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Original Article

PANDEMIC IMPACT ON TRAFFIC TRENDS AND PATTERNS IN THE CITY OF BELGRADE

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Highlights:

- factors influencing the transport mode change in Belgrade are: gender, level of education; income, the transport mode used before the pandemic and the average distance travelled;
- the level of cycling, walking and the usage of e-scooter increased during the pandemic in Belgrade;
- female respondents are more inclined to change the mode of transport than male respondents;
- the respondents who travelled shorter average distances had a significantly higher chance to change the mode of transport;
- in situations similar to this pandemic, bicycles and e-scooters can be part of the offer of the public transport system on short distances.

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Abstract. The appearance of the COVID-19 virus has caused great changes in all spheres of life. Probably the most visible change is the cities' lockdown, with the suspension of traffic and transport systems. The capital of the Serbia – Belgrade also went through a complete lockdown, which lasted for almost 2 months (53 days). In that period, nearly all activities were reduced, producing significant losses for the whole economic development, healthcare, food supply chain, transport sector and most importantly public transport system. The behaviour of users in such situations can greatly influence the change in the share of certain modes of transport in the overall modal share. The aim of this article is to examine the influence of the COVID-19 pandemic on the transport mode choice for different trip purposes, as well as the examination of different impact factors, such as gender, age, education level, employment status, income, transport mode used before the pandemic, and average distance travelled, on the change of mode of transport. Data of 1143 users were analysed through a survey, for the area of the city of Belgrade, using the McNemar–Bowker test and binary logistic regression. The results showed that pandemic had a significant impact on the transport mode change for all trip purposes. The key factors influencing the change in the mode of transport are factors related to gender, level of education, income, the type of transport used before the pandemic and the average distance travelled. It is also interesting to note that the results showed a significant number of transfers to individual modes of transport, as well as micromobility vehicles and walking. Therefore, this article provides the necessary help in understanding the transport system user's behaviour, which can facilitate the choice of adequate measures, modes and activities for decision-makers in these specific situations.

Keywords: COVID-19, impact factors, modal share, transport mode change, user behaviour, user attitudes, safety perception.

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Introduction

Different factors, depending on the level of prevalence, severity of consequences, the existence of preventive measures, and similar, can affect changes at the global level to a greater or lesser extent. One such change and impact is still being measured around the world and is still ongoing. COVID-19 spread very quickly from Asia to all other continents and caused almost unimaginable changes and consequences. Each country is struggling in its own way with the new situation in an effort to prevent new negative consequences. Perhaps the biggest changes and the hardest blows are suffered by the world economy, which has suffered significant losses in just a few months. It is also important to note the impact of COVID-19 on the psychological state of transport users and their behavioural patterns, as a consequence of physical and social distancing (Dam *et al.* 2020; Lemke *et al.* 2020). The impact of COVID-19 is mostly reflected in changes in environmental quality, socioeconomic impacts, mental state of people,

and the way traffic engineers use the current situation to "open up", modify and change cities and urban space.

Generally speaking, the influence of the new situation is best depicted through: environmental quality, socioeconomic impacts, management and governance and transportation and urban design (Sharifi *et al.* 2020).

In addition to the evidently bad effects that this virus has all over the world, there are potentially further mid- and long-term negative impacts of the pandemic, which must be prevented as much as possible. Nevertheless, this article will try to show and look at certain positive effects in traffic, which the pandemic brought with it, such as the potential of active modes of transport (walking and cycling), as well as the emergence of new transport options (e-scooters) that can respond and satisfy the daily movement requirements in these specific situations.

Probably the most important change that accompanies the appearance of COVID-19 is the lockdown of cities, the interruption of passenger air traffic, rail, water and road traffic, which fortunately resulted in a significantly positive impact on the ecology and the environment.

When it comes to traffic, the 1st wave was suffered by the tourism and air transport sector. Road traffic all around the globe, as well, is in the state of decrease. For example, in Budapest (Hungary) mobility was reduced by 51% and the number of daily trips dropped from 10.1 to 4.3 million (Bucsky 2020). In South Korea nationwide traffic in 2020 decreased by 9.7%, compared to 2019 (Lee *et al.* 2020). In Australia the overall mobility is about 2/3 of the pre COVID-19 period, even though there is a large increase in the activities such as: shopping, recreation, etc. (Beck, Hensher 2020a; Beck *et al.* 2020). This result is particularly important because it describes several interesting patterns that emerged over the course of the pandemic. 1st-of-all, the levels of mobility measured in different countries depend to a large extent on the strategy applied to prevent the spread of the pandemic. In particular, a reduction in the overall level of mobility due to the mandatory lockdown of cities during the 1st, 2nd or 3rd wave of the pandemic is quite expected. What is interesting here is the behaviour of people in the time between the lockdowns, when there was no great pressure due to restriction of travel/movement. In this sense, it is interesting to mention that the largest number of people (in different countries, from different researches) opted for active ways of movement, primarily walking and cycling, as well as the purposes for which they would relax or increase their physical activity (Abdullah *et al.* 2020; Anke *et al.* 2021; Mars *et al.* 2022). It is important to mention that even during the lockdown, the largest number of users opted for walking as their primary type of movement (Anke *et al.* 2021). On the other hand, in the Somerville (US), the conducted research states the dramatic decrease of traffic: 71% decrease of cars and 46% decrease of trucks, just between March and May (Hudda *et al.* 2020), during the 1st lockdown. An aspect that is important to note here is the increase in the use of passenger cars for the period when the lockdown was not in force. Bearing in mind the characteristics of these vehicles (possibility of individual driving/movement, physical distancing, door-to-door transport, etc.) the increase in the use of passenger cars in modal split is quite expected.

The influence of COVID-19, from the mobility aspect, is almost equal for every age category. The research conducted in Birmingham (US) stated the decrease of driving days per week was by 37% and vehicle miles driven by 35% for adolescents (Stavrinos *et al.* 2020). Also, a similar distribution by purposes and mode of transportation was observed between men and women during the pandemic compared to the period before the pandemic (Mars *et al.* 2022). These results indicate an almost uniform way of behaviour of users during the beginning and the initial wave of the pandemic, regardless of the impact factor: gender, age, social status, etc.

When it comes to the urban transportation systems, the biggest problem is in the great reduction of public transport use and the change in mobility patterns in general. This outcome is practically expected, because of the characteristics of these vehicles and the way of transporting people (Musselwhite *et al.* 2020). In Sweden's most populated areas: Stockholm, Västra, Götland and Skåne there was a severe decrease in public transport ridership (40…60%) compared to the other modes (Jenelius, Cebecauer 2020). In the city of Coruña (Spain) the bus use values were reduced to the 8…16% level of those related to the 2017–2019 period. There has even been a decline in the use of bike-sharing systems across the world's major cities for the same cause as for public transport (Li *et al.* 2022). The reason for such results can be sought in the already mentioned way of transporting people in public transport vehicles and bike-sharing systems, which is explained and supported through literature. For example, surveys conducted in Germany, France, Italy, Japan, China, the US and the UK have shown that the risk of infection is the main influencing factor when choosing a mode of transport. Research has even shown that the risk of infection outweighs the importance of the cost of transportation (Hattrup-Silberberg *et al.* 2020). Another similar study also analysed the influence factors on the choice of the mode of transport during the pandemic. In this research, as the most important factors the respondents cited: concern about infection, safety and security, cleanliness and passengers with face masks (Abdullah *et al.* 2020). Similarly, general traffic values were at the 23…38% level of the previous period – before the pandemic (Orro *et al.* 2020). As a result, an unpromising outcome was recorded in Qingdao (China), where 56.3% respondents said that they would decrease the usage of buses in the post-COVID-19 period (Sui *et al.* 2020). Now, many years and strategies of promoting public transport as the most sustainable mode have been completely erased in just a couple of months by COVID-19. This only shows the vulnerability of the public transport, which came to the light during the 1st wave of the pandemic. Cities, their governments and transportation experts will have to find new ways of making public transport adequate, competitive, acceptable and safe again.

In spite of the previously mentioned decrease of traffic, the need for travel, movement and mobility still exists. This situation has largely paved the way for the development of new modes of transport (such as micromobility subsystems) and the reuse of some existing ones, such as bicycles. This change was observed in many American and European cities. For example, in New York (US) some subway users transferred to the bicycles, while the bike trip average duration also increased from 13 to 19 min (Teixeira, Lopes 2020). In Glasgow (UK), non-commuting and general bicycle activities increased after the government interventions (Hong *et al.* 2020). The promising results also suggest that the use of bicycles and walking in the modal share will further increase, even after the pandemic (Zafri *et al.* 2021), which is a good indicator of the bicycle subsystem's (and active modes of transport in general) strength and resilience in critical situations. This is especially important in the situation of recovery of public transport and potential multimodal integration with, e.g., system of public bicycles and e-scooters. In that case, there is the possibility of realizing shorter trips (or the 1st and last km) by micromobility vehicles, while public transport would be used for longer distances. In this way, the pressure on the public transport system would be significantly reduced, especially in specific situations such as the current pandemic.

As mentioned before, major consequences of COVID-19 have been recorded in the decrease of traffic, and changes in the modal share. Therefore, the main aim of this article is to examine the influence of the COVID-19 pandemic on the transport mode choice for different trip purposes. Also, a separate part of this article refers to the examination of various impact factors that result in a change of mode of transport. This aspect is particularly important for future timely response and selection of adequate measures in similar situations. This article focusses on the modal share changes in the city of Belgrade (Serbia) and their determinants. Given the current relevance of this topic, as well as its still insufficiently researched impact, especially in the field of transport and traffic system for the Serbia, the main reason for conducting this research is to provide information from the context of Belgrade, the capital of the Serbia. On the other hand, the importance of this article is reflected in providing useful knowledge about the behaviour of transport system users in emergency situations, which enables timely measures in similar situations, as well as facilitated actions of decision-makers in the future.

1. Methodology

1.1. Study structure and sample

For the purposes of this article, a short questionnaire was developed, which was composed of 3 parts. Accordingly, a quantitative research method was used for data collection. The research was conducted online through an internet survey, while the survey was realized for a period of 15 days, during the month of July 2020 for the city of Belgrade in the Serbia. This is the period when the lockdown was lifted, that is, when free movement is enabled again. In this way, the validity of the analysed data was provided due to the possibility of choosing all available modes of transport, as well as the analysis of different trip purposes during the pandemic. The questionnaire was sent by e-mail to multiple organizations, companies, faculties, student groups, schools as well as pensioners and employment organizations in order to obtain the representativeness of the population, and to include different population groups in the research. Due to the validity of the data, the goal was to include all age categories of users, which is why the questionnaire was sent to all available services, organizations and city institutions, that were willing and able to cooperate.

The questionnaire was divided into 3 main sections, as shown in Table 1.

The 1st section consists of 5 basic questions related to the socio-demographic and economic characteristics of the users: gender, age, education, profession and income. The 2nd section covers the users' patterns of behaviour examined through the average distance travelled and transport mode usage, before and during the pandemic, for the different trip purposes. Based on these questions, the authors wanted to obtain information on the average trip distance, which is done in one direction depending on the stated purposes. In this article, the following purposes were chosen: going to work/school, visit, shopping, recreation and leisure. The before-during question was used with the goal to determine how the occurrence of the COVID-19 pandemic affected the change of the mode of transport for the defined purposes. Accordingly, 2 questions were asked:

- *what movement type/mode of transport did you most often use for the stated purposes BEFORE the COVID-19 pandemic occurred?*
- *what movement type/mode of transport did you most often use for the stated purposes DURING the COVID-19 pandemic?*

The structure of the 2 mentioned questions is defined so as to cover the most common purposes of transport, as well as the most common modes of transport. The modes of transport chosen in this article were: a private car, public transport, walking, a bicycle and e-scooter, as shown in Table 1. The last, 3rd section contains one question by means of which the authors wanted to gain insight into the respondents' health safety perception of different modes of transport during the COVID-19 pandemic. The same 5 modes of transport were used in this question as in the previous 2. The authors of the article asked the respondents to answer the following question: *given the appearance of the COVID-19 virus and the need for physical distancing, evaluate the impact of certain types/modes of transport from the HEALTH SAFETY aspect*. A 5-step scale was used for this question, as shown in Table 1. All questions were of the closed-ended type. The incomplete answers, and respondents with missing data were excluded from further analysis, which reduced the total number of respondents to 1143.

Table 1. Questionnaire structure

1st section: Users' socio-demographic and economic characteristics				
Gender	Age	Education	Employment status	Monthly income
a) male	a) <18	a) primary school	a) permanently employed	a) without income
b) female	b) 18…25	b) high school	b) occasionally employed	b) <€250
	c) 26…35	c) faculty	c) student	c) €250…500
	d) 36…45		d) retiree	d) €501…750
	e) 46…55		e) unemployed	e) €751…1000
	f) 56…66			f) €1001…1250
	g) >66			g) €1251…1500
				h) >€1500

2nd section: Users' pattern behaviour						
What is the average travel distance you make in one direction for the following trip purposes? (Work/school; visit; shopping; recreation; leisure)						
a) <0.5 km	b) 0.5…1 km	c) 1…2 km	d) 2…3 km	e) 3…5 km	f) 5…8 km	g) >8 km

What way of movement/mode of transport did you most often use, BEFORE the COVID-19 pandemic occurred, for the stated purposes? (work/school; visit; shopping; recreation; leisure)				
a) private car	b) public transport	c) walking	d) bicycle	e) e-scooter

What way of movement/mode of transport did you most often use, DURING the COVID-19 pandemic, for the stated purposes? (work/school; visit; shopping; recreation; leisure)				
a) private car	b) public transport	c) walking	d) bicycle	e) e-scooter

3rd section: Self-awareness about health safety aspect of different modes of transport during COVID-19				
Given the appearance of the COVID-19 virus and the need for physical distancing, evaluate the impact of certain types/modes of transport from the HEALTH SAFETY aspect				
Private car	Public transport	Walking	Bicycle	E-scooter
5 step scale	*5 step scale*	*5 step scale*	*5 step scale*	*5 step scale*
1 – very unsafe	1 – very unsafe	1 – very unsafe	1 – very unsafe	1 – very unsafe
5 – very safe	5 – very safe	5 – very safe	5 – very safe	5 – very safe

1.2. Variables and statistical analysis

The data were analysed using IBM SPSS 22 (*https://www.ibm.com/support/pages/downloading-ibm-spss-statistics-22*). The McNemar–Bowker test of paired samples was used to determine the impact of the COVID-19 pandemic on the transport mode usage. The χ^2 test of independence and binary logistic regression were used in order to define influencing factors on the transport mode changes during the COVID-19 pandemic.

The article defines 11 hypotheses that can be classified into 3 groups, namely those related to: different trip purposes, socio-demographic characteristics and traffic characteristics (Table 2). The mentioned hypotheses are explained in more detail further in the article.

Firstly, the impact of the COVID-19 pandemic on the transport mode change for different trip purposes was analysed. Therefore, the following hypotheses were defined:

- H1: there is a statistically significant influence of COVID-19 on the choice of the mode of transport for the purpose of going to work/school;
- H2: there is a statistically significant influence of COVID-19 on the choice of the mode of transport for the visit purpose;
- H3: there is a statistically significant influence of COVID-19 on the choice of the mode of transport for the purpose of shopping;
- H4: there is a statistically significant influence of COVID-19 on the choice of the mode of transport for the purpose of recreation;
- H5: there is a statistically significant influence of COVID-19 on the choice of the mode of transport for the purpose of leisure.

Afterwards, socio-economic and traffic factors that may have an impact on the transport mode change during the COVID pandemic were analysed. With this in mind, the following hypotheses were defined:

- H6: there is a statistically significant influence of gender on the change of the mode of transport during the COVID-19 pandemic;
- H7: there is a statistically significant influence of the respondents' age on the change of the mode of transport during the COVID-19 pandemic;
- H8: there is a statistically significant influence of the education on the change of the mode of transport during the COVID-19 pandemic;
- H9: there is a statistically significant influence of the employment status on the change of mode of transport during the COVID-19 pandemic;
- H10: there is a statistically significant influence of the income on the change of the mode of transport during the COVID-19 pandemic;
- H11: there is a statistically significant influence of the trip distance on the change of the mode of transport during the COVID-19 pandemic.

Table 2. Structure and clustering of defined hypotheses

No	COVID-19 influence on the transport mode choice for the different trip purposes	Influence of socio-demographic characteristics on the transport mode change during COVID-19	Influence of traffic characteristics on the transport mode change during COVID-19
1	work/school	gender	average trip distance
2	visit	age	
3	shopping	education level	
4	recreation	employment status	
5	leisure	income	

Binary logistic regression has been used to a large extent in many traffic analyses. For example, Milenković *et al.* (2019) used binary logistic regression to determine factors that had an influence on users' willingness to accept the congestion pricing. In this article, binary logistic regression was carried out in order to estimate the impact of several factors on the likelihood that the users would change the transport mode during the pandemic. Also, this analysis served to estimate how well a set of predictors predicted or explained the dichotomous dependent variable – users' decision regarding the transport mode usage during the pandemic. 5 models were developed – one for each specific trip purpose (work/school, visit, shopping, recreation and leisure trips). In the models, the dependent variable, which refers to the change in the transport mode usage during the pandemic is classified as dichotomous. Independent variables such as gender, age, education level, employment status, average monthly income, average distance travelled and transport mode usage for different trip purposes are also classified as categorical. The category with the highest share of respondents was selected as a reference group.

The last part considers the research question that refers to the change in the respondents' health safety perceptions of different modes of transport during the COVID-19 pandemic. The basic idea of this question is to determine the "weakest link" in the city's transport offer, from the user's point of view, in order to potentially improve the resilience of certain modes of transport during the pandemic and similar situations in the future.

2. Results

2.1. Sample characteristics

The total sample consisted of 1143 respondents and it involved all categories regarding age, level of education, employment status, and income (Table 3). Within the analysed sample, a slightly higher percentage of the respondents were women (53%). When it comes to the age structure of the respondents, the most represented category included the respondents aged 19...25 (44.9%), followed by the respondents aged 26...35 (27.1%). The share of the graduated respondents was slightly bigger (56%) than the share of the non-graduated respondents (44%). Most of the respondents were permanently employed (40.6%). In terms of the average monthly income, most of the respondents had no income (31%), followed by those with the monthly income of €250...500 (21%) and those with the monthly income of €500...750 (18%). The gender structure of the city of Belgrade involves more women (52.6% of women compared to 47.4% of men). The employment rate in the area of Belgrade amounts to 51.5%, while the average net income in 2019 amounted to €582. Taking into account the age structure and socio-economic features of the respondents, one can conclude that the general characteristics of the sample correspond to the general characteristics of the population in Belgrade.

Table 3. Demographic and socio-economic characteristics of the respondents

Respondents characteristics	Number	%
Gender		
female	602	52.7
male	541	47.3
Age		
≤18	57	5.0
19...25	513	44.9
26...35	310	27.1
36...45	102	8.9
46...55	91	8.0
56...65	42	3.7
≥65	28	2.4
Education level		
non graduated	505	44.2
graduated	638	55.8
Employment status		
permanently employed	464	40.6
occasionally employed	133	11.6
student	427	37.4
retiree	46	4.0
unemployed	73	6.4
Income		
no income	351	30.7
<€250	131	11.5
€250...500	236	20.6
€501...750	207	18.1
€751...1000	104	9.1
>€1000	114	10.0

2.2. Impact of the COVID-19 pandemic on the transport mode choice for different trip purposes

Public transport was a dominant mode of transport for travelling for work purposes before the pandemic, as shown in Table 4. However, its usage significantly decreased during the pandemic, and the private car was the dominant mode of transport.

For travelling for the visit purpose, the private car was also the dominant transport mode, regardless of whether there was the pandemic or not. It should be underlined that walking was the dominant for the remaining trip purposes. Namely, walking is the most frequent mode of travelling for the purpose of shopping, recreation and leisure, regardless of the pandemic's occurrence. The results of McNemar–Bowker test of paired samples are shown in Table 5.

On the basis of the presented analysis, it can be concluded that the COVID-19 pandemic had a statistically significant impact on the transport mode change, regardless of the trip purpose. The transport mode changes shown in Table 4 are particularly evident for work and visit trips, as confirmed by the values of the McNemar–Bowker test. There were also significant changes regarding the use of public transport during the pandemic compared to its use in the period before the pandemic. In general, the percentage of the public transport use significantly decreased during the pandemic, regardless of the trip purpose. Consequently, the percentage of the use of other modes of transport increased. The highest share was achieved by private cars, while a number of users started using micromobility vehicles. Such results were confirmed empirically, i.e., by simple field observations, with a significantly smaller number of public transport users during the pandemic, compared to the period before the pandemic.

Table 4. Transport mode usage, by purpose, before and during the COVID-19 pandemic

Transport mode	Before COVID-19		During COVID-19	
	Number	%	Number	%
Work/school				
private car	309	28.2	450	41.0
public transport	490	44.7	285	26.0
walking	244	22.2	286	26.1
bicycle	25	2.3	38	3.5
e-scooter	29	2.6	38	3.5
Visit				
private car	444	38.8	518	45.3
public transport	404	35.3	207	18.1
walking	249	21.8	339	29.7
bicycle	26	2.3	39	3.4
e-scooter	20	1.7	40	3.5
Shopping				
private car	367	32.1	442	38.7
public transport	180	15.7	88	7.7
walking	556	48.6	565	49.4
bicycle	33	2.9	38	3.3
e-scooter	7	0.6	10	0.9
Recreation				
private car	134	11.7	191	16.7
public transport	103	9.0	48	4.2
walking	743	65.0	730	63.9
bicycle	144	12.6	148	12.9
e-scooter	19	1.7	26	2.3
Leisure				
private car	231	20.2	290	25.4
public transport	214	18.7	104	9.1
walking	552	48.3	602	52.7
bicycle	107	9.4	107	9.4
e-scooter	39	3.4	40	3.5

2.3. Impact factors on the transport mode change due to the COVID-19 pandemic

2.3.1. Descriptive statistics for work/school trips

Due to the significance and share of work trips in the total distribution of daily trips, the following part of the article thoroughly presents the model and analysis results only for travelling with the purpose of going to work/school.

Table 6 shows the results of the descriptive statistics and the χ^2 test of independence for work/school trips. The obtained results show that the variables relating to gender, age and mode of transport have a statistically significant relationship with the users' transport mode change for work trips ($\chi^2 = 5.209$, $p = 0.022$; $\chi^2 = 15.032$, $p = 0.010$; $\chi^2 = 199.603$, $p < 0.001$, respectively).

Although the parameter of the average distance travelled was not statistically significant, a few interesting results obtained in the analysis will be mentioned here. The results of the analysis regarding the change of the private car usage showed an increase in the usage of this mode of transport during the pandemic. This increase is particularly evident for travelling for work purposes regardless of the distance travelled. For instance, for distances <1 km,

Table 5. McNemar–Bowker test of paired samples of transport mode usage before and during the COVID-19 pandemic, for different travel purposes

Before/during	Work/school		Visit		Shopping		Recreation		Leisure	
	χ^2-value	p-value	χ^2-value	p-value	χ^2-value	p-value	χ^2-value	p-value	χ^2-value	p-value
Transport mode*	197.72	<0.001	195.19	<0.001	83.54	<0.001	73.66	<0.001	103.87	<0.001

Note: * – transport modes analysed in this table are: private car, public transport, walking, bicycle and e-scooter.

Table 6. Descriptive statistics and the results of the χ^2 test of independence for work/school trips

Characteristic	Transport mode change (work/school)				χ^2-value	*p*-value
	No		Yes			
	Number	%	Number	%		
Gender						
male	418	79.6	107	20.4	5.209	0.022
female	422	73.8	150	26.2		
Age						
≤18	50	87.7	7	12.3	15.032	0.010
19…25	369	71.9	144	28.1		
26…35	244	78.7	66	21.3		
36…45	84	83.2	17	16.8		
46…55	70	82.4	15	17.6		
56…65	23	74.2	8	25.8		
Education level						
non graduated	367	79.1	97	20.9	2.852	0.091
graduated	473	74.7	160	25.3		
Employment status						
permanently employed	359	77.4	105	22.6	5.072	0.167
occasionally employed	106	79.7	27	20.3		
student	314	73.5	113	26.5		
unemployed	61	83.6	12	16.4		
Income						
no income	268	76.4	83	23.6	7.293	0.200
<€250	101	80.2	25	19.8		
€250…500	156	74.6	53	25.4		
€501…750	139	71.3	56	28.7		
€751…1000	83	81.4	19	18.6		
>€1000	93	81.6	21	18.4		
Transport mode						
private car	290	93.9	19	6.1	199.603	<0.001
public transport	277	56.5	213	43.5		
walking	225	92.2	19	7.8		
bicycle	21	84.0	4	16.0		
e-scooter	27	93.1	2	6.9		
Average distance travelled						
<0.5 km	80	82.5	17	17.5	5.404	0.493
0.5…1 km	86	74.8	29	25.2		
1…2 km	118	79.2	31	20.8		
2…3 km	119	71.3	48	28.7		
3…5 km	109	76.8	33	23.2		
5…8 km	135	77.6	39	22.4		
>8 km	193	76.3	60	23.7		

the private car usage increased by 6%, while for distances larger than 8 km, the private car use rose by 23%. It should be also underlined that there was a rise of the private car use with the increase in the average distance travelled for both observed time periods (both before and during the pandemic).

During the pandemic, the greatest percentage decrease was observed for the use of public transport for all trip purposes, regardless of the distance travelled. For example, in case of travelling for work purposes, the public transport usage decreased by 13.4% for shorter distances (<1 km), while the decrease of 22% was recorded for distances greater than 8 km.

When analysing walking during the pandemic, the results showed the increase in this travel mode for distances <3 km, regardless of the trip purpose. If only travelling for work purposes is considered, this increase amounts to 7% for distances <3 km. In general, walking is the most frequent travelling mode for the shortest distances. For instance, out of all respondents who walked, the largest percentage was recorded for distances <2 km (29%) for travelling with the purpose of going to work/school.

The bicycle usage recorded an increased trend during the pandemic. For work trips, the most significant increase was registered for distances 1…3 km, amounting to 2%.

When it comes to e-scooters, they are mostly used at the 0.5…3 km distances for all trip purposes regardless of the pandemic's occurrence. Travelling for leisure purposes is the exception since here the largest share of e-scooters is recorded for 1..5 km distances. The greatest increase in the use of this mode of transport during the pandemic was registered for travelling for visit purposes for 0.5…1 km distances, amounting to 4%. For work trips, the greatest rise of the e-scooter use during the pandemic was recorded for the distances of 3…5 km and 5…8 km (2.8 and 2.2%, respectively).

2.3.2. Results of the model of the transport mode change for work/school trips

The preliminary model for travelling for work purposes included the variables such as gender, age, level of education, employment status, income, transport mode and average distance travelled. It had a higher predictive power than the null model (χ^2 = 271.637; p < 0.01) and explained 33.1% of the variance of the dependent variable (R_N^2 = 0.331).

The final model presented in Table 7 contained only the variables, which were proven to be statistically significant in the preliminary model (income, transport mode and average distance travelled). It had a greater predictive power than the null model (χ^2 = 264.168; p < 0.001) and it explained 32.3% of the variance of the dependent variable (R_N^2 = 0.323).

The obtained results show that the respondents with the income lower than €250 have a 1.8 times higher chance, those with the €250…500 income have a 2.8 times higher chance, while those with the €751…1000 income have a 2.5 times higher chance to change the mode of transport during the pandemic in comparison to the respondents without any monthly income. On the other hand, the analysis of the mode of transport used before the pandemic shows that private car users have a 19.2 times lower chance, those who walk to work/school have a

23.3 times lower chance, those who use bicycles have a 4.4 times lower chance, while those using e-scooters have a 14.9 times lower chance to change the mode of transport than the public transport users.

Taking into account the average distance travelled to work/school, it can be seen that the respondents with the average travelled distance <0.5 km have a 3.8 higher chance to change the mode of transport, those with the 0.5…1.0 km travelled distance have a 4.4 times higher chance, while those with the 1.0…2.0 km travelled distance have a 2 times higher chance to change the mode of transport when compared to the respondents with the average travelled distance from 5.0 to 8.0 km.

2.3.3. Descriptive statistics for other trip purposes

The analysis of other trip purposes provided similar results to the results obtained for travelling for work/school purposes. For instance, the results show that female respondents are more inclined to change the mode of transport than male respondents, regardless of the trip purpose. Both examined groups had the highest percentage changes regarding travelling for visit purposes (31% of females and 22% of males changed the mode of transport).

Table 7. The final model of the binary logistic regression – transport mode change for work/school trips

	Transport mode change for work/school trips				
	Wald *Z*	*p*-value	Odds ratio	95% confidence interval	
				lower	upper
Intercept	***1.623***	***0.203***	***0.577***		
Income	***29.039***	***0.000***			
no income (ref.)					
<€250	6.748	0.009	1.844	1.162	2.926
€250…500	17.573	0.000	2.776	1.722	4.474
€501…750	2.784	0.095	1.744	0.907	3.354
€751…1000	7.179	0.007	2.439	1.270	4.683
>€1000	1.511	0.219	0.709	0.410	1.227
Transport mode	***174.024***	***0.000***			
public transport (ref.)					
private car	112.926	0.000	0.052	0.030	0.089
walking	90.755	0.000	0.043	0.022	0.082
bicycle	6.900	0.009	0.226	0.074	0.685
e-scooter	12.609	0.000	0.067	0.015	0.298
Average distance travelled	***22.213***	***0.001***			
5…8 km (ref.)					
<0.5 km	9.122	0.003	3.756	1.591	8.864
0.5…1 km	15.902	0.000	4.358	2.114	8.985
1…2 km	4.656	0.031	2.023	1.067	3.838
2…3 km	1.966	0.161	1.487	0.854	2.587
3…5 km	0.228	0.633	1.157	0.636	2.103
>8 km	0.145	0.704	1.105	0.660	1.853

The analysis of the transport mode change per age category shows that the respondents aged 19…25 had the highest percentage of the transport mode change in comparison to all other age groups. For example, 33% of the respondents aged 19…25 changed the mode of transport for travelling for visit purposes, while 25% of the respondents changed the mode of transport for travelling for leisure, which accounts for the largest percentage change among all trip purposes.

The level of education shows that the graduated respondents are more inclined to change the mode of transport for 2 out of 4 trip purposes (visit and recreation) in comparison to the non-graduated respondents.

The employment status shows that students and occasionally employed respondents are more inclined to change the mode of transport than other user categories. For instance, it is interesting to mention that the transport mode was most often changed for travelling for visit purposes regarding all user categories.

The analysis of the users' income showed that the lowest transport mode change was recorded for the respondents with the highest income, i.e., the income higher than €1000, for all trip purposes except for recreation trips.

The results related to the transport mode change depending on the transport mode used before the pandemic should also be mentioned. In general, the largest number of the respondents changed the mode of transport regardless of the trip purpose if they had previously used the public transport. The largest percentage of change was perceived for travelling for shopping purposes (62% of the respondents changed the mode of transport).

Analysing the average distance travelled, it was determined that at the 2…3 km distance, the greatest number of the respondents changed the mode of transport for travelling for shopping purposes (25% of the respondents). For the 0.5…1 km distances, 38% of the respondents changed the mode of transport for visit purposes. It is interesting to mention that the shortest distances (<0.5km) registered the largest percentage of transport mode changes for recreation trips.

2.3.4. Results of the model of the transport mode change for other trip purposes

When it comes to all the remaining trip purposes, travelling for visit purposes explained the greatest percentage of the variance of the dependent variable – 33.8%. The smallest percentage of the variance of the dependent variable was explained by the model for travelling for shopping purposes – only 4.1%.

Generally speaking, the results show a significant trend regarding the impact of gender on the transport mode change. Namely, males have a generally lower chance to change the mode of transport during the pandemic than females, regardless of the trip purpose. If the trip purposes are considered separately, it can be noticed that trips for visit purposes have the largest number of factors, which have a statistically significant influence on the transport

mode change during the pandemic. For instance, when it comes to travelling for visit purposes, the respondents who previously used a private car, bicycle, e-scooter or walked have a significantly lower chance to change the mode of transport during the pandemic than the public transport users. The same situation refers to recreation and leisure trips. In addition, the average distance travelled has a significant impact on the transport mode change for travelling with the purpose of visit. The users who travelled shorter distances (<3 km) had a significantly higher chance to change the mode of transport during the pandemic than the respondents who travelled the average distance of 5...8 km. In addition, the respondents with the monthly income lower than €250 have a lower chance to change the mode of transport during the pandemic than the respondents with no income. The results show that the retirees have a significantly lower chance to change the mode of transport for visit trips in comparison to the permanently employed respondents. Furthermore, the non-graduated respondents have a lower chance to change the mode of transport than the graduated respondents.

2.3.5. Users' attitudes towards the health safety of different modes of transport during the pandemic

Several significant characteristics can be seen in Figure, which shows the users' attitudes towards the health safety of the selected modes of transport during the COVID-19 pandemic. 1st, it can be noticed that a very high percentage of the users positively evaluated all the presented modes of transport except the public transport. If the respondents with the evaluation "very safe" and "safe" are observed together, their share for each mode of transport separately is higher than 70%. The total of 84% of the respondents evaluated a private car as the safest mode of transport from the health aspect, while 83% of the respondents selected walking, 84% bicycles and 73% e-scooters as the safest mode of transport.

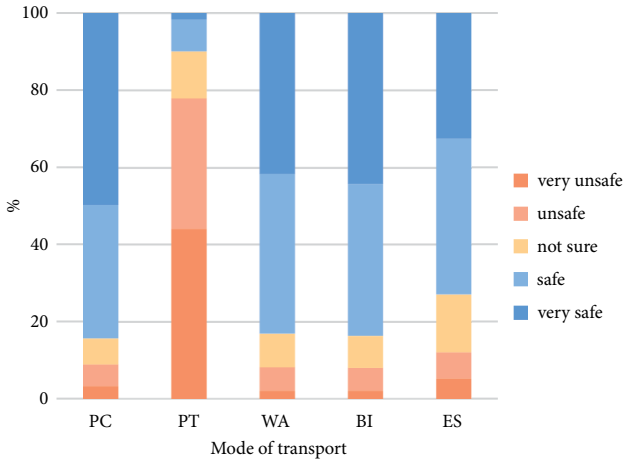

Figure. User attitudes about health aspect of different modes of transport during COVID-19 pandemic (abbreviations shown on the diagram have the following meaning: PC – private car, PT – public transport, WA – walking, BI – bicycle, ES – e-scooter)

On the other hand, highly negative evaluations assigned to the subsystem of the urban public passenger transport represent a very significant indicator. The total of 78% of the respondents evaluated the public transport as a "very unsafe" and "unsafe" mode of transport, 12% of the respondents were neutral, while only 10% of the respondents evaluated this mode of transport as "safe" or "very safe".

The mentioned results point to the fact that the public transport is actually the "weakest link" during the pandemic situation we are in now. Accordingly, the public transport subsystem requires significant attention from traffic engineers and decision-makers, in order to ensure its resilience during similar situations in the future. Bearing in mind that this subsystem represents an important part in the development of modern and sustainable cities, its improvement and more active treatment in the future is certainly needed (Bajčetić *et al.* 2018; Susnienė 2012).

3. Discussion

In general, the urban public transport has experienced the most evident usage decrease during COVID-19, which differs depending on the country (Jenelius, Cebecauer 2020). The results shown in this article correspond to the mentioned findings, primarily in terms of the noticeable decrease of the public transport use amounting to 12% on average regardless of the trip purpose. The greatest percentage of decrease was determined for travelling for work purposes (as much as 19%), as well as for the purpose of going to a visit (17%). At this point, it is important to mention the measures adopted by the city of Belgrade, which relate to the maintenance of the share of public transport in the modal split. For example, the city authorities proposed the maximum number of passengers that can be in the vehicle at the same time, in order to ensure more space and required physical distance. Also, every passenger was required to wear a face mask during the ride. Another interesting measure includes the type of the vehicle in operation. Namely, on some lines (where certain traffic and spatial conditions are met), instead of standard buses, trams or trolleybuses, larger capacity vehicles (articulated buses, trams and trolleys) were used, in order to maintain more conformity and physical distance. Moreover, special signage was designed at the bus stops to remind and guide passengers to maintain physical distance. Similar measures were applied to a large number of public facilities (schools, hospitals, etc.). Also, a special operation mode of certain institutions has been defined, as well as "time windows" when certain user groups can perform regular activities (dog walking, shopping, paying bills, etc.), in order to reduce the burden on the public transport system. Although there was resistance to some proposals at the beginning, users soon complied with the proposed measures, bearing in mind that these were the conditions for safe use of the public transport, while meeting the basic requirements and recommendations of

the Ministry of Health. In general, the user's willingness for fast changes and action in such situations will largely determine the success of the applied measures. A large number of countries, in the 1st period, failed to bring the pandemic under control precisely because of the indecision and unwillingness of users-people.

Other results in this article show that there was an increase in the private car use as a means of transportation during the pandemic for all trip purposes. Private cars can be regarded as more suitable and safer means of transportation from the health safety aspect than the public transport vehicles, which explains this result. Our results for Serbia align with the findings of Eisenmann *et al.* (2021) for Germany and point to a decrease in the use of public transport compared to an increase in the use of private cars.

It should also be mentioned that a certain number of users have started using bicycles, e-scooters and walking, which confirms the potential and possibility of these modes of transport to respond to the unexpected traffic changes and satisfy the existing movement demands during the pandemic.

In general, the results presented in this article show the significant impact of the COVID-19 virus on the transport mode change regardless of the trip purpose. This result can be explained by the users' caution or fear degree, which leads to using safer transport modes from the health aspect and those which provide a certain degree of physical distancing, primarily private cars. A survey of more than 10000 Chinese students examined the basic reasons for worry and fear while travelling and studying abroad during the pandemic. As many as 79% of the respondents stated that they were "very worried" for their own health (Durnin 2020). Therefore, the preventive measures related to the transport mode usage or change are absolutely justified, as confirmed by the results in this article.

We should mention the use of bicycles, the user's distance travelled and changes in the usage of this mode of transport. As already mentioned, the occurrence of the pandemic has not led to the general decrease of bicycle usage. On the contrary, the bicycle usage increased. Although small changes were recorded, there was an increase in cycling at the distances greater than 5 km for recreation purposes. These results have been expected bearing in mind the nature of the pandemic. The authors of this article believe that this result is the consequence of the insufficiently developed infrastructure intended for these traffic users. Namely, this user share would be considerably higher if there were the suitable cycling infrastructure in the territory of the city of Belgrade.

The role of e-scooters should also be underlined. During the pandemic, their usage increased to the greatest degree for travelling for work/school purposes and visits. Regarding work trips, the largest rise of the e-scooter usage was recorded for shorter distances, primarily 3…5 km distances (3%). These are the distances where the largest number of e-scooter users was registered regardless of the research period (before or during the pandemic). These results correspond to global experiences (Mathew *et al.* 2019; PBOT 2018), which indicate the potential of e-scooters to become a competitive mode of transport at the mentioned distances (Glavić, Milenković 2019; Trpković *et al.* 2019), and to fill the gap between walking and public transport use.

The analysis of different factors that have the influence on the transport mode change during the pandemic has provided several significant conclusions. 1st, the obtained results show that the respondents' gender has a statistically significant influence on the transport mode change for all purposes except for travelling with the purpose of going to work/school. In general, male respondents are less inclined to the transport mode change than female ones, although research has confirmed that men are more prone to the risk of COVID-19 (Mirsoleymani, Nekooghadam 2020). On the other hand, the research has shown that women generally accept and conduct the preventive measures in a more favourable way (Agüero *et al.* 2011). Therefore, the obtained results are mainly expected, particularly considering the men's lowered caution in these situations.

The variable related to the transport mode used before the pandemic also has a statically significant influence – each category within this variable is influential for all trip purposes except for trips for shopping purposes. The obtained results show that the respondents using private cars, bicycles, e-scooters or walk have a significantly lower chance to change the mode of transport due to the COVID-19 pandemic than the public transport users. This result is also expected having in mind the basic features of this system. In fact, the basic idea and goal of this system is mass transportation, i.e., simultaneous transportation of a large number of people located in the common space (bus, carriage, and alike). This feature has become the major shortcoming of the public transport system during the pandemic. On the other hand, all other modes of transport/movement enable individual ("distanced") travelling, which decreases the risk of the virus transmission and infection rate.

Income also has a statistically significant influence on the transport mode change due to the COVID-19 pandemic. This variable is statistically significant for travelling for the purpose of going to work/school and visits. When it comes to travelling to work, the respondents with the income amounting to <€250, €250…500 and €751…1000 have a higher chance to change the transport mode during the pandemic than the respondents without monthly income. This result can be explained from the economic aspect, since people with higher income can afford the transport mode change, while people with no income may find it difficult. The transport mode change might require additional external costs such as fuel costs, ticket costs, etc. This group of trips also involves travelling to and from school, where a certain number of respondents without income includes people younger than 18. These people are usually limited to only one mode of transport – walk-

ing if distances are short. In case of longer distances, these respondents use public transport. The reason why this respondent group has a lower chance to change the mode of transport can be seen in their limitation to use other modes of transport.

The criterion related to the average distance travelled has a statistically significant influence on the change of the mode of transport during the pandemic for work/school, visit and leisure trips. The statistically significant results were obtained only for the groups of the respondents who covered the average distances <2 km. When it comes to work trips, these are the respondents with the average travelled distances <0.5 km, 0.5…1 km and 1…2 km. For trips with the purpose of visit, these are the respondent groups covering the average distances <0.5 km, 0.5…1 km, 1…1.5 km and 1.5…2 km. For leisure trips, the statistically significant results were obtained for the respondent group with the average distance travelled <0.5 km. All mentioned respondent groups have significantly higher chances to change the mode of transport than the reference group. The explanation can be found in the length of the distance travelled. All the respondents prone to the transport mode change travel shorter distances for which different transport modes/types of movement can be used (cars, public transport, walking, bicycles and e-scooters). On the other hand, out of the offered modes of transport, the respondents from the reference group can use only a private car or public transport for their trip distances. Similar results were obtained in another study (Ma *et al.* 2020), where the authors confirmed that the transport mode choice was sensitive to the change of distance and that there was a negative correlation between these variables. For the reference group, the transport mode change would require additional costs mentioned in the previous paragraph. For instance, if they do not possess a private car, public transport users would not probably decide to buy one. In addition, there is a low probability for private car users to change the mode of transport and start using public transport during the pandemic. Namely, in their research, numerous authors have already confirmed that the availability or possession of a private car significantly decreases the probability of using some other mode of transport (Halldorsdottir *et al.* 2011; Heinen, Chatterjee 2015; Scheiner 2010), which is why this parameter is not analysed in more detail in this article.

The last question for the respondents presented in the article is related to the subjective attitude of the respondents towards the health safety of the offered modes of transport during the pandemic. The responses to this question add to the presented results and mainly explain different behaviours of the respondents regarding the transport mode change. The detailed analysis of this indicator determined that as many as 78% of the respondents evaluated the public transport as "very unsafe" and "unsafe", while only 10% of the respondents felt "very safe" and "safe" in the public transport vehicles. These results correspond to the results of the research conducted in the Netherlands and Australia (Beck, Hensher 2020b; De Haas *et al.* 2020). On the other hand, the respondents evaluated the following modes of transport as "very safe" and "safe" in total: private car (84% of the respondents), walking (83% of the respondents), bicycle (84% of the respondents) and e-scooter (73% of the respondents). The low percentage of safety in the public transport vehicles is a consequence of the organization of passenger transport where all users are obliged to share a very small space. Other modes of transport enable individual movement and realization of travelling while distancing from other traffic participants, which represents an advantage in the given situation.

Conclusions

This article analysed and presented the results of the impact of the COVID-19 pandemic on the user behaviour and transport mode change, as well as the factors, which influenced the change of the mode of transport during the pandemic. In addition, the analysis included the users' attitudes towards the health safety of different transport modes during the pandemic in Belgrade. The results showed that the COVID-19 pandemic had a significant influence on the transport mode choice regardless of the trip purpose. These findings were additionally emphasized in the users' attitudes about the health safety of different transport modes. A significant number of users stated that the public transport represented an exceptionally unsafe mode of transport from the health aspect during the pandemic, which was also confirmed empirically, i.e., by simple field observations, with a smaller number of passengers using public transport during the pandemic, compared to the period before the pandemic. The obtained results showed that the key factors influencing the transport mode change were the respondents' gender, level of education, income, the transport mode used before the pandemic and the average distance travelled, depending on the trip purpose. The mentioned data indicate that in the future, transport engineers in such situations should pay special attention to characteristic population categories (e.g., with lower and middle incomes, users who travel short distances, etc., who are prone to changes in the type of transport), and provide them with an adequate alternative, i.e., ensure the resilience of the transport system in such situations, reduce the number of potential transfers, or, in an ideal situation, direct the transfer of users towards sustainable ways of movement: walking, cycling, etc.

It should be highlighted that the respondents who travelled shorter average distances had a significantly higher chance to change the mode of transport. This finding indicates that the alternative modes of transport such as bicycles, e-scooters and walking can have an important role in these situations. In fact, these modes of transport represent a very good alternative to the public transport, considering their ability to efficiently respond to sudden changes like the ones we have witnessed. Moreover, the contribution of these modes of transport can be realized

by integrating them with the public transport, which would considerably decrease the share of private cars in the modal share in the post-pandemic period. This is one of the important results of this work, which can serve to the transport engineers/professionals as a guideline for the formation of a resilient transport system, which will be able to respond to similar needs and situations in the future.

Generally speaking, the outbreak of the COVID-19 virus has shown that measures and activities should be directed at users themselves in certain situations. The traffic system could not cope with the fast changes but users accepted them easily and adapted them to their own needs and activities. Although the public transport has stagnated during the long period of the pandemic, other modes of transport can spontaneously alleviate the lack of this subsystem, as shown in the article. In addition, this pandemic can help us reach certain conclusions related to the operation of a city's traffic system and its infrastructural capacities. Namely, the obtained results have pointed at certain shortcomings and advantages of different modes of transport in unexpected situations such as the COVID-19 pandemic, which primarily asked for the physical distance of users. Therefore, decision-makers must consider such circumstances when planning a city's traffic system in order to minimize the effects of this and similar situations. The user aspect should be taken into account, and users should be encouraged to use ecologically more suitable and healthier modes of transport/movement such as bicycles, e-scooters or walking in these situations.

The limitation of the article potentially reflects through the sample size and the research area. Although the collected data and respondent number satisfy the requirements of this study, the sample could be additionally increased to involve the respondents from other areas and cities, since the article analysed only the area of the city of Belgrade (Serbia). Additional significant influential factors on the users' behaviour during the pandemic or similar emergency situations, which can be further examined are the following: informing of users and introducing incentive measures for using certain modes of transport; experience and knowledge acquired in similar situations; and the impact of the environment or media. In addition, an interesting part of the future research would be the analysis of the pandemic impact on the movement characteristics of elderly users, e.g., the level of activity of various subcategories within this group, as one of the riskier user's categories.

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References

Abdullah, M.; Dias, C.; Muley, D.; Shahin, M. 2020. Exploring the impacts of COVID-19 on travel behavior and mode preferences, *Transportation Research Interdisciplinary Perspectives* 8: 100255. https://doi.org/10.1016/j.trip.2020.100255

Agüero, F.; Adell, M. N.; Giménez, A. P.; López Medina, M. J.; Continente, X. G. 2011. Adoption of preventive measures during and after the 2009 influenza A (H1N1) virus pandemic peak in Spain, *Preventive Medicine* 53(3): 203–206. https://doi.org/10.1016/j.ypmed.2011.06.018

Anke, J.; Francke, A.; Schaefer, L.-M.; Petzoldt, T. 2021. Impact of SARS-CoV-2 on the mobility behaviour in Germany, *European Transport Research Review* 13: 10. https://doi.org/10.1186/s12544-021-00469-3

Bajčetić, S.; Tica, S.; Živanović, P.; Milovanović, B.; Đorojević, A. 2018. Analysis of public transport users' satisfaction using quality function deployment: Belgrade case study, *Transport* 33(3): 609–618. https://doi.org/10.3846/transport.2018.1570

Beck, M. J.; Hensher, D. A. 2020a. Insights into the impact of COVID-19 on household travel and activities in Australia – the early days of easing restrictions, *Transport Policy* 99: 95–119. https://doi.org/10.1016/j.tranpol.2020.08.004

Beck, M. J.; Hensher, D. A. 2020b. Insights into the impact of COVID-19 on household travel and activities in Australia – the early days under restrictions, *Transport Policy* 96: 76–93. https://doi.org/10.1016/j.tranpol.2020.07.001

Beck, M. J.; Hensher, D. A.; Wei, E. 2020. Slowly coming out of COVID-19 restrictions in Australia: Implications for working from home and commuting trips by car and public transport, *Journal of Transport Geography* 88: 102846. https://doi.org/10.1016/j.jtrangeo.2020.102846

Bucsky, P. 2020. Modal share changes due to COVID-19: the case of Budapest, *Transportation Research Interdisciplinary Perspectives* 8: 100141. https://doi.org/10.1016/j.trip.2020.100141

Dam, P.; Mandal, S.; Mondal, R.; Sadat, A.; Chowdhury, S. R.; Mandal, A. K. 2020. COVID-19: impact on transport and mental health, *Journal of Transport & Health* 19: 100969. https://doi.org/10.1016/j.jth.2020.100969

De Haas, M.; Faber, R.; Hamersma, M. 2020. How COVID-19 and the Dutch 'intelligent lockdown' change activities, work and travel behaviour: evidence from longitudinal data in the Netherlands, *Transportation Research Interdisciplinary Perspectives* 6: 100150. https://doi.org/10.1016/j.trip.2020.100150

Durnin, M. 2020. *COVID-19 Update: China Survey Results*. British Council, UK. Available from Internet: https://opportunities-insight.britishcouncil.org/insights-blog/covid-19-update-china-survey-results

Eisenmann, C.; Nobis, C.; Kolarova, V.; Lenz, B.; Winkler, C. 2021. Transport mode use during the COVID-19 lockdown period in Germany: the car became more important, public transport lost ground, *Transport Policy* 103: 60–67. https://doi.org/10.1016/j.tranpol.2021.01.012

Glavić, D.; Milenković, M. 2019. Electric micro mobility vehicles technologies, opportunities, assessment and forecast, in *7th International Conference "Towards a Humane City: Environmentally Friendly Mobility"*, 6–7 December 2019, Novi Sad, Serbia, 199–205.

Halldorsdottir, K.; Christensen, L.; Jensen, T. C.; Prato, C. G. 2011. Modelling mode choice in short trips: shifting from car to bicycle, in *European Transport Conference 2011*, 10–12 October 2011, Glasgow, Scotland, 1–21. Available from Internet: https://aetransport.org/public/downloads/Tylq7/4904-514ec5fd34e78.pdf

Hattrup-Silberberg, M.; Hausler, S.; Heineke, K.; Laverty, N.; Möller, T.; Schwedhelm, D.; Wu, T. 2020. *Five COVID-19 after Shocks Reshaping Mobility's Future*. McKinsey & Company. Available from Internet: https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/five-covid-19-after-shocks-reshaping-mobilitys-future

Heinen, E.; Chatterjee, K. 2015. The same mode again? An exploration of mode choice variability in Great Britain using the national travel survey, *Transportation Research Part A: Policy and Practice* 78: 266–282. https://doi.org/10.1016/j.tra.2015.05.015

Hong, J.; McArthur, D.; Raturi, V. 2020. Did safe cycling infrastructure still matter during a COVID-19 lockdown?, *Sustainability* 12(20): 8672. https://doi.org/doi:10.3390/su12208672

Hudda, N.; Simon, M. C.; Patton, A. P.; Durant, J. L. 2020. Reductions in traffic-related black carbon and ultrafine particle number concentrations in an urban neighborhood during the COVID-19 pandemic, *Science of the Total Environment* 742: 140931. https://doi.org/10.1016/j.scitotenv.2020.140931

Jenelius, E.; Cebecauer, M. 2020. Impacts of COVID-19 on public transport ridership in Sweden: analysis of ticket validations, sales and passenger counts, *SSRN* 2020: 3641536. https://doi.org/10.2139/ssrn.3641536

Lee, H.; Park, S. J.; Lee, G. R.; Kim, J. E.; Lee, J. H.; Jung, Y.; Nam, E. W. 2020. The relationship between trends in COVID-19 prevalence and traffic levels in South Korea, *International Journal of Infectious Diseases* 96: 399–407. https://doi.org/10.1016/j.ijid.2020.05.031

Lemke, M. K.; Apostolopoulos, Y.; Sönmez, S. 2020. Syndemic frameworks to understand the effects of COVID-19 on commercial driver stress, health, and safety, *Journal of Transport & Health* 18: 100877. https://doi.org/10.1016/j.jth.2020.100877

Li, X.; Farrukh, M.; Lee, C.; Khreis, H.; Sarda, S.; Sohrabi, S.; Zhang, Z.; Dadashova, B. 2022. COVID-19 impacts on mobility, environment, and health of active transportation users, *Cities* 131: 103886. https://doi.org/10.1016/j.cities.2022.103886

Ma, S.; Yu, Z.; Liu, C. 2020. Nested logit joint model of travel mode and travel time choice for urban commuting trips in Xi'an, China, *Journal of Urban Planning and Development* 146(2): 04020020. https://doi.org/10.1061/(asce)up.1943-5444.0000574

Mars, L.; Arroyo, R.; Ruiz, T. 2022. Mobility and wellbeing during the COVID-19 lockdown. Evidence from Spain, *Transportation Research Part A: Policy and Practice* 161: 107–129. https://doi.org/10.1016/j.tra.2022.05.004

Mathew, J. K.; Liu, M.; Seeder, S.; Li, H.; Bullock, D. M. 2019. Analysis of e-scooter trips and their temporal usage patterns, *ITE Journal* 89(6): 44–49.

Milenković, M.; Glavić, D.; Maričić, M. 2019. Determining factors affecting congestion pricing acceptability, *Transport Policy* 82: 58–74. https://doi.org/10.1016/j.tranpol.2019.08.004

Mirsoleymani, S.; Nekooghadam, S. M. 2020. Risk factors for severe coronavirus disease 2019 (COVID-19) among Iranian patients: who was more vulnerable?, *SSRN* 2020: 3566216. https://doi.org/10.2139/ssrn.3566216

Musselwhite, C.; Avineri, E.; Susilo, Y. 2020. Editorial JTH 16 –The Coronavirus Disease COVID-19 and implications for transport and health, *Journal of Transport & Health* 16: 100853. https://doi.org/10.1016/j.jth.2020.100853

Orro, A.; Novales, M.; Monteagudo, Á.; Pérez-López, J.-B.; Bugarín, M. R. 2020. Impact on City bus transit services of the COVID–19 lockdown and return to the new normal: the case of a Coruña (Spain), *Sustainability* 12(17): 7206. https://doi.org/10.3390/su12177206

PBOT. 2018. *2018 E-Scooter Findings Report*. Portland Bureau of Transportation (PBOT), Portland, OR, US. 36 p. Available from Internet: https://www.portland.gov/sites/default/files/2020-04/pbot_e-scooter_01152019.pdf

Scheiner, J. 2010.Interrelations between travel mode choice and trip distance: trends in Germany 1976–2002, *Journal of Transport Geography* 18(1): 75–84. https://doi.org/10.1016/j.jtrangeo.2009.01.001

Sharifi, A.; Khavarian-Garmsir, A. R. 2020. The COVID-19 pandemic: impacts on cities and major lessons for urban planning, design, and management, *Science of the Total Environment* 749: 142391. https://doi.org/10.1016/j.scitotenv.2020.142391

Stavrinos, D.; McManus, B.; Mrug, S.; He, H.; Gresham, B.; Albright, M. G.; Svancara, A. M.; Whittington, C.; Underhill, A.; White, D. M. 2020. Adolescent driving behavior before and during restrictions related to COVID-19, *Accident Analysis & Prevention* 144: 105686. https://doi.org/10.1016/j.aap.2020.105686

Sui, Y.; Zhang, H.; Shang, W.; Sun, R.; Wang, C.; Ji, J.; Song, X.; Shao, F. 2020. Mining urban sustainable performance: spatio-temporal emission potential changes of urban transit buses in post-COVID-19 future, *Applied Energy* 280: 115966. https://doi.org/10.1016/j.apenergy.2020.115966

Susnienė, D. 2012. Quality approach to the sustainability of public transport, *Transport* 27(1): 102–110. https://doi.org/10.3846/16484142.2012.668711

Teixeira, J. F.; Lopes, M. 2020. The link between bike sharing and subway use during the COVID-19 pandemic: the case-study of New York's Citi Bike, *Transportation Research Interdisciplinary Perspectives* 6: 100166. https://doi.org/10.1016/j.trip.2020.100166

Trpković, A.; Stanić, B.; Tica, S.; Jevremović, S.; Živanović, P. 2019. Micromobility revolution – challenges and potentials, in *7th International Conference "Towards a Humane City: Environmentally Friendly Mobility", 6–7 December 2019, Novi Sad, Serbia*, 231–237.

Zafri, N. M.; Khan, A.; Jamal, S.; Alam, B. M. 2021. Impacts of the COVID-19 pandemic on active travel mode choice in Bangladesh: A study from the perspective of sustainability and new normal situation, *Sustainability* 13(12): 6975. https://doi.org/10.3390/su13126975