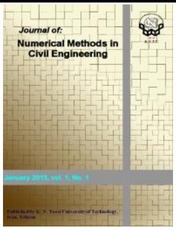
Numerical Methods in Civil Engineering, 7-3 (2023) 78-93



Numerical Methods in Civil Engineering

Journal Homepage: https://nmce.kntu.ac.ir/

Subway System Usage by Elderly: Application of a Hybrid Choice Model

Ali Edrisi[*], Mahsa Hayati Salout[**], Houmaan Ganjipour[***], Vahed Barzegari[****]

ARTICLE INFO

RESEARCH PAPER

Article history:
Received:
June 2022.
Revised:
September 2022.
Accepted:
September 2022.

Keywords:
Elderly mobility,
Subway system,
Health importance,
Mental satisfaction,
Hybrid choice model

Abstract:

Worldwide. In the context of increasing aging in the cities, elderlies with different characteristics such as sociodemographic, mental, and physical problems may face many barriers to their mobility. We need new mathematical models to understand and predict how different factors affect the subway system, which helps older adults to eliminate their obstacles and experience a flexible and independent trip while using the subway system. This research provides a comprehensive methodology for identifying the factors and calculate their impact on subway usage in three steps, namely survey design, model estimation, and forecasting subway usage by elderlies with different characteristics. To achieve this purpose, we use stated preference data collecting of 236 persons gathered from elderly people in Tehran during April and May 2021. To estimate the model, we examine the elderly's attitudes and features toward subway choice and anticipate subway usage through a hybrid discrete choice model. The findings from the case study indicate that improving mental satisfaction followed by facility and service coverage satisfaction and education will increase the probability of elderly's subway usage. By contrast, physical problems, staff services and lack of facilities, aging, illness, and high income had adverse effects.

1. Introduction

Aging has become a universal phenomenon to be considered for establishing a suitable public transportation in sophisticated metropolitan and mega cities. Elderly population (60 years above) for Iran residents will be increased from 8% in 2011 to 21.7% In 2050 [1]. However, this figure is not just for Iran, developed countries are also experiencing this situation and developing countries like Iran are confronted with the same scenario. From studies, developing countries have increased in population and birth rate reduction occurs over less amount of time [2]. To illustrate the point, Sundling et al. (2014) find that transportation facilities must be enhanced to be able to handle the needs of the feeble group as ratio of the elderly in the world is increasing [3].

* *Assistant Professor, Department of Civil Engineering, K. N. Toosi University of Technology, Tehran, Iran E-mail address: edrisi@kntu.ac.ir (Corresponding author)*

** *Department of Civil Engineering, K. N. Toosi University of Technology, Tehran, Iran E-mail address: hayatimahsa@yahoo.com*

*** *Ph.D., Department of Civil Engineering, K. N. Toosi University of Technology, Tehran, Iran E-mail address: Ganjipour.h@email.kntu.ac.i*

**** *Ph.D. Candidate, Department of Civil Engineering, K. N. Toosi University of Technology, Tehran, Iran E-mail address: vahedbarzegari@email.kntu.ac.ir*

https://doi.org/10.52547/NMCE.2022.436

Cheshmberah et al. (2014) state that the elderly in Iran encounter many health and social problems, including illiteracy, problems with daily activities, financial issues, life dissatisfaction, and lack of health insurance which create barriers to mobility [4]. It is a significant concern that mobility restrictions are prevalent in the elderly [5]. With respect to the findings of Satariano et al. (2012), lack of mobility will have harmful consequences for the elderly, such as health problems, depression, social isolation [6]. However, mobility, including outdoor activities and accessible public transport, will improve the life elderly population quality ([7]; [8]). For this reason, Srichuae et al. (2016) find that supportive environments such as transportation and access to public space are among the important needs of the elderly [9]. In addition to being able to walk and become mobile, these items make them able to be self-sufficient and don't depend or rely on others [10]. Furthermore, older people often prefer to stay home, make fewer and shorter trips, use non-car transport modes ([11]; [12]).

Also, Metz (2003) state that elderly's travel behaviors are different and these differences arise from numerous factors as gender, age, income, education, illness, and supportive environments [8]. For example, Spinney et al. (2009) notice that the population the aged 65 to 75, in comparison with those aged is 85 or over, would like to spend more than 70 minutes a day outside of the house, and it implies that age can have a negatively relationship with mobility [13]. As age increases, traveling by public transport despite having health problems becomes more complex and causes all modes to be less frequently used ([14]; [15]). But the elderly who have high physical health conditions will continue their activities as pedestrians, car drivers, and bus passengers and the increase in age will not affect their choice of public transport method [16].

In many countries, elderlies are keener to use a private car, and the factors that lead them to these preferences are reliability, comfort, personal security, and flexibility. Among them, older men prefer to use their car as drivers [17]. On the other hand, older women, who are not able to drive a car, prefer to travel by public transportations systems or travel by cars as passengers [18]. But in recent decades, rate of women's use of personal vehicles as a driver has been increasing [12].

Considering the increasing car usage by elderly, many concerns are posed. Risk of injury and fatality in traffic threatens these groups more than other age groups [19]. In many countries, research has shown that the tendency to use a car is more among people aged 65 to 84 than other modes of travel ([20]; [10]; [15]). Also, car usage declines as the users' age increases. Generally, results show that the physical and mental ability of the elderly to drive decreases over time and therefore, their dependency on transit increases [21]. Hence, the government and relevant organizations are working to improve public transportation systems to minimize using private cars and solve the problems that elderly people may face by using public transportation.

To improve this situation, urban planners need to identify factors influencing elder mobility while using the public transportation system. Srichuae et al. (2016) find three types of factors such as (1) individuals' independence, (2) distribution of public spaces, and (3) urban systems [9]. Therefore, designing the urban environment by urban planners should be compatible with elderly mobility. Sundling et al. (2014) determine barriers that limit the elderly use of the railway transportation system, and they examine 16 cases of illnesses [3]. They then focus on three diseases selected by elderlies [3]. Also, different factors such as gender, age, and income are explored in previous studies and results show that elderlies with lower income have more tendency to travel using public transport systems [17]. Similar implications are achieved by another study and the data investigation show that distance from the public transport system and income negatively affect transit use [21].

Yuan et. al. (2019) focus on the bus transit service usage by older people. They use structural equation model to investigate the effects of 10 factors such as safety and security, time scheduling, driver service [22]. They find out that time schedule and reliability have little effect on the elderly's perspective. This result seems logical because most of the elderly are retired and thus have more time to reach their destination. In contrast, some factors such as service and security, convenience and driver service are among the most important factors [22]. Shao et al. (2019) highlight the importance of investigation of elderly trip characteristics [23]. They then compare the distance, frequency and start time of elderly in weekday and weekend using GPS and buses smart card data. Results show that older people have less travel on weekends, but their trip frequency and trip distance grow. Also, findings prove that geospatial expansion of target group's travel on weekend is larger than young people [23].

Fatima and Moridpour (2019) consider Melbourne, Australia as case study and analyze the travel pattern and accessibility of public transport systems for senior people with age 65 and above [24]. They also investigate the applied strategies that can improve the transport system for elderly. They then propose some suggestions to facilitate the access of the elderly to public transportation systems. They conclude that strategies such as shuttle bus route services and modifying public transport time table can motivate older adults to use public transportation systems [24]. DU et al (2020) focus on healthcare trips and study the factors affecting the trip mode choice of senior people using multinomial logistic models [25]. They divide the target group in two categories, namely, those line in core area and those live in suburb. Results show that elderly use bus and walking more than other modes [25].

Al-Rashid et al. (2021) consider older women (with age 65 and over) as target group and study the effects of three psychological factors (perceived social norms, social support, and neighborhood social environment) on the older women's social inclusion [26]. They find that if social planners address these factors, older women experience a better public transportation accessibility. Also, they use SPSS software and SmartPLS to analyze data gathered using face-to-face questionnaires [26]. Noor et al. (2022) explore seven studies published between 2007 and 2020 to indicate the association between the sustainable public transportation and elderly [27]. They find that the use of public transportation by the elderly has decreased in recent years. They also determine that different factors such as cost, safety, distance to public transportation station, and road traffic affect the elderly mode choice [27].

This survey is designed to examine the factors affecting the use of subway systems by the elderly in the city of Tehran. Three major components of this research are listed below:

Survey design: Our goal for survey design is to collect information about socioeconomic and elderly's features.

Modeling: We wish to catch the effect of individuals' attitudes and perceptions. We assume that consideration of the importance of health conditions and mental and service satisfaction significantly affect decisions.

Application: We want to provide a model according to the characteristics of each elderly, and we will anticipate that the elderlies prefer public transport of choice, which helps us forecast demand and find ways to increase the use rate.

The main objective is to improve the system's current conditions to increase the satisfaction of the elderly by providing facilities and services for those with physical and mental problems which affect their choices. By considering information gathered from the literature review, we acknowledge that many previous researchers have conductive factors affecting mobility and evaluating accessibility to the subway system ([28]; [9]). Srichuae et al. (2016) present a binary logistic regression model to highlight the factors that can affect elder mobility in public spaces and travel modes that they use to access public areas [9].

Also, Prasertsubpakij and Nitivattananon (2012) propose a model to contribute to the balanced integration of the multi-faced concept of accessibility [28]. They choose women, the elderly and disabled as target group to explore the accessibility performance of metro using both empirical and theoretical approaches [28]. As well as, Shrestha et al. (2016) discuss different older people needs such as availability, acceptability, accessibility, and affordability [7]. They use the dimensional homogeneity and statistical k-means cluster to analyze their model [7]. Also, Sundling et al. (2014) investigate the accessibility of railway systems for the elderly with and without disabilities and use a logistic regression for analysis [3].

According to studies, most scholars use the logistics model for estimations. In comparison, we use the hybrid choice model for our analysis. This model has led to evaluating attitudes' impact on choice by incorporating structural equation models (SEM) and discrete choice models (DCM). Therefore, this model first identifies elderlies' features, then we would like to probe their impact on using the urban subway system. We obtain a logistic regression equation that will result in the elderly's probability of using or avoiding the subway system.

2. Data

2.1. Data collection

The present study was carried out in Tehran, with a population of over 8.8 million people. At the same time, 8.2 % of this portion is associated with elderlies (aged 60 and older), which is gradually increasing. Random sample Data collecting of 236 persons (above 60 years old) From April to May 2021 has been carried out with two methods: paper-based and online questionnaires. One hundred seventy-four data were collected via elderly in public places such as parks and passengers leaving subway stations in different areas of Tehran (using the paper-based questionnaire method). The City of Tehran is divided into 22 urban regions; each has its administrative center. Also, 20 of the 22 metropolitan areas are located in Tehran County's Central District, while districts 1 and 20 are located in "Shemiranat" and "Ray" counties, respectively. All information was collected from the 22 districts except for district number 20. Collecting the questionnaires with this method was a real time-consuming and challenging process to complete.

From what we experienced during surveying and gathering information from suitable aged candidates, we identified the process to be challenging. This challenging procedure is due to various reasons associated with age, lack of tolerance, and health issues (for instance, hearing and vision). During surveying, distributors were asked to assist candidates by writing down instead of filling the questionnaire independently by candidates, which caused time restrictions for distributors to complete the targeted number of questionnaires per day. Also, aged people were more likely to answer questions indirectly and usually wanted to relate to other social and economic dilemmas. Therefore, we were forced to listen and record helpful information instead of getting a direct answer, which again caused time-related issues while gathering information. On the other hand, an online questionnaire was sent to 47 friends and acquaintances who were asked to send it to their grandparents or those over 60 years old. With this method, 62 data were obtained.

2.2. Questionnaire Design

We use this study as expressed performance and survey questionnaire designed to enhance the transport system for elderly people having mental, and physical problems, also this study provides an opportunity to identify the factors associated with mobility patterns as well as priorities of elderly people. So, it is necessary to mention that this questionnaire is composing of following six sections:

Travel information: including the importance of transport system in life, travel goals, car ownership, driver's license, and train usage.

Overall accessibility: such as access flexibility and availability to train stations.

Mental satisfaction: elderly's feeling when they are commuting by subway in which we have investigated these parameters such as relaxation, attractiveness, convenience, security, bewilderment, as well as safety and superiority.

Health condition: it investigates the importance of health conditions affecting choosing subway consisting of having the ability to coordinate movements, concentration, having stress, and anxiety, multitasking abilities, physical power, lower tolerance and fatigue, chronic illnesses, and visual and hearing impairment.

Service satisfaction: this is known as the elderly's satisfaction with the present subway system, including service, facility, appearance, ride comfort, information service, scheduling, etc.

General information: gathered data of elderly socioeconomic features such as education, income, marital status, employment status, etc.

2.3. Results of Questionnaire Study

The responses regarding indicators are reported in this part. We explore some sections of the questionnaire introduced above. Meanwhile, sections including mental satisfaction, health condition, and services satisfaction due to having a large number of indicators have been discarded.

2.3.1. Travel information

Paying attention to relationships between modes, and trip purpose, as we can see from table 1, it is found that most of the trips have occurred by private car as well as by walking and subway, among other modes. Of 57.6% of trips are done for the bank and post office, 50.8% belong to grocery trips. Also, 53% of sports trips are carried out by walking. According to gathered data, 55.9% are for trips to visit friends and relatives, 34.4% for medical trips, and 30.9% are related to other shopping trips that are carried out by private car. For the subway, it can be considered that 22.9% accounts for daily community trips, 17.8% of the other shopping trips and 17.4% of social activities are carried out by the subway.

2.3.2. General information

According to table 2, it can be shown that, of all data collected from elderlies, 54.6% of people belong to men over 60. Moreover, the highest percentage of age accounts for 60-69 while the lowest rate accounts for more than 90.

Another aspect investigated in this table is the marital status of which 73.5% are related to married people, while 3.4% belong to divorced ones. Furthermore, another factor considered here is employment status, in which we see that men, in comparison with women, have the highest percentage of employment status before the retirement period. Also, some women considered as retired are those getting retirement pensions from their husbands, including widowed and unemployed ones. By comparison between men and women, we observe that men have the same level of satisfaction in terms of health as women. Another essential aspect of studying is an illness in which most people have no special problem. In other words, there are not any considerable differences between men and women in terms of disease. As we are investigating our data, it can be shown that 40.7% of elderlies' income varies between 100 and 200 million IRR , and among them, those having lower income tend to use train compared to people with higher income, it is evident that those elderlies have higher education more likely to use subway system with 47.5%.
According to the table2, there is an item called the driver's license. The conclusion can be drawn that the number of men having driver's licenses are more than the number of women. However,41.9% of elderlies have one car in their household, and about 25.4% have more than two cars, but just about 32.6 % do not have a car, which shows most of the elderly have a personal vehicle. Meanwhile, the other item in this section is the frequency of using the train in which 17.4% of them had never used the train while the others had used it in different quantities. According to this table, most elderlies prefer to walk to the train station (42.8%). By contrast, 0.4% of them tend to go by bicycle or motorcycle. Final factor considered here is depending on the mobility of others, in which it is shown that 81.8% of elderlies don't need to be supported.

Table 1: Travels mode choice information for elderly.

Travels modes / Travels purpose	Private car %	Taxi %	Bus %	Subway %	Walking %	Bicycle %	Flexible transport %	N/A %
Grocery shopping	28.8	0.8	5.9	3.4	50.8	0.8	0.4	8.9
Other shopping	30.9	8.9	10.6	17.8	21.2	0	1.3	9.3
Bank/post office	12.7	2.5	8.1	5.9	57.6	0.4	0.8	11.9
Medical appointments	34.4	14.4	9.3	14	6.4	0.8	13.6	7.2
Visiting friends or relatives	55.9	7.6	5.5	12.3	4.2	0.4	11	3
Eating out	46.6	4.7	4.2	3	13.6	0.4	1.3	26.3
Social activities	16.9	4.7	8.1	17.4	18.2	0.8	2.5	31.4
Leisure trips	51.3	1.7	6.8	16.1	5.5	1.3	3	14.4
Sport	10.6	1.7	4.2	6.4	53	3.4	0	20.8
Daily commuting	16.5	5.9	8.1	22.9	14	1.3	2.5	28.8
Pilgrimages	12.7	3.4	4.2	6.8	28	1.3	0.8	42.4
All trips	28.9	5.1	6.8	11.4	24.8	1	3.4	18.6

Table 2: Sample descriptive statistics.

User's characteristics	Percentage		Percentage		Percentage
gender		**Health dissatisfaction**		**Mode accessibility to train station**	
male	56.4	Very good	14.4	walking	42.8
female	43.6	Good	39	bus	17.8
total	100	normal	34.3	taxi	14.4
age		Not good	12.3	car(passenger)	6
Between 60-69	58.1	total	100	Private car	7.2
Between 70-79	30.9	**illness**		bicycle	0.4
Between 80-89	10.2	Yes	32.6	motorcycle	0.4
More than 90	.8	No	67.4	NA	11
total	100	total	100	total	100
		Number of cars in household		**income**	
Marital status		None	32.6	Less than 10 million IRR	16.5
Married	72.5	One	41.9	Between 10 and 20 million IRR	40.7
Single	6.8	two	18.2	Between 20 and 50 million IRR	22.9
widowed	17.4	three	5.1	More than 50 million IRR	6.8
divorced	3.4	More than three	2.1	NA	13.1
total	100	total	100	Total	100
Employment status		**Having a driver's license**		**Education**	
Retired	61	yes	70.3	Primary education	22.5
Unemployed	21.2	no	29.7	Secondary education	27.5
Full-time employed	9.3	total	100	Higher education	47.5
Part-time employed	3.4	**Frequency of using train**		NA	2.5
volunteer	4.2	Every day	11.9	total	100
NA	0.8	1-3 trips / week	30.1	**Depending on others for mobility**	
total	100	1-3 trips/month	23.7	yes	18.2
		Less than 1 trips/month	16.9	No	81.8
		never	17.4	total	100
		Total	100		

3. Theoretical Background

3.1. Hybrid choice model framework

The hybrid choice model (HCM) is a new descendant of discrete-choice models on integrating discrete-choice and latent-variables models. This model has been proposed to consider measurable and latent variables such as people's perceptions and attitudes (such as a sense of satisfaction) in the context of identifying the choice model. HCM clarifies better decision-making behavior and incorporates socioeconomic characteristics with psychological characteristics ([29]; [30]).

The method has been developed sequential and simultaneous for estimating models with both observed and latent variables. In order sequence, the latent variables are constructed before entering the discrete choice models and then entered into discrete-choice modeling as an observed variable (measurable). But, simultaneously, both processes are done in one step. Although it is assumed that the simultaneous method provides more precise estimates, the sequential method has been tried so far due to the greater complexity and lack of basic software for its calculations. Typically, discrete choice models use observed variables, such as the characteristics of selective options (travel time and travel costs) and socio-economic variables (age and gender) as the main variables of travel choice models [31]. This approach has been criticized by behavioral scientists for ignoring the psychological aspects of individuals (latent variables), because these variables can affect the people choice [32].

Hybrid choice models are composed of the two following models. The latent variable model consists of measurement models that determine the relationship between the indicators (indicators are usually questions used to measure latent or qualitative variables) and the latent variables and structural models that can describe latent variables using personal data or predict and explain them as regression equations. The second model is the nucleus of discrete models, which is based on the utility function of each option, the probability of choosing this option is estimated [29].

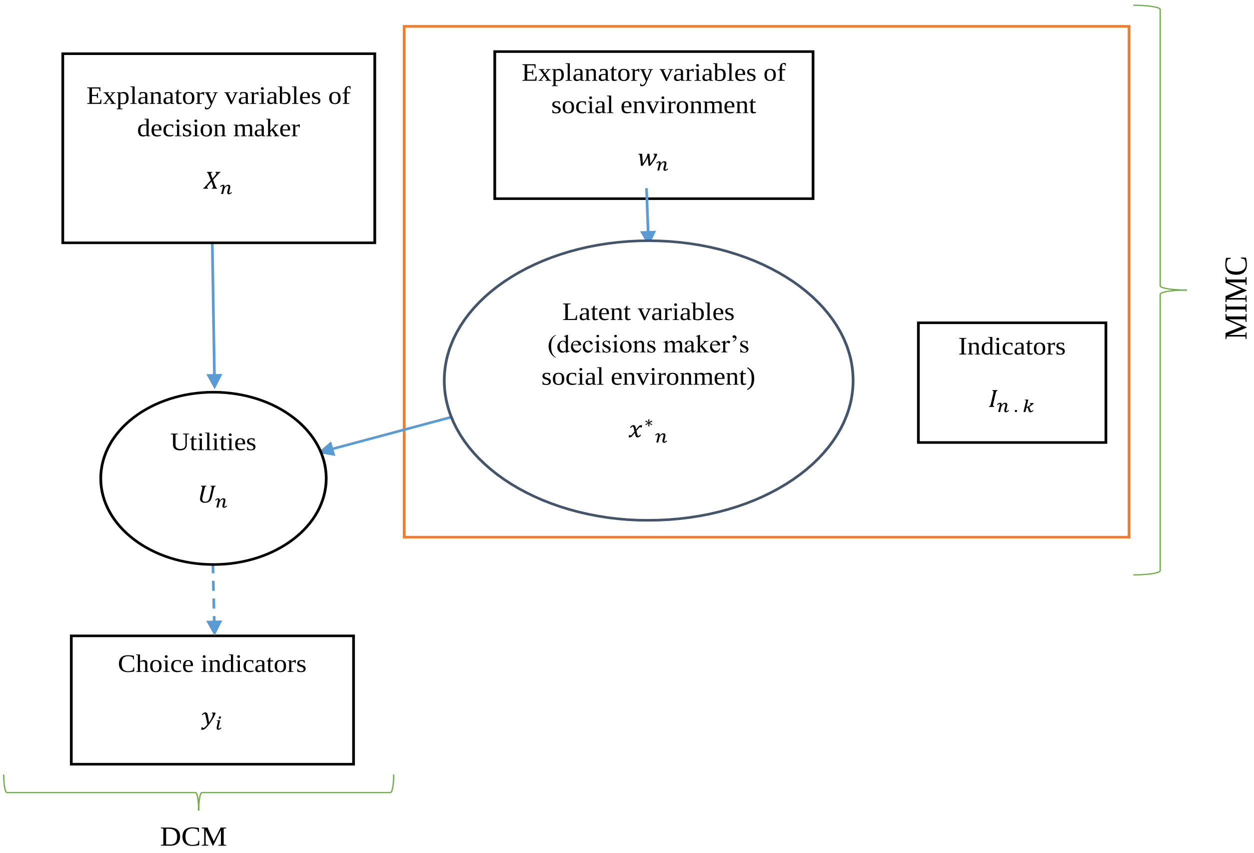


Fig. 1: Modeling framework.

Figure 1 shows the framework of modeling process. The measurement equations are as follows:

$$I = \alpha + \lambda Z^* + \upsilon \quad (1)$$

$$y_n = \begin{cases} 1 & \text{if individual n selects subway} \\ 0 & \text{otherwise} \end{cases} \quad (2)$$

Latent variables are indicated by I in Equation. (1). The association between responses is shown by a vector of parameters α. Also, λ and υ are the vector of unknown parameters (for relating the latent variables to indicators) and the vector of independent error terms, respectively. Equation (2) is consist of term y_n that is a binary choice indicator and it is one if the railway system mode is chosen and zero otherwise. The structural equation and utility function are as follows:

$$Z^* = X_1 b + \omega \;, \omega \sim N(0, \textstyle\sum \omega), \quad (3)$$

$$U = X_2 \beta + \varepsilon \;, \varepsilon \sim \text{iid EV1}(0,1), \quad (4)$$

where Z^*, X_1 and X_2 are the latent variables vector, explanatory variables, and attributes matrices of alternatives and explanatory variables, respectively. Also, the effect of observable variables on latent variables should be described and *b* is used to show that effect as a matrix of unknown parameters. Random disturbance terms and their variance are entered into the Equation (3) using ω and $\sum \omega$, respectively. Equation (4) is consist of some variables and parameters. *U* and β are utilities and an unknown parameters vector for describing the alternatives and explanatory variables effect on utility and vector of an unknown parameter associated with latent variables present in the utility function, respectively. The random disturbance terms vector is represented by ε.

The likelihood function that is used to indicate the common probability of the choice model with the latent variable and its indicators is formulated as:

$$P(y_{in}, I|X_1.X_2.\delta) = \int P(y_{in}|C_s.X_2.\beta) f_I(I|Z^*.\lambda) f_{Z^*}(Z^*|X_1.b) dZ^*. \quad (5)$$

The choice model, latent variables measurement, and latent variables structural equations are embedded into Equation (5). Also, all coefficients are determined by a set δ.

4. Model result

This section presents the specification and estimation results of the hybrid choice model designed to identify the factors that affect the elderly in choosing the subway system. For this reason, we assume that the information decision-makers receive from the travel environment shows the effects of the individual's satisfaction with the system and affects these decision-making attitudes and ideas. We assume that physical problems, mental happiness, and service satisfaction affect their choice of the subway system. We aim to acquire an effective model to predict the use or avoidance of Tehran's subway system by elderlies.

4.1. Preliminary analysis

Factor analysis is applied to reveal the latent structure (dimensions) of a group variable, which diminishes attribute space from a more significant number of variables to a smaller number of factors [33]. Factor analysis can either be exploratory or confirmative. Exploratory factor analysis (EFA) is the most proper when the number of factors and their mutual associations are not revealed. While Confirmatory factor analysis can be allocated to test if measured (indicator) variables load as predicted about the expected number of factors [34]. An exploratory factor analysis is conducted in this research. In the first analysis, attributes are having a measurement system analysis (MSA) value less than 0,4 (MSA < 0,4), including access to local stations, sanitation of trains and stations, the physical condition of the train (AC, fan, seat and toilet condition, and audio systems), preferring not to use the train in peak hours, and these attributes cannot be figured out and must be excluded from the analysis. After the variable has been excluded, the next step is doing factor analysis without these variables. Also, a principal component analysis with "varimax" rotation are carried out. Eventually, with this analysis, we receive seven factors. These factors are our latent variables. We name them as follows: the importance of physical problems (IOPP), importance of internal side problems (INSP), mental satisfaction (MNTS), facilities and services coverage satisfaction (FSCS), lack of facility (LACF), ticket office services satisfaction (TICS) and staff services satisfaction (STAFS).

4.2. *Hybrid choice model*

As presented in the previous section, we choose the HCM framework that is consist of two main components, namely, a MIMIC model and a logistic regression model. We use the HCM framework to describe how our latent variables can affect subway choice for daily activity [29]. In this section, we first calculate latent variables through the MIMIC model. After calculation, we use latent variables to obtain the logistics regression model [31].

4.2.1. A latent variable model (LVM)

This model incorporates determining elderlies' attitudes by socioeconomic characteristics. Accurately, these latent variables are inclusive of the importance of physical problems (IOPP), mental satisfaction (MNTS), facilities and services coverage satisfaction (FSCS), lack of facility (LACF), and staff services satisfaction (STAFS). The importance of inner side problems (INSP) and ticket office services satisfaction (TICS) are not included in the HCM because in the resultant model, they are not statistically significant, and we exclude them from the model.

According to the model results, due to the existence of five latent variables, and to avoid repeating the contents, tables 3 to 12 are embedded into the paper to present the description and analysis of the variables. The characteristics of the structural equation are given by two first columns of tables related to structural equations (Equation 3), and the third column describes each explanatory variable. The estimated parameters in the structural equations are written in the "Estimate" column, and the t-test presented in the tables shows a meaningful level. It should be noted that if the value of the t-test is between 1.96 and -1.96, the hypothesis is rejected (at a significant level of 95%). If this value is more significant than 1.96 or less than -1.96, the assumption is confirmed at a considerable level of 95%. When this value is more than 2.56 or less than -2.56, it can be said that the hypothesis is confirmed with a higher probability of 99%. As a result, the factor analysis measures the latent variables by Equation (1)

- Importance of physical problems (IOPP)

Table 3: Specification table and estimation results of IOPP.

coefficient	Explanatory variable	Variable description	Estimate	t-test	P-value
$b_{emp-full\ time}$	$X_{emp-full\ time}$	1 if participant have full-time job, 0 otherwise	0.393	3.396	0.001
b_{dep}	X_{dep}	1 if participant Depends on others for mobility, 0 otherwise;	0.299	2.322	0.020
b_{car}	X_{car}	1 if they have car, 0 otherwise;	0.323	3.004	0.030
$b_{D.License}$	$X_{D.License}$	1 if they have driver's license, 0 otherwise;	- 0.416	—3.691	0.000
ω_{IOPP}		random disturbance terms N (0,1)	0.533	4.862	0.000

indicators of latent variables IOPP include:

$I_{1.1}$: Loss of ability to coordinate movements

$I_{1.2}$: Physical power loss

$I_{1.3}$: Increasing fatigue and lower endurance

$I_{1.4}$: Chronic illnesses/ inner organs function is reduced

Table 4: Parameters estimation of measurement equation of IOPP.

indicators	λ_{IOPP}	t-test	α_{IOPP}	t-test	υ_{IOPP}	t-test
$I_{1.1}$	1	-	3.435	25.232	1.620	13.968
$I_{1.2}$	1.2	7.815	3.282	22.023	1.130	8.198
$I_{1.3}$	1.590	8.898	2.913	16.283	0.579	5.591
$I_{1.4}$	1.110	7.666	3.551	24.887	1.313	10.475

- Mental satisfactions (MENTS)

Table 5: Specification table and estimation results of MENTS.

coefficient	Explanatory variable	Variable description	Estimate	t-test	P-value
$b_{MarST-single}$	$X_{MarST-single}$	1 if participant is single, 0 otherwise	-0.415	-2.237	0.025
$b_{MarST-widowed}$	$X_{MarST-widowed}$	1 if participant is widowed, 0 otherwise	-0.290	-2.435	0.015
$b_{illness}$	$X_{illness}$	1 if participant is ill, 0 otherwise	-0.396	-3.842	0.000
b_{Dep}	X_{Dep}	1 if participant Depends on others for mobility, 0 otherwise	-0.365	-3.086	0.002
ω_{MENTS}		random disturbance terms N (0,1)	0.640	6.693	0.000

Indicators of latent variables MENTS include:

$I_{2.1}$: I feel relaxed when travelling by train

$I_{2.2}$: I enjoy travelling by train

$I_{2.3}$: It's convenient for me to travel by train

$I_{2.4}$: I feel quite safe when I am travelling by train

$I_{2.5}$: I never feel confused when I am in a railway station

$I_{2.6}$: I trust the train as a safe means of transport

$I_{2.7}$: I prefer to use the train rather than the bus

$I_{2.8}$: I think rail travel is easy for disabled peopl

Table 6: Parameters estimation of measurement equation of MENTS.

indicators	λ_{MENTS}	t-test	α_{MENTS}	t-test	υ_{MENTS}	t-test
$I_{2.1}$	1	-	3.503	43.101	0.846	11.197
$I_{2.2}$	1.003	17.484	3.394	41.802	0.815	12.571
$I_{2.3}$	1.103	13.264	3.543	41.277	0.753	12.233
$I_{2.4}$	1.099	13.250	3.622	46.318	0.589	14.003
$I_{2.5}$	0.879	10.420	3.777	51.682	0.739	10.957
$I_{2.6}$	1.139	12.526	3.887	53.191	0.368	8.237
$I_{2.7}$	0.906	10.047	3.881	51.465	0.845	11.356
$I_{2.8}$	0.653	8.851	2.345	27.973	1.116	15.072

- Facility and services coverage satisfaction (FSCS)

Table 7: Specification table and estimation results of FSCS.

coefficient	Explanatory variable	Variable description	Estimate	t-test	P-value
$b_{L-family}$	$X_{L-family}$	1 if participant is living with their family, 0 otherwise	0.137	2.659	0.008
b_{Dep}	X_{Dep}	1 if participant Depends on others for mobility, 0 otherwise	-0.261	-3.572	0.000
b_{car}	X_{car}	1 if participant have a car, 0 otherwise	-0.133	-3.146	0.002
ω_{FSCS}		random disturbance terms N (0,1)	0.189	3.646	0.000

Indicators of latent variables FSCS include:

$\mathbf{I_{3.1}}$: Connections between the subway system and other public transport systems

$\mathbf{I_{3.2}}$: Punctuality of trains

$\mathbf{I_{3.3}}$: Connections between train services

$\mathbf{I_{3.4}}$: Seat availability

$\mathbf{I_{3.5}}$: Safety & security equipment in the train or station

$\mathbf{I_{3.6}}$: The gap between the train and the platform edge

$\mathbf{I_{3.7}}$: Train frequency

$\mathbf{I_{3.8}}$: The time available to get on/off the train

$\mathbf{I_{3.9}}$: Availability of trains

$\mathbf{I_{3.10}}$: Operating hours

$\mathbf{I_{3.11}}$: Complaint handling

$\mathbf{I_{3.12}}$: Provision of information about train schedules/platforms

$\mathbf{I_{3.13}}$: Safety information for passengers on board and in the station

Table 8: Parameters estimation of measurement equation of FSCS.

indicators	λ_{FSCS}	t-test	α_{FSCS}	t-test	υ_{FSCS}	t-test
$I_{3.1}$	1	-	3.540	49.417	0.720	13.356
$I_{3.2}$	1.462	7.152	3.864	47.147	0.449	13.466
$I_{3.3}$	1.149	6.301	2.565	29.568	1.109	15.702
$I_{3.4}$	1.146	6.585	3.692	49.777	0.622	9.687
$I_{3.5}$	1.699	7.774	3.660	43.142	0.378	8.624
$I_{3.6}$	1.730	7.324	3.667	40.596	0.431	8.711
$I_{3.7}$	1.683	7.108	3.790	44.372	0.341	6.085
$I_{3.8}$	1.832	8.008	3.764	39.912	0.334	9.898
$I_{3.9}$	1.341	7.562	3.709	48.462	0.441	10.331
$I_{3.10}$	1.667	7.642	3.860	45.942	0.304	10.735
$I_{3.11}$	1.197	6.898	3.112	43.466	0.431	14.378
$I_{3.12}$	1.465	6.842	3.402	37.600	0.868	11.600
$I_{3.13}$	1.457	6.996	3.431	38.544	0.784	14.638

- Staff services satisfaction (STAFS)

Table 9: Specification table and estimation results of STAFS.

coefficient	Explanatory variable	Variable description	Estimate	t-test	P-value
$b_{L-family}$	$X_{L-family}$	1 if participant is living with their family, 0 otherwise	0.215	2.664	0.008
$b_{MarST-single}$	$X_{MarST-single}$	1 if participant is single, 0 otherwise	-0.325	-2.138	0.032
ω_{STAFS}		random disturbance terms N (0,1)	0.706	9.312	0.000

indicators of latent variables STAFS include:

$I_{4.1}$: Appearance of staff

$I_{4.2}$: Staff availability to help passengers

$I_{4.3}$: Staff behavior

Table 10: Parameters estimation of measurement equation of STAFS.

indicators	λ_{STAFS}	t-test	α_{STAFS}	t-test	υ_{STAFS}	t-test
$I_{4.1}$	1	-	3.642	54.167	0.111	4.669
$I_{4.2}$	1.119	28.520	3.588	48.745	0.139	3.891
$I_{4.3}$	0.790	12.815	3.124	42.572	0.797	11.178

- Lack of facility satisfaction (LACFS)

Table 11: Specification table and estimation results of LACFS.

coefficient	Explanatory variable	Variable description	Estimate	t-test	P-value
$b_{age>80}$	$X_{age>60}$	1 for age more than 80, 0 otherwise	0.260	3.055	0.002
$b_{MarST-widowed}$	$X_{MarST-widowed}$	1 if participant is widowed, 0 otherwise	-0.165	-2.386	-0.017
$b_{emp-full\ time}$	$X_{emp-full\ time}$	1 if participant have full-time job, 0 otherwise	0.254	2.699	0.007
$b_{emp-Voluntary}$	$X_{emp-Voluntary}$	1 if participant have Voluntary job, 0 otherwise	0.404	2.155	0.031
$b_{income>5}$	$X_{income>5}$	1 if participant have income more than 50 million rials, 0 otherwise	-0.295	-2.918	0.004
ω_{LFAC}		random disturbance terms N (0,1)	0.222	4.178	0.000

Indicators of latent variables LFACS include:

$I_{5.1}$: Availability of parking facilities

$I_{5.2}$: Facilities for disabled in stations (toilet, special seat, wheelchair space)

$I_{5.3}$: Facilities for disabled on board (toilet, special seat, wheelchair space)

Table 12: Parameters estimation of measurement equations of LACFS.

indicators	λ_{LFAC}	t-test	α_{LFAC}	t-test	υ_{LFAC}	t-test

$I_{5.1}$	1	-	2.243	30.995	0.943	15.654
$I_{5.2}$	1.556	7.555	1.732	24.733	0.450	6.034
$I_{5.3}$	1.970	7.290	1.741	22.010	0.281	2.859

Structural equations demonstrate that those elderly dependent on others for mobility will increase the importance of IOPP. We can find that the significance of this latent variable is greater for elderlies with a full-time job. Also, we find that those elderlies whose husbands have passed away and are widowed and those who are single or have illness and dependence on others for movement, in terms of the mental impact, will have a negative influence on MENTS. However, explanatory variables including car ownership and depending on others for mobility negatively impact FSCS but living with the family will increase service satisfaction. Meanwhile, single seniors have a negative impact on staff services. On the other hand, those living with their family positively impact it (STAFS). Also, the latent variable, lack of facility, can be seen in tables. Older elderly (age above >80) and the elderly who are employed, whether in a full-time or voluntary job, will increase dissatisfaction with this variable. On the other hand, the elderly with an income of more than 50 million rials have a more significant impact on reducing this variable, as well as widowed ones (LFAC).
The measurement model is a relationship between exogenous and endogen variables. According to the model's results, with increasing the MENTS, these indicators can be much more affected, such as safety, security, convenience, and enjoying traveling. However, the attributes of lower endurance and loss of physical power are more affected by IOPP, also in FSCS. The time available to get on/off the train, the gaps between the train and the platform edge, safety and security equipment, operating hours, and train frequency have higher coefficients than other indicators. They increase the amount of STAFS and cause more staff available to help passengers because it has a more significant coefficient. Also, improving the lack of facilities will increase elderlies' satisfaction with attributes such as facilities for the disabled in stations and onboard (toilet, special seat, wheelchair space).
According to the covariance matrix, table 13, the relationships between latent variables are significant. Most have a positive and negative coefficient, near zero, but the relationship between SFCS and LFAC, MENTS, and LFAC has not been significant (P-value> 0.05). The correlation coefficient varies between -1 and +1. If two variables have a complete correlation, the correlation coefficient is expressed by +1 or -1 concerning positive or negative impact, respectively. If one variable increases (decreases) the other variable, the effect is positive (negative). If we see no correlation between two variables, the correlation coefficient is expressed by zero.
To negotiate the model fit of confirmatory factor analysis, as shown in table14, we first notice the criteria of the several model fit indices. If RMSEA values are good, acceptable, marginal, and poor, their values are less than 0.05, between 0.05 and 0.08, between 0.08 and 0.1, and greater than 0.1, respectively. Our sample's RMSEA value is 0.048. Therefore, it indicates a good fit. Also, this sample's GFI and AGFI values are 0.943 and 0.927. We recall that GFI and AGFI are determined concerning the sample size. The comparative fit index value is 0.903. The results show that GFI, AGFI, and CFI are greater than 0.9. Consequently, they show a good fit. which shows a good fit. Also, the amount of chi-square to the degree of freedom is less than 3, which means that observed and expected values are close, and the model is a good fit.

4.2.2. *Logistics regressions*

This model has been proposed to consider measurable and latent variables such as people's perceptions and attitudes. A regression model is a model for a binary dependent variable such as disease or health, use or non-use, win or lose. Where it can take only two values, "0" and "1," which means a random event in two possible situations, the total probability of each one will eventually be one. Logistic regression is the Sub-branch of a discrete choice model. Because the logistic regression model integrates five latent variables, including IOPP, MENTS, FSCS, LACFS, and STAFS, simultaneous estimation of the various components of HCM is a computational calculation. Hence, we carry out the estimation using a continuous procedure.
The choice utility can be defined as a attributes function of the alternatives and the latent variables (Equation 4). The specified utility consists of experimental characteristics such as age, gender, education, illness, mode accessibility, health satisfaction, car ownership, and the effect of the latent variables. We define the utility of the subway system as:

$$U_{subway} = X_{age}\beta_{age} + X_{gender}\beta_{gender} + X_{education}\beta_{education} + X_{illness}\beta_{illness} + X_{Hsatis}\beta_{Hsatis} + X_{ModAC}\beta_{ModAC} + X_{Carown}\beta_{Carown} + C_{FSCS}x^{*}_{FSCS} + C_{Lfac}x^{*}_{Lfac} + C_{STAFS}x^{*}_{STAFS} + C_{MNTS}x^{*}_{MNTS} + C_{PHYP}x^{*}_{PHYP} + \upsilon_{subway}, \quad (6)$$

where X_{age} is 4, 3, 2, 1, and zero if the participant's age is more than 90, between 80 and 89, between 70-79, between 60-69, and otherwise, respectively. X_{gender} is one if the participant is female and zero otherwise. $X_{education}$ can take four different values depending on the level of education (higher education is equivalent to 3, secondary education is equivalent to 2, primary education is equivalent to 1, and those less than primary are equivalent to 0). $X_{illness}$ is one if the participant is ill and zero otherwise. Depending on the participant's health satisfaction (not good, normal, good, and very good), X_{Hsatis} varies from 4 to zero. An aged person can access the subway station by walk, bus, taxi, car as passenger, car as driver, motorcycle, bicycle, and other modes. With respect to the mode accessibility to the subway station, the range of X_{ModAC} is from seven (is the participant accesses the station by walk) to zero (if the participant does not access the station using the mention modes). If the participant has a car, X_{Carown} is one. If the participant does not have a car, X_{Carown} is zero. The measurement and structural equation were shown in the previous section, and Figure 2 presents the modeling framework of the case study. Regarding the model outputs of binary logistic regression, according to the table15 shows the significance of factors in the model. To calculate the higher choice model, including the combination of SEM and discrete choice model, we have used R software to calculate latent variables with the MIMIC model and binary logistic regression. The parameters influencing elderlies in using the subway were mentioned before. Overall, all estimated parameters are suitable because their amount is less than the determined quantity (0.05); it can be concluded that there is a contradictory relationship between age increasing and using the subway system, and among all parameters having a negative effect, lack of facility (LFAC), as well as women, illness, the importance of physical problems and staff services satisfactions have the highest negative impact on using of the subway.

Table 13: Covariance matrix.

variables	Covariance	t-test	p-value
IOPP~MENTS	-0.131	-2.603	0.009
IOPP ~FSCS	-0.057	2.320	0.020
IOPP ~STAFS	-0.079	-1.760	0.078
MENTS~FSCS	-0.198	-5.322	0.000
MENTS~LFAC	0.035	1.433	0.149
MENTS~STAFS	0.365	6.357	0.000
SFCS~LFAC	0.018	1.259	0.0208
SFCS~STAFS	0.216	4.759	0.000
LFAC~STAFS	0.052	2.157	0.031

Table 14: Fit Indexes.

Index	The measured values in the model	Allowed amount
Chi-square (x^2/ df)	1.49	Less than 3
Root mean square error of approximation (RMSEA)	0.048	Less than 0.08
Goodness-of-fit index (GFI)	0.943	More than 0.9
Adjusted GFI (AGFI)	0.927	More than 0.9
Comparative fit index (CFI)	0.903	More than 0.9

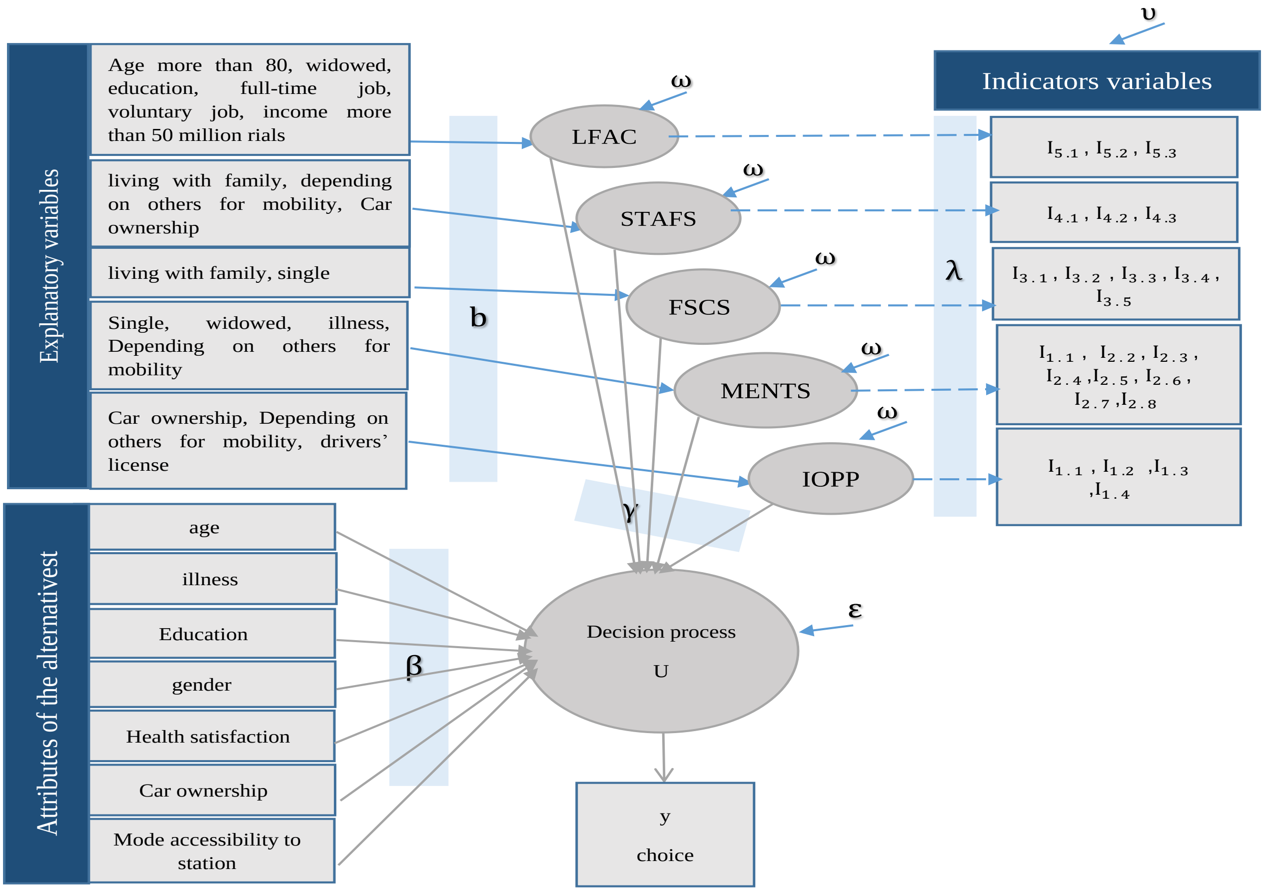


Fig. 2: Modeling framework for elderly subway choice.

Table 15: logistics regression results, bellow 0.05 is significant.

parameters	**Estimate**	**t-test**	**p Value**
age	-3.044	-2.508	0.012
gender	-5.009	-2.009	0.044
education	1.381	1.876	0.061
illness	-4.803	-2.197	0.028
Health satisfaction	-1.374	-1.864	0.062
Mode accessibility to station	1.370	2.747	0.006
Car ownership	-1.838	-2.142	0.032
MNTS	7.974	2.557	0.011
FSCS	7.579	2.447	0.014
LFAC	-6.752	-2.590	0.010
STAFS	-3.417	-2.069	0.038
IOPP	-3.985	-2.388	0.017
intercept	15.933	2.314	0.021
Log-Likelihood	-18.85		
McFadden R^2	0.82702		
Likelihood ratio test chisq	180.25		
p.value = <	2.22e-16		

By increasing facilities and services allocated specially for disabled people as well as ill ones, it causes improved circumstances for people suffering from physical problems and illness. While other common subway services and facilities, education, mental satisfaction, easier and faster mode accessibility to the station, evoke that people can use the subway system more and more, and these services satisfaction consists of general welfare facilities such as safety operating hours, train frequency and so on.

5. Discussion and Conclusion

Our study investigates the impact of the elderly's features on selecting a subway system. We use SP data gathered from older people in the parks and passengers leaving the subway station in different districts of Tehran during April-May 2021. According to the collected data, it is found that 16% of seniors never use the subway system. Moreover, the finding of this research suggests that the respondent's health condition, as well as some kinds of functional limitations or disease, create barriers during their trips. Meanwhile, most participants expressed that health parameters, including loss of physical power, lower endurance, and increasing fatigue, have much more impact than other barriers on choosing the subway for their daily activity. Also, the physical decline will reduce outdoor mobility ([3]; [16]). On the other hand, the lack of sufficient seats and facilities for the disabled reduces usage because many elderly people have a deficient ability to function due to physical problems and illnesses. Because of the long distance to stations, it is tough for them to walk and take long journeys. Another problem is that entrances to the stations do not have an escalator, and some people cannot use the station because of physical problems or wheelchairs. In other words, using the subway for the elderly who use the wheelchair is very difficult because there is no provision for them unless they have companions to help them.

Also, age, gender, income, and education are closely related to elderlies' choices. With aging, the subway is less frequently used, and women are more likely to travel as car passengers and depend on others for their mobility, but older men tend to travel by car as a driver. That is to say, older people living alone tend to travel more as car drivers and less as car passengers, and lower-income people tend to travel more by subway. In addition, educated people with good health conditions tend to use the subway ([13]; [21]; [17]). Meanwhile, several studies have demonstrated that the more they have a car and driver's license availability, the less they use public transportation [12]. Also, we conclude that there is a significant negative effect between willingness to choose the subway system with a driver's license and car ownership. As we showed in table 1, 28.9% of all trips were carried out by car, While 11.6% by subway.

By examining the mental satisfaction of individuals, we find that the elderly in Iran have a high degree of mental satisfaction with this system, such as relaxation, attractiveness, and convenience. Also, the elderly who do not work or are retired have more willing to use the subway during off-peak hours to carry out their activities. Because they are more comfortable, feel relaxed, and have an excellent experience of using it again, but those who are compelled to travel during peak hours prefer to use other modes of transportation instead of the subway system, and the reasons behind this fact are being reluctant to use because of congestion and poor culture. On the other hand, some are afraid of being in tight spaces (claustrophobia) and underground. Consequently, they prefer the subway to be on the ground. In addition, according to studies, those with access to a travel environment are more inclined to travel more often, and those traveling more can overcome and be dominant over travel barriers such as ticket machines and scarce information [3]. So, we can obtain the same result by learning more about the environment and overcoming their fears, which leads to increased mental satisfaction.

The other aspect that we understand is elderlies' satisfaction of service, in which most people have been satisfied with the current conditions of this system, such as safety, security, availability, punctuality of trains, and operating hours. But the factors that cause dissatisfaction is lack of facilities for disabled people, not having parking facility, as well as common existing problems in ticket and staff services. In Iran, travel by subway is free for the elderly over 60, and they can make all of the trips free of charge. This issue can be achieved by requesting the cards called the senior card. So, elderlies in Iran are satisfied with the price of their trips by subway. Thus, this paper aims to facilitate the development of a subway system that would meet the specific demand of feeble travelers (and would-be travelers often ignored).

Moreover, this exploratory research has improved our knowledge of elderly persons' characteristics needed to use the subway system. Regarding the limitation of the study, the sample may not be representative of the resident of Tehran as we could not access older adults who have severe physical problems and rarely leave their homes. Therefore, the results of this study might not be generalizable to the behavior of residents in Tehran. Moreover, the SEM fit criteria within HCM must be calculated and reported, which is required for further research. Therefore, future research can investigate what changes to the system may help these potentially poor health travelers overcome essential obstacles or what strategies can increase mental satisfaction to make travel more attractive. Also, future studies can investigate the effects of psychiatric features on people, such as depression, mental impairment, and anxiety, because nobody has considered these parameters yet. Future research can consider more diseases, including cardiovascular disease, diabetes, and cancer, as only functional and physical problems were entered into the model in this research.

Conflicts of interest

The authors declare that there is no conflict of interest.

References

[1] Nations, U. (2015). World Population Ageing. Report. World Population Ageing.

[2] Oizumi, K., Kajiwara, H., & Aratame, N. (2006). Facing up to the problem of population aging in developing countries: new perspectives for assistance and cooperation. Report. Tokyo: Institute for International Cooperation, Japan International Cooperation Agency (JICA).

[3] Sundling, C., Berglund, B., Nilsson, M. E., Emardson, R., & Pendrill, L. R. (2014). Overall accessibility to traveling by rail for the elderly with and without functional limitations: The whole-trip perspective. International journal of environmental research and public health, 11(12), 12938-12968.

[4] Cheshmberah, A., Hoseini, M., Shojaee Zadeh, D., & Moghimi-Dehkordi, B. (2014). Determinants of physical health of older people in Iran. International Scholarly Research Notices, 2014.

[5] Yong, V., Saito, Y., & Chan, A. (2010). Changes in the prevalence of mobility limitations and mobile life expectancy of older adults in Singapore, 1995-2005. Journal of aging and health, 22(1), 120-140.

[6] Satariano, W. A., Guralnik, J. M., Jackson, R. J., Marottoli, R. A., Phelan, E. A., & Prohaska, T. R. (2012). Mobility and aging: new directions for public health action. American journal of public health, 102(8), 1508-1515.

[7] Shrestha, B. P., Millonig, A., Hounsell, N. B., & McDonald, M. (2017). Review of public transport needs of older people in European context. Journal of population ageing, 10, 343-361.

[8] Metz, D. (2003). Transport policy for an ageing population. Transport reviews, 23(4), 375-386.

[9] Srichuae, S., Nitivattananon, V., & Perera, R. (2016). Aging society in Bangkok and the factors affecting mobility of elderly in urban public spaces and transportation facilities. Iatss Research, 40(1), 26-34.

[10] Gabriel, Z., & Bowling, A. N. N. (2004). Quality of life from the perspectives of older people. Ageing & Society, 24(5), 675-691.

[11] Páez, A., Scott, D., Potoglou, D., Kanaroglou, P., & Newbold, K. B. (2007). Elderly mobility: demographic and spatial analysis of trip making in the Hamilton CMA, Canada. Urban Studies, 44(1), 123-146.

[12] Rosenbloom, S. (2004). Mobility of the Elderly. Transportation in an Aging Soceity, 3-21.

[13] Spinney, J. E., Scott, D. M., & Newbold, K. B. (2009). Transport mobility benefits and quality of life: A time-use perspective of elderly Canadians. Transport policy, 16(1), 1-11.

[14] Kim, S. (2011). Assessing mobility in an aging society: Personal and built environment factors associated with older people's subjective transportation deficiency in the US. Transportation research part F: traffic psychology and behaviour, 14(5), 422-429.

[15] Mercado, R., Páez, A., & Newbold, K. B. (2010). Transport policy and the provision of mobility options in an aging society: a case study of Ontario, Canada. Journal of Transport Geography, 18(5), 649-661.

[16] Wretstrand, A., Svensson, H., Fristedt, S., & Falkmer, T. (2009). Older people and local public transit: Mobility effects of accessibility improvements in Sweden. Journal of Transport and Land Use, 2(2), 49-65.

[17] Truong, L. T., & Somenahalli, S. (2011, September). Exploring mobility of older people: a case study of Adelaide. In Proceedings of the Australasian Transport Research Forum, Adelaide, Australia.

[18] Gagliardi, C., Spazzafumo, L., Marcellini, F., Mollenkopf, H., Ruoppila, I., Tacken, M., & Szemann, Z. (2007). The outdoor mobility and leisure activities of older people in five European countries. Ageing & Society, 27(5), 683-700.

[19] Hakamies-Blomqvist, L. (2004). Safety of older persons in traffic. Transportation in an aging society: A decade of experience. Technical Papers and Reports from a Conference. Transportation Research Board, 22-35.

[20] Choo, S., & Mokhtarian, P. L. (2004). What type of vehicle do people drive? The role of attitude and lifestyle in influencing vehicle type choice. Transportation Research Part A: Policy and Practice, 38(3), 201-222.

[21] Kim, S., & Ulfarsson, G. F. (2004). Travel mode choice of the elderly: effects of personal, household, neighborhood, and trip characteristics. Transportation Research Record, 1894(1), 117-126.

[22] Yuan, Y., Yang, M., Wu, J., Rasouli, S., & Lei, D. (2019). Assessing bus transit service from the perspective of elderly passengers in Harbin, China. International Journal of Sustainable Transportation, 13(10), 761-776.

[23] Shao, F., Sui, Y., Yu, X., & Sun, R. (2019). Spatio-temporal travel patterns of elderly people–A comparative study based on buses usage in Qingdao, China. Journal of Transport Geography, 76, 178-190.

[24] Fatima, K., & Moridpour, S. (2019). Measuring public transport accessibility for elderly. In MATEC Web of Conferences (Vol. 259, p. 03006). EDP Sciences.

[25] Du, M., Cheng, L., Li, X., & Yang, J. (2020). Factors affecting the travel mode choice of the urban elderly in healthcare activity: comparison between core area and suburban area. Sustainable cities and society, 52, 101868.

[26] Al-Rashid, M. A., Shamsul Harumain, Y. A., Goh, H. C., & Ahmad, Z. (2021). Psychosocial factors of public transport users and social inclusion implications among older women in Pakistan. Journal of Urban Planning and Development, 147(4), 04021046.

[27] Noor, N. F. M., Kadir Shahar, H., Hamid, T. A., Zainalaludin, Z., Ahmad, S. A., Rokhani, F. Z., ... & Akahbar, S. A. N. (2022). Understanding Travel Behavior and Sustainability of Current Transportation System for Older Adults in Malaysia: A Scoping Review. Sustainability, 14(21), 14140.

[28] Prasertsubpakij, D., & Nitivattananon, V. (2012). Evaluating accessibility to Bangkok Metro Systems using multi-dimensional criteria across user groups. IATSS research, 36(1), 56-65.

[29] Ben-Akiva, M., McFadden, D., Train, K., Walker, J., Bhat, C., Bierlaire, M., ... & Munizaga, M. A. (2002). Hybrid choice models: Progress and challenges. Marketing Letters, 13(3), 163-175.

[30] McFadden, D. (1986). The Choice Theory Approach to Market Research. Marketing Science, 5(4), 275–297.

[31] Ben-Akiva, M. E., Lerman, S. R., & Lerman, S. R. (1985). Discrete choice analysis: theory and application to travel demand (Vol. 9). Massachusetts: MIT press.

[32] Gärling, T. (1998). Behavioural assumptions overlooked in travel choice modelling. Travel Behaviour Research: Updating the state of play, 3-18.

[33] Garson, G.D. (2013). Factor Analysis (Statistical Associates Blue Book Series). New York: Statistical Associates Publishing.

[34] Floyd, F. J., & Widaman, K. F. (1995). Factor analysis in the development and refinement of clinical assessment instruments. Psychological assessment, 7(3), 286.