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Will modal shift occur from subway to other modes of transportation in the post-corona world in developing countries?

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ABSTRACT
Developing countries are more fragile in the face of the crippling Covid-19 pandemic. Transportation is one of the major industries that has been hardly hit worldwide, and it is more worrying for these countries that already have challenges such as high modal share of private cars, air pollution, and high fatalities due to car accidents. This paper is one of its first kinds that studies the impact of this pandemic on the transportation of Tehran, the capital of Iran, which is one of the forefronts of the battle. In the first step and to get better insights from the travel behavior of passengers due to the pandemic, an online questionnaire is developed and distributed. Priorities for mode choice before and during the pandemic decrease and increase in the share of different modes and the impact of having a high-risk person in the family is studied. Subway had the most decrease and private cars had the highest increase. Hence, two logit models are developed to explain the variables that affect shifting away from the subway and shifting to private cars. Based on the results, a follow-up survey some months later and ridership trends of public transportation during the pandemic, four scenarios are envisaged for the post-corona world, the most probable one is highlighted and policies are recommended to better manage the situation.

1. Introduction

The world has faced unprecedented challenges during the Covid-19 pandemic, and different aspects of human lives have been deeply affected. Transportation is one of the sectors that has been profoundly disturbed due to the nature of lockdown and the need for social distancing. While passengers traveling between cities and countries have been kept to absolute necessities by enforcing various limitations, urban transportation needs to function, especially for the sake of health and public services. Although many companies have tried to use distance working, most of them still ask their employees to be present at work part-time and use teleworking as far as possible.

Transportation can be a double-edged sword during the pandemic: it can cause the virus to spread, leading to more cases and deaths. It can also help to maintain necessary mobility in cities. The consequences of Covid-19 on transportation have been very severe to the extent that it has been called “A mobility crisis” World Bank (2020). Hence it is very important to study the situation closely, monitor the changes that arise, and implement appropriate policies to tackle them.

Although nearly all parts of the world have been struggling with the challenges since the outbreak, the consequences have not been identical for all the countries. Obviously, developed countries have better financial means and infrastructures to manage the situation, while developing countries might have shortcomings that exacerbate the situation.

According to World health Organization (2021), Iran has been among the top 12 countries by the number of deaths due to this pandemic (over 79,000 cases as of May 2021). Iran has a population of about 82 million (rank 19 in the world), and its gross domestic product (GDP) ranks 28th (The World Bank, 2020), but the overall quality of transportation is 82nd in the world (World Economic Forum, 2019).

Iran is a large producer and exporter of natural gas and oil. The energy market in the country is heavily subsidized, and this has resulted in “low productivity in the energy-intensive industries, deterioration of the environment in urban areas, and a huge burden on the government budget” (Moshiri, 2013). Diesel and gasoline prices are among the cheapest in the world (Fig. 1). Too low gasoline prices have had an enormous impact on transportation and modal choice, including low incentives for energy-efficient car technologies and alternate fuels, the high average age of vehicles, and a large share of single-passenger vehicles (Jafari and Baratimalayeri, 2008).

Tehran, the capital of Iran, is the largest and most populous city, with a population of about 9 million. The modal share of urban transportation...
in Tehran is about 10% for subway, 16% bus, 23% taxi and the majority of the rest is for private cars leading to over 650 fatalities in 2018 (Tehran municipality, 2019). As the north of Tehran is bounded by the Alborz mountain range, the geographical location of Tehran and cool Alborz mountain range, the geographical location of Tehran and cool temperatures in cold seasons (especially December) results in polluted air (Sabzevari et al., 2014). In 2019, the quality of air in Tehran was for 29 days clean, 250 days healthy and 81 days unhealthy for sensitive groups (22%) and 5 days (1%) unhealthy for all (Air Quality Control Company of Tehran, 2020), resulting to many days of school closures. Therefore, even in ordinary situations, there are lots of urban transportation challenges in the capital and in the face of Covid-19 pandemics. Afterward, a questionnaire is designed to analyze the role of transportation in these situations. For instance, a model has been developed by Goscé and Johansson (2018) to estimate how airborne diseases spread by London underground. Crowd models have also been used to predict how Covid-19 can transmit in confined spaces based on parameters like exposure time and the number of people (Ronchi and Lovegrove, 2020).

Transportation can also cause viruses and infected cases to spread across the countries and continents. Zheng, Xu, Wang, Ning, and Bi (2020) found a strong positive correlation between the frequency of transportation services from Wuhan (the city where the outbreak started in China) and infected cases in other cities. In a similar study, high-speed train and air travel between Wuhan and destination cities were positively, and distance was negatively correlated with the number of infected cases at destinations (Y. Zhang, Zhang and Wang, 2020). The simulation model and the Sankoff algorithm were also used by Reimering et al. (2020) to predict how air transportation can contribute to spreading the influenza pandemic.

International World Health Organization recommends keeping the distance of at least 1 m when interacting with others (WHO, 2020). This is difficult to observe in confined spaces such as the subway. Moreover, as subways are underground with limited fresh air, various works have been done on analyzing potential risks to health, which can intensify when respiratory-related diseases increase (like in winter), let alone pandemics. A comprehensive survey of how ventilation in subway stations may pose a risk to the health of passengers was done by Wen et al. (2020).

For all the above-mentioned reasons, together with the decrease of activities and concern of people for their health, the travel behavior of people during the Covid-19 pandemic has changed considerably (Parady et al., 2020). Although interventions by transportation authorities have been implemented, such as recommendatory or mandatory mask-wearing, their full observation by all citizens is disputable (Dzisi and Dei, 2020), especially in developing countries (Mogaji, 2020). These interventions and lockdowns can be mathematically optimized by considering costs, benefits, and utility of trips, such as the model proposed by Oum and Wang (2020). All in all, there is a sharp decline in daily use of public transportation in different countries of the world that struggle with the pandemic, including Australia, Brazil, India, the United Kingdom, Japan, Kenya, Hong Kong, South Korea, and the United States (Tirachini and Cats, 2020).

It must be noted that pandemics and especially the recent Covid-19 one, do not affect genders the same (de Paz et al., 2020). In terms of transportation, as women use public transportation more than men, it is expected that its consequences hit them harder (Dave, 2020). As previously mentioned, this will be investigated as one of the research questions of the present paper.

Among many challenges that have been brought up, there were some

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**Fig. 1.** Average retail prices of diesel and gasoline in selected countries (Fattouh and El-Katiri, 2013) based on World Bank Statistics.
positive sides of the pandemic on transportation including: the decrease in road transportation fatalities (Colonna and Intini, 2020), the potential shift toward more active travel modes such as bike-sharing and cycling in the post-pandemic era (Teixeira and Lopes, 2020), decrease in energy consumption of the transportation sector (Nizetic, 2020) and reduction in carbon footprint and emissions (Le Quéré et al., 2020).

Overall, the interactions of the pandemic and transportation have three major aspects, which are the spread of the disease, changes in mobility patterns, passenger travel behavior and freight supply chain, and finally, impacts on the environment (Loske, 2020). The World Bank (2020) has also summarized them as:

- Decrease in ridership of all modes of transportation, especially aviation and public transportation
- Decrease in shared mobility
- Disturbance in global supply chains
- Unused transportation capacity and lost opportunity cost
- Change in travel behavior and mode choice
- Reduction of carbon footprint resulting from transportation activities
- Loss of some transportation-related jobs

It can be concluded that although many papers have been rapidly published on the topic of transportation and the Covid-19 pandemic, still many areas have been left to be explored. This is especially important for developing countries that, even in ordinary situations, have many transportation-related challenges such as low use of public transportation, traffic jams, and air pollution. Moreover, up to the time of writing this paper, the authors found no published research that studied this topic for Iran.

3. Methodology

In this research, an online questionnaire was used to collect data as due to the pandemic it was risky to use pen and paper. The questionnaire of this research included three sections: demographic questions, travel behavior before the Covid-19 pandemic, and travel and people travel behavior after the outbreak of the Covid-19 pandemic. In the first section, people were mainly asked about gender, age, education, job, car and motorcycle ownership, and the number of household members. The second and third sections of the questionnaire consisted of questions about the major purpose of trips, possibility of remote working, the average number of trips per week, mode choice, importance and priorities of factors (cost, time, convenience, safety and security, door to door transport, social distance, cleanliness, and hygiene, wearing the mask) in choosing travel mode and finally the rate of use of online services like online shopping, banking services, and food ordering.

The number of minimum samples in this study for the alpha level of 5% was calculated 384, according to Cochran’s formula (Kotlik and Higgins, 2001) (equation (1) shown below). In the formula, n is the sample size, N is the size of the target society, Z is the value of the normal average number of trips per week, mode choice, importance and prior and motorcycle ownership, and the number of household members. The second and third sections of the questionnaire consisted of questions about the major purpose of trips, possibility of remote working, the average number of trips per week, mode choice, importance and priorities of factors (cost, time, convenience, safety and security, door to door transport, social distance, cleanliness, and hygiene, wearing the mask) in choosing travel mode and finally the rate of use of online services like online shopping, banking services, and food ordering.

The number of household members was one (1.5%), two (15.9%), three (33.5%), four (37.7%), and five or more (11.4%). 4.6% did not own a car in their household, 52.1% had one car, 36.7% had two cars, and 6.6% had three or more. This is because the survey was focused on the residents of Tehran, which has a car ownership rate that is highest in Iran. 16.4% of the respondents had a motorcycle (which is rather popular in the capital due to heavy traffic).

As Table 1 shows, there is a sharp increase in personal car/motorcycle use after the pandemic (+20.1%), and the use of the subway had the most decrease (~21.3%) followed by a 14.5% decrease in using BRT and Bus. Although riding a bicycle is not very common in the busy capital due to many reasons, including lack of designated lanes, some steep streets, and the large area of the city, the use of bicycle had 500% increase after the pandemic, which is noteworthy. It definitely saves the user from observing social distancing and relevant worries of sharing public transportation with others and is not as costly as using personal cars. The major proportion of time after the pandemic was in spring and summer with pleasant weather to enjoy a bicycle ride which may change in rainy autumn or snowy winter. The same pattern can be seen for walking with a more than fourfold increase.

A follow-up survey was done in April 2021 to analyze changes in travel behavior and modal share compared to July 2020.120 respondents of the previous survey who had provided their information were contacted again and filled out the questionnaire for the second time. The results are added as separate columns in Table 1. It can be seen that the use of private car has decreased since July 2020. This is partly due to traffic restrictions (9 pm-4 a.m.) that were imposed to control Covid-19 which did not exist during the previous survey (July 2020). This also explains slight increase for using internet taxi as they were exempt from these limitations. The use of subway did not change significantly, but users of the bus increased. This is also consistent with the official statistics of UITP (2021). Shifting toward active mode of walking continued by 5.1% increase.

Cost and travel time have always been identified as major criteria of passengers for their mode choice (Blainey et al., 2012) during ordinary times. While this was confirmed in our study for the before case, observing social distance became the first criteria during the pandemic (July 2020), followed by the use of masks by other people and cost. Travel time was downgraded to the fifth priority.

Regarding the priority of factors during the pandemic, there is a significant difference between the first, the second, and the third priorities of men and women. Ranking for women’s priorities are 1) the use of masks by other people, 2) social distance, and 3) cost of travel. For men, the ranking is 1) social distance 2) cost, and 3) use of masks by other people. Table 2 shows how priorities of factors for mode choice have changed during the pandemic.

Priorities of passengers changed in the follow-up survey. The use of masks by other people became the first priority. This is also consistent with the increase in the share of bus passengers as social distancing can not be observed in bus but wearing masks is compulsory. The reason why subway did not witness the same increase could be due to lack of night services (after 10:30 p.m. while there are some bus routes that operate 24 h). Air circulation, as one of the main recommendations to avoid spread of Covid-19 virus, is also better observed in buses due to possibility of opening windows whereas as in subway air circulation is very limited underground. Travel time has moved up to get closer to its
A vulnerable/high-risk family member is defined in this study as the presence of at least one vulnerable person that fits into this definition (we call them the higher risk group). Table 3 shows the change in the mode choice of these people relative to healthy people. It can be seen that use of urban and internet taxis has considerably increased (54.3% in total). The main reason people shifted from public transportation such as the subway to private cars and motorcycle is to observe social distance. After the Covid-19 outbreak, the dominant mode of transportation for people over the age of 55 was the subway, bus, and BRT. It is worth mentioning that in Iran, citizens over the age of 65 can travel on public transportation for free by using a specially issued card. After the Covid-19 outbreak, the dominant mode of almost all age groups were private cars and motorcycles, and only people over 65 shifted to walking. As previously mentioned in Table 1, after the covid-19 outbreak, the subway had the most decrease in the number of riders (by 21.3 percent). In contrast, private cars and motorcycles gained the largest mode share (54.3% in total). The main reason people shifted from public transportation such as the subway to private cars and motorcycle is to observe social distancing and to stay away from crowded places, which increase the use of online services for people who have a high-risk family member is higher than others, as presented in Table 5. Moreover, Anova test results show that the average use of online services in different age groups are significantly different from each other (Table 6) and people in the age range of 26–45 have the highest use of these services.

In this survey, respondents were asked if they had a vulnerable or high-risk person to the Covid-19 (as defined by the World Health Organization) in their family. About 40% of respondents stated they had at least one vulnerable person that fits into this definition (we call them the higher risk group). Table 3 shows the change in the mode choice of these people relative to healthy people. It can be seen that use of urban and internet taxis has considerably increased (+7.4%) if there was a vulnerable/high-risk person in the family while for the other group use of taxi did not have a considerable change. In the former group, the decrease in the use of the subway was slightly more than the latter. Another interesting observation is that although there was a sharp increase in the use of private cars of both groups, some in the higher risk group (potentially due to health conditions) preferred not to drive the car themselves hence used taxi more.

Before the covid-19 outbreak, only 18% of people were able to do remote working, but after the pandemic, more than 50% of respondents were able to do remote working, and 45% of people had to continue working just like in the past. 15% of these people have jobs like medical occupations, service, and operational jobs (fireman, police, drivers, etc.)

The use of online services has increased by 40% since the outbreak of the covid-19. The average use of online services in women is significantly higher than men (significant at 5% level), which is shown in Table 4. Also, T-test results confirm that the average use of online services in different age groups are significantly different from each other (Table 6) and people in the age range of 26–45 have the highest use of these services.

In Table 1, the mode of transportation was divided into two main groups: individuals with at least one vulnerable person that fits into this definition (we call them the higher risk group) and the others. Table 3 shows the change in the mode choice of these people relative to healthy people. It can be seen that use of urban and internet taxis has considerably increased (54.3% in total). The main reason people shifted from public transportation such as the subway to private cars and motorcycle is to observe social distance. After the Covid-19 outbreak, the dominant mode of transportation for people over the age of 55 was the subway, bus, and BRT. It is worth mentioning that in Iran, citizens over the age of 65 can travel on public transportation for free by using a specially issued card. After the Covid-19 outbreak, the dominant mode of almost all age groups were private cars and motorcycles, and only people over 65 shifted to walking.

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Table 1
Mode choice of the respondents before and during the pandemic.

| Mode                                | Before Covid-19 Pandemic (%) | July 2020 (%) | Change (July 2020–Before pandemic) (%) | April 2021 (%) | Change (April 2021–July2020) (%) |
|-------------------------------------|------------------------------|---------------|----------------------------------------|----------------|-------------------------------|
| Private Car or Motorcycle           | 34.2                         | 54.3          | -20.1                                  | 40.8           | -13.5                         |
| Urban and Internet Taxi            | 14.4                         | 17.6          | +3.2                                   | 21.7           | +4.1                          |
| Subway                              | 30.6                         | 9.3           | -21.3                                  | 9.2            | -0.1                          |
| BRT and Bus                         | 17.4                         | 2.9           | -14.5                                  | 7.5            | +4.6                          |
| Bicycle                             | 0.2                          | 1             | -0.8                                   | 0.8            | -0.2                          |
| Walking                             | 3.2                          | 14.9          | -11.7                                  | 20             | +5.1                          |

Table 2
Priorities for mode choice of respondents before and during the pandemic.

| Priorities | Before Covid-19 pandemic | During Covid-19 pandemic (July 2020) | During Covid-19 pandemic (April 2021) |
|------------|--------------------------|--------------------------------------|--------------------------------------|
| 1. Cost    | Social Distance          | Use of Masks by Other People         |
| 2. Travel Time | Use of Masks by Other People          | Social Distance |
| 3. Convenience | Cost                  | Cost                                |
| 4. Safety and Security | Cleanliness and Hygiene | Travel Time |
| 5. Door to Door Transport | Travel Time | Safety and Security |
| 6. Social Distance | Safety and Security | Cleanliness and Hygiene |
| 7. Cleanliness and Hygiene | Convenience | Door to Door Transport |
| 8. Door to Door Transport | Convenience | |

Table 3
Impact of a vulnerable/high-risk family member in mode shift during the pandemic.

| Mode                                | One or more vulnerable/high-risk person in the family | No vulnerable/high-risk family member |
|-------------------------------------|------------------------------------------------------|--------------------------------------|
|                                      | Before Pandemic | After Pandemic | Change | Before Pandemic | After Pandemic | Change |
| Private Car or Motorcycle           | 36.6           | 53.4           | +16.8  |
| Urban and Internet Taxi            | 14.3           | 21.7           | +7.4   |
| Subway                              | 31.1           | 8.7            | -22.4  |
| BRT and Bus                         | 15.5           | 2.5            | -13    |
| Bicycle                             | 0              | 0.6            | 0.6    |
| Walking                             | 2.5            | 13             | 10.5   |

Table 4
The T-test between genders on the use of online services.

| Levene’s Test for Equality of Variances | T-test for Equality of Means |
|----------------------------------------|-----------------------------|
| F | Sig. | t | df | Sig. |
|---|------|---|----|-----|
| Equal Variances Assumed | 0.585 | 0.445 | 2.013 | 407 | 0.045 |
| Equal Variances Not Assumed | 2.006 | 392.451 | 0.046 |

Table 5
The T-test between the two groups with/without a high-risk person in the family on the use of online services.

| Levene’s Test for Equality of Variances | T-test for Equality of Means |
|----------------------------------------|-----------------------------|
| F | Sig. | t | df | Sig. |
|---|------|---|----|-----|
| Equal Variances Assumed | 0.095 | 0.758 | -2.797 | 407 | 0.005 |
| Equal Variances Not Assumed | -2.769 | 330.109 | 0.006 |
In this section, factors affecting the shift from the subway to other modes, and also factors affecting the shift from other modes to private cars and motorcycles, are analyzed by developing logit models. The first one investigates factors that had the greatest impact on people not using the subway after covid-19 and using other modes. In this logit model, the variable was changing transportation mode from the subway to other modes (still using the subway: 0, shifting to other modes: 1), and in order to obtain independent variables with the greatest effect, a large number of socio-economic variables and also variables related to the type of travel were examined, and several models were tested. Finally, the best model was chosen, and statistically significant variables were used in the model, and other variables were removed. As Table 7 shows, the number of work trips in the week (negatively correlated) and income (positively correlated) were the two most influential variables leading people to shift from the suburb to other modes.

The second logit model was developed and calibrated to identify parameters that cause people to use private cars and motorcycles or to shift to them. The independent variable in this model is the binary variable of shifting from other modes to private cars and motorcycles. As shown in Table 8, gender, age, job, and the existence of vulnerable/high-risk person in the family are the most important variable that affects on using personal car and motorcycle.

To compare the status of public transportation in Tehran with other cities of the world during the pandemic, we summarized major recent published research, which are presented in Table 9. It can be concluded that shifting away from public transportation, increasing use of private cars and increasing active traveling have been a worldwide trend.

5. Scenario planning for the post-corona transportation

There is always uncertainty and complexity about the future but facing this unprecedented global challenge of the Covid-19 pandemic intensifies them like never before. Scenario planning that envisages multiple futures and plans accordingly is one of the useful tools in these situations, and there are various qualitative and quantitative methods for it which have been comprehensively reviewed by Amer et al. (2013). We use the methodology that was initially proposed by Galtung (1980), identify two major uncertainties, and based on the results obtained in the previous sections, scenarios are written accordingly. “Time of pandemic ending” and “shifting back to the subway and other public transportation” were identified as the two major uncertainties; hence we propose the following four scenarios as shown in Fig. 2 and explain with policy implications afterward.

Scenario 1. - “Business as usual”: The covid-19 pandemic will finish in short/medium term, and people will shift back to use public transport, especially the subway as before. As social distancing, wearing masks, and cost are the top three priorities of the passengers during the pandemic (Table 2), transportation authorities need to pay close attention to these factors to maintain the faith of their users. It is strongly advised that wearing a mask be compulsory onboard the subway and other modes of transportation. The idle capacity of the rolling stock (which is free due to shifting to other modes) can be used to reduce the load factor and enabling better social distancing. Reduced fare (in response to 3rd priority) can be provided for traveling off-peak to decrease overcrowdedness. It is worth mentioning that subway fare does not differ in peak and off-peak times. The first logit model showed (Table 7) that the number of work trips is negatively associated with shifting from the subway to other modes. As currently there is no discount for loyal riders, and the ticket price is high, transportation authorities can advise that the subway fare be reduced or free for passengers. It is expected that the subway will be the first choice again post-corona pandemic.

Scenario 2. - “authoritarian control”: The covid-19 pandemic will finish in the short/medium term, but shifting back to the subway may not automatically occur. Some people will continue using private cars, motorcycles, and taxis due to the accumulated fear of the virus, getting accustomed to the convenience of private cars, and cheap fuel prices in the country. The modal share of public transportation in this scenario is very sensitive to the policies that are implemented by the government and other authorities. To enable public transportation to gain its advantage over private vehicles, public authorities can advise the use of public transport by providing free parking lots near subway stations, and by the use of incentives such as free ticket for one or two months.

Table 6
ANOVA test between different age groups on the use of online services.

| Sum of Squares | df | Mean Square | F    | Sig.  |
|---------------|----|-------------|------|-------|
| Between Groups | 54,805 | 5 | 10,961 | 5.430 | 0.000 |
| Within Groups  | 813,532 | 403 | 2.019 |      |       |
| Total          | 868,337 | 408 |      |      |       |

Table 7
Logit model that explains shifting from the subway to other modes.

| Coefficient | Sig.  |
|-------------|-------|
| Constant    | 0.396 | 0.007 |
| Number of work trips in the week | -0.187 | 0.007 |
| Income      | 0.484 | 0.00 |
| L1|L1_base | R² | X² |
| -159.654 | -167.751 | 0.041 | 10.479 |

Table 8
Logit model that explains shifting from other modes to private cars.

| Coefficient | Sig.  |
|-------------|-------|
| Constant    | 1.702 | 0.04 |
| Gender      | -0.986 | 0.004 |
| Age         | 0.070 | 0.00 |
| Job         | 0.418 | 0.015 |
| Existence of a high-risk person in the family | 0.689 | 0.043 |
| LL      | 167.751 | 0.041 |
| LL_base | 109.953 | 4.709 |

Table 9
Summary of published research on modal share of public transport during Covid-19 pandemic.

| Authors          | Country/ Region/City | Major findings |
|------------------|----------------------|----------------|
| Molloy et al. (2021) | Switzerland          | 90% decrease in public transportation; increase in cycling |
| J. Zhang, Hayashi, and Frank (2021) | worldwide | Decrease in public transportation, increase in use of private car (mostly in China and South Korea) and active travel (mainly in Europe) and motorcycle (India) |
| Bucsky (2020)    | Budapest             | 80% decrease in public transportation; most increase in modal share for cycling |
| Tan and Ma (2021) | China                | Choosing subway during the pandemic depends on walking distance to the station and job |
| Anke et al. (2021) | Germany | 3% increase in modal share of private car, decrease in modal share of bus and tram by 14% |
| Bhaduri et al. (2020) | India | Modal share of private car and motorcycle increased by 5%; active travel increased by 4%; decrease of 6% in modal share of public transport |
| Fatmi et al. (2021) | Canada | Decrease in travel companions was observed |
| Falchetta and Noussean (2020) | Europe | Decrease in carpooling; increase in use of private cars |
| Gaskin et al. (2021) | US | Strong correlation between using public transportation and Covid-19 cases was observed |
| Abdullah et al. (2021) | Pakistan | Major shift to active travel for trips shorter than 5 km and to private car for longer ones |
| Das et al. (2021)  | India               | “age, gender and income” affect shifting away from public transportation and change in mode |
previous share, the stricter limitation should be imposed on the use of private cars. Unfortunately, the opposite has been seen during the Corona pandemic, such as lifting congestion charging in the city center of Tehran, which led to a considerable increase in air pollution (Tehran Times, 2020). Implementing effective policies is more critical in autumn and winter when air pollution in the capital peaks leading to school and university closures in the past years. If shifting back to public transportation was not successful, providing more online services, such as online education, is recommended as the second-best solution (Tables 4–6 can advise which groups are better targets).

Scenario 3. “Transformation”: The covid-19 pandemic will not finish in short/medium term, but after a while, some passengers will shift back to the subway for reasons such as financial issues and getting used to the fear of virus as time passes by. In this scenario, there is a transform from the current situation as passengers increase while the pandemic goes on. As social distancing, wearing masks, and cost are the top three priorities of the passengers during the pandemic (Table 2), transportation authorities need to pay close attention to these factors to maintain the faith of their users. Monitoring passengers to wear masks and instructing them to observe social distancing are inevitable. Having quantitative targets such as the maximum number of passengers per wagon or the maximum number of passengers allowed to enter stations (controllable at ticket gates) can be plausible solutions to avoid the crowd. Other measures must also be taken for the gradual increase of passengers, like better rolling stock scheduling and improved ventilation systems.

Scenario 4. “Disaster”: The covid-19 pandemic will not finish in short/medium term, and people will not use public transportation for fear of getting infected and prefer to use private cars, motorcycles, and taxis. This so-called disastrous scenario may lead to huge financial deficits for transportation companies and the layoff of employees and drivers. Government should be aware that the health and financial burden of air pollution in Tehran is very high and is estimated to be about 3 billion USD per year (Bayat et al., 2019). Hence compensating for the loss of transportation companies, trying to maintain the jobs, and tackling the concerns of subway passengers in the hope of shifting scenario 4 towards scenario 3 would even be financially beneficial for the government when the big picture is considered. For this purpose, new priorities of passengers for mode choice (Table 2) should be transparently fulfilled, and the general public should be informed of all the initiatives taken in this regard to reduce the worry of using public transportation. Policies suggested in scenario 3 are still applicable. In the meantime, more limitations should be imposed on the use of private cars.

The logit model presented in Table 7 showed that those with higher income shift from the subway to other modes much easier; hence transportation authorities should be aware of which target groups of passengers they are trying to maintain or attract. It was shown that families with high-risk person shift more to other modes (Table 3). These passengers and their direct family members are unknown to the transportation companies, and launching special transportation services, travel cards, and any sort of support for them might prove to be effective.

To identify the most probable scenario, we use the results of our two surveys and also consider the actual trend of subway and bus ridership (Fig. 3). It can be seen that bus and metro ridership is gradually recovering and increasing toward its pre-pandemic quantities. However, recovery of bus is faster than metro. These are in line with the finding of our research and the two surveys. With the vaccination of Covid-19 underway in many parts of the world, “business as usual” scenario seems the most probable one.

6. Policy implications

Based on the obtained results, the following policies are recommended:

6.1. Strict supervision on wearing masks by passengers

Currently, the first priority is wearing masks which used to be social distancing. Hence to restore passenger faith and decrease their fear from getting the disease, strict control over wearing masks by passengers is needed and penalties might be necessary for those who do not obey. Even after the end of pandemic passengers may not feel safe right away.
and wearing masks on public transport may be needed for some time.

6.2. Conducting regular surveys

Covid-19 pandemic has hit the world hard not only physically but also mentally and emotionally. In our research, priorities of passengers in Tehran during Covid-19 pandemic changed over time. Therefore surveys are suggested to be conducted regularly to monitor changes in priorities of passengers and their needs in order to implement correct policies.

6.3. Providing updated health information

Public transportation should act very proactively in the face of health concerns and provide updated honest information and instructions to passengers promptly. For instance, passengers have realized that wearing masks is more important than social distancing (which practically cannot be observed in public transportation). Collaborating in international task forces and using experiences of other cities are advised during and post the pandemic.

6.4. Facilitating, promoting and investing more on active modes of transportation

Share of active modes of traveling (walking and cycling) has increased since the start of the pandemic. There would be increasing need for relevant infrastructure such as cycle lanes and pedestrian lanes in Tehran. Municipality should invest more to promote these modes in Tehran. Smart shared bikes which is a new phenomenon in Tehran has had positive impacts in this regard too. Apart from physical facilities, campaigns and cultural initiatives to promote these modes (that are virtually non-existent) are suggested to be organized during and after the pandemic.

6.5. Addressing passengers with a high-risk person in their family

The results of our research show that those who have a high-risk family member have different travel behaviors like using private cars more and public transportation less. Addressing their concerns and providing instructions to decrease the risk of infection is suggested not only for Covid-19 but also for other contagious diseases like influenza.

7. Conclusions

In an oil-exporting country with cheap fuel prices, people easily shift away from public transportation (especially subway) to private cars, and the situation has been exacerbated due to the pandemic. In this study, the authors developed an online questionnaire, which was distributed by email and social media to various targeted groups in the city of Tehran. Results showed that the subway had the most decrease in the number of users followed by BRT and bus. Passengers of these modes shifted to using their private cars and taxi (including internet taxies). Although using a bike is a scarce scene in the capital, respondents identified an increase of 500% compared in their bike use compared to before the outbreak. Walking also witnesses a considerable increase from 3.2% to 20%.

Priorities of mode choice have clearly changed from cost, travel time, and convenience (before the pandemic outbreak) to wearing masks. Social distancing and cost (after the outbreak). Transportation authorities must pay close attention to this change and try to take appropriate policies to fulfill them; otherwise, passengers will shift away from public transportation for fear of being infected. Some groups are more susceptible to this shift, including people with a more vulnerable/high-risk family member. T-test results showed that there is a statistically significant difference between genders and also people with/without a high-risk person in their family for the use of online services to substitute traveling as far as possible. Moreover, ANOVA results confirmed the difference between different age groups in this regard.

Two logit models were developed to see how people shift from the subway to other modes (the first model) and from other modes to private cars (the second model). The number of work trips had a negative impact, and income had a positive impact on shifting away from the subway. Gender, age, job, and the existence of a high-risk family member were found to be statistically significant variables effective in shifting to private cars during the pandemic.

Based on the results obtained from the questionnaire, four possible scenarios are forecasted for the future by considering two major uncertainties regarding the time the pandemic will end and whether people will shift back to the subway. These scenarios were called “business as usual,” “authoritarian control,” “transformation,” and “disaster,” which were benchmarked from the existing literature on forecasting the future. Various policies were recommended for each scenario, and the foundation for all of them is fulfilling the newly emerged concerns of social distancing and wearing masks rather than conventional mode choice factors. Transportation authorities need to maintain the faith of passengers that their health is of utmost importance, and operational planning (such as rolling stock circulation, the monitoring load factor of trains) needs to fulfill these in action. On the other hand, in a city that the share of public transportation is already low, implementing policies that make private cars more attractive (such as lifting congestion charging in the city center of Tehran) must be taken cautiously as shifting back people to public transportation might not be easy. Moreover, the big picture and huge costs of air pollution and the toll it takes on citizens by health problems must be considered than short-term outcomes.

The follow-up survey showed that priorities of passengers for
choosing their preferred mode of transportation has changed and wearing masks has reached the top. Use of private cars decreased and since early months of the pandemic but use of bus is gradually increasing. Ridership statistics show that passengers who are shifting back to public transportation are increasing although the growth rate of bus is higher than subway. We conclude that the “business as usual” scenario is the most probable one in the post-corona world and recommend four policies accordingly. Policy makers should monitor these changes by regular surveys to be able to act accordingly. Further studies are suggested to focus on users of each mode of transportation separately to gain more insights into their travel behavior and mode choice.

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