Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.
Investigating factors affecting university students’ use of subway before and after COVID-19 outbreak: A case study in Tehran

Seyedeh Sara Maljaee, Melody Khadem Sameni

School of Railway Engineering, Iran University of Science and Technology, Iran

ARTICLE INFO

Keywords:
Public transportation
Subway
Mode choice
Travel behavior
COVID-19

ABSTRACT

Identifying and examining factors affecting the use of the subway is critical for developing countries as they struggle with high levels of auto use and resulting congestion, noise and air pollution. In this research, we surveyed students of a top-ranked university in the capital of Iran before and after the COVID-19 outbreak to identify the factors affecting their use of the subway. Chi-square tests show that gender, level of education, and being the only child of the family have the highest impact on using a private car. These variables had no significant influence on students’ mode choice to university before the COVID-19 pandemic, when students’ mode choice was only a function of their residence location. However, the pandemic has affected priorities for mode choice. For instance, hygiene and social distancing, which were previously insignificant to students, are now among their top criteria, and travel time and cost are less important for students than in the past. As a result, subway use has significantly decreased. Based on the results of the research, when making relevant policies, more attention should be paid to the groups of women, undergraduate students and single children that are more likely to use private cars.

1. Introduction

The high modal share of private cars has led to many problems in the city of Tehran. Air pollution is a serious challenge in many metropolitan cities in developing countries, and the capital of Iran is no exception. Various impacts of air pollution in Tehran include over 5000 estimated cases of excess mortality every year (Naddafi et al., 2012a; Naddafi et al., 2012b), having a significant role in vitamin D deficiency (Hosseinpahan et al., 2010), increased risk of developing diseases (Sayadi et al., 2011), increased cardiovascular disease and hospitalization (Hosseinpoor et al., 2005; Karimi and Samadi, 2019; Kianiabadi et al., 2019) and increased emergency hospital admissions for heart and respiratory diseases due to exposure to particulates (Kermani et al., 2016).

Although many factors contribute to the use of private cars, including low gasoline prices (Moshiri, 2020), studying travel behavior among different age groups is very informative to take appropriate policies for shifting towards public transportation. It is important to encourage groups, such as employees and students, to use the subway in terms of the frequency of their trips (Rotaris and Danielis, 2015). Although the subway has many advantages, such as low fares and avoiding traffic jams, various reasons can lead people to use private cars. Factors such as the convenience of using door-to-door transportation, accessibility of subway stations, stopping at different stations, and crowd contribute to this (Blainey et al., 2012), while the COVID-19 pandemic complicates the situation even further.

Although a good number of papers were published on the subject of mode choices around the world from different perspectives, a limited number of studies focused on students’ commute to university campuses, particularly in developing countries. The case study of this paper considers university students who are at a critical age that their travel behavior is shaping. Moreover, they would be future employees and managers who influence other people.

The structure of the present study, which is fundamentally a layout of the work, is as follows: The current section clarifies the basis of the study. It is followed by a brief description of the foundation and purpose of the research. The following section presents a literature review and analysis of existing models. The third section describes a case considered in terms of its statistical and topographical data and related features. Section four presents the methodology, design of the questionnaire, and data collection. Descriptive and inferential statistics are presented in the fifth section. Discussions and recommendations are concluded in the final section.
2. Literature review

A good number of papers were published to review transport mode choice literature in general. (Barff et al., 1982; Idris et al., 2014; Wu et al., 2020). A number of these papers have examined mode choice with an approach to public transportation and the problems that excessive use of private vehicles poses (Hoffmann et al., 2017; Hensher et al., 2013; Buehler, 2011; Chiu Chuen et al., 2014). At the same time, some other previous research has examined the factors influencing mode choice in general (Li et al., 2015; Madhuwanthi et al., 2015; Kamarzanni et al., 2015). Several factors, including gender (Hatamzadeh et al., 2017), age, income (Ha et al., 2020), and whether or not there are children in the family (McCarthy et al., 2017), can also influence mode choice. Previous studies have also shown that the choice of transportation mode depends on individual characteristics, social effects (Javaid et al., 2020), and living environment (Boulange et al., 2017; Kim and Ulfarsson, 2004).

A number of these papers have studied the subway on a case-by-case basis (Lee et al., 2005; Oh et al., 2009; Raveau et al., 2014). In the case of the subway, it has been shown that factors such as travel time and distance, travel costs, individuals’ income (Rith et al., 2020), safety (Mayo and Taboada, 2020), etc. affect its use, as well as demographic components such as age and gender (Kim et al., 2021; Sameni and Tilenoie, 2020; Zhang et al., 2020), and built environment (Gan et al., 2021). Furthermore, a number of these papers have examined the impact of subway use on other modes of transportation and vice versa (Chen et al., 2020; Xu et al., 2015). Regarding the choice of the subway, the subway does not create door-to-door transportation, and in this regard, it can cause the problem of first- and last-mile (Guo and He, 2021; Guo et al., 2020), which is one of the factors that affect the rate of its use and the walking distance of subway station from the initial point of travel or to the final destination affects its mode choice (Liu et al., 2022).

Other papers focus on specific age groups or socioeconomic status (Panter et al., 2008; Fatima et al., 2020). Travel behavior changes across different stages of life (Scheiner and Rau, 2020). Youth travel behavior is complicated in terms of their “desire to drive”, “identity, self-image, and social recognition” (Line et al., 2010). Moreover, when it comes to the youth community, it ought to be noted that this group can incorporate a vast extend of individuals including school students, studying young adults, and working young adults. Travel behavior is generally diverse among mentioned groups for reasons such as owning a driver’s license and individual income (Simons et al., 2017). Indeed, despite there are a limited number of papers that investigate young adults’ travel behavior in developing countries (Etminani-Ghasravadashi et al., 2018), significant differences were observed between the travel behavior of youth in developed countries and developing countries, the latter less keen on public transport (Belgiawan et al., 2014).

Moreover, among the youth, the travel behavior of university students should be studied with more focus since their daily destination is the university where they study, and the sporadic schedule of their classes and their distinctive ways of life from other young adults are variables that cause students to have a more interesting and complex travel behavior (Limanond et al., 2011). Understanding students’ travel behavior is particularly critical for policymakers and public transport administrators, and understanding the variables affecting these behaviors makes it conceivable to oversee travel demand and the use of public transportation (Mohammadzadeh, 2020). A study in Canada uncovered that travel cost might be a vital figure for college students’ travel mode choices (Whalen et al., 2013). Travel cost is a defining factor for the mode choice of students, while other components, such as travel time, physical environment, way of life, and attitudinal factors, should be considered (Moniruzzaman and Farber, 2018). Since students often need to arrive at the college at certain times to attend their courses on time, travel time may also play a significant role in their mode choice (Nguyen-Phuong et al., 2018; Shannon et al., 2006). Whether or not a student lives on campus while they are a student has an impact on their means of transportation. Their usage of private vehicles and, in turn, their travel behavior are first impacted by this (Sarangi and Manoj, 2020).

Since the COVID-19 outbreak pandemic, many studies were published in the last two years that examine its effect on travel behavior. (Abdullah et al., 2020; Bhaduri et al., 2020; Luan et al., 2021). This illness and its transmission, along with lockdown and limitations in numerous nations worldwide, is a major part in changing individuals’ travel patterns (Aaditya and Rahul, 2021). Many measures were taken to reduce travel during the COVID-19 pandemic to decrease travel demand (Yang et al., 2021). It was anticipated, that using private transportation compared to public transit has increased essentially amid the pandemic (Abdullah et al., 2021b). The subway as one of the main modes of public transport is no exception to that and the COVID-19 outbreak has decreased subway use like other modes of public transportation as well (Khadem Sameni et al., 2021). Additionally, throughout the pandemic, shopping replaced jobs and school as the main reasons people traveled (Abdullah et al., 2021a). In general, it is safe to say that the COVID-19 pandemic has had a major negative influence on mobility, especially public transit. It is crucial to prepare for increased usage of private automobiles and their negative impacts. For public transportation to regain its modal share, (Dai et al., 2021), it is essential to look at the variables influencing mode choices across all demographic groups, especially in developing countries.

3. Location and characteristics of the case study

To proceed with the research objectives and to study the travel behavior of students before and after the COVID-19 outbreak, we selected [Details omitted for double-blind reviewing], which is one of the top-rank universities within the country and located in Tehran, as a case study.

Tehran is the capital of Iran and the most populous city in the country. In Tehran, there are various modes of intercity transportation, including cars, buses, subways, taxis, and bicycles. Moreover, [Details omitted for double-blind reviewing] is one of the universities in Tehran which has more than 400 faculty members and over 12,000 students. The main campus is located in the northeast of Tehran, expanded to 42 acres (Fig. 1). Fig. 1 shows the location of the university on the map, and also in this figure, the distance from the nearest subway station to the nearest university entrance is shown, which is a relatively long distance for walking (about 730 m). Another important point about the case study of this research is the price of a subway ticket in Tehran, which is equal to $0.11 for a full round trip.1

To further describe the case study, it should be said that the population of Tehran, according to the latest official statistics published by the Management and Planning Organization of Tehran Province (TMPORG), is equal to 13,267,637 people, of which 1,781,280, or 13.5%, are young adults (15–24 years old) (TMPORG, 2016). Moreover, the number of higher education students in Iran in 2021 is equal to 3,616,114, which 693,068 of them aka 19% are studying in Tehran, and 38% of the total youth population in Tehran are students of higher education which has the highest percentage among other provinces of the country (TMPORG, 2021b).

It is also important to note that students in Iran, especially in Tehran, due to the wide range of universities, like public or private universities,2 can be considered representative of the entire population because people from all strata of society, regardless of their income, can have higher

---
1 The price of a subway ticket on a round trip in Tehran is 40,000 Iranian Rials, which is equal to $ 0.11 based on average exchange rate of Rials to US Dollars in 2021.
2 The definition of a public university and a private university in Iran is similar to its general definition in the world. Public universities in Iran are generally free, except in special cases, but private universities have tuition fees.
education, and students are not just from affluent families. Especially in [Details omitted for double-blind reviewing], because it is a state university and its tuition is free.

Regarding the subject of car ownership in Iran, the official statistics of the statistical center of Iran (SCI) show that the rate of car ownership in Iran is about 53% of all urban households, thus 47% of urban households in Iran do not even own one private car, but on the other hand, in terms of class differences between the highest and lowest strata of society, 48% of households own 2 or 3 private cars (SCI, 2021). In the case of Tehran, statistics published in 2021 show that 59% of the total population of households in Tehran own at least one private car (THMPORG, 2021a).

In general, currently, the possibility of owning a private car for young people and students of higher education in Tehran is almost average. But we cannot have a definite opinion because this issue can depend on various factors, such as age, degree, being the only child of the family, etc., which we intend to examine in this study.

[Details omitted] provides dormitories for its students at all levels of education. Two main dormitories, one female and one male dormitory, are located inside the main campus (Fig. 2), and another male dormitory, is located 11 km outside the university (Fig. 3).

In general, [Details omitted double-blind reviewing], is one of the most famous universities in Tehran, which has a good percentage of students throughout the country. Many people, mainly students, faculty members, and staff, travel to and from the university daily which causes huge travel demand. It is very difficult to find a parking lot in neighboring streets. There are various ways to get to and from this university. Moreover, according to the amount of private car ownership in Tehran,
the factors affecting the use of the subway by the students of this university are examined.

4. Methodology

At first, a comprehensive review of the literature was done to set the theoretical background of the research. A questionnaire-based survey is designed to gain an in-depth understanding of student travel mode options and the underlying causes. Collected data are thematically analyzed along with statistical analysis. Inferential statistics are then used to extrapolate the findings of the statistical sample to the statistical population to examine the data in this study. Descriptive statistics are initially used to express the characteristics of the statistical sample.

4.1. A questionnaire-based survey

The questionnaire used to collect data in this study includes a set of questions based on the basic principles of questionnaire design, such as clarity and comprehensibility, the neutrality of questions and avoidance of suggested questions, and observing the order of questions in a way that does not cause confusion for the respondent and cover all the objectives studied. The questions are answerable and the set of responses is appropriate for each question (Ornstein, 2013). The questionnaire was presented to students online due to the COVID-19 pandemic. A web link was generated from a relevant website, and then the questionnaire link appropriate for each question was used to extrapolate the findings of the statistical sample to the statistical population to examine the data in this study. Descriptive statistics are initially used to express the characteristics of the statistical sample.

This questionnaire includes demographic-related questions such as age, gender, level of education, being the only child of the family, the faculty of the university in which the students’ study, and having the possibility of using a private car. Furthermore, since it was mentioned before and the university offers dormitories for students on the main campus and outside the university, a question is provided to clarify whether the students stay in their own house or student dormitory inside or the dormitory outside the university, during the academic year. The following section of the questionnaire asks students about their current travel patterns, including students’ opinions about travel mode choices before and after the COVID-19 pandemic. Students are also asked to express the significance of factors like quick arrival, low travel costs, maintaining social distance, etc. when making these decisions. A 5-point Likert scale was used to respond to this question, with 1 being given very small significance and 5 being given extremely high significance. In this manner, the closer the average response of the sample is to 5, it implies that the issue has a great significance for students, and the closer this number is to 1, the less important it is. In the last section, an open question to provide suggestions or criticisms.

Regarding the prevalence of COVID-19, this research questionnaire has been distributed online. The statistical sample size calculated using Cochran’s formula yielded 373 people with a 5% error. 390 questionnaires were completed by students, of which 11 were incomplete and unusable, and finally, the research continued with 379 questionnaires. SPSS software was used to calculate descriptive as well as inferential statistics (chi-square test). Existing challenges and suggestions to improve them are subsequently addressed.

5. Results

The first part of this questionnaire examines demographic variables such as age, gender, degree, and field of study. The results of this part show that out of the 379 students who completed the questionnaire, 215 are male (57%) and 164 are female (43%). More than 70% of the statistical sample are in the range of 18 to 22 years and only 4% of the students are in the range of over 26 years. Also, about 80% of the statistical sample are undergraduate students and 20% are postgraduate students (Table 1). Regarding the issue of student’s field of study, it is necessary to pay attention to the fact that the university under study is a technical and engineering university in general and offers only fields of engineering and some basic sciences such as physics and mathematics and doesn’t include a wide range of fields, such as medical sciences or humanities,
Table 1
Descriptive statistics of – socio-demographic variables.

| Gender | Male | Female |
|--------|------|--------|
| Frequency | 215 | 164 |
| Percent | 57 | 43 |

| Age | Frequency | Percent | Frequency | Percent |
|-----|-----------|---------|-----------|---------|
| 18-22 | 278 | 73.4 | 22-26 | 84 |
| 22-26 | 278 | 73.4 | 22.2 | 4.4 |

| Level of education | Undergraduate students | Postgraduate students |
|------------------|-------------------------|-----------------------|
| Frequency | Percent | Frequency | Percent |
| 302 | 79.6 | 77 | 21.4 |
| 25 | 6 | 70 | 18.5 |

| Faculty | mathematics, physics | mechanical, civil, architecture engineering, and urban planning | electrical, industrial, computer engineering | railway and automotive engineering | materials, metallurgy, and chemical engineering |
|---------|----------------------|-------------------------------------------------|---------------------------------|---------------------------------|---------------------------------|
| Frequency | Percent | Frequency | Percent | Frequency | Percent | Frequency | Percent | Frequency | Percent |
| 25 | 6 | 123 | 32.5 | 94 | 24.8 | 67 | 17.7 |
| 278 | 73.4 | 278 | 73.4 | 278 | 73.4 |

| Being the only child of the family | Being the only child | Having siblings |
|-----------------------------------|----------------------|----------------|
| Frequency | Percent | Frequency | Percent |
| 25 | 6 | 20 | 5.6 |
| 25 | 6 | 18.5 |

| Possibility to use a private car | Having the possibility | Not Having the possibility |
|---------------------------------|------------------------|---------------------------|
| Frequency | Percent | Frequency | Percent |
| 222 | 58.6 | 157 | 41.4 |
| 222 | 58.6 | 157 |

| Student accommodation during the academic year | Students own housing | Student dormitory inside | Student dormitory outside |
|-----------------------------------------------|---------------------|-------------------------|--------------------------|
| Frequency | Percent | Frequency | Percent | Frequency | Percent |
| 263 | 69.4 | 72 | 19 | 44 | 11.6 |

Therefore, student’s major has not been specifically considered in this research, and instead, to examine the students’ field of study, all the faculties of the university are divided into 5 categories based on their geographical location in the main campus, each category including the faculties that are located next to each other in terms of location. It was determined that depending on the size of the main campus, the distance between faculties, and the distance between the closest university door and the subway station, the location of the faculties could have an impact on the frequency with which students use the subway (for instance, the faculty of civil engineering is located closest to the subway station and is only 700 m away, whereas the faculty of mathematics is located farthest away and is 1100 m away) (Fig. 1). The results show that the first category which includes the faculty of mathematics and physics, has the lowest frequency, 6% of total respondents. The next category is the faculty of mechanical engineering, civil engineering, architecture engineering, and urban planning, which include 18.5% of the total student sample. The next category with a rate of 32.5% includes the faculty of electrical engineering, industrial engineering, and computer engineering. The category of railway engineering and automotive engineering is 24.8% of the total respondents, and the last category of materials engineering, metallurgy, and chemical engineering is 17.7% of the total sample (Table 1).

In the case of the representativeness of the sample concerning the student’s field of study, it should be said that the population of each group of the five faculty groups is as follows: for the faculties of mathematics and physics, the number of students is equal to 634 people, i.e. 5% of the total population of the university and for the faculties of mechanical engineering, civil engineering, architecture, and urban planning, which include 18.5% of the total student sample. The next category with a rate of 32.5% includes the faculty of electrical engineering, industrial engineering, and computer engineering. The category of railway engineering and automotive engineering is 24.8% of the total respondents, and the last category of materials engineering, metallurgy, and chemical engineering is 17.7% of the total sample (Table 1).

In this part of the questionnaire, respondents were asked whether they were the only child of the family or not. The purpose of asking this question is to examine the effect of having several children on a family on the possibility of using a private car and later the travel behavior, which the results show that 90% of the statistical sample have siblings and only 10% are the only child in the family. Moreover, 58% of respondents stated that it is possible for them to use a private car and 42% of them stated that there is no such possibility for them.

Besides, regarding the place of residence of students during the normal school year and before the COVID-19 outbreak, the results show that almost 70% of the sample live in their housing, and 30% of the people stay in the dormitory inside or outside the university (Table 1). Cross-Tabulation and chi-square analysis show that undergraduate students live more in their own homes than postgraduate students, with 72% of undergraduate students staying at home, compared to 55% of postgraduate students.

This section examines the mode choice of students before and after the COVID-19 outbreak. Afterward, the effects of a few variables such as time, cost, hygiene, etc. within the travel behavior of students before and after the COVID-19 pandemic is analyzed, and at last, by the chi-square test, the impact of several components on using private car and student’s mode choice to university is studied.

Moreover, the last part of the questionnaire contains an open question in which the students could have suggestions or criticisms. The most frequent issue stated by the students is the long distance between the subway station and the university entrance, which is mentioned in Section 3, which is about 730 m. It’s mentioned in Section 2 that previous studies showed that since the subway doesn’t create a door-to-door transportation, the distance from the subway station to the final destination can affect its use. Therefore, it is necessary to take measures in this regard. Furthermore, congestion and overcrowding in subway cars, especially during peak hours, is another problem that many students have mentioned is effective in their use of the subway.
5.1. Descriptive statistics

In this part of the research, descriptive statistics, which quantitatively describe or summarize the features from a collection of information (Mann, 2007), including frequency and frequency percentages are used to describe the sample.

To compare the typical means of student transportation to and from the university in the same sample before and after the COVID-19 outbreak, two questions of similar nature are presented in the questionnaire. The first asks students to identify the mode they used to commute to the university before the COVID-19 outbreak, and the second asks them to identify the mode they use following the COVID-19 outbreak. Before the COVID-19 outbreak, 223 respondents, or nearly 60% of the total, reported subway as their mode choice to university, which is a relatively high modal share. Then, the highest frequency belongs to buses and bus rapid transit (BRTs) with 16% of the total, then walking with 10%, after that private cars with a 10% utilization rate, and in the end, using taxis or online taxi services with 6.5% and the lowest amount. However, after the outbreak of COVID-19, the number of respondents who reported the subway as their mode choice to university decreased to 105 (33% reduction). Meanwhile, there has been a significant increase in using the private cars, taxis, and online taxi services after the outbreak of COVID-19, which is equal to 26%, and 17%, respectively. However, using buses as well as walking has not changed as much as the previous three modes. The use of buses has decreased by 10%, and walking has decreased by 3% (Table 2).

The statistical analysis of the 5-point Likert-related questions shows, based on the obtained average, it can be said that the foremost critical figure for students in their mode choice before the COVID-19 outbreak was no delay in reaching the destination with an average of 4.35. The slightest imperative issue with an average of 3.07 is hygiene and keeping a social distance (Table 3). However, after the COVID-19 pandemic, as expected, the most important criteria for student’s mode choice are to observe hygiene and maintain social distance with an average of 4.73. Other variables, such as no delay in reaching the destination, which was previously very critical, have misplaced a significant amount of their importance (Table 4).

5.2. Inferential statistics

In this part of the research, inferential statistics is used to determine whether the patterns discovered in the sample also apply to the statistical community. Since our variables are two groups or more and independent and unpaired, and the case variables and our measurement levels, mode choice to university, and the possibility of using a private car, are of the nominal type, the chi-square comparison test is the suitable (Simpson, 2015). Furthermore, cross-tabulation analysis examines the relationships between variables after using the chi-square test to discover significant relationships between variables.

First, it is necessary to explain that the issue of private car ownership in this research and the relevant questionnaire is presented and examined in two separate parts. Once, the private car is considered one of the modes of transportation along with other modes including subway, bus, taxi, and walking,4 and again in a direct question in which it is asked whether it is possible to use a private car for students in Tehran or not.5 The reason for this is because it is unclear precisely what proportion of Iranian students own a private automobile and what variables influence it when it comes to the problem of private car ownership among young people and students of higher education in Tehran. On the other hand, previous research has shown that owning a private car can directly affect people’s mode choice (Dissanayake and Morikawa, 2010; He and Thogersen, 2015). Therefore, first, we examine the impact of various factors on the possibility of having a private car. Then we independently review the factors that can affect the mode choice in general.

5.2.1. Factors affecting the possibility of using a private car

In this section, we perform four chi-square tests to determine the impacts of demographic variables on the possibility of using a private car for students. Thus, we examine the effect of variables of gender, age, level of education, and being an only child of the family on the possibility of using a private car.

To determine whether the above-mentioned variables are independent, we compare the p-value calculated by the SPSS software to the significance level, which is equal to 0.05. Suppose the p-value is less than or equal to the significance level, in that case, the null hypothesis will be rejected, and it will be concluded that there is a significant difference between the variables. But, if the p-value exceeds the significance level, we will fail to reject the null hypothesis.

5.2.1.1. Gender and the possibility of using a private car. To discover whether people’s gender has an impact on using a private car or not, the chi-square test is used. Our null hypothesis is that there is no significant difference between gender and the possibility of using a private car. But, the calculated p-value by SPSS software is 0.015 and less than 0.05, so there is a significant difference between gender and the possibility of a private car. Moreover, cross-tabulation analysis shows that women are more likely to use a private car (65%) than men (53%) (Table 5).

5.2.1.2. Age and the possibility of using a private car. The null hypothesis is established as follows: there is no significant relationship between age and the likelihood of utilizing a private automobile to investigate the effect of the variable age on that likelihood. There is no significant difference between the age variable and the likelihood of driving a private car, according to the computed p-value of 0.57 (greater than 0.05), which does not rule out the null hypothesis.

5.2.1.3. Level of education and the possibility of using a private car. In this section, we examine the impact of the level of education on the possibility of using the private car for students. The null hypothesis is that there is no significant difference between the level of education and the possibility of using a private car. The results show that the p-value (0.034) is less than 0.05; hence the null hypothesis is rejected, and there is a significant difference between the level of education and the possibility of using a private car, and the results of the cross-tabulation analysis show that 61% of undergraduate students have stated that they can use a private car. In comparison, 46% of postgraduate students

---

Table 2

| Students’ major travel mode choice to university before and after the COVID-19 outbreak. |
|------------------------------------------|----------|----------------|---|
|                                         | Before COVID-19 outbreak | After COVID-19 outbreak |
|                                         | Frequency | Percent | Frequency | Percent |
| Private car                             | 31        | 8      | 125       | 33.3    |
| Taxis or online taxi services           | 26        | 6.5    | 80        | 21      |
| Bus                                     | 60        | 16     | 22        | 5.8     |
| Subway                                  | 223       | 59     | 105       | 27.7    |
| Walking                                 | 40        | 10.5   | 28        | 7.4     |

---

4 Questions 7 and 8 of the questionnaire in the appendix.
5 Questions 6 of the questionnaire in the appendix.
The reason could be that postgraduate students are mostly in the age range from 22 to 28 years and older, which means that their year of birth is between 1995 and 1999. The undergraduate students are between 18 and 22 years old, meaning they were born between 2000 and 2003. The fertility rate in Iran in 1995 was 2.941, but this number decreased to 1.878 in 2003 (World-Bank, 2019). Reducing the average number of children in each household in the new generation has caused each child to receive more facilities than the children of the previous generation, and the possibility of using a private car is one of them.

This age and generation difference makes postgraduate students have fewer restrictions on studying at a university outside their home city than undergraduate students. Therefore, there is a higher number of postgraduate dormitory students. Students studying in a city other than their place of residence are less likely to use a private car.

5.2.2. Being the only child of the family and the possibility of using a private car

Being the family’s only child is one factor that has been rarely studied in previous studies. The null hypothesis in this section is that there is no significant difference between being the only child of the family and the possibility of using a private car. But, the fact that the p-value (0.003) is less than the significant level, rejects the null hypothesis; hence there is a significant difference between being the only child and the possibility of using a private car. Considering the results of cross-tabulation analysis, 82% of students who do not have siblings use a private car, while this number is 56% for people who have one or more sibling(s) (Table 7). This can be because of the same reason mentioned in the previous section: the fewer children in a household, the more facilities they have.

5.2.3. Factors affecting mode choice to university

In this section, to examine the effect of demographic variables on students’ travel behavior, as in the previous section, we perform six chi-square tests that determine the impact of gender, age, level of education, being the only one child, faculty of study and students’ place of residence on their mode choice to university before and after COVID-19 Pandemic, to find out which variables were influential on mode choice before COVID-19 outbreak and whether they are still important after the outbreak.

### Table 3
Priorities of students for mode choice to university before COVID-19 pandemic.

|                          | Average | Standard deviation | Percentage of respondents |
|--------------------------|---------|--------------------|---------------------------|
|                          |         |                    | Very low | Low | average | High | Very high |
| Travel time              | 4.25    | 0.800              | 0.5    | 2.4 | 15.4    | 37.1 | 44.6      |
| Travel cost              | 3.98    | 0.990              | 1.3    | 6.9 | 21.1    | 33.6 | 37.1      |
| Safety and security during the trip | 3.93    | 1.089              | 3.2    | 8.3 | 18.8    | 31.9 | 37.8      |
| Hygiene and social distance | 3.07    | 1.314              | 13.1   | 23.6| 26.3    | 17.2 | 19.8      |
| No delay in reaching the destination | 4.35    | 0.769              | 0.5    | 1.9 | 9.3     | 38.9 | 49.3      |
| Communication with other modes of transportation | 3.56    | 1.162              | 6.2    | 11.8| 24.1    | 33   | 24.9      |
| Wide range of choices for departure time from the destination | 3.66    | 1.0352             | 3.5    | 7.8 | 31.5    | 33.6 | 23.7      |

### Table 4
Priorities of students for mode choice to university after COVID-19 pandemic.

|                          | Average | Standard deviation | Percentage of respondents |
|--------------------------|---------|--------------------|---------------------------|
|                          |         |                    | Very low | Low | average | High | Very high |
| Travel time              | 3.85    | 1.003              | 1.9    | 6.4 | 28.4    | 31.6 | 31.6      |
| Travel cost              | 3.44    | 1.226              | 7      | 15.6| 30.1    | 21.2 | 26.1      |
| Safety and security during the trip | 4.42    | 0.799              | 0.5    | 1.9 | 10.8    | 28.6 | 58.2      |
| Hygiene and social distance | 4.73    | 0.601              | 0.5    | 0.3 | 4       | 16.2 | 79        |
| No delay in reaching the destination | 3.88    | 1.012              | 1.9    | 7.5 | 23.9    | 34   | 32.7      |
| Communication with other modes of transportation | 3.38    | 1.274              | 10.8   | 14.6| 23      | 29.5 | 22.2      |
| Wide range of choices for departure time from the destination | 3.52    | 1.142              | 5.7    | 11.9| 30.4    | 28.5 | 23.6      |

### Table 5
Test results for gender and the possibility of using a private car.

| Variable                     | Possibility of using a private car | Impossibility of using a private car | Total | P-Value |
|------------------------------|-----------------------------------|--------------------------------------|-------|---------|
| Gender                       |                                    |                                      |       |         |
| Men                          | 114                                | 101                                  | 215   | 0.015   |
| Women                        | 108                                | 56                                   | 164   |         |
| Total                        | 222                                | 157                                  | 379   |         |

### Table 6
Test results for the level of education and the possibility of using a private car.

| Variable | Possibility of using a private car | Impossibility of using a private car | Total |
|----------|-----------------------------------|--------------------------------------|-------|
| Undergraduate students | 186                                | 116                                  | 302   |
| Postgraduate students  | 35                                 | 41                                   | 76    |
| Total              | 222                                | 157                                  | 379   |

### Table 7
Test results for being the only child of the family and the possibility of using a private car.

| Variable                     | Possibility to use a private car | Impossibility of using a private car | Total | P-Value |
|------------------------------|-----------------------------------|--------------------------------------|-------|---------|
| Being an only child          |                                    |                                      |       |         |
| Only child                   | 194                                | 151                                  | 345   | 0.003   |
| With Siblings                | 28                                 | 6                                    | 34    |         |
| Total                        | 222                                | 157                                  | 379   |         |
after the pandemic; furthermore, to find out which variables are affective on student’s mode choice after COVID-19 outbreak and whether they used to affect mode choice to university before the pandemic or not.

5.2.3.1. Gender and mode choice for university. The null hypothesis presented in this section is that the gender of individuals is not influential in their mode choice to university and, consequently, in their use of the subway. We investigated this factor using the chi-square test. The calculated P-value (0.07) turned out to be more than the significant level, therefore we failed to reject the null hypothesis, and it can be stated that there is no significant difference between the gender and mode choice, in general, to come to the university, but as discussed before gender affects using private cars.

Furthermore, after the COVID-19 outbreak, the null hypothesis is that the variable gender doesn’t affect students’ mode choice to university. But, in this section, the calculated p-value is equal to 0.004, which rejects the null hypothesis. It can be concluded that the variable gender which didn’t affect students’ mode choice to university before, does affect it after the COVID-19 outbreak. The results of the cross-tabulation analysis show that men use the subway after the pandemic more than women; 36% of men say they use the subway after the outbreak, compared to 19% of women (Table 8). As previous research has shown; after the COVID-19 outbreak, women are one of the groups whose travel behaviors are more affected by the pandemic (Carboni et al., 2021; González-Sánchez et al., 2021). The reason why women use the subway less after the COVID-19 outbreak may be that, as previous research in Iran has shown, women are more likely to be concerned about maintaining social distance than men because they are more concerned about the spread of the virus and infection (Mohammadpour et al., 2020).

5.2.3.2. Age and mode choice to university. The calculated p-value of 0.88 in this section indicates that the null hypothesis that there is no significant difference between age and mode choice to university before the pandemic cannot be discarded. Therefore, it can be stated that the age variable did not affect the students’ mode choice before the COVID-19 epidemic. Furthermore, to examine the impact of this variable on students’ mode choice to university after the pandemic, the chi-square test was used as well, and the calculated p-value is more than 0.05 (0.773), so the variable age doesn’t affect students’ mode choice to university after COVID-19 outbreak either.

5.2.3.3. Level of education and mode choice for university. To study the effect of the level of education on mode choice to university before and after the pandemic, the chi-square test is used. In this section, the null hypothesis is that level of education, and mode choice to university are the independent variables in both cases. The results show that as p-value in both cases before and after the COVID-19 pandemic is more significant than 0.05 (0.985 and 0.07, respectively), so there is no significant difference between the level of education and mode choice to university neither before nor after the outbreak of COVID-19.

5.2.3.4. Being the only child of the family and mode choice to university. In this part, it was assumed that being the family’s only child doesn’t affect mode choice, so the chi-square test was used to investigate it. The statistical analysis of SPSS software shows that since the P-value (0.659) is more than 0.05, there is no significant difference between being the family’s only child and the mode choice to university.

To investigate the effect of the same variable on students’ mode choice to university after the pandemic, the null hypothesis is considered that there is no significant difference between being the only child of the family and mode choice to university. But, this time, the calculated p-value was equal to 0.01 that, rejects the null hypothesis, and based on the results of cross-tabulation analysis, after the COVID-19 outbreak, 60% of those who are the only child in the family reported that they use private cars as their mode choice to university and only 18% of them use the subway. At the same time, this number for those who aren’t the only child is equal to 32% for private cars and 30% for the subway (Table 9).

5.2.3.5. Faculty of study and mode choice to university. As mentioned earlier, due to the size of the university, there is a relatively large distance between the faculty with each other and to the main door of the university and the subway station. Therefore, we examined the effect of the faculty of the students on their mode choice university. The null hypotheses assumed that there is no significant difference between the school of study and the student’s mode choice neither before nor after the pandemic, and the calculated p-values, which are respectively equal to 0.818 and 0.103, confirm the hypotheses.

5.2.3.6. Student accommodation and mode choice to university. Moreover, the chi-square test is used in this section to examine whether students’ accommodation during their studies affects their mode choice before the COVID-19 outbreak. The null hypothesis is that there is no significant difference between the student place of residence and their mode choice to the university. But the calculated p-value which is equal to 0.00, rejects the null hypothesis, and the results show that 11% of students staying in their own home use a private car to come to university. In contrast, this number for the students that their accommodation is the dormitory inside or outside the university is 0. Furthermore, 63% of students living in private homes use the subway. In comparison, this number is 41% of students living in dormitories inside the university and 52% for students living in dormitories outside the university (Table 10). Since the results show that students living in dormitories almost do not use a private car to come to university, to attract students to use the subway instead of a private car, more attention should be paid to students staying in their own homes.

On the other hand, research into the impact of student housing on their mode choice to the university after the COVID-19 outbreak does not make much sense, as campus dormitories were closed entirely when the pandemic started, and all students stayed in their housing.6

In conclusion, this study aims to investigate the impact of the COVID-19 outbreak on the students’ use of subways. The results show that subway use decreased by more than 30% after the pandemic. The most important factor for students in their mode choice after the pandemic is to observe health and maintain social distance. The issue of the possibility of using a private car is mentioned, which was less addressed in Iran. Based on the results of the tests that were performed in this section, it can be concluded that none of the components of gender, the level of education, and being the only child of the family directly influenced a student’s mode choice to university before the COVID-19 outbreak. Still, their impact is only significant for the possibility of using a private car. However, the results of chi-square tests show that the possibility of using a private car has an impact on students’ mode choice to the university itself (P-value is equal to 0.04), so the factors that affect it can later have indirect implications on mode choice. When such a possibility is not feasible for some individuals, they use public transportation more as the previous studies show that private car owners use public transport less (Abdullah et al., 2021c). Therefore, to improve using public transportation, particularly among students, it is better to pay more attention to women, those who are the only children of the family, and undergraduate students compared to other groups.

Moreover, to investigate the effect of the COVID-19 outbreak on students ‘use of the subway, the impact of all demographic variables on students’ mode choice to university after the onset of the pandemic was investigated. Unlike the previous section, where it was found that none

---

6 This study was conducted in the spring of 2020, in the first months of Covid-19 outbreak in Iran, before vaccination. At that time, the dormitory was closed entirely and students could not stay there.
of the variables of gender, age, level of education, and being one child have a direct effect on students’ mode choice before the outbreak of the virus, the variables of gender and being the only child of the family has an impact on students’ mode choice and their use of subway after the pandemic so that men and people who are not the only child use the subway more than women and those who are the only child of the family.

Moreover, it can be said that after the COVID-19 pandemic, students’ travel behavior has changed significantly, and the foremost influential factor in their mode choice is hygiene and social distance, their gender, and being the family’s only child and other variables have a negligible effect.

6. Discussion and conclusion

This section provides a summary of all the findings, and some practical suggestions are provided. Descriptive and inferential statistics have been utilized to examine and discover a more profound understanding of student travel behavior after expressing the study’s objectives and reviewing the relevant literature. Moreover, at the end of the questionnaire, there was an open question in which students had the opportunity to express their challenges in using the subway, and they could submit their suggestions.

The focus of this paper, in addition to show to what extent students’ mode choice to university before the COVID-19 outbreak, the difference in travel behavior among students is a function of gender, age, level of education and being the only child of the family have also been examined.

Statistical analysis of data collected from 379 questionnaires completed by the students of Technology University shows: About 58% of people reported that before the COVID-19 outbreak, they used the subway to come to university, while after the COVID-19 outbreak, using a private car is the most common mode for 33% of the total population. Before the COVID-19 pandemic, the most crucial affecting factor on students’ mode choice was travel time and no delay in reaching the destination. The least important factor for them was hygiene and maintaining social distance. After the COVID-19 pandemic, the impact of these factors on the student mode choice changed entirely so that the most critical issue became hygiene and maintaining social distance. According to the results extracted from the chi-square test, the following can be mentioned: There is a significant difference among gender, the level of education and the possibility of using a private car, and women, as well as undergraduate students and those who are the only child on the family, are more likely to use private car. On the other hand, there is no significant difference between the factors mentioned above and student’s mode choice to university before the COVID-19 outbreak. The difference in students’ travel behavior is only a function of their place of residence during the academic year. But the results show that after the COVID-19 outbreak, the difference in travel behavior among students is a function of their gender and being the family’s only child. Men and those who have siblings use the subway more than the other groups.

6.1. Practical suggestions

In this section, to provide practical suggestions based on the results obtained by the research, the summary of the key outcomes of this research and related suggestions for each result is presented below:

1. The results of the descriptive statistics analysis show that after the pandemic, subway usage decreased by 30%, and private car usage increased by 26% that the main reason is the risk of further transmission of the virus in the subway and public transport in general. In this regard, the presented suggestions are:
a. One of the factors that transmit the virus more while using public transportation is paying for their ticket and services by cash. One of the measures which can be taken to eliminate cash and reduce pollution transmission in this way is to either the use of subway for students be free for a while, or the use of special cards for students to pay the ticket fees instead of cash.

b. In subway cars, creating a physical distance by marking where passengers are sitting or standing would be helpful. Also, reducing the capacity of the subway helps reduce congestion.

c. Using technology, such as mobile applications that can report the congestion of the subway station and subway cars to students on an hourly basis so that students can transfer their trip to another hour would also be helpful.

d. Increasing the attractiveness of the subway in the age of COVID-19 to increase its use by taking measures such as reducing the time interval of the subway, offering discounts on ticket prices, especially for students, or offering discounts, loyalty and reward programs and providing free internet at stations or inside the subway cars.

e. More investment can be made in cycling as an environmentally-friendly mode of transport that, compared to the subway, have much less risk of disease transmission. In this regard, special cycling routes on the usual routes leading to the university are suggested to be built. For example, between the dormitory outside the university and the university itself, so that students can use bicycles instead of using a private cars.

2. The most important factor for students in mode choice to university after the COVID-19 pandemic is to maintain hygiene and social distance. Other items are less important because following the outbreak of COVID-19, public transportation, especially the subway, has become one of the most dangerous places to transmit the disease in terms of the large population, the proximity of people to each other and the closure of space. Therefore, taking measures in the subway, such as observing social distance when using public transportation and disinfecting them continuously, can increase its use by minimizing the possibility of disease. In this regard, increasing the quality of health services, which can include improving air conditioning systems, and frequent cleaning of subway cars, should be considered. Observing these protocols should be closely monitored to maintain the face of passengers and, in this case, students. Screening and forcing the use of masks or having stations at the subway station to sell or offer masks and disinfectants for free can also be helpful. Also, in subway stations, measures such as, providing educational posters containing information about COVID-19, and continuous disinfection of staircase railings or escalators that are touched by people frequently, can be done. Most of these mentioned measures should be carried out by the subway authority of Tehran, as well as actions such as holding expert and joint management meetings on how to clean and deal with the spread of COVID-19 in the subway, in cooperation with related institutions such as the Ministry of Health, should also be carried out.

3. Students in the comments section of the questionnaire stated that the long distance between the subway station and the entrance door of the university is one of the main problems in using the subway. Although students usually do not have a particular source of income, cost does not seem to be a defining factor in choosing the subway (3rd priority before the pandemic and 6th priority after the pandemic). However, travel time and no delay in reaching the destination have higher priorities for students. Considering the long walking distance between the nearest subway station and the university, taking some initiatives can facilitate students’ access, such as providing a shuttle bus that can be used by student ID card or shared bicycle.

4. Students have stated in the comments section that the congestion of the subway, especially during peak hours, is problematic for them to use the subway. In general, the solution to reduce congestion in subway cars is to increase the number of vehicles, which requires financial support from the government. Also, improving the quality of subway services, such as increasing the number of trains in a line that should be done by the subway authority, to prevent congestion will increase its use in the whole community and not only students. One of the other measures that can lead to the reduction of subway congestion, especially during peak hours, is to create a difference in subway ticket prices between peak and non-peak hours so that tickets are offered at a lower price during non-peak hours, which causes unnecessary trips during peak hours to be moved to non-peak hours. Also, university can consider this point in the timetable of courses and avoid offering popular courses at peak hours. This is especially important during the pandemic as observing social distancing is among the top priorities for mode choice.

5. The results of inferential statistics show that the difference in the possibility of using a private car among students is a function of their gender, level of education, and being the only child, students’ mode choice to university after the COVID-19 outbreak is also a function of their gender and being the only child of the family and women and those who are the only child in the family are more likely to use private cars. Therefore, in this regard following steps can be done:

   a. The reason that single children are more likely to use a private car than others is that single children have more facilities at home than people with two or more children in the family, this could be why undergraduate students are more likely to use a private car. Because undergraduate students are in a newer generation than postgraduate students, and as mentioned earlier, in Iran, the average number of children in each family is decreasing from generation to generation. So, in this regard, more attention should be paid on this group at the national level as well as university level.

   b. Regarding the fact that women have stated that they prefer to use a private car after the pandemic, it should be noted that in Iran, there are women-only passenger cars in subways, which normally the passengers of these cars are fewer than other train cars and they are more secluded. One of the reasons that women use the subway less after the COVID-19 outbreak, is that after the pandemic, a number of men, in addition to other subway cars, use women-only passenger cars due to being more secluded and less risk of disease transmission. In this case, more screening and more control at the entrances and inside the women-only passenger cars, to prevent men from entering them can be helpful. If possible, increasing the number of women-only passenger cars is advised.

6. The study results also show that before the pandemic, students’ mode choice to university was a function of their place of residence. Hence, the students living in private homes use the subway less than dormitory students. The reason for this may be that dormitory students generally come to Tehran from other cities to study and stay in the dormitory during the academic year. Naturally, they have fewer facilities than the main city where they live, and the reason they use their car less may be that they do not even have access to a car and inevitably use public transportation. So, in this regard, it can be suggested:

   a. It is necessary to take measures to encourage students to use the subway voluntarily, so even students who live in their own homes and are not obliged to use the subway, are encouraged to use it. Discounts on student ticket prices can be an example of these measures.

   b. Another measure which can be helpful in the issue expressed in this study is the establishment of a sustainable transport center at the university that sets policies and can affect the modal share of the students. This center can first conduct studies and use previous ones, and take measures to encourage students to use more active and public modes of transportation by various measures,
such as holding contests, and workshops, as well as implementing other suggestions mentioned above.

Future research is suggested to conduct similar studies in other universities in Iran and other developing countries. It is recommended to consider factors affecting the use of the subway by faculty members and university staff.

Appendix

The full text of the questionnaire is as follows:

Hello Dear Students.

This questionnaire is used to examines the factors affecting students’ use of the subway. If you are a bachelor, master or doctoral student at the [Details omitted for double-blind reviewing], please fill it out. It is hoped that the results of this project will be used to improve transportation planning in the country. Thank you in advance for your cooperation.

1. Gender? □ Male □ Female.
2. Age? □ 18 to 22 years □ 23 to 26 years □ 26 years and up.
3. Degree? □ Undergraduate student □ Postgraduate student.
4. Are you the only child of the family? □ Yes □ No.
5. Type of accommodation during the school year before the COVID-19 pandemic?
   □ Private house □ Student dormitory inside the university □ Student dormitory outside the university
6. Is it possible for you to use a personal / family car in Tehran?
   □ Yes □ No.
7. What was your usual mode choice to university before the COVID-19 outbreak?
   □ Private car □ Taxi or online taxi services □ Bus or BRT □ Subway □ Walking.
8. What is your usual mode choice to university after the COVID-19 outbreak?
   □ Private car □ Taxi or online taxi services □ Bus or BRT □ Subway □ Walking.
9. Before COVID-19 outbreak, how important was each of the following factors to you in your mode choice to university?

| Factor                                      | Very low | Low | average | High | Very high |
|---------------------------------------------|----------|-----|---------|------|-----------|
| Travel time                                 |          |     |         |      |           |
| Travel cost                                 |          |     |         |      |           |
| Safety and security during the trip         |          |     |         |      |           |
| Hygiene and social distance                 |          |     |         |      |           |
| No delay in reaching the destination        |          |     |         |      |           |
| Communication with other modes of transportation |      |     |         |      |           |
| Wide range of choices for departure time from destination |      |     |         |      |           |

10. After COVID-19 outbreak, how important is each of the following factors to you in your mode choice to university?

| Factor                                      | Very low | Low | average | High | Very high |
|---------------------------------------------|----------|-----|---------|------|-----------|
| Travel time                                 |          |     |         |      |           |
| Travel cost                                 |          |     |         |      |           |
| Safety and security during the trip         |          |     |         |      |           |
| Hygiene and social distance                 |          |     |         |      |           |
| No delay in reaching the destination        |          |     |         |      |           |
| Communication with other modes of transportation |      |     |         |      |           |
| Wide range of choices for departure time from destination |      |     |         |      |           |

11. Please list your suggestions and criticisms about using the subway to get to university below.

References

Aaditya, B., Rahul, T., 2021. Psychological impacts of COVID-19 pandemic on the mode choice behaviour: a hybrid choice modelling approach. Transp. Policy 108, 47-58.
Abdullah, M., Dias, C., Muley, D., Shahin, M., 2020. Exploring the impacts of COVID-19 on travel behavior and mode preferences. Transp. Res. Interdiscipl. Perspect. 8, 100255.
Abdullah, M., Ali, N., Hussain, S.A., Asham, A.B., Javid, M.A., 2021a. Measuring changes in travel behavior pattern due to COVID-19 in a developing country: a case study of Pakistan. Transp. Policy 108, 21-33.
Abdullah, M., Ali, N., Javid, M.A., Dias, C., Campisi, T., 2021b. Public transport versus solo travel mode choices during the COVID-19 Pandemic: self-reported evidence from a developing country. Transp. Eng. Aust. 100078.
Abdullah, M., Ali, N., Javid, M.A., Dias, C., Campisi, T., 2021c. Public transport versus solo travel mode choices during the COVID-19 pandemic: self-reported evidence from a developing country. Transp. Eng. Aust. 5, 100078.
Barff, R., Mackay, D., Olshansky, R.W., 1982. A selective review of travel-mode choice models. J. Consum. Res. 8, 370–380.
Belgiawan, P.F., Schm¨ocker, J.-D., Abou-Zeid, M., Walker, J., Lee, T.-C., Ettema, D.F., Fujii, S., 2014. Car ownership motivations among undergraduate students in China, Indonesia, Japan, Lebanon, Netherlands, Taiwan, and USA. Transportation 41, 1227–1244.
Kim, K., Kwon, K., Horner, M.W., 2021. Examining the effects of the built environment on travel mode choice among different age groups in Seoul using a random forest model. Transp. Policy 103, 46–55.

Lee, K.-L., Kim, J.-K., Kwon, S.-J., 2005. A study on characteristics of subway utilization and passengers’ accessibility at new towns in Korea. J. Asian Archit. Build. Eng. 4, 85–95.

Li, M., Song, G., Cheng, Y., Yu, L., 2015. Identification of prior factors influencing the mode choice of short distance travel. Discret. Dyn. Nat. Soc. 2015.

Limandor, T., Butsingkorn, T., Chermkhunthod, C., 2011. Travel behavior of university students who live on campus: A case study of a rural university in Asia. Transp. Policy 18, 163–171.

Line, T., Chatterjee, K., Lyons, G., 2010. The travel behaviour intentions of young people in the context of climate change. J. Transp. Geogr. 18, 238–246.

Liu, L., Kong, H., Liu, T., Ma, X., 2022. Mode choice between bus and bike sharing for the last-mile connection to urban rail transit. J. Transp. Eng. Part A: Syst. 148, 04022017.

Luan, S., Yang, Q., Jiang, Z., Wang, W., 2021. Exploring the impact of COVID-19 on individual’s travel mode choice in China. Transp. Policy 106, 271–280.

Madhwanthi, R., Marasanghe, A., Raje, J., Dharmawansa, A.D., Nomura, S., 2015. Factors influencing to travel behavior on transport mode choice-a case of colombo suburban area in Sri Lanka. Int. J. Affect. Eng. 15 (2), 63–72. IJAE-D-15-00044.

Mann, P.S., 2007. Introductory Statistics. John Wiley & Sons.

Mayo, F.L., Taboada, E.B., 2020. Ranking factors affecting public transport mode choice of commuters in an urban city of developing country using analytic hierarchy process: the case of Subway Cebu, Philippines. Transp. Res. Interdiscipl. Perspect. 4, 100078.

Mccarty, L., Delbosc, A., Currie, G., Molloy, A., 2017. Factors influencing travel mode choice among families with young children (aged 0–4): a review of the literature. Transp. Res. 37, 707–781.

Mohammadpour, M., Ghorbani, V., Khosravani, A., Ahmadii, S.M., Ghamvani, M., Maleki, M., 2020. Anxiety, self-compassion, gender differences and COVID-19 predicting self-care behaviors and fear of COVID-19 based on anxiety and self-compassion with an emphasis on gender differences. Iran. J. Psychiatry 15, 213–219.

Mohanadzadeh, M., 2020. Gender and modal change: the case of Tehran's tertiary students’ travel mode choices in Auckland: insights and policy implications. J. Transp. Geogr. 87, 102788.

Moniruzzaman, M., Farber, S., 2018. What drives sustainable student travel? Mode choice determinants in the Greater Toronto Area. Int. J. Sustain. Transp. 12, 665–683.

Moshtari, S., 2020. Consumer responses to gasoline price and non-price policies. Energy Policy 137, 111078.

Naddaf, K., Hassanzad, M.S., Yunesian, M., Momennia, F., Nahidzadeh, R., Faridi, S., Cholupour, A., 2012a. Health impact assessment of air pollution in megacity of Tehran, Iran. Iran. J. Health Sci. 9, 28.

Naddaf, K., Hassanzad, M.S., Yunesian, M., Momennia, F., Nahidzadeh, R., Faridi, S., Cholupour, A., 2012b. Health impact assessment of air pollution in megacity of Tehran, Iran. J. Iran. J. Health Sci. Eng. 9, 1–7.

Nguyen-Phuc, D., Amoh-Gyimah, R., Tran, A., Phan, C., 2018. Mode choice among university students in school in Danang, Vietnam. Travel Behav. Soc. 13, 1–10.

Ohto, Y.T., Kim, T.H., Park, J.J., Rho, J.H., 2009. An empirical analysis of influencing factors toward public transportation demand considering land use type Seoul subway station area in Seoul. KSCE J. Civ. Environ. Eng. Res. 29, 467–472.

Ormeinstein, M., 2013. Designing a questionnaire. In: A Companion to Survey Research, pp. 358–359.

Penter, J.R., Jones, A.P., Van Sluijs, E.M., 2008. Environmental determinants of active travel in youth: a review and framework for future research. Int. J. Behav. Nutr. Phys. Act. 5, 1–14.

Ravenscroft, G., Gu, Z., Munoz, J.C., Wilson, N.H., 2014. A behavioural comparison of route choice on subway networks: time, transfers, crowding, topology and demographics. Transp. Res. A Policy Pract. 66, 185–195.

Ritch, M., Fillone, A., 2005. Air pollution and hospitalization due to angina pectoris in Tehran, Iran: a time-series study. Environ. Res. 99, 126–131.

Ritch, M., Fillone, A.M., Jose Bienvenido, M., 2020. Development and application of factors influencing to travel behavior on transport mode choice-a case of colombo suburban area in Sri Lanka. KSCE J. Civ. Environ. Eng. Res. 29, 467–472.

Sarangi, P., Manoj, M., 2020. Escorting and mode choice decisions of members of an older adult’s peer group. J. Transp. Eng. Part A: Syst. 148, 04022017.

Sawar, S., 2019. The effects of air pollution on vitamin D status in healthy women: a cross sectional study. J. Nutr. Food Sci. 9, 367–375.

Schmidt, A.O., Yang, V., He, S.Y., 2021. The role of objective and perceived built environments in improving the subway attraction for the post-COVID-19 era: the role of fare-free public transport policy. Transp. Policy 103, 21–30.

Selvaraj, S., Bhalo, K., Chakraborty, A., 2017. Estimation of mortality, hospitalization and hospitalization due to angina pectoris in Tehran, Iran: a time-series study. Environ. Res. 99, 126–131.

Semeni, M.K., Tieloenie, A.B., 2020. How priorities of men and women for choosing railway transportation differ? A case study. Transp. Res. Prog. 48, 3062–3069.

Sarangi, P., Manoj, M., 2020. Escorting and mode choice decisions of members of an older adult’s peer group. J. Transp. Eng. Part A: Syst. 148, 04022017.

Sayadi, A.R., Sayadi, M.H., Shabanlari, Z., 2011. Impact of airborne pollution on human health aspects in Tehran city (Iran). Pollut. Res. 30, 251–256.

Scheiner, J., Rau, H., 2020. Mobility and Travel Behavior across the Life Course: Qualitative and Quantitative Evidence. Emerald Publishing.

SCI, 2021. Household Income and Expenditure Survey [Online]. Available. https://www. amar.org.uk/english/Statistics-by-Topic/Household-Expenditure-andIncome [Accessed].

Shamim, A., Giles-Corti, B., Pikora, T., Bulsara, M., Shilton, T., Bull, F., 2006. Active commuting in a university setting: assessing commuting habits and potential for mode change. Transp. Policy 13, 240–253.

Simon, D., De Bourdeaudhuij, I., Clarys, P., De Geus, B., Vandelanotte, C., Van Damme, J., 2008. Environmental determinants of active travel in youth: a review and framework for future research. Int. J. Behav. Nutr. Phys. Act. 5, 1–14.

Simpson, D., De Bourdeaudhuij, I., Clarys, P., De Geus, B., Vandelanotte, C., Van Damme, J., 2008. Environmental determinants of active travel in youth: a review and framework for future research. Int. J. Behav. Nutr. Phys. Act. 5, 1–14.

Simpson, D., De Bourdeaudhuij, I., Clarys, P., De Geus, B., Vandelanotte, C., Van Damme, J., 2008. Environmental determinants of active travel in youth: a review and framework for future research. Int. J. Behav. Nutr. Phys. Act. 5, 1–14.

Simpson, D., De Bourdeaudhuij, I., Clarys, P., De Geus, B., Vandelanotte, C., Van Damme, J., 2008. Environmental determinants of active travel in youth: a review and framework for future research. Int. J. Behav. Nutr. Phys. Act. 5, 1–14.

Simpson, D., De Bourdeaudhuij, I., Clarys, P., De Geus, B., Vandelanotte, C., Van Damme, J., 2008. Environmental determinants of active travel in youth: a review and framework for future research. Int. J. Behav. Nutr. Phys. Act. 5, 1–14.

Simpson, D., De Bourdeaudhuij, I., Clarys, P., De Geus, B., Vandelanotte, C., Van Damme, J., 2008. Environmental determinants of active travel in youth: a review and framework for future research. Int. J. Behav. Nutr. Phys. Act. 5, 1–14.
THMPORG, 2016. Population of Tehran Province by Gender and Major Age Group [Online]. Available. https://amar.thmporg.ir/statistical-tables [Accessed].

THMPORG, 2021a. Percentage of Urban Sample Households Using Major Livelihoods by Province [Online]. Available. https://amar.thmporg.ir/statistical-tables [Accessed].

THMPORG, 2021b. Students of Different Courses of Higher Education Institutions in Tehran Province According to the Major Group of Study and Gender [Online]. Available. https://amar.thmporg.ir/statistical-tables [Accessed].

Whalen, K.E., Paez, A., Carrasco, J.A., 2013. Mode choice of university students commuting to school and the role of active travel. J. Transp. Geogr. 31, 132–142.

World Bank, 2019. Fertility Rate, Total (births per woman) - Iran, Islamic Rep. [Online]. Available. https://data.worldbank.org/indicator/SP.DYN.TFRT.IN?locations=IR [Accessed].

Wu, L., Wang, W., Jing, P., Chen, Y., Zhan, F., Shi, Y., Li, T., 2020. Travel mode choice and their impacts on environment—a literature review based on bibliometric and content analysis, 2000–2018. J. Clean. Prod. 249, 119391.

Xu, Y., Zhang, Q., Zheng, S., 2015. The rising demand for subway after private driving restriction: evidence from Beijing’s housing market. Reg. Sci. Urban Econ. 54, 28–37.

Yang, Y., Cao, M., Cheng, L., Zhao, K., Zhao, X., De Vos, J., 2021. Exploring the relationship between the COVID-19 pandemic and changes in travel behaviour: a qualitative study. Transp. Res. Interdiscipl. Perspect. 100450.

Zhang, Y., Guo, X., Li, S., Sun, H., 2020. Research on Crowding Discomfort in Public Transport, 2020. CICTP.