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The impacts of COVID-19 on older adults’ active transportation mode usage in Isfahan, Iran

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ABSTRACT

Aims: Since active mobility is essential for older adults’ health and well-being, especially in crises, this study aims to investigate and compare factors affecting active mode choice of older adults (AMCOA) in the pre- and post-COVID-19 outbreak and evaluate changes in their active mobility behavior and no research has been conducted this subject.

Methodology: The sample study of this cross-sectional study includes individuals over 60 years old residing in Isfahan, Iran. For interviews based on a structured questionnaire, which was drafted based on reviewing the literature, 453 participants were randomly selected in 15 municipality districts of Isfahan. A binary logistic regression model was used to analyze the data.

Result and Discussion: The results indicate that in the post-outbreak the average walking duration per week decreased from 59 to 29 min; while, the share of this mode has increased from 40% to 65%. Also, the share of bicycles and the average cycling duration per week increased from 9% to 18% and from 9 to 15 min, respectively. Moreover, trip frequency, bicycle ownership, quality of walking and cycling routes, intersections safety, neighborhood security and greenery, traffic calming, CBD accommodation, and public transportation accessibility have positive effects on AMCOA; while, trip distance and vehicle ownership affect negatively. The results reveal that older adults have turned to the bicycle for most of their long trips during the pandemic because it is not subjected to traffic restrictions. Besides, the findings show that increasing bicycle ownership and improving bike-sharing infrastructure make the bicycle a resilient alternative when public transportation and private vehicles are not efficient.

Conclusion: Policymakers and urban planners should consider that an elderly-friendly neighborhood with mixed, dense, and accessible land uses and services, as well as safe and secure routes can increase older adults’ active mobility in the crises.

Aims: Since active mobility is essential for older adults’ health and well-being, especially in crises, this study aims to investigate and compare factors affecting active mode choice of older adults (AMCOA) before and during the first wave of COVID-19 outbreak and evaluate changes in their active mobility behavior and no research has been conducted this subject.

1. Introduction

The advantages of walking and cycling are known for their health benefits for everyone, especially older adults. Walking requires less physical ability than cycling, so it is more possible for older adults; however, cycling increases access to opportunities over long

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distances and increases their mobility range (Consortium, 2012). Literature have also shown that at least 150 min of active mobility (e.g. walking and cycling) per week reduce the disease caused by aging (WHO, 2014; Oxley, 2015; Srichuea et al., 2016; Yang et al., 2018). Active mobility also means active travel modes usage on separate or integrated trips with other modes (Koszowski et al., 2019).

Previous studies have shown that older adults who lose their mobility have higher rates of morbidity and mortality. Besides, they are more likely to experience poor quality of life, depression, and social isolation (Gill et al., 2012; Lampinen and Heikkinen, 2003). So, mobility, especially active mobility, is essential for older adults' health, well-being, and welfare (Corrigan and McBurney, 2008; Webber et al., 2010; Yen and Anderson, 2012). Hence, walking and cycling should be an inseparable part of older adults' life, especially during critical situations. A recent crisis, the COVID-19 pandemic that was first reported in Wuhan region of China in late December 2019, has affected older adults in many countries around the world (Beck and Hensher, 2020; Chinazzi et al., 2020).

The first wave of the outbreak in Iran was reported on February 19, 2020; then, intra- and inter-city travel were banned or severely restricted; also, quarantine, public transportation and job closures, and odd-even traffic restrictions were on the agenda (Shaer et al., 2021). Therefore, mobility of citizens and older adults (that are vulnerable to viruses due to the weakness of their immune system) was remarkably reduced by restrictions on using travel modes such as private vehicles and public transportation. So, it is expected that the restrictions increase the adoption of alternative modes, such as walking and cycling (Abu-Rayash and Dincer, 2020; De Vos, 2020; Teixeira and Lopes, 2020). Thus, evaluation of factors influencing older adults’ walking and cycling to maintain their active mobility during and after the pandemic is essential.

Recently, many studies have examined the effect of COVID-19 outbreak on travel behavior and pattern. For example, Molly et al. (2021) analyzed mobility behavior of 1439 Swiss residents. Their results show that there was a remarkable decline in daily travel distance and public transport usage; while, bike usage increased significantly (Molloy et al., 2021). Besides, after the pandemic, there was a modal shift from motorized to active modes for short distances and citizens turned from public transport to private vehicles (Abdullah et al., 2021; Bucsky, 2020; Scorrano and Daniels, 2021; Thombre and Agarwal, 2020). Aaditya and Rahul (2021), Das et al. (2021), Shakibaei et al. (2021), and Tarasi et al. (2021) have also shown that the outbreak and lockdown have changed travel mode usage from public transport to private car. Also, activities such as commuting, recreation, and shopping decreased remarkably (Aaditya and Rahul, 2021; Das et al., 2021; Shakibaei et al., 2021; Tarasi et al., 2021).

Furthermore, Politis et al. (2021) have demonstrated that the frequency of travel decreased by fifty percent during the pandemic. Also, walking has increased and public transport usage was considerably declined (Politis et al., 2021). In addition, Dunton et al. (2020) found that there was a decrease in adults’ physical activity (vigorous and moderate) and walking (min/week) in the U.S. during the pandemic (Dunton et al., 2020). Moreover, Shaer et al. (2021) have shown that the average active travel time of the CBD residents before and during the outbreak is more than that of the non-CBD residents (Shaer et al., 2021). Cusack (2021) has illustrated that commuters’ active mode usage in Philadelphia, Pennsylvania, USA was increased during the pandemic (Cusack, 2021).

In summary, although many papers have evaluated the pandemic effects on travel behavior and mode choice before and after (or during) the outbreak (Awad-Núñez et al., 2021; Brand et al., 2021; Hino and Asami, 2021; Nurse and Dunning, 2020; Valenzuela-Levi et al., 2021; Zhang and Fricker, 2021), to our knowledge, no research has been conducted to evaluate the active mode choice of older adults during the COVID-19 outbreak. Hence, the present study aims to investigate and compare factors affecting active mode choice of older adults before and during the first wave of the outbreak and to evaluate changes in their active mobility behavior. To this end, the following questions will be answered:

- What factors affect older adults’ walking and cycling before and during the COVID-19 outbreak?
- What has changed older adults’ trip purposes during the first wave of the outbreak? And what are the most important factors affecting the choice of active travel mode for those trips?
- What effects does the use of other travel modes before the outbreak have on the choice of active travel mode during that?

This paper begins with a review of the literature that is followed by a description of the study’s methodology; it then presents the results and a discussion of the findings. Finally, the conclusion and suggestions for future research are presented.

2. Literature review

In order to investigate the changes in older adults’ active mobility due to the COVID-19 outbreak and evaluate factors affecting AMCOA before and during the first wave of the outbreak, identifying factors that affect their travel behavior and mobility is essential. Therefore, in this section by reviewing the literature, the most important factors have been identified.

2.1. Personal characteristics

Having a driving license and a private vehicle increases the likelihood of older adults’ trips. Older adults without a driving license use more public transport or travel as car passengers with friends and family members (Habib, 2015; Plazinić and Jović, 2018). Besides, having a private vehicle reduces the likelihood of using public transport, cycling, and walking (Hou, 2019; Moniruzzaman et al., 2019). In addition, previous studies showed that the transition from employment to retirement affects older adults’ travel mode choice and behavior (Ahern and Hine, 2012; Ryan and Werstrand, 2019; Sjönborg 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 cars than retirees because of time constraints (Ahern and Hine, 2012). Furthermore, The household structure has a strong impact on older adults’ mobility. Older adults living in crowded and overcrowded families have a low tendency to use public transport for long trips since they
almost travel with family members (Böcker et al., 2017; Plazinić and Jović, 2018).

2.2. Trip features

In general, aging not only reduces distance, duration, and frequency of trips but also changes travel mode. Travel distance also has a considerable impact on the choice of travel mode (Du et al., 2020; Plazinić and Jović, 2018). The increment of travel time and distance changes individuals’ trip mode, especially older adults, from active mode to public transportation and cars (as a driver or passengers) (Böcker et al., 2017). Furthermore, shopping, recreational, treatment, and social trips are common among them (Ryan and Wretstrand, 2019; Šimeček et al., 2018; Yoshikawa and Bednarz, 2013).

2.3. Built environmental features

Older adults living in high-density areas have less travel time due to the proximity of facilities; then, they choose active modes of travel and rarely use a private car due to traffic and congestion (De Vos and Alemi, 2020). However, in low-density districts, active modes are not favorable for them due to the scattered land uses and inappropriate access to public transportation stations; therefore, they travel by car as a driver or car passenger with friends and family members (Du et al., 2020; Plazinić and Jović, 2018; Yang et al., 2018). On the other hand, the built environment factors such as mixed land use, vegetation and design, security, and accessibility of facilities influence travel mode choice and trip generation. Then, an age-friendly environment not only reduces car dependency among older adults and increases the use of sustainable transportation modes such as walking, cycling, and public transport (Cao et al., 2010; Cheng et al., 2019; Du et al., 2020; Hou, 2019; Moniruzzaman et al., 2013; Oxley, 2015; Sríruah et al., 2016; Yang et al., 2018; Yoshikawa and Bednarz, 2013) but also increases older adults’ quality of life and wellbeing (Du et al., 2020; Yang et al., 2018, 2019). Moreover, Habib (2015) has also indicated that proximity to Central Businesses Districts (CBD) increases sustainable transportation modes usage. However, traffic congestion and low safety in the CBD might reduce the use of these modes (Böcker et al., 2017; Hou, 2019).

By reviewing the literature, factors affecting older adults’ travel behavior and mobility were identified. Next, the questionnaire of this study was drafted based on the most important factors such as individuals characteristics (age, the number of family members, job, cars in the household, income, having a driving license, car and bike ownership, the possibility to use the car, and residential location), trips characteristics (destination, purpose, duration, and frequency) and characteristics of the built environmental (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

Logistic regression is a special type of multiple regression in which the dependent variable is discrete. The difference between Logistic regression model and Linear regression model is that the dependent variable in the logistic regression is binary. One of the aims of this study is to investigate and compare factors affecting active mobility mode choice of older adults; so, the choice of active mobility mode as a dependent variable has a binary value: Y takes only a value of 0, or 1. One indicates the use of cycling and/or walking as active modes, and zero indicates the use of other modes (private vehicles, buses, subways, taxis, etc.). The dependent variable p represents the probability of Y taking 1. The expression p/p-1 indicates the odds ratio or the probability of 1 to the probability of 0. Xij is the independent variable kth of the kth, β0 is a constant coefficient and βi are the coefficients of the independent variables (Albert and Anderson, 1984; Bujang et al., 2018). Demographic information, travel and neighborhood data were independent variables.

\[
\text{Logit} (p) = \ln \left( \frac{p}{1-p} \right) = \beta_0 + \beta_1 x_{1i} + \ldots + \beta_k x_{ki}
\]

\[i = 1, \ldots, n\]

\[p = \Pr(y_{i-1})\]

\[p = \Pr(y = 1 | x; \beta) = \frac{e^{\beta_0 + \beta_1 x_{1i} + \ldots + \beta_k x_{ki}}}{1 + e^{\beta_0 + \beta_1 x_{1i} + \ldots + \beta_k x_{ki}}} = \frac{1}{e^{-\beta_0 - \beta_1 x_{1i} - \ldots - \beta_k x_{ki}}}\]

\[R^2_{\text{log}} = 1 - \exp \left[ -\frac{2}{N} (L(B) - L(0)) \right]\]
\[ R^2_N = \frac{R^2_{cs}}{1 - \exp\left(\frac{2 \cdot (0)}{N}\right)} \]

### 3.2. Describing the questionnaire and variables

The structured questionnaire includes demographic information, trip information before and during the first wave of the outbreak, and environmental information. Validity of the questionnaire has been confirmed by Lawshe’s method (Kennedy et al., 2019; Lawshe, 1975) and several professors of the Department of Transportation Engineering, Isfahan University of Technology (5 professors) and the Department of Urban Planning of Art University of Isfahan (4 professors). The variables extracted from the questionnaire for modeling are presented in Table 1 and the questionnaire is presented in the Appendix 1.

### 3.3. Case study

Isfahan city with a population about 2 million is the center of Isfahan Province, located at the crossroads of the main north-south and east-west routes of Iran (Mansourianfar and Haghshenas, 2018; Tavassoli and Tamannaei, 2020). Its population growth rate in 1956 was 5.8% and decreased to 1.89% in 2016. This trend indicates that there is a significant growth in the population aged 60 years and over and the occurrence of the population aging phenomenon. At present, the population aged 60 years and over is about 10%

### Table 1

Definitions of variables.

| Symbol | Variables and their definitions |
|--------|----------------------------------|
| AMWB   | Choice of active mode            |
| TRFC   | Trip frequency                   |
| TRDS   | Trip distance                    |
| PRSH   | Shopping                         |
| PRRG   | Religious                        |
| PRTM   | Health-care visit                |
| PPRC   | Recreational                     |
| PRMF   | Friends and relatives visit      |
| PRWK   | Work                             |
| PRCF   | Conveying family                 |
| TMWK   | Walk                             |
| TMBE   | Bike                             |
| TMCR   | Car                              |
| TMCP   | Car passenger                    |
| TMPT   | Public transportation            |
| TMOR   | Others                           |
| HHSZ   | Size                             |
| HHCR   | Car                              |
| IDSX   | Sex                              |
| IDED   | Employed                         |
| IDLI   | low income                       |
| IDMI   | Middle income                    |
| IDHI   | High income                      |
| IDHE   | High education                   |
| IDME   | Middle education                 |
| IDLE   | Low education                    |
| IDDL   | Driving license                  |
| IDCO   | Car ownership                    |
| ICBO   | Bicycle ownership                |
| IDLC   | Living in CBD                    |
| NHWR   | Walking routes quality           |
| NHCR   | Cycling routes quality           |
| NHCT   | Security                         |
| NHTC   | Traffic calming                  |
| NHFA   | Intersections safety             |
| NHCG   | Greenery                         |
| NHVT   | Public transportation accessibility | 5-point Likert scale (very poor = 1, excellent = 5) |
(215,000 individuals) and it is predicted that by 2040, the percentage of older adults population will reach 30%.

3.4. Data collection

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: $n = \frac{Z^2 pq}{d^2 \left( \frac{N}{n} - 1 \right)}$

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 and discussion

Among 453 participants, a majority are men, a large majority are retired, a majority have a driving license, a small majority own a private vehicle, and a minority have a bicycle. The related socio-demographic characteristics are shown in Table 2.

4.1. Older adults’ active mobility behavior

In general, before the COVID-19 outbreak, 1403 different trips were recorded (religious: 138, shopping: 393, recreational: 435, business: 147, visiting friends and relatives: 153, health-care: 56, and accompanying family members: 81) and during the first wave of the outbreak, 735 trips were recorded (shopping: 304, recreational: 366, visiting friends and relatives: 14, business: 45, and accompanying family members: 6).

The percentages of trip purposes and frequency per week are presented in Table 3, the percentages of trip purposes per each mode
before and during the outbreak are also listed in Table 4. The percentages of different travel modes usage before and during the outbreak are also shown in Fig. 2 and the changes in the travel mode are illustrated in Fig. 3.

Table 3 shows that recreational trips followed by shopping have the largest share among all trip purposes before and during the pandemic. However, these two types of trips have increased during the pandemic and other trips have been canceled or have rarely been done. Moreover, recreational and shopping trips have almost the same frequency per week before and during the pandemic. Generally, the average trip frequency per week has declined from 10.5 before the outbreak to 3.7 during it.

Table 4 demonstrates that most shopping (48.94%), religious (75%), and recreational trips (72.23) were made by foot before the pandemic. It is also true for during the outbreak (shopping: 53.72 and recreational: 84.89), but religious trips were canceled. A private vehicle has also a remarkable role in work trips before and during the outbreak, 72.34% and 55.56%, respectively. Older adults usually used a bike for shopping (15.47%), recreational (12.64), and work trips (10.64) and they rarely used a bicycle for religious and visiting family trips before the outbreak. However, the use of bicycles has increased significantly during the outbreak. Older adults also used public transportation for a variety of trips before the pandemic and it has not been used during it.

Fig. 2 shows that the share of walking and cycling have increased during the outbreak; while, the share of other modes have decreased remarkably. The changes in the share of walking and cycling is because of the restrictions on the use of other modes such as

Table 2
Socio-demographic information of participants. (N = 453).

|                    | n | %  |
|--------------------|---|----|
| Total              | 453|    |
| Sex                |    |    |
| Male               | 292| 64.4|
| Female             | 161| 35.6|
| Currently working  |    |    |
| No                 | 361| 79.7|
| Yes                | 92 | 20.3|
| Age category       |    |    |
| 60-69              | 295| 65.1|
| 70-79              | 128| 28.2|
| 80+                | 30 | 6.7 |
| Monthly Income     |    |    |
| < 1.5 million toman| 193| 42.6|
| 1.5-3 million toman| 199| 44  |
| >3 million toman   | 61 | 13.4|
| Living in CBD      |    |    |
| Yes                | 109| 24  |
| No                 | 344| 76  |
| Having a Driving license | |   |
| Yes                | 310| 68.4|
| No                 | 143| 31.6|
| Car ownership      |    |    |
| Yes                | 237| 52.3|
| No                 | 216| 47.7|
| Bike ownership     |    |    |
| Women              |    |    |
| Yes                | 2  | 0.4 |
| No                 | 159| 35.1|
| Men                |    |    |
| Yes                | 127| 28  |
| No                 | 165| 36.5|
| Education          |    |    |
| >12                | 53 | 11.7|
| 8-12               | 128| 28.3|
| <8                 | 272| 60  |

Table 3
The percentages of trip purposes and frequency per week before and during the COVID-19 outbreak.

| Purpose             | Percentage | Avg. Frequency per week |
|---------------------|------------|-------------------------|
|                     | Before the outbreak | During the outbreak | Before the outbreak | During the outbreak |
| 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  | 10.34      | 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 trip per week** | **3.7 trip per week** |
Table 4
The percentages of trip purposes per each mode before and during the COVID-19 outbreak.

| Purpose             | Walk | Bike | Car | C.P¹ | P. T² | Sum  | Walk | Bike | Car | C.P | P. T | Sum |
|---------------------|------|------|-----|------|-------|------|------|------|-----|-----|------|----|
|                     | Before the outbreak |       |     |      |       |      |       |     |     |     |      |     |
| Shopping            | 48.94 | 15.47 | 26.69 | 2.71 | 6.19  | 100% | 53.72 | 18.14 | 27.44 | 0.70 | *   | 100% |
| Religious           | 75.00 | 2.94  | 11.76 | 10.29 | 0.00  | 0    | 0    | 0    | 0   | 0   | 0    | 0   |
| Health-care         | 3.70  | 0     | 16.67 | 68.52 | 11.11 | 0    | 0    | 0    | 0   | 0   | 0    | 0   |
| Recreational        | 72.23 | 12.64 | 8.58  | 4.97  | 1.58  | 0    | 84.89 | 15.11 | 0.00  | 0.00 | 0.00 | 100%|
| Visiting relatives  | 0     | 0.71  | 31.91 | 39.01 | 28.37 | 0    | 0    | 0    | 0   | 0   | 0    | 0   |
| Work                | 7.45  | 10.64 | 32.34 | 0     | 9.57  | 8.89 | 31.11 | 55.56 | 4.44  | 100%|
| Accompanying family | 0     | 0     | 100.00 | 0   | 0    | 0.00 | 100  | 0    | 0   | 0   | 100%|
| Others              | 3.57  | 3.57  | 30.36 | 0     | 62.50 | 0    | 0    | 0    | 0   | 0   | 0    | 0   |

Note: *: Public transportation was not available at the time of the interview, 1: car passenger and 2: Public transportation.

Fig. 2. The percentages of different travel modes used before and during the COVID-19 outbreak.

Fig. 3. The average walking and cycling time per week before and during the COVID-19 outbreak.

Fig. 4. Modal shift due to the outbreak. Note: Public transportation was not available at the time of the interview.
increased from 9.5 to 22.7 min. The increase in the duration of bicycle trips was due to the absorption of 23% of public transportation by AMCOA. Therefore, urban planners and policymakers should keep in mind that in a crisis, when motorized transportation modes do not have their former efficiency, an older adult-friendly neighborhood and safe walking and cycling infrastructure can maintain older adults in their active mobility. For older women, in addition to factors such as trip distance and quality of walking routes, intersections safety and policies to increase bicycle ownership, such as preparing affordable bicycles or improving bike-sharing systems, can be effective in maintaining older adults’ active mobility in such critical situations when other methods (such as public transportation and private cars) are not as efficient as before. Also, preventive and incentive measures to increase cycling from early ages are necessary to turn it into a habit. In support of this, previous studies stated that most older adults cyclists had cycled throughout their lives and only a few of them started cycling at these ages (Johnson and Rose, 2015; Ryan et al., 2016). Then, it can be expected that having a cycling background can make this mode resilient in critical situations.

Table 5 displays the average trip indicators of active modes before and during the outbreak. Modal share indices, the average trip frequency by each mode per week, the average trip time of each mode, and the average trip time by each mode per week are calculated for each active mode.

The results of Table 5 also indicate that the total time of walking per week decreased from 59 to 29 min because the frequency of weekly walking mode decreased from 4.2 to 2.4 and the average time per walking trip decreased from 14 to 12.1 min; however, the share of walking mode has increased from 40% before the outbreak to 65% during it. Also, despite the decrease in the frequency of cycling trips from 0.95 before the pandemic to 0.66 per week during that, the share and average time of cycling per week increased from 9% before the outbreak to 18% and from 9 to 15 min during that, respectively. Finally, the average time of each cycling trip increased from 9.5 to 22.7 min. The increase in the duration of bicycle trips was due to the absorption of 23% of public transportation and 4.76% of private vehicle trips. This indicates that older adults have turned to bicycles for most of their long trips during the COVID-19 outbreak. Overall, although the share of active modes increased from 49% to 83%, its frequency per week decreased from 5.15 to 3.1, and its average weekly duration has decreased from 68 to 44 min.

### 4.2. Active mode choice of older adults

Modeling for the odds of AMCOA before and during the first wave of COVID-19 outbreak was performed for all trips by different purposes, gender, CBD, and non-CBD location. Generally, the most important factors affecting AMCOA before the outbreak are the trip distance (with a negative effect), frequency of trips, bicycle ownership, vehicle ownership (with a negative effect), neighborhood security, CBD location, and recreational trips. During the outbreak, in addition to the previous factors, the quality of walking routes, as well as the beauty and greenery of the neighborhood, are significant factors that affect AMCOA. The details of the models and their variables are listed in Tables 6 and 7.

Since in all models trip distance has a significant negative relationship with AMCOA, proper location of facilities and services near older adults’ accommodation, as well as dense and mixed land uses increase older adults’ mobility and physical activity in critical situations such as the COVID-19 spread.

The models also show that bicycle ownership has a significant effect on AMCOA in various trips, especially recreational. Therefore, policies to increase bicycle ownership, such as preparing affordable bicycles or improving bike-sharing systems, can be effective in maintaining older adults’ active mobility in such critical situations when other methods (such as public transportation and private cars) are not as efficient as before. Also, preventive and incentive measures to increase cycling from early ages are necessary to turn it into a habit. In support of this, previous studies stated that most older adults cyclists had cycled throughout their lives and only a few of them started cycling at these ages (Johnson and Rose, 2015; Ryan et al., 2016). Then, it can be expected that having a cycling background can make this mode resilient in critical situations. Future studies should consider that cycling background could be a criterion in cycling during the COVID-19 outbreak.

Neighborhoods that increase active mobility and facilitate physical activity are consistent with active aging and the goals of age-friendly cities (Bhuyan et al., 2020; Finlay et al., 2021; Marquet et al., 2017; WHO, 2007). This study also shows that traffic calming, the safety, security and greenery of the neighborhood, and the quality of walking and cycling routes have a significant effect on AMCOA. Therefore, urban planners and policymakers should keep in mind that in a crisis, when motorized transportation modes do not have their former efficiency, an older adult-friendly neighborhood and safe walking and cycling infrastructure can maintain older adults’ active mobility.

Furthermore, cycling is less popular among women because of religious issues in Iran; then, walking is the predominant mode of active mobility. For older women, in addition to factors such as trip distance and quality of walking routes, intersections safety and

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**Table 5**

The average trip indicators of active modes before and during the COVID-19 outbreak.

|               | Modal share (%) | The average frequency of trip by each mode per week | The average trip time of each mode (min) | The average trip time of each mode per week (min) |
|---------------|-----------------|-----------------------------------------------|----------------------------------------|-----------------------------------------------|
|               | Before | During | Before | During | Before | During | Before | During | Before | During |
| Walking       | 40     | 65     | 4.2    | 2.4     | 14     | 12.1    | 59     | 29     |
| Cycling       | 9      | 18     | 0.95   | 0.66    | 9.5    | 22.7    | 9      | 15     |
| Active travel | 49     | 83     | 5.15   | 3.1     | 13.2   | 14.6    | 68     | 44     |
Table 6

| MODEL | $R^2$ | $-2LL$ | Constant | Distance | Frequency | Bicycle ownership | Car ownership | Security | greenery | Traffic Calming | Living in CBD | Recreational trips | Public transportation accessibility | Family car |
|-------|-------|--------|----------|----------|-----------|------------------|---------------|----------|---------|----------------|-------------|------------------|-------------------------------|-----------|
| All   | 0.9   | 356    | B 0.9    | -0.96    | 0.25      | 2.14             | -1.6          | 0.45     | 0.011   | 0.011          | 4.8          | 0.000            |                               |           |
| Shopping | 0.64 | 148    | B 3.43   | -1.55    | 0.23      | 2.18             | -4.06         | 0.77     |         |                |             | 0.005            |                               |           |
| Recreational | 0.81 | 71.5   | B -2.5   | -0.62    | 1.1       | 4                |               |          |         |                |             | 0.089            |                               |           |
| Work  | 0.15  | 73     | B -7.7   | 0.004    | 0.023     | 0.001            |               |          |         |                |             | 0.041            |                               |           |
| Men   | 0.88  | 280    | B 0.22   | -0.9     | 0.24      | 1.6              | -1.9          | 0.79     |         |                |             | 0.042            |                               | 0.017     |
| Women | 0.91  | 59     | B 3.5    | -1.83    | 0.001     | 0.000            | 0.000         | 0.000    |         |                |             | 0.000            |                               |           |
| CBD   | 0.94  | 36.1   | B 7.13   | -1.44    | 3.85      | -3.47            |               |          |         |                |             | 7.3              |                               |           |
| NON-CBD | 0.89 | 293    | B -2.9   | -0.93    | 0.28      | 1.85             | -1.53         | 0.5      |         |                |             | 4.7              |                               | 0.36      |

Note: B. Variables Coefficients, Sig. T-student (95% significance level).
Table 7
Modeling of the choice of active travel modes during the COVID-19 outbreak.

| MODEL  | \( R^2 \) | \(-2\text{ LL}\) | Constant | Distance | Frequency | Bicycle ownership | Car ownership | Walking route quality | cycling route quality | Security | greenery | Traffic Calming | safety of intersections | Recreational trips |
|--------|-----------|----------------|----------|----------|-----------|-------------------|---------------|---------------------|----------------------|----------|----------|----------------|------------------------|------------------|
| All    | 0.93      | 69             | B 6      | -1.76    | 0.45      | 1.7               | -7.3          |                     | 1.35                 |          | 0.005    | 0.000          | 0.000                  | 10               |
| Shopping | 0.97    | 19.22          | B 12.18  | -5.06    |           |                   | 7.3            |                      | 1.35                 | 0.000    |          | 0.000          | 0.000                  | 10               |
| Men    | 0.86      | 124.3          | B 7.2    |          |           |                   |                | 0.026              | 0.001                | 0.005    | 0.000    | 0.000          | 0.000                  | 10               |
| Women  | 0.25      | 68.1           | B -9.03  |          |           |                   |                | 1.15               | 0.83                 | 0.002    | 0.000    | 0.000          | 0.000                  | 10               |
| CBD    | 0.92      | 21             | B 5.67   |          |           |                   |                | 0.041              | 0.036                | 0.004    | 0.000    | 0.000          | 0.000                  | 10               |
| Non-CBD| 0.82      | 138            | B -7.12  |          |           |                   |                |                     | 0.85                 | 1.32     | 0.74     | 0.75           | 0.75                   | 10               |

Note: B. Variables Coefficients, Sig. T-student (95% significance level).
neighborhood security are also important factors in walking before and during the outbreak. Therefore, increasing street lighting, police patrols, security cameras, and police stations, especially in the crises, are essential to rise the feeling of security of older women during walking.

In shopping trips by active modes before the COVID-19 outbreak, travel distance and vehicle ownership had negative effects; although, the frequency of trips, greenery of the neighborhood, and bicycle ownership had positive effects. Also, before the outbreak, almost 65% of shopping trips were done by active modes. Therefore, policies in order to decrease trip distance (such as increasing density of and mixing land uses) and neighborhood beautification can rise the use of active modes in shopping trips and reduce the negative effect of vehicle ownership. During the outbreak, in addition to trip distance (with a negative effect), neighborhood security has a considerable effect on AMCOA in shopping trips. However, this factor was not effective before the pandemic.

Bicycle ownership and recreational trips (with coefficients of +3.85 and + 7.3 respectively) had positive effects and car ownership (with coefficients of −3.74) had negative effects on AMCOA in CBD areas before the outbreak; while, during that, car ownership did not affect AMCOA in these areas because of traffic restriction plans. For non-CBD residents, in addition to mentioned factors for CBD residents, neighborhood greenery and security, public transportation accessibility, quality of cycling routes, traffic calming, and intersection safety have positive effects on AMCOA. Shaer et al. (2021) have shown that the average walking and cycling time of the CBD residents before and during the outbreak is more than that of the non-CBD residents, which is due to the quality of built environment factors in the CBD (Shaer et al., 2021).

To investigate the effect of used modes before the outbreak on AMCOA during the outbreak, the binary logistic regression model was also used. In this model, choosing active modes during the outbreak is the dependent variable and independent variables are public transportation usage, private vehicle usage, cycling, and walking before the outbreak. The result of the model shows that during the pandemic walking, cycling, and using public transportation have positive effects and using a private vehicle has a negative impact. The details of the mode change models and their variables are listed in Table 8.

In models of changing the modes of walking, cycling, and the use of public transportation before the outbreak had positive and the use of private vehicles harmed AMCOA during the outbreak. The positive effect of using public transportation is because of pedestrian access to the stations makes the users of this mode accustomed to walking and physical activity. Besides, the negative effect of using a private vehicle can be due to being accustomed to this mode, which it is difficult for older adults to change their modes in the crisis caused by the COVID-19 outbreak.

5. Conclusion

The results reveal that active mobility has an effective role in supporting older adults’ mobility during the COVID-19 outbreak because it is not subject to traffic restrictions like private vehicles and social restrictions and crowd avoidance like public transportation. The increase in the duration of cycling during the outbreak indicates that older adults have turned to bicycles for most of their long trips. Furthermore, the COVID-19 outbreak has caused older adults to use active modes more than other modes; however, the total trip time per week and the time of active mobility have decreased in general.

Bicycle ownership was identified as an effective factor in the odds of active travel mode choice. Therefore, policies to increase bicycle ownership, such as preparing affordable bicycles or improving bike-sharing systems, can be effective to maintain older adults’ active mobility when other modes are not as efficient as before. Finally, policymakers and urban planners should consider that an older adult-friendly neighborhood with mixed, dense, and accessible land uses and services, as well as safe and secure routes can increase older adults’ active mobility in the crises.

6. Recommendations and limitations

The research field study was conducted during the quarantine scheme, traffic restrictions, and closure of organizations and some jobs. So, it is suggested that the effect of the COVID-19 outbreak on active travel be investigated in situations when traffic restrictions will have been lifted and organizations and jobs have returned to normal situations. It is also suggested that future research consider other micro mobility modes ((e)scooters, e-bicycles, etc) and their effects on the choice of active travel modes of older adults. In addition, further study should consider the impact of religious issues on the use of the bicycle by women in Iran and should examine the COVID-19 outbreak effects on older women bicycling in Iran in comparison with other non-religious societies. However, the previous studies in others countries (The US and New Zealand) showed that younger women were particularly sensitive to negative images associated with bicycling (Frater and Kingham, 2018; Underwood et al., 2014).

In this study, subjective built environmental factors were investigated. Subjective measures have often been considered a substitute

Table 8
The details of the mode change models and their variables.

| MODEL | R Square (N.K.) | – 2 LL | Constant | Walking before | Cycling before | Public transportation use before | Car use before |
|-------|----------------|--------|----------|----------------|---------------|-------------------------------|---------------|
| 1     | 0.072          | 656    | B        | 0.3           | 1.8           | 0.8                           | 0.6           |
|       | Sig 0.043      | 0.000  | 0.043    | 0.000         | 0.004         | 0.027                         |               |
| 2     | 0.16           | 611    | B        | 1.6           | 0.93          | 0.86                          | – 1.54        |
|       | Sig 0.000      | 0.000  | 0.000    | 0.02          |               | 0.000                         |               |

Note: B. Variables Coefficients, Sig. T-student (95% significance level).
for objective measures when objective data are unavailable. While, in order to evaluate the effects of the built environment factors on older adults’ active travel during the COVID-19 outbreak, both objective and subjective measures are necessary (Barnett et al., 2020; Ma and Dill, 2015).

CRediT authorship contribution statement

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

Appendix A. Supplementary data

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