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Differences in spatial patterns of long-term care depending on severity in Hokkaido, Japan

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Abstract

The increasing demand for long-term care (LTC) among the ageing population is a serious problem worldwide, which has greatly increased also in Japan since the introduction of the LTC insurance system there. Since there is a difference between insurers with respect to the proportion of people needing LTC, this study aimed at clarifying the spatial patterns of LTC. Insurer (n=156) LTC data for the period 2012-2019 were obtained from Ministry of Health, Labour, and Welfare and those needing LTC were classified into three classes: total, mild and severe with age- and sex-adjusted proportions needing LTC. Global and local Moran's *I* statistics were calculated for each 2-year period to clarify the trends of global and local spatial clusters. From 2012 to 2019, the mean proportion of mild class cases increased (10.6% to 11.6%), whereas that of severe class cases decreased slightly (5.9% to 5.7%). The spatial pattern of the proportion of each class revealed positive spatial autocorrelation. Based on analysis by local Moran's *I*, differences in spatial patterns were emphasised between the mild and severe classes. In Hokkaido, High-High clusters of mild cases were identified in the central and southern parts and severe ones in the northern and southern parts. Spatial patterns differed depending on the LTC class. Some insurers had distinctly higher or lower certification rates than those of their neighbourhoods.

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Introduction

The increased number of elderly people in the world is posing multiple problems. As a strategy for dealing with an ageing society, the Japanese government started the long-term care insurance (LTCI) system in 2000 (Campbell and Ikegami, 2000). Since the introduction of the LTCI system in Japan, the number of people certified as in need of long-term care (LTC) or support has greatly increased, from approximately 2.56 million in April 2001 to approximately 6.58 million in March 2019 (Ministry of Health, Labour and Welfare, 2001, 2018). The LTCI system has shifted the responsibility of care giving from the family to the society and provides support to older adults with disabilities and to their families (Tsutsui and Muramatsu, 2005). There are two categories of insured persons, one for persons ≥65 years old (category 1) and the other for those 40-64 years old (category 2). People in the former category can receive LTC services under seven categories if they have special needs in their daily lives (Ministry of Health Labour and Welfare, 2018), while those in category 2 with a specific disease are eligible for receiving LTC services from the LTCI. In principle, the LTC insurer is the municipality in which they live, and Japanese citizens have therefore a duty to pay LTCI premiums; they are subsequently entitled to receive LTC services after certifying the need for LTC (Ministry of Health Labour and Welfare, 2018).

The system is administered according to the LTCI Act and aims to establish equality for older people. However, the per capita LTC benefit for category 1 insured persons varies between prefectures and the disparity is approximately 1.6 times (Ministry of Health, Labour and Welfare, 2013). Additionally, the frequency of use of home nursing services varies depending on the area of res-

idence for older adults (Naruse *et al*., 2017). A previous study targeting prefectures revealed that for those aged ≥65 years, the mean body mass index (BMI) and the smoking rate affect the need for LTC among men, while the mean of total time/week spent watching sports and television, listening to the radio or reading books and newspapers affect the need for LTC among women (Fengming and Yoshida, 2019). Individual factors that lead to a need for LTC include age, sex, locomotor function, cognitive function, homebound status and place of residence (Sato *et al*., 2020b). Regional and individual characteristics may cause disparities in the proportion of people needing LTC. In contrast, preventive care strategies implemented by insurers may also be the cause of the disparity in the proportion of people needing LTC. Despite differences in implementation methods between insurers, their aim is to maintain the health of community-dwelling older adults by encouraging them to improve their lifestyle and participate in social activities (Shinkai *et al*., 2016; Sato *et al*., 2020a).

According to a study on the utilisation of LTC services in Japan, the utilisation of day-care services is positively related to lower mortality among community-dwelling frail older adults (Kuzuya *et al*., 2006), and LTCI assist Japanese households in the reduction of welfare losses associated with disabled family members (Iwamoto *et al*., 2010). In Korea, LTC service users had lower mortality rates than non-LTC users (Choi and Joung, 2016; Sohn *et al*., 2020). In China, the length of hospital stays shortened and hospitalisation costs decreased after the LTCI system was introduced (Feng *et al*., 2020). Therefore, the LTCI system can contribute to improving individual outcomes and optimising social medical costs.

Previous studies of spatial disparities in healthcare have focused on the incidence of infectious diseases or diseases such as cancer. Global Moran's *I* and local indicators of spatial association (LISA) (Anselin, 1995) are commonly used to identify spatial clusters in spatial analysis. Teixeira *et al*. (2021) clarified the spatial clusters of hospital-acquired infections in Portugal. In Brazil, spatial clusters of hepatitis B detection rates and mortality have been identified (Vivaldini *et al*., 2019). Spatial autocorrelation with respect to the incidence of breast and prostate cancers has been clarified in Slovakia (Vilinová, 2020). In the context of LTC, geographic misdistribution of opportunities to receive LTC services has been found in Tokyo by LISA (Miyazawa, 2003). The visualisation of spatial clusters is the first step in determining the specific factors in a region, and this helps formulate policies that focus on collaboration with neighbourhood insurers. However, to the best of our knowledge, no spatial analysis has focused on insurers in Japan. To fill this gap, this study aimed to analyse and evaluate the spatial patterns of the proportion of people needing LTC in Hokkaido, Japan. Additionally, our objective was to identify the regions based on a homogeneity criterion. Analyses were conducted at the LTC insurer level.

Materials and methods

Study site and population

The target location of this study, Hokkaido Prefecture, is located in the northern part of Japan and consists of 179 municipalities with a total land area of 83,424 km^2 (Hokkaido Government, 2020). In 2015, the recorded population was 5,381,733, with approximately 80% living in urban areas (Statistics Bureau Ministry of Internal Affairs and Communications, 2015). There are 156 LTC insurers in Hokkaido, which is a low number compared with the number of municipalities. Several municipalities collaborate to administer the same LTC insurer (Ministry of Health, Labour and Welfare, 2018).

Data collection

The study used data from 2012 to 2019 from 156 insurers in Hokkaido from the Internet (https://mieruka.mhlw.go.jp). Excluding category 2 insured persons, we obtained the age- and sex-adjusted proportions of people ≥65 years old needing LTC.

Data analysis

A first analysis expressed the temporal pattern of the mean proportion of people needing LTC. Secondary, choropleth map depicted the spatial pattern of LTC by 2-year time periods, *i.e*. 2012-13, 2014-15, 2016-17 and 2018-19, using the Jenk optimisation classification, a method that reduces the variance within classes and maximizes the variance between them (Jenk, 1967). Finally, global, and local spatial autocorrelation methods were applied to assess the spatial characteristics of the proportion of people needing LTC. The analysis was conducted using three categories of LTC (total, mild and severe). The mild class includes requiring support levels 1 and 2 and care levels 1 and 2; the severe class includes requiring care levels 3-5. In general, the possibility of persons leaving their home and moving to an LTC facility increases as their care requirement moves beyond level 3.

Moran's *I* statistics were used to detect significant autocorrelation of the proportion of people needing LTC through the four different time periods. Global Moran's *I* statistics are shown in equation a. The value of Moran's *I* ranges from –1 to +1. When the value is close to zero, the phenomenon is presumed to be randomly distributed. In contrast, the further away the value is from zero, the stronger the autocorrelation. A positive autocorrelation means that values in an area are like those in neighbouring areas, whereas a negative autocorrelation means that values in an area are heterogeneous with neighbouring areas.

To identify local patterns among LTC insurers, we also applied LISA (Anselin, 1995) using equation b, wherein the variables significantly correlated with the variables of their neighbours. Based on LISA results, five types were expressed: i) High-High (HH) cluster meaning LTC insurers with a high variable whose neighbours also had a high variable; ii) Low-Low (LL) cluster meaning LTC insurers with a low variable with neighbours who also had a low variable; iii) High-Low (HL) outlier meaning LTC insurers with a high variable surrounded by insurers with a low variable; iv) Low-High (LH) outlier meaning LTC insurers with a low variable surrounded by insurers with a high variable; and v) absence of any kind of significant local spatial autocorrelation.

$$I = \frac{n\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}(a_i-\bar{a})(a_j-\bar{a})}{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}\sum_i(a_i-\bar{a})^2} \quad (1)$$

$$I_i = \frac{(a_i-\bar{a})\sum_{j=1}^{n} w_{ij}(a_j-\bar{a})}{\frac{\sum_{i=1}^{n}(a_i-\bar{a})^2}{n}} \quad (2)$$

where n is the number of LTC insurers; a_i, a_j is the value of the variable in region i or j, respectively; $\bar{a}$ the arithmetic average for

the given variables; and W_{ij} the spatial weight based on the queen contiguity matrix (an approach which defines neighbours as spatial units sharing a common edge or a common vertex) that thus considers all insurers that share at least one vertex as neighbours. A method with row standardisation was employed (Anselin, 1988). Two insurers without neighbour insurers were excluded from the global and local Moran's *I* calculations. ArcGIS pro ver. 2.7. (ESRI, Redlands, CA, USA, https://www.esri.com/en-us/home) was used to analyse the data. The number of permutation tests was set to 999 under the LISA. All values were defined as statistically significant at P<0.05.

Results

Temporal patterns and spatial distribution 2012-2019

The proportion of people needing LTC in Hokkaido, Japan, from 2012 to 2019 is shown in Figure 1, with Figures 2-4 expressing the spatial distribution using a choropleth map. The proportion of people needing LTC (mean ± standard deviation) in each class was for the total: 16.5±2.1% to 17.3±2.4%; the mild class: 10.6%±1.8% to 11.6%±2.2%; and the severe class: 5.9%±2.1% to 5.7%±2.4%. Proportions in the mild class increased by 1% but decreased in the severe by 0.2%. Consequently, the total proportion of people needing LTC increased slightly from 2012 to 2019. According to spatial distribution analysis, in 2018-19, insurers with higher proportions of the mild class were observed in central Hokkaido, while insurers with higher proportions of the severe class were seen in the southern and northern regions as well as in a parts of the eastern region.

Global spatial autocorrelation

Global Moran's *I* indicated significant clusters in the proportion of people needing LTC in Hokkaido. Total and mild classes showed significant positive spatial autocorrelation during all time periods, while the severe class showed a significant positive spatial correlation during 2014-2019 (Table 1). These results imply the existence of a spatial cluster of insurers along with a high or low proportion of people needing LTC in Hokkaido.

Spatial pattern of insurers with a high or low proportion of people needing long-term care

Spatial clusters and outliers of insurers were expressed with one of the five types, for each period, using LISA (Figures 5-7). For the total, a large HH cluster was observed in the same region for all periods. Additionally, HH clusters in the southern region expanded from 2012 to 2019. In contrast, LL clusters and HL outliers coexisted in the northern and eastern regions. This implies that differences in the proportion of people needing LTC were between neighboured insurers. Interestingly, some insurers were consistently high or low for all periods (Figure 5). The spatial pattern of the mild class was similar to that of the total class. It accounted for more than half of the total class. Large HH clusters in central and western Hokkaido and LL clusters in northern Hokkaido were characterised as mild (Figure 6). By contrast, the spatial pattern of the severe class was significantly different from those of the total and mild classes. The first HH cluster was consistent in the southern region for all periods investigated. In 2018-19, a HH cluster was added to the northern region and two LL clusters were observed (Figure 7).

Discussion

This study targeted LTC insurers in Hokkaido, Japan, and is the first to clarify the spatial patterns of people needing LTC. HH and LL spatial clusters emerged in different regions between the mild and severe classes for all periods. Insurers with high or low proportions were not randomly distributed and we identified regions where the factor of differences needs to be investigated in more detail. Spatial clusters and outliers can be a basic source for evaluating the equity of LTCI systems. Additionally, although the process of LTC certification has an artificial aspect in which the level of LTC needs is determined by experts, our study methods indicate that LISA can also be applied to the proportion of people needing LTC.

High or low proportions included positive and negative aspects, respectively. Insurers with low proportions may indicate that community-dwelling older adults are healthy and do not need LTC care, or that they lack health literacy and access to the LTC.

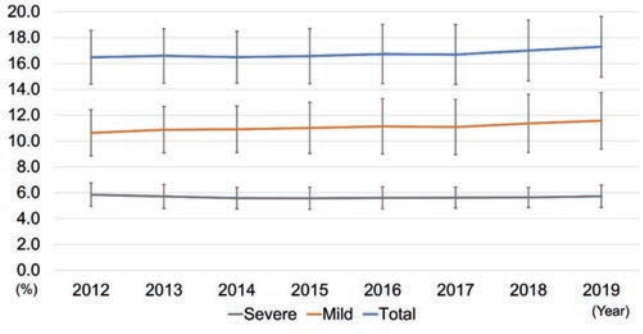

Figure 1. Temporal patterns of the proportion of people needing long-term care in Hokkaido, Japan 2012-2019.

Table 1. Statistics applied to the mean proportion of persons needing long-term care in Hokkaido 2012-2019.

Period	Total		Mild		Severe	
	Moran's *I*	z-score	Moran's *I*	z-score	Moran's *I*	z-score
2012-13	0.13*	2.56	0.19*	3.79	0.10	1.92
2014-15	0.23*	4.41	0.25*	4.97	0.18*	3.54
2016-17	0.21*	4.04	0.23*	4.46	0.17*	3.34
2018-19	0.21*	4.02	0.26*	4.98	0.24*	4.54

*P<0.05.

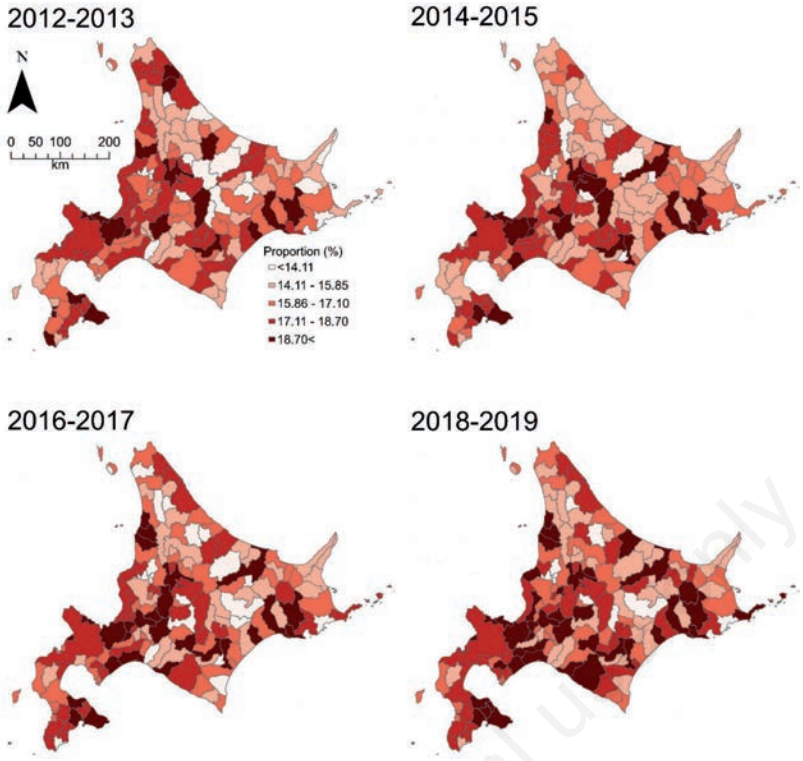

Figure 2. Spatial distribution of total proportion of people needing long-term care in Hokkaido, Japan 2012-2019. Jenks classification based on 2012-2013 was used to determine the intervals.

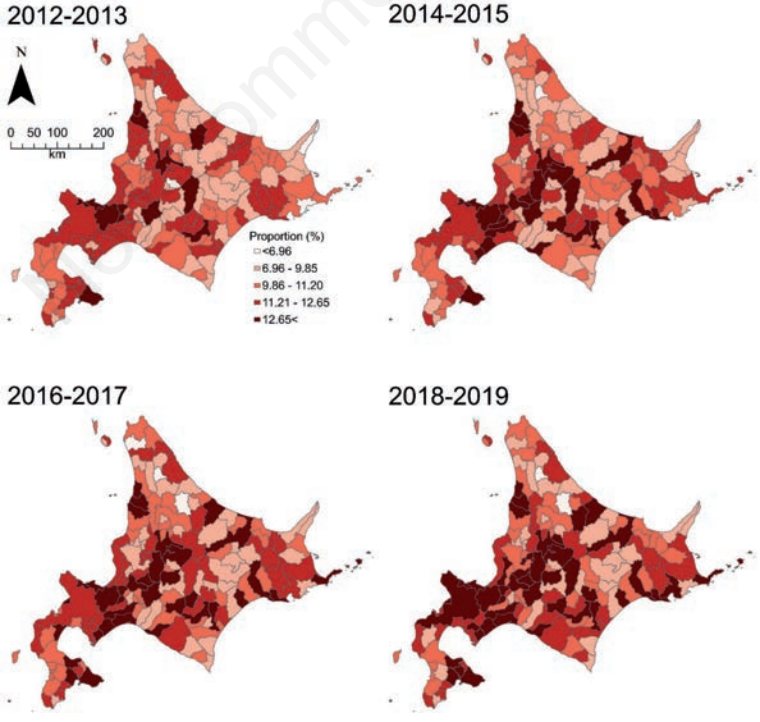

Figure 3. Spatial distribution of mild proportion of people needing in Hokkaido, Japan, 2012-2019. Jenks classification based on 2012-2013 was used to determine the intervals.

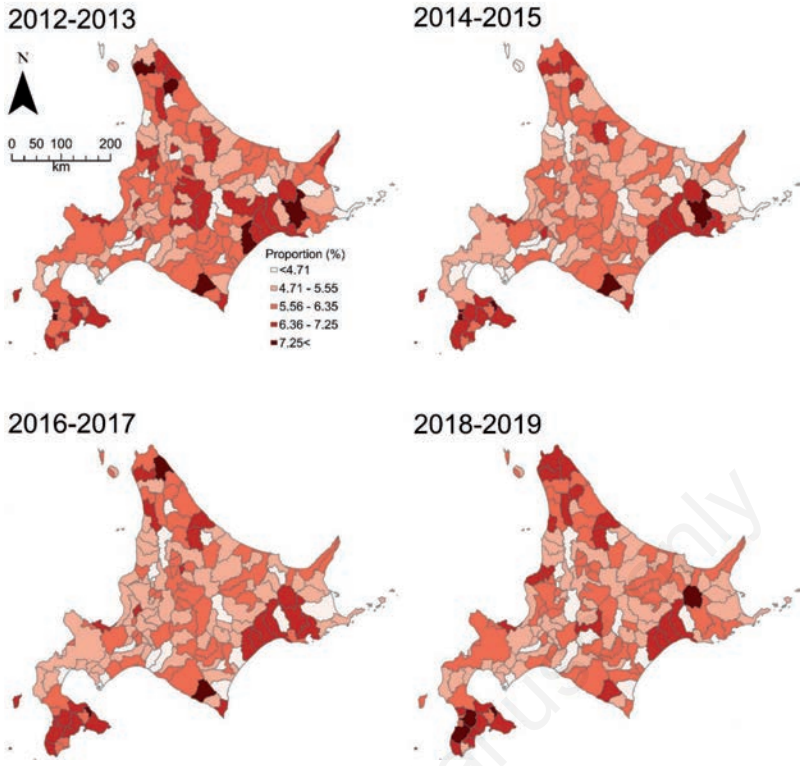

Figure 4. Spatial distribution of the proportion of people needing severe class in Hokkaido, Japan, 2012-2019. Jenks classification based on 2012-2013 was used to determine the intervals.

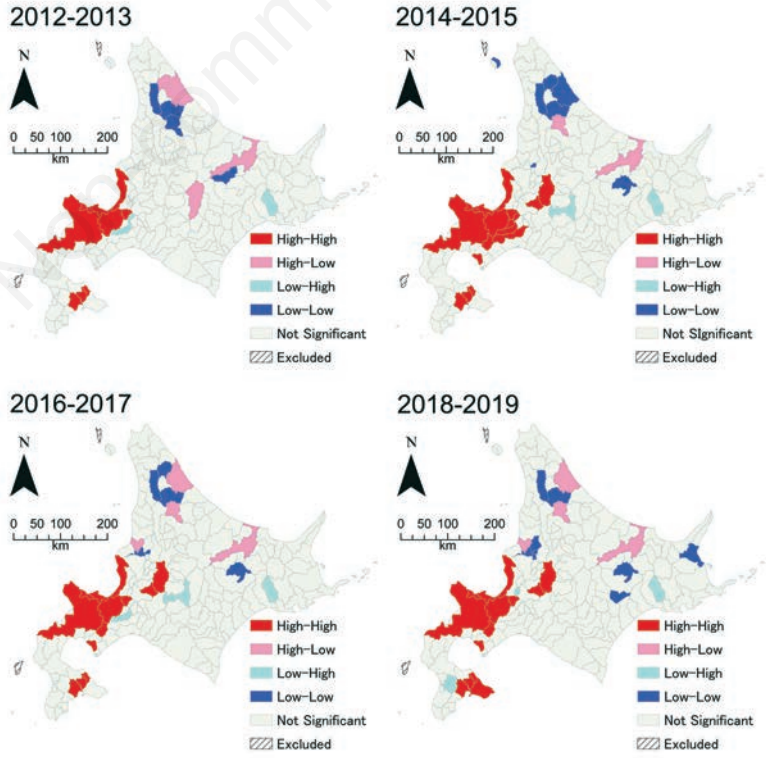

Figure 5. Spatial patterns of the total proportion of people needing long-term care, by insurers, 2012-2019.

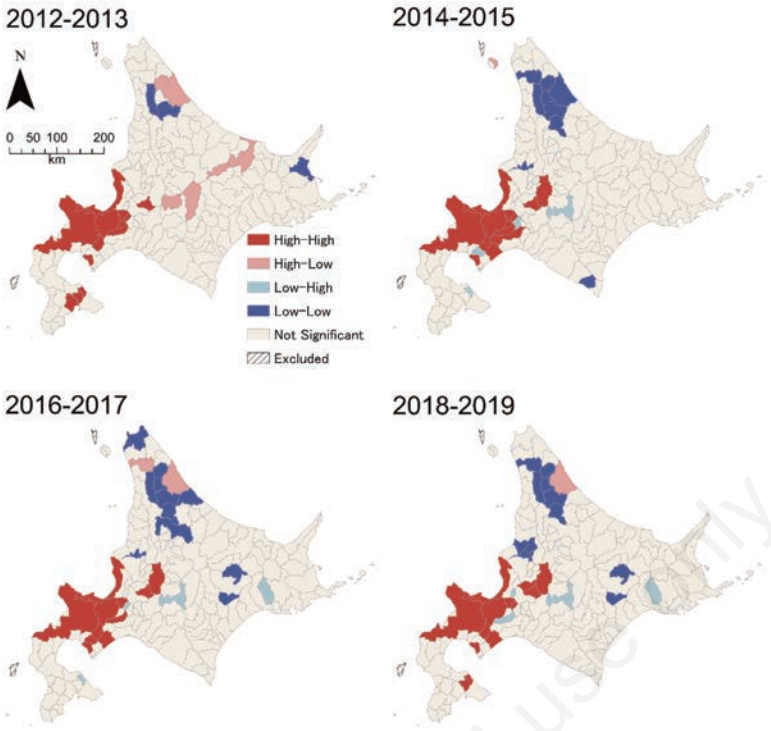

Figure 6. Spatial patterns of the proportion of people needing mild class, by insurers, 2012-2019.

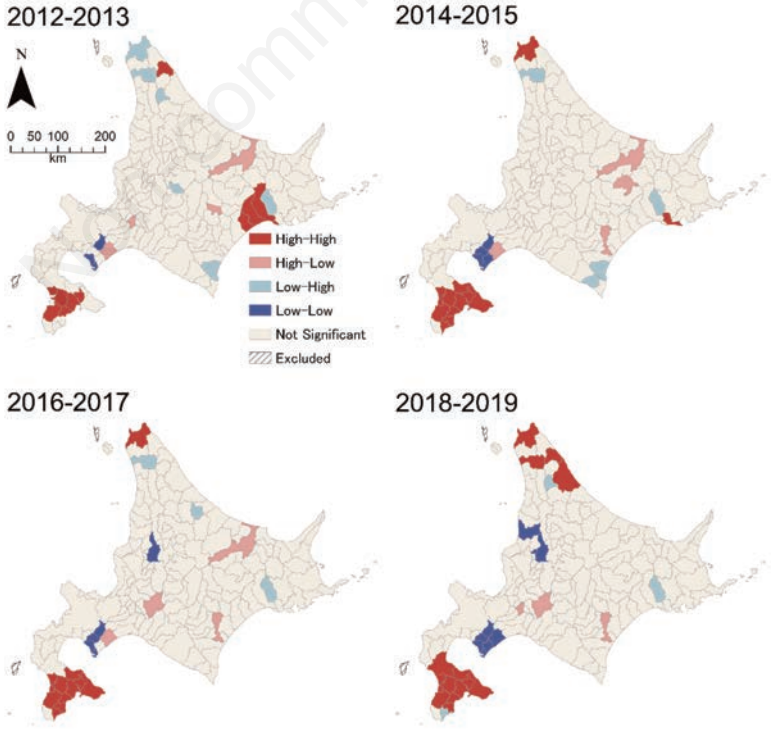

Figure 7. Spatial patterns and outliers of the proportion of people needing severe class, by insurers, 2012-2019.

Since LTCI is used on request of an insured person, the decision to use LTC services depends on them. In contrast, the existence of potential factors from the HH cluster and HL outlier in those regions can be inferred.

In the process of LTC certification, the primary decision is made using computer software and the secondary decision by experts from each insurer's certification committee for LTC needs. A previous study (Mitsubishi UFJ Research and Consulting Co., Ltd., 2016) revealed that the results of the primary decision are, in many cases, changed to a more severe level in the secondary decision. Compared with the primary decision, the secondary decision tends to evaluate the LTC need as more severe. In other words, as people requesting LTCI increase, people certified at any LTC level also increase. Therefore, it can be inferred that in areas with factors that promote requests for LTCI, the number of applications will increase, and the proportion of people needing mild LTC will also increase. In the Netherlands, the use of LTCI is limited by a care authorisation evaluation system that is independent of the supplier (Bakx *et al*., 2021). Similarly, in Japan, each insurer's certification committee for LTC needs is independent, and medical experts only advise on applications for LTC certification. The area where this study showed a large HH cluster for the proportion of people needing mild LTC is around Sapporo City, which has many medical resources (Hokkaido Government, 2018). In Japan, the supplier-induced demand hypothesis has been reported in the medical field (Sekimoto *et al*., 2015). Considering the supplier-induced demand hypothesis with respect to applications for LTC, it can be argued that applications are facilitated in areas with more medical resources. Meanwhile, it is natural for healthcare professionals to advise patients on strategies to support their lives. One of these strategies is the LTCI system.

Previous studies on the effects of mild LTC certification showed that it prevented LTC levels from worsening in a group of people aged ≥85 years who were certified as requiring support level 1; however, the effect of long-term preventive care services with support levels 1 and 2 is limited (Ito *et al*., 2021). Additionally, a randomised controlled trial in the UK reported no apparent benefit of exercise for fall prevention when compared with advice using only documents (Lamb *et al*., 2020). Thus, early intervention by public insurance may not necessarily be effective in maintaining or improving LTC levels. In contrast, according to the Ministry of Health, Labour and Welfare, approximately 70% of the users of in-home care services are certified as having a mild LTC level (Ministry of Health Labour and Welfare, 2018). In addition, previous studies have reported that the use of LTC services reduces the burden on family care-givers (Umegaki *et al*., 2014) and contributes to the maintenance of care-givers' health (Miyawaki *et al*., 2020). Therefore, if they are properly certified for LTC and have access to its services, the insured can continue to live at home, potentially reducing the burden on their families as caregivers. Thus, evidence is required in HH or HL areas regarding whether a high proportion leads to improved quality of life for older people and their families as care-givers.

Persons certified as requiring higher levels 3-5 of care accounted for approximately 85% of facility service users, and their physical and mental conditions made their need for LTC services more essential than for those with mild LTC. Cerebrovascular disease and dementia were the main diseases that lead to conditions requiring care these levels (Ministry of Health, Labour and Welfare, 2019a, 2019b). The HH cluster for the severe LTC class in the northern part of Hokkaido in the present study (Morii *et al*., 2021) corresponds to the area with the least accessibility which were revealed by Morii *et al*. (2021). Considering that cerebrovascular disease is one of the main causes of severe certification, poor accessibility to acute ischemic stroke care may be a factor for the increased proportion of people with severe LTC. Meanwhile, the southern part of Hokkaido, a HH cluster, has a mix of areas with good and poor accessibility to healthcare (Morii *et al*., 2021). This area may contain more complex factors. The causes of the spatial clusters in the higher proportion of people needing severe LTC may be related to the disease structure and healthcare system in the region and require clarification of the causes and countermeasures.

Finally, several insurers were identified as LL clusters and LH outliers. These insurers may effectively prevent the severity of LTC needs. In 2015, an amendment to the LTCI Act introduced the 'Comprehensive Service for Preventive Care and Daily Life Support', and all insurers were required to complete the implementation of the service by 2018 (Masui *et al*., 2019). This service is administered by insurers adjusted to the insurer's local situation; therefore, different outcomes might be obtained regarding these impacts.

Limitations and strengths

This study has some limitations. First, we focused on only one prefecture. Hokkaido has characteristics that differ from other Japanese prefectures. For example, the land area is largest, and the population density is the lowest in Japan. Thus, our findings cannot be generalised for the whole of Japan. Second, the study had no data on the person responsible for the secondary decision for LTC certification. If the same person belongs to the certification committee of neighbouring insurers, or if the experts are biased, the potential of a decision bias needs to be considered. Finally, the study was analysed based on the geographical adjacency. However, the LTC certification rate is related to various social factors. Therefore, further studies using other indicators are required to understand this disparity. However, our study has also several notable strengths. We demonstrated the applicability of LISA in LTC. Using this method, it is possible to evaluate the LTCI system by focusing on multiple insurers and based on the context of LTC, identify the geographic boundaries.

Conclusions

The LTCI system is important for older adults and their family members. However, the utilisation of LTC is likely to be affected by people's lifestyles and health status, leading to differences among LTC insurers. Since the administrative area of insurers and the area of activity of community-dwelling older adults are different, this may lead to a difference in the number of people needing LTC and the number considered by insurers as needing LTC.

This study visualised the spatial clusters and outliers of the proportion of people needing LTC and revealed that spatial patterns have different characteristics depending on the LTC class. Our results contribute to providing clarity regarding the specific regional factors related to LTC. Moreover, it emphasises the necessity of considering the existence of spatial clusters and analysing the relationship not only with the insurer alone but also with neighbouring insurers when making policies for preventive care and the promotion of care services and when evaluating LTCI.

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