SPACE-TIME ACCESSIBILITY MEASURES FOR EVALUATING MOBILITY-RELATED SOCIAL EXCLUSION OF THE ELDERLY

Izumiyama, Hiroshi
Institute of Environmental Studies, The University of Tokyo, Tokyo, Japan
Email: izumiyama@ut.t.u-tokyo.ac.jp

Ohmori, Nobuaki
Department of Urban Engineering, The University of Tokyo, Tokyo, Japan
Email: nobuaki@ut.t.u-tokyo.ac.jp

Harata, Noboru
Department of Urban Engineering, The University of Tokyo, Tokyo, Japan
Email: nhara@ut.t.u-tokyo.ac.jp

SUMMARY

Towards aged society, it is important to provide better mobility and accessibility for the elderly and disabled people, so that they can live their independent lives in community. The elderly have a wide range of constraints on participating in out-of-home activities; for example, physical disadvantages, keeping regular lifestyles for their health and entrenched habits, limited space-time areas of activity engagement for both safety problems and limited ability of information acquisition, and monetary budget constraint. In addition, people who cannot drive a car depend more on public transport service and need their household members' help when they go out. Therefore, their choice sets of feasible activity-travel patterns are strongly restricted by these constraints. This is regarded as one of the mobility-related "social exclusion" problems. It should be useful to analyze the feasibility of activity participation of the elderly under personal and environmental constraints they face in their daily lives. The objectives of this study are (1) to propose and validate a method for evaluating mobility-related social exclusion based on the concept of space-time accessibility and (2) to investigate the elderly people's constraints in their activity schedules by examining how they adjust activity schedules when participating in out-of-home activities.

Space-time accessibility measures represent the ease to participate in out-of-home activities, considering possibility of activity engagement under space-time constraints. Data required for the analysis consist of activity schedules of individuals, transportation network, and locations and opening hours of activity opportunities. In December 2005, we conducted a questionnaire survey to collect information on activity diaries and scheduling adjustment for participating in a medical care activity at two general hospitals. The respondents were people of 65 years and over who came to either of the two hospitals in Akita city. The number of samples was 70. Based on space-time constraints of daily in-home mandatory and maintenance activities, space-time accessibility measures to participating in a medical care activity at the hospitals were calculated. Information on spatial distribution of the elderly population from the Population Census data was used for analysis of accessibility evaluation in urban scale. Geographic information system (GIS) was used for data management and representation of the results.

From a series of analyses, we identified a considerable gap in accessibility between individuals with and without car, and between urban and suburban areas. It was also found that the elderly adjusted their activity schedules (adjustment in start time, duration of activities) to participate in a medical care activity as compared to their daily regular schedules. The proposed method makes it possible to evaluate the impacts of policy measures for mitigating mobility-related social exclusion, which incorporate not only the improvement of transportation services, but also the improvement of activity opportunities and household activity schedules.

Key Words: space-time accessibility; social exclusion; the elderly

INTRODUCTION

Towards aged society, it is important to provide better mobility and accessibility for the elderly and disabled people, so that they can live their independent lives in community. The elderly have a wide range of constraints on participating in out-of-home activities; for example, physical disadvantages, keeping regular lifestyle for their health and entrenched habits, limited space-time areas of activity engagement for both safety problems and limited ability of information acquisition, and monetary budget constraint. In addition, people who cannot drive a car depend more on public transport service and

sometimes need their household members' help when they go out. Therefore, their choice sets of feasible activity-travel patterns are strongly restricted by these constraints. Furthermore, especially in local cities, motorization has been promoting relocation of large-scale facilities (shopping centers, hospitals, etc.) to suburban areas, and the level of public transport service has been decreasing. More often, the elderly with lower mobility face the situations that they cannot participate in out-of-home activities as they like. This is regarded as the mobility-related "social exclusion" problem. Kenyon et al. (2002) defined the mobility-related exclusion as "*the process by which people are prevented from participating in the economic, political and social life of the community because of reduced accessibility to opportunities, services and social networks, due in whole or in part to insufficient mobility in a society and environment built around the assumption of high mobility*." It should be useful to analyze the feasibility of activity participation of the elderly under personal and environmental constraints they face in their daily lives.

Conventionally, travel time or generalized travel time from a reference location such as home or the workplace to an activity opportunity is used for a basic measure of accessibility. However, it represents only the effort (or ease) of overcoming spatial separation. Essentially, both spatial and temporal components of accessibility, which represent potential of participating in activities at opportunities, should be evaluated taking into account the fact that travel is a demand derived from engaging in activities. The space-time prism constraint formalized by Hägerstrand (1970) is a very useful idea for specifying alternative feasible activity-travel patterns in time and space. Burns (1979) expanded the concept of accessibility into space-time dimensions, "space-time accessibility," introducing the activity duration at opportunities based on the prism constraints. Lenntorp (1978) operationalized Hägerstrand's approach by developing PESASP model that calculated the total number of space-time paths given a specific activity program and the urban transport network. In recent studies, Kwan (1998) and Miller (1999) operationalized the space-time accessibility measures on a real world transport network using Geographic Information Systems (GIS). These space-time accessibility measures represent the potential of activity participation under space-time constraints, which incorporates activity duration at and opening hours of activity opportunities, and individual activity schedule. Therefore, it could be useful as a measure of mobility-related social exclusion. The authors have proposed the advanced space-time prism concept with individual scheduling adjustment (Ohmori et al., 1999) and evaluated the impacts of changes in transport system and activity opportunities on

space-time accessibility to hospitals for the elderly (Ohmori and Harata, 2004). However, it has not been investigated how the elderly adjust their schedules. The objectives of this study are (1) to propose and validate a method for evaluating mobility-related social exclusion based on the concept of space-time accessibility and (2) to investigate the elderly people's constraints in their activity schedules by examining how they adjust activity schedules when participating in out-of-home activities.

METHODS FOR MEASURING ACCESSIBILITY

1. Study Area

A case study was conducted in Akita, a local city in Japan. The population consists of about 318,000 and the ratio of people aged 65 years and over (the elderly) is 17.5% (the 2000 Population Census). In the near future, the ratio of the elderly of Akita prefecture is expected to be the highest in Japan. Accessibility to a medical care activity at general hospitals was evaluated as one of the most important activities for the elderly people's daily lives. Two accessibility measures were defined in this study: (1) the minimum required time for travel and activity participation; and (2) the percentage of the elderly who can engage in the activity under space-time prism constraints. Two travel modes, car and bus (with walk access/egress), were considered in the analyses. Data on population of the elderly at 216 residential zones (about 1 km × 1 km square), road and bus networks, and location of general hospitals with the attribute of opening (consultation) hours were prepared in MapInfo GIS.

2. Minimum required time for travel and activity participation

Travel time by car from each residential zone to the hospitals was assumed the travel time traveling the route of the minimum travel time calculated on the road network. Travel time by bus was assumed the travel time traveling the route of the minimum generalized travel time calculated using the equivalent coefficients of different modes: in-vehicle time, walk access/egress, transfer and waiting (Nitta et al., 1995; Ohmori and Harata, 2004). Bus network data (a total of 800 bus stops and 121 routes) were originally prepared by the authors. The minimum required time for travel and activity participation was defined as the total time of traveling from home to the hospital and from the hospital to home and the required activity time at the hospital.

3. Feasibility of activity participation as a space-time accessibility measure

This measure explicitly incorporates not only the minimum required time for travel and activity participation but also space-time prism constraints formalized from the individual activity schedule and opening hours of opportunities. Based on the authors' previous work, activities were classified into three types: Activity (a) is an almost fixed activity (sleep and meals); Activity (b) is a planned but flexible activity (personal care, housework, etc.); and Activity (c) is a discretionary activity (hobbies and entertainment, reading books, watching TV, etc.). The feasibility of medical care activity participation at hospitals was calculated based on the advanced space-time prism concept (Ohmori et al., 1999 and 2003); a person starts traveling at the earliest end time of an Activity (a), arrives at the hospital within the consultation hours, spends time for waiting, consulting a doctor and getting some medicine, leaves the hospital and returns home at the latest start time of the next Activity (a) (see Figure 1). In the authors' previous study, it was assumed that the start/end time of activity (a) was fixed, whereas in this study the start/end time of activity (a) can be adjusted within a certain time window.

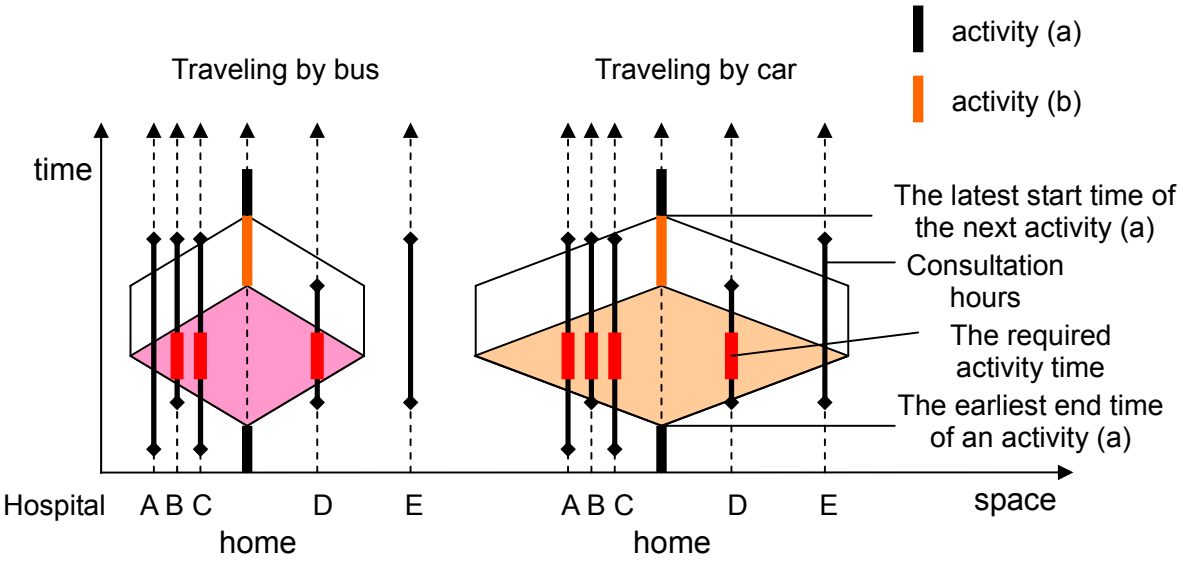


Figure 1 Differences in feasibility of activity participation at hospitals when traveling by car and bus under space-time constraints

4. Questionnaire survey

We conducted a questionnaire survey in December 2005, in Akita city. A total of 357 questionnaire sheets were distributed to the elderly people at two major general hospitals (Hospital A and B in Figures 2, 3 and 4) and 70 valid questionnaires were returned. Information obtained was socio-demographic characteristics (age, sex, occupation, household members, home location, license holding, etc.), activity-travel

diary on the day, the earliest and latest start time and duration of sleeping and having meals in daily life, and undesired adjustment of activity schedules on the survey day. A total of 42 respondents were male, 34 were 75 years or over, 38 had driving license and only 1 was a fulltime employee. Travel mode to the hospitals were car-driver (32 respondents), car-passenger (18), bus (7), taxi (6), walk (4) and other (3). Some respondents used a different travel mode in returning home, e.g., car-passenger when coming to the hospital but taxi when returning home.

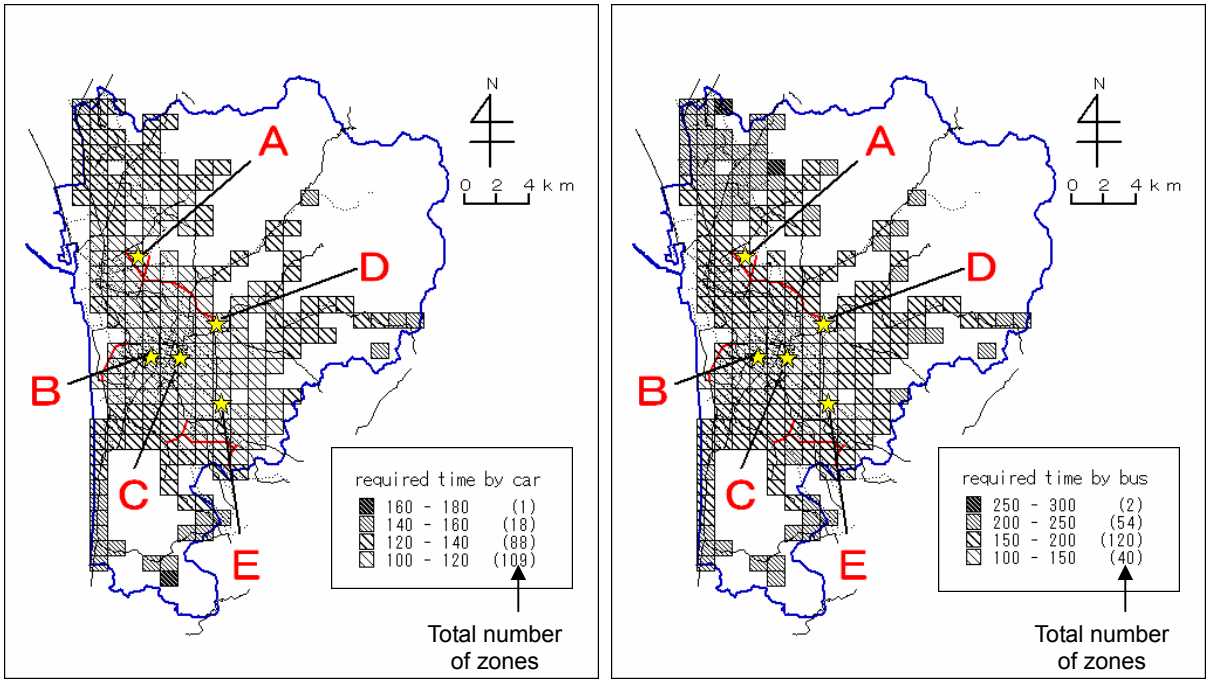
EVALUATION OF ACCESSIBILITY

1. Minimum required time for travel and activity participation

In Figure 2, each square zone represents the "shortest" required time for travel and activity participation among 5 hospitals. When traveling by car, the required time is 100–120 minutes for about half of the zones and even the maximum time is less than 180 minutes. However, when traveling by bus, the required time is less than 150 minutes for only about 20% of the zones and for about 30% of the zones mainly in north and south part of the city is more than 200 minutes. Figure 3 shows its difference between car and bus. For about 50% of the zones, the difference is more than 50 minutes. In particular, the elderly living in suburban areas and without car availability need longer time for consulting a doctor at general hospitals.

2. Feasibility of activity participation as a space-time accessibility measure

It was assumed that daily activity schedules of the elderly depended on age and sex. For 4 segment groups, younger (aged 65–74 years) men, younger women, older (75 years and over) men and older women, different sets of activity schedules were created from a total of 65 respondents' information on the timing and duration of Activities (a) and (b) as described in the previous section. The elderly of 4 groups in each 216 zone were supposed to have the same distribution of activity schedules as the sample. The percentage of the elderly who can engage in the activity at hospitals was calculated using the number of population of the 4 groups in the 2000 Population Census data. The required activity time at the hospital was set as 1.68 hours (the mean time spent at hospitals in the activity diary). As shown in Figure 4, when traveling by car, the percentages of the elderly who cannot engage in the activity at any of the five hospitals are less than 5% for most zones and the maximum is less than 10%. However, when traveling by bus, the number of the zones of where the percentage is less than 10% is



Traveling by car　　Traveling by bus

Figure 2 Minimum required time for engaging in a medical activity when traveling by car and bus in each zone (minutes)

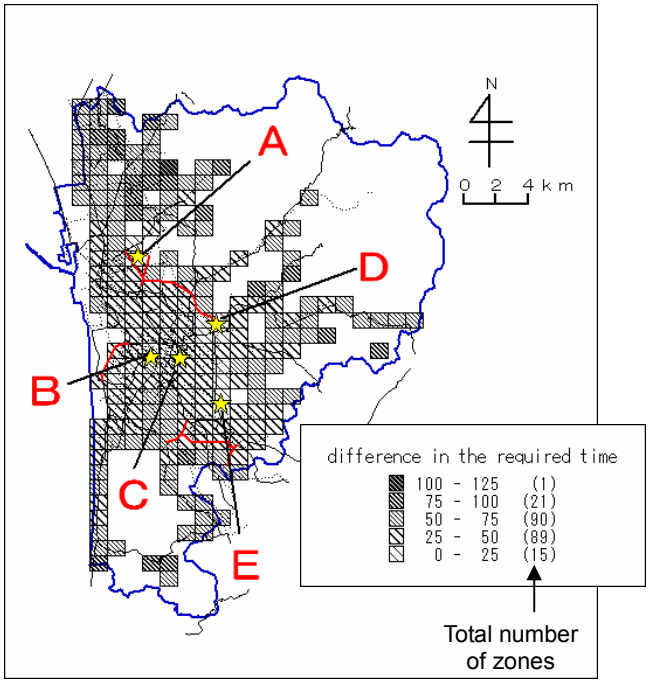
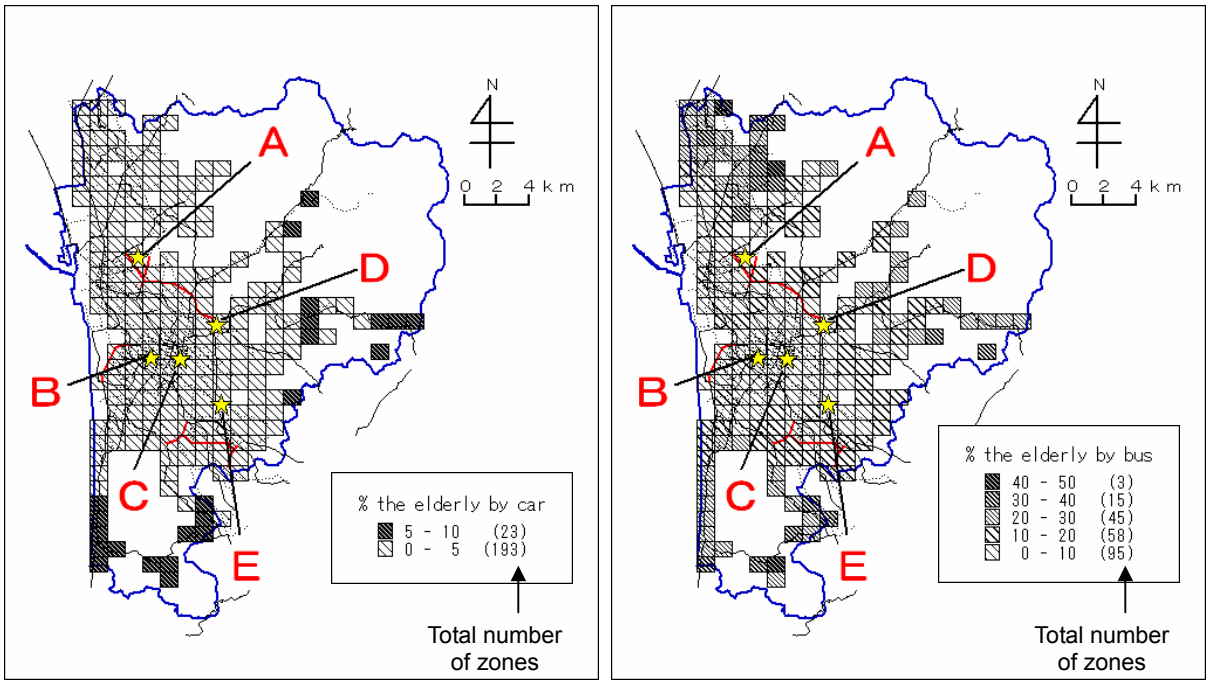


Figure 3 Difference of the minimum required time between traveling by car and bus in each zone (minutes)

only 95 and there are the zones showing relatively higher percentages (more than 30%) mainly in north and south part of the city. The result shows the existence of the elderly who cannot engage in consulting a doctor at any general hospitals when keeping their daily regular activity schedules.



Traveling by car Traveling by bus

Figure 4 Percentages of the elderly who cannot participate in a medical care activity at any of the five hospitals under space-time constraints in each zone

4. Activity adjustment when going to hospital

Respondents were asked whether they had any of the following activities on the survey day:

- Activities of which they would like to have increased or decreased the duration more than 15 minutes;
- Activities which they would like to have started more than 15 minutes earlier or later;
- Activities which they would like to have conducted before (or after) noon; and
- Activities which they would like to have conducted but were not able to have done at all.

it is considered that the respondents who had any of the above activities made some undesired adjustment of their activity schedules for participating in a medical activity at hospitals. A total of 33 respondents had the activities and among them 19 respondents adjusted Activity (a); for example, 8 of them delayed the start time of having lunch, 5 advanced the start time of having breakfast, 3 reduced the duration of sleeping, etc. The

ratio of the respondents who did this undesired adjustment of Activity (a) was higher for female (39% of the female respondents), younger elderly (39%), car-passenger user (39%) and bus user (43%). If the elderly came to hospitals by car-passenger mode escorted by other household members, we asked the drivers whether they did undesired activity adjustment for the escorting the elderly. We received answers from only 8 drivers but 3 of them answered that they did it for mandatory and maintenance activities. Medical care activity participation at hospitals affected not only activity schedule of the elderly but also that of the drivers. The result also supports that the proposed space-time accessibility measure which evaluates possibility of out-of-home activity participation within space-time prisms with scheduling adjustment is reasonably operationalized.

CONCLUSION

From a series of analyses, we identified a considerable gap in accessibility between individuals with and without car, and between urban and suburban areas. It was also found that the elderly did undesired adjustment of their activity schedules (adjustment in start time, duration of activities) to participate in medical care activity at hospitals compared to those in regular days, which also supports the validity of the space-time accessibility measure with scheduling adjustment previously proposed by the authors (Ohmori et al., 1999 and 2003; Ohmori and Harata, 2004). The method makes it possible to evaluate the impacts of policy measures for mitigating mobility-related social exclusion, which incorporate not only the improvement of transportation services, but also the improvement of activity opportunities and household activity schedules. Further research concerns analyses of car-passenger mode availability by introducing car-driver's schedule constraints (Ohmori et al., 2003), the use of more detailed GIS data on zones and transport network for taking account of walk environment, and accessibility evaluation including activities engaged in by information and communications technologies (ICTs) such as telemedicine. This study examined accessibility as the potential of social exclusion, whereas investigating the relationship between accessibility and "activity space" (Schönfelder and Axhausen, 2003) based on the revealed travel pattern needs to be explored in the future research.

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