🏆 *reviewed paper*

A Mode Choice Model for the Elderly: Case of Mashhad City, Iran

AmirReza Mamdoohi, Fatemeh Naqavi

(AmirReza Mamdoohi, Assistant Professor, Faculty of Civil and Environmental Engineering, Tarbiat Modares Universiy, Tehran, Iran, armamdoohi@modares.ac.ir)

(Fatemeh Naqavi, M.Sc. Student, Faculty of Civil and Environmental Engineering, Tarbiat Modares Universiy, Tehran, Iran, f.naqavi91@gmail.com)

1 ABSTRACT

Although much research has been conducted on mode choice, very little has focused on the topic for the elderly. Considering the very particular behavior of this population group, different factors are expected to influence their decisions. Travel behavior of the elderly are mostly studied in developed countries. However, developing countries will have a great share of the elderly in a few decades. This paper aims to analyze Mashhad's elderly travel behavior statistically through the application of multinomial logit model. A questionnaire is then designed based on the literature and the particular sample in Iran and administered to a sample of 499 elderly people through a field survey. The questionnaire contains socio-economic and trip characteristics questions. That includes travel origin and destinations, mode of travel, purpose and frequency of travel, number of the people along with respondents, household size, educational attainment, monthly household expenses, number of cars in the household, elderly car-ownership and having a driving license. To determine the statistically significant variables and Multi Nomial Logit model is used and the results indicate that the elderly in Masshad tend to use public transport more. Also, car users are mostly women and they prefer to be car passengers. Elderly with higher educational attainment and income tend to use car more. Elderly prefer to walk more as they get older and elderly men walk more than women. The walking mode has a negative correlation with the travel distance.

Keywords: mixed model, multinomial logit model, mode choice, elderly, transport

2 INTRODUCTION

Developing countries have a great share of the elderly population increase. By 2050, 8 out of every 10 elderly will be living in a developing country. Over the past three decades, the Islamic Republic of Iran has been experiencing rapid socio-demographic and economic changes that have placed Iran amongst the countries that will have an old age structure by the mid-21st century. These changes have occurred so rapidly that social institutions were unable to acquire necessary capacities and capabilities to cope with and keep pace with them. Only during recent years, these emerging issues attracted the attention of official institutions and bodies [Khosravi et al., 2014].

The elderly population itself is ageing too. The share of 80+ (oldest old) which is now 14 percent will reach 19 percent in 2050, and there is not much time left to adapt facilities in order to improve future life quality of this group [Khosravi et al., 2014]. The number of people aged 60 years or over is expected to double between 2015 and 2030 in Iran [United Nations, 2013]. Quality of life in old age is related to mobility [Metz, 2000]. As Ipingbemi mentioned, in most cities in developing countries, gross inadequacies of public transport, overcrowded buses, environmental pollution, and poor road infrastructure are the major mobility challenges of urban population [Ipingbemi, 2010].

Despite the problems mentioned, it is an important consideration for policy makers to realize the elderly travel characteristics and behavior. To better understand how the elderly travel in Iran, this paper focuses on Mashhad's elderly and suggests a Multinomial Logit Model for travel mode choice of this group, considering socio-economic and trip characteristics. This paper considers some attitudinal factors and checks whether these factors affect mode of travel.

The next section reviews the existing literature on travel behavior and mode choice of the elderly. The third section explains data and methods. It contains a statistical analysis of the data that gathered as the material of this study. In section four, model results are presented. Finally, there are conclusions and discussions in the last section.

ISBN 978-3-9504173-2-6 (CD), 978-3-9504173-3-3 (print)
Editors: Manfred SCHRENK, Vasily V. POPOVICH, Peter ZEILE, Pietro ELISEI, Clemens BEYER

3 LITERATURE REVIEW

This section reviews the existing literature on the effects of an ageing population on travel behavior. It focuses on travel mode choice of the elderly in both developed and developing countries.

Rosenbloom used data from the US, Australia, Germany, New Zealand, Norway, and the United Kingdom to study environmental problems caused by an aging population and increased automobility. The results show that in spite of cultural and policy differences, older people around the world are more likely to have a license, to take more trips, and to do so more often as the driver of a car than older people just a decade ago; they are also less likely to use public transit and all these lead to increased environmental pollution [Rosenbloom, 2001].

Collia et al. highlighted travel patterns of older adults living in the United States and compared basic travel characteristics of older adults (age 65+) with younger adults (ages 19–64). The results indicate that although older Americans travel extensively, they are less mobile than their younger counterparts. This pattern is more pronounced among older women and among those with mobility problems. Older women consistently take the least number of trips per day, have the lowest driving rates and travel the shortest distances. Older Americans travel extensively and rely on personal vehicles as heavily as their younger counterparts. 89% of the elderly travel in personal vehicles, and excluding personal vehicle and walking, all other means of transportation account for about 2% of daily travel [Collia, Sharp and Giesbrecht, 2003].

Stern used a correlated multinomial logit model and a Poisson model to measure the factors affecting demand for different types of transportation by elderly and disabled people in rural Virginia. The results indicate that the number of trips were smaller for females, older seniors and people with walking difficulties. High education and being married resulted in more trips. In order to examine the travel distances of senior citizens, (log-)linear regression models are usually used. The results indicate that a paratransit system providing door-to-door service is highly valued by transportation-handicapped people; Taxis are probably a potential but inferior alternative even when subsidized; Buses are a poor alternative, especially in rural areas where distances to bus stops may be long; Making buses handicap-accessible would have a statistically significant but small effect on mode choice; Demand is price inelastic; and total number of trips taken is insensitive to mode availability and characteristics [Stern, 1993].

Van den Berg et al. studies trip-making for social purposes, with a special focus on the demographic ageing factors. Using social activity diary data, models are estimated to predict the number of social trips, the travel distance and mode of transport for social trips. With regard to transport mode choice the results indicate that older seniors (75+) are less likely to choose the bicycle, relative to driving. No other significant age effects were found. Significant effects were found for gender, household structure, education level, car ownership, having a disability, urban density, distance and the purpose of the social activity [Van den Berg, Arentze and Timmermans, 2011].

Schmöker et al. analyzed the choice of mode made by both older and disabled people (including the younger disabled) for shopping trips to determine what policies can best meet their mobility and activity. The model specification was quite sensitive to the assumed costs associated with each mode, in particular for the choice of driving. Assumptions were made regarding the costs of unchosen alternatives (which is a requirement in all choice modelling with revealed preference data), they found the best model fit when marginal costs associated with car use are included, namely petrol and parking costs, rather than a full average cost associated with driving (which includes capital depreciation and maintenance costs) [Schmöcker et al., 2008].

Li et al. explored the factors that might affect the elderly people's mode choice behavior in Taiwan. Under the structure of disaggregated demand analysis, a conceptual framework on elderly people's mode usage was formulated. Empirical results showed that age, gender, employment status, and living environment are the significant factors that influence mode usage of the elderly in Taiwan [Chang and Wu, 2005].

Newbold et al. used the 1986, 1992, and 1998 General Social Surveys and pseudo-cohort methods to address changing driving behavior among older Canadians, and to compare it among different age cohorts. Results indicate that while older Canadians undertake fewer trips, and travel for different reasons than those in the labor force, their reliance upon the private automobile for transportation is no less significant and the number of trips by car with older drivers increase over the study period as the population ages [Newbold et al, 2005].

Mercado and Paez investigated the determinants of mean trip distance traveled by different mode types. They used data from the Hamilton metropolitan area in Canada, and multilevel models to investigate the variables that impact distance traveled, with a specific focus on demographic aging factors. The results suggests that while this effect of age is present for all modes analyzed (car driving, car passenger, and bus) it is considerably more marked for car driving; also there are significant effects compounded by the interrelated factors of gender, employment constraints, household contextual factors; and neighborhoods with high commercial and residential mix showed a negative relation with distance traveled only in the case of car driver [Mercado and Páez, 2009].

Kim and Ulfarsson analyzed the mode choice of the elderly and how it relates to activity purpose, using a Multinomial Logit model. The results showed that the elderly prefer car between private car, carpool, public transport and walking. This mode is negatively influenced by age and is positively influenced by vehicle ownership, high income and living alone. The elderly prefer walking when going on recreational or personal trips [Kim and Ulfarsson, 2004].

Hu et al. presented a survey and analysis of elderly people travel behavior in Changchun, China, including the different gentle elderly people s trip frequency per day, trip purpose, and mode choice. Then compared the difference between developing countries and developed countries on elderly people travel behavior, as well as analyzed the reason of these phenomena [Hu, Wang and Wang, 2013].

Ipingbemi assessed the travel characteristic and mobility crisis of the elderly in Ibadan Metropolis. The use of bus and walking accounted for 30% and 29.6% of the modal split. Chi-square analysis indicated significant variations in terms of travel time and transport cost in the three density zones. Vehicle design, long access and waiting time as well as poor facilities at the terminals were identified as constraints to the effective mobility of the elderly [Ipingbemi, 2010].

4 DATA AND METHOD

In this section there is a brief introduction to the available modes of travel in Mashhad followed by Data Collection part, in which the properties of the questionnaire and the data is discussed. Then in the third part, the used method in this study is explained.

4.1 Modes of travel in Mashhad

There are three primary travel modes in Mashhad. Public Transport including bus, LRT and taxi; driving a car or being a car passenger; and walking. Bikes can't be ridden by women in Mashhad due to cultural issues. Also, there are a few bicycle lines with limited access to different parts of the city. So, not many people use bicycles. The elderly in Mashhad don't have subsidies for transportation in specific hours of the day. Also, there isn't any special service or any fare discount for them. Taking these into account, this paper aims to introduce a model that estimates travel mode choice of the elderly in Mashhad.

4.2 Collecting Data

For the purpose of this paper, a questionnaire mainly based on LATS (London Area Travel Survey) questionnaire was developed and then localized, in December 2015. To consider the distribution of the elderly in the city, an estimation of the rate of the elderly over the total population in each zone then calculated, using Statistical Center of Iran's data of 2011. A face to face survey with 524 respondent were conducted in February 2016. The final number of records used for mode choice modeling is 499 records and it excludes bikes and motorcycles due to their little share in the sample.

The questionnaire has three sections. The first section asks about trip information (i.e. mode of travel, purpose and frequency of travel, number and relation of the people along with respondents during their travel), while the second part asks about personal information (i.e. age, gender, work status, personal and household characteristics, car-ownership and educational attainment) and the third part is about individual perceptions on environment, safety, comfort, convenience and flexibility of mode of travel. The third section was not found statistically significant and therefore we don't mention it in the following sections. Also by asking residential area of the respondents, travel distance was measured afterward.

Sample characteristics are shown in Table 1. Men and women have almost equal shares in this sample. Age is categorized in three groups. The youngest person in the sample is 60 and the oldest is 105 years old.

ISBN 978-3-9504173-2-6 (CD), 978-3-9504173-3-3 (print)
Editors: Manfred SCHRENK, Vasily V. POPOVICH, Peter ZEILE, Pietro ELISEI, Clemens BEYER

Educational attainment grouping starts from the option “less than middle school” because most elderly, especially older women, has primary education or no education at all due to economic and cultural issues of their time. In order to have an income index, household average monthly expenses is asked. In traditional families in Mashhad, men has all the responsibilities to financially support the family and for this reason a few elderly women in the sample (3%) are not aware of the average household monthly expenses. Most elderly in the sample don’t live alone and 41% of them has a bigger household size than 2.

Variables used in the Model	All related categories	N	%
Gender **(gender: female =1 , male=0)**	Woman Man	252 247	51 49
Age	60-64 65-70 70<	307 114 78	61 23 16
Household size **(HH 1 : If Household size is 1 = 1; otherwise = 0)**	1 2 3 4 5 +6	86 208 138 47 17 3	17 42 28 9 3 1
Educational attainment **Education 1 (Less than Middle school =1; otherwise = 0)**	Less than Middle school Middle school High school diploma Associate degree Bachelor’s degree Masters and higher degree	236 83 93 26 40 21	47 17 19 5 8 4
Household average monthly expenses (million tomans) **(1 USD = 32,457.90 IRR)**	Less than 1 1-2 2-3 3-4 4-5 5< I don’t know	236 163 70 8 6 0 16	47 33 14 2 1 0 3
Elderly car-ownership	none 1 2 +3	296 166 37 3	59 33 7 1
# Cars in household	none 1 2 +3	232 216 48 0	46 44 10 0
Driving license **(License: having license =1, otherwise= 0)**	Men women	196 44	78 19
Trip Frequency **(Trip frequency 2: If trip frequency is 2-4 days a week =1; otherwise = 0)**	5 or more days a week 2-4 days a week Once a week 1-3 times a month Less than once a month Made journey once only	106 72 86 66 130 39	21 15 17 13 26 8
Trip Purpose **(purpose 3 : If trip purpose is visiting friends / relatives =1; otherwise = 0)**	Returning home Workplace Visiting friends/relatives at their home Personal business (e.g. doctor, hospital, bank) Shopping Sport or entertainment pilgrimage	113 28 88 99 107 44 20	23 6 17 20 21 9 4
# along with respondent	none 1 2 +3	320 138 35 6	64 28 7 1
Gender 1 (Gender of the person along with respondent: female =1, male =0)	Woman Man		

Table 1: Sample characteristics

Having a driving license among men and women is calculated separately. 78% of men and 19% percent of women have a driving license in this sample. There is a major holy shrine in Mashhad and thus trip purposes contain pilgrimage. Also work status is not used in the model, because of the small share of this question response.

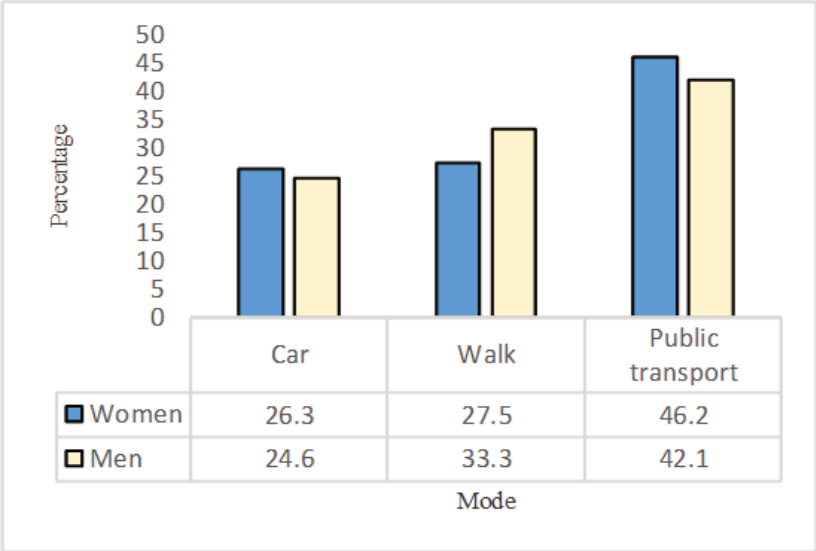

Figure 1: Elderly users of each mode by gender

According to Figure 1, elderly men tend to walk more than women while a greater percentage of women use public transport and car as their mode of travel.

By only 19% percent of driving license, it is concluded that women prefer to be car passengers while men prefer to drive.

	Car	**Walk**	**Public Transport**
Women	11.7	13.7	19.0
Men	7.1	7.9	12.3

Table 2: Percentage of the elderly with someone along during travel

Table 2 shows that older women who use car have a greater share of traveling with at least one person along with them. Elderly men tend to walk more than women while women use public transport more.

According to Table 3, average travel distance for the elderly that use car is higher than other modes. Those who walk have a smaller average walking time to the nearest bust stops, although the difference for this measure among three groups are not very considerable.

	Car	**Walk**	**Public Transport**
Average Travel Distance (km)	5.3	3.4	4.4
Average Travel Time (min)	16.0	41.3	29.0
Average Walking time to the nearest bus station (min)	9.5	8.51	9.3

Table 3: Average travel time and distance by each group of users

		Car		**Walk**		**Public Transport**	
Age	60-64	78	25%	98	32%	134	43%
	65-69	30	26%	31	27%	54	47%
	+70	20	27%	25	34%	29	39%

Table 4: Percentage of elderly by mode and age

As indicates, how share of each travel mode changes by increasing age of the elderly. By increasing age, elderly prefere to walk more and this result is similar with Hu et al. [Hu, Wang and L. Wang, 2013] findings. In this part, sample characteristics were presented. In the following part, the modelling method is explained briefly.

4.3 Method

To determine the relation between personal and trip characteristics and mode of travel of the elderly, a multinomial logit model (MNL) is applied to distinguish the differences among different options provided by the questionnaire. MNL is the simplest practical discrete choice model. Discrete choice models are derived

ISBN 978-3-9504173-2-6 (CD), 978-3-9504173-3-3 (print)
Editors: Manfred SCHRENK, Vasily V. POPOVICH, Peter ZEILE, Pietro ELISEI, Clemens BEYER

from the assumption of utility maximization of decision makers' behavior. The net utility (U_{ni}) for option n and individual i is formulated as follows:

(1) $$U_{ni} = V_{ni} + \varepsilon_{ni}$$

Where V_{ni} is the observed part and ε_{ni} is the random part. V_{ni} is a function of the observed attributes and is a linear combination of these attributes. The logit choice probability is:

(2) $$P_{ni} = \frac{e^{V_{ni}}}{\sum_j e^{V_{ni}}}$$

The logit model is obtained by assuming that each εni is independently, identically distributed extreme value. The distribution is also called Gumbel and type I extreme value [Train, 2009].

Variables used in modeling are listed in Table 1. Also, statistically significant dummy variables are specified in the Table 5.

5 RESULTS

In this section, statistically significant variables are represented in Table 5. The choice of travel is between car, walking and public transport as mentioned earlier. By adding another constant to the model, the constants would indicate that, if all explanatory variables are evaluated at zero, people are less likely to walk or use a car and more likely to use public transport. By increasing travel distance, it is less likely that elderly walk as expected.

Mode of travel	Variable	Parameter	P-Value
Car	Constant	-0.79301	0.0029
	Gender	0.92433	0.0016
	No License * gender 1	0.45739	0.0147
	Education1	-0.29789	0.0055
	License	-0.33688	0.0174
	Monthly expense	0.08477	0.0190
Walk	Travel distance	-0.02726	0.0012
	License	0.88280	0.0826
Public transport	Trip frequency 2	-0.28142	0.0109
	Education 1	0.17570	0.0187
	#along * Purpose 3	-0.65208	0.0143
	Gender 1 * gender * purpose 3* HH 1	0.77451	0.0539
	Walking time to the nearest bus station	-0.51328	0.0246
Number of observations	499		
Log-likelihood (no coefficient)	-534.6508		
Log-likelihood	-489.2842		
R-squared	0.0849		
R-squared adjusted	0.1075		

Table 5: MNL model for Mashhad elderly mode of travel

Older people in Mashhad make the majority of their trips by public transport according to Table 4, which is similar to results of Hu et al. [Hu, Wang and L. Wang, 2013].Women, who are accompanied by another woman and travel with the purpose of visiting friends or relatives and live alone, tend to use public transport rather than car, and this group is statistically significant in the model. Statistical analysis have shown that men prefer to drive more than women while women prefer to be car passengers and it confirms the results of the Netherlands [Van den Berg, Arentze and Timmermans, 2011], London [Schmöcker et al., 2008] and Taiwan [Chang and Wu, 2005]. Elderly with higher than primary education tend to use car more. High trip frequency (2-4 times a week) has a negative influence on using public transport.

With regard to Table 1, car users are mostly women and the majority of this group don't have a driving license (81%) and the model shows these results as well. As monthly household expenses increase, elderly are more likely to choose car. Monthly expenses is considered as an income index and it can be concluded that as income level increases elderly prefer to use car more and this result is similar to findings of Schmöcker et al. [Schmöcker et al., 2008]. For walking mode, travel distance has a negative sign which shows that as the distance increases, it is less likely for the elderly to choose this mode. Driving license is positively significant in this mode. According to Figure 1, in this sample men use walking mode more than women, and they mostly have a driving license. According to the model, as the walking distance to the

nearest bus station increases, it is more likely for public transport users to choose this mode. Average travel time to the nearest bus station is shown in Table 3 for all three modes. The difference among these distances are not significant. Also the distance is asked from the elderly and is not calculated exactly.

6 CONCLUSION

The elderly is a significant part of the society and their travel characteristics is necessary due to their specific travel pattern and its involvement in transport planning. This study was conducted to find out the travel characteristics of the elderly in Mashhad, the second populated city of Iran. The research in this exclusive sample indicates that 47 percent of the elderly has a less than middle school level of education and their monthly expenses are less than 1 million tomans (1 USD = 32,457.90 IRR) on average. Elderly with higher educational attainment and higher income tend to use car more. In addition, 46 percent of the elderly do not own a car in the household and 59 percent of the elderly don't have a car of their own. 78 percent of the elderly men and 19 precent of the elderly women in the sample have a driving license.

All variables were tested to find out the statistically significant variables through an Multi Nomial Logit model then.The results indicate that the elderly in Mashhad tend to use public transport more than other modes. Car users are mostly women and with a 19 percent rate of having a license, they are mostly car passengers. By increasing travel distance elderly are less likely to walk. Walking has a greater share among elderly men.

It is recommended that similar studies with focus on one specific purpose, or one city zone or a greater number of respondents being conducted to obtain more detailed results.

7 ACKNOWLEDGEMENT

We hereby sincerely thank Mashhad Traffic and Transportation Organization for their contributions in data collection.

8 REFERENCES

KHOSRAVI, A., M. ALIZADEH, M. TORKASHVAND AND N. AGHAEI, Population Ageing in IR Iran, (2014).
UNITED NATIONS. (2013). World Population Aging.
METZ, D. H. (2000). Mobility of older people and their quality of life. Transport policy 7(2).
IPINGBEMI, O. (2010). Travel characteristics and mobility constraints of the elderly in Ibadan, Nigeria. Journal of Transport Geography 18(2).
ROSENBLOOM, S. (2001). Sustainability and automobility among the elderly: An international assessment. Transportation 28(4).
COLLIA, D. V., J. SHARP AND L. GIESBRECHT (2003). The 2001 national household travel survey: A look into the travel patterns of older Americans. Journal of safety research 34(4).
STERN, S. (1993). A disaggregate discrete choice model of transportation demand by elderly and disabled people in rural Virginia. Transportation Research Part A: Policy and Practice 27(4).
VAN DEN BERG, P., T. ARENTZE AND H. TIMMERMANS (2011). Estimating social travel demand of senior citizens in the Netherlands. Journal of Transport Geography 19(2).
SCHMÖCKER, J.-D., M. A. QUDDUS, R. B. NOLAND AND M. G. BELL (2008). Mode choice of older and disabled people: a case study of shopping trips in London. Journal of Transport Geography 16(4).
CHANG, H.-L. AND S.-C. WU (2005). Exploring the mode choice in daily travel behavior of the elderly in Taiwan. Journal of the Eastern Asia Society for Transportation Studies 6.
Newbold, K. B., D. M. Scott, J. E. Spinney, P. Kanaroglou and A. Páez (2005). Travel behavior within Canada's older population: a cohort analysis. Journal of Transport Geography 13(4).
MERCADO, R., & PÁEZ, A. (2009). Determinants of distance traveled with a focus on the elderly: a multilevel analysis in the Hamilton CMA, Canada. Journal of Transport Geography, 17(1), 65-76.
KIM, S., & ULFARSSON, G. (2004). Travel mode choice of the elderly: effects of personal, household, neighborhood, and trip characteristics. Transportation Research Record: Journal of the Transportation Research Board, (1894), 117-126.
HU, X., J. WANG AND L. WANG (2013). Understanding the travel behavior of elderly people in the developing country: a case study of Changchun, China. Procedia-Social and Behavioral Sciences 96.
TRAIN, K. E. (2009). Discrete choice methods with simulation, Cambridge University Press.