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Stjepan Lakušić – EDITOR

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Faculty of Civil Engineering
University of Zagreb
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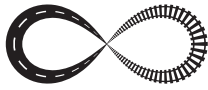
EVALUATION OF DIFFICULTY IN MAKING HOSPITAL BY EACH TRANSPORTATION MODE IN DEPOPULATED AREA – USING NATIONAL HEALTH INSURANCE DATA

Yuma Morisaki[1]**, Makoto Fujiu**[2]**, Junichi Takayama**[2]**, Kiyoko Yanagihara**[3]**, Tatsuya Niahino**[2]**, Masahiko Sagae**[4]**, Kohei Hirako**[5]

[1] *Division of Environmental Design, Graduate School of Natural Science and Technology, Kanazawa University, Japan*
[2] *Faculty of Environmental Design, Institute of Science and Engineering, Kanazawa University, Japan*
[3] *Faculty of Health Sciences, Institute of Medical, Pharmaceutical and Health Sciences, Kanazawa University, Japan*
[4] *Faculty of Economics and Management, Institute of Human and Social Sciences, Kanazawa University, Japan*
[5] *Organization of Frontier Science and Innovation, Kanazawa University, Japan*

Abstract

In Japan, the declining birthrate and the aging population are progressing remarkably. About public transportation, such as route reduction, abolishing due to reducing customers are serious problems in rural areas, Japan. Furthermore, there are social problems such as ensuring mobility for those who need public transportation in regional areas where the public transportation quality declined. Based on above problems, we targeted aged patients who are considered to need public transportation in Hakui-City, Ishikawa Prefecture in this study. The purpose of this study is to propose the index of quantitative assessment on difficulty attending the hospital for aged person who lives in depopulated areas considering regional characteristics. Analysis procedure is as follows. First, principal component analysis considering regional charasteristics in hakui-city in terms of neighborhood units was evaluated. Second, Utilizing National Health Insurance Data in Hakui-city, number of patients by diseases were examined for each district. As a result of this analysis using principal component analysis and National Health Insurance Data, it became possible to evaluate accessibility and to examine the details of the number of aged patients by disease in Hakui-City in terms of neighborhood units. The authors conclude that result of this analysis is an important suggestion for revitalizing regional public transportation and measures to realign it. These results can be effectively utilized to solve problems in the area with similar problems in Japan. It is expected that Japan's aging will proceed further in the future, then, one of results of this study which is accessibility for aged patients is useful to take some countermeasures for aged patient in Japan.

Keywords: aged person, making hospital, depopulated area, mobility

1 Introduction

1.1 Current state and problems of depopulated area

In Japan, in the course of the rapid economic growth since the 1950s, the Japanese population has become more concentrated in urban areas owing to large-scale population movement. This trend has led to the problem of depopulation that is accompanied by the decrease in population living in local agricultural, mountainous, and fishing village areas. In Japan, which is on the verge of becoming a society with a majority of elderly persons, the problems of decay in education, healthcare, fire prevention, and transportation infrastructure that have accompanied the decline of vitality of Japan's regional cities and agricultural, mountainous, and fishing village areas where depopulation is progressing cannot be ignored. Particularly, in view of today's so-called "super-aging" trend, the fact that many elderly persons are living in depopulated areas [1], and the risks posed by the higher susceptibility of elderly persons to contracting diseases, the following issues are essential and must be addressed as soon as possible: enhancement of the healthcare system in depopulated areas, facilitation of access to healthcare institutions, and provision of public transportation infrastructure.

1.2 Purpose of this study

In this study, elderly persons at high risk of contracting a disease were included as subjects. The purpose of the study was (a) to conduct a quantitative assessment about the extent of the difficulty in visiting a hospital from a detailed unit of the machiaza or, loosely, the "town neighbourhood" in depopulated areas and (b) to inhibit the decay and obsolescence of the provision of healthcare and public transportation in the future. In addition, regarding the variables considered for quantitative assessments, by utilizing a geographic information system (GIS), the difficulty in visiting healthcare institutions is evaluated by setting variables that focus on the characteristics of the region, such as the terrain, state of local roads, and provision of local transportation infrastructure. Moreover, the difficulty of visiting a hospital and actual state of the environment for seeing a doctor in depopulated areas, in other words, the question of the number of patients living in a given town neighbourhood, is clarified. This is done by checking the number of patients in each town neighbourhood and the values of the quantitative assessments, which are derived by utilizing the National Health Insurance database (hereinafter "KDB data") that includes healthcare big data.

2 Previous Studies

2.1 Studies focusing on elderly patients living depopulated areas

Many studies focusing on elderly patients living in depopulated areas have been conducted to date. For example, MORIYAMA et al. [2] focused on the importance of ensuring life transportation for elderly persons living in hilly and mountainous areas; they proposed a demand forecast model for public transportation services based on a discrete continuous model. To consider the population trends, MORITA et al. [3] selected areas that were depopulated and had population with advanced age; they clarified the reasons why people settle in or move from such areas. In addition, they classified the settlements based their characteristics and proposed the mode of intensive habitation for the target areas. In addition, studies focusing on elderly persons with diseases living in depopulated areas were also conducted. To examine the characteristics of the quality of life of elderly persons with chronic diseases living in depopulated areas, TAKAHASHI et al. [4] focused on three regions: Iwate Prefecture, Miyagi Prefecture, and Tokyo Metropolitan Area. These authors conducted a comparative analysis with factorial analysis of variance. In addition, KOIZUMI et al. [5] clarified the circumstances

of the social activities and lives of elderly patients with chronic diseases and examined the support methods for life management. IDE et al. [6] conducted a geographical information-type analysis about the difficulty encountered by elderly persons in depopulated areas in visiting hospitals using a Voronoi analysis, which is a mathematical index of neighborliness.

2.2 Positioning of this study based on previous studies

As noted in section I, this study conducts quantitative assessment to measure the difficulty in visiting healthcare institutions from each town neighborhood in depopulated areas. It also clarifies the actual state of the environment for seeing a doctor in depopulated areas by comparing the assessment values with the number of patients calculated using KDB data. This study mainly focuses on elderly persons with diseases. Differences with the studies of MORIYAMA et al. [2] and MORITA et al. [3] can be clearly observed as regards the methods used for the quantitative assessment of the difficulty in visiting a healthcare institution. Moreover, although TAKAHASHI et al. [4] and KOIZUMI et al. [5] focused on elderly persons with diseases living in depopulated areas, their data acquisition methods differed from those used in this study. In this study, one difference from the standpoint of novelty is that the number of patients was calculated by utilizing KDB data, which are healthcare big data. Finally, while the study of IDE et al. [6] is similar to this study as it conducted geographical information-type analysis using GIS, this study carries out quantitative assessment by considering the regional characteristics of the analysis target area, such as the difference in elevation and distance to a bus stop.

3 Summary of Hakui City, Ishikawa Prefecture, the Analysis Target Area

In this study, the analysis target area is Hakui City, Ishikawa Prefecture, which meets the criteria of a depopulated area as defined by the Act on Special Measures for the Promotion of the Independence of Depopulated Areas. It was designated as a depopulated area as of April 1, 2014.
Hakui City is located within Ishikawa Prefecture on the Sea of Japan. It has a population of 22,268 persons with 8,530 households (as of April 1, 2017) and an area of 81.85 km². In addition, comparing the population composition ratios of the depopulated areas with those of all of Japan as of 2010, the percentage of persons aged 65 years and above is large at 32.8 %. The aging rate, which is the proportion of the population accounted for by elderly persons, was 36.2 % as of April 1, 2016, which demonstrates an extremely high level compared with the aging rate of Japan as a whole, which is only 26.7 % (as of October 1, 2015) [7].

4 Analysis Method and Results

In this section, a detailed account of the analysis methods used in this study and their results is provided.

4.1 Calculation of the number of patients by town neighborhood employing the KDB data

As noted in section I.2, in this study, a detailed calculation of the number of patients for the town neighborhood units is carried out using KDB data. Here, the analysis target disease is hypertension, which has many patients both worldwide and in Japan; this disease has a tendency toward increase [10,11] and requires routine visits to the hospital. Moreover, the calculation is carried out by narrowing the scope to elderly persons (persons aged 65 years and above), who are at particularly high risk of contracting the disease among all hypertension patients and who may need to make regular hospital visits for treatment.

Among the forms output by the KDB data, the "Ministry of Health, Labour and Welfare Form (Form 1-1)" contains descriptions by month of whether or not a patient has been hospitalized or treated on an outpatient basis; amount of the costs; and whether or not there are major diseases such as the lifestyle diseases, including diabetes, hypertension, ischemic heart disease, and cerebrovascular disease. These data make it possible to ascertain the history of each individual's visits to the hospital on a monthly basis. Table 1 shows a part of the "Ministry of Health, Labour and Welfare Form (Form 1-1)" with an example of items that might be used to identify an individual. This example is processed to leave the remainder blank.

Table 1   An Example of Ministry of Health, Labour and Welfare Form (Form 1-1)

Sex	Age	Birthdate (year)	Birthdate (month)	Adress	Inpatient Outpatient Category		Cost	Hypertension	Diabetes mellitus	Dyslipidemia	Hyperuricemia	Ischemic heart disease	Cerebrovascular	Individual number
					Outpatient		29,740		●	●		●		6154
					Outpatient		11,870	●		●				6407
					Inpatient		535,930							3673
					Inpatient		25,800	●	●					6144
	Individual attributes				Outpatient	Inpatient Outpatient Category	12,410			Existence of Primary Disease				Individual number
					Outpatient		7,880							
					Outpatient	Cost	50						●	
					Outpatient		20	●						

4.2 Assessment of the difficulty in visiting the hospital

In this section, the variables employed when performing quantitative assessments of the difficulty in visiting the hospital from the 65 town neighborhood units of Hakui City, Ishikawa Prefecture, are described. To consider the actual circumstances and characteristics of the region, such as the terrain, state of local roads, and provision of local transportation infrastructure, it was decided to use the following four variables in the assessments in this study:
1) Difference in elevation within a town neighborhood
2) Distance as the crow flies to the closest bus stop
3) Distance as the crow flies to the closest healthcare institution with an internal medicine department
4) Road length per unit inhabitable area

These variables focus solely on the geographical features of the region. The "inhabitable area" employed in variables II, III, and IV is obtained by subtracting the forest and field areas and lake and marsh areas from the total area of each town neighborhood.
With respect to the assessment items in I to IV, the value of each variable for each town neighborhood is calculated and standardized based on geographical information analysis with GIS. As far as the standardization is concerned, the mean of each item is subtracted from the values of each data set, and the value obtained by dividing the resulting values by the standard deviation is employed. Regarding each value for each town neighborhood for which standardization is conducted, comprehensive indexation of the four variables is done by performing a principal component analysis, and then quantitative assessments are conducted. Here, the index of difficulty encountered by elderly persons in visiting the hospital, for which an analysis is conducted in this study, is proposed as the Aged People's Difficulty of "Medical Examinee" Index (APMI).

4.3 APMI(difficulty in visiting the hospital) obtained by principal component analysis

In this section, results of the principal component analysis conducted with variables in I to IV above are presented (see Table 2 and Figure 1). Table 2 shows the eigenvalues, contribution rates, and cumulative contribution rates of principal components 1 to 4. In this study, the first principal component, whose contribution rate is 47.89 %, is used as the APMI as is. Figure 1 shows the principal component loading of each variable in the first principal component. The loading is highest for variable III followed by variables I, II, and IV. The principal component

loading of variable I is the second highest at 0.7381, and this result indicates that it has a larger effect on the difficulty of visiting the hospital than the variables related to the state of transportation, such as distance to the bus stop and road density. These results, as shown in Figure 1, indicate that variable IV has negative loading. However, the more is the density of road length oriented towards "dense (positive)," the more negative is the load it imparts (the difficulty in visiting the hospital becomes lower, meaning that it is an environment where it is easy to visit the hospital). This means that the difficulty in visiting a hospital in an area where the provision of roads is inadequate (a depopulated area) increases, and so these results are thought to reflect reality.

Table 2   Eigenvalues, Contribution Rates, and Cumulative Contribution Rates of Principal Components 1 to 4

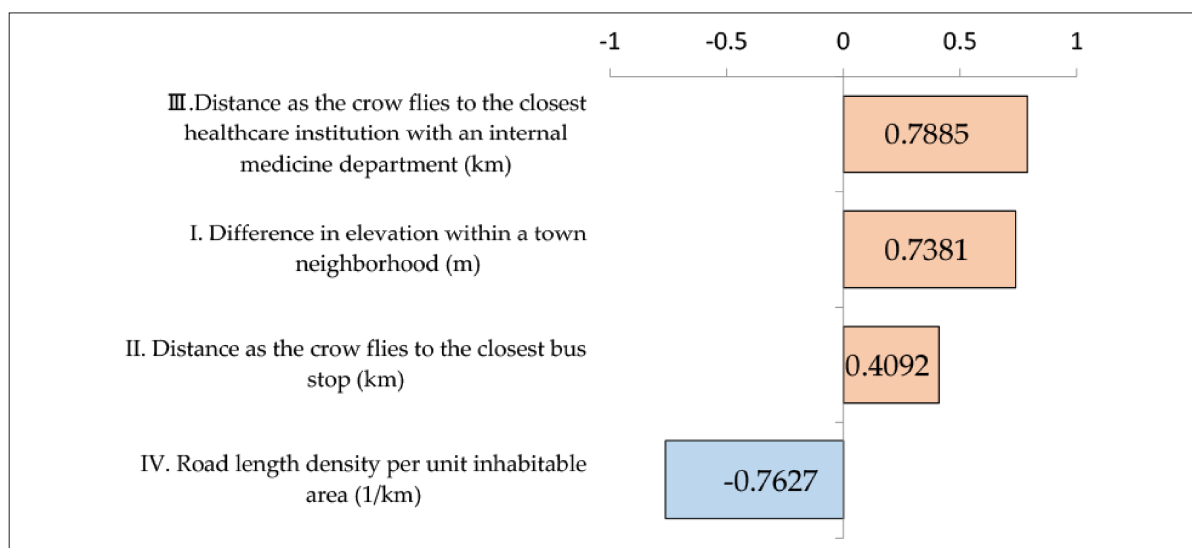| Principal Component	Eigenvalue	Contribution Rate	Cumulative Contribution Rate
1	1.916	47.89 %	47.89 %
2	1.073	26.82 %	74.72 %
3	0.557	13.91 %	88.63 %
4	0.455	11.37 %	100.00 %

Figure 1   Principal Component Loading of Each Variable in the First Principal Component

4.4 Relationship between KDB and APMI

In this section, scatterplots are prepared for the relationship between the number of hypertension patients aged 65 years and above in fiscal years 2016 and the APMI. Figure2 shows a scatterplot of the relationship between the number of hypertension patients aged 65 years and above as of fiscal year 2016 and the APMI. Figure 2 shows that the number of hypertension patients aged 65 years and above is less than 150 persons in majority of the cases, and the APMI is concentrated in the range between -2 and 2. With respect to the area that falls to the eastern side of Hakui City, that is, Mikohara-machi, Sengoku-machi, and Sugaike-machi, the numbers of hypertension patients calculated from KDB data were 61, 7, and 9, respectively. In Takidani-machi, Shibagaki-machi, and Kaminakayama-machi, which are on the northern side of Hakui City, the APMI is relatively high, and the numbers of patients were 26, 121, and 5, respectively. Thus, it was possible to put in relief the actual state of the environment for seeing a doctor in Hakui City, namely, how many hypertension patients aged 65 years and above are present in towns where the APMI is found to be high.
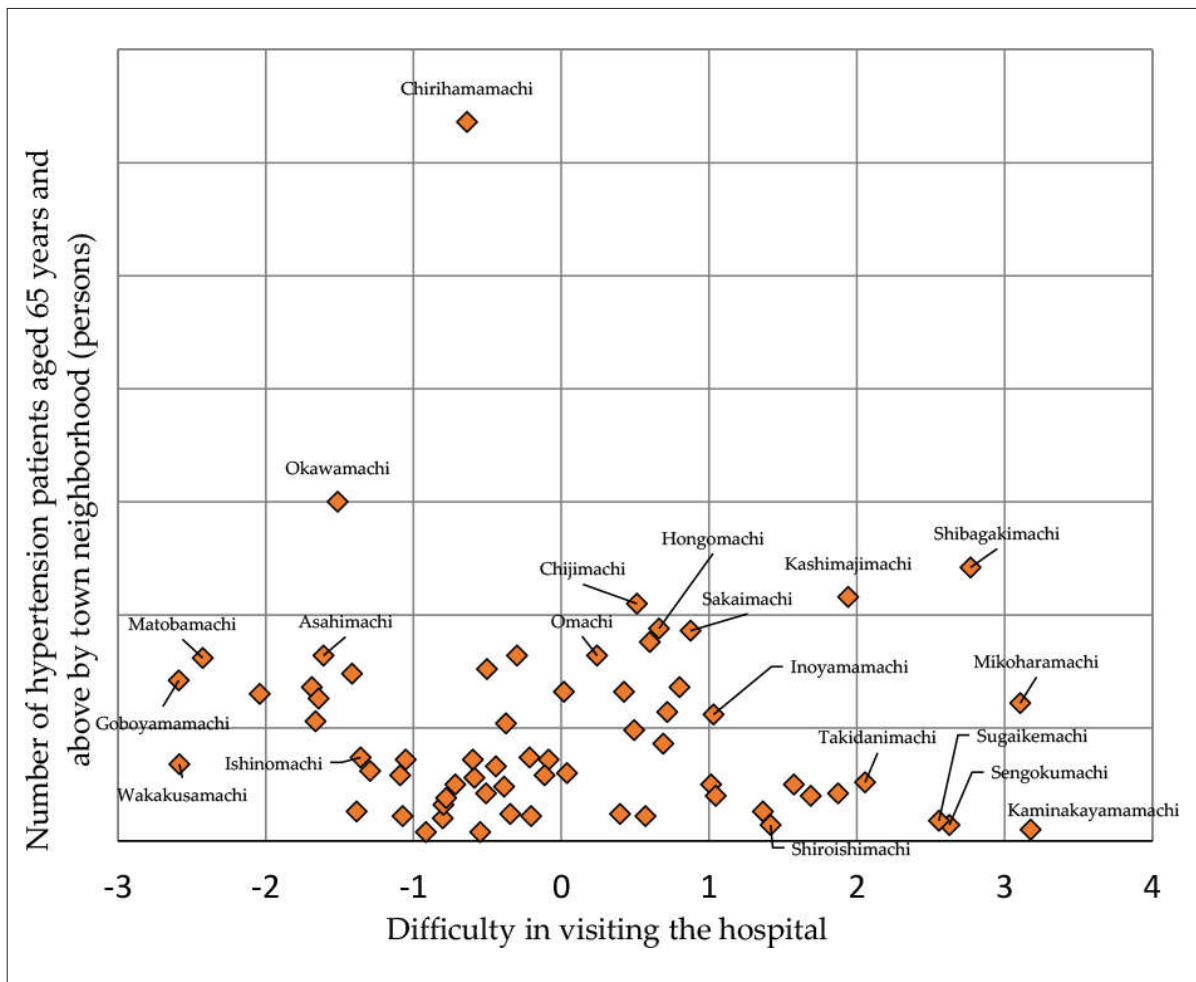
Figure 2 Relationship between the Number of Hypertension Patients Aged 65 Years and Above As of Fiscal Year 2016 and the APMI

5 Summary and Future Issues

In this study, the actual state of the environment for seeing a doctor based on the questions of how many patients there are in each town neighborhood and the extent to which patients experience difficulty in visiting the hospital in the district was clarified. The study used KDB data and proposed an index of difficulty in visiting the hospital (or APMI) from the town neighborhood units of Hakui City, Ishikawa Prefecture, which is a depopulated area. The difference in elevation within a town neighborhood, distance as the crow flies to the closest bus stop, distance as the crow flies to the closest healthcare institution with an internal medicine department, and road length per unit inhabitable area were used as the four variables. Thus, one possibility for proposing the index of the APMI using principal component analysis and for assessing the difficulty in visiting the hospital was identified.

With respect to the variables of the principal component analysis employed in the calculation of the APMI, in this study, the observed values were measured using distance as the crow flies to the closest healthcare institution and bus stop. However, for research in the future, the analysis can be refined by calculating the distance to the bus stop and healthcare institution using the actual road network. Upon such refinement, it will be necessary to implement a large-scale questionnaire survey in Hakui City, Ishikawa Prefecture, the analysis target area, to verify the difficulty in visiting hospitals based on a qualitative understanding of the environment for visiting hospitals for the residents of Hakui City.

References

[1] Current State of the Depopulation Countermeasures; Depopulation Countermeasures Office, Group for Creating Regional Potential, Ministry of Internal Affairs and Communications: Location, 2016.

[2] Moriyama, M., Fujiwara, A., Zhang, J., Sugie, Y.: Proposal of a demand forecast model for public transportation services for helping elderly persons in hilly and mountainous areas. J. Jpn. Soc. Civ. Eng. 2005, 786, 39–51.

[3] Morita, T., Tsukada, S., Sano, K.: Analysis of population trends and residential intentions oriented towards intensive habitation in depopulated and advanced age areas: A case study in Kuni-Mura, Gunma Prefecture. J. City Plan. Inst. Jpn. 2010, 45(3), 511–516. [Reference] Esveld, C.: Modern Railway Track, Second edition, TU-Delft, 2001.

[4] Takahashi, R., Fukazawa, H., Degumo, Y., Shimizu, Y., Araki, A., Inoue, J., Ito, H.: A comparative of the actual state of the lives of elderly diabetes patients living in local areas. Abbreviated Journal Name 1994, 31(5), 404–410.

[5] Koizumi, M., Hoshino, M., Miyamoto, M., Ito, M.: Support methods for health management from the standpoint of the state of health and disease and the social activities of the elderly chronic disease patients residing in depopulated areas. Abbreviated Journal Name 2000, 50(3), 287–293. [Reference] Person, A. Personal communication, 20 November 2008, Position of Person in Company, Name of Company or University, City, Country.

[6] Ide, M., Hayakawa, T., Kashiwada, R., Yoneda, E., Ando, N., Watariguchi, T., Suzuki, Y., Kobayashi, S., Tsuzuki, M., Esaki, Y., Kato, K., Amano, H., Miyaji, M.: A geoinformatics-type analysis of the difficulty encountered by elderly persons residing in hilly and mountainous areas in visiting the hospital. J. Jpn. Assoc. Rural Med. 2012, 61(4), 582–601.

[7] Hakui City Official Site. Available online: http://www.city.hakui.ishikawa.jp/ (accessed on 5 March 2018).

[8] Ministry of Health, Labour, and Welfare, 2014 Outline of Patient Survey. Available online: http://www.mhlw.go.jp/toukei/saikin/hw/kanja/14/index.html (accessed on 5 March 2018).

[9] World Health Organization. World Health Day 2013: Measure Your Blood Pressure, Reduce Your Risk, 3 April 2013. Available online: http://www.who.int/mediacentre/news/releases/2013/world_health_day_20130403/en/ (accessed on 5 March 2018).