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# Priority for future COVID-19 vaccinations in Brazil: should public transport users be a target group?

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Considering the recent emergence of effective vaccines against COVID-19 and the scarce resources to assist most of the world population immediately, societies need to define the order in which groups of citizens will get access to new vaccines. Vaccination campaigns should prioritize the immunization of vulnerable individuals and people tasked with helping others, thus reducing human losses and minimizing social and economic damage. In Brazil, public transport users in large cities present high levels of vulnerability, due to factors related to the spatial configuration, the organization of transport systems and the high percentage of people of low socio-economic status within large suburbs that depend exclusively on public transport to access jobs and basic services. Immunizing public transport users can produce relevant practical effects in combating COVID-19 in Brazil, such as saving public resources, reducing the number of deaths and achieving greater efficiency in the sectorized control of the disease within cities. Therefore, we suggest that policymakers should consider the frequent users of public transport from large Brazilian cities as a target group in vaccination campaigns, affording this group some priority based on adequate risk mapping at the local level.

**Keywords:** Vaccine. COVID-19. Public transport. Target group.

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## Introduction

The COVID-19 pandemic requires fast and effective solutions worldwide, which puts governments, policymakers, private sectors and scientists under huge pressure. Vaccine development appears to be the most promising means of dealing appropriately with this health crisis. The range of technology platforms and approaches considered increased the chances of success in vaccine development, such as nucleic acid, virus-like particle, peptide, viral vector, recombinant protein, live attenuated virus and inactivated (THANH LE *et al.*, 2020). Given the recent emergence of effective vaccines, the negative effects of the pandemic might be minimized by optimizing mass vaccination processes, not only by achieving a high enough vaccination rate quickly, but also by selecting priority groups smartly.

In the countries most affected by the pandemic, there is no consensus in the political arena regarding who should have access to vaccines first. In the report “Ethics and COVID-19: resource allocation and priority-setting”, the World Health Organization (WHO) highlights that the main ethical principles for deciding which groups might be prioritized in a context of scarce resources are equality and best outcomes (WHO, 2020). This report also suggests that future COVID-19 vaccination should prioritize people presenting higher risk factors, such as individuals with comorbidities (cardiovascular disease, obesity, diabetes and hypertension), elderly and marginalized populations, as well as people tasked with helping others, such as health and sanitation workers, food sector workers and public transport staff.

In Brazil, data from National Health Ministry reveal that the novel coronavirus (SARS-CoV-2) has rapidly disseminated in the country, especially within large urban centers. On June 4, 2021, the country reached 469,388 deaths and 16.8 million recorded cases, which correspond to 12.69% and 9.78% of the global records, respectively. On that same date, Rio de Janeiro (26,667), Sao Paulo (30,978), Manaus (8,993), Brasilia (8,740), Fortaleza (8,569), Salvador (6,737) and Recife (4,317) presented the highest number of deaths among cities in Brazil (BRASIL, 2021). In addition, Belo Horizonte, the core municipality of the third largest metropolitan region of Brazil recorded 5,115 deaths. These disturbing epidemiologic records create the necessary conditions for testing new vaccines in Brazil. In fact, the country has established partnerships involving technology transfer for testing vaccines, articulating consolidated national centers (such as FIOCRUZ and Butantã) with foreign institutions and companies, such as Oxford-AstraZeneca (UK) and Sinovac (China). Despite the success of these partnerships in vaccine development, the vaccination campaign in Brazil is significantly belated. The country recorded 47,636,424 people who received the first dose of the vaccine until June 4, 2021, which corresponds to 22.3% of the total population. To this date, Brazil is the 64th country in the world in the global ranking of immunized population per 100 inhabitants.

The Brazilian vaccination plan recently included 77.2 million people within the priority group, considering only two main categories:

- people aged 60 or over institutionalized, people with institutionalized disabilities, indigenous peoples living on indigenous lands, health workers;
- people aged 75 or over; traditional riverside peoples and communities; traditional *quilombola* peoples and communities, people aged 60 to 74, people with comorbidities, people with severe permanent disabilities, homeless people, prison inmates, prison staff, education workers, security and rescue forces, military, transport workers (including truck drivers), port workers, industrial workers (BRASIL, 2021).

Epidemiologists have been criticizing priority groups in the national vaccination plan, especially the recent inclusion of truck drivers and industrial workers (DIAS, 2020). If the priority group is huge, there is no real priority. In addition, it is not clear what the vaccination priority will be when completing the immunization of these 77.2 million people. The definition of this order of priority is also essential for planning actions, such as the registration of specific vaccination groups.

### **Future priorities for vaccination Covid-19: the public transport users**

After vaccinating these two defined groups, we suggest that Brazilian policymakers should also consider the group of public transport users in large cities when deciding on vaccination priority, due to the inherent risks associated with crowds in public transport, the high social vulnerability of most users as well as the significant failures in the public transport financing in Brazil.

According to Zhen *et al.* (2020), the disincentive or prohibition of the use of public transport is present in most international guidelines. However, authorities need to guarantee that public transport is able to support the functioning of essential activities within cities (BARCELOS; BLANK, 2020; SILVA *et al.*, 2020). These recommendations are based on the consensus that there is a strong relationship between the spread of viral diseases and public transport (MATEUS *et al.*, 2014; SILVA *et al.*, 2020). OECD argues that public transport has been significantly affecting COVID-19 dissemination within cities and urban networks (ECDC, 2020). According to the recent report released by the European Center for Disease Prevention and Control (ECDC, 2020), crowding in public transport might increase direct (respiratory droplets) and indirect (contaminated surfaces) COVID-19 transmission among users and staff. In addition, Pardo *et al.* (2021) show that high density and mixing levels of people within buses and subways can convert the public transport system into places prone to disseminating COVID-19. According to the authors, safe operation of public transport must address some key factors such as ventilation, user behavior (masks and eye protection), silence and distance between passengers (1-2 meters). However, all these factors are not always adopted promptly, which makes the public transport an important site of COVID-19 dissemination (PARDO *et al.*, 2021).

In fact, recent studies confirm the high risks involving public transport in this pandemic. The studies by Zheng *et al.* (2020) indicated that cases imported through the public transport network were an important factor in the dispersion of Sars-Cov-2. Hu *et al.* (2021) also concluded there is a high risk of transmission between train passengers, and that it varies according to travel time and seat location. Harris (2020) demonstrates that subway and bus lines seed the massive COVID-19 through New York City given the strong positive correlation between the distance from public transport stations and households presenting COVID-19 cases. Regarding mobility restriction, Badr *et al.* (2020) find a strong correlation between its decrease and the reduction in the growth of Covid-19 cases. In contrast, private transport provides a relatively safe environment for people compared to subway and buses (LEIVA *et al.*, 2020).

Studies have also investigated possible associations between COVID-19 and public transport within large urban centers in Brazil. In a survey conducted by the city of São Paulo on 3,217 households between August 18 and 20, the total prevalence of COVID-19 in the city was 11% (SÃO PAULO, 2020). In these serological surveys, researchers used venous collection and serum separation by applying the IGM/IGG immunochromatographic test in adults. Among public transport users, 11.3% of people were infected with the virus. The survey shows that people who work at home had a lower prevalence (4.4%). In addition, 16% of people living in households with 5 people or more had contact with the disease. Previous studies show that most people who live in households with 5 people or more in São Paulo live in poor peripheries and depend on public services, such as transportation and health (LIBÂNIO, 2016). Rodrigues (2020) shows that public transport users in Sao Paulo were heavily affected by COVID-19, given the strong positive association between neighborhoods presenting high number of users and contamination levels. Silva *et al.* (2020) also found a spatial correlation between the use of public transport and cases of the disease in Recife. In Belo Horizonte, Leiva, Sathler and Orrico Filho (2020) find that COVID-19 cases were higher in the central areas, which concentrate public services, such as transport. In Belo Horizonte, as we observed in other major cities in Brazil, most transport users live in peripheral areas and must pass through central areas, given the topology of public transport network in the city (LEIVA; SATHLER; ORRICO FILHO, 2020). Considering the radio-centric structure of transport system in Belo Horizonte, these results suggest that immunizing public transport users can contribute to decrease COVID-19 dissemination coming from the center areas towards poor peripheries.

Furthermore, people of low socio-economic status mostly use buses and subways in large sprawling Brazilian cities. In 2011, the per capita family income of 71.81% of public transport users in Brazil was up to one minimum wage (IPEA, 2012), while this figure drops to 50.00% among car users. According to Patel *et al.* (2020), poor population are more likely to live in overcrowded homes, which decreases compliance with social distancing, and also more likely to work in occupations that do not allow home-office activities. Furthermore, poverty is associated with lower levels of personal knowledge

about pandemics (TIMMERMANN, 2020), precarious work (MENÉNDEZ *et al.*, 2007), limited savings (SÁNCHEZ-PÁRAMO, 2020), high dependence of public services and high incidence of comorbidities (MENDENHALL *et al.*, 2017). Integration of epidemiologic and socioeconomic data in Brazil indicates that people of low socio-economic status have been strongly affected by COVID-19 (RODRIGUES, 2020).

According to IPEA (2012), 65% of the Brazilian population uses public transport as the main means of travel. In view of this high percentage, vaccination policies should focus on individuals who use it frequently and who depend on public transport for daily commuting. According to ANTP (2020), 60 million people used public transport in Brazil daily in 2018, which corresponded to 28.64% of the country's total population.

Data from the metropolitan regions of Belo Horizonte, Rio de Janeiro and São Paulo on total number of trips, percentage of trips and travel time according to the transport mode (Public, individual, non-motorized and others) reveal relevant information about commuting flows in the three largest and most dynamic urban centers in Brazil. These three cities have a significant volume of daily trips (15.8 million in total), especially São Paulo (8.79 million) and Rio de Janeiro (4.46 million). Additionally, the average travel time among public transport users is high in the three cities, exceeding 1 hour, which enhances exposure to the risk of contamination by COVID-19 during the trips. Rio de Janeiro has the highest percentage of users of public transport (67%), while only 17% of commuters used individual private transport.

**TABLE 1**  
Commuting trips and average travel time, by transport mode  
Belo Horizonte, Rio de Janeiro and Sao Paulo – 2012-2017

Municipalities		Public transport	Individual	Non-motorized	Others	Total
Belo Horizonte	Number of trips	855.769	962.984	630.385	155.795	2.604.933
	Trips (%)	33.0	37.0	24.0	6.0	100.0
	Commuting time	01:14:44	00:34:26	00:17:42	00:52:38	00:42:30
Rio de Janeiro	Number of trips	2.977.536	762.886	650.732	23.904	4.415.057
	Trips (%)	67.0	17.0	15.0	1.0	100.0
	Commuting time	01:01:18	00:45:26	00:17:25	01:04:34	00:50:34
Sao Paulo	Number of trips	3.867.676	2.978.962	1.944.633	-	8.791.271
	Trips (%)	44.0	34.0	22.0	-	100.0
	Commuting time	01:06:17	00:30:23	00:11:30	-	00:39:53

Source: Origin Destination Survey Belo Horizonte (2012); Origin Destination Survey Rio de Janeiro (2012); Origin Destination Survey São Paulo (2017).

According to Table 2, the vast majority of public transport users in these three metropolitan regions earn less than two minimum wages (54% of users in Rio de Janeiro, 68% in São Paulo and 78% in Belo Horizonte). In contrast, the percentage of users of private individual transportation earning less than two minimum wages is significantly lower in Belo Horizonte (44%), Rio de Janeiro (26%) and São Paulo (34%) compared to the figures presented by public transport users.

**TABLE 2**  
**Commuters, by income class per minimum wage (MW), according to transport modes**  
**Belo Horizonte, Rio de Janeiro and Sao Paulo – 2012-2017**

		Income			In percentage
Municipalities		Up to 2 MW	2 to 5 MW	Higher than 5 MW	Total
Belo Horizonte	Public transport	78.0	20.0	2.0	100.0
	Individual	44.0	43.0	13.0	100.0
	Non-motorized	80.0	18.0	2.0	100.0
	Others	56.0	39.0	5.0	100.0
Rio de Janeiro	Public transport	54.0	32.0	14.0	100.0
	Individual	26.0	36.0	38.0	100.0
	Non-motorized	70.0	18.0	12.0	100.0
	Others	28.0	48.0	24.0	100.0
Sao Paulo	Public transport	68.0	28.0	4.0	100.0
	Individual	34.0	49.0	17.0	100.0
	Non-motorized	72.0	24.0	4.0	100.0
	Others	-	-	-	-

Source: Origin Destination Survey Belo Horizonte (2012); Origin Destination Survey Rio de Janeiro (2012); Origin Destination Survey São Paulo (2017).

These data suggest that policymakers must create policies to protect frequent public transport users from COVID-19. In the largest metropolitan regions, public transport is the only viable method to access jobs, education and services for most of the 11.4 million inhabitants living in the slums in Brazil (IBGE, 2011). While much of suburban population in sprawling cities in the developed world has access to cars, people of low socio-economic status living in suburbs within large Brazilian cities usually face high exposure to COVID-19 in public transport, which challenges policies seeking economic re-opening during pandemics.

Furthermore, the inefficiency of the transport system and significant failures in the public transport financing structure in Brazil are probably associated with the high rates of COVID-19 dissemination among bus and metro staff and users. In large Brazilian sprawling cities, public transport usually connects urban centralities to distant peripheries through radio-centric networks dominated by high competition between buses and cars (ALVARENGA PEREIRA COSTA; TEIXEIRA, 2014; MARX *et al.*, 2019). The urban form and the transport structure of São Paulo, Belo Horizonte or Rio de Janeiro affect congestion levels and average travel time, which increase the economic inefficiency of maintaining the system (FERRAZ; TORRES, 2004). In addition, most travel costs are included in the ticket price on Brazilian public transport (MARX *et al.*, 2019). The lack of smart financing mechanisms for the transport system and the low economic viability of the planned routes through areas of low population density increase the vulnerability of the public transport system in times of pandemic. In most large Brazilian cities, the drastic reduction in passenger demand during the initial months of the pandemic encouraged restrictions on the availability of public transport. Therefore, as demand rises, availability should grow at the same rate, avoiding unnecessary crowds within buses and subways and waiting stations.

In this scenario, researchers and journalists have investigated the possible scenarios in a post-pandemic world within the transport sector. The negative perception of public opinion about public transport as involving more health risks can affect the pace of recovery of lost demand (BAZANI, 2020; COLOMBO *et al.*, 2020; PULLANO *et al.*, 2020; TIRACHINI; CATS, 2020; XAVIER, 2020).

Given the centrality of public transport in discussions on cities and COVID-19, the International Association of Public Transport (UITP) asked the European Union to include policies addressing urban public transport in its recovery plan (XAVIER, 2020). Barcelos and Blank (2020) indicate that actions taken during the pandemic, such as reinforcing the cleaning of spaces and the scheduling of commercial activities, must consider the implementation of policies seeking the economic sustainability of public transport. Therefore, the authors argue that expanding tariff integration and alternative forms of payment can improve operating indicators within large urban centers. In our opinion, vaccination among public transport users can also help cities reduce economic gaps caused by the commute decrease within the public transport system during the COVID-19 pandemic.

Prioritizing public transport users in vaccination can convey a relevant message to the population: public transport is a relevant tool to create democratic cities and social justice. At the same time, this policy will be effective by immunizing a population group that is more likely to become infected (in transport or in spaces associated with transport) compared to private transport users or people who work at home. Immunization will protect not only frequent users of public transport in Brazil, but also other residents that do not commute daily, such as most of the elderly population. Most of public transport users in Brazil present vulnerabilities associated with poverty and inequality and depend exclusively on the public health system (PEREIRA *et al.*, 2020). Therefore, prioritizing the vaccine for public transport users may reduce the demand on public hospitals, help save public resources and significantly reduce deaths, since COVID-19 mortality in Brazil is higher among people of low socio-economic status. With the re-opening of most of the country's economic activities and the intensification of commuting involving center-periphery, the immunization of public transport users can increase the efficiency of policies sectorizing the epidemiological control of the disease, which focus on specific neighborhoods or regions of the city. Infected public transport users who make long journeys can spread the disease comprehensively within large cities, contributing to the existence of new outbreaks in areas already under control. Therefore, the immunization of individuals who frequently use public transport in large cities may contribute to decreasing the levels of infection and deaths, avoiding new waves of infection.

Large cities in Brazil usually present better mechanisms to identify frequent public transport users. For example, in Belo Horizonte, registered users have the BHBUS card, which makes payment easier. This card includes the identification (name and photo) of a significant portion of frequent users of public transport in the city. This information is available in the system's registry, but could also be checked with employers who would inform the municipal

government the number of employees benefiting from the transportation voucher. The main challenge is to include the informal population within this campaign, although part of these public also use the BHBus card.

This discussion can support public policies not only in Brazil, but also in other developing countries where COVID-19 has spread widely. Considering all the points mentioned, the pace of vaccination in Brazil and also the limitations to implement our ideas (such as identifying this target group), we believe that authorities in Brazil (especially local authorities) should consider frequent public transport users in vaccination after completing the immunization of the priority group defined by the National Plan. Prioritizing public transport users seems more appropriate for large and medium-sized cities, where public transport is very relevant in daily commutes. In addition, larger cities usually have more tools to identify public transport users, such as the BHBus system in Belo Horizonte. Based on local singularities, each city can define the way they consider our suggestions. There are different options, as follows: 1) public transport users between 18 and 59 years can have access to the vaccine first; 2) after completing the vaccination among older people, it is also possible to establish this kind of priority only among younger adults (such as 18 to 40 years), which present lower risks associated with aging; 3) even considering transport users first within specific groups of age when age is the main criteria can be positive in larger urban areas. Therefore, there is no single receipt for considering our suggestions to prioritize public transport users in vaccination campaigns in Brazil (or even in other cities worldwide).

In summary, considering the recent emergence of effective vaccines against COVID-19 and the scarce resources to assist most of the world population immediately, societies need to define the order in which groups of citizens will access the new vaccines. As WHO (2020) suggested, vaccination campaigns should prioritize the immunization of vulnerable individuals and people tasked with helping others, thus reducing human losses and minimizing social and economic damage. In Brazil, public transport users in large cities present high levels of vulnerability, due to factors related to the spatial configuration, the organization of transport systems and the high percentage of people of low socio-economic status within large suburbs that depend exclusively on public transport to access jobs and basic services. Immunizing public transport users can produce relevant practical effects in combating COVID-19 in Brazil, such as saving public resources, reducing the number of deaths and achieving greater efficiency in the sectorized control of the disease within cities. Therefore, we suggest that policymakers should consider the frequent users of public transport from large Brazilian cities as a target group in vaccination campaigns, affording this group a certain level of priority based on the adequate risk mapping at the local level, especially in larger urban centers.

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## Resumo

*Prioridade para futuras vacinações contra a Covid-19 no Brasil: os usuários de transporte público devem ser um grupo-alvo?*

Considerando o recente surgimento de vacinas eficazes contra a Covid-19 e os escassos recursos para atender imediatamente à maior parte da população mundial, as sociedades precisam definir a ordem em que os grupos de cidadãos terão acesso às novas vacinas. As campanhas de vacinação devem priorizar a imunização de indivíduos vulneráveis e encarregados de ajudar outras pessoas, reduzindo as perdas humanas e minimizando os danos sociais e econômicos. No Brasil, os usuários de transporte público nas grandes cidades apresentam altos níveis de vulnerabilidade, diante de fatores relacionados à configuração espacial, à organização dos sistemas de transporte e ao alto percentual de pessoas de baixo nível socioeconômico em grandes periferias que dependem exclusivamente do transporte público para acesso a empregos e serviços básicos. A imunização dos usuários do transporte público pode produzir efeitos práticos relevantes no combate à Covid-19 no Brasil, tais como economia de recursos públicos, redução do número de óbitos e maior eficiência no controle setorizado da doença nas cidades.

Portanto, sugerimos que os formuladores de políticas devem considerar os usuários frequentes de transporte público das grandes cidades brasileiras como um grupo-alvo nas campanhas de vacinação, dando a esse grupo um certo nível de prioridade com base em um mapeamento de risco adequado em nível local.

**Palavras-chave:** Vacina. Covid-19. Transporte público. Grupo-alvo.

## Resumen

*Prioridad para futuras vacunaciones contra la covid-19 en Brasil: los usuarios de transporte deben ser un grupo objetivo?*

Teniendo en cuenta la reciente aparición de vacunas eficaces contra la covid-19 y los escasos recursos para atender de inmediato a la mayoría de la población mundial, las sociedades deben definir el orden en el que los grupos de ciudadanos tendrán acceso a las nuevas vacunas. Las campañas de vacunación deben priorizar la inmunización de personas vulnerables y personas encargadas de ayudar a otras para reducir las pérdidas humanas y minimizar los daños sociales y económicos. En Brasil, los usuarios del transporte público en las grandes ciudades presentan altos niveles de vulnerabilidad, dados los factores relacionados con la configuración espacial, la organización de los sistemas de transporte y el alto porcentaje de personas de nivel socioeconómico bajo dentro de los grandes suburbios que dependen exclusivamente del transporte público para acceder a empleos y servicios básicos. La vacunación de los usuarios del transporte público puede producir efectos prácticos relevantes en el combate a la covid-19 en Brasil, como el ahorro de recursos públicos, la reducción del número de muertes y una mayor eficiencia en el control sectorizado de la enfermedad en las ciudades. Por lo tanto, sugerimos que los formuladores de políticas consideren a los usuarios frecuentes del transporte público de las grandes ciudades brasileñas como un grupo objetivo en las campañas de vacunación y le den a este grupo cierto nivel de prioridad basado en un adecuado mapeo de riesgos a nivel local.

**Palabras clave:** Vacuna. Covid-19. Transporte público. Grupo objetivo.

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