

Influence pandemic COVID-19 on the socio-economic efficiency of urban transport systems

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Abstract. The COVID-19 pandemic has fundamentally changed the way people live, think and behave, especially in cities. The pandemic, without exaggeration, has affected all spheres of economic and social life, including affecting the functioning of urban transport systems, which are a multifunctional structure that ensures the mobility of the population. Taking into account the changes that have taken place during the COVID-19 pandemic, which had a significant impact on the functioning of urban transport systems, they face new challenges, including in the sphere of ensuring environmental safety and developing new types of mobility. Special attention in this paper is paid to such issues as studying the impact of a new coronavirus infection on the behavior of citizens of world megacities based on the analysis of international experience, determining the impact of a pandemic on the objective indicators of urban transport systems. Taking into account the identified patterns, the main short-term and long-term trends that have developed under the influence of COVID-19 are identified, a comparative description of the measures taken by the city authorities to control the virus is presented, and their possible consequences are analyzed. Examples of successful projects and activities implemented by city administrations in response to the pandemic are given to ensure the long-term sustainability of the development of transport systems.

1 Introduction

It is necessary to implement the principles of a sustainable and efficient urban transport policy in modern conditions. While implementing this policy, transport is assigned one of the leading roles in improving socio-economic efficiency and reducing total costs through optimization and strict regulation of logistics processes [1]. Many scientific studies conducted by domestic and foreign authors are devoted to the issues of the concept of development of the urban transport system, which determine the key goal of implementing transport policy - ensuring the mobility of the population [2, 3, 4, 5, 6, 7, 8, 9, 10].

Transport policy should be based on the understanding that any changes in urban transport will inevitably have an impact on the city's economy, ecology and society [11]. Therefore, when choosing tools, it is necessary to identify the main areas of interaction between the transport system and other elements of the city, taking into account its

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economic development, the characteristics of the institutional environment, as well as the features of urban planning and development [12]. At the same time, the change in the transport behavior of citizens is becoming one of the factors of sustainable urban development [13].

As you know, over the past two years, the global economy has functioned in the face of extraordinary international and national responses to the COVID-19 pandemic, which has changed not only the lives of all people, but also the situation on a global scale [14]. Not a single country was left out, and among the vital sectors affected by the pandemic, in the first place, was the transport industry. Non-pharmaceutical measures introduced in transport in response to the spread of a new coronavirus infection have significantly hampered the functioning of value chains, the movement of goods and people around the world [15].

The coronavirus pandemic has become a catalyst for changes in the transport industry that have radically affected the mobility of the population, and also revealed fundamental issues of improving the socio-economic efficiency and sustainability of the urban transport system, so it is necessary to determine holistic approaches to the formation of a comprehensive program on transport, environment and health protection.

2 Materials and methods

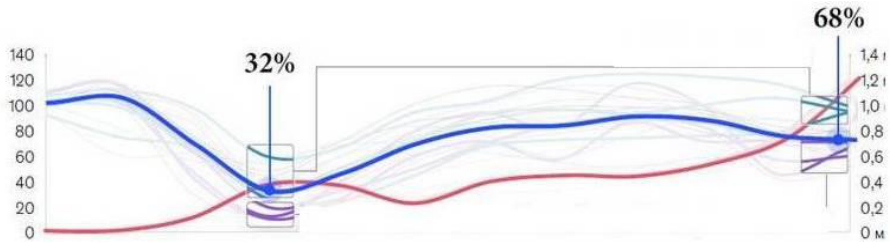
Materials from specialized literature, scientific and practical conferences, statistical data reflecting current trends in the impact of the COVID-19 pandemic on urban transport systems in the world and domestic practice were used in the study. The instrumental and methodological apparatus of the study is based on a systematic approach, structural and comparative analysis, the method of expert assessments.

3 Results

An analysis of the impact of the coronavirus pandemic on the transport systems of world mega cities was made in this paper. The following criteria were used to select the study of cities: the city plays one of the leading roles in the economy of its country (gross regional product per capita should be more than 10 thousand US dollars); the population of the city should exceed 5 million people; the city must be represented in international data sources. The study includes such metropolitan areas as: Moscow, St. Petersburg, Paris, Berlin, Madrid, London, New York, Los Angeles, Chicago, Toronto, Mexico City, Buenos Aires, Tokyo, Singapore, Bangkok, Shanghai, Istanbul and Sydney.

1. *The impact of the COVID-19 pandemic on the structure of urban mobility.* The mobility of the population has significantly decreased due to the adoption of restrictive measures and an increase in the share of remote employment (Fig. 1). [16]

Thus, the average number of movements of citizens at the peak of restrictive measures was only 32% of the level recorded before the start of the pandemic. I would like to note that at present, mobility has not fully recovered - only up to 68% of the level observed before the beginning of 2020.



Blue line is the average mobility of citizens.

The red line is the number of sick cases per month, million people.

Fig. 1. Change in the level of mobility of the population of megacities in 2020 Source: McKinsey & Company report. Transport systems of 25 cities of the world.

Along with the general level of mobility, the attitude of the population towards existing modes of transport has changed due to the pandemic. The analysis showed that people began to drive their own cars much more often. Accordingly, there has been a very significant shift in the structure of modality: before the pandemic, the share of public transport was 60%, but at the end of 2020 it was only 46% [17]. As the first wave of the pandemic ended and the most severe restrictions were removed, urban residents continued to prefer private transport.

The most important question, however, is the increase in the share of personal transport systemic or temporary? According to experts, we should expect a long-term continuation of the trend, since surveys have shown that after the pandemic, residents of megacities plan to make 47% of trips by private car against 48% at present, which, in our opinion, is due to a complex of changes in people's behavior. Although some citizens will continue to use public transport, in most transport systems in 2022-2023 the shift in favor of private transport will continue.

This trend is associated with a number of negative social consequences from the point of view of the long-term development of transport systems: road congestion, air pollution in cities, and an increase in premature mortality.

2. *The impact of changing the level of service on the performance of urban transport systems.* It is absolutely obvious that the reduction in the mobility of the population as a whole has led to a decrease in the number of trips, including by public transport [18]. The passenger traffic on public transport in 2020 relative to the level recorded before the pandemic is shown in Fig. 2.

However, the management of the vast majority of urban transport companies did not shift the consequences of the reduction in their income to the citizens, and ticket prices were not increased to a level exceeding inflation, given the important social role of transport systems in the life of the population and despite the actual decrease in revenue during the pandemic. But judging by the statements published in the press by representatives of city administrations, some transport operators were forced to reduce the level of service. At the same time, the authorities of a number of cities acted in the opposite way, increasing the level of service in 2020, which allowed them to maintain higher passenger traffic than in those megacities where the level of service was decreased.

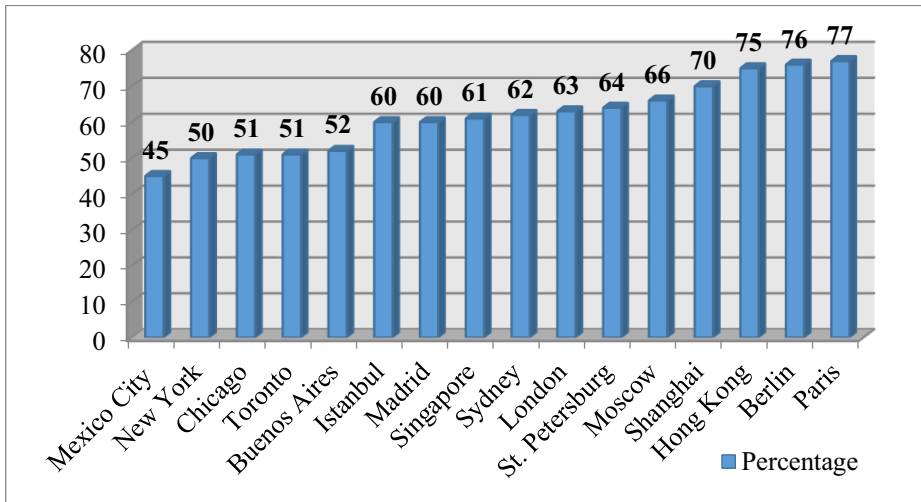


Fig. 2. The passenger traffic on public transport in 2020 relative to the level recorded before the pandemic Source: prepared by the author

3. *The Impact of Perceptions of Safety and COVID-19 Responses.* Citizens became less likely to use public transport during the pandemic, as they believe that it has a very high risk of being infected by the virus. At the same time, I would like to note that, according to many experts, an important role in reducing the incidence among public transport passengers is played by measures to ensure epidemiological safety, in particular [19]:

- mandatory wearing of personal protective equipment for passengers and public transport workers;
- frequent disinfection of vehicles and subway premises using effective innovations;
- markers, stickers and barriers to maintain social distance;
- maintaining or increasing the frequency of public transport;
- cycling infrastructure improvement;
- setting certain limits on the number of passengers in public transport.

A number of studies have noted the effectiveness of such events, but it is possible that their implementation still does not have a direct impact on how citizens assess the risk of contracting a coronavirus infection in public transport. The analysis showed that, despite the existence of an indirect relationship between these two indicators, in some cities the measures taken have a less significant impact on the perception of epidemiological risk when traveling by public transport. Perhaps this is due to the lack of sufficient information from the city authorities about such initiatives. In cities where effective communication is established, residents are much more aware of ongoing activities and assess the risk of infection in public transport as lower. However, the total number of new COVID-19 infections is also a very important factor when population is assessing the likelihood of infection.

4. *Impact of urban projects contributing to the sustainable development of transport systems.* The administrations of megacities began to implement various projects during the pandemic, primarily aimed at ensuring the epidemiological safety of the population (29%), since the priority is to minimize the risks of contracting the virus in public transport (Table 1) [16].

Table 1. Categories of projects implemented under the influence of the pandemic

Categories	Project examples	Share in the total number of projects
Ensuring epidemiological safety	Improving the quality standards of vehicle disinfection. Limiting the number of passengers in vehicles	29%
Development of types of movement associated with physical activity	Construction of temporary bike lanes. Increasing the number of bikes available on shared services	28%
Declining popularity of private transport	Introduction of paid zones for cars within the city. Decrease in the permitted speed of vehicles in the city center	17%
Digitalization of public transport	Development of application functionality for tracking passenger traffic in real time. Implementation of an electronic check-in system for public transport passengers	16%
Improving the efficiency of public transport	Construction of new dedicated lanes	10%

For example, disinfection standards have been introduced in the transport system of the Russian capital. In accordance with sanitary standards, all 269 metro stations are disinfecting doors, stairs and handrails of escalators, as well as ticket machines. The frequency of washing depends on the passenger flow and averages 1.5-2 hours. In metro trains, in addition to their regular washing, quartz treatment is performed when entering the depot. The air conditioning systems in the trains of the “Oka” and “Moskva” series are equipped with built-in UV lamps, while portable UV units are used to treat the rest of the trains.

To mitigate the risks of using public transport, public transport digitalization projects (16%) are also being implemented, which should primarily ensure the transparency of public transport load indicators so that users can make an informed decision about the start time of the journey, taking into account the expected number of contacts with other passengers. For example, the New York City Transportation Authority (MTA) tracks public transit usage using the MYmta app. Special sensors based on infrared radiation technologies and recognition of three-dimensional objects are used to determine the number of passengers. The sensors are mounted above the doors of the buses and connected to a GPS tracker installed in each vehicle [20].

The projects of other categories are being implemented in order to support the sustainability of transport systems in the long term and reduce the increase in the share of personal transport in the structure of modality. In total, their share is 55%, as the city authorities understand the importance of returning residents to public transport.

4 Discussion

The analysis of the impact of the COVID-19 pandemic on the transport systems of the world's megacities allows us to identify the following trends:

1. Decreased mobility of the population is noted. The COVID-19 pandemic has led to a systemic shift in the structure of the mobility of citizens, since rather stringent and prolonged restrictions were introduced related to the need to maintain social distance. Given the increasing spread of remote job formats, it can be assumed that the level of mobility of the population may not recover even after the end of the pandemic.

2. Reducing revenues and reducing the level of service of transport systems is witnessed. Since the population began to use public transport less, giving preference to private cars, the revenue of transport systems in the studied cities decreased by an average of 37%, as a result of which some administrations are forced to reduce the level of service on public transport.

3. Decreased satisfaction with public transport is noted. As the data for the five cities studied (New York, Chicago, Mexico City, Buenos Aires, St. Petersburg) show, the lower the level of service is the lower is the satisfaction of citizens with public transport and its popularity, which leads to an increase in the share of personal transport in the structure of modality. St. Petersburg is an exception, since many residents are extremely dissatisfied with the situation around public transport, but do not have the choice of using vehicles. There is a less significant reduction in the share of public transport in the modality structure of those cities where the level of service remains at the same level or grows, on the contrary.

4. There is a perception of public transport as more dangerous from an epidemiological point of view. According to urban residents, the risk of contracting a new coronavirus infection in public transport is certainly much higher than when traveling in a private car. Through security measures and good communication with the public, some city governments have managed to soften the perception of public transport as “dangerous” and have maintained its popularity during the pandemic.

5. There is the growth in the share of personal transport in the structure of modality. Due to a decrease in satisfaction with public transport and the perception of personal transport as safer, its share in the modality structure of the studied cities increased on average from 40 to 48%. With a further decline in the share of remote employment, this trend could lead to serious negative consequences, including a decrease in the efficiency of urban transport systems. The results of a survey of urban residents show that at the end of the pandemic period, most of them plan to continue to actively use personal transport, which can provoke the emergence of health problems associated with physical inactivity, and possibly an increase in premature mortality.

6. Implementation of projects aimed at improving the efficiency of transport systems. The sustainable development of the urban environment will be facilitated by the implementation of projects aimed at reducing the use of personal transport and promoting those modes of transportation that are associated with physical activity, in particular, walking, cycling, etc.

5 Conclusions

There are currently several major trends in the global urban transport system:

- decrease in the mobility of the population with an increase in the share of personal transport in the modality structure of most transport systems;
- decrease in popularity of public transport due to the fact that it is more often perceived as associated with the risks of infection with COVID-19;
- reduction in the revenue of transport systems due to a decrease in the mobility of the population and, as a result, a forced decrease in the level of service in urban public transport.

In the long term, these trends may lead to a further increase in the number of personal vehicles on the roads, which will create additional pressure on transport systems and cause an even more significant decrease in public transport revenue.

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