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Analysis of Passenger Behaviour During the Covid-19 Pandemic Situation

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Abstract: The unexpected arrival of COVID-19 significantly affected passenger behaviour and changed travel habits. This paper aims to assess passenger mobility due to the pandemic based on an online questionnaire survey conducted in two countries, Slovakia and the Czech Republic. This paper focused on evaluating the importance rate of selected factors depending on the means of transport. We describe how the most frequently used means of transport (regular travel habits) affect the degree of importance of selected factors during COVID-19, including the journey to work and school. The Likert scale measuring method involves finance, comfort, sustainability, time, and safety as decisive factors, whereas the Kruskal-Wallis test examines proposed hypotheses. We demonstrated the contingency of the importance rate and the frequently used means of transport for commuting to work or school. The questionnaire ranks time and safety among the most important variables affecting the selection of transport means.

Keywords: Public transport, transport means, travel factors, COVID-19, Kruskal-Wallis test

1. Introduction

People's daily lives were affected during the COVID-19 pandemic, which influenced the corresponding mobility and travel. Data-driven tools gave us valuable insight into human behaviour [1-3]. The importance of the COVID-19 pandemic gained increased attention after the subsequent

declaration by the World Health Organization. Recent studies have examined the impact of the COVID-19 pandemic on transport from various aspects, e. g. choice of a vehicle [4,5], daily travel [6,7] and fear of public transport [8,9].

Public transport has become potentially dangerous for passengers given the fear of virus infection. Therefore, researchers focused on changes in travel behaviour [10], finding differences in passengers' views of public transport and travel by car [11]. Prioritizing one over the other also differs depending on the day of the week or the purpose of travel [12].

The set of attributes of different types of transport is perceived differently by users, which can lead to people preferring one mode over others. Experts conducted a similar survey in Sweden, exploring how society reflected changes in mobility as an element of everyday life and corresponding travel [13]. A study in South-Eastern Europe evaluated changes in passenger behaviour, looking at the link between the willingness to prefer public transport and the optimal level of vehicle occupancy [14]. Another study analysed significant predictors in public transport, revealing the social distance in public transport vehicles as a crucial factor [15].

The analysis uses a thorough non-parametric test – Kruskal-Wallis, comparing more than two independent samples. This test was also used in the study [16], examining the two most popular ICT services in urban transport. The authors in [17,18] investigated how the pandemic affects human mobility patterns. Using the Kruskal-Wallis test, they evaluated significant differences between 124 countries grouped into four clusters according to the severity of the government's policy to fight against COVID-19. The authors used Kruskal-Wallis tests in [19] to assess differences in mobility behaviour by age, sex, BMI and education before blocking and during blocking periods.

The pandemic presented a challenge and an opportunity for future sustainable transport. Last but not least, it highlighted the need for public transport services. During the exceptional situation, the importance of passengers' requests to choose a vehicle for everyday activities as opposed to changes.

2. Data and Methods

This paper analyses data from a questionnaire survey reflecting mobility affected by the pandemic situation in Slovakia and the Czech Republic. We used the Kruskal-Wallis test for a more detailed statistical evaluation of the obtained data. It involves a non-parametric alternative to one-way ANOVA and allows for comparing multiple independent groups.

2.1 Sample

The questionnaire sample contained almost 2000 respondents divided according to three criteria (country, status and gender). These data on mobility during COVID-19 reflected an online questionnaire conducted in the spring of 2022. Most respondents (almost 70%) came from the Czech

Republic. Female students represented the largest group (899 female respondents, more than 45%), while Czech female students formed the largest subgroup in the subset. In contrast, men represented less than 12% of the respondents.

2.2 Kruskal-Wallis Test

Kruskal-Wallis H Test (called one-way ANOVA on ranks) for one-way Analysis of Variance (ANOVA) is often used tool as the non-parametric counterpart of the parametric one-way Analysis of Variance (ANOVA). They are applied when determining statistically significant differences for comparing three or more groups. The Kruskal-Wallis test usually measures ordinal variables, and one-way ANOVA is typical for continuous variables. Moreover, if data are ordinal yet not meeting normal distribution, Kruskal-Wallis Test is used with ranked data. The test is an extension of Mann-Whitney U [20-22].

One of the assumptions for applying the test is the independence of observations, the independent variable is continuous or ordinal, and the sub-sample size is equal to or greater than 5. The mean rank represents the average of all ranked observations in each group [23].

3. Results and Discussion

We found that the importance of price, comfort, sustainability, time, and safety in choosing vehicles for commuting to work or school significantly differ depending on the most frequently used means like car, train, public transport, or walking.

Respondents who most often commute to work or school by train consider the fare very important, while expenses for car commuters are insignificant. Second, car travellers to work or school indulge in comfort more than others, whereas pedestrians favour sustainability. On the other hand, respondents commuting by car or train do not care about this aspect. However, time is vital for most respondents, especially for work or school commuters. Finally, car or train passengers appreciate safety.

The study [24] addresses demand-side aspects that appear to be influenced by psychological and economic factors. Psychological factors, primarily the fear of contagion, influence travellers' willingness to travel and, at least in the medium term, people will avoid travelling in large groups and crowded places. The quality attributes commonly cited as priorities for regional travellers are frequency, convenience, reliability, journey time and network coverage, as reported by the authors in [25]. Comfort on board is a higher priority for regional passengers, which becomes increasingly important with longer travel times.

The total sample of our research consists of almost 2,000 respondents from the Czech and Slovak Republic commuting to work or school using a car, train, public transport or walking. The final

sample varies depending on the hypothesis because some respondents were not willing/able to express the importance rate for selected factors using a Likert scale ('very important, rather important, rather unimportant, and very unimportant'). The fifth option was 'I don't know/no answer'. As can be seen, most respondents commented on time as one of the factors. On the other hand, sustainability was the least rated factor. More than 1,600 respondents rate other factors.

The authors in [26] focused on the overall reduction in daily travel and the factors influencing people's decisions to refrain from daily travel. The time reduction depended on the purpose of the trips, the means of transport, the fear of the coronavirus, the main occupation and changes caused by the epidemic. We suggest the correlation between the coronavirus fear and the reduction of travel time. Overcrowding in the vehicle and travel time are two critical factors that determine preferences for personal transport in public transport [27,28].

Moreover, Table 1 reveals that we reject the null hypothesis (p-value<0.05) while accepting the alternative. In other words, the results demonstrate that the importance rate reflects the frequently used means of transport for commuting to work or school. Finally, Table 1 contains extra data on sample size, Test statistics, and degrees of freedom (df).

Table 1 Hypothesis Test Summary. Source: authors

	Null Hypothesis	N	Test Statistic	df	Sig.
1	The distribution of importance rate for the travel costs is the same across categories of transport means including walking.	1,632	130.253	3	0.000
2	The distribution of importance rate for comfort is the same across categories of transport means including walking.	1,667	93.288	3	0.000
3	The distribution of importance rate for sustainability is the same across categories of transport means including walking.	1,327	58.500	3	0.000
4	The distribution of importance rate for time is the same across categories of transport means including walking.	1,817	108.772	3	0.000
5	The distribution of importance rate for security is the same across categories of transport means including walking.	1,649	40.131	3	0.000

The results demonstrate that preferred means of transport (passenger transport behaviour) affects the importance rate of all factors. The characteristics of an individual’s travel behaviour significantly influence their information seeking behaviour before using public transport. In particular, the frequency of trips made by public transport users, who typically make "< 1 trip per week" and "5 or more trips per week", was important for pre-travel information-seeking behaviour. [28] For the selected factors described by the Likert scale, we used an ordinal variable for the degree of importance and a nominal variable for the most preferred means of transport, including walking for commuting to work or school, using the Kruskal-Wallis test.

This test is suitable for ordinal variables and numerical variables without normal distribution as an analogue to one-way ANOVA. ANOVA compares the mean of numerical variables, unlike the Kruskal-Wallis Test. This test compares the mean rank, in other words, each statistical unit is assigned

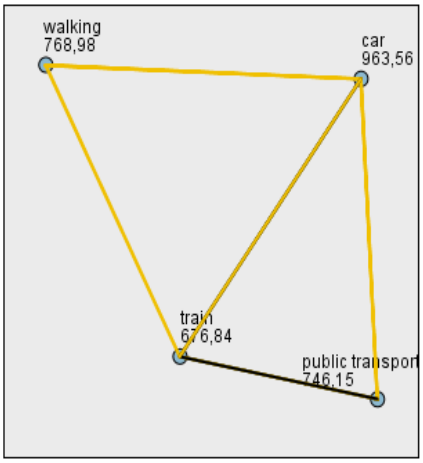
a rank number and the rank numbers are added for each group (means of transport). Then the mean for each group is calculated.

3.1 Travel Costs

Table 2 shows that the importance rate for travel costs is statistically significantly different for four pairs of means of transport, namely train (mean rank 676.84) and walking (mean rank 768.98), train (mean rank 676.84) and car (mean rank 963.56), public transport (mean rank 746.15) and car (mean rank 963.56), walking (mean rank 768.98) and car (mean rank 963.56) based on pairwise comparisons using Bonferroni correction (adj. sig < 0.05).

Table 2 Pairwise Comparisons – travel costs. Source: authors

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig. [a]
Train-public transport	69.311	34.103	2.032	0.042	0.253
Train-walking	92.136	32.165	2.864	0.004	0.025
Train-car	286.715	26.775	10.708	0.000	0.000
Public transport-walking	22.826	36.733	0.621	0.534	1.000
Public transport-car	-217.404	32.119	-6.769	0.000	0.000
Walking-car	-194.579	30.054	-6.474	0.000	0.000



a Significance values have been adjusted by the Bonferroni correction for multiple tests.

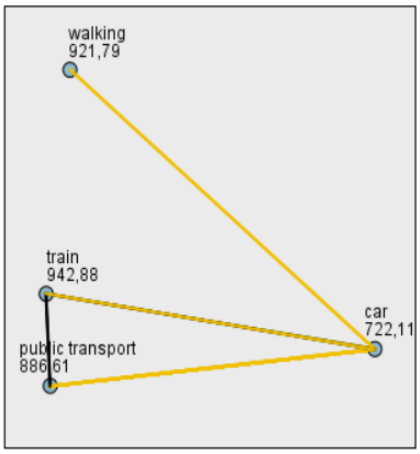
The evaluation of these factors in Britain showed that in addition to fare, other environmental factors played a role in the choice of train transport, such as overcrowding, especially during peak times [29]. When using a car and walking, the price factor was not as important as in the case of public transport [30].

3.2 Comfort

Table 3 shows that the importance rate is statistically significantly different for all pairs containing the car, namely car (mean rank 722.11) and public transport (mean rank 886.61), car (mean rank 722.11) and walking (mean rank 921.79), and car (mean rank 722.11) and train (mean rank 942.88) based on pairwise comparisons using Bonferroni correction (adj. sig. < 0.05). On the other hand, it was found that there is no statistically significant difference between the other pairs in the importance rate describing comfort as one of the selected factors in choosing a means of transport for commuting to work or school.

Table 3 Pairwise Comparisons – comfort. Source: authors

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig. [a]
Car-public transport	164.502	32.063	5.131	0.000	0.000
Car-walking	199.674	29.949	6.667	0.000	0.000
Car-train	-220.767	26.123	-8.451	0.000	0.000
Public transport-walking	35.172	37.823	0.930	0.352	1.000
Public transport-train	-56.264	34.872	-1.613	0.107	0.640
Walking-train	-21.092	32.939	-0.640	0.522	1.000



a Significance values have been adjusted by the Bonferroni correction for multiple tests.

In their analysis, Eisenmann et al. [31] focused on Germany during the Covid-19 pandemic. The authors describe how public transport declined while individual modes of transport gained in importance. They suggest that the long-term effects of increased interest in public transport (much of which is explained by altered perceptions of 'convenience') is the shift to using cars and walking.

The authors [32] conclude that public transport has the potential to attract users who currently prefer private cars if the quality of the provided services is improved. Planned improvements should be based on the context and requirements of the individual characteristics of each sample, focusing on individual motivation of private motor vehicle users.

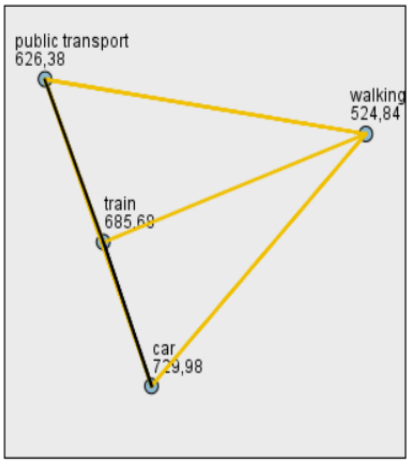
3.3 Sustainability

Table 4 shows that the importance rate for sustainability as one of the factors is statistically significantly different for four pairs, namely walking (mean rank 524.84) and public transport (mean rank 626.38), walking (mean rank 524.84) and train (mean rank 685.68), walking (mean rank 524.84) and car (mean rank 729.98), and public transport (mean rank 626.68) and car (mean rank 729.98) based on pairwise comparisons using Bonferroni correction (adj. sig. < 0.05) except for public transport and train, and train and car. These two pairs are not statistically significantly different.

According to [33], carbon footprint was evaluated as a less important element when considering the mode of transport people use. The primary goal of transport policy in terms of sustainability is to attract passengers to public transport. This factor proved to be less important during the pandemic.

Table 4 Pairwise Comparisons – sustainability. Source: authors

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig. [a]
Walking-public transport	-101.542	34.158	-2.973	0.003	0.018
Walking-train	-160.839	29.957	-5.369	0.000	0.000
Walking-car	-205.139	27.642	-7.421	0.000	0.000
Public transport-train	-59.297	32.039	-1.851	0.064	0.385
Public transport-car	-103.597	29.886	-3.466	0.001	0.003
Train-car	44.300	24.976	1.774	0.076	0.457



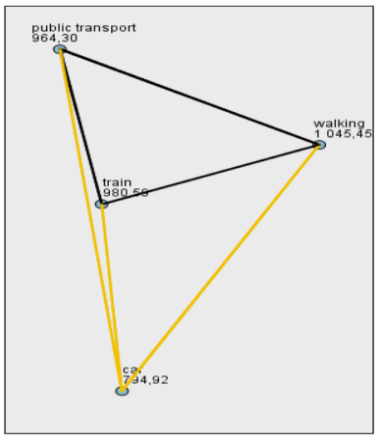
a Significance values have been adjusted by the Bonferroni correction for multiple tests.

3.4 Time

Table 5 shows that the importance rate for the time is statistically significantly different for all pairs including car (mean rank 794.92) and public transport (mean rank 964.30), car (mean rank 794.92) and train (mean rank 980.59) and car (mean rank 794.92) and walking (mean rank 1,045.45) unlike the other based on pairwise comparisons using Bonferroni correction (adj. sig. < 0.05).

Table 5 Pairwise Comparisons – sustainability. Source: authors

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig. [a]
Car-public transport	169.378	29.836	5.677	0.000	0.000
Car-train	-185.668	24.932	-7.447	0.000	0.000
Car-walking	250.524	27.984	8.952	0.000	0.000
Public transport-train	-16.290	32.595	-0.500	0.617	1.000
Public transport-walking	81.146	34.985	2.319	0.020	0.122
Train-walking	64.856	30.909	2.098	0.036	0.215



a Significance values have been adjusted by the Bonferroni correction for multiple tests.

Punctuality, reliability, and frequency of service are significant attributes of the quality of public transport, as stated in [34].

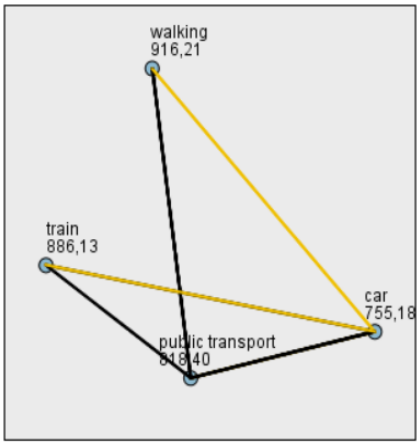
3.5 Safety

Finally, as for safety, it was found that the importance rate is statistically significantly different for two pairs, namely car (mean rank 755.18) and train (mean rank 886.13), and car (mean rank 755.18)

and walking (mean rank 916.21) based on pairwise comparisons using Bonferroni correction (adj. sig. < 0.05) compared to other pairs (see Table 6).

Table 6 Pairwise Comparisons – safety. Source: authors

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig. [a]
Car-public transport	63.219	32.035	1.973	0.048	0.291
Car-train	-130.946	26.753	-4.895	0.000	0.000
Car-walking	161.024	29.908	5.384	0.000	0.000
Public transport-train	-67.727	34.97	-1.937	0.053	0.317
Public transport-walking	97.805	37.439	2.612	0.009	0.054
Train-walking	30.078	33.033	0.911	0.363	1.000



a Significance values have been adjusted by the Bonferroni correction for multiple tests.

As crowded and unhygienic environment increases the risk of infection, ensuring cleanliness and avoid overcrowding are essential elements for prioritizing individual car transport [35]. Nevertheless, it was found [30] that men and women are affected differently by various factors. For example, personal safety and road safety are more important for women. Increased use of private cars and active modes of transport (e.g., walking) and decreased use of public transport for primary travel purposes were recorded in Pakistan during COVID-19 [36]. Such observations suggest that people tend to use safer (in terms of infection) modes of transportation during a pandemic. In Poland, passengers feel less safe when using public transport, which significantly affects attitudes towards using this mode of transport in everyday life. Almost half of the respondents in the survey declared a decrease in the use of public transport services and even stated a resigned attitude towards these means of transport [37-39].

4. Conclusion

The presented research deals with the importance of factors such as price, comfort, safety, sustainability, and time on selecting a mode of transport through a questionnaire survey on a sample of respondents from the Czech Republic and Slovakia. The results from the questionnaire showed different significance level for each tested factors and categories of follow-up. According to the Likert scale, the majority of respondents identified time as one of the most important factors, while sustainability was rated the least. Sustainability in the choice of a mode of transport is not statistically significantly different for public transport and train, and car and train. However, we accepted an alternative hypothesis stating that the degree of importance is influenced by the frequently used means

of transport for commuting to work or school. In terms of comfort, the degree of importance as one of the factors in choosing a means of transport is statistically significantly different for all pairs containing a car. Travel costs were identified as very important, especially for respondents who commute to work by train and public transport, unlike others. The results show that fares are an important rather than a very important factor for respondents who commute by car. Comfort was extremely important for users of private cars. Other respondents who walk to work, use public transport or train rated convenience as an important factor rather than a very important factor. Sustainability was rated rather unimportant or very unimportant among all factors. It is quite important regardless of which means of transport we most often use for commuting to work or school. However, most respondents consider sustainability to be a rather or very unimportant factor. Time was considered the most important factor of all. Finally, safety is considered a very important factor for respondents who commute by public transport and car as opposed to others, as safety is quite important for those who commute by train or walk.

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