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Analyzing transport mode choice for aging society in Thailand

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Abstract

This research aims to study the factors affecting elder's transportation mode selection by considering 4 transportation types including bicycle or motorcycle, car and public transportation (which includes bus, taxi, and public motorcycle) in accordance with common transportation types in Thailand. The methodology used for analysis was a multinomial logistic regression of which independent variable was nominal scale and using a car to be the base model compared to the elderly people's change of transportation mode for result interpretation. The study results concluded the common characteristics of aging mobility that travel frequency is less than once a week, travel time is the morning, and most of activities is shopping. The private car transportation should be improved for the convenience. In addition, motorcycle and bike lanes should be developed for serving aging people due to their less income, and travel time use which is less than 30 minutes. Furthermore, public transportation should be also enhanced to accommodate their travel activities such as going to the hospital, and shopping.

Keywords: Elderly people, Mobility, Mode of transportation, Activity, Multinomial logistic regression

1. Introduction

1.1 Background

At present, the number of the world population has been continuously increasing, especially the population aged more than or equal 60 years which is about 901 million. As the growth rate is about 3.26% a year, it is forecast that in 2050 the elderly people will be around 2.1 billion [1]. In Thailand, the number of elderly people also tends to continuously increase. From 2009−2014, the rate of elders increased by 12.2%. When considering Figure 1, from 1970 to 2014, the proportion of age and sex has changed outstandingly. In the 1970s, the age range of childhood had the highest proportion and decreased in accordance with more increasing years of age. In 1990, the teenagers and working age range were the highest but in 2014, the proportion of elderly people was higher than other age ranges with more females than males. According to the forecast, in 2030, the number of elderly people will be the highest.

In other words, Thailand is regarded as one of the ASEAN countries entering aging society referring to the larger number of elderly people and decreasing childhood and labor age [2] as shown in Figure 2. Thus, the provision of facilities or welfare for aging people especially fundamental infrastructure, which is relevant to Thailand 4.0 government policy providing aging people's opportunities both for business and facilities, is very important. Therefore, to follow the government policy, the development of transport fundamental infrastructure is very important as it is an opportunity stimulating elderly people to go out for activity participation. Doing various activities often results in better life quality, healthier life, and mind of elderly people [3-6] . In addition, traveling to do activities is unavoidable [7].

Despite that the elderly people travel behavior has been studied in Thailand but the study area is only specified in Bangkok [8] , this research has focused on the factors resulting in transport mode selection and the model predicting transport mode choice of elderly people in Thailand (except Bangkok due to its diverse travel modes such as Bangkok (Mass) Transit System Skytrain or taxis, which are more than those of other provinces in Thailand. Accordingly, the objective of this research is to study the factors affecting the transport mode choice of elderly people in Thailand and that alternative must safer. The model results are considered to develop any suitable type of transport modes for their traveling in their specified areas.

The research questions are including, 1) what traveler's characteristics which affecting to mode selection? 2) What

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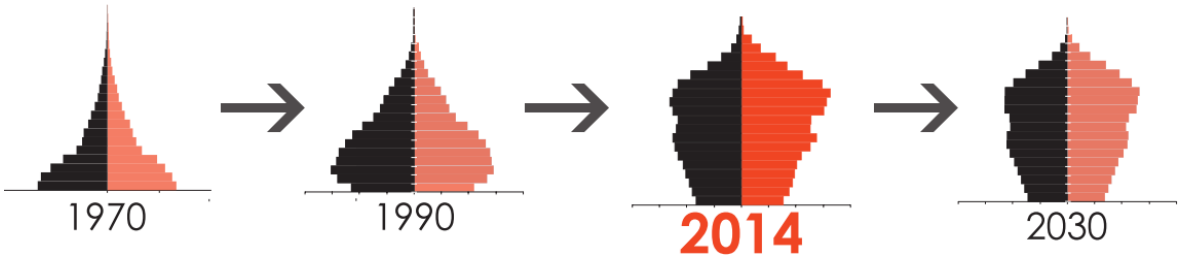

Figure 1 Thai population pyramids: year 1970, 1990, 2014 and 2030
Source: Foundation of Thai Gerontology Research and Development Institute [9]

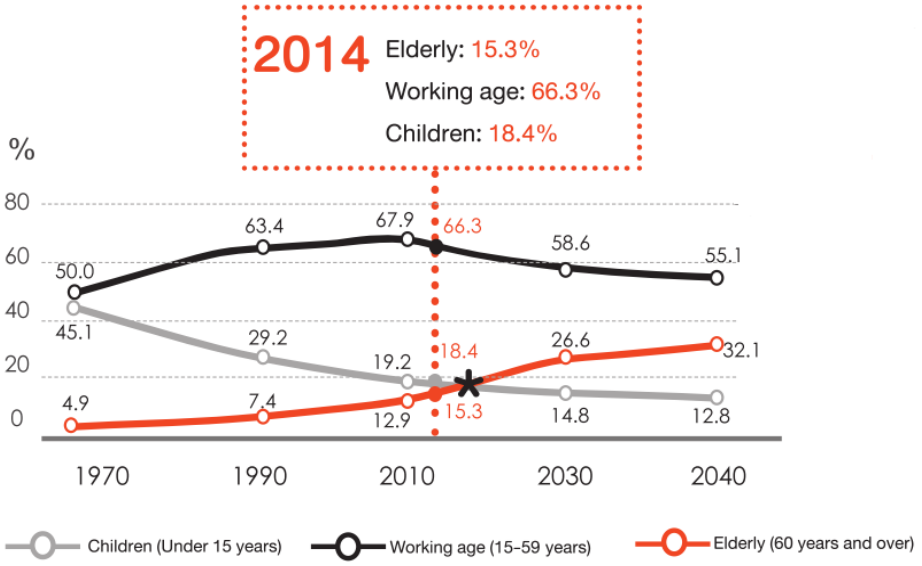

Figure 2 Population of children, working–age and elderly population
Source: Foundation of Thai Gerontology Research and Development Institute [9]

factors of travel behaviors are affecting to model selection? And 3) how the aspect of activity which effecting to mode selection?

1.2 Literature review

The definition of aging society refers to people who are over 60 years with the increase in physically and mentally weak state. The mentioned change depends on genesis, environment, and consumption. In Thailand, elderly people denote to Thai people who have names on civil registration aged 60 years up [10]. However, the elderly people have not same characteristics; they are different according to the age ranges. The World Health Organization has divided elderly people by the criterion of increasing age status including Early elderly people (60 – 69 years) middle elderly people (70 – 79 years), late elderly people (over 80 years) [9].

Factors affected to mobility of elderly people means the mode of transportation which elderly people aged over 60 years chose to travel. Generally, the factors affecting the choice of transportation types resulted from their own economy and society or the convenience of accessing to the areas for doing various activities. For this part, the researcher has reviewed factors affecting the transportation modes choice to be guidelines for designing questionnaires for data collection and analysis.

Characteristics of traveler: The freedom of traveling [11] refers to the difference between travelling alone, travelling with family or travelling with others. The time spent for travelling and doing activities [8]. The physical individual factors, sex affecting the choice of transportation mode. In other words, the limitation of mobility choice of females was more than that of males [12-14], as well as the age range which affected driving ability or limited physical abilities [13, 15]. For education level, it was relevant to levels of income [16-17]. Most elders who had high education or income often had car possession [3, 18], Family attributes factors, driving ability and driver license possession factor [3, 12, 19]. The residence factors, if the residences are in urban area, elders often choose public transportation often more due to higher accessibility. If they are in rural areas, they potentially use personal cars for traveling. Additionally, the current house characteristics or duration of domicile [20], the types of residence [17] and the number of family members [21-22]. In term of other factors including attributes of individuals, travel resource of individuals and residence location attributes [11, 23-24] or factors of different geographical areas divided by each country's attributes also affecting the choice of transportation mode [25], elderly people considered the perfect terminal [26] for public transport.

Travel behavior: Jon E. Burkhardt [4] has studied the behavior of elderly people in choosing the transportation mode which identified that the elderly people' firstly assessed the travel quantity by considering 3 main parts including; Travel patterns which mean the assessment about traveling aspects such as destination, the number of travels, the distance. Travel frequency, and Travel mode considering

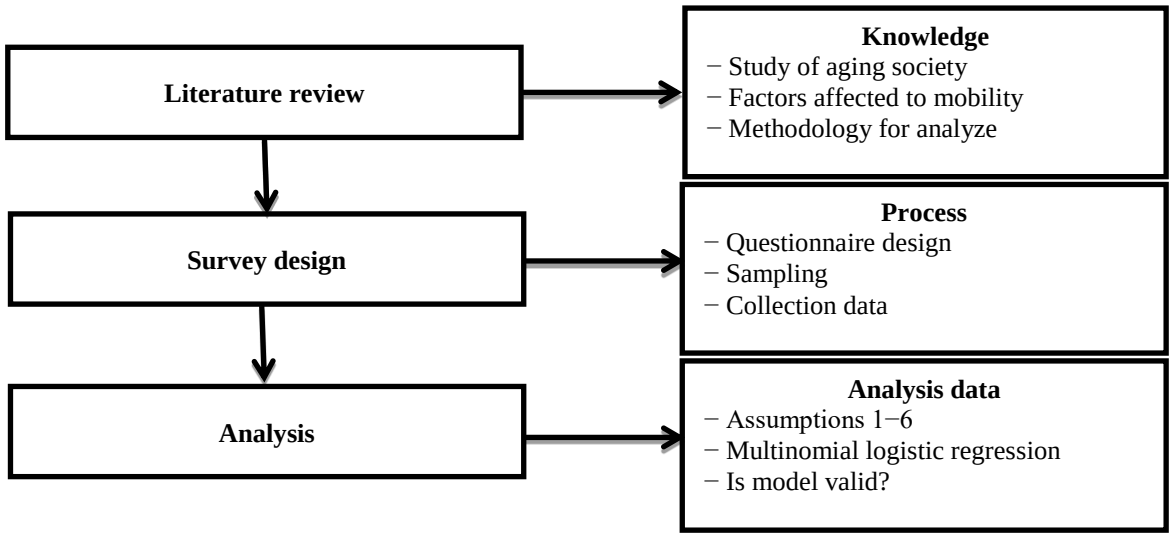

Figure 3 Research procedures

the suitability for example, Accessibility [16, 20]. In addition to travel aspect, elderly people considered travel cost and travel time [27-28].

Aging activity: From a comparative study of previous research, there is a direct correlation of age impacting and limiting activities. The evidence reveals a marked difference with elderly people having limitations or reductions with regards to physical activities when compared to children and middle age adults. These limitations directly affect the choice of activity with elderly people with regards to level of accessibility at shopping destinations [24]. Studies comparing seniors (elderly) and young parents' activities consisting of three distinct domains; shopping, leisure, and other [17, 29]. were used. Studies focused on the consideration of distance with regards to how far an elderly person will walk to purchase an item were also incorporated [30-31]. Another study focused on the general activities of Australian elderly [32]. A study from California revealed that most elderly performed both social and recreational activities [23]. Another study focusing on elderly users' behavior with regards to activities and land use was included [33]. One study explored the activities of elderly people in Thailand [33]. Also included are studies from Hong Kong examining the needs with regards to public open spaces and the activities of the elderly residing there [34-35].

The dangerous mode for elderly peoples: The study on crossroads design was conducted for older drivers by considering the relationship between age and driving ability. According to the study of elderly people's driving safety, it was found that the ability in speed adjustment on most problematic physical characteristics of streets including straight streets and crossroads areas [36]. Straight streets as well as alongside scenic streets often caused problems. Driver's age over 75 and 77 years had a high risk of maximum accidental occurrences [37-38]. Some studies found that the factors caused the increasing fatalities were when the age of drivers was over 80 years, followed by in the age range of 70−79 years in the head−on collision [39-40]. The elderly people had driving problems most was when parking and driving at night when it rained. Driving alone or the limitation of elderly peoples' sight was not driving problem [41-44]. Elderly people had limited ability in walking than middle age [45].

Multinomial logistic regression (MLR): In this study, Dependent variables were categorized variables or nominal scales which were the mode of transportation. Thus, MLR was suitable [20, 46]. MLR was used for various studies on elderly people for example, Safety of elderly people, factors affecting the level of injury severity [29], the study on risk factors of elders' getting more injury severity [37], or the severity of injuries in motor vehicles crashed [39], the study on travel behavior such as the study on accessibility to public system areas and mode share [47] or the study on travel behavior by train in Australia ,many studies on elders' travel behavior for example, the assessment of elders' traveling by considering economic and social factors in United States of America [20], the study on effects of Japanese elderly's decision on mobility choice [48], and the study on Thai elders' choosing mobility type in Thailand [8].

2. Methods

2.1 Research procedures

Figure 3 represents the research procedures consisting of three main components**;**

1) The literature review of the studies from Section 1.2 which encompassed issues such as limitation concerns regarding elderly activities, factors affecting elderly mobility, and a review of statistical analysis of elderly mobility.
2) The design and implementation of the survey questionnaire for collecting data directly from the elderly.
3) Data analysis from three domains consisting of an evaluation with regards to the alignment of data with the Multinomial Logistic Regression analysis and regression along with assessing the validity of the elderly mobility model employed.

2.2 Survey design

The Questionnaire was the close−ended questionnaire designed for the elders' accuracy in filling out. It included 2 main parts which were general information and residence characteristics of respondents. All question items were drawn from the previous review which comprised gender, age, religion, marital status, education, city zone, time in home, number of people in a family, house characteristics, house owner, inmate house, sickness, body normally, driving

ability, driver license, occupation, and salary. The second section asking about travel behavior. The question items were distance, people in traveling, the frequency of activity, travel cost, travel time, beginning time in traveling, time in activity and activity. This research classified the elderly people's activities frequently affecting the choice of transportation modes into 4 main categories including 1) health activities about regular and irregular doctor appointment, the place for doing activities such as hospitals or common clinics 2) shopping activities which included big department stores or small convenient stores, and markets 3) exercise activities for which the sources were, for example, common public parks where elderly people can cycle, walk, or run, and 4) religious activities which were usually praying and respecting homage to Buddha images, or making merit. Most of activities took place at temples or churches [3, 8]

Upon completion of the questionnaire, it was subjected to assessment through the Item-Objective Congruence (IOC) method. The data was further validated through review by five experts in statistics and engineering transportation for numerical relevance.

In terms of the data collected by using simple random sampling, It can be explained as follows; the average proportion of the elderly people in 2018 was 16.06%. [49] The regions with the highest elderly proportion which were selected were central and northeastern regions. After that, provinces were randomly selected in these two regions including the province with the average value less than 1 and that with the average value more than 1. Therefore, the 4 provinces were the samples drawn from 76 provinces excluding Bangkok, which is a special administrative province with completely different mode of transportation. The samples were respondents from Nakorn Ratchasrima (the elderly proportion 16.45%), Burirum (the elderly proportion 15.16 %), Lopburi (the elderly proportion 17.79%) and Saraburi (the elderly proportion 15.9%) owing to the consideration of similar aging mobility. The data collection was conducted by accidental sampling method. To explain, when seeing the elderly people in various places of activities such as department stores, hospitals, in case of their accessible convenience, the face- to- face interview was promptly conducted. The number of inclusively obtained data was from 402 respondents.

2.3 Analysis method

Data analysis had 3 steps as follows;

a) For the examination of data condition before the multinomial logistic regression analysis, in order to convince accuracy analysis, the 6 conditions are as follows; 1) dependent variables needed nominal scale measurement, 2) independent variables were continuous, ordinal or nominal, 3) Both of independent and dependent variables needed to be mutually exclusive and exhaustive categories, 4) the relationship of each variable had not multicollinearity problem, 5) independent variables had linear relationship to dependent variables and 6) Each pair of independent variables and dependent variables needed to be mutually related.

b) According to multinomial logistic regression analysis, dependent variables were 4 modes of transportation including walk or bicycle, motorcycle, car and public transit while independent variables were economic and social status and elders' travel information with the consideration of confidence interval at 95% according to likelihood ratio estimation [8, 50]. The obtained result of data an analysis was all K−1 model, where K was the number of dependent variable data by interpreting from the obtained model in comparison with Base model as follows;

$$\text{logit}\,(y=k)=\log\left(\frac{P(Y=\text{Mode}_k)}{P(Y=\text{Mode}_{base})}\right)=\beta_0+\beta_1\cdot x_{i2}+\beta_2\cdot x_{i2}+\ldots+\beta_p\cdot x_{in} \quad \text{for } i=1\ldots n,\ k=0,1,2,3\ldots \tag{1}$$

Where k was the value of determined dependent variables, $Mode_{Base}$ was mode of transportation to be determined as the fundamental model for comparison, β_i was the value of parameter resulted from base model, X_i was dependent variables taken into base model for its interpretation. It would be the comparison when the variable value was changed from base (^{b}) affecting to the odd ratio or *B(EXP)*. This initiated the opportunity for changing mobility from the base model. For example, if odd ratio value was less than 1, it could be interpreted that the increase of variable would turn people to use base model progressively.

c) The examination of a statistically significant result was considered by the Pearson Chi-square statistic by looking at *p-value*. In case of $p<0.05$, it would identify that model does not fit the data well. −2Log likelihood at Intercept only was the value indicating that coefficient of the model is zero, and −2 Log likelihood at final model was the value of coefficient at the full model. When considering the comparison, in case of significant $p<0.05$, it could be interpreted that the prediction of the model having independent variables was better than the model having only constant value [20]. This Pseudo R−square(ρ^2) value which was a common measure of overall model fit. The ρ^2 statistic is $\rho^2 = 1 - LL(\beta)/LL(0)$, When $LL(\beta)$ is log likelihood at the final model (at convergence with parameter), $LL(0)$ is log likelihood at the intercept−only model. ρ^2 statistic lies between zero and one if a statistic close to one suggests that the model is predicting the outcome with near certainly [51-52].

3. Results

3.1 Descriptive statistics

Table 1 shows the percentage of data collection obtained from 402 samples. For mobility types, it was found that the aging mobility mode mostly chosen is Walk or Bicycle 38.81% (n=156), followed by Motorcycle 27.86% (n=112), and car 23.63% (n=95) respectively while public transit system equals 9.70% (n=39). The condition for multinomial logistic regression analysis is that the number of elderly people choosing each type must be more than 20 [8, 11, 53]. For the appropriate number of sample size for Multinomial logistic regression (MLR) analysis, it was considered from events per predictor variable (EPV). From the studies of de Jong, et al. [54], Peduzzi, et al. [55] it was found that EPV should be more than 10. In case of this study which consists of 24 independent variables, EPV will be 402/24 = 16.75. In addition, for the proportional number of samples in each transportation mode as shown in Table 1, the lowest proportional value of each independent variable is 5, which is rather low. However, according to Kim [20], Kim and Ulfarsson [56] the lowest proportional number is 4. Thus, this data set can be taken for developing MLR analysis.

For age range, most respondents are in the age range of 60−69 years, accounting for 65.17%, followed by 70−79 years equal to 28.61%, and females are in higher proportion than males. Regarding driving ability, 61.94% of elderly people is able to drive cars. Regarding occupations, most of

Table 1 Descriptive statistic

		Mode of transportation								Total (%)
		Non-motorized		Motorcycle		Car		PT		
		Freq.	%	Freq.	%	Freq.	%	Freq.	%	
Province (PROV)	Nakorn Ratchasima	73	18.16%	44	10.95%	54	13.43%	22	5.47%	48.01%
	Lopbori	21	5.22%	24	5.97%	10	2.49%	5	1.24%	14.93%
	Saraburi	12	2.99%	18	4.48%	11	2.74%	5	1.24%	11.44%
	Burirum	50	12.44%	26	6.47%	20	4.98%	7	1.74%	25.62%
Gender [a] (GEN)	Male	49	12.19%	57	14.18%	40	9.95%	6	1.49%	37.81%
	Female	107	26.62%	55	13.68%	55	13.68%	33	8.21%	62.19%
Age [a] (AGE)	60-69 Years	84	20.90%	85	21.14%	68	16.92%	25	6.22%	65.17%
	70-79 Years	61	15.17%	20	4.98%	22	5.47%	12	2.99%	28.61%
	80-89 Years	8	1.99%	7	1.74%	5	1.24%	5	1.24%	6.22%
Education [a] (EDU)	No education	16	3.98%	16	3.98%	5	1.24%	5	1.24%	10.45%
	Primary school	116	28.86%	65	16.17%	62	15.42%	29	7.21%	67.66%
	High school	14	3.48%	15	3.73%	16	3.98%	5	1.24%	12.44%
	Bachelor and higher	8	1.99%	13	3.23%	12	2.99%	5	1.24%	9.45%
City zone [a] (ZONE)	Metropolitan	59	14.68%	57	14.18%	42	10.45%	15	3.73%	43.03%
	Micropolitan	58	14.43%	40	9.95%	33	8.21%	16	3.98%	36.57%
	Rural	39	9.70%	15	3.73%	20	4.98%	8	1.99%	20.40%
Number people in house [a] (HHZ)	1 people	11	2.74%	6	1.49%	5	1.24%	5	1.24%	6.72%
	2 people	28	6.97%	19	4.73%	19	4.73%	10	2.49%	18.91%
	3 people	26	6.47%	23	5.72%	18	4.48%	6	1.49%	18.16%
	> 3 people	87	21.64%	64	15.92%	53	13.18%	18	4.48%	55.22%
Sickness [a] (SICK)	No sickness	79	19.65%	67	16.67%	58	14.43%	26	6.47%	57.21%
	Sickness	77	19.15%	45	11.19%	37	9.20%	13	3.23%	42.79%
Body normal [a] (BN)	Abnormal body	94	23.38%	60	14.93%	51	12.69%	21	5.22%	56.22%
	Normal Body	62	15.42%	52	12.94%	44	10.95%	18	4.48%	43.78%
Driving [a] (DRI)	Cannot Driving	72	17.91%	27	6.72%	28	6.97%	26	6.47%	38.06%
	Driving	84	20.90%	85	21.14%	67	16.67%	13	3.23%	61.94%
Car ownership [a] (CAR)	No one	97	24.13%	31	7.71%	32	7.96%	30	7.46%	47.26%
	Owner car	59	14.68%	81	20.15%	63	15.67%	9	2.24%	52.74%
Driver license [a] (LIC)	No driving license	125	31.09%	48	11.94%	51	12.69%	37	9.20%	64.93%
	Have driving license	31	7.71%	64	15.92%	41	10.20%	5	1.24%	35.07%
Occupation [a] (OCC)	State employee	5	1.24%	9	2.24%	7	1.74%	5	1.24%	6.47%
	House maid	37	9.20%	18	4.48%	20	4.98%	6	1.49%	20.15%
	Business owners	46	11.44%	35	8.71%	34	8.46%	15	3.73%	32.34%
	Agriculture	52	12.94%	24	5.97%	23	5.72%	7	1.74%	26.37%
	Other	18	4.48%	22	5.47%	8	1.99%	11	2.74%	14.68%
Salary [a] (SALA)	Less than 10,000 ฿	132	32.84%	75	18.66%	61	15.17%	35	8.71%	75.37%
	10,000 - 14,999	13	3.23%	25	6.22%	13	3.23%	5	1.24%	13.93%
	15,000 - 19,999	10	2.49%	12	2.99%	16	3.98%	5	1.24%	10.70%
Inmate house [a] (FM)	Other	40	9.95%	24	5.97%	22	5.47%	9	2.24%	23.63%
	With child	116	28.86%	88	21.89%	73	18.16%	30	7.46%	76.37%
House characteristic [a] (HST)	single house	140	34.83%	99	24.63%	88	21.89%	35	8.71%	90.05%
	Other	15	3.73%	13	3.23%	7	1.74%	5	1.24%	9.95%
Duration live in [a] home (TLA)	< 20 year	24	5.97%	22	5.47%	21	5.22%	9	2.24%	18.91%
	other	132	32.84%	90	22.39%	74	18.41%	30	7.46%	81.09%
Status [a] (STA)	single	13	3.23%	8	1.99%	5	1.24%	7	1.74%	8.21%
	married	120	29.85%	92	22.89%	76	18.91%	22	5.47%	77.11%
	Divorce	22	5.47%	12	2.99%	15	3.73%	10	2.49%	14.68%
Activity [c] (ACTI)	Hospital	15	3.73%	20	4.98%	40	9.95%	16	3.98%	22.64%
	Shopping	40	9.95%	51	12.69 %	23	5.72%	17	4.23%	32.59%
	Park	5	1.24%	5	1.24%	8	1.99%	5	1.24%	5.72%
	Religion	96	23.88%	34	8.46%	20	4.98%	6	1.49%	38.81%

Table 1 (continued) Descriptive statistic

		Mode of transportation								Total (%)
		Non-motorized		Motorcycle		Car		PT		
		Freq.	%	Freq.	%	Freq.	%	Freq.	%	
Distance [b] (DIST)	<0.5 Km	77	19.15%	23	5.72%	5	1.24%	5	1.24%	27.36%
	0.6-3 Km	63	15.67%	58	14.43%	29	7.21%	10	2.49%	39.80%
	3-8 Km	10	2.49%	22	5.47%	28	6.97%	5	1.24%	16.17%
	>8 Km	5	1.24%	8	1.99%	33	8.21%	21	5.22%	16.67%
Mobility with [b] (MOBL)	Himself	126	31.34%	62	15.42%	18	4.48%	28	6.97%	58.21%
	With family	21	5.22%	49	12.19%	73	18.16%	5	1.24%	36.82%
	with the other	5	1.24%	5	1.24%	5	1.24%	5	1.24%	4.98%
Frequency [b] (FREQ)	1 Time/day	50	12.44%	51	12.69%	28	6.97%	14	3.48%	35.57%
	1 time/week	55	13.68%	29	7.21%	14	3.48%	9	2.24%	26.62%
	1 time/month	19	4.73%	16	3.98%	26	6.47%	9	2.24%	17.41%
	< 1 time/month	32	7.96%	16	3.98%	27	6.72%	7	1.74%	20.40%
Cost [b] (COST)	<20 ฿	152	37.81%	82	20.40%	29	7.21%	13	3.23%	68.66%
	20-49 ฿	5	1.24%	20	4.98%	26	6.47%	8	1.99%	14.68%
	More than 49฿	5	1.24%	10	2.49%	34	8.46%	18	4.48%	16.67%
Travel time [b] (TT)	< 10 min	90	22.39%	47	11.69%	8	1.99%	6	1.49%	37.56%
	10-29 min	53	13.18%	55	13.68%	52	12.94%	10	2.49%	42.29%
	More than 29 min	13	3.23%	10	2.49%	35	8.71%	23	5.72%	20.15%
Time begins mobility [b] (TIM)	Morning	138	34.33%	89	22.14%	72	17.91%	35	8.71%	83.08%
	Afternoon and next	17	4.23%	23	5.72%	23	5.72%	5	1.24%	16.92%
Time in activity [c] (TIA)	<30 min	12	2.99%	7	1.74%	5	1.24%	5	1.24%	7.21%
	30-60 min	36	8.96%	34	8.46%	19	4.73%	5	1.24%	23.38%
	60-120 min	45	11.19%	25	6.22%	17	4.23%	5	1.24%	22.89%
	>120 min	58	14.43%	39	9.70%	56	13.93%	31	7.71%	45.77%

Note: freq. denotes frequency. PT is public transportation. [a] is factors of characteristics group, [b] is factors of travel behavior group and [c] is factors of the activity group. Metropolitan means an Urban area or Center Business District (CBD), Micropolitan means sub-urban area. House characteristic denotes types of residence. Abnormal body means the elderly has a congenital disease such as diabetic mellitus. Driver license means having a license of the elderly. Mobility with means Travel companions such as their children and relation.

them are merchants or business owners, and agriculturists 32.34%, and 26.37% respectively. In terms of income, most of their income is less than 10,000 baht, accounting for 75.37%. For details of aging mobility, most travels are short-distance travels in the range of 0.6−3 Km and less than 0.5 Km, accounting for 39.8% and 27.36% respectively. Most participants travel alone, followed by traveling with family equal to 58.21% and 36.82% respectively. For travel frequency, most of them travel once a day, followed by once a week, accounting for the proportion of 35.57% and 26.62% correspondingly. For the details of activities, most were religious activities 38.81%, followed by shopping, healthcare and exercise at 32.59, 22.64 and 5.72% respectively.

3.2 Result of multinomial logistic regression

a) The Assumption assessment has been already mentioned in section 2.3. The results of Assumption analysis No.1, 2 and 3 were according to the condition. For No.4, multicollinearity problem examined by correlation value of each pair of variables, it was found that no pair had value more than 0.8 resulting in unproblematic data analysis. Regarding No. 5, the independent variables used were not continuous variables, so they didn't need any assessment. In term of No. 6, the chi−square test was used to test the relationship between each of independent variables and dependent variables by considering asymptotic significance. It was found that no significant variables, which were excluded from the model analysis, were religion, house character, inmate house, and normality of body.

b) For the test of a statistically significant result, in the first part, model fitting information showing the value of –2 Log likelihood while the model estimated intercept only, which was not parameter estimated value, was 1036.268 and the value of finalized model was 482.831, Degree of freedom= 96 (P-value < 0.000). This could indicate that this model could better explain or predict the data than the parameter not estimated. For the value indicating variance between independent variables and dependent variables, the values of Pseudo R-Square were 0.533. These all three values met the acceptance criteria [47].

c) For the multinomial logistic regression, the results of parameter estimated according to Table 2, had 3 models as mobility models were set to be dependent variables having 4 alternatives including walking or bicycle, motorcycle, car and public transit. This research allocated car to be base model in comparison of the probability of other mobilities. Since from data collection, elders used personal cars had rather risks of accidents because of their physical limitation in case of increasing years of age, sometime the policies might avoid the using car and motorbike of aging peoples, and it was easily seen when compared with other mobility types.

4. Discussion

When comparing between the models of Walk / Bicycle model and Car in terms of social characteristics, the elderly chose Walk rather than Car as well as elderly people who do not possess vehicles. This issue relatively makes sense because they are the models of mode choice behaviors for captive users. This result is confirmed by the study of

Table 2 Multinomial logistic regression model

MODE[a]		B	Std.	P-value	Exp(B)
Walk or Bicycle	Intercept	−5.917	2.409	0.014	
	[EDU=High school]	−1.903	1.01	0.059	0.149
	[EDU=Bachelor and higher] [b]				
	[CAR=No one]	1.3	0.696	0.062	3.670
	[CAR=Owner car] [b]				
	[OCC=State employee]	−3.76	1.431	0.009	0.023
	[OCC=House maid]	−2.741	1.000	0.006	0.065
	[OCC=Business owners]	−2.395	0.949	0.012	0.009
	[OCC=Other] [b]				
	[SALA=Less than 10,000 ฿]	1.614	0.931	0.083	5.024
	[SALA=15,000 − 19,999] [b]				
	[DIST=<0.5 Km]	3.067	0.868	<0.000	21.482
	[DIST=0.6−3 Km]	3.403	1.097	0.002	30.06
	[DIST=3−8 Km]	3.092	1.157	0.008	22.017
	[DIST=>8 Km] [b]				
	[MOBL=With family]	−2.72	1.244	0.029	0.066
	[MOBL=Other] [b]				
	[FREQ=1 time/week]	1.948	0.829	0.019	7.016
	[FREQ=Less than 1 time/month] [b]				
	[TIM=Morning]	1.64	0.817	0.045	5.154
	[TIM=Afternoon and next] [b]				
Motorcycle	Intercept	−8.024	2.276	<0.000	
	[EDU=No education]	2.804	1.301	0.031	16.508
	[EDU=Bachelor and higher] [b]				
	[OCC=House maid]	−2.579	0.891	0.004	0.076
	[OCC=Business owners]	−2.616	0.839	0.002	0.073
	[OCC=Other] [b]				
	[SALA=Less than 10,000 ฿]	1.751	0.772	0.023	5.762
	[SALA=10,000 − 14,999]	0.965	0.753	0.200	2.624
	[SALA=15,000 − 19,999] [b]				
	[ACTI=Shopping]	2.338	0.772	0.002	10.359
	[ACTI=Religion] [b]				
	[DIST=<0.5 Km]	3.972	1.451	0.006	53.104
	[DIST=0.6−3 Km]	2.016	0.761	0.008	7.507
	[DIST=3−8 Km]	2.009	0.8	0.012	7.456
	[DIST=>8 Km] [b]				
	[MOBL=Himself]	3.197	1.502	0.033	24.459
	[MOBL=With family]	1.471	1.487	0.323	4.354
	[MOBL=with the other] [b]				
	[FREQ=1 time/week]	1.807	0.765	0.018	6.094
	[FREQ=Less than 1 time/month] [b]				
	[COST=<20 ฿]	2.257	0.705	0.001	0.956
	[COST=More than 49฿] [b]				
	[TIM=Morning]	1.524	0.712	0.032	4.59
	[TIM=Afternoon and next] [b]				
	[TIA=<30 min]	2.126	1.29	0.099	8.381
	[TIA=>120 min] [b]				
Public transport	[CAR=No one]	1.847	0.9	0.04	6.342
	[CAR=Owner car] [b]				
	[LIC=No driver license]	2.633	1.103	0.017	13.92
	[LIC=Have driver license] [b]				
	[OCC=House maid]	−4.479	1.227	<0.000	0.011
	[OCC=Business owners]	−3.59	1.074	0.001	0.028
	[OCC=Agriculture]	−3.585	1.153	0.002	0.028
	[OCC=Other] [b]				
	[ACTI=Hospital]	2.156	1.041	0.038	8.641
	[ACTI=Shopping] [c]	2.986	1.079	0.006	19.807
	[MOBL=With family]	−4.747	1.298	<0.000−	0.009
	[MOBL=with the other] [b]				
	[FREQ=1 time/week]	2.437	1.131	0.031	11.444
	[FREQ=Less than 1 time/month] [b]				
	[TT=10−29 min]	−2.559	0.887	0.004	0.077
	[TT=More than 29 min] [b]				

Note: [a] The reference category is car. [b] The parameter is set zero it's reference value. [c] the reference of vale is the other activities. The value of Pseudo R−Square is 0.533.

Shao, et al. [57], for income, the elderly people having income less than 10,000 baht per month. This is relevant to the study of Kim and Ulfarsson [56] who found that the elderly people having high income tend to drive a car more than those whose income is lower. The frequency of doing activities is about once a week. Elderly rather chose to start traveling in the morning than in the afternoon (odds ratio=9.6) as its hotter weather was not suitable for doing activities. The travel distance which is shorter than 8 kilometers evidently tends to be chosen by elderly for their walking or cycling. This is relevant to [8] the study. If elderly do not spend a long time on doing activities as well as short-time travel or the short travel distance, they often choose transportation modes which were not complicated.

For the factors affecting motorcycle use when compared with car use, it includes the income per month of the elderly who had lower income or less than 15,000 baht a month. The reason was that the car was costly, so they turn to use motorcycles [19, 56]. For the aspects of activities, in case of doing shopping activity, the elderly travel by motorcycle rather than by private car because most of them do shopping at the convenience stores nearby [8]. It can be seen by the parameter which predicts from the Travel distance which is shorter than 8 kilometers, and Travel time for doing activities which is less than twenty minutes. For mobility which the elderly people need, it shows that most elderly traveled alone by motorcycle once a week and they need low-cost traveling. These issues potentially illustrate motorcycle mobility, one of aging mobility which the elderly choose.

For choosing public transit system, in case of socioeconomic characteristics or travel behavior of aging people in that case, the elderly people had no car, no driving ability, no driver license. For activity aspects, most of them did health activities (odds ratio=8.641) and shopping (odds ratio=19.807). This result is not consistent with the study of Kim and Ulfarsson [56] stating that the elderly people will not choose public transportation with the purpose of shopping activity. However, this result can be confirmed with the study of Srichuae, et al. [8] who studied the elderly behavior in Thailand (Only in Bangkok). The study results found that the destination of shopping activity which is a traditional market significantly affected public transportation mode choice. The reason why they use public transit system to traditional markets because they are nearby and can be accessed by only one car ride, and the reason why they do not choose a car to do health activities since at present, many hospitals are so crowded that there are not enough parking spaces. Accordingly, the elderly people possibly choose public transit system. This issue is confirmed by the study of Ipingbemi [26] stating that parking spaces resulted in the decision of aging mobility. For public transportation, most of elderly people travel with others in travel time more than 29 minutes, and their travel frequency is about once a week.

The factors affecting the elderly to drive cars to do activities are auto ownership, high education referring to above higher vocational level, the income range is over 15,000 baht per month [56]. For Education, elderly with lower education choose walking or riding bicycle to do activities because education level potentially results in higher income leading to car possession and driving ability [19-20]. For car mobility of the elderly people, it includes the low travel frequency (less than once per month), travel time more than 29 minutes. People in traveling result in car mobility mode more than other mobility types. If the elderly change other people in traveling to their family [8], this results in the car mobility mode choice more than non-motorized and public transit system because family members potentially drive the cars in that travel.

5. Conclusion and implementation

This research aims to study factors affecting mobility modes by considering 4 mobility types including non-motorized (Walk or Bicycle), Motorcycle, Car, and Public transit system (including Bus, Taxi and Public motorcycle) which were analyzed by multinomial logistic regression. The results from the model could be used for other provinces in Thailand, because they had similar transportation systems, except Bangkok due to its more diverse types of transportation systems than other provinces [58]. The research questions include;

1) *What travelers' characteristics affect transport mode selection?* Most elderly are likely to choose private cars. The characteristics of the elderly people include having education higher than secondary education, possessing cars, holding driver license, gaining salary more than 15,000 per month. For walking or cycling mode choice, the elderly people often have salary less than 10,000 baht, while the elderly who choose motorcycle have income less than 15,000 baht. The elderly who choose public transportation mode are likely to be captive users who have no car and no driver license.

2) *What factors of travel behaviors affect model selection?* For car travel behavior, it includes traveling that takes longer than 29 minutes and distance length more than 8 kilometers, traveling with family, and the frequency of travel which is less than once per month. For other travel modes (including walking or bicycles, motorcycles, and public transit system are traveling less than 8 kilometers, travel time less than 29 minutes, with a high activity frequency of about once per week.

3) *How does the aspect of activity affect mode selection?* The elderly people often choose public transit system and motorcycle modes to go shopping at the convenience stores or traditional market nearby while they often choose public transit system to go for doing heath activities.

Implementation of the study is the development of any suitable type of transport modes for their traveling in their specified areas. For the examples of policies which were obtained from this study, the elderly people, whose income is less than 15,000 baht, most of their activities are shopping, going to hospitals, as well as their low rate of car ownership, the public transit system should be improved such as the use of suitable vehicles for the elderly instead of mini buses (Songthaew). To explain, the floor of the vehicle must not be too high for the elderly to step on, or the establishment of a bus stop should contribute to the elderly such as the availability of roofs and seats etc.

Limitations of the study. As the proportion of traveler's mode choice in each mode can pass only the standard condition, the number of respondents are not large enough. It is the limitation of this study For future research, the more variables should be added to understand travel behavior of aging society, such as the variable of urban form [59]. In terms of the research area, the future study should select Bangkok to understand model choices of aging mobility of which the finding might be challenging due to the complexity of transportation mode. In addition, the accessibility of transportation model of aging society should be studied to

provide the policies increasing the equal accessibility of the elderly people in Thailand.

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