020a). For the elderly, free public transportation was maintained only for those who could prove the use of the service for health purposes. The renewal of student cards was prohibited (STRANS, 2020a). Reduction in water transport of passengers (ferryboats) (MARQUES, 2020a). The ferries and speedboats could circulate with only 70% of capacity, but with the lack of adhesion of the population, the percentage was reduced to 50% (G1 BA, 2020). The operation of all subway lines was suspended from March to May, and from June on, there was a gradual resumption, with sanitation of the trains and stations, visual identification for distance, cleaning of air-conditioning units, open windows, availability of alcohol gel dispensers and reduced schedules (METROFOR, 2020a). Implementation of an awareness campaign with posters with guidelines to encourage walking or cycling, linking the benefits of distance and strengthening the immune system with physical activity (METROFOR, 2020a). Health Transport program only for frontline hospital professionals (MARQUES, 2020b).
Southeast Region comprised by the States of: Espírito Santo; Minas Gerais; Rio de Janeiro; São Paulo	Only essential service workers were allowed to board public transportation, physical barriers were installed at train stations and bus terminal (FIGUEIREDO, 2020). The bus fleet was reduced to 55% (AGÊNCIA BRASIL, 2020). Maximum limit of people according to the number of seats available. (DEVENS, 2020). Trips with standing passengers were allowed, but with a predetermined limit according to the size of the vehicle and signposted with proper positioning for standing passengers (MARQUES, 2020c). Availability of 70% alcohol gel for all users and intensification of the cleaning of vehicles and station equipment, with daily washing and disinfection on the platforms, turnstiles,

	benches, pedestrian crossings, walls and pillars. Integration and transfer stations with demarcated spaces (PELEGI, 2020c). Installation of partitions to prevent contact between drivers and passengers (KOHLER; LUZ, 2020). Mandatory use of masks by drivers and passengers and the removal from circulation of buses with ventilation restricted to air conditioning (MOREIRA, 2020b). Intensive actions of information and communication, with posters and audible warnings with the individual protection measures (MARQUES, 2020d). Interstate and intercity transportation between municipalities was banned and later resumed with the reduction of the fleet (DEVENS, 2020).
Midwest Region comprised by the States of: Goiás; Mato Grosso; Mato Grosso do Sul	Subway trains were required to keep the windows open, in addition to daily thorough cleaning at the beginning of the trips when passing through the central station (MOURA, 2020). Cleaning the buses twice a day and with all passengers seated (REVISTA DO ÔNIBUS, 2020a, 2020b). Availability of alcohol for bus drivers and conductors (LIMA, 2020). In buses without air conditioning maintenance of open windows to facilitate air circulation. In buses with air conditioning, use of the system in open ventilation mode, in order to exchange air with the outside; and reinforce the daily internal cleaning of the buses, disinfecting and cleaning the handrails at the end stops (AMTU, 2020a). There was a period of interruption of public and interstate transportation (GOVERNMENT OF THE STATE OF GOIÁS, 2020a). Suspension of public transportation on Saturdays and Sundays, only users who could prove employment/work in essential service (MARQUES; MOREIRA, 2020). VLT (Light Rail Vehicle), started to release the doors automatically to avoid contact with passengers' hands (SUMMIT MOBILIDADE URBANA, 2020a). Enforcement in terminals to ensure safety and avoid crowds, in addition to reinforcing the mandatory use of masks (MIRANDA, 2020).
South Region comprised by the States of: Paraná; Rio Grande do Sul; Santa Catarina	Reduced capacity for 50% of passengers and suspension and reduction of available bus lines (MINISTÉRIO PÚBLICO DO PARANÁ, 2020). The collective transports traveled only with seated passengers (AGÊNCIA BRASIL, 2020). The government banned the circulation of municipal and intercity public transport (GOVERNMENT OF PARANÁ STATE, 2020). Installation of containers with alcohol gel in stations and terminals, reinforcement in the hygienization of buses and in the cleaning of vehicles in the garages, as well as audiovisual information campaign and placement of posters (GALOR, 2020). Removing the seals from the bus windows so that they could remain open during the whole trip (SUMMIT MOBILIDADE URBANA, 2020a).

Source: OWN ELABORATION, 2021.

5 DISCUSSION

The Pandemic of COVID-19 devastated thousands of lives. However, it may bring a change to new directions, to the pursuit of Sustainable Development (HOFFMANN, 2020). Since 2015, the UN, in partnership with 193 member countries, including Brazil, defined the 2030 Agenda. This agenda provides for the implementation of 17 Sustainable Development Goals, based on the three pillars: environmental, social and economic. There are many challenges to be overcome by the 2030 Agenda, especially when it comes to structural problems that are still basic, such as population growth and the concentration of people living in urban spaces. Therefore, according to the UN (2020), the crisis imposed by COVID-19 also

brought the possibility to rebuild and ensure for the next generations mobility, sustainable and productive infrastructure. That is, to develop intelligent and sustainable cities that can be resilient to social, economic, and environmental risks (SILVA; TAROUCO; EDELWEISS, 2018). The current impact on mobility may reflect deeply on the post-pandemic world (DE VOS, 2020).

At the same time that these means of transportation can contribute to the spread of the virus, they can become rapid responses to the epidemic when associated with the use of technologies. Information systems, such as passenger information queries, peak times, and mobility can assist in preventing and controlling the disease (MCCALL, 2020). In Tuscany, Italy, reward platforms (Good_Go and SabeMyBike) with incentives for bicycling and walking were implemented. During the pandemic became key to avoid using public transport, ensure mobility, and prevent contagion (PETRI; PRATELLI, 2019; PRATELLI et al., 2020). In the UK, a regional bus company installed air-cleaning devices in the driver cabs of its fleet to combat the spread of COVID-19, so the technology filters more than 95% of airborne viruses, and other contaminated particles, by releasing 30,000 litres of clean air per hour (STATE, 2020). Therefore, adopting some measures that encourage the use of active modes of transportation, such as using bicycles whenever possible or investing in public transport safety, are strongly recommended. They are environmentally, socially, and economically sustainable, besides often reducing travel time (SHAKIBAEI et al., 2021).

Table 2 presents literature-based sustainable action suggestions for public transport aligned with SDG 11 and synergistically with the other SDGs for the post-COVID-19 future.

Table 2 – Suggestions for sustainable mobility actions aligned to SDG 11 - Sustainable Cities and Communities

Issues with current measures	Consequences	Suggestions for sustainable mobility actions aligned to SDG 11 - Sustainable Cities and Communities
Reduction of available fleets and transport limitation capacity.	Agglomeration of socially vulnerable populations, especially during peak hours, given the mandatory use of public transportation as the only option (BASU; FERREIRA, 2021). Overcrowding of passengers in public transportation, and consequently risks of contracting the virus (BASU; FERREIRA, 2021). Congestion with the increased use of private vehicles (BELLONE et al., 2021).	Frequency of public transport can be altered to accommodate the number of passengers according to zones and peak times, i.e., if necessary, increase schedules and routes to accommodate everyone within the predetermined measures (NICOTRA et al., 2020). Staggering economic activities and lower fares at off-peak times to encourage use at alternative times (GKIOTSALITIS; CATS, 2020).
Lack of organisation in the dissemination of information	Delay in the dissemination of information regarding restrictions and changes in public transport (HERRERA; GODOY-FAÚNDEZ, 2021). Slow response and loss of credibility of urban management to ensure the health of users (HERRERA; GODOY-FAÚNDEZ, 2021). Mismatch of information between public	Ensure that public transport and cities fulfil their role to be sustainable and serve everyone equally (PRATELLI et al., 2020). Establish clear policies for queries and complaints about possible public transport user needs (HASSELWANDER et al., 2021). Enhancing strategic city management to address risks and crises in an agile manner (BASU; FERREIRA, 2021).

	authorities and public transportation companies (TORRISI; INTURRI; IGNACCOLO, 2021).	
Lack of options and stimulus for Sustainable Mobility	Escape from public transportation (SHAKIBAEI et al., 2021; TIRACHINI; CATS, 2020a). Increased use of private and individual vehicles to avoid contamination (BASU; FERREIRA, 2021). Meanwhile, increased emission of pollutant gases and worsened air quality (BASSO; MONTERO; SEPÚLVEDA, 2021).	Encourage cost reduction for clean energy-based cars and transportation, such as solar electric cars (SZYMAŃSKA; PANFILUK; KIRYLUK, 2021). Encourage changes and investments in urban roads and infrastructure to make more room for light mobility with a focus on cyclists and pedestrians (PRATELLI et al., 2020).
Lack of adequate sanitation, such as masks, alcohol, and water available for handwashing.	Users who move in high-risk environments and areas contribute to the spread of the virus (BURNS et al., 2021). Non-effectiveness of sanitation and cleaning measures proposed by laws and decrees (AWAD-NÚÑEZ et al., 2021).	Screening of sanitation and users and employees, such as temperature gauging and distribution of PPE (SHEN et al., 2020). Job creation with the inclusion and permanent reinforcement of cleaning professionals (SILVA; TAROUCO; EDELWEISS, 2018). Encourage passengers to be co-responsible for maintaining personal and transportation cleanliness and hygiene (SHEN et al., 2020).
Public Misinformation	The lack of transparency allows rumours, speculation, and misinformation to be released to the public and causes a lack of recognition of the outbreak's severity (CARTENÌ; D'ACIERNO; GALLO, 2020).	Transparency and easy access to all information are essential to avoid misinformation, especially with the help of new technologies (HÖRCHER; SINGH; GRAHAM, 2021). Place panels, informative and dynamic boards, and interactive apps promoting health education for passengers, employees, and partners (SHEN et al., 2020).

Source: OWN ELABORATION, 2021.

6 FINAL CONSIDERATIONS

The findings of this paper aimed to evaluate the measures applied by the Brazilian State Capitals and Federal District to public transportation during the Pandemic of COVID-19. At the same time, it analysed the proposed sustainable mobility actions, considering if they were aligned (or not) with the Sustainable Development Goals. It was argued that these measures could be expanded to other crises, not restricted only to public health problems, but to stimulate the creation of a new post-pandemic scenario. Therefore, it is necessary to think and create strategies to minimise agglomerations and the risk of contagion from COVID-19 and future healthy crises in a transportation system designed to move crowds of people. The mobility of public transportation is a basic need of the population. No one should be left behind, especially socioeconomically vulnerable groups who depend on public transport daily and maintain essential services. Therefore, transportation must be accessible, safe, and economically viable, even in continental-sized countries like Brazil. To ensure that the SDGs are implemented and that sustainable urban mobility is effectively achieved, it is necessary to create clear and adequate policies so that the management of cities is sustainable in itself. As well as cooperation between public authorities and private transport companies, not only restricted to transport but also investment in public roads and investment in public streets and infrastructure, including proper cleaning and sanitation of vehicles, available to all users and

employees.

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