Identifying Aging Villages with Primary Care Shortages: A Geographic Information System Approach

Tsanyu Kuo

College of Social Science, National Chengchi University (NCCU), Taiwan
108265501@nccu.edu.tw

Abstract

This study aims to identify villages with low or no public medical resources. Two counties in Taiwan—Chiayi and Yunlin—were selected for this purpose because they have the highest aging ratio in Taiwan, which could potentially lead to high demands for primary care clinics. The enhanced two-step floating catchment area method was used to calculate the potential spatial accessibility of each village. Spatial autocorrelation analysis was further used to locate spatial clusters of villages with low clinic accessibility. This study found that 45.4% of the population living in the villages in Chiayi and Yunlin had insufficient medical resources while 0.74% (8,799 people) had no access to primary care clinics at all. The study recommends that health authorities shift public medical resources from oversupplied areas (i.e., southwestern Chiayi) to shortage areas (i.e., eastern Chiayi and western Yunlin) to increase their medical resources.

Keywords: Aging society, Primary care services, GIS, Spatial accessibility, Spatial autocorrelation

1 Introduction

This study investigates the accessibility of primary care clinics and its relationship with aging communities. The goal is to identify villages (1) with low spatial accessibility of primary care clinics, (2) a high aging percentage, and (3) low distribution of public clinics. Meeting all three criteria means that a village is suffering from a medical resource shortage.

Having low clinic accessibility means that a village has a low supply of medical resources and a high percentage of the population that are over 65 years old, which means that the village has a high potential for medical demands. This study adds a third layer to this analysis: the distribution of public clinics. Taiwan's medical operators are mostly private. The value of health authorities is to fill the supply gaps that are ignored by the market-driven medical providers. In other words, if a village has a high medical demand but low medical supply due to the market mechanism, it is the public sector's responsibility to step in and increase the supply.

This study focuses on the relationship between medical resource and aging population and is motivated by the prediction that Taiwan will become a super-aged society (i.e., with more than 20% of the population over age 65) by 2026 and the estimation that there will be zero population growth before 2027. This would lead to a growth of medical demands. It is important for health authorities to ensure good spatial distribution of medical institutions, not only for the physical welfare of the elderly but also to alleviate the burden of the working population.

Among all medical institutions, primary care clinics are the most accessible. They diagnose illnesses in the early stages and provide a direct referral to nearby hospitals, which is especially crucial for the older population. According to American Academy of Family Physicians, improvement of primary care clinics can result in better health care, as family physicians are familiar with their patients' medical history. This has been proven to decrease overall outpatient visits to medical institutions. Primary care can be further broken down into family medicine, internal medicine, paediatric medicine, obstetrics, and gynaecology [1-3].

This study investigates the *potential accessibility* of primary medical care in Chiayi County and Yunlin County in Taiwan, as both have the highest ratio of the aging population at 19.68% and 18.52%, respectively. Despite its proximity to Chiayi County, Chiayi City is excluded from the study because it has a relatively lower percentage (15.94%) of elderly.

The National Health Insurance Administration (NHIA) is aware of the conditions in Chiayi and Yunlin and has implemented mobile health care services (MHS) to improve the medical resource accessibility in these areas. This program provides incentives to encourages doctors to provide services in villages where there are currently no registered medical institutions. The present study also evaluates if the program is allocating resources to the areas where services are most needed.

In recent years, the development of Geography

*Corresponding Author: Tsanyu Kuo; E-mail: 108265501@nccu.edu.tw
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Information System (GIS) has allowed researchers to have more discussions on the connection between medical resource accessibility and medical treatment outcome. This type of research tends to calculate the ratio between medical resources and population [4]. Other studies have investigated the distance or travel time that patients need to reach medical service points [5-6]. By obtaining spatial analysis data, researchers have also been able to identify areas with lower medical resources accessibility, and thus provide policy suggestions for improvement [4].

The current study uses the demographic data from the Ministry of Interior and the primary care clinic data from the NHIA to conduct an *enhanced two-step floating catchment area analysis* (E2SFCA) to calculate the accessibility indicator. Moreover, this study uses spatial autocorrelation to identify potential cold spots where medical resources are scarce.

Health authorities usually evaluate medical services by calculating the medical resource-to-population ratio within an administrative region. However, this ratio does not consider the impact of distance on patients' medical-seeking behaviour and the possibility of patients traveling to other regions to receive treatment. The E2SFCA allows us to consider these two factors and provides us with a more comprehensive method to evaluate medical resource accessibility. In Taiwan's case, Change, Wen and Lai [7] have pointed out that there are significant differences between the result of E2SFCA and NHIA's medical resource evaluation method. The latter ignores the spatial aspect and could result in a medical resource supply-demand mismatch.

Spatial accessibility, based on the method of Chang, Wen and Lai [7], is then combined with *non-spatial accessibility* indicators (e.g., aging ratio) to identify villages with low accessibility and high potential medical needs. Low medical supply may be due to the market mechanism; we thus investigate if public primary care clinics have helped to improve the villages' medical accessibility and fill the gap between patients' needs and private providers' supply.

In short, this study aims to combine spatial and non-spatial perspective to identify villages that suffer from primary care shortages. This method is repeatable and helps government agencies to target the regions that need resources the most.

2 Literature Review

This section reviews the studies on medical accessibility and measuring potential accessibility.

2.1 Medical Accessibility

Medical accessibility can be separated into four main categories: *potential accessibility, revealed accessibility, spatial accessibility, and aspatial accessibility* [8].

Potential accessibility signifies the probable entry into the health care system and, specifically, the number of potential patients and their possible characteristics. *Revealed accessibility* focuses on the actual use of health care services, that is, patients' actual medical visits and their subjective satisfaction of the services. *Spatial accessibility* stresses the importance of the spatial or distance variables, which can be a barrier or a facilitator while investigating the impact of proximity on patients' access to medical services. *Aspatial accessibility* emphasises the non-geographic barriers, such as social class, income, ethnicity, age, or gender. Its goal is to understand if accessibility is influenced by patients' socioeconomic status or other personal traits.

GIS-based research on accessibility focuses on the spatial interaction between patients and medical providers. Joseph and Philips [9] introduced the ideas of *potential* and *revealed accessibility*. The former signifies medical service accessibility within a space; the latter emphasises patients' actual utilisation of medical resources. Anderson [10] simply defined potential accessibility as "the presence of enabling resources". Khan [8] further described it as the availability of medical resources within a certain spatial region or a certain distance. To reach medical resources, one would need to locate the points of services, define the maximum service distance, and assume the entire population consists of potential medical users. The basic units of analysis are medical service areas—be it defined by travel time or spatial distance—rather than administrative regions.

In sum, this study focuses on citizens' *potential spatial accessibility* to primary care clinics. *Revealed accessibility* is not included due to the limitation of resources for field research on patients' actual medical-seeking behaviour. The study defines accessibility as "the potential medical resource that citizens have access to within a reasonable spatial distance". We also examine the correlation between accessibility and other non-spatial elements such as aging population and public clinic distribution. The aim is to identify villages that are suffering from a shortage of primary health care.

2.2 Measuring Potential Accessibility

In the field of paediatric research, Gnanasekaran, Boudreau, Soobader, Yucel, Hill and Kuhlthau [11] calculated the ratio between the number of paediatric specialists and the number of children, to emphasize the risk of delayed care. This method also has its limitation, as it does not consider the possibility of patients seeking treatment outside of their region, nor does it put into account the spatial impact on patient's willingness to seek treatment. The more distant the clinics are, the less likely patients would seek treatment there.

The *floating catchment area method* [4] has the advantage of assuming patients will search for medical resources within a reasonable travel distance or travel time. Any institutions that can be reached within this distance and time are potentially accessible medical resources.

The *floating catchment area method* can be further categorised into three levels: (1) *one-step floating catchment area method* (1SFCA), (2) *two-step floating catchment area method* (2SFCA), and (3) E2SFCA.

The 1SFCA method calculates spatial accessibility from either the provider or the receiver's perspective. For example, outstretch an area of 15 km from a clinic and calculate the medical provider-to-population ratio.

The 2SFCA method takes both the medical providers' resources and the receiver's location into consideration. The first step is the same as the 1SFCA to find the loading of each supplier. The second step is to outstretch an area of 15 km from each village's population gathering point, identify the clinics that are located inside these 15-km areas, and add up these clinic's score obtained from the first step. The final score is then used as an indicator for medical resource spatial accessibility [13].

The E2SFCA is based on the 2SFCA but adds weighted values to travel time and travel distance [2]. For example, the same doctor can be reached by a patient within a 15-km range and another within a 30-km range of the clinic, but the accessibility indicator for the patient living 30 km away from the clinic should be weighed lower than that of the 15-km patient.

E2SFCA considers (1) patients' cross-boundary medical-seeking behaviour, (2) the number of medical resources that can be reached by patients, and (3) the impact of distance on patient's accessibility. Given the comprehensive assumption of the E2SFCA, this study uses it as the core method of analysis.

3 Methodology

This section presents the assumptions of this study and introduces the spatial analysis methods used: the E2SFCA, local indicators of spatial association (LISA).

3.1 Data and Assumptions

This study used the demographic data from the Ministry of Interior, the road network data from the Ministry of Transportation and Communication, and the primary care clinic data from the National Health Insurance Administration as its fundamental dataset. The road network data covers the available roads in Taiwan, so both urban area and mountainous terrain are included in the calculation.

To calculate accessibility, we made two assumptions: (1) village centre is the geometric centre point weighted by population, and (2) 15 km is a reasonable distance for reaching a clinic in Taiwan.

In order to use a point to represent a village, we aggregate data from 'minimum statistical area' (MSA), the smallest spatial unit defined by the Taiwan Ministry of Interior. For example, Village Z has three MSA (Area1, Area2, Area3), each with different population (P_1, P_2, P_3), X coordinate (X_1, X_2, X_3) and Y coordinate (Y_1, Y_2, Y_3) for its centre point. The X coordinate calculation is shown below; the same method applies to the Y coordinate. This method was utilised in past research to more accurately pinpoint village centre [12].

$$X\ coordinate\ of\ village\ A = \frac{P_1X_1 + P_2X_2 + P_3X_3}{P_1 + P_2 + P_3} \quad \textbf{(1)}$$

This study adopted Chang, Wen and Lai [7] assumption, taking 15 km of road distance as a reasonable range for reaching a clinic. Compared to the assumption of 15 miles or 30 minutes' drive suggested in North American research [14], 15 km is more feasible in Taiwan as the island-nation is smaller in scale and with narrower roads.

3.2 The E2SFCA Method

This study used the E2SFCA method introduced by Luo and Qi [2] as the main analysis method. This section demonstrates how the spatial accessibility indicator is calculated.

Figure 1 is a map of two towns (upper town and lower town), both are marked by thick border lines. The upper town has eight villages (Village A to Village H) and one clinic (Clinic α); the lower town has six villages (Village I to Village N) and one clinic (Clinic β). Each village point is the geometric centre of the village, with the entire population concentrated on that point. For explanation purposes, here we assume there is only one patient in each village.

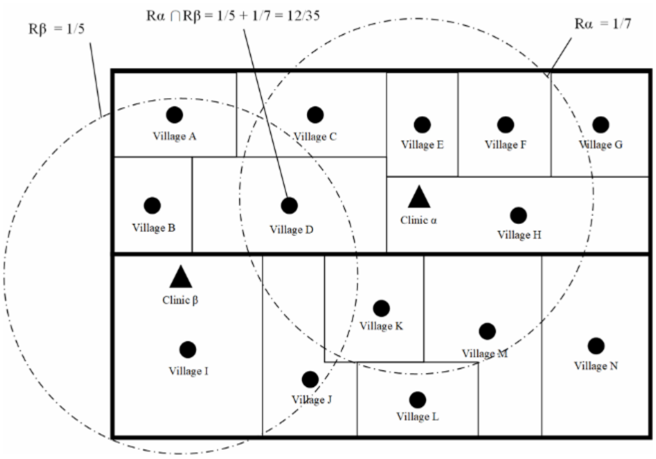

Figure 1. 2SFCA

Luo and Wang [13] introduced the 2SFCA, which is calculated by first outstretching a 15-km range from each clinic to see how many villages are covered within this range. For example, seven villages (Villages C, D, E, F, H, K, M) fall within the 15-km range of Clinic α. So, the medical resources accessible to each of these villages from Clinic α is $\frac{1}{7}$. The same calculation applies to Clinic β with the result of $\frac{1}{5}$. The second step is to calculate the resource for each village. For villages that are covered by only one clinic (e.g., Village A), the medical resource it enjoys would be the same as other villages within the same range. For example, Villages A, B, I, J all enjoys $\frac{1}{5}$ of the resources coming from Clinic β. For the areas that are covered by both clinics' ranges, like Village D, the combined medical resource is $R_\alpha + R_\beta = \frac{1}{7} + \frac{1}{5} = \frac{12}{35}$. If we evaluate Village D's resource using the traditional provider-to-population ratio method, it would only have access to the upper town resource, which would be Clinic α divided by eight villages (i.e., $\frac{1}{8}$), neglecting the possibility that Village D can also be served by Clinic β of the lower town.

Although the 2SFCA method provides a good framework to understand the spatial accessibility of medical resources, it does not take into account the impact of proximity (i.e., patients are less likely to seek treatment when the distance increases). Luo and Qi [2] introduced the E2SFCA, in which distance is weighted to account for its impact. This method was also used by Chang, Wen and Lai [7] in evaluating Taiwan's medical doctor distribution.

Figure 2 depicts three layers of circles around each clinic, with each layer representing a 5-km difference. The innermost circle represents the range of 0-5 km from the clinics; the middle circle, 5-10 km; and the outer circle, 10-15 km. As the distance increases in 5-km increments, patients would be less likely to utilise the medical resources of the clinics. Therefore, this study added a weighted value of $\frac{1}{2}$ to account for the impact of proximity.

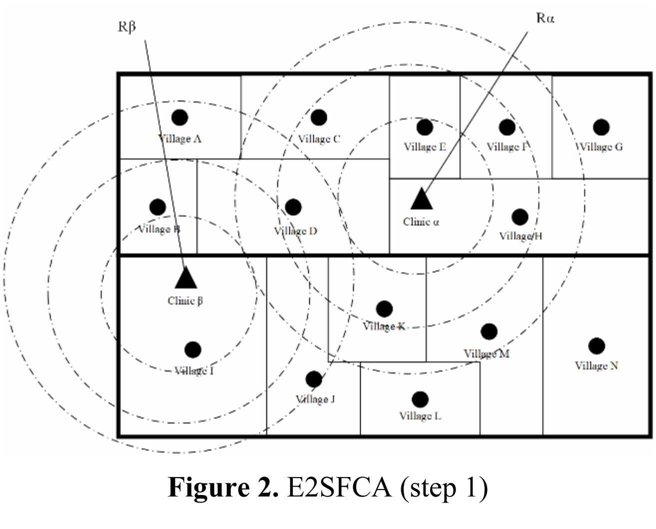

Figure 2. E2SFCA (step 1)

The first step is to calculate the shared medical resource of each clinic but with weighted values. The number of layers is denoted as n. In this case, there are three layers, with each range weighted an extra $\frac{1}{2}$ compare to the previous circles. V_n represents the number of villages that are located within the range of layer n. Take Clinic α for example, there is one village that falls within the 0-5 km range, five within the 5-10 km range, and one within the 10-15 km range. The clinic-to-patient ratio of Clinic α (R_α) is as below:

$$R_\alpha = \frac{1}{\left(\Sigma\left(\frac{1}{2}\right)^{n-1} \times V_n\right)} = \frac{1}{(1\times 1) + (\frac{1}{2}\times 5) + (\frac{1}{4}\times 1)} = 0.2\overline{6} \quad (2)$$

The same applies to Clinic β:

$$R_\beta = \frac{1}{(1\times 1) + (\frac{1}{2}\times 1) + (\frac{1}{4}\times 3)} = 0.\overline{4} \quad (3)$$

The second step is to calculate the medical resource each village has. As demonstrated in Figure 3, both Clinic α and Clinic β are within the 15 km-range of Village D; Clinic β is also in the range of 5-10 km, and Clinic α, the range of 10-15 km. Village D's medical resource indicator is then calculated by adding the value of R_α and R_β while considering the distance-weighted variables.

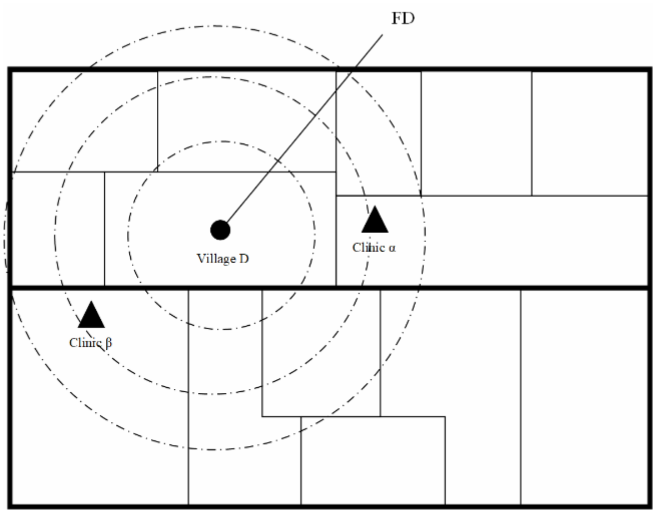

Figure 3. E2SFCA (step 2)

We denote n as the number of circle layers. In this example, three layers represent different distances: the inner circle is 0-5 km from Village D, the middle circle is 5-10 km, and the outer circle is 10-15 km. R_n is the R values of the institutions that fall within layer n. In Village D's example, Clinic β and Clinic α fall within the second and third layer of Village D. Therefore, the final accessibility for Village D (F_D) is as below:

$$
\begin{aligned}
F_D &= \Sigma\left(\left(\frac{1}{2}\right)^{n-1} \times \Sigma R_n\right) \\
&= 0 + \left(\frac{1}{2} \times \frac{4}{15}\right) + \left(\frac{1}{4} \times \frac{4}{9}\right) \\
&= 0.2\overline{4}
\end{aligned}
\quad \textbf{(4)}
$$

We can interpret the result of Village D as: within a range of 15 km, every patient has access to around 0.24 clinics, or, every clinic is accessible by 4.09 patients.

MHS is not included in the calculation as it is more of a project-based service, and the weekly service hours vary from village to village. This study only evaluates if MHS is distributed in the villages where accessibility is low, making sure that public resource is provided where it is needed the most.

Medical spatial accessibility will be combined with non-spatial data to categorise villages so that resource shortage villages can be identified.

3.3 Spatial Autocorrelation

In the previous section, we have located the centre point of each village and calculated the number of clinics accessible by total population in each village. This process essentially transforms polygon data into point data. This research then uses point data (i.e. output of E2SFCA) to conduct a spatial autocorrelation to analyse spatial settlements. For example, if Village X has high medical resource accessibility, if the nearby Village Y and Village Z also have relatively high spatial accessibility, then we can say that Village X is the 'spatial hot point' of the cluster of these three villages.

Spatial autocorrelation has two main categories: global and local. For global spatial autocorrelation, Global Moran's I is one of the most used methods. The formula is as below:

$$
I = \frac{N}{W} \times \frac{\Sigma_i \Sigma_j wij(x_i - \bar{x})(x_j - \bar{x})}{\Sigma_i (x_i - \bar{x})^2}, i \neq j \quad \textbf{(5)}
$$

Where $\bar{x}$ is the mean of all x values; x_i is the clinic-patient ratio in spatial unit i; x_j is the clinic-patient ratio in spatial unit j; wij is a matrix that shows if i and j have neighbouring relationships. If they do, then wij would be 1, and if not, 0. Note that the neighbouring relationship with oneself (i.e., wii or wjj) is 0; N is the number of spatial units; W is the sum of all the wij combinations.

The value of Moran's I falls between -1 and 1. A positive value means a positive correlation and vice versa. If the absolute value is closer to 1, then it means that there is a cluster among the units. On the contrary, if the absolute value is closer to 0, then the spatial units are more dispersed.

Global spatial autocorrelation can describe if the observed spatial units are clustered, randomly distributed, or dispersed. However, it cannot highlight where exactly the hot spots are located. Based on Moran's I, Anselin [15] introduced LISA, which divides the whole region into subunits and pinpoints the spatial relations among these subunits. The formula for LISA is as follows:

$$
I_i = (x_i - \bar{x})\, \Sigma_i w_{ij} (x_j - \bar{x}), i \neq j \quad \textbf{(6)}
$$

I_i describes the correlation between the observed value of spatial unit *i* and its neighbours. If I_i is larger than 0, then spatial unit *i* has a positive relationship with its neighbours, forming a cluster of similar values. In contrast, if I_i is smaller than 0, then spatial unit *i* has a negative relationship with its neighbours, forming a cluster of dissimilar values. If I_i is close to 0, then spatial unit *i* has no significant correlation with its neighbour, indicating a random distribution.

Anselin [15] suggests five scenarios of spatial correlation: (1) Not significant: spatial unit *i* does not correlate with its neighbours. (2) High-High: the observed value of spatial unit *i* is higher than average, and those of the neighbouring units are also higher than average. Such an area is a hot spot among the observed values. (3) Low-Low: the observed value of spatial unit *i* is lower than average, and those of the neighbouring units are also lower than average. Such an area is a cold spot of the observed values. These areas are the focus of this study, as they identify the locations where medical resources are scarce. (4) Low-High: the observed value of spatial unit *i* is lower than average, but those of the neighbouring units are higher than average. (5) High-Low: the observed value of spatial unit i is higher than average, but those of the neighbouring units are lower than average. Based on result of LISA, we can provide suggestions where government could improve services.

4 Findings

This section presents the findings on the spatial aspects of primary care clinic accessibility and non-spatial aspects such as aging and public medical resource allocation. Integrating spatial and non-spatial data would allow us to identify villages with primary care shortages.

4.1 Primary Care Clinics Spatial Accessibility

Figure 4 demonstrates the clinic accessibility in Chiayi and Yunlin regions through a quantile map. We can see that accessibility is higher in central Chiayi, southwestern Chiayi, and northern Yunlin. In Chiayi County, the diffusion is centred around Chiayi City, the business centre of the Chiayi region. Border villages between Chiayi and Tainan City in the south also reflect higher clinic accessibility. This may be due to its proximity to Xinying District of Tainan City, which is the administrative centre of northern Tainan.

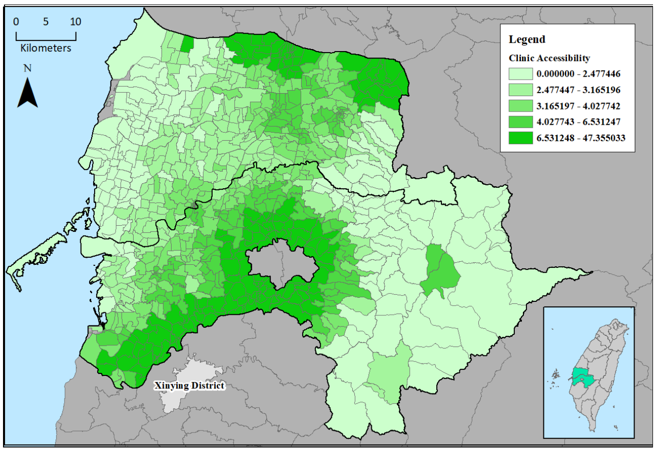

Figure 4. Clinic accessibility (quantile map)

To clearly identify the regions with high primary care clinic accessibility (hot spots) and those with low primary care clinic accessibility (cold spots), we used the GIS software GeoDa to conduct the LISA analysis to find spatial clusters of accessibility distribution (Figure 5). The results highlighted the coastline in the west and mountainous region in the east as two cold spots that need improved medical accessibility. While the southern part of Chiayi and the central-northern and northeastern part of Yunlin have higher clinic accessibility clustering in the region.

The cold spots are located in the mountainous east and coastal west. Resource cold spots in Yunlin include the following townships: Gukeng (GK), Mailiao (ML), the southern part of Lunbei, Taixi, Dongshi, Baozhong, the northern part of Yuanchang (YC), Sihu, Kuohu, and Shuilin (SL).

In Chiayi, the cold spots are Meishan, Alishan (ALS), Dapu (DP), eastern Zhuqi, eastern Fanlu, and eastern Zhongpu township.

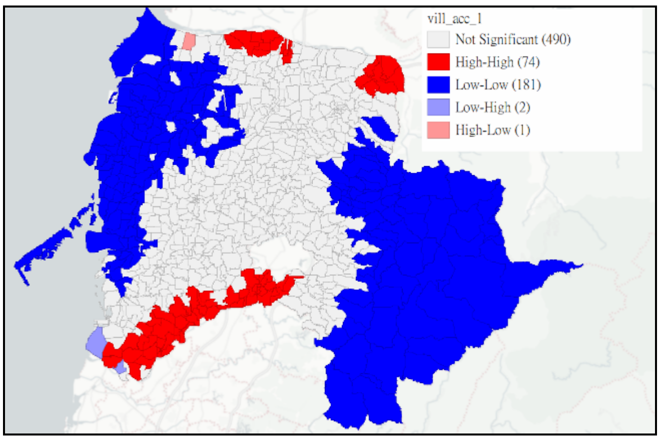

Figure 5. Clinic accessibility using LISA

The National Health Insurance Committee defines medical resource underserved areas as places where one doctor needs to serve more than 2,600 patients. That is equivalent to every 10,000 patients having less than 3.8462 doctors serving them. Figure 6 classifies the villages into three levels: Sufficient accessibility (accessibility >3.8462); Insufficient accessibility (0< accessibility <3.8462); No accessibility (accessibility =0)

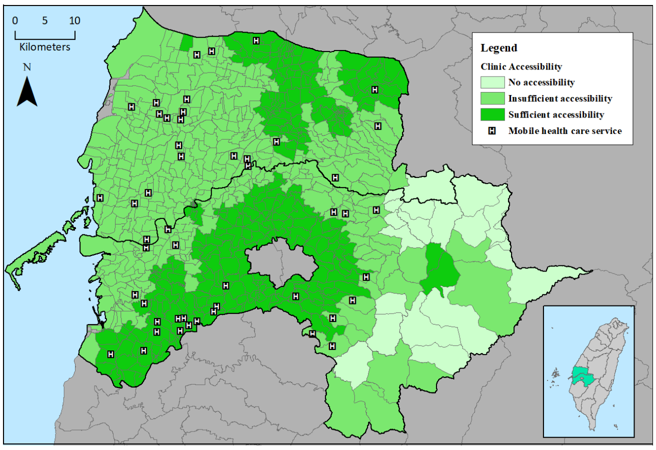

Figure 6. Clinic accessibility classified by NHI definition with mobile health care service distribution

Based on this categorisation, sufficient clinic accessibility is found in northeastern Yunlin, central and southwestern Chiayi. Places with insufficient accessibility are mostly in the coastal areas of western Yunlin. Villages with no accessibility within the 15-km range are mostly in the mountainous areas of eastern Chiayi. This means that 45.4% of the population (537,776 people) are in villages with insufficient clinic accessibility, while 0.74% (8,799 people) have no clinic accessibility at all.

MHS that provide family medicine services are deployed across both counties, but there seems to be an unequal distribution of the services. Southern Chiayi, where resources are relatively abundant, have a higher concentration of MHS available. However, in eastern Chiayi, where there is no accessibility, no MHS is available. This paper recommends that the NHIA consider shifting some MHS resources to the villages in eastern Chiayi, giving more incentives for doctors to participate in MHS.

4.2 Aging Population Distribution

Figure 7 uses the World Health Organisation's (WHO) definition of an aging society to classify villages in the Chiayi-Yunlin region. A village that has more than 7% of the population over 65 years old is considered an aging society; over 14%, an aged society; and over 20%, a super-aged society.

While super-aged villages are spread across the region, the coastal area tends to have a higher concentration of aging communities.

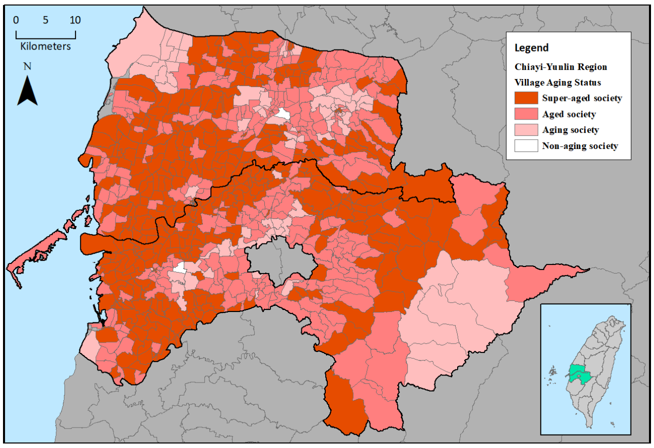

Figure 7. Classify villages by aging society the definition of the World Health Organisation

4.3 Public Resource Distribution

In the previous sections, we identified the regions where primary care medical resources are lacking and places where there are higher aging indicators. In this section, we investigate the distribution of public resources. Public clinic accessibility and MHS locations are visualised through Figure 8.

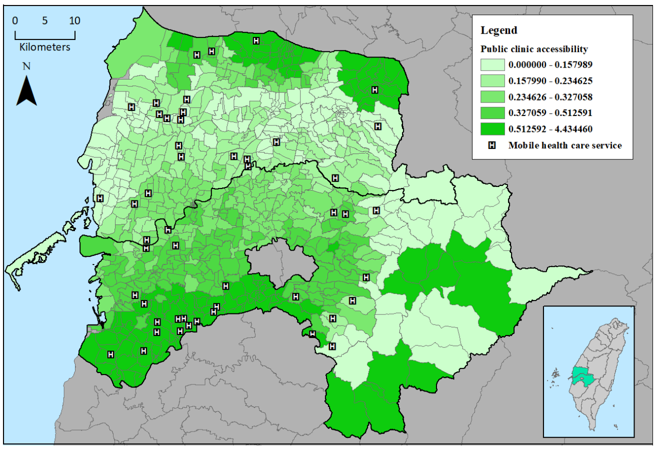

Figure 8. Clinic accessibility contributed by public clinics with mobile medicine service (quantile map)

Taiwan's clinics are mostly operated by the private sector. If the market-driven mechanism leaves a supply gap, it is the responsibility of the public sector to set up service points to ensure a more equitable distribution of medical resources.

The average public resource accessibility is 0.44. Compared with the NHIA standard for physician-to-patient ratio (i.e., 3.8462 doctors for every 10,000 people), public clinics provide only minor help. However, Figure 8 shows that the villages in the eastern part of the region, where medical resources are scarce, receive more public resources; this means the NHIA is helping to bridge the gap between the medical demand and supply in ALS and DP.

However, primary care resource hot spots (northeastern Yunlin, central-northern Yunlin, and southwestern Chiayi) also have more public resources, meaning that these areas have an oversupply. An extreme case can be found in YZ, where five villages can reach NHIA-defined sufficient accessibility with public resources alone. The NHIA should consider shifting some public resources to villages that are suffering from low accessibility, such as the coastal villages in the Chiayi-Yunlin region, to achieve a more equitable distribution of primary care services.

The MHS programs are mostly located in the southwestern part of Chiayi where resources are relatively rich. MHS is also available in eastern Chiayi. These services are within the area of resource cold spot, which should help to improve the accessibility in mountain towns. In Yunlin, the majority of MHS are well-fitted in resource cold spots along the coast, except for two mobile services that are located in the resource-rich northeast and central north.

In conclusion, although medical resource cold spots are covered by MHS in the coastal west and public clinics in the mountainous east, resource hot spots also receive strong public support. This paper recommends that NHIA shift some public resources from the hot spots to the cold spots to achieve a more equitable distribution of health services.

4.4 Identifying Primary Care Shortage

To pinpoint the villages that are suffering from a shortage of primary health care, we categorised all 748 villages in Chiayi and Yunlin by clinic accessibility level, aging society level, and public resource or MHS program access. The summary of the categorisation is in Table 1.

Table 1. The number of villages in various clinic accessibility scenarios

Clinic Accessibility	Chiayi	Yunlin	Sum
Sufficient Accessibility	205	137	342
Insufficient Accessibility	134	253	387
Aging Society	5	18	23
Public clinic available	5	18	23
Aged Society	26	87	113
Public clinic available	26	87	113
Super-aged Society	103	148	251
Public clinic available	103	148	251
No Accessibility	18	1	19
Aging Society	3	0	3
Public clinic not available	3	0	3
Aged Society	6	0	6
Public clinic not available	6	0	6
Super-aged Society	9	1	10
Public clinic not available	9	1	10
Grand Total	357	391	748

As the purpose of this study is to provide a repeatable framework to identify the most challenging communities in accessing primary care, we focused on villages with (1) insufficient or no access to primary care clinic, (2) aging society (i.e., aged population ≥7% of the total population), and (3) no access to a public resource (i.e., public clinics or MHS).

From Figure 9, we can see the spatial distribution of Chiayi and Yunlin villages with a primary care shortage. They are mostly concentrated in the eastern part of Chiayi and only accounts for less than 1% of the population in the region.

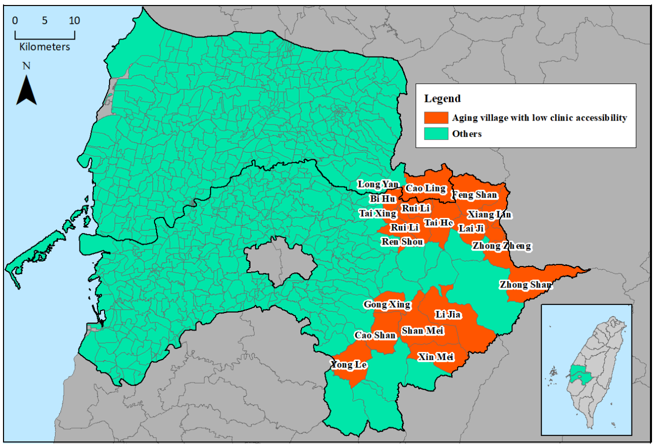

Figure 9. Spatial distribution of villages with primary health care shortage in Chiayi and Yunlin

5 Discussion and Conclusion

This study aims to explore for whom and where primary care shortages post a challenge. Chiayi County and Yunlin County were selected because they have the highest ratio of the aging population in Taiwan.

At first, we calculated each village's potential spatial accessibility to primary care clinics using the E2SFCA method, allowing us to find the population-to-clinic ratio with consideration of distance and cross-regional medical-seeking behaviour. We also used the spatial autocorrelation analysis to identify spatial clusters of both high and low accessibility areas. In general, the mountainous region in the eastern part of Chiayi and coastal towns in the western part of Yunlin have low clinic accessibility. 45.4% of the citizens have insufficient accessibility to a clinic and 0.73% of the population in this region has no access to primary care within a 15-km range.

Second, we examined some aging-related indicators. We mainly used the WHO's categorisation of an aging society to separate the villages into four groups: non-aging, aging, aged, and super-aged. We found that both counties tend to have high aging indicators with general exceptions in the urban and industrial areas.

Third, we calculated the accessibility contributed by public clinics and pinpointed the locations of MHS programs. As Taiwan's health care is operated by market-driven private clinics, we wanted to investigate if public resources are in place when the citizens' demands and primary health care supplies do not match. We conclude that public clinics and MHS are available in eastern Chiayi, and MHS are present in western Yunlin, which showed that public resources are in the neighbourhoods that are in need. However, public resource contribution is also high in resource-rich areas, specifically southwestern Chiayi.

We finally integrated our findings on clinic accessibility, aging condition, and public resource distribution to identify villages with primary health care shortage. These villages are mostly in the eastern part of Chiayi, accounting for 0.74% of the total population and 0.83% of the elderly population in the region.

In conclusion, this study found that only less than 1% of the population in the Chiayi-Yunlin region have serious primary care shortage in both spatial and non-spatial aspects. However, health authorities should work to improve the areas with insufficient accessibility, which accounts for 45.4% of the population. This study recommends shifting public resources from high-accessibility communities to resource cold spots as some areas currently have an oversupply of medical resources, such as southwestern Chiayi. This would allow a more equitable distribution of clinic accessibility, potentially improving the citizens' health care conditions.

This study has a few limitations. First, due to limited resources, we did not include field studies. Our results were bound by government open data. For example, we were able to identify the areas with low accessibility, but we could not point out the specific reason why an area suffers from this disadvantage. Second, multiple transportation methods were not considered. We only used the road networks and distance to estimate accessibility without putting into account the use of train networks. Third, each clinic has different medical resources, and each village has different health pre-conditions. The study was not able to categorise these two variables and add weighted values into the accessibility calculations due to limited access to medical data.

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Biography

Tsanyu Kuo is a doctoral student at NCCU and a project manager at TAITRA. Before joining NCCU, he worked for ASUS Computer as a product manager. He received his master's degree in Social Policy from the London School of Economics. His current research focuses on health policy evaluation using GIS.