IATSS Research 40 (2016) 26–34

Contents lists available at ScienceDirect

IATSS Research

Research article

Aging society in Bangkok and the factors affecting mobility of elderly in urban public spaces and transportation facilities

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ARTICLE INFO

Article history:
Received 16 April 2015
Received in revised form 1 November 2015
Accepted 24 December 2015
Available online 30 December 2015

Keywords:
Aging society
Mobility
Out-of-home activities
Transportation modes
Urban public spaces

ABSTRACT

Urbanization and aging of societies are two global trends in urban areas, especially in rapidly developing countries. Mobility of the elderly to access to public spaces is hindered by inadequate transportation infrastructure and services. The current study assesses this mobility problem in terms of access to public spaces using various modes of transportation. It utilized a mix of quantitative and qualitative methods. The data were obtained from elderly people aged 60 and older living in three different urban areas of Bangkok. Data collection was done using a questionnaire-based survey. Logistic regression was utilized for determining the significant factors affecting mobility of the elderly. It was found that the ability to travel without assistance, the distribution of public spaces with accessible transportation services, urban density, and urban development patterns influenced the mobility of elders. This study suggests inclusion of universal design principles in public projects, community planning, and the integration of transportation planning and urban systems.

1. Introduction

Aging of societies has become a global phenomenon. The proportion of people aged 60 and older will double from 11% in 2006 to 22% in 2050 [1]. This is a particular problem in some developed countries like Japan and South Korea [2]. Increasing population and declining birth-rates occur over much shorter periods in developing countries [2]. Thailand's population is aging very rapidly. Its percentage of senior citizens increased from 5% in 1970 to 10% in 2006. It will likely be 30% by 2050 [3]. The population of Bangkok is aging faster than in Thailand's other provinces. The office of the National Economic and Social Development Board reported that in 2008 the proportion of elderly in Bangkok was 10% and in 2020 it will be 21% [4].

An increased elderly population requires changes in their living environment to make their lives easier. The major problems of the elderly are related to biological aging and the resulting decline in functional capacity. The rate of decline is largely determining by factors related to lifestyle, social, environmental, and economic factors [1]. Rapid Urbanization in Bangkok resulted from growth with insufficient infrastructure [5]. This led to a shortage of basic services, inadequate transportation facilities, and deficient urban design. Low quality of life inhibits elder mobility and their participation in the society. Out-of-home activities enable the elderly to connect with people, places, and participate in activities that enrich their lives. The elderly need supportive environments that include transportation and access to public spaces. This study aims to elucidate the factors affecting elder mobility and their access to public spaces and transportation facilities in Bangkok. This study is useful for urban development and transportation planning to enable mobility of elderly people in developing cities with an increasingly aged society.

2. Literature review

The concept of mobility involves travel and access to desired places. Mobility is defined as the ability of any person to move between points in a community [6] at desired times with information about travel options and the ability to pay for transportation. [7]. Mobility encompasses six elements: travel and access to desired people/places, psychological benefits, a sense of independence, physical well-being and health, community involvement in social activities, and potential travel as in the case of an emergency [8]. Good mobility and decent transportation are important for the elderly to participate in society as age-related health problems and travel with access to public spaces becomes more difficult [9–11]. Mobility is often related to trip frequency, distance traveled, and mode of transportation [12,13]. It is possible to evaluate mobility from

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Peer review under responsibility of International Association of Traffic and Safety Sciences.

http://dx.doi.org/10.1016/j.iatssr.2015.12.004

the perspective of a number of stakeholders [13,14]. Mobility can be measured in several ways as shown in Table 1.

Urban development to support the elderly has been promoted by the World Health Organization (WHO) to develop age-friendly cities, within urban environments that allow older people to remain active and healthy participants in society. Access to transportation, buildings, and outdoor places are components of age-friendly cities. They enable the elderly to independently engage in out-of-home activities.

3. Methodology

This study was designed to elucidate factors influencing elder mobility for out-of-home activities in urban Bangkok. The concept of mobility relates individuals, their means of transportation and destinations. The framework of the current study's methodology is shown in Fig. 1.

3.1. Explore urban development and aging of society in Bangkok

The population of Bangkok is over 5.7 million, or 8.9% of the country's population [30]. Family size has become smaller. In 1960, there were 6.2 people per family compared to 2.3 in 2005. The numbers of children and people of working age declined, while the elder population steadily increased (Fig. 2). It is projected that the elder population (aged 60 and older) will exceed the population of children (aged less than 15 years) in 2020 [3].

Population density in inner city areas remains higher than in the suburbs. However, the population growth rate in the suburbs is also quite high. Areas of urban development in Bangkok can be divided into three zones: a commercial and historical zone, intermediate areas engulfed in urban sprawl, and the outer zone, which is currently used for residential and commercial purposes [31]. The built-up and residential areas consist of three categories. They are (1) an inner core area for conservation and tourism (high density), (2) an intermediate zone for the new Central Business District (CBD) and transportation hubs (medium density), and (3) newer residential districts (low density).

3.2. Selection of the study areas in Bangkok

Area selection considered 4 factors: (i) urban development patterns accounting for the state of physical, economic, and social factors in the City of Bangkok; (ii) urban infrastructure and service facilities, which are evolving along the main roads in the corridors of the developing axis; (iii) proportion of elderly; and (iv) predominate residential areas of the community.

Expansion of residential areas of Bangkok occurred along the main roads radiating from the city center. The main road corridor follows a northeast to southwest axis. This corridor was divided three zones. As shown in Fig. 3, the three circles represent the different urban development density zones of Bangkok. The center of the circles was set at the heart of the city where the selected road corridor begins. The smallest circle represents the inner zone with high urban density. The middle circle encompasses the intermediate zone where there is medium urban density. The largest circle depicts the outer zone having a lower urban density as categorized by BMA. In each of these zones, the district with the highest elder population was selected. In each district, sub-districts with predominately residential areas were selected for inclusion in the study. These sub-districts were (1) Jakrawat (JWK), (2) Bang Sue (BSE), and (3) Thungsonghong (TSH) (Fig. 3).

3.3. Pre-survey, selection of study parameters and variables, and population sampling

A preliminary survey was conducted in one district in the intermediate zone where the BMA recorded a large elder population. The intermediate zone is the area that is home to typical residential areas of Bangkok. It contains single family houses, condominiums, shophouses,

Table 1
Factors affecting mobility of the elderly.

Factors	Explanation	Literature
1.Individual		
1.1 Opportunities for social and recreation time	-The elderly tend to go outside their homes for leisure activities more than other age groups because the elderly have more free time.	[15,16]
1.2 Age, gender, disability	-Being female, of advanced age, and disabled negatively impacts mobility. -Women tend to require more assistance to maintain mobility.	[17] [18,19]
1.3 Marital status, income, support from children, living arrangement, and support networks	The elderly living with family and children tend to have extra responsibilities. They have more out-of-home activities and are more likely to need transportation to maintain mobility.	[15,18,20,21]
1.4 Financial status	Lack of financial support may reduce personal independence, access to activities, and social participation.	[6,11,22]
1.5 Housing type and residence location	-Living in apartments or high density of residences is associated with more trips.	[21]
1.6 House ownership and educational level	-Being highly educated and owning a house is associated with more trips outside the home.	
1.7 Ability to drive and vehicle availability	- The ability to drive, availability of a license and car ownership influence the transportation mode used.	[6,11,22]
1.8 Physical conditions	-Disabilities make common activities exhausting. The elderly often prefer to spread activities out over longer periods of time. The feeling of lost independence may make the mobility hazardous and impossible. -Physical impairment makes walking difficult for the elderly.	[6,11,19,20,23,24]
1.9 Psychological condition	-Independence and freedom positively affect elder mobility.	[25]
2. Destinations (public space)		
2.1 The choice of places and activities.	-Desired activities motivate the elderly. -Shopping malls attract older women more than men.	[17]
2.2 The location of out-of-home activities	-Geographically dispersed activities can make journeys longer.	[6]
3. Transportation		
3.1 Transportation choices.	-In the developed countries, most elderly rely on cars. In developing countries, they rely on public transportation. The use of public transportation by the elderly is increasing.	[11,26,27]
	-Location of one's residence influences the choice of transportation modes.	[18]
	-Available transportation in communities influences transportation mode used by the elderly.	[6,15]
	-Cars and taxis are commonly used by the elderly living in suburbs since there are few alternatives and activities are more dispersed. In dense urban areas, most activities can be reached by walking or public transit.	[7]
3.2 Distant and travel time.	-Length of time required for travel influences elder mobility.	[28,29]

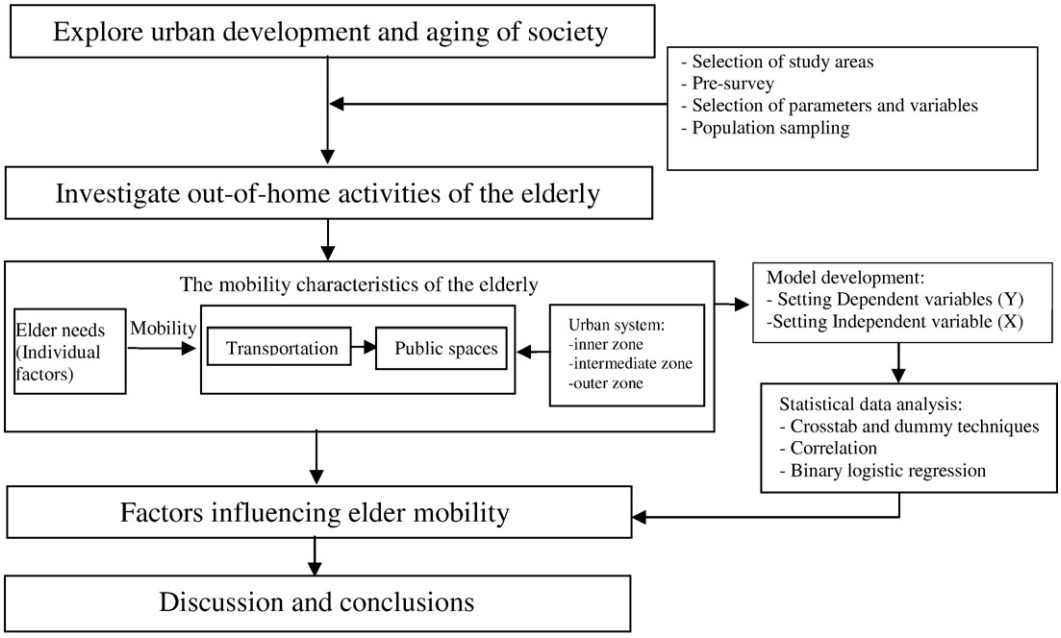


Fig. 1. Study methodology.

and townhouses, among other types. In the intermediate zone, the survey focused on the places frequented by the elderly, such as temples and parks.

This survey was done to determine the types of public spaces (destinations) for out-of-home activities. Thirty elderly people were asked about their common out-of-home activities. This revealed that their activities were primarily for health care, shopping, religious activities, recreation, and exercise in descending order of importance. This was used to develop the survey employed in this study.

Public spaces and transportation are key features of a city's physical environment that impact mobility options for the elderly. This study investigated the influence of "public spaces" and "modes of transportation" upon elder mobility. Public spaces accessed by the elderly were of four types: (1) health care centers, (2) shopping centers, (3) public parks, and (4) religious facilities. Available modes of land transportation in Bangkok include walking, bicycling, and public modes of transport (i.e., city buses, vans, BRT, taxi, motorcycle taxi, three-wheeled taxis, BTS, MRT, airport rail link, conventional trains, private cars, and private motorcycles).

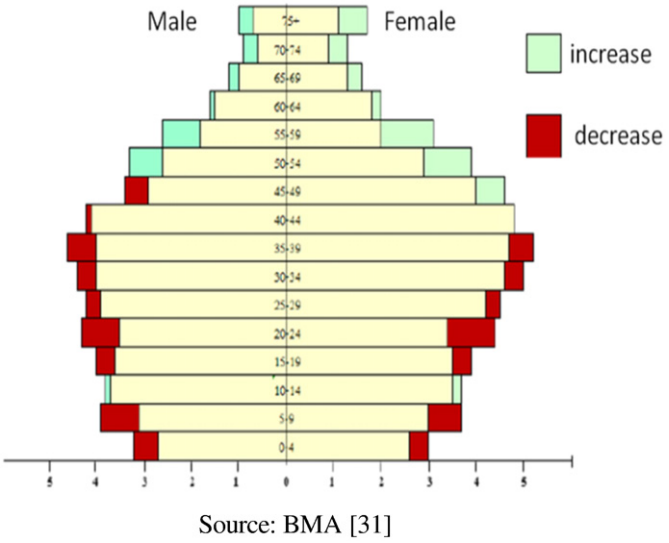


Fig. 2. Age distribution of Bangkok's population in 2001 and 2008. Source: BMA [31].

A questionnaire was developed asking about individual demographics, out-of-home activities, travel patterns, and location of the respondent's residence. Population sampling focused on the elder distribution in the selected sub-districts. A sample size was determined that had a 95% confidence level [32]:

$$n = \frac{N}{1 + Ne^2}$$

n = sample size
N = total population
e = level of precision

The total number of elderly in the three selected sub-districts (N) was 26,411, (1) Jakrawat = 8500, (2) Bang Sue = 8955, (3) Thung Song Hong = 8956. As a result, the required sample size (n) was 292, 94 in JKW, 99 in BSE, and 99 in TSH. Convenience sampling was adopted due to the population involved. Respondents aged 60 and over, who lived in the selected sub-districts, were interviewed until the required sampled size was obtained.

3.4. Model development

Model development was done to elucidate the factors that influence elder mobility. SPSS was used to determine the significant factors.

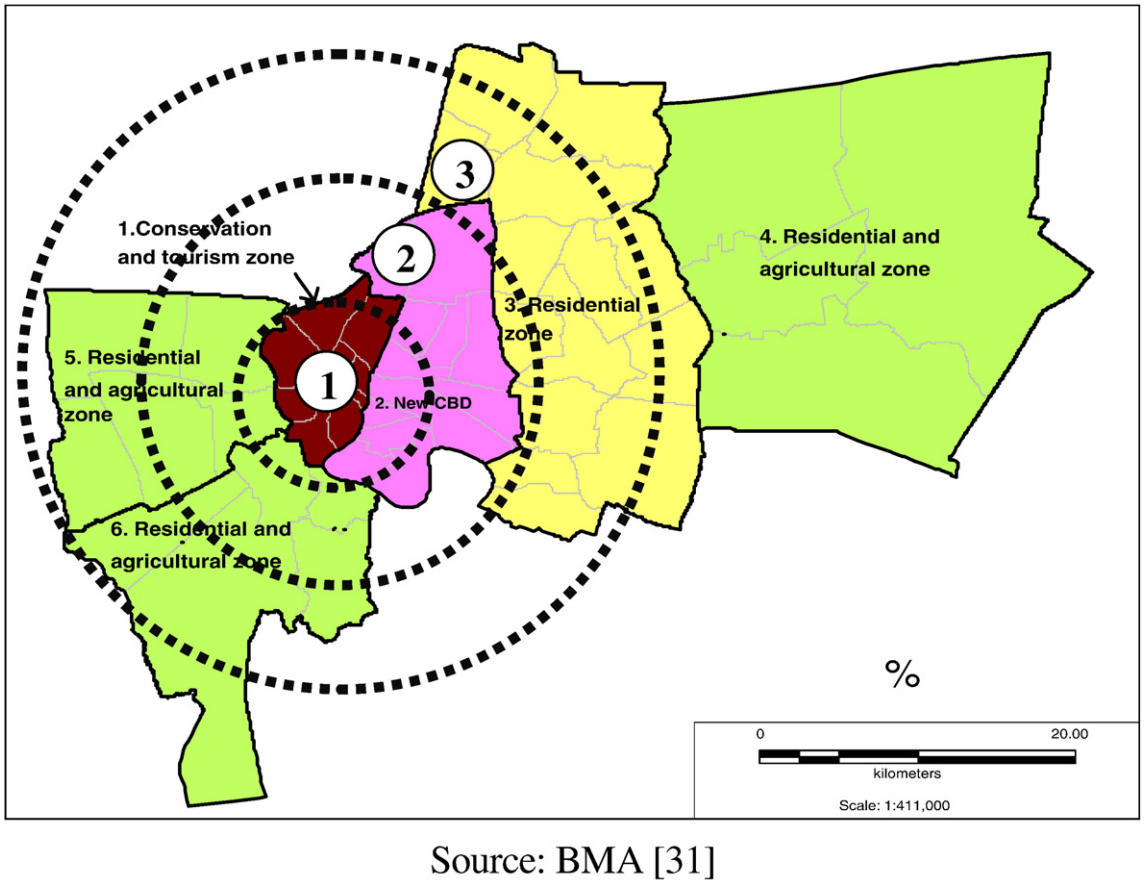
3.4.1. Dependent variables (Y)

3.4.1.1. Submodel I. The dependent variable was "public space" (Y1).

The dependent variable (Y1) was defined as

Y1=1 if the public spaces were accessed by the elderly for their out−of −home activities;otherwise,Y1=0

The minimum sample size that can be statistically analyzed is 20 (n ≥ 20) [33]. Each type of public space was classified in



Source: BMA [31]

Fig. 3. Selected study areas in Bangkok. Source: BMA [31].

terms of a hierarchy. The ten public spaces analyzed are highlighted in Table 2.

The number of respondents means the number of elderly people answering our questionnaire who choose to access specific types of public spaces. Multiple choice questions were used in the survey. The respondents were asked about the place and purpose of their visit. For example, if they wanted to travel for health care activities, which place(s) do they regularly visit? The multiple choice answers included items such as, specialist or general hospital, base hospital, community/district health center, and private health clinic. We also asked them for the specific name and general address of these places to ensure the hierarchy of the public spaces.

3.4.1.2. Submodel II. The dependent variable was "Transportation mode" (Y2).

The transportation modes (Y2) used by the elderly to access specific public spaces were determined. The dependent variable (Y2) was defined as:

$Y2 = 1$ if a mode of transportation was used for mobility to access service centers; otherwise, the dependent variable was $Y2 = 0$.

Statistically analyzed transportation modes are highlighted in Table 3. The results showed that the common modes of transportation for the elderly included walking, motorcycle taxis, cars, buses, and taxis.

Table 2
Number of respondents accessing different specific public spaces (Y1), (N = 292).

Out-of-home activities	Public space hierarchy	Abbreviation	Number of respondents accessing specific public spaces
1.Health care	**1.1 Specialist or general hospital (>500 beds)**	**H1**	**119**
	1.2 Basic hospital (<500 beds)	**H2**	**108**
	1.3 Community health center (operated by BMA)	H3	14
	1.4 Health clinic (privately operated)	**H4**	**24**
2.Shopping	**2.1 Department store**	**S1**	**34**
	2.2 Supermarket or discount store	**S2**	**88**
	2.3 Traditional market	**S3**	**122**
	2.4 Neighborhood shops	S4	6
3. Religious	**5.1 Royal temples**	**R1**	**5**
	5.2 Community temples	**R2**	**44**
	5.3 Other facilities for religious activities	R3	**34**
4.Recreation	4.1 Large or major public parks (>125 rai*)	P1	13
	4.2 Medium public parks (25–125 rai*)	**P2**	**74**
	4.3 Small public parks (<25 rai*)	**P3**	**112**
	4.4 Community recreation spaces or sports fields	P4	1

Note: Specific public space used to analyze statistically ($n \geq 20$) are highlighted.
* A rai is a unit of land area equal to 1600 m^2 (40 × 40 m).

Table 3
Number of respondents accessing specific public spaces using different modes of transportation (Y2), (N = 292).

Mode of transportation		Specific public spaces used to analyze statistically (n)			
		H1, H2, H4	S1, S2, S3	P2, P3	R1, R2
1	**Walking**	13	**63**	**39**	**54**
2	Bicycles	5	9	8	5
3	**Motorcycle taxis**	11	**29**	10	12
4	**Private cars**	**73**	**50**	14	**50**
5	**Buses**	**80**	**46**	10	**30**
6	**Taxis**	**96**	**29**	11	**32**
7	Vans	0	2	0	0
8	Three wheeled taxis	4	13	8	14
9	BTS	3	0	0	0
10	MRT	4	0	0	0
11	Trains	0	0	0	0
12	Private motorcycles	1	4	2	5

Note: Mode of transportation used for statistical analysis (n ≥ 20). Statistically analyzed transportation modes are highlighted.

3.4.2. Independent variables (X)

Table 4 shows the independent variables (X) that affect elder mobility. The independent variables were related to the individual, available transportation modes, travel patterns, destinations, and the urban spatial environment.

3.5. Data analysis

Crosstab and dummy techniques, bivariate correlation, and logistic regression were used for statistical analysis. Crosstab and dummy techniques were used to classify and contrast categories of data with baseline information. Crosstab was used to categorize independent variables into percentile groups. When the independent variable was categorical, dummy variables were used to contrast different categories [37]. Correlation analysis was used for finding the significant variables in relation to each dependent variable. Bivariate correlation was used to determine the empirical relationships between dependent variables and independent variables [38]. There was significant correlation at 95% and 99% confidence levels. Binary logistic regression was used to determine variables that significantly influenced the dependent variables [37].

4. Characteristics of respondents, their out-of-home activities, public spaces, and transportation modes

The data were collected using a questionnaire as was discussed in Section 3.3. Most of the respondents were 60–69 years old. Only 5% were over 80. Almost all of the respondents were Buddhists. Married people accounted for 73% of the respondents and 56% of the elderly were female. The majority of the respondents lived with their family. The average household size was 3.87 people. The household size increased in the suburbs. As seen in Fig. 4, health care was the most common out-of-home activity. The elderly widely used special and general hospitals for this activity more often than the smaller health care centers. Shopping ranked as the second most frequent activity and almost half of the elderly shopped at traditional markets. The third was travel to religious activities and the majority of religious activities were at community temples. The last activities were recreation and exercise. The elderly mostly used medium and small public parks for this purpose.

For transportation, 31.7% of the elderly used public transit, 24.4% used non-motorized means, and 14.7% travelled by a private mode. Fig. 5 show that walking was the most common way that the elderly

Table 4
Independent variables (X).

Variable name	Range of possible value for X variables	Sources
1 Age (AGE)	(1) 60–69, (2) 70–79, (3) 80–89, (4) ≥90 (years old).	[17,34]
2 Gender (GDR)	(1) Male, (2) Female.	[19,18,29,34,35]
3 Religion (RGS)	(1) Buddhist, (2) Christian, (3) others.	[15]
4 Marital status (MRS)	(1) Single, (2) married, (3) divorced, (4) widowed.	[20,18,15]
5 Education (EDN)	(1) No education, (2) primary school, (3) secondary school, (4) associate degree, (5) bachelor's degree, (6) master's degree or more.	[21]
6 Regular income (RGC)	(1) No income, (2) very low (<156), (3) low (156–469), (4) medium (469–939), (5) high (939–1563), (6) very high (≥1563) (USD per month). (32 THB = 1 USD, as of May 1, 2012).	[20,18,21]
7 Employment status (EMP)	(1) Retired civil servants, (2) retired employee, (3) business owner, (4) private employee, (5) casual worker, (6) others.	[21,15]
8 Household size (HHZ)	(1) 1, (2) 2, (3) 3, (4) 4, (5) 5, (6) 6, (7) more than 6 (persons).	[20,18,29]
9Time living at the current address (TLA)	(1) <1, (2) 1–5, (3) 6–10, (4) 11–20, (5) ≥21 (years).	[1]
10 House ownership (HWN)	(1) Owns a house, (2) does not own a house	[21]
11 Housing type (HST)	(1) Single house, (2) condominium, (3) shophouse, (4) flat, (6) others.	[21,18]
12 Ability to drive (DRS)	(1) Car, (2) motorcycle, (3) bike, (4) others, (5) none.	[21,26,14,11]
13 Physical capacity (Phy1 to Phy 8)	Having (1) ability to deal with information, (2) sight, (3) hearing, (4) use of arms, hands and fingers for motor movements, (5) leg and feet movements, locomotion, walking speed, (6) ability to bend, kneel, and sit, (7) correct body weight and size, (8) memory.	[1,6,23,15,16,18,19,20,29]
14Psychological capacity (Psy 1 to Psy 4)	(1) Sense of confidence, (2) sense of independence, (3) ability to make decisions, (4) satisfaction with life.	
15 Socioeconomic satisfaction (SE1-SE3)	(1) Enough income, (2) relationship with others, (3) social participation, cultural or traditional events.	
16 Frequency of visiting desired places (FQP)	(1) 1/day, (2) 1/week, (4) 1/month, (5) 2–3/month, (7) 1/year, (6) others.	[12]
17 Distance from home (DST)	(1) ≤0.5 km, (2) 0.6–3 km, (3) 3.1–8 km, (4) >8 km	[12,18,19]
18Independence of mobility (IDP)	(1) Self reliant, (2) with family members, (3) with group, (4) with caregiver, (5) others	[18,19]
19 Transportation modes used (TRM)	(1) Walking, (2) bicycle, (3) motorcycle, (4) private car, (5) bus, (6) taxi, (7) three wheel vehicle (8) mass rapid transit system	[12,14,6,22,36,26,27,15,21,11,7,17]
20 Travel time (TTM)	(1) <10 min, (2) 10–29 min, (3) 30–59 min, (4) ≥60 min.	[19,20,18]
21 Departure time (DPT)	(1) Morning, (2) daytime, (3) evening, (4) nighttime	[35]
22 Activity time (ATT)	(1) <10 min, (2) 10–30 min, (3) 30–60 min, (4) 1–2 h, (5) >2 h.	[19,20,18]
23 Residential location (RLC)	(1) Inner zone, (2) intermediate zone, (3) outer zone.	[14,21,18,29,7,34]
24 Destination (HSRP)	(1) Hospital, (2) shopping center, (3) religious place, (4) park.	[13,19,18,17].

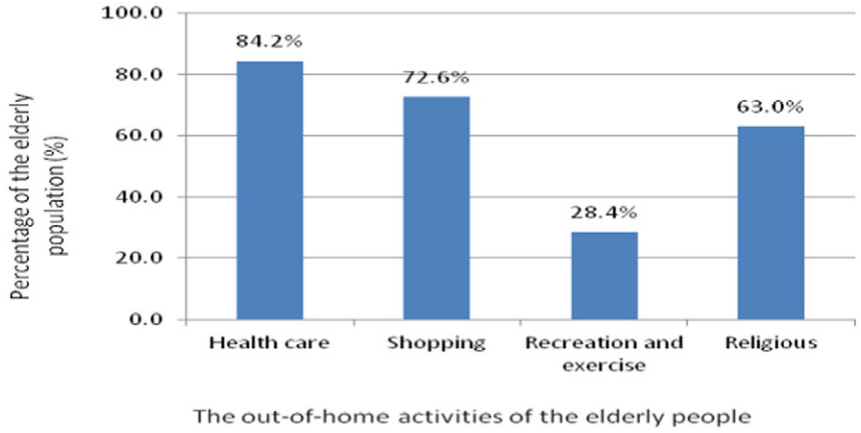


Fig. 4. The major out-of-home activities of the elderly in the selected areas of Bangkok.

travel. Automobile usage accounted for a high proportion of transportation. Bus trips were common in all areas, as was the use of taxis. Motorcycle taxis were generally used for trips of short distances. Rapid transit was not often used by the elderly.

5. Results

5.1. Factors influencing elder mobility in public spaces (YI)

From the model outputs of binary logistic regression, Table 5 shows the significant factors of model Y1. The factors that influenced elder mobility in their access to service centers were (1) distance (DST), (2) travel time (TTM), (3) residence location (RLC), and (4) independent mobility of the elderly (IDP). Most of the R^2 values in this model were higher than 0.5; however, the R^2 values for some public spaces were relatively small.

Short distances (<3 km) promoted mobility to access low-order public spaces that serve activities of everyday life and leisure (e.g., daily shopping, religious activities, and recreation). The average distance for shopping was 2.52 km, for recreation and exercise, it was 1.74 km, and for religious activities, 3.00 km. Longer travel distances (3–8 km) enabled access to essential activities in higher order public spaces. These included specialist or general hospitals and involved less frequent visits (once every 2–3 months). The average distance to access specialist or general hospitals was 6.47 km. Sometimes, a short distance can result in a long travel time due to traffic congestion. Likewise, a short travel time (10–30 min) influenced the elder mobility in their access to various types and orders of public spaces. This is because elderly with physical limitations find travelling longer distances difficult. Furthermore, this study found that most healthy elders tended to go by themselves for out-of-home on a daily basis. This reflects their independence. The results showed that independence (of mobility) enabled elder access to low- and medium-order shopping places. The reasons for this may involve their family responsibilities. Accessing shopping places is not a heavy burden because these places were often located in the center of the community. Moreover, this study analyzed residential locations in three urban zones having different densities and development patterns. The results showed that being in the inner zone (high density) promoted elder access to low- and medium-order public spaces. This study found that provision for appropriate and affordable services to meet the needs of the elderly is essential for them to maintain their mobility.

5.2. Factors influencing mobility and transportation mode used to access public spaces (Y2)

Table 6 shows the significant factors of model Y2. The factors influencing the transportation mode used (walking, cars, buses, taxis, and public motorcycles) by the elderly were (1) destination (HSRP), (2) residence location (RLC), (3) distance (DST), (4) housing type (HST), and (5) independent mobility of the elderly (IDP). Most of the R^2 values in this model were small, which implied that there are other factors impacting elder mobility beyond the variables considered. Low R^2 values also suggest that the elderly are a heterogeneous group.

High- and medium-order public space destinations for essential and leisure activities (hospital care and shopping) were facilitated by the

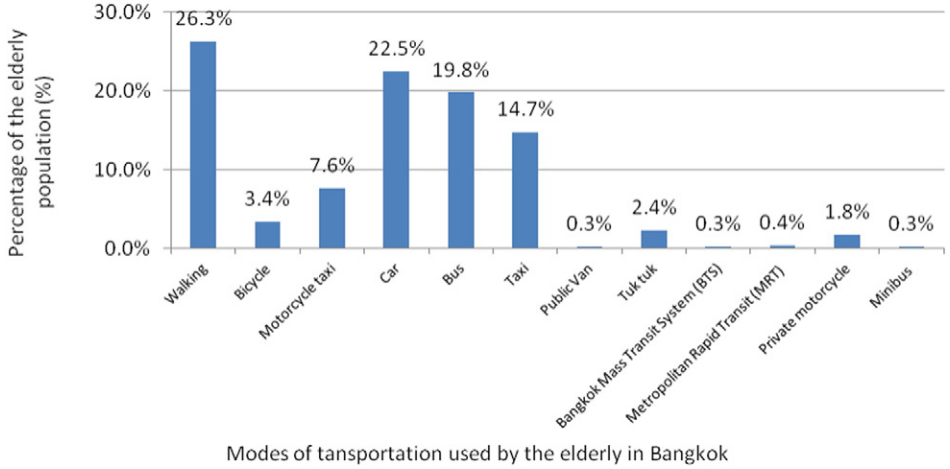


Fig. 5. Percentage distribution of transportation modes used by the elderly.

Table 5
Summary of factors influencing use of service centers accessed by the elderly.

Public spaces	Specific public spaces	AGE	RGC	HHZ	Phy6	FQP	DST	IDP	TTM	DPT	RLC	R^2
Health care centers	H1					√√	√√			√√		0.672
	H2			√√								0.511
	H4										√	0.180
Shopping centers	S1								√			0.415
	S2						√√	√√				0.672
	S3						√√	√√				0.669
Religious centers	R1	√√	√		√							0.075
	R2						√√		√√	√√		0.705
Public parks	P2										√√	0.240
	P3						√√					0.454

Note: √ significance ($\alpha < 0.05$) and √√ significance ($\alpha < 0.01$).

use of door-to-door modes of transportation. These are convenient, but more costly. However, the elderly need convenient transportation when they are faced with the fatigue associated with activities of long duration. More than 80% of elderly spent 1–6 hours at special, general hospitals, and base hospitals, 53% spent 1–2 hours at department stores, supermarkets, and discount stores. This may have contributed to travel difficulties. Travel to low order of public spaces for daily and leisure activities (traditional markets, small parks, and community temples) was accomplished by simple modes of transportation such as walking, using buses, and motorcycle taxis. This reflects that the locations of these public spaces were most likely to be in the respondent's neighborhood. Having a short distance influences elder mobility by enabling use of simple transport modes. However, the elderly often do not like to use cars and buses unaided. Lack of ability to drive and an inadequate bus system may encourage walking. The elderly who are independently mobile tend to walk, especially for shopping at supermarkets or discount stores. In Bangkok, this type of store is quite prevalent.

In terms of urban spatial systems, the zone in which one's residence was located influenced the use of various modes of transportation. In the inner zone, the elderly were less likely to use buses and cars due to congestion, pollution, poor bus stops, and risk of accidents. Moreover, in this zone, most of elderly lived in shophouses. This is a type of housing from which walking to access various public spaces is easy since there generally is sidewalk access. In the intermediate zone, the elderly were less likely to use cars, motorcycles taxi, and walking. This zone has well-developed public transit and therefore public transportation was more attractive. In the outer zone, the elderly tended to use taxis because the area was underserved by public transit. Developments in outer areas are scattered with very few destinations within walking distance.

In summary, the findings show that “distance and destinations,” “independence (of mobility),” and “urban systems and housing type” influenced elder mobility, access to public spaces, and transportation modes used.

Table 6
Summary of factors influencing modes of transportation used by the elderly to access service centers.

Transportation modes used to access public spaces		AGE	GDR	RGS	MRS	EDN	RGC	EMP	HWN	HST	DRS	Phy6	Phy7	Psy4	SE3	FQP	DST	IDP	TTM	DPT	ATT	RLC	HSRP	R^2
Walk	S1					√√				√														0.272
	S2																	√√				√√		
	S3													√			√				√√			
	P2							√		√						√	√√							0.329
	P3															√	√		√					
	R1																√√							0.310
	R2														√√			√√			√		√√	
Car	H1	√									√√		√					√√	√			√		0.221
	H2																						√√	
	H4									√													√√	
	S1					√				√√													√√	0.222
	S2																				√√			
	R1							√√		√								√√						0.346
	R2														√√			√√					√√	
Bus	H1						√√										√√	√√						0.162
	H2																	√√						
	H4																	√√						
	S1																					√		0.134
	S2																	√√						
	S3																√				√√		√	
	R1	√														√√			√√					0.144
	R2																√							
Taxi	H1																				√√		√	0.190
	H2																		√√					
	H4																					√√		
	S1				√				√		√							√√			√√			0.191
	S2																						√√	
	R1			√					√√										√√					0.195
	R2															√√								
Public Motorcycle	S1							√																0.252
	S2																√√					√√		
	S3											√								√√			√	

Note: √ significance ($\alpha < 0.05$) and √√ significance ($\alpha < 0.01$).

6. Discussion

6.1. Distance and destinations

The majority of the elderly tended to travel short distances. Many elders are troubled with fatigue and their mobility has declined. This finding is supported by other published studies [12,39] and exemplifies the concept of aging in place. The current study found that the public spaces accessed within short distances are usually categorized in a lower and medium-order hierarchy with ease of access in or near the community. Short walking distances are favored for elder mobility because walking does not require the assistance of others, has no cost, and does not require the ability to drive or ride. Walking benefits the elderly in their interactions with the people and the surrounding environment. Additionally, the elderly have leisure time to walk. Walking is an exercise that benefits elder health, as well as helping to keep them active and independent. Temelova and Dvorakova [39] found that walking was done for daily shopping, while public transit was used for health care visits. This finding suggests the need for development of approaches in neighborhoods that promote compact walkable communities. Mixtures of spaces for housing, shops, and other uses are common in Bangkok. Such development encourages social networks that provide a sense of familiarity and safety. However, city planning should avoid land use conflict that often arises in community development.

Temelova and Dvorakova [39] indicated that the elderly are more likely to make longer trips to visit doctors. The current study confirmed this result. Medical services are essential but less frequently used. In Bangkok, hospitals are clustered in the city's center. This result supports the central place theory, in which there is a parameter range and threshold for service centers that must be satisfied. As for the higher-order service centers, the elderly tended to use door-to-door modes like cars and taxis. This is supported by Prasertsabpakij and Nitivattananon [40]. Longer travel distances are necessary to access these services [27]. Nordbakke [35] confirmed that for some activities, the barriers to walking or using public transport are too great to overcome. The elderly will travel longer and further for high-order services (e.g., medical care) than for low-order services (e.g., grocery stores, fast-food restaurants, hair salons).

6.2. Independence (of mobility)

Independence promotes walking and reduces the use of vehicles. Previous research indicated that independence was related to the physical capacity of one's body, socioeconomic status, and social networks of the elderly. Elder socialization results in an improved quality of life [12]. In the current study, the majority of respondents were independent and mobile. Therefore, walkways should be designed to promote walking by the elderly as is often done in developed countries. This could be part of an integrated universal design for urban infrastructure and facilities.

The findings of the current study also indicated that the elderly who use buses tended to rely on other people to assist them. The majority of the respondents were aged 60–69 years. This group was less likely to use buses for personal mobility as the system inadequately serves elderly riders. However, bus fares are affordable by everyone. Schwanen and Páez [12] argued that using buses was perceived as a sign of independent mobility. Coughlin [16] found that public transit is more affordable for the elderly and necessary for independent mobility. Carr [17] indicated that the younger among the elderly had higher incomes than those who were very old. This impacted their transportation choices.

The findings also revealed that the elderly who use cars tended to rely on other people. More than 56% of the respondents who used private cars indicated that they depended upon their family members, a group of friends, or care givers. In contrast, a study of mobility and well being in later life done in the UK [41] showed that the elderly disliked being driven by others. Moreover, they avoided formation of structures and durable relationships rooted in dependence. However, Eastern cultures understand dependence upon others in more positive terms. Nordbakke [35] found that friendships and living in partnerships had positive effects upon travel. Schwanen and Páez [12] saw that the elderly who lacked support networks experienced consequent decreases in their quality of life.

6.3. Urban system and housing type

Urban systems and residential environments influenced transportation modes used. Living in the inner zone did not promote the use of cars and buses. This result is consistent with Limtanakool [42], who found that high-density areas were associated with a smaller number of private cars and more people walking. Dense traffic, lack of parking lots, and sidewalks were generally observed in this zone. However, mixed modes of transportation on roads and sidewalks may increase the risk of injury to the elderly in this zone. In the intermediate zone, there was less use of cars, motorcycle taxis, and walking because public transit is fully available in this area. Elderly in the outer zone had greater reliance on taxis. This is because other forms of public transport are limited. Taxis are the most convenient mode here, regardless of one's ability to drive or own a car.

7. Conclusions

This study assesses three types of factors that influence elder mobility in the study area. The first is the individual's independence, i.e., their mobility without assistance. The second is the distribution of public spaces. The third type is the urban systems. Independence encompasses physical and mental health, socioeconomic status, family support, and their impacts upon transportation choices. It is also impacted by the existing transportation infrastructure and services. The distribution of public spaces reflects a proper arrangement of small public spaces for daily and leisure activities within walking distance. These strongly influence elder mobility. Therefore, the community planning and neighborhood design is important for supporting elderly mobility. In distant areas, door-to-door modes of transportation are needed for convenient access to specific goods and services. In areas of high population density with adequate transportation services, the elderly prefer simpler modes of transpiration to access available public spaces near their homes. In outlying areas with limited public services and inadequate public transportation, the elderly access services using door-to-door modes and travel longer distances to access essential services.

The study suggests urban development and planning consider the urban structure, including public space hierarchy and provisions for transportation network services in different urban spatial systems to support the mobility of the elderly.

Acknowledgment

The authors thank the Royal Thai Government, Asian Institute of Technology, and the Fundamental Research Fund for the Central Universities, Beijing Jiaotong University, who financially supported this study through research grants. The authors also thank the respondents for their cooperation.

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