Measurement and Evaluation of Mobility for Daily Travel by Residents in Housing Developments in Suburban Area Using Capability Approach

Kazuki TERAYAMA*and Michiyasu ODANI*

Abstract:

In housing developments in suburban areas in Japan, where the residents are rapidly aging, securing and maintaining mobility for daily travel, such as shopping, and going to the hospital, especially by elderly residents who have difficulty driving cars, is an extremely important issue. Therefore, in order to create a suitable transportation policy for an aging society, it is first necessary to measure and evaluate individual mobility accurately, considering its diversity. This study aims to develop a new index for measuring and evaluating individual mobility using a capability approach proposed by Amartya Sen, based on our questionnaire survey, given to residents in a housing development in a suburban area of Kobe City. The main findings of this study are as follows:

1) The index of availability of a travel mode was defined as the product of individual resources and the ability to use those resources. It was assumed that individual mobility was described by a set of indices of three travel modes (walking, driving a car and using a car as a passenger).

2) Using indices of availability of the three travel modes, we showed the differences in individual mobility among age groups so as to reveal decrease in their mobility with age. We also classified respondents of each age group into mobility groups employing a cluster analysis so as to clarify the diversity of their mobility within each age group.

3) The number of elderly residents with poor mobility was estimated by setting the threshold of availability of each travel mode. Comparing the distribution of those residents with the location of facilities used by them in their daily lives in the study area, we found the lower accessibility districts where more elderly residents with poor mobility have to walk longer distances and along steeper routes to get to such facilities.

Keywords*:*

housing development in suburban area, mobility, capability approach, elderly residents

* Kobe University
E-Mail: 117w308w@stu.kobe-u.ac.jp

* This is an abstract peer-reviewed by the International Affairs Committee of the City Planning Institute of Japan for ISCP2014.

1. Introduction

In housing developments in suburban areas in Japan where the residents are rapidly aging, securing and maintaining mobility for daily travel, such as shopping, and going to the hospital, especially by elderly residents who have difficulty driving cars, is an extremely important issue. When focusing on elderly people's mobility, it should be noted that mobility is not always uniform among the elderly and depends on various factors; some elderly can drive a car, while others have difficulties even walking, due to poor physical condition. Therefore, in order to create a suitable transportation policy for an aging society, it is first necessary to measure and evaluate individual mobility accurately, considering its diversity.

Recently, the capability approach, as proposed by Amartya Sen[1)], has attracted attention in the field of study related to travel behavior (Beyazit[2)]; Martens and Golub[3)]; Nordbakke[4)]). We feel this approach to be appropriate for our study of the challenges noted in the subject above. Some previous studies using the capability approach in the field are as follows. Inoi et al. [5)] proposed achievable indicators of activities such as shopping and going to the hospital, and evaluated the effect of a community bus on those activities. Eitoku and Mizokami[6)] defined quality of mobility as QOM (Quality of Mobility) to evaluate individual's service level for traffic, and estimated the change in QOM caused by road improvement. Kita et al. [7)] proposed an accessibility index by public transport use in order to evaluate ease of opportunity to achieve an activity, considering the influence of a physical function of walking along a slope.

This study aims to develop a new index for measuring and evaluating individual mobility using the capability approach, based on our questionnaire survey, given to residents in a housing development in a suburban area of Kobe City. The index is used to calculate mobility of each resident in the study area and then residents are classified into mobility groups by age group in order to clarify the diversity in individual mobility within specific age groups. Finally, we estimate the number of elderly residents with poor mobility and show the spatial distribution of such residents within the study area.

2. Development of an index to measure individual mobility

2.1 Concept of measurement of individual mobility

In the capability approach proposed by Amartya Sen, individuals capabilities are defined as a set of "functionings" described by resources owned by each person and their ability to utilize these resources, thus making it possible to clarify the diversity of their capabilities. "Functionings" are "being" and "doing" that a person can achieve by using his or her resources and the ability to utilize these resources.

Chikaraishi et al. [8)] explained the concept of individual mobility as mobility where individual capability is a set of "functionings", defined by the capability approach. Individual mobility is composed of resources such as cars owned, public transportation services, and the ability to use these resources, such as physical ability, or the possibility of adjusting one's schedule to share a car with other drivers, etc.

In this study, in line with the capability approach, we assume that individual mobility corresponds to capability, and can be measured by a set of indices of availability of three travel modes for each person. Here, the three travel modes are "walking", "driving a car" and "using a car as a passenger." The resources and the ability to use those resources, which are taken into account in this study, are shown by travel mode in Table 1. We assume that resources are defined as manpower, tools, and services, which are provided by outside parties and the ability

to use those resources is defined as restrictions caused by physical function or time margin for activities, etc.

Table1. Resources and abilities to use resources by each travel mode

	resource	ability to use resource
walking	—	・physical ability ・walking speed
driving a car	・driver's license ・number of cars owned	・difficulty driving a car ・necessity of adjusting one's schedule to share a car with other drivers ・dynamic visual acuity
using a car as a passenger	・number of people who can pick them up and drop them off by car	・necessity of adjusting one's schedule to use a car as a passenger

(1) Availability of walking

With regards to walking, we don't take resources into account, but only walking ability. In this study, walking ability is described by "physical ability" and "walking speed." Physical ability, in our survey, is rated based on a scale of one to four with one being "don't feel any difficulties," two being "feel some burden when climbing stairs," three being "feel some difficulty going out without using a walking stick or cane," and four being "feel some difficulty going out without some others' assistance." Walking speed is a good way to describe walking ability, and is known to be different between males and females and decreases with age.

(2) Availability of driving a car

Resources are "driver's license" and "number of cars owned." Abilities to use resources are "difficulty driving a car", "necessity of adjusting one's schedule to share a car with other drivers" and "dynamic visual acuity". Both "difficulty driving a car" and "necessity of adjusting one's schedule" were rated based on a scale of one to five in our questionnaire survey. Dynamic visual acuity plays one of the most important roles in driving ability and is known to decrease with age.

(3) Availability of using a car as a passenger

"Number of people who can pick up them and drop them off" is assumed to be a resource. The ability to use this resource is "necessity of adjusting one's schedule to use a car as a passenger." This ability is rated on a scale of one to five, in our survey.

2.2 Formulation of an index to measure availability of a travel mode

We assume that availability of a travel mode can be defined as the product of individual resources and the ability to use those resources. Therefore, the index to measure availability can be expressed as:

$$A_i = \prod_{j=1}^{J} r_{ij} \times a_{ij} \quad , \tag{1}$$

$$a_{ij} = \prod_{n=1}^{N_j} \exp\left(-C_{ijn}\right) \quad , \tag{2}$$

where A_i is availability of a travel mode for individual i, and r_{ij} and a_{ij} represents jth resources and the ability to use jth resource respectively (j=1,…,J). As shown in Eq. (2), a_{ij} is given as an exponential function of C_{ijn} (n=1,…,N_j), which describes the decreasing phenomenon, n, of the ability to use jth resource. C_{ijn} is estimated based on the results of our questionnaire survey to residents, or is obtained from the observation results of past studies.

3. Outline of study area and data used

3.1 Study area

Figure 1 shows a map of the study area, a housing development area, called "Nishi Kobe new town", in Kobe city, Japan. The housing was built around 1971. Its total population is 11,866 and the average ratio of elderly people (people aged 65 and over) was 26.6% as of 2013. In the study area, 85% of the total number of houses are detached houses, and the rest are apartment houses which are located only in D-3 district.

As for the public transportation services in the study area, two railway stations are located outside the study area and bus routes cover almost all of the study area. However, the level of service provided by public transport is extremely low except during peak hours in the morning and evening.

In the study area, there is a large electric appliance store, a medium-sized supermarket, and three small food retail stores. There are three clinics located inside the study area, and four clinics outside.

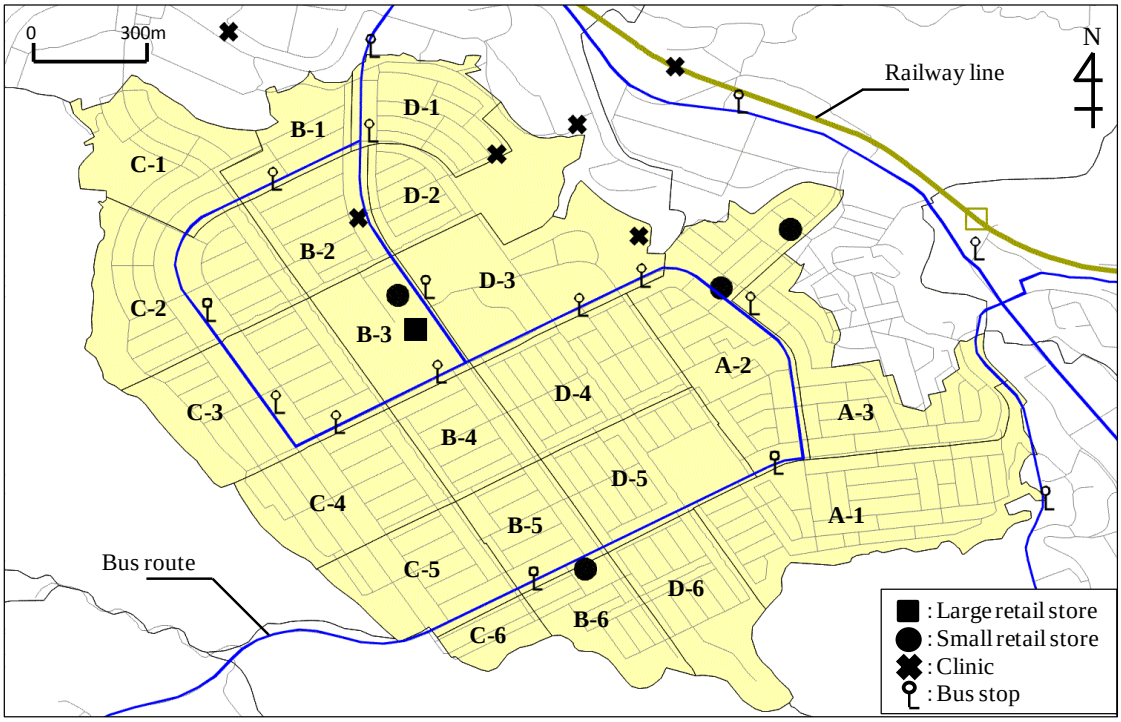

Figure1. Map of Nishi Kobe new town in Kobe City, Japan

3.2 Data used

The authors conducted a questionnaire survey to residents in the study area in October, 2013. In our survey, we asked about their personal attributes (age, gender, job, physical ability, driver's license, number of cars owned, etc.), daily travel behavior such as shopping and going to the hospital (travel mode, distance, frequency, destination, etc.), and opinions on transportation conditions and the environment around their houses.

Three questionnaires per household were placed in the mailboxes of 1,000 households on a random basis in 20 residential districts of the study area. Answer sheets were returned by mail. A total of 351 households answered the questionnaire. The collection rate was 35.1%. The total number of valid answers was 518 (1.48 respondents per household). The proportion of male to female in respondents was almost the same. Respondents aged 65 and over accounted for 56.9% of the total.

4. Fundamental analysis of respondents' resources and ability to use those resources

4.1 Characteristics of respondents' resources and ability to use those resources

Table 2 shows characteristics of factors related to respondent's resources and their ability to use those resources. From the table, the following was found.

As for physical ability, 83.1% of respondents don't feel any difficulty in walking, while 12.7% of respondents feel some burden when climb stairs, and a few feel some difficulty going out without using a walking stick or some others' assistance.

The majority of respondents hold a driver's license, and have at least one car in the household. About half of the respondents don't feel any burden when driving and don't need to adjust their schedule with other drivers, while 10.9% of the respondents feel slight or more burden when driving and 25.6% of the respondents need to adjust their schedule slightly or more with other drivers.

Respondents who can ask someone to pick them up and drop them off account for 46.7%. The most frequent answer regarding the number of people who respondents can ask for a ride is one person. The percentage of respondents who need to adjust their schedule is more than those who don't.

4.2 Analysis of factors influencing respondents' travel decisions

In this survey, some factors describing respondents' ability to use resources were obtained qualitatively, not quantitatively (for example, physical ability of a respondent is rated based on a scale of one to four). Then we tried to qualify those factors.

Respondents in the survey were asked how a decrease in their ability to use resources influenced their decisions of whether to go out or not, by each travel mode. A logistic regression model was employed to analyze the influence of respondents' ability on their decisions.

The dependent variable is respondents' decisions of traveling by each travel mode (if give up going out: 1, otherwise: 0). Explanatory variables of each travel mode are as follows;

In the case of walking, we used two dummy variables (if apply: 1, otherwise: 0) for two levels of physical ability; "feel some burden when climbing stairs" and "feel some difficulty going out without a walking stick or some others' assistance."

In the case of driving a car, two dummy variables for two levels of difficulty in driving were employed; "feel much burden" and "feel slight burden." In the same way two dummy variables for two levels of necessity of adjusting their schedule with other drivers; "feel much

necessity" and "feel slight necessity," were used.

In the case of using a car as a passenger, we used two dummy variables for two levels of necessity of adjusting a schedule to the convenience of people who can pick up and drop off; "feel much necessity" and "feel slight necessity."

Table 3 summarizes the estimation results of each travel mode. These models show good overall convergence, and all the parameters are significant at 1%, and their signs are plausible. In this table, odds ratio [(1)], calculated from the parameter of each level of respondents' ability estimated in the analysis, is also shown. We supposed that the odds ratio represents quantitatively the degree to which respondents' travel behavior is restricted by a decrease in the level of their ability. From the estimation results, the following can be said.

Estimated models demonstrate that a decrease in the ability to use resources, in any travel mode, shows a tendency to force respondents to give up going out. In walking, respondents who feel some difficulty going out without using a walking stick or some others' assistance are restricted much more than respondents who feel some burden when climbing stairs. When driving a car, respondents' possibility of going out decreases as difficulty driving a car and necessity of adjusting their schedule increases. When using a car as a passenger, the more necessity for adjusting their schedule respondents feel, and the less chance they have of going out.

Table2. Respondents' resources and abilities to use those resources

		N	%
Physical ability	don't feel any difficulty	393	83.1%
	feel some burden when climbing stairs	60	12.7%
	feel some difficulty going out without using a walking stick	6	1.3%
	feel some difficulty going out without some others' assistance	7	1.5%
	other	7	1.5%
Driver's license	not have	113	22.0%
	have	401	78.0%
Number of cars owned	0	39	7.6%
	1	256	50.1%
	2	176	34.4%
	3 or more	40	7.8%
Difficulty driving a car	feel much burden	15	3.8%
	feel slight burden	28	7.1%
	neither	34	8.6%
	don't feel so much burden	98	24.9%
	don't feel any burden	219	55.6%
Necessity of adjusting one's schedule to share a car with other drivers	feel much necessity	36	9.2%
	feel slight necessity	64	16.4%
	neither	15	3.8%
	don't feel so much necessity	102	26.1%
	don't feel any necessity	174	44.5%
Number of people who can pick up and drop off respondents by car	0	95	20.8%
	1	213	46.7%
	2	110	24.1%
	3 or more	38	8.3%
Necessity of adjusting one's schedule to use car as a passenger	feel much necessity	86	24.1%
	feel slight necessity	119	33.3%
	neither	17	4.8%
	don't feel so much necessity	79	22.1%
	don't feel any necessity	56	15.7%

Table3. Estimation results

variables		parameters	odds ratio	wald-statistic	
Walking (physical ability)	feel some burden when climbing stairs (if apply:1, otherwise:0)	2.949	19.1	76.8	**
	feel some difficuly ging out without using a walking stick or others' assistance (if apply:1, otherwise:0)	3.404	30.1	40.7	**
	constant	-2.631		167.9	**
	n		463		
	χ^2		108.2		**
Driving a car (difficulty driving a car)	feel slight burden (if apply:1, otherwise:0)	1.765	5.8	16.9	**
	feel much burden (if apply:1, otherwise:0)	2.322	10.2	13.6	**
	constant	-2.140		147.5	**
	n		380		
	χ^2		25.2		**
Driving a car (necessity of adjusting schedule with other drivers)	feel slight necessity (if apply:1, otherwise:0)	1.617	5.0	25.7	**
	feel much necessity (if apply:1, otherwise:0)	1.864	6.4	23.1	**
	constant	-2.036		117.3	**
	n		375		
	χ^2		38.5		**
Car passenger (necessity of adjusting schedule with people who can pick up and drop off respondents)	feel slight necessity (if apply:1, otherwise:0)	1.457	4.3	14.9	**
	feel much necessity (if apply:1, otherwise:0)	1.705	5.5	19.0	**
	constant	-2.398		58.0	**
	n		330		
	χ^2		25.7		**

**:significant at the level of 1%, *:significant at level of 5%

5. Calculation of indices of availability of three travel modes and analysis of characteristics of individual mobility

5.1 Calculation of indices of availability of three travel modes

To calculate the indices of availability of the three travel modes for each respondent using the equations defined in section 2.2, we need to specify r_{ij} (individual *i*'s *j*th resource) and C_{ijn} (individual *i*'s parameter describing the decreasing phenomenon *n* of the ability to use *j*th resource).

(1) Availability of walking

As mentioned before, we don't consider resource with regards to walking.

Walking ability is evaluated by "physical ability" and "walking speed". As for physical ability, we used odds ratio calculated from parameters of each level of physical ability (for example, "feel some burden when climbing stairs") in logistic regression analysis in section 4.2, was normalized into the values of 0 to 1. As for walking speed, we used observation results which were measured by gender and age group by Akutsu [9]. Walking speed was normalized into the values of 1 to 0 where the maximum equals 0 and the minimum equals 1. We used these normalized values as C_{ijn}, which correspond to respondents' answers in our survey or their personal attributes as age and gender.

(2) Availability of driving a car

The resources of driving a car (r_{ij}), are "driver's license" and "number of cars owned". Driver's

license is introduced as a dummy variable (if hold a license: 1, otherwise: 0). The number of cars owned is defined as the total number of cars in each household.

The ability to use these resources are described by the following three factors; "difficulty driving a car", "necessity of adjusting one's schedule to share a car with other drivers" and "dynamic visual acuity". As for the former two factors, we used the odds ratios obtained from parameters in logistic regression analysis, which were normalized into the values of 0 to 1, in the same way as "physical ability" described above. As for dynamic visual acuity, we used observation results which were measured by age group by Mitsui [10], and normalized visual acuity into the values of 1 to 0 in such a way that the maximum equals 0 and the minimum equals 1. We used these normalized values as C_{ijn}.

(3) Availability of using a car as a passenger

The resource of using a car as a passenger (r_{ij}), is "number of people who can pick up and drop off the respondents." This resource is introduced as the total number of people in each household and also friends.

The ability to use this resource is described by "necessity of adjusting one's schedule to use a car as a passenger". We also used the odds ratio calculated from parameters estimated in logistics analysis, which was normalized into the values of 0 to 1. We used these normalized values as C_{ijn}.

Using calculation results of the indices of availability of the three travel modes for each respondent, we showed the difference in individual mobility among age groups. Here, levels of availability of each travel mode were normalized into the values of 0 to 1 with the highest level being 1 and the lowest level being 0.

Figure 2 represents average levels of availability of the three travel modes by age group. As shown in this figure, all three indices of availability show a tendency to decrease as age group becomes older.

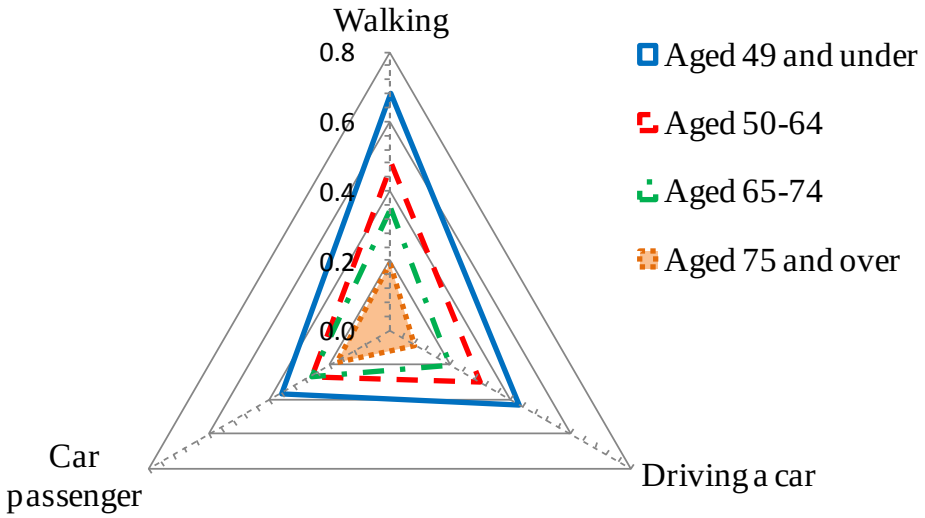

Figure2. Average levels of availability of three travel modes by age groups

5.2 Diversity of individual mobility within an age group

Individual mobility is not always uniform within an age group as was discussed before. We tried to classify respondents into mobility groups by age group with similar levels of availability of the three travel modes using a cluster analysis, so as to demonstrate the diversity of individual mobility within an age group. Levels of availability of each travel mode were normalized into the values of 0 to 1 as described above.

As for the results of the cluster analysis, respondents of each age group were classified into mobility groups (i.e. aged 49 and under: 3 groups, aged 50-64: 4 groups, aged 65-74: 4 groups, aged 75 and over: 3 groups). Table 4 summarizes calculation results of the average level of availability of the three travel modes by mobility group obtained in each age group. Mobility groups by age groups are presented in Figure 3. From this figure, the following types can be seen in mobility groups in each age group.

In every age group, mobility groups can be divided into two types, either easy for respondents to use a car (Type 1) or difficult for them to use a car (Type 2).

Mobility groups of Type 1 also include two types, a group with a high level of availability of driving a car (Type 1-a) and a group with a high level of availability of using a car as a passenger (Type 1-b).

For Type 1-a, the average level of availability of driving a car gradually decreases as the age group becomes older. In contrast, Type 1-b shows the peak average level of availability of using a car as a passenger in the group aged 50-64. The reasons for this phenomenon can be assumed as follows: in older groups aged 65 and over, the number of people who give respondents a ride decreases because of the decrease in the number of family members as the age of the group becomes older. In the younger group, aged 49 and under, most residents travel by driving their own cars or walking, and the necessity for car passenger is relatively low.

Mobility groups of Type 2 include two types, a group with a high level of availability of walking (Type 2-a) and a group with a low level of availability of walking (Type 2-b).

In the younger group aged 49 and under, Type 2-a can be seen with Type 1-a and Type 1-b, but Type 2-b is not seen. In the group, aged 50-64 and 65-74, both groups of Type 2-a and Type 2-b appear at the same time, and finally in the group, aged 75 and over, only Type 2-b, having difficulty of using a car, can be found, meaning that this type has the lowest mobility among the four age groups.

Table4. Calculation results of average level of availability of each travel mode by mobility groups in each age group

		Walking	Driving a car	Car passenger	n
Aged 49 and under	Average	0.685	0.429	0.364	56
	Group 1	0.708	0.815	**0.313**	18
	Group 2	**0.558**	**0.249**	0.459	28
	Group 3	1.000	**0.238**	**0.192**	10
Aged 50-64	Average	0.479	0.294	0.265	116
	Group 1	0.604	0.632	**0.255**	18
	Group 2	**0.379**	0.551	0.862	7
	Group 3	0.565	**0.172**	**0.175**	43
	Group 4	**0.369**	**0.239**	**0.261**	48
Aged 65-74	Average	0.352	0.198	0.264	142
	Group 1	0.405	0.406	0.289	29
	Group 2	0.361	0.327	0.703	12
	Group 3	0.402	**0.115**	**0.198**	78
	Group 4	**0.112**	**0.152**	**0.230**	23
Aged 75 and over	Average	0.196	0.082	0.180	53
	Group 1	0.313	0.159	**0.075**	16
	Group 2	0.292	**0.053**	0.469	14
	Group 3	**0.057**	**0.046**	**0.076**	23

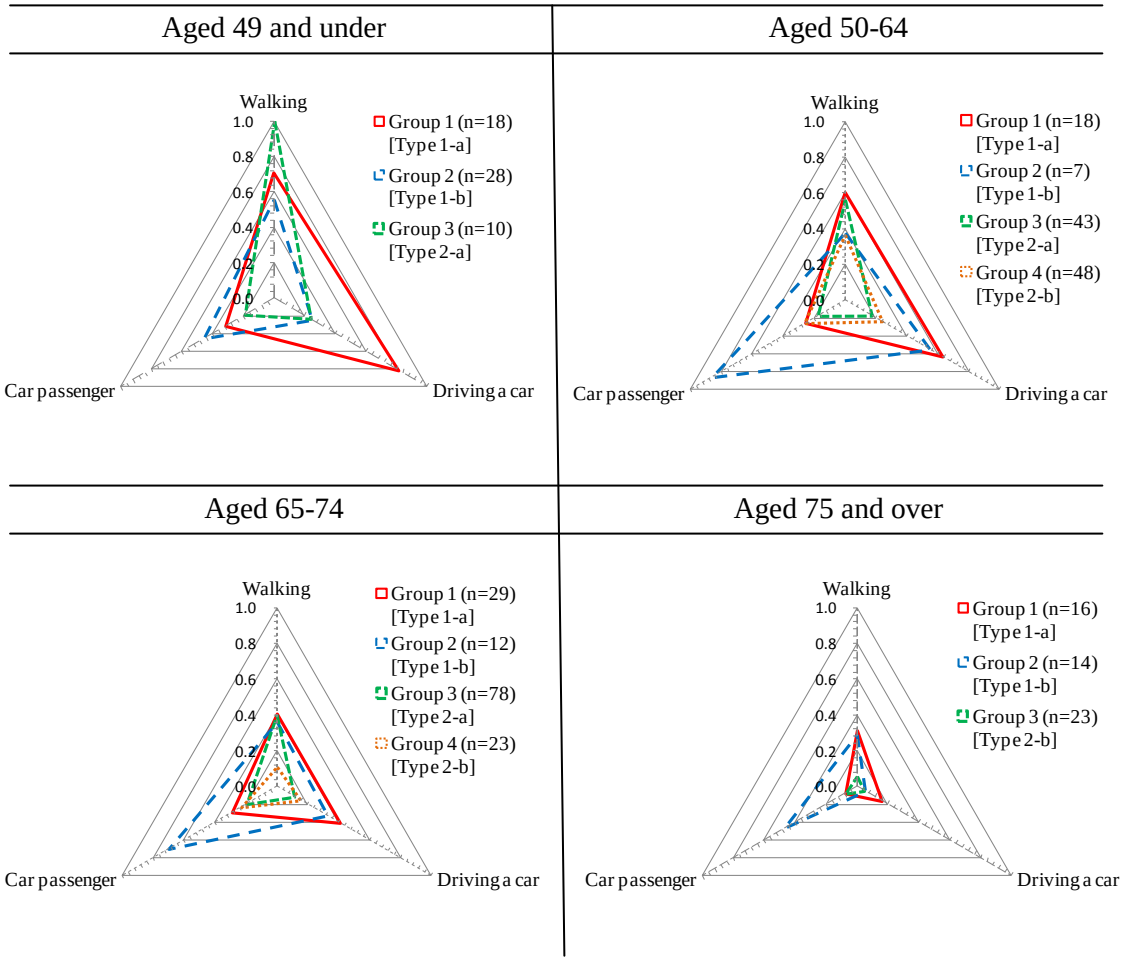

Figure3. Mobility groups by age groups

6. Estimation of the number of residents with poor mobility and their distribution in the study area

In this section, we estimate the number of elderly residents with poor mobility and show their spatial distribution in the study area.

We set the threshold of availability of each travel mode and assume that elderly residents with poor mobility are defined as those with all three indices of availability lower than the thresholds. There are number of ways to decide the threshold. In this study assumed the threshold be the level of availability of each travel mode in which 30% of the elderly respondents are included.

Table 5 shows the number of elderly respondents by how many indices of availability are lower than the thresholds of the three indices for travel modes. The result is summarized by age groups; a) aged 65 and over, b) aged 65-74 and c) aged 75 and over. As shown in this table, elderly respondents (aged 65 and over) with all three indices of availability higher than the thresholds account for 43.6%. On the other hand, elderly respondents with all three indices of availability lower than the thresholds, who are those with poor mobility, account for 6.2%. Comparing two age groups, b) aged 65-74 and c) aged 75 and over, the latter group has a higher percentage of respondents with two or three indices under the thresholds than the former.

The number of elderly residents with poor mobility is estimated by multiplying the elderly population of each residential district by the percentage of elderly respondents with poor mobility in the study area as mentioned above (6.2%). Figure 4 shows the spatial distribution of the number of residents with poor mobility by district on the map of the study area. In this figure, the number is indicated by the size of the circle. From this figure, the following can be pointed out: A-1 district has the highest number of elderly residents with poor mobility, followed by D-3, C-2 and A-2 district.

Comparing the spatial distribution of elderly residents with poor mobility with the location of facilities, such as retail stores, clinics and bus stops etc., which residents often visit in their daily lives, it was found that elderly residents in A-1 district have to walk longer distances and along steeper routes to get those facilities. It is surmised that those residents, therefore, have relatively lower accessibility in daily travel.

Table5. Number of indices of availability which is lower than the threshold of each travel mode

The number of indices of availability which is lower than the threshold of each travel mode	Elderly (aged 65 and over)		Aged 65-74		Aged 75 and over	
	n	%	n	%	n	%
0	85	43.6%	74	52.1%	11	20.8%
1	75	38.5%	57	40.1%	18	34.0%
2	23	11.8%	9	6.3%	14	26.4%
3	12	6.2%	2	1.4%	10	18.9%

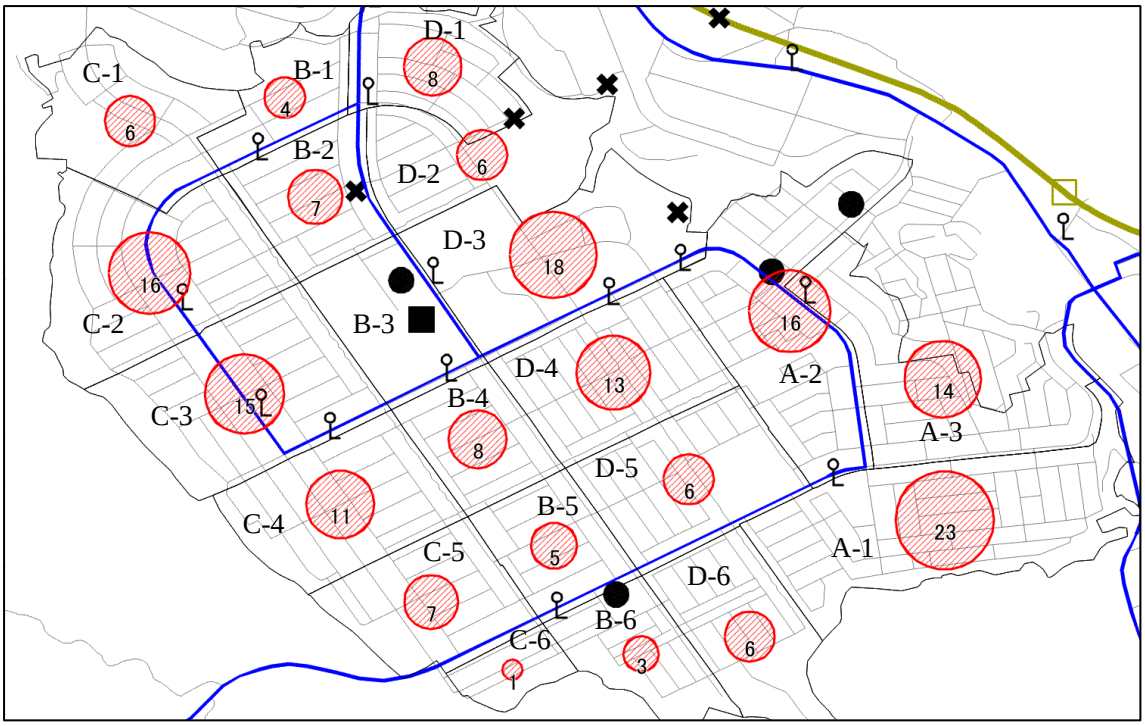

Figure4. Spatial distribution of elderly residents with poor mobility

7. Conclusion

In this study, we proposed using indices of availability of three travel modes to measure and evaluate individual mobility, based on the capability approach, and formulated those indices. Then, we calculated indices to show diversity in individual mobility by age group and estimated the number of elderly residents with poor mobility and their distribution in the study area. The main findings of this study are as follows:

1) The index of availability of a travel mode was defined as the product of individual resources and the ability to use those resources. It was assumed that individual mobility is described by a set of the indices of three travel modes (walking, driving a car and using a car as a passenger). In formulation of this index, we sought to quantify the influences of various factors describing the ability to use the resources, based on the results of our questionnaire survey. In addition, we introduced an exponential function so as to explicitly describe the decreasing phenomena of these abilities.

2) Using the indices of availability of the three travel modes, differences in individual mobility among age groups, as well as diversity within each age group was revealed. In order to clarify this diversity, we classified respondents of each age group into mobility groups employing a cluster analysis.

3) The number of elderly residents with poor mobility was estimated by setting the threshold of availability for each travel mode. Comparing the distribution of those residents with the location of facilities used by residents in their daily lives in the study area, we showed the lower accessibility districts where more elderly residents with poor mobility have to walk longer distances and along steeper routes to get to those facilities.

Finally, we would like to suggest the following points as possible avenues of future research.
1) Factors which describe individual resources and the ability to use those resources, other than the ones introduced in this study, need to be examined. In addition to the three travel modes, it is necessary to take public transportation and bicycles into account when measuring individual mobility.
2) The index of availability of each travel mode was formulated as the simple product of the individual resources and the ability to use those resources (this ability is expressed as an exponential function). Then, we need to examine the possibility of applying a different formulation for the index.

Note:
(1) Odds ratio means that the degree to which event (Y) under situation (A) is likely to happen compared with situation (B), specifically how many times higher. In the case of walking, respondents who feel some burden when climbing stairs give up going out 19.1 times (odds ratio) more often than respondents who don't feel any such burden.

References:
1) Sen, A., 1985. Commodities and Capabilities, Oxford University press
2) Beyazit, E., 2011. Evaluating Social Justice in Transport: Lessons to be Learned from the Capability Approach, Transport Reviews: A Transnational Transdisciplinary Journal 31:1: 117-134
3) Martens, K., Golub, A., 2012. "A justice-theoretic exploration of accessibility measures": Accessibility Analysis and Transport Planning Challenges for Europe and North America: 195-210
4) Nordbakke, S., 2013. Capabilities for mobility among urban older women: barriers, strategies and options, Journal of Transport Geography, 26: 166-174.
5) Inoi, H., Nitta, Y., Nakamura Y., 2004. Evaluation of the effect by the community bus considering Capability Approach, Infrastructure Planning Review of the Japan Society of Civil Engineers, Vol.21: 167-174 (in Japanese)
6) Eitoku, Y., Mizokami, S., 2008. A Method on Evaluation of Differences in QoM among Regions, Infrastructure Planning Review of the Japan Society of Civil Engineers, Vol.25: 109-120 (in Japanese)
7) Kita, H., Ono, Y., Kishino, K., 2012. Development of the Accessibility Index Considering Physical Performance in Public Transport Use, Journal of Japan Society of Civil Engineers D3, 983-990 (in Japanese)
8) Chikaraishi, M., Fujiwara, A., Zhang, J., Tsukai, M., 2012. Conceptualizing and Measuring Elders' Mobility: A Capability Approach, Proceedings of Infrastructure Planning, Vol. 45, CD-ROM (in Japanese)
9) Akutsu, K., 1975. Science of walking, Fumaido publication, 56-57 (in Japanese)
10) Mitsui, T., 2001. Older Driver's Visual Ability and Recognition of Road Sings, Expressways and Automobiles, 44: 37-41 (in Japanese)