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Evaluating the effects of the COVID-19 outbreak on the older adults’ travel mode choices

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ABSTRACT

Background and aims: To increase the older adults’ mobility during the COVID-19 outbreak, providing appropriate conditions for using different transportation modes and organizing transportation facilities for the older adults are essential. Hence, this study aims to evaluate and compare factors affecting the older adults’ travel mode choice to investigate transportation policies for increasing their independent mobility in the post-outbreak that has not been addressed in previous research.

Methodology: The population of this cross-sectional study consisted of Isfahan citizens aged 60 years and over. For interviews based on a structured questionnaire, 453 participants were randomly selected in 15 municipality districts of Isfahan. Multinomial logistic models were used to analyze the data.

Findings: The results show that despite the decrease in the average frequency of travels per week, the increase in the share of walking and cycling modes, making shopping and recreational travels on foot, and cycling can indicate the resilience of walking and cycling in critical situations. The results also reveal that active modes have effective roles in the older adults’ mobility in the post-outbreak because they are not subject to traffic restrictions like private vehicles and social constraints and crowd avoidance like public transportation.

Discussion and conclusion: Policies such as the proper location of facilities, increasing density and mixing of land uses, landscaping, traffic reduction, increasing ownership of bicycle and tricycle (to eliminate the problems of falling in getting on and off the bicycles), driving training courses for the safe driving, and intersections safety improvement are essential to maintain the older adults’ mobility after the outbreak. With more capacity and low occupancy, the public transportation system, high-quality accessibility, and safe routes will also attract the older adults’ travels in the crisis.

1. Introduction

Since aging has adverse effects on social and individual health (Desrosiers et al., 2004), to increase older adults’ quality of life, it is necessary to identify and remove these adverse effects, the most important of which is the reduction in mobility. Previous research demonstrated that mobility – the ability to move independently within the environments of daily life – is essential to the health, well-being, and welfare of older adults (Spinney et al., 2009; Webber et al., 2010; Wong et al., 2018; Yen and Anderson, 2012). Older individuals who lose independent mobility have higher morbidity, mortality, and self-vehicle disability rates. They are also more likely to experience low quality of life, depression, and social isolation (Gill et al., 2012; Lampinen and Heikkinen, 2003). In transportation studies, mobility is measured by daily travel rates, distance, and use of different transportation modes. Therefore, diverse modes of transportation and access to facilities and services increase mobility and ultimately enhance social health and people’s quality of life, especially older adults (Collia et al., 2003). So, identifying factors affecting older adults’ travel mode choice and providing appropriate conditions for using different transportation modes in order to increase their mobility, especially in critical situations, are essential.

One of these critical situations is the COVID-19 outbreak which is rapidly affecting many countries around the world. First reported in late December 2019 in Wuhan City, China, COVID-19 disease is now reported in most countries (Beck and Hensher, 2020; Chinazzi et al., 2020). Then, reductions in unnecessary social interactions were initiated to control the virus outbreak so that intra-city and inter-city travel were banned or severely reduced in many cities (de Haas et al., 2020; Oum and Wang, 2020). As a result, the use of private vehicles (due to

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traffic restrictions) and public transportation (as the riskiest areas for the spread of the virus) were banned and partially restricted.

While these measures are necessary to prevent the COVID-19 outbreak, it is problematic for many vulnerable sections of society and people who still need to leave home to do essential work such as buying food or medicine and working. Because older adults are more vulnerable to bacteria and viruses, restrictions on using modes such as a private vehicle and public transportation to prevent the spread of COVID-19 have led to a significant reduction in their mobility. Thus, concerning the control measures taken to avoid the spread of the virus, investigating factors affecting older adults' travel mode choice and providing efforts to develop resilient transportation infrastructure is essential. Hence, the present study aims to evaluate and compare factors affecting older adults' travel mode choice due to issues and limitations (such as quarantine, public transportation and jobs closures, and odd-even traffic restrictions) caused by the crisis of the COVID-19 outbreak.

To our knowledge, no research has been conducted on investigating factors affecting older adults' travel mode choice during the COVID-19 outbreak. The present study was undertaken in Isfahan-Iran. In Iran, the first cases of the disease were reported on February 19, 2020. Then, the upward trend of cases began in all parts of the country so that in a short time, all Iranian provinces became infected with the disease. In this study, 453 senior citizens in different areas of Isfahan City were interviewed about travels and environmental information in the pre-and post-COVID-19 outbreak. Multinomial logistic models were used to analyze the data. To this end, the following questions need to be answered:

- What has changed older adults' travel purpose in the post-COVID-19 outbreak?
- What are the most critical factors affecting older adults' travel mode choice before and after the quarantine and traffic restrictions?
- What are the appropriate policies in critical situations to improve transportation for older adults?
- What effects the restrictive policies (quarantine, public transportation, and job closures) had on the use of non-motorized, public, and private transportation?

In the next section, the literature review; in the third section, the research methodology; after that, the results, then the discussion, and finally the conclusions and suggestions are presented.

2. Literature review

To investigate the changes in older adults' travel behavior due to the COVID-19 outbreak and to evaluate factors affecting older adults' travel mode choice in the pre-and post-outbreak, identifying factors that affect their mode choice is essential. Therefore, in this section, by reviewing the literature, the most critical factors can be determined.

2.1. Individuals characteristics

**Gender:** Considering the gender difference in choosing travel modes for older adults, the utility of travel and the ability to use the modes of use are different for men and women. Gender affects travel mode choice so that women are more likely to use public transportation and active modes (walking and cycling), have less variety and travel distance than men (Berg et al., 2015; Oxley, 2015).

**The driving license and private vehicle ownership:** Having a driving license and a private vehicle increases the likelihood of older adults’ travels. Older adults without a driving license use more public transportation or travel as vehicle passengers with friends and family members (Habib, 2015; Plazinić and Jović, 2018). Besides, Possessing a private vehicle reduces the likelihood of using public transport, cycling, and walking (Hou, 2019; Moniruzzaman et al., 2015).

**Age:** Habib (2015) showed that older adults' age has a significant effect on travel mode, in which people aged 65–70 travel longer than people aged 70+ (Habib, 2015). With increasing age, walking will replace the vehicle, while people aged +65 walk more than people aged 55–64 (Hou, 2019).

**Employment status:** The transition from employment to retirement affects older adults’ travel mode choice and mobility (Ahern and Hine, 2012; Ryan and Wretstrand, 2019; Stjernborg et al., 2014). Retirees walk more than employed people because of their flexible schedules. Employees are also less likely to use public transportation and more likely to use private vehicles than retirees because of time constraints (Ahern and Hine, 2012).

**Income:** Cao and Handy (2010) and Yang et al. (2018) showed that socio-economic factors, especially income, have a significant effect on travel behavior and mode choice for older adults. Older adults have more time and less revenue because of retirement, often preferring cheap travel modes (Cao et al., 2016; Yang et al., 2018).

**Household structure:** The household structure is effective in older adults’ choice of transport modes. Older adults living in overcrowded families have a low tendency to use public transport for long travels, as they mostly travel with family members (Böcker et al., 2017; Plazinić and Jović, 2018).

**Household vehicles:** Increasing the number of vehicles in the family reduces public transport and active travel (Böcker et al., 2017; Cao et al., 2016; Yang et al., 2018). Older adults who do not have a family vehicle use public transport more than those who have a vehicle in the family. Having a vehicle or more in the family reduces active travel (Yang et al., 2018).

2.2. Travel characteristics

**Travel purposes:** Older adults plan their travels according to their purpose (Srichuae et al., 2016; Turner et al., 2017). Shopping, recreational, treatment, and social travel are common among older adults, constituting most of older adults’ travels (Ryan and Wretstrand, 2019; Simecek et al., 2018; Yoshikawa and Bednarz, 2013).

**Travel distance and time:** By aging, distance, duration, and frequency of travels are reduced, and the used transportation mode differs. Travel distance also has a considerable impact on travel mode choice (Du et al., 2020; Plazinić and Jović, 2018). As travel time and distance increase, people’s travel mode—especially older adults’ travel mode-changes from active modes to public transportation and vehicles (as drivers or passengers) (Böcker et al., 2017).

2.3. Characteristics of the built environment

Older adults living in high-density areas have less travel time due to facilities’ proximity, so they choose active modes and rarely use a private vehicle due to traffic and congestion (De Vos and Alemi, 2020). However, in low-density areas, active modes are not favorable for older adults due to the scattered land uses and inaccessible access to public transportation stations. Then, they travel by vehicle as a driver or vehicle passenger with friends and family members (Du et al., 2020; Plazinić and Jović, 2018; Yang et al., 2018). Besides, older adults’ residential location’s utility depends on their travel behavior, so they prefer a residence that does not require a private vehicle (Cao et al., 2010; Stjernborg et al., 2014). Also, public transportation stations’ optimum location and density will increase public transportation use (Hou, 2019; Oxley, 2015; Yoshikawa and Bednarz, 2013). Chiatti et al. (2017) state that proximity to stations is essential for maintaining older adults’ mobility and welfare.

On the other hand, the built environment factors such as mixed land use, the built environment vegetation and design, security, and accessibility of facilities influence travel mode choice and travel generation. An appropriate design of the built environment and development of walking and cycling infrastructure may reduce vehicle dependency and greenhouse gases. It also can increase the use of sustainable...
transportation modes such as walking, cycling, and public transport; ultimately improve older adults’ quality of life and well-being (Cao et al., 2010; Cheng et al., 2019; Du et al., 2020; Hou, 2019; Moniruzzaman et al., 2013; Oxley, 2015; Srichuay et al., 2016; Yang et al., 2018; Yoshikawa and Bednarz, 2013).

Habib (2015) indicated that proximity to the CBD reduces private vehicle traffic and increases sustainable transportation modes. Moniruzzaman et al. (2013) and Yang et al. (2018) also showed that the effect of the built environment on active modes is greater than the income level, and the high-income older adults living near the CBD also choose these modes for daily travels. It is worth mentioning that high traffic and low safety in the CBD can reduce ATM use (Bocker et al., 2017; Hou, 2019). However, one of the essential strategies that enhance older adults’ health, mobility, and quality of life is appropriating routes in the residential and built environments for walking and cycling on short and day travels. One of the reasons for older adults not using bicycles is the safety problems and the inability to use bicycles because of reduced physical ability (Ahmad et al., 2019; Yoshikawa and Bednarz, 2013).

By reviewing the literature, factors affecting older adults’ travel mode choice were identified. Therefore, the research questionnaire was drafted based on the most important factors such as demographics (age, gender, the number of family members, job, vehicles in the household, income, having a driving license, vehicle and bicycle ownership, the possibility to use the vehicle, and residential location), travel characteristics (destination, purpose, duration, and frequency), and characteristics of the built environment factors (walking and cycling routes quality, security, traffic calming, the safety of intersections, greenery and vegetation, and public transportation accessibility). The questionnaire is presented in Appendix 1.

3. Methodology

3.1. Research method

The logit model is the most popular type of random utility model derived from consumer economics theory, and McFadden initially developed it. In utility maximization behavior, an individual q decides to select one choice among discrete alternatives ($C_q$) by evaluating their associated attributes X. The individual q chooses the alternative j that provides the largest utility (Lee et al., 2018; Train, 2009):

$$j \in C_q \text{ if } U_{jq} \geq U_{mq} \forall m \neq j$$

(1)

In reality, researchers do not observe the complete utility of the individual. Thus, the utility can be classified into two parts: an observed utility $V_{jq}$ and an unobserved utility $\varepsilon_{jq}$: The observed utility generally contains two sets of attributes: 1) covariates associated with both the individual and the alternative $X_{jq}$; and 2) decision-maker characteristics, $S_j$. The observed (stated) utility (V) is a value determined from a linear combination of the attributes used, which captures the attractiveness of an alternative bounded to the given model specification as follows:

$$V_{jq} = V (X_{jq}, S_j)$$

(2)

In these models, the utility function is generally shown as Eq. (3):

$$U_{jq} = V_{jq} + \varepsilon_{jq}$$

(3)

In contrast, the unobserved utility $\varepsilon_{jq}$ cannot be observed by researchers. This unobserved part mainly results from the specification of the observed utility $V_{jq}$. In practice, statistical approaches can’t include all possible attributes. Therefore, researchers treat the unobserved terms as a stochastic element. Specifically, the logit model is derived by assuming that each unobserved term, $\varepsilon_{mq}$, is IID extreme values, i.e., Gumbel and type 1 extreme values. By combining two utilities, we can get the probability of individual q choosing alternative j by solving these mathematical formulations:

$$P_{jq} = P \left( U_{jq} > U_{mq} \right) \forall m \neq j \in C_q$$

(4)

$$P_{jq} = P \left( \varepsilon_{jq} - \varepsilon_{mq} \leq U_{jq} - U_{mq} \right) \forall m \neq j \in C_q$$

(5)

$$P_{jq} = \frac{\exp(V_{jq})}{\sum_{m \in C_q} \exp(V_{mq})}, \quad V_{jq} = \beta X_{jq}$$

(6)

where $X_{jq}$ is the vector of observed explanatory variables to choose a given alternative, and $\beta$ is parameters for the observed utility, $\varepsilon_{jq}$ and the maximum likelihood (-2LL) were conducted to compare models and, to check the significance of variables in the models, T-student is used with 95 percent confidence level (Albert and Anderson, 1984; Bujang et al., 2018), and Nlogit version 6 software was utilized for modeling.

3.2. Describing the questionnaire and variables

The structured questionnaire includes demographics (age, gender, number of household members, average monthly income, vehicle ownership, bicycle ownership, motorcycle ownership, driving license, and number of vehicles in a household), travel information in the post and pre-COVID-19 outbreak (purpose, destination, type, mode, duration, distance, and frequency of travel per week) and environmental information (status of walking and cycling routes, the safety of intersections, the built environment security and greenery), and traffic calming measures (such as installing traffic signs, speed bumps, etc.). Using SPSS software, the 40-sample COPXAB’s alpha as 0.831 confirmed the reliability of the questionnaire. Its validity was confirmed by the Department of Transportation’s faculty members of the Isfahan University of Technology. The independent variables extracted from the questionnaire for modeling are presented in Table 1, and the questionnaire is presented in Appendix 1.

3.3. Data collection

The city studied in this study is Isfahan city with about 1.8 million people, the capital of Isfahan province, located in the center of Iran, and now has the third-largest population in the country. Its population growth rate in 1956 was 5.8% and decreased to 1.89% in 2016. From 1996 to 2016, the birth rate was declining. This issue indicates an increase in the population aged +60 years and the occurrence of population aging. At present, the population aged +60 years is about 12.5% (215,000 individuals), and it is predicted that by 2040, the population aged +60 years will have reached 30%. Landscapes of Isfahan are shown in Fig. 1.

The sample study of this cross-sectional study includes Isfahan citizens aged 60 years and over that 453 people took and completed the questionnaire. In the first stage, we identified the most attractive places in 15 municipality districts of the city to travel for older adults including parks, local shops, malls, bakeries, and so on. The 15 municipality districts of Isfahan are also shown in Fig. 1. The intercept interviews were conducted in the field for 15 days from 8 a.m. to 6 p.m. Furthermore, the places were randomly selected and older adults also were randomly invited to the interview. We also explained the study and its aims to the participants and subjects verbally. Moreover, inclusion criteria included having at least 60 years old, making at least one trip (older adults staying at home were not approached in this study), and willingness to participate in the survey, and exclusion criteria were reluctant to participate. Also, each interview lasted between 20 and 30 min and the participants were given masks and sanitary gloves as gifts. The minimum sample size, obtained from Cochran’s Formula, was equal to 384.

Cochran Formula: $n = \frac{\chi^2_{\alpha \beta}}{1 + \frac{\chi^2_{\alpha \beta} - 1}{N}}$
Table 1
Definitions of variables.

| Symbol | Variables and their definitions |
|--------|---------------------------------|
| TRFC   | Travel frequency |
| TRDS   | Travel distance |
| PRSH   | Shopping |
| PRBG   | Religious |
| PRPM   | Health care |
| PRRC   | Recreational |
| PRMF   | Friends and relatives |
| PRWK   | Work |
| PRCF   | Conveying family |
| TMWK   | Walking |
| TMBE   | Cycling |
| TMCR   | Vehicle |
| TMCP   | Vehicle passenger |
| TMPT   | Public transportation |
| TMOR   | Others |
| HHSZ   | Size |
| HHCR   | Vehicle |
| IDSX   | Gender |
| IDED   | Employed |
| IDLI   | low income |
| IDMI   | Middle income |
| IDHI   | High income |
| IDHE   | High education |
| IDME   | Middle education |
| IDLE   | Low education |
| IDD   | Driving license |
| IDCO   | Vehicle ownership |
| ICBO   | Bicycle ownership |
| IDLC   | Living in CBD |
| NHWR   | Walking routes quality |
| NHBR   | Cycling routes quality |
| NHCT   | Security |
| NHTC   | Traffic calming |
| NHPA   | Public transportation accessibility |
| NHCG   | Intersections safety |
| NHVT   | Greenery |

where \( N \) is the total population, \( n \) is the sample size, \( Z \) is the value for the selected alpha level, e.g., 1.96 for a 95 percent confidence level, \( p \) is the estimated proportion of an attribute that is present in the population, \( q \) is 1-\( p \) (in this study, \( p \) and \( q \) are considered 0.5), \( d \) is the acceptable margin of error for proportion being estimated (in this study, \( d \) is considered 0.05) (Kotrlik and Higgins, 2001).

4. Results

A comparison of the results of socio-demographic information of participants with National Population and Housing Census (Iran, 2018) and Isfahan Comprehensive Transportation & Traffic Studies (ICCTS) shows that out of the 453 participants, 24% live in the CBD, while around 16% of Isfahan’s older adults live in these areas. Besides, around 64% of participants had a driving license, while 59% of total older adults in Isfahan had a driving license. Moreover, in this research, about 52% of the sample study had a private vehicle, and 44% of total citizens aged 60 years old and over in Isfahan had a private vehicle. Furthermore, 80% of interviewees were retired, approximately; while 86% of Isfahan’s older adults were retired. The results of socio-demographic information of participants and census data percentage are listed in Table 2.

Before the COVID-19 outbreak, 1403 different travels were recorded, including 138 religious travels, 393 shopping travels, 435 recreational travels, 147 business travels, 153 friends and relatives visit travels, 56 health care travels 81 travels aimed at accompanying family members. For the post-outbreak, 735 travels were recorded, including 304 shopping travels, 366 recreational travels, 14 friends and relatives visit travels, 45 business travels, and six travels to accompany family members.

As Table 3 shows, the travel frequency per week has reduced from 10.5 to 8.7 due to the traffic restrictions and quarantine. But the frequency of travels for shopping and recreation has not decreased significantly, while other travels have been eliminated or drastically reduced. Table 4 shows that most shopping and recreational travels were made on foot in both pre-and post-outbreak, while work travels were made by private vehicles. In the pre-outbreak, most religious and official travels were made on foot. Public transportation, respectively, and older adults for health care travels traveled as vehicle passengers with family members. Fig. 2 illustrates that in the post-outbreak, changes in walking and cycling are due to the restrictions on the use of private vehicles and public transportation to prevent the COVID-19 spread. Therefore, it can be inferred that older adults have turned to active travel modes as alternatives for daily travels.

Fig. 3 shows that the COVID-19 outbreak has changed travel modes so that 2.5% of the walking mode has changed to cycling and 6.5% to the private vehicle. Also, 2.5% of private vehicle mode has changed to walking, 4.8% to cycling, and 9.5% to the accompanying family members (vehicle passenger, CP). Switching from the private vehicle to other modes shows the effect of traffic restrictions such as the odd-even traffic plan on the use of this mode. Further, 61.6% of public transportation (PT) was changed to accompanying family members, 23% to cycling, and 15.4% to a private vehicle. Failure to change the cycling mode to other modes and attract traveling from other modes indicates this mode’s resilience in critical situations. The details of the models and their variables are listed in Table 5.
the built environment \((U = 0.84, \text{Sig} = 0.000)\) on the utility of cycling; and intersections safety \((U = 1.22, \text{Sig} = 0.025)\), travel distance \((U = 0.56, \text{Sig} = 0.000)\), and vehicle ownership \((U = 3.5, \text{Sig} = 0.000)\) on the utility of vehicle have significant impacts. It is worth mentioning that older adults did not use public transportation during the interview and in the post-outbreak. But their answers about the use of public transportation in the pre-outbreak have been used.

4.1. Measures to improve non-motorized transportation

4.1.1. Walking

The statistics revealed that the frequency of travels per week has reduced due to the quarantine’s traffic restrictions. However, the frequency of shopping and recreational travels has not decreased significantly. Also, in both pre- and post-outbreak, most of these travels were made on foot. Besides, changes in walking and cycling are due to the

| variable       | n  | % in sample | % in census data |
|----------------|----|-------------|------------------|
| Gender         |    |             |                  |
| Male           | 291| 64.2        | 51               |
| Female         | 162| 35.8        | 49               |
| Currently working |  |             |                  |
| No             | 361| 79.7        | 86               |
| Yes            | 92 | 20.3        | 14               |
| Age category   |    |             |                  |
| 60-69          | 295| 65.1        | 58               |
| 70-79          | 128| 28.2        | 29               |
| +80            | 30 | 6.7         | 13               |
| Income         |    |             |                  |
| –1.5           | 193| 42.6        | –                |
| 1.5-3          | 199| 44          | –                |
| +3             | 61 | 13.4        | –                |
| Living in CBD  |    |             |                  |
| Yes            | 109| 24          | 16               |
| No             | 344| 76          | 84               |
| Having Driving license |  |             |                  |
| Yes            | 310| 68.4        | 54               |
| No             | 143| 31.6        | 46               |
| Vehicle ownership |   |             |                  |
| Yes            | 237| 52.3        | 44               |
| No             | 216| 47.7        | 56               |
| Bicycle ownership |   |             |                  |
| Yes            | 129| 28.4        | –                |
| No             | 324| 71.6        | –                |
| Education      |    |             |                  |
| +12            | 53 | 11.7        | 26               |
| 8-12           | 128| 28.3        | 11               |
| –8             | 272| 60          | 63               |
older adults’ residential area facilitates access to different destination locations. The increase in density and mixing of land uses reduce travel distances. Besides, landscaping by vegetation makes walking routes attractive. Finally, traffic reduction by traffic calming devices increases older adults’ safety and mobility in critical situations such as the COVID-19 spread.

4.1.2. Cycling

An entire shift of the cycling mode in the pre-outbreak to other modes in the post-outbreak and absorption of travels from others indicates this mode’s resilience in the crisis. Meanwhile, the multinomial logistic model results illustrate that bicycle ownership and recreational travels in both pre-and post-outbreak affect bicycle utility, cycling routes quality, greenery, and gender (being a man) in the pre-outbreak. Moreover, intersections’ safety and security of the built environment are useful in the post-outbreak. Therefore, in crisis, cycling infrastructure enhancement such as improving pavement, lighting, installing signposts, landscaping, and widening of routes can effectively maintain older adults’ mobility. The models also show that bicycle ownership has a significant effect on cycling. So, policies to increase bicycle ownership, such as offering installments and discounted bicycles to older adults, can help maintain mobility. Preventive and incentive programs are also needed to grow cycling from an early age. In critical situations - such as virus outbreaks - where modes such as public transportation are not as effective as before, cycling can be a good alternative. Confirming this policy, Ryan et al. (2016) and Johnson and Rose (2015) argued that the majority of older adult cyclists cycled throughout their lives, with a small number turning to it in old age (Johnson and Rose, 2015; Ryan et al., 2016).

It should be noted that a reduction in physical, mental, and perceptual ability due to aging makes older adults more vulnerable to cycling and walking than young people (Scheiman et al., 2010). However, knowing these factors, accidents and injuries caused by these modes in older adults can be prevented. Further, most older adults’ injuries during the use of active modes are caused by getting on and off the bicycles, falling due to the loss of balance, and being distracted due to aging, and decreasing mental and physical ability (Boele-Vos et al., 2017; Engbers et al., 2018). As a result, safety and the risk of falling are the most critical concerns for older adults. Therefore, by increasing older adults’ walking and cycling in the post-outbreak, it is necessary to consider safety issues and identify risk factors to decline accidents and injuries caused by active modes. Hence, tricycles can eliminate falling due to the loss of balance and getting on and off the bicycles in the post-outbreak.

Moreover, since travels for shopping have not changed significantly, tricycles can also benefit these travels. Older adults have problems with the weight of the purchased goods and restrictions in using private vehicles. Therefore, tricycles increasing policies in the post-COVID-19 outbreak should be on the agenda of policymakers.

### Table 3
The percentages of travel purposes and frequency per week in the pre-and post-COVID-19 outbreak.

| Purpose         | Percentage | Avg. Frequency per week |
|-----------------|------------|-------------------------|
|                 | Before     | After                   | Before     | After                   |
| Shopping        | 27.6%      | 40.6%                   | 3.46       | 3.12                    |
| Religious       | 10.27%     | 0%                      | 1.45       | 0%                      |
| Health care     | 3.93%      | 0%                      | 0.1%       | 0%                      |
| Recreational    | 31.46%     | 50.3%                   | 3.39%      | 3%                      |
| Visiting relatives | 19.34%   | 1.96%                   | 0.4%       | 0.08%                   |
| Work            | 6.48%      | 6.3%                    | 1.2%       | 0.5%                    |
| Accompanying family | 5.84%   | 0.84%                   | 0.37%      | 0%                      |
| Others          | 4.08%      | 0%                      | 0.13%      | 0%                      |
| Sum             | 100%       | 100%                    | 10.5 travel per week | 3.7 travel per week |

### Table 4
The percentages of travel purposes for each mode in the pre-COVID-19 outbreak and after it.

| Mode Purpose        | Walk Before | During | Bicycle Before | During | Private vehicle Before | During | Vehicle passenger Before | During | P.T Before |
|---------------------|-------------|--------|----------------|--------|-------------------------|--------|--------------------------|--------|------------|
| Shopping            | 48.94%      | 53.72% | 15.47%         | 18.14% | 26.69%                  | 27.44% | 2.71%                    | 0.70%  | 6.19%      |
| Religious           | 75.00%      | 0%     | 2.94%          | 0%     | 11.76%                  | 0%     | 10.29%                   | 0%     | 0%         |
| Health care         | 3.70%       | 0%     | 0%             | 0%     | 16.67%                  | 0%     | 68.52%                   | 0%     | 11.11%     |
| Recreational        | 72.23%      | 84.89% | 12.64%         | 15.11% | 8.58%                   | 0.00%  | 4.97%                    | 0.00%  | 1.58%      |
| Visiting relatives  | 0%          | 0%     | 0.71%          | 0%     | 31.91%                  | 0%     | 39.01%                   | 0%     | 28.37%     |
| Work                | 7.45%       | 8.89%  | 10.64%         | 31.11% | 72.34%                  | 55.56% | 0%                       | 4.44%  | 9.57%      |
| Others              | 3.57%       | 0%     | 3.57%          | 0%     | 30.36%                  | 0%     | 0%                       | 0%     | 62.50%     |

*Note: Public transportation was not available during the interview (P.T: Public transportation).
A. Shaer and H. Haghshenas

Table 5

|                | Before the outbreak | After the outbreak | U* | Sig | U* | Sig |
|----------------|---------------------|--------------------|----|-----|----|-----|
| Walking routes quality | 0.54                | 0.49               | 0.88| 0.03| 0.88| 0.03|
| Vehicle ownership | 2.9                 | 2.6                | 0.005| 0.000| 0.005| 0.000|
| Travel distance | 0.3                 | 0.3                | 0.000| 0.000| 0.000| 0.000|
| Bicycle ownership | 1                    | 1.2                | 0.025| 0.000| 0.025| 0.000|
| Middle education | 1.5                 | 0.5                | 0.044| 0.000| 0.044| 0.000|
| Work Gender Security | -0.14               | -0.07              | 0.007| 0.000| 0.007| 0.000|
| Living in CBD | 0.2                  | 0.1                | 0.000| 0.000| 0.000| 0.000|
| Leisure Greenery | 0.1                  | 0.1                | 0.000| 0.000| 0.000| 0.000|
| Work gender | 0.2                  | 0.1                | 0.000| 0.000| 0.000| 0.000|
| Driving experience | -0.15               | -0.08              | 0.006| 0.000| 0.006| 0.000|
| Education | 0.1                  | 0.1                | 0.000| 0.000| 0.000| 0.000|
| Travel mode choice | 0.5                  | 0.5                | 0.020| 0.000| 0.020| 0.000|
| Public transportation | 0.4                  | 0.4                | 0.000| 0.000| 0.000| 0.000|

Note: U: Utility (Variables Coefficients), Sig: T-student (95% significance level), pt: Public transportation, pv: Private vehicle.

5. Conclusion

Despite the decrease in the mean travel frequency per week, the increase in the share of walking and cycling modes, making shopping and recreational travels (predominant travels in the post-outbreak) on foot, and cycling travel mode can indicate the resilience of walking and cycling in critical situations. The results also reveal that active modes have effective roles in older adults’ mobility in the post-outbreak because they are not subject to traffic restrictions like private vehicles and social constraints and crowd avoidance like public transportation.

Since travel distance and safety from traffic have significant effects on older adults’ travel generation, a built environment with mixed, diverse, dense, and accessible land uses, as well as safe and secure routes and intersections can increase older adults’ mobility in critical situations such as the COVID-19 spread. Furthermore, rising ownership of bicycles or tricycles (to reduce the risk of falling) and equipping bicycle-sharing infrastructure to tricycles in the post-outbreak should be on policymakers’ agenda.

In vehicle-dependent countries such as Iran, intersections such as a
separated left-turn phase and line and driving training courses for older adults are essential for safe driving in the crisis. Public transportation may also be a high-risk environment; therefore, providing gloves, face masks, and disinfectants for older adults and social distance observance in the fleet could encourage older adults to use public transportation post-COVID-19 outbreak. Improvement of station access routes is also essential to use public transportation.

6. Limitations and recommendations for further research

The research field study was conducted at the quarantine scheme, traffic restrictions, and closure of organizations and some land uses. So, it is suggested that the effect of the COVID-19 outbreak on travel behaviors of older adults be investigated in situations where traffic restrictions will have been lifted, and organizations and land uses have returned to normal situations.

More research is needed to examine the behavior and women’s active travel mode choice compared to men in critical situations, such as the COVID-19 outbreak due to the increasing women’s use of private vehicles and bicycles. It is also suggested that future research consider cycling modes (e.g., using tricycles and electric bicycles) and their effects on the choice of travel modes of older adults.

In this study, subjective built environment factors were investigated. Subjective measures have often been considered a substitute for objective measures when objective data are unavailable. In contrast, both objective and subjective measures are necessary to evaluate the effects of the built environment characteristics on older adults’ active travel during the COVID-19 outbreak. However, recent studies argue that both objective and subjective measures should be included when possible because different associations were found between the objective measures and perceived measures of the same environmental attributes with active travel behavior (Ma and Dill, 2015). Also, cycling and walking are aggregated in this study, but these two modes have different characteristics. Then, the differences should be analyzed in future researches.

Credit author statement

Amin Shaer: Writing - review & editing. Hossein Haghshenas: Writing review & editing.

Appendix 1

Questionnaire

1. Individuals information:

2. Travel information before the outbreak
3 Travel informations after the outbreak

| Duration | Frequency | Trip mode | Destination | Trip purpose | Changes in trips due to the outbreak |
|----------|-----------|-----------|-------------|--------------|-------------------------------------|
| 1        |           |           |             |              |                                     |
| 2        |           |           |             |              |                                     |
| ....     |           |           |             |              |                                     |

4 Neighborhood and the built environment informations
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