Spatial Factors Associated with Fall among the Elderly in Thailand

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Abstract
Fall is the leading cause of injury-related visits to emergency departments around the world, including in Thailand, and the primary etiology of accidental deaths in elderly people. Fall among the elderly is an increasing problem, causing a high degree of morbidity, mortality, and use of healthcare services. This study statistically identified aimed to determine the association of spatial factors with falls among elderly people in Thailand. The participant consisted of 40,489 elderly people and was conducted using a data set from the national statistical office of Thailand in 2017 and other data. A Moran's I and local indicators of spatial association (Lisa) were used to identify the spatial autocorrelation between poverty incidence, the proportion of patients with non-communicable diseases, and the population-to-village health volunteers' ratio with falls among elderly people in Thailand. The results showed that there was spatial global autocorrelation between poverty incidence, the proportion of patients with non-communicable diseases, and the population-to-village health volunteers among elderly people in Thailand with Moran's I values of 0.176, 0.049, and 0.034, respectively. Therefore, the focus should be on promoting and preventing non-communicable diseases, as well as promoting income-generating jobs for the elderly by closely supervising village health volunteers and elderly caregivers to reduce the risk of falls among the elderly and improve their quality of life.

Keywords: Fall in Elderly, Spatial Autocorrelation, LISA, Moran's

1. Introduction

Currently, the tendency of the aging population is constantly increasing, which reverses Thailand's fertility rate. Therefore, health care, particularly the promotion of protection for the elderly, are essential for maintaining good health (Pongboriboon, 2020). Their capacity to care for their own and others' health declines as the increasing age (Kulprateepunya et al., 2020) The elderly are susceptible to illness and falling is one of the most important physical and psychological issues facing the elderly (Bergen et al., 2016). Falls may occur in a variety of ways, including falling on flat ground; sliding, tripping, stumbling, being struck, pushed by another individual, or falling from a height, down a ladder, etc. According to current data, falls tend to increase every year, resulting in disability and death. Moreover, falls in the elderly cause various complications that require hospitalization, which means losing medical costs, time, and the capacity to do everyday chores (Mishra et al., 2017). Therefore, promoting and preventing falls among the elderly in Thailand is important (Boonruangsak and Sudnongbua, 2019).

In the future, technology has come to assist human existence, particularly through geographic information systems (GIS) that are utilized to solve issues and develop in many circumstances across all disciplines by delivering policy information, culture, customs, ways of life, and socioeconomic situations in many regions in an acceptable manner (Thammawongsa at el., 2021). This will allow Thailand to realize its objective of successfully developing and resolving health problems in each region (Khashoggi and Murad, 2020).

Currently, several studies have applied GIS in health systems and medicine (Prasit et al., 2021 and Thammawongsa et al., 2021) . The socio-economic condition in each area is an index that represents the living conditions and the living environment of the people in that area. Because of this, it is important and helpful for relevant agencies to use GIS to make policies and plans that will help reduce population inequality in the country and help people reach their goals and improve their well-being (McLafferty, 2003).

Health determinants in terms of social and economic conditions that are associated with elderly falls are described above. Consistent with previous research, it was discovered that access to health services, which is linked to falls, was associated with low-income seniors (Tasuwanin, 2 0 1 6) . The village health volunteers (VHV) play an important role in caring for and promoting actions in primary health care services. Thailand has village health volunteers offering health care to the local community. He plays a crucial role in geriatric health care, particularly for elderly patients with complications or those who are unable to travel to the hospital (Rasiri et al., 2021) . The high population-to-VHV ratio affects comprehensive and effective health care for the population, it will be difficult, particularly among the elderly with non-communicable diseases, who are vulnerable groups requiring special care (Tasuwanin, 2 0 1 6) . As a result, the elderly get more continuous and long-term care and need greater reliance on others or family care. While the body deteriorates with age, there is joint degradation, loss of balance, and mobility difficulties, resulting in a greater demand for caregivers and increased access to high-level medical services. Enough health professionals are necessary to provide the elderly with quality health care and access to healthcare services (Boonruangsak and Sudnongbua, 2019). In terms of family income, social and economic situations also have an impact. According to studies, families with sufficient income are enabled to select more suitable and effective medical treatments. In contrast to low-income households, access to medical services is more difficult than for other groups. (Tonboot and Wattanadumrong, 2021) However, despite the aforementioned, no research on spatial correlation patterns of falls among the elderly in Thailand has been discovered. Therefore, the purpose is to evaluate the study hypothesis that spatial of poverty incidence, the proportion of patients with non-communicable diseases, and the population-to-VHV ratio were associated with falls in the elderly. to allow organizations associated with the elderly to participate in developing policies and plans to reduce inequalities in the economic and social situations of the country's population, including identifying different methods to assist people, particularly the elderly to live better and longer lives.

2. Methods and Materials

2.1 Study Design and Population

This cross-sectional study used a data set from the Report on the 2017 Survey of the Older Persons in Thailand among 172,698 participants who participated in the National Statistical Office (NSO). The survey used multistage random sampling to select the participants from all 77 provinces, representing the total population. The inclusion criteria of our study were those who had completed the data on older people's falls. A sample of 40,489 respondents to the National Statistical Office's 2017 Elderly Survey of Thailand met the criteria and was included in the analysis. The exclusion criteria were as follows: 1) age < 60 years old 2) individuals and the exact history of missing data.

2.2 Variables and Data Collection

Variables and information gathering the National Statistical Office's 2017 Thailand elderly population survey data copy form was used to collect most of the study's data. The researcher selected the variables from a review of concepts, theories, and related research based on the study's conceptual framework. Regarding spatial variables, there are three variables: 1) The poverty incidence is the proportion of the total population whose average annual household income is below the poverty line. This is an annual time series from the 2017 household socio-economic survey conducted by the National Statistical Office. 2) The proportion of patients with non-communicable diseases is the proportion of patients with non-communicable diseases per 100,000 population in each province, comprising the four diseases: diabetes, hypertension, heart disease, and stroke from the 2017 department of health, ministry of public health and 3) the population-to-village health volunteers ratio is the ratio of the total population to the number of village health volunteers in that province, as determined by the village health volunteer database from the 2017 department of health service support, ministry of public health.

2.3 Statistical Analysis

This study used the quantum GIS program to determine the spatial distribution patterns of independent factors and falls among the elderly. The GeoDa program was used to analyze spatial autocorrelation by specifying 3 k-Nearest Neighbor provinces that connect as a criterion to identify groupings using the weight matrix to analyze spatial correlation (Anselin et al., 2006 and Cliff and Ord, 1981). Bivariate Moran's I analysis was used to identify the global autocorrelation within the country. Global autocorrelation statistics provide a single measure of spatial autocorrelation for an attribute in the country (Anselin et al., 2006 and Anselin, 1993). The Moran scatter plot is a plot in which the spatially lagged variable is plotted on the y-axis and the original variable is plotted on the x-axis. Both variables were normalized, and the graph was divided into four quadrants: high-high (upper right) and low-low (lower left) indicate positive spatial autocorrelation, while high-low (lower right) and low-high (upper left) indicate negative spatial autocorrelation. Moran's I is equal to the slope of the linear fit to the scatter plot (Anselin et al., 2006 and Anselin, 1996). Moran's, I have an expected value of -1/(n-1) and is interpreted similarly to the product-moment correlation coefficient. Informally, a value of +1 indicates a high degree of positive spatial autocorrelation (i.e., clustering of similar values), a value of 0 indicates random spatial ordering, and a value of -1 indicates a high degree of negative spatial autocorrelation (Anselin et al., 2006 and Anselin, 1993).

Then, a local indicator of spatial association (LISA) was employed to determine the variables' local spatial autocorrelation patterns (Anselin,1993 and1995). This procedure generates a spatial association for each unique location. The maps identify locations with significant local Moran statistics (LISA significance maps) and categorize them according to the type of association (LISA cluster maps) (Anselin et al., 2006). On the map, dark red is an indication of spatial clusters when having a high frequency of an independent factor with a high proportion of falls among the elderly in the identified province with three neighboring provinces (high surrounded by high or hot-spot or high-high). The dark blue location is an indication of spatial clusters when a low frequency of the factor with a low proportion of falls among the elderly is identified province with three neighboring provinces (low surrounded by low or cold-spot or low-low). In contrast, the light red and light blue are indicators of spatial outliers (respectively, high surrounded by low or high-low, and low surrounded by high or low-high) (Anselin et al., 2006 and Anselin, 1995). The statistical significance level was 0.05. The simulation used 999 permutations to evaluate the sensitivity of the results.

2.4 Ethical Considerations

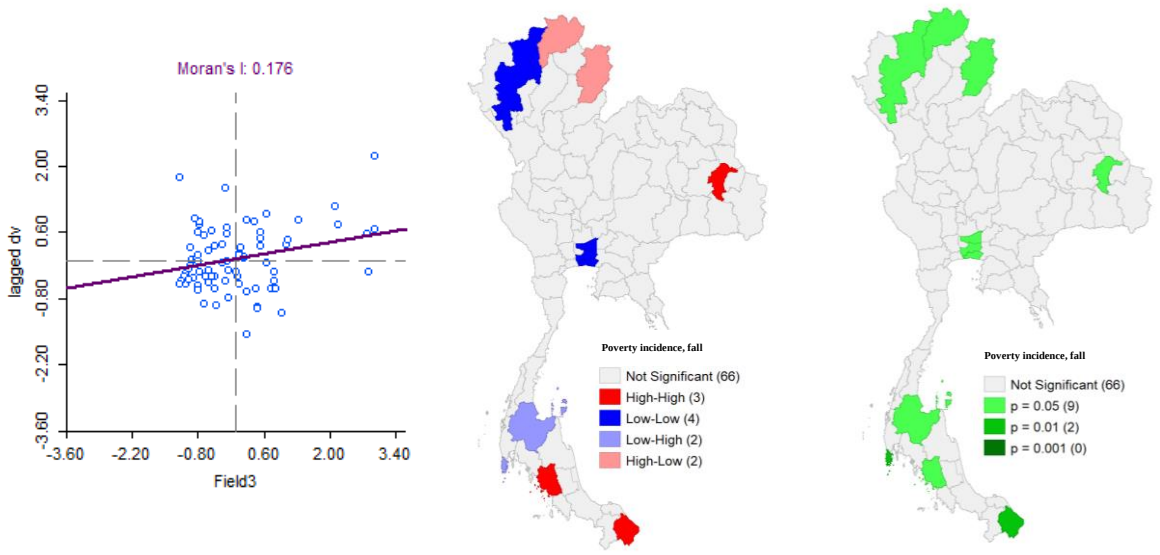
The study was approved by the ethics review board of the center for ethics in human research, Khon Kaen University (no. HE602053), and requested permission to use the research data of the National Statistical Office (NSO).

3. Results

Bivariate Moran's I analysis and local indicators of spatial association analysis (LISA) were used to examine spatial correlations, with the boundaries of interconnected areas serving as the criteria for defining nearby areas. It revealed a correlation between spatial factors and falls among Thailand's elderly population. Three spatial factors were found to have significant spatial correlations with elderly falls in Thailand at p 0.05

3.1. Poverty incidence has a spatial correlation with an elderly population distribution pattern that falls in the same direction. (Moran's I=0.176), and the LISA analysis indicated hot spots or high-high clusters of poverty incidence and high levels of falls among the elderly have 3 provinces: Yasothon, Trang, and Narathiwat provinces. In addition, there were 2 provinces with low Poverty Incidence with high levels of falls among the elderly in Phuket, and Surat Thani Province surrounded by low levels of Poverty Incidence in three neighboring provinces (low-high cluster). There were provinces with high poverty incidence and low levels of falls among the elderly, in Nan, and Chiang Rai province surrounded by low poverty incidence in three neighboring provinces (high – low cluster). In contrast, LISA analysis showed clusters of a province with a low poverty incidence and falls among the elderly with also low values of surrounding 3 provinces (cold-spot or low-low clusters). There were low-low clusters found in Bangkok, Samut Prakan, Pathum Thani, and Chiang Mai province (Figure 1).

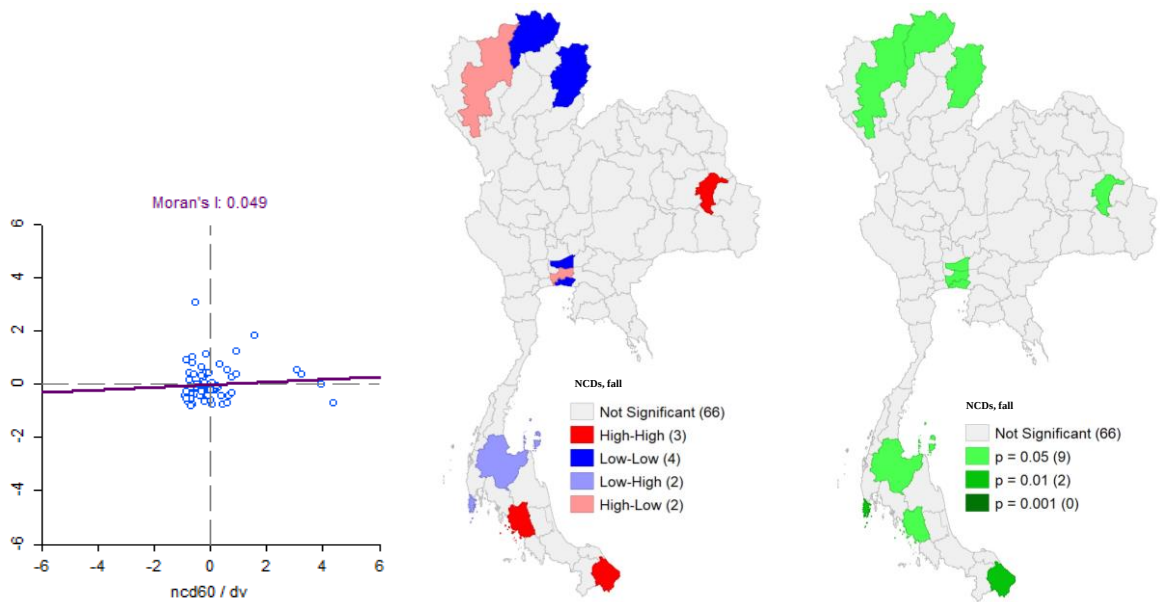
2017-based information



(a) (b) (c)

Figure 1: LISA and Moran's I scatter plot matrix of poverty incidence with falls among elderly in Thailand; (a) Moran's I scatter plot matrix (Bivariate: poverty incidence and falls in elderly); (b) Cluster maps of poverty incidence and falls among elderly in Thailand; (c) Significance maps of poverty incidence and falls among elderly in Thailand

2017-based information

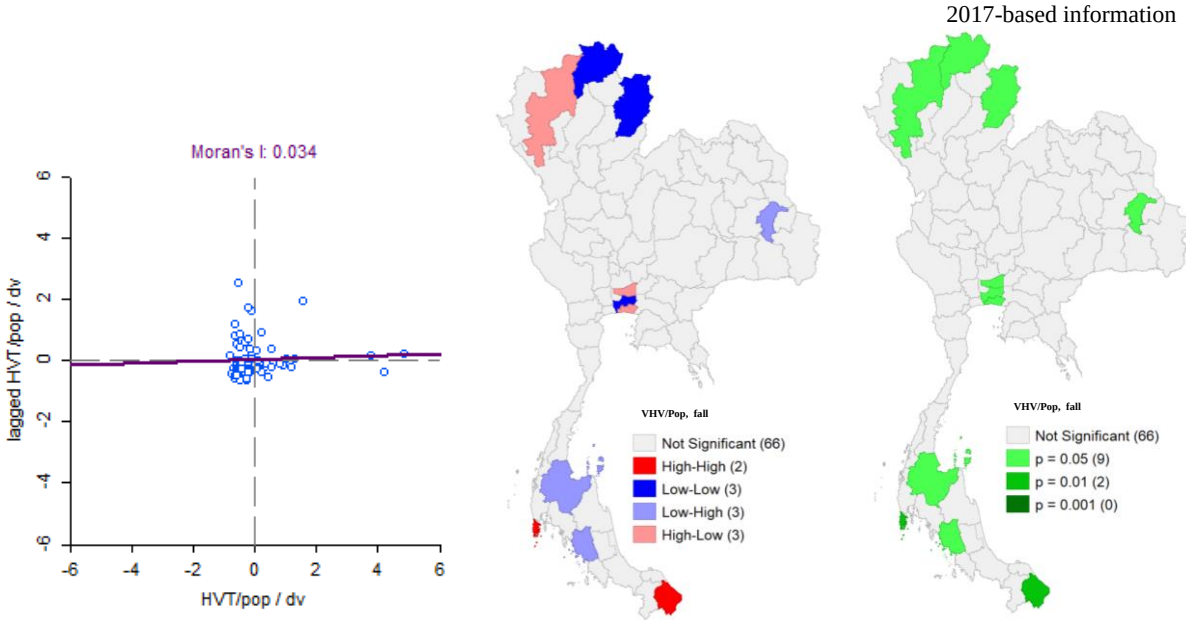


(a) (b) **2** (c)

Figure 2: LISA and Moran's I scatter plot matrix of the proportion of patients with non-communicable diseases with falls among elderly in Thailand; (a) Moran's I scatter plot matrix (Bivariate: proportion of patients with non-communicable diseases and falls among elderly in Thailand); (b) Cluster maps of the proportion of patients with non-communicable diseases and falls in elderly; (c) Significance maps of the proportion of patients with non-communicable diseases and falls among elderly in Thailand

3.2 Proportion of patients with non-communicable diseases has a spatial correlation with an elderly population distribution pattern that falls in the same direction, (Moran's I = 0.049) and the LISA analysis indicated hot spots or high-high clusters of the proportion of patients with non-communicable diseases and high levels of falls among the elderly have 3 provinces: Yasothon, Trang, and Narathiwat province. In addition, there were 2 provinces with a low proportion of patients with non-communicable diseases with high levels of falls among the elderly in Phuket, and Surat Thani province was surrounded by low levels of the proportion of patients with non-communicable diseases in three neighboring provinces (low-high cluster). And there were provinces with a high proportion of patients with non-communicable diseases and low levels of falls among the elderly, in Bangkok, and Chiang Mai province surrounded by a low proportion of patients with non-communicable diseases in three neighboring provinces (high-low cluster). In contrast, LISA analysis showed clusters of a province with a low proportion of patients with non-communicable diseases and falls among the elderly with also low values of surrounding 4 provinces (cold-spot or low-low clusters). There were low-low clusters found in Samut Prakan, Pathum Thani, Nan, and Chiang Rai province (Figure 2).

3.3 Proportion population per village health volunteer has a spatial correlation with an elderly population distribution pattern that falls in the same direction (Moran's I= 0.034), and the LISA analysis indicated hot spots or high-high clusters of the proportion population per village health volunteers and high levels of falls among the elderly have 2 provinces: Phuket, and Narathiwat province. In addition, there were 3 provinces with a low proportion of population per village health volunteers with high levels of falls among the elderly in Yasothon, Surat Thani, and Trang province was surrounded by low levels of proportion population per village health volunteers in three neighboring provinces (low-high cluster). There were provinces with a high proportion of population per village health volunteer and low levels of falls among the elderly, in Samut Prakan, Pathum Thani, and Chiang Mai Province surrounded by a low proportion of population per village health volunteer in three neighboring provinces (high-low cluster). In contrast, LISA analysis showed clusters of a province with a low proportion of population per village health volunteers and falls among the elderly with also low values of surrounding 3 provinces (cold-spot or low-low clusters). There were low-low clusters found in Bangkok, Nan, and Chiang Rai province (Figure 3).



(a) (b) (c)

Figure 3: LISA and Moran's I scatter plot matrix of proportion population per village health volunteers with falls among elderly in Thailand; (a) Moran's I scatter plot matrix (Bivariate: proportion population per village health volunteers and falls in elderly); (b) Cluster maps of proportion population per village health volunteers and falls among elderly in Thailand; (c) Significance maps of poverty incidence and falls among elderly in Thailand.

4. Discussion

Geographic information systems (GIS) is an information technology that enables the efficient use of geographic information systems for jobs. It can collect geographical information that may be changed, analyzed, displayed, and presented (Longley et al., 2001). Seeing dimensions and spatial relationships is to grasp the problem, and it serves as information for planning the use of spatial resources and for making decisions. Especially so that health effects and harm can be avoided, and policies can be made to deal with health problems in each area in a way that fits with the way people live, their culture, and their traditions (Nykiforuk and Flaman, 2011). It is shown from previous studies that GIS plays an important role in the health of the elderly, particularly falls in the elderly, who suffer from deterioration of the body and decreased body function. If he were to fall, he would sustain severe injuries and spend more time in the hospital than any other age group. Whereas GIS is a geographic information technology system that contributes to enhancing access to local contexts (Ceccato and Willems, 2019). Based on a study of how the prevalence of falls among the elderly in border provinces falls, it was found that most of the working-age population moved to provinces with better economies to find work, while the elderly population was forced to live alone in rural areas without a caregiver, making them very likely to fall (Department of Medical Service, 2019). Multiple studies have shown that the following factors contribute to senior falls: hazardous residential interior and exterior conditions (Ranaweera et al., 2013). The location of the restroom is inconvenient or difficult to access (Savita et al., 2 015) . Homes with inadequate illumination and those without railings or railings lack structural integrity (Shi, et al, 2014). Essential and necessary for reducing the risk of falls are safe environments and home environment management. Research on home modifications for low-income older persons determined that the appropriate price range for renovating a house was in the average range of 2 0 ,0 0 0 baht/house, while the cost of constructing a new house was 8 0 ,0 0 0 baht per property (Panraluk, 2014).

This is a big cost for low-income earners. Therefore, economic circumstances, urban prosperity, and people's income are vitally important since they are directly related to access to healthcare systems and the supply of services. Convenience and the creation of a safe environment to reduce and prevent elderly falls in the area. As for the spatial factor of the proportion of patients with non-communicable diseases, it was found that they were spread out in Thailand in the same direction as falls among the elderly. Consistent with studies in various areas, it was found that the risk factors for falls in the elderly were: non-communicable diseases, (Williams et al., 2015) having diabetes, (Agudelo-Botero et al., 2018) having hypertension and using hypertension medications, (Silvia Deandrea, et al., 2010) and having cardiovascular diseases (Azidah et al., 2012). As a result of this disease, most patients have sensory impairments such as bone joint sensations, vibration, pressure, pain in the legs, and loss of balance response. Moreover, there is a dysfunction of the motor neuron system. Refractive errors cause cataracts or cloudy lenses, which make it hard for people to see clearly. It makes it harder for older people to walk and keep their balance, which makes them more likely to fall (Timar et al., 2016). From the research that led to the use of GIS, it can be inferred that provinces with a lot of non-communicable diseases had more elderly people who fell (Miertova et al., 2018 and Zhao, 2019). The aforementioned reasons demonstrate that the environment of topography and non-communicable diseases increases the risk that elderly individuals with chronic diseases would then fall due to chronic disease complications; therefore, close supervision of the elderly is essential in an environment that promotes falls.

In addition to family and medical professionals, Thailand is the only country that uses village health volunteers (VHV) to promote the health and quality of life of the elderly inside the nation's rural communities; these volunteers play a significant role in the health care of the elderly (Rasiri et al., 2021) . According to the Thai Ministry of Public Health's standard, the recommended ratios for the operation of VHVs are as follows: 1 VHV providing health care for 10-15 families and 1 VHV providing health care for 7 patients (Department of Health Service Support, 2011). From this study, it was found that in every province of Thailand there was population-to-volunteer ratio of more than 7 people, which was found to be the highest proportion in Sakon Nakhon province, with a high proportion of 397.74 people per VHV. Therefore, the population-to-volunteer ratio in the area is an index of the sufficiency of primary health care services, as well as access to medical and public health services. The study reveals that elderly individuals who live alone without a caregiver are a major contributor to the increased likelihood of falling among the elderly (Noopud, 2020).

Also, older persons who received less encouragement and prompting from carers were 1.04 times more likely to fall than those who received regular encouragement and prompting (Muangsiri et al., 2017). Because of this, the Thai government has set up a long-term care system for public health care for elderly people who are dependent (LTC). This system will be run by a multidisciplinary health team with local health volunteers so that the elderly can get the right care. The administration of the LTC system that employs caregivers for the elderly who are dependent must be trained and registered, defined as 1 person per dependent person throughout ranges of 5 -10 individuals (Department of health service support, 2011). According to GIS research, a high population-to-volunteer ratio has made it difficult to provide comprehensive health care and efficient medical services. In addition, the elderly lack the chance to receive care from caregivers who have the expertise and ability to improve community health. Therefore, it is essential to expand the number of public health volunteers and caregivers for the elderly so that the provinces that lack them can provide a significant percentage of the population with access to efficient and complete health services (Wangpitipani, 2018).

5. Conclusion

When Thailand becomes a fully aged society, the application of a geographic information system (GIS) is of utmost importance, especially when putting policies that will help the health of the elderly in a way that is right for each province while each area differs in culture, tradition, and way of life. Especially in the southern and northeastern regions of Thailand, where falls are most prevalent. Therefore, the government should thus focus on the determinants of health and reduce social inequality, the economy, and access to health services within each province. This will create a foundation for long-term health promotion and rejuvenation of the elderly, prevent illness, disability, and death, which are significant causes of elderly falls and diseases, and create a high quality of life that will lead to the elderly's permanent health.

6. Suggestion

The relevant government and private agencies, as well as regional and local authorities, should be involved in the planning of policies for the prevention of falls among the elderly in Thailand. In particular, budget support for non-communicable disease prevention activities, such as helping older people find jobs that pay well, and support for the manpower of the healthcare profession and VHVs to reduce their proportion of the population per VHV, is enough to meet the appropriate proportion of elderly health promotion in the ratio of 1 to 7–10 people to prevent falls and lower the rates of morbidity, disability, and death.

In further studies, spatial factors in the green area, nighttime light, and store density datasets in other nations should be studied. And a long-term prospective study that collects data on risk factors and anti-fall factors of the elderly covers all issues, including social, economic, environmental, and individual factors that are consistent with the context of every region of Thailand that can be database set to plan to prevent risk factors and design appropriate health care activities that reduce risk and prevent falls among the elderly in the area.

Limitations

The secondary data were obtained from the National Statistical Office of Thailand therefore, there are limitations in terms of variables and data integrity.

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