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EVALUATION OF THE IMPACT OF COVID-19 PANDEMIC ON TRANSPORTATION: A CASE STUDY OF IRAN

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Abstract:

Coronavirus first appeared in January 2020 and has spread dramatically in most parts of the world. In addition to exerting enormous impacts on public health and well-being, it has also affected a broad spectrum of industries and sectors, including transportation. Countries around the world have imposed restrictions on travel and participation in activities due to the outbreak of the virus. Many countries have adopted social distancing rules requiring people to maintain a safe distance. Therefore, the pandemic has accelerated the transition into a world in which online education, online shopping, and remote working are becoming increasingly prevalent. Every aspect of our life has witnessed a series of new rules, habits, and behaviours during this period, and our travel choices or behaviours are no exception. Some of these changes can be permanent or have long-lasting effects. To control this situation, these changes must first be recognised in various aspects of transportation in order to provide policies for similar situations in the future. In this regard, this study seeks to examine how transportation sectors have changed in the first waves of the pandemic. Iran has been selected as the case study in this paper. This research is divided into two parts. The first part focuses on the effects of the Coronavirus pandemic on rural transportation in Iran. This is followed by assessing the impacts of the virus on urban transportation in Tehran (the capital of Iran). The behaviour of more than 700 travellers in terms of trip purpose, travel time, and mode choice is evaluated using a questionnaire. Results indicate that the number of passengers has reduced dramatically in rural transportation systems. In such systems, considerations such as keeping social distancing, disinfection of passengers and their luggage, and unemployment of a group of personnel working in the transportation industry have been more evident. In urban transportation, education trips have dropped the most. This might relate to an increase in online teaching and health concerns. The same pattern can be seen in the passengers who used bicycles, public taxis, and other public transportation systems. Finally, during the pandemic, drivers' speed has increased, which justifies the need for traffic calming for drivers.

Keywords: *Covid-19, Transportation, Social distancing, Influence, Travel behaviour*

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1. Introduction

By the end of December 2019, a new virus caused the outbreak of Coronavirus disease 2019 (COVID-19). Only since a few weeks after starting the pandemic, COVID-19 has profoundly changed lives, causing tremendous human suffering and challenging the foundations of societal well-being, such as transportation (OECD, 2018). This was due to simple and fast virus transmission between people (Abdullah et al., 2021). As of June 20th, 2022, there have been 544,313,024 confirmed cases of COVID-19, including 6,340,754 deaths affecting 230 countries around the world (Worldometers, COVID-19 Pandemic, 2021).

Transportation systems are major elements of any country's economy and have a considerable impact on the shape of society, so it is often mentioned as a country's lifeblood circulation system (Chamier-gliszczyński, 2012a, 2012b; Chamier-Gliszczyński & Bohdal, 2016). The purpose of transportation is to provide a mechanism for exchanging goods, people, information and to support economic improvements for society (Jacyna et al., 2021). The Coronavirus outbreak created controversy about its potential outcomes on the logistics and transportation industry (Mazareanu, 2020). The transportation system was not ready to deal with the virus, like many other areas of society.

One of the most challenging aspects of the pandemic was transportation mode choice. Public transport has been the primary mode of transportation for years, and ever since, it has been recognised as a source of virus contamination. As a result, commuters have become more reluctant to travel by this mode, which caused a remarkable decline in its popularity (Loa et al., 2021). In a study, using a mobility-dependent infection rate, an epidemic spreading model that uses mobility was introduced. It was found that using subway transport data to indicate the general mobility trends within a city, and therefore the effective infection rate, improved the accuracy of forecasting COVID-19 spread in New York City (Malik et al., 2022).

These new travel behaviours are mostly due to the fact that social distancing cannot be maintained in a closed and populated environment like a bus or train (Bucsky, 2020). Bauer et al., (2021) conducted a survey among bus and tram drivers in Krakow, Poland during the pandemic. The majority of drivers said the current solutions to protect passengers were not adequate, thus, they recommended expanding the scope of protective measures, such as adding more courses for public transport (Bauer et al., 2021).

Wilbur et al., (2020) remarked a drop of about 66% in public transportation in the United States during the same time (Wilbur et al., 2020). Buscky (2020) stated that the number of daily trips and mobility experienced a reduction (Bucsky, 2020). In Australia, both total generated trips and bike-sharing decreased after the COVID-19 outbreak (Beck & Hensher, 2020). Similarly, the pandemic caused a decrease in bike-sharing usage and rental in Beijing (China) (Chai et al., 2020). In addition, due to restrictions during the Coronavirus outbreak, travel behaviours significantly changed in a way that daily routine travels were limited to shopping and work activities (Fatmi, 2020). Nikiforiadis et al., (2020) studied how COVID-19 affected bike-sharing in Greece and showed that the number of people using bike-sharing for their trips did not change significantly (Nikiforiadis et al., 2020). Variations in travel behaviours were studied at the same time in Bangladesh and it was shown that buses continued to be the most preferred transportation mode (Anwari et al., 2021).

Molloy et al., (2021) found a reduction of around 60 percent in the average daily travelled kilometres and a decrease of about 90% in public transportation (Molloy et al., 2021). Zheng et al., (2020) studied correlations between COVID-19 cases and service frequency and concluded that public transportation played an essential role in the spread of COVID-19 (Zheng et al., 2020). Muley et al., (2021) determined the impact of the COVID-19 pandemic and preventive measures on traffic and found a 30 percent drop in traffic, but no significant differences in daily one (Muley et al., 2021). Tan and Ma (2021) studied choice behaviours in rail transit mode, utilising a logistic regression model, and realised that commuters are less likely to travel by rail transit during the COVID-19 pandemic (Tan & Ma, 2021). A latent segmentation-based ordered logit (LSOL) was used in the study of Khaddar and Fatmi (2021) to find the effects of daily activity engagement, including travel activity and sociodemographic characteristics on travel satisfaction during COVID-19 (Khaddar & Fatmi, 2021). Aghabayk et al., (2021) examined the potential changes in travel behaviours of public transportation by analysing the crowding perception and crowding disutility in the metro rail system of

Tehran. The authors concluded that crowding has more disutility for rail passengers, and the value of having a seat while travelling increased during the pandemic (Aghabayk et al., 2021). Lee et al., (2021) analysed the effects of respondents' personal and perceived details on their mobility behaviours and willingness to use public transportation in the post-pandemic period in Pakistan. The authors observed a significant decrease in users' mobility during the pandemic, which is gradually recovering back to normal (Lee et al., 2021). Similarly, Abdullah et al., (2021) investigated the impacts of the COVID-19 outbreak on travel behaviours and mode preferences in Pakistan. The authors suggested that past policies concerning various modes of travel should be revisited in the post-COVID-19 world (Abdullah et al., 2021). Shaer and Haghshenas (2021) examined the potential effects of the COVID-19 pandemic on active transportation modes usage among older adults in Isfahan, Iran. The results showed that although the average walking duration decreased in the post-pandemic world, the share of this mode has increased significantly (Shaer & Haghshenas, 2021). In another study, conducted by Ye et al., (2021), the authors analysed the impact of social media on human mobility before and after the COVID-19 pandemic and its impacts on personal vehicle and public transit use in New York City. This study provided insights into the complicated effects of both anti-pandemic measures and user-generated content, such as social media, on users' travel preferences during the outbreak (Ye et al., 2021). Shokouhyaret al., (2021) studied the challenges and opportunities that the COVID-19 pandemic has caused in shared mobility (Shokouhyar et al., 2021).

Iran was one of the first countries affected by Coronavirus and has always had large numbers of confirmed cases and deaths. The present study analyses changes in demand for different modes of transportation in rural transportation in Iran by statistically comparing the periods before and during the outbreak of Coronavirus. We have more frequent trips in urban areas, for various purposes, accomplished by different modes. Consequently, the passengers' travel behaviour was evaluated separately before and during Coronavirus outbreak in Tehran, Iran.

This paper aims to answer the following questions by conducting a study on pre-COVID with one of the main waves of COVID in 2020:

– To what extent can the movement of passengers and goods be affected, considering different modes of rural transportation? What were the impacts of the COVID-19 pandemic on the service condition of each mode in the rural transportation systems?
– What changes have occurred in the urban trips (trip purposes, trip modes, and trip time distribution)?
– What changes have occurred in the driving behaviours?

The paper has four sections. In the following section, the method is presented in more detail. Then the results for determining the changes in rural transportation and travellers' behaviour in urban areas are shown and discussed, followed by a conclusion.

2. Method

The present study analyses the impacts of COVID-19 on both rural and urban transportation. The required data is collected from two sources: (1) transportation statistics of different travel modes, gathered from related national organisations and (2) micro-level data that is related to travel behaviour of people before and during the COVID-19 outbreak, collected by a questionnaire. The T-test is utilised to compare the means for the periods before and during the pandemic.

In order to make comparisons for rural transportation between the periods before and during the Coronavirus outbreak, the statistics related to demands for rail, air, road, and marine modes in March and April of 2019 and 2020 were collected. For rural transportation, we have used general statistics regarding changes in the movement of passengers and goods. Then, the results are interpreted.

For urban transit, the focus will be on passengers' travel behaviour. There are various modes of travel in urban areas, such as passenger cars, regular buses, bus rapid transit (BRT), metro, public taxi, private taxi, walking, and cycling. In addition, trips are made for different purposes, such as education, work, shopping, leisure, and others. Evaluating the changes in passengers' travel behaviours during the COVID-19 pandemic can help improve cities' readiness for future similar situations.

In this case study, people in Tehran have been interviewed. Samples were selected randomly from different groups of people.

The data collection process started with creating a questionnaire, and individuals living in Tehran, Iran, were surveyed online, starting from mid-May to mid-June 2020. The survey form was sent via Instagram, LinkedIn, WhatsApp, Email, and other social media tools. The form was created in the Google Forms platform, which can control the relative frequency of respondents from different categories. Based on the relative frequencies, the samples for each group were collected in the same proportion.

Each question in the survey form was asked in the form of a multiple-choice question. The first part of the questionnaire relates to demographics and if the respondents were infected by COVID-19. The variables included in the questionnaire are presented in Table 1.

In the second part, the status of passengers' trips before the COVID-19 pandemic was asked. The questions relate to the trip purpose, travel mode, time of trips, and dangerous driving behaviours. The same questions have been asked for the period during the Coronavirus outbreak.

The next step was to explore whether there was a significant change in the number of trips with various purposes before and during the COVID-19 pandemic. Then, those passengers, who have been affected the most by this virus concerning their trip purpose, are identified. Afterwards, the same procedure was done for mode choice and trip distribution by independent t-test.

The COVID-19 has caused panic and stress among citizens, in addition to negatively affecting their economic situation. These reasons might have a negative impact on driving behaviours (Barnard & Chapman, 2018; Clapp et al., 2011). We used the DBQ (Driver Behaviour Questionnaire) forms indirectly to evaluate this issue. Consequently, first, items related to driving behaviour with a medium or high-risk level were identified (Reason et al., 1990). Subsequently, aberrant driving behaviours in the DBQ that are relatively similar have been merged, and finally, we came up with fewer items (Table 2).

In our survey, we assessed the impact of the COVID-19 pandemic on drivers' speed, traffic violations, attention to traffic rules, aggressive driving, concentration while driving, and near-crash experiences. Finally, based on the outputs from travel behaviour analyses before and during COVID-19, several points are highlighted about urban transportation in such situations.

3. Results and discussion

In this section, the impact of the COVID-19 pandemic on rural transportation (between two cities) and travel behaviour in urban areas is presented.

3.1. Rural transportation

For rural transportation, statistics of changes in the railway system, air transport, roadway transport, and marine transportation are presented for the periods before and during the Coronavirus pandemic.

3.1.1. Railway system

The length of the railway network in Iran is currently 11,494 kilometres, which is used to move both cargo and passengers. Rail cargo transportation mainly relates to mining areas and ports. In this section, in Table 3, a comparison has been made between the number of passengers and the amount of cargo transferred in March and April of 2019 and 2020, as the periods before and during the COVID-19 pandemic, respectively.

Table 1. Passengers' characteristics asked in the questionnaire (Sample size: 458)

Variable	Categories	Relative frequency
Gender	Male	55.0
	Female	45.0
Age (year)	<12	0.7
	12-18	3.3
	18-24	37.3
	24-30	16.6
	30-40	21.0
	40-50	10.0
	50-60	6.8
	>60	4.4

Variable	Categories	Relative frequency
Education level	School	9.6
	High School	27.3
	Bachelor's Degree	45.4
	Master's Degree	15.1
	Ph.D.	2.6
Marital status	Single	59.2
	Married	40.8
Job & Occupation	Studying at school	3.9
	Studying in college	29.5
	Tutor/Teacher/Professor	3.5
	Retailer	14.4
	Lawyer	0.9
	Medical staff	2.8
	Housekeeper	11.4
	Employee	11.6
	Laborer	0.4
	Engineer	10.0
	Driver	0.7
	Freelancer	1.7
	Others	9.2
Monthly income (USD)	<.60	37.6
	60-180	31.9
	180-350	20.5
	350-530	8.1
	>530	2.0
Owning a vehicle or being allowed to use the family vehicle	No	35.6
	Yes	64.4
Number of days having access to a vehicle in a week	0	32.1
	1	4.6
	2	6.8
	3	7.6
	4	4.1
	5	2.6
	6	1.7
	7	40.4
Teleworking possibility	No	41.0
	To somewhat	34.6
	Yes	24.4
Have you been infected by COVID-19 yet?	No	95.0
	Yes	5.0
Being influenced by a relative infected with COVID-19	No	75.4
	Yes	24.6
Anxiety and stress level created by COVID-19 outbreak	None	15.1
	Very little	14.2
	Little	29.3
	Much	29.1
	Very Much	12.3
Effect of COVID-19 on economic situation	None	46.7
	My income has become much less	23.1
	My income has become little less	27.7
	My income has become little more	1.7
	My income has become much more	0.7

Table 2. Questions in relation to driving behaviour before and during the pandemic

Item	Levels
How much your driving speed has increased during the pandemic in comparison to before the pandemic?	None Much less Little less Little more Much more
How much your traffic violations has increased during the pandemic in comparison to before the pandemic?	None Much less Little less Little more Much more
How much your attention to traffic rules has increased during the pandemic in comparison to before the pandemic?	None Much less Little less Little more Much more
How much your aggressive driving has increased during the pandemic in comparison to before the pandemic?	None Much less Little less Little more Much more
How much your concentration has increased during the pandemic in comparison to before the pandemic?	None Much less Little less Little more Much more
How much your near crash experiences has increased during the pandemic in comparison to before the pandemic?	None Much less Little less Little more Much more

Table 3 indicates that we have experienced a significant decrease by about 67 and 94 percent in the number of passengers during the COVID-19 pandemic in March and April, respectively. Also, a reduction has been experienced in cargo transportation by rail because of the Coronavirus, but this reduction was negligible and was not as significant as that for passengers.

Table 3. Comparing the changes in rail transport before and during the pandemic

	March		
	2019	2020	Reduction
Passenger	2,290,353	756,025	67%
Cargo (ton)	4,001,200	3,806,032	5%
	April		
	2019	2019	2019
Passenger	2,297,675	2,297,675	2,297,675
Cargo (ton)	3,895,856	3,895,856	3,895,856

The main points relating to railway transportation during the Coronavirus outbreak are as follows; some of these points have been noticed by field observations:

- The COVID-19 pandemic did not significantly affect cargo transportation. During this time period, rail transportation was primarily used to transport mineral products, and most mines were operating. However, because of the decline in demand for the industrial markets worldwide, cargo transportation by rail is expected to decrease in the following months.
- The space of train cabins is small, and social distancing cannot be practiced for passengers. About three square meters of space is devoted to the cabins, which are usually for six or four passengers. In the near future, it is necessary to provide a plan to decrease passengers in each cabin up to a maximum of three passengers.
- Because of social distancing, the capacity of a passenger train might be diminished; therefore, a higher frequency of services can offset some of this reduced capacity. Trains can be improved in frequency and availability in order to avoid dangerous shift to cars.
- There is no particular plan for controlling passengers' tickets at railway stations, and usually, a queue is formed, and the controls are done manually. No special control is applied in each queue to maintain a distance between passengers. The process of ticket control should be automatic and intelligent in the future to decrease delays and provide a sufficient gap between passengers.
- A large number of people are still gathered in the station building before boarding the train. These buildings do not have enough space to maintain social distancing.
- Due to the reduction in rail passengers and the decrease in rail services, many people have lost their jobs, including those who worked in the railway transportation industry. Specifically, it consists of temporary seasonal or yearly contract workers and employees, belonging to low-income social groups before the pandemic.
- Transport by rail can provide advanced technology for controlling the spread of the virus, including equipping train cabins with automatic disinfection systems.

3.1.2. Air transport

There are 56 airports and 16 airlines operating in the country. In Table 4, the number of flights and passengers transported in the whole country in March and April of 2019 and 2020, as the periods before and during the COVID-19 pandemic, are shown.

Table 4. Comparing the changes in air transport before and during the pandemic

	March		
	2019	2020	Reduction
Passenger	3,608,713	1,661,621	54%
Cargo (ton)	28,976	17,725	39%
	April		
	2019	2020	Reduction
Passenger	3,791,882	1,291,882	66%
Cargo (ton)	30,372	9,111	70%

Statistics indicate that substantial reductions of about 54 and 66 percent occurred in the number of air passengers during March and April. In addition, the number of flights decreased by 39 and 70 percent during these two months. Air cargo transportation also experienced a reduction of about 52 and 65 percent because of the COVID-19 pandemic. The main points relating to air transport during the Coronavirus outbreak are as follows:

- The distance between seats inside aeroplanes is insufficient for performing social distancing. Although we have observed a significant decrease in air passengers, no plan has been proposed to allocate seats so that passengers can keep their social distancing. Through online applications in some airports, travellers can book their own seats and are not constrained by social distance when choosing seats.
- Airlines provide medical supplies such as facemasks, personal protective equipment, gloves, water, hygiene kits, cleaning supplies, and hand sanitisers. In addition, airline meals were eliminated to avoid COVID-19 spread on flights. These are helpful and effective methods for controlling virus spread in aeroplanes.
- In terminals, queues are formed for boarding passes, ticket control, and security and among others. Although there are signs and markings on the floor to keep social distancing in queues, it is not adequate, and travellers do not pay much attention to the recommendations. Nevertheless, the control of distances in a queue in airports is much better than the railway system. However, it is necessary to consider online ticketing services at all airports and even make them mandatory. Also, the exit gates should be equipped with intelligent ticket control equipment, and a disinfectant tunnel should be used before boarding the plane.
- There are many challenges in the security control part of the airports. Maintaining sufficient distance is difficult because of space scarcity, and items such as handbags, coats, cell phones are constantly in touch with conveyor belts, baskets and might be contaminated.
- Airline employees, airport employees, and workers with short-term contracts have been laid off because of the decline in passengers and the number of flights.
- According to the current pattern and experiences, some trips may be removed from regular travel cycles in the future. For example, some administrative affairs that are now temporarily licensed to be done by local offices might continue in the same form, or some business meetings held online might be the same in the future. Thus, the elimination of a significant part of air travel may take place shortly.
- Similar to the railway system, disinfection must be considered for passengers' luggage being brought to aeroplanes.
- Major changes must occur in flight schedules to ensure the optimum number of flights during this period.

3.1.3. Roadway transport

There are 88,873 kilometres of rural roads in Iran, and roads account for 94% of intercity trips. Therefore, this mode is the most popular type of transportation for intercity trips in Iran. Table 5 shows decreases in the percentage of passengers and cargo in roadway transport in five major provinces in Iran, comparing March and April of 2020 to the same period in 2019. We have only considered several major roads in each province.

The values in Table 5 represent considerable reductions in the number of passengers and the amount of cargo moved by roads before and during the Coronavirus outbreak. The main points relating to roadway transport during the pandemic are as follows:

- The frequency of accidents has decreased significantly in this period, and statistics show that the number of deaths and injuries caused by accidents in March and April reduced by 16.6 and 34.4 percent, respectively. This indicates that demand management can reduce the number of accidents in Iran. Various measures have been taken to reduce road accidents, especially during the holidays. Other countermeasures include more police control, educational and cultural programs, and improving roads' condition. However, the results were not satisfying, and even the number of road accidents increased. Coronavirus showed that managing demands and eliminating some trips could improve road safety.

- Reduction in the number of passengers on intercity buses and rental vehicles has put many drivers and terminal employees at risk of unemployment.
- In bus terminals, social distancing is hardly maintained, and less attention has been devoted to this issue. In addition, disinfection and hygiene are not considered seriously by passengers and drivers inside the buses.
- Similar to the railway system and air travel, the luggage brought inside a bus must be disinfected.
- Automation and digitalization of bus terminal processes can help to alleviate fear of infection although it may lead to unemployment of some workers.
- Despite the large reductions in passenger travel during the COVID-19 pandemic, freight movements were not much affected. The reason for this is that trucking is an essential service for the Iranian economy. Drivers have continued to work throughout the pandemic, despite decreased demand for certain goods and services.

3.1.4. Marine transportation

Water transportation mainly relates to goods in Iran. The changes in the amount of cargo in March and April before and during COVID-19 are shown in Table 6.

Based on Table 6, it can be concluded that the number of goods transferred by water in Iran during the COVID-19 pandemic decreased by 10 and 22 percent. This pertains to the decrease in industrial and business demand during this pandemic.

Table 5. Comparing the changes in road transport before and during the pandemic

	March		
	2019	2020	Reduction
Passenger	16,843,618	11,549,646	31%
Cargo (ton)	2,563,722	2,142,353	16%
	April		
	2019	2020	Reduction
Passenger	21,701,558	10,462,232	52%
Cargo (ton)	2,322,374	1,462,835	37%

Table 6. Comparing the changes in marine transport before and during the pandemic

	March		
	2019	2020	Reduction
Cargo (ton)	12,781,974	11,513,869	10%
	April		
	2019	2020	Reduction
Cargo (ton)	11,911,161	9,279,203	22%

3.2. Urban Transit

Urban transportation offers more variety in terms of trip purpose, travel time, and trip mode. For this reason, instead of using the general statistics, the behaviour of travellers in Tehran (capital of Iran) is evaluated. For this purpose, using a questionnaire, citizens were asked about the trips they made in the periods before and during the Coronavirus outbreak. Then, it has been inferred based on the provided database about travel behaviour during the COVID-19 pandemic. More than 700 people were interviewed, and after data cleaning, about 458 cases remained.

3.2.1. Trip purpose

We compared changes in the frequency of different trips before and during the pandemic by an independent t-test. In Table 7, the differences in means of the number of trips for various trip purposes are provided. In this Table, the frequency of trips for the interval before the COVID-19 pandemic was more significant than during it for all cases. In the last column of this Table, the percent of changes in each trip are outlined.

Education trips had the highest decrease during the pandemic. This relates to the fact that the majority of education programs have been offered online during this time. Other trips have also experienced considerable reductions.

Table 8 indicates those groups who have received the greatest impact from COVID-19 on each trip. To obtain these figures for each variable, the categories with the highest reduction in the relative frequency of a specific kind of trip are determined.

Table 7. Differences between means of trips with different purposes for before and after the pandemic

Trip Purpose	P-value	Mean Difference (Before–After)	Lower	Upper
Education	0.000	1.90	1.54	2.26
Work	0.001	1.94	1.32	2.57
Shopping	0.000	1.35	1.02	1.68
Leisure	0.000	1.50	1.20	1.79
Other	0.001	1.57	1.25	1.89

With respect to educational trips, male respondents aged 12 to 18 years, and with a high school degree show the greatest decline in trips. The following can be deduced from Table 8:

- All the educational classes in Tehran during the COVID-19 pandemic have been held online. Thus, students' characteristics do not impact the reduction of such trips.
- In work trips, the anxiety from COVID-19 has been the main reason in reducing such trips. The respondents declared that although their economic loss was substantial, they preferred to quit their jobs or accomplish them remotely because of the panic over the virus.
- For shopping, leisure, and other trips, the impact of travellers' characteristics was negligible on their reduction. Since malls, shopping centres, trade markets, recreational facilities, parks, sports clubs, swimming pools, and among others were closed during this period, the number of such trips decreased.
- Young travellers between the ages of 18 to 24 received the most significant impact from the COVID-19 in the reduction of frequency of their trips for education, work, leisure, and other purposes.

3.2.2. Mode choice

In Table 9, the differences in means of the number of trips accomplished by different modes are provided. In addition, percent of changes in using each mode are outlined.

All travel modes have experienced a reduction in demand because of the reduction in daily trips. The highest decrease belongs to cycling and public taxis, mainly due to high stress and concern about COVID-19 infection. Although walking is done in an unenclosed environment and the risk of contagion is low, especially those with higher stress and concern about infection reduced their walking duration and cycling after the pandemic started. This study was done in the second wave of the COVID-19 outbreak, and at that time, less information was available about this virus. Thus, people preferred to shift to automobiles instead of walking because of the fear of infection. This behaviour might be different in other countries.

Table 8. The most influenced groups of respondents for each trip purpose

	Trip purpose				
	Education	**Work**	**Leisure**	**Shopping**	**Others**
Age	12-18	24-30	24-30	40-50	24-30
Education level	High school	M.Sc.	M.Sc.	M.Sc.	M.Sc.
Vehicle access (days)	0	7	3	7	7
Family members infected	Yes	Yes	Yes	Yes	Yes
Economic loss (change)	Little less	Much less	None	Much less	Little less
Gender	Male	Female	Male	Male	Male
Income (USD)	Less than 60	350-530	180-350	180-350	180-350
Teleworking possibility	To somewhat	To somewhat	-	-	-
Respondent infected	Yes	Yes	No	No	No
Anxiety and stress caused by virus	Very much	Much	None	Little	Little

Table 9. Differences between means of trips done by different modes before and during the pandemic

Mode	P-value	Mean Difference (Before-After)	Lower	Upper	Percent of changes
Bus	0.000	0.55	0.37	0.74	-65.4
BRT	0.000	0.46	0.30	0.63	-67.5
Public Taxi	0.000	0.96	0.74	1.17	-69.1
Private Taxi	0.000	0.50	0.25	0.75	-39.1
Metro	0.001	0.82	0.57	1.07	-56.1
Walk	0.000	0.62	0.42	0.82	-21.3
Cycle	0.000	0.87	0.77	0.98	-76.5

Similarly, the groups, who have received the highest impact from COVID-19 based on the decrease in their travel frequencies, are shown by each mode in Table 10.
The following can be deduced from Table 10:

- The reduction in bus usage relates to the overall decrease in urban trips. The passengers, who were most affected by the COVID-19 in this mode, did not have access to passenger cars nor the possibility of teleworking. Their anxiety about the virus was also average for them. These facts indicate that bus trips were eliminated because of the recession brought about by the COVID-19 pandemic.
- BRT passengers have decreased because of teleworking and anxiety about Coronavirus infection. Since BRTs are often overcrowded, social distancing cannot be maintained.
- The number of passengers in public and private taxis has decreased because of teleworking and anxiety about Coronavirus infection.
- The metro passengers have shifted to their passenger cars, which is the main reason for the decline in such trips.
- Travellers with higher incomes have received the most negligible impact from COVID-19 for their mode choice. This shows that wealth, and subsequent ownership of several private vehicles, can directly affect the use of public transportation in Iran.
- Young travellers between the ages of 18 to 24 have received the highest impact from COVID-19 on their mode choice.

3.2.3. Travel time distribution

This section seeks to compare the changes in departure times of trips before and during the pandemic. Thus, a day was divided into ten intervals consisting of 6:00 to 8:00, 8:00 to 10:00, 10:00 to 12:00, 12:00 to 14:00, 14:00 to 16:00, 16:00 to 18:00, 18:00 to 20:00, 20:00 to 22:00, 22:00 to 00:00 and 00:00 to 6:00. The departure times were asked in the periods before and during the pandemic. We have tried to consider all intervals to include all of the trips during a day. A number is then assigned to each time interval from 1 to 10, and the mean differences were compared by t-test in Table 11.

Table 10. The most influenced groups of respondents for each mode

	Mode				
	Bus	BRT	Taxi	Private taxi	Metro
Age	24-30	18-24	24-30	18-24	18-24
Education level	M.Sc.	B.Sc.	School	M.Sc.	High school
Vehicle access (days)	3	0	0	0	3
Family members infected	Yes	Yes	Yes	Yes	Yes
Economic loss (change)	Little less	Much less	Much less	Little less	Much less
Gender	Male	Male	Female	Female	Male
Income (USD)	Less than 60	Less than 60	Less than 60	60-180	Less than 60
Teleworking possibility	Yes	To somewhat	Yes	To somewhat	Yes
Respondent infected	No	No	Yes	No	Yes
Anxiety and stress caused by virus	Little	Much	Much	Much	Little

Table 11. Differences between means of the number of intervals in which passengers' trips are made before and during COVID-19

P-value	Mean Difference (Before-After)	Lower	Upper
0.000	1.11	0.84	1.37

According to the results, it can be stated that there has been a slight difference in the time intervals in which passengers' trips were started before and during the pandemic. This pertains to the fact that most daily trips occur at fixed time intervals for the aim of work or education. During the Coronavirus outbreak, about one time-interval has been removed from daily trips, which may explain the overall decrease in trips as indicated previously.

3.2.4. Changes in driving behaviour

In Figure 1, the impact of the COVID-19 pandemic on driver's speed, traffic violations, attention to traffic rules, aggressive driving, concentration during driving and near-crashes experience has been evaluated. In this figure, none means that there was no change in that behaviour during the pandemic compared to the period before the pandemic. "Much less" and "little less" refer to the decrease in the frequency of that behaviour after the outbreak. "Little more" and "much more" mean that the frequency of that behaviour has increased.

As shown in Fig. 1, most behaviours did not change much after the pandemic based on what drivers announced. During the COVID-19 pandemic, speeding has been more prevalent among drivers. A possible explanation is that drivers have more agility in overcoming shortages caused by home quarantine and economic losses. In addition, traffic congestion due to the reduced demand can cause an increase in speed. This can lead to the habit of travelling at high speeds for an extended period. Consequently, we might see an increase in the number and severity of accidents. In addition, on some roads, crashes might occur for these vulnerable groups due to the previous expectations of pedestrians and cyclists about lower speeds.

On the basis of analyses and knowledge of the local situation, these points can be mentioned about urban transportation during the COVID-19 pandemic.

- Walking and cycling have a bright prospect during a pandemic since social distancing can be maintained and they are more flexible than public transportation systems. However, it should be noted that Tehran lacks proper pedestrian and bicycle infrastructure. The reduction in motorized traffic during the pandemic provides an opportunity for urban planners to promote active modes of transportation.
- We need to limit COVID-19's overestimation and restore travellers' psychological attitudes toward risk to pre-crisis levels.
- Positive points in taxis have been observed, including electronically-paid fares, a reduction in the number of backseat passengers, and more drivers considering personal hygiene. In the future, these can be retained to make travel more comfortable for passengers.
- Employers have been trying to control the office with the presence of employees for years. However, despite the initial resistance, most of them have provided employees with the chance of telecommuting. This has been satisfying for employers themselves in some cases. They have realised that only the amount of time spent in the office is not important and that employee productivity is more crucial. Elimination of some work trips in the future can provide a chance to reduce traffic congestion and air pollution in Tehran.
- Online shopping has become popular and replaced traditional methods. This can help to reduce shopping trips in the future.
- Educational trips have been eliminated because of the online teaching method. This may be the case in the future for some courses and can help decrease education trips.
- A slight increase has occurred in the average speed of vehicles in daily trips.

4. Conclusions

This paper explored the effects of the COVID-19 outbreak (in the first wave) on rural transportation in Iran as the case study. In addition, changes in the travel behaviour of citizens living in Tehran, as the most populated city in Iran were studied.

As expected, in rural transportation, a considerable reduction has been experienced in passengers' demand, for rail, air, road, and water modes, with rail transportation experiencing the highest drop and water the lowest. In regard to rail mode, as early as possible, an effective plan should be devised to limit the number of passengers per cabin to three.

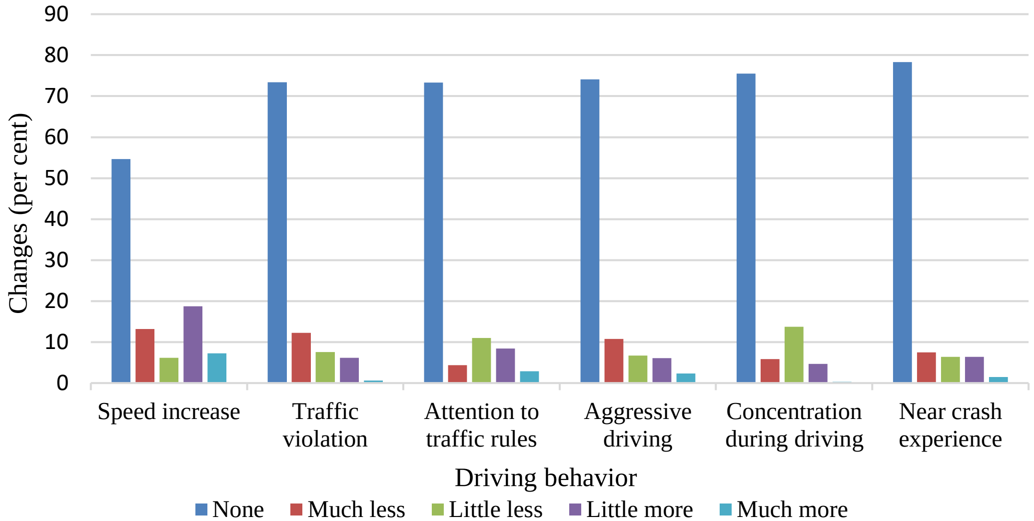

Fig. 1. Changes in driving behaviour

Increased frequency of services can partially compensate for a reduction in capacity due to social distancing. The decline in cargo transportation was not as large as that in the number of passengers, but because of the recession in the industries and trade, a reduction in cargo transportation compared to previous years was observed. As for air travel, there may be a reduction in the near future, since some trips may be excluded from regular travel cycles. A great deal of change must also take place in flight schedules so that the maximum number of flights can be offered during this period. Regarding road transportation, the number of accidents has dropped substantially in this period. It can be confidently stated that demand management and reducing certain trips can make roads safer. Travel conditions require some modifications to maintain mobility while keeping passengers safe from virus contamination. These countermeasures include but are not limited to disinfection of passengers' baggage, keeping social distancing in the fleet and queues, increasing the frequency of services, providing some online services to decrease the queue length and among others. Because of the decrease in travel demand, which might continue in the future, there will be a risk of unemployment in the transportation industry.

In urban transit, however, studies have been conducted on travel behaviour during the COVID-19 outbreak. In this regard, changes in the frequency of trips with different purposes, travel mode, the time distribution of travel, and unfavourable driving behaviours during the COVID-19 outbreak were compared to normal conditions. The results showed that all trips had experienced considerable reductions, primarily due to online teaching, teleworking and other restrictions in daily trips during the second wave of the COVID-19 outbreak. Anxiety from COVID-19 was primarily responsible for the decline in work trips. Teleworking became the preferred method of completing workers' tasks during the virus pandemic. In terms of reduced travel frequency, young travellers aged 18 to 24 were most affected. Moreover, as expected, the frequency of trips by public transportation systems also decreased, mainly due to the fact that social distancing could not be maintained. Higher income groups were least affected by mode of choice. This proves the fact that wealth, which can result in owning several vehicles, directly contributes to public transportation use in Iran. Nevertheless, surprisingly cycling as a sustainable transport mode has experienced the highest decrease. Because of the anxiety about infection, most of the passengers shifted to private cars, an issue that might threaten sustainability in the future. Finally, the evaluation of some unfavourable driving behaviours during this pandemic indicated that an increase in drivers' speed has occurred. Since the pandemic has lasted two years, this can be alarming for the future since this increase in speed might change driving habits and make traffic control complicated. Traffic calming programs for drivers during the pandemic can be suggested.

Overall, the reduction in the number of trips in urban transit is not worrying but desirable for megacities. In recent years, the main effort of the related organisations in Tehran was to solve the problem of traffic congestion by increasing the supply, and less attention has been paid to demand management. Online education and teleworking are two issues that can be used not only during an outbreak but also during normal times to eliminate some unnecessary trips.

The main limitation of this study is the reliance on self-reports of driving behavior, since there were no data on observed driving. Another limitation of this research is data collection related to the second wave of COVID-19 outbreak in July 2020 in Iran. It is suggested that future research should collect another set of data (covering urban and rural areas) when vaccinations may ease restrictions. The last suggestion for future subjects is considering multivariate analysis to see trade-offs between the time saved in long commutes in congested and crowded situations and the time spent in travel using slow modes (e.g., walking) for shopping and personal purposes.

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