GEOGRAPHICAL DISTRIBUTION IMPROVEMENT OF PHYSICIANS IN THAILAND AND JAPAN: A COMPARATIVE LONGITUDINAL SECONDARY DATA ANALYSIS

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การปรับปรุงระบบการกระจายแพทย์สู่ภูมิภาคในประเทศไทยและญี่ปุ่น: การวิเคราะห์เปรียบเทียบระยะยาวด้วยข้อมูลทุติยภูมิ

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ฮิโรมิชิ ทาคาฮาชิ : การปรับปรุงระบบการกระจายแพทย์สู่ภูมิภาคในประเทศไทยและญี่ปุ่น: การวิเคราะห์เปรียบเทียบระยะยาวด้วยข้อมูลทุติยภูมิ. (GEOGRAPHICAL DISTRIBUTION IMPROVEMENT OF PHYSICIANS IN THAILAND AND JAPAN: A COMPARATIVE LONGITUDINAL SECONDARY DATA ANALYSIS) อ.ที่ปรึกษาหลัก : ศ. ดร. สถิรกร พงศ์พานิช

ความเป็นมา: ในหลายๆประเทศรวมถึงประเทศไทยและญี่ปุ่นได้มีการพูดถึงการกระจายตัวอย่างเหมาะสมของบุคคลากรทางการแพทย์และสาธารณสุขลงไปในพื้นที่ต่างๆของประเทศซึ่งเป็นสิ่งที่สำคัญและจำเป็นอย่างยิ่งที่จะทำให้ประชากรสามารถเข้าถึงบริการต่างๆอย่างทั่วถึงกัน วัตถุประสงค์ของการศึกษาในครั้งนี้เพื่อศึกษาเปรียบเทียบระยะยาวของการกระจายตัวของแพทย์ในทุกภูมิภาคของประเทศรวมถึงนโยบายต่างๆที่เกี่ยวข้องของประเทศไทยและประเทศญี่ปุ่น ณ.ช่วงระยะเวลาปี 2008-2018

ระเบียบวิธีวิจัย: การวิจัยในครั้งนี้เป็นการวิจัยเปรียบเทียบระยะยาวเชิงพรรณนาซึ่งใช้ข้อมูลทุติยภูมิสาธารณะของภาครัฐทั้งหมด โดยใช้ข้อมูลเกี่ยวกับจำนวนแพทย์ สัดส่วนจำนวนแพทย์ต่อจำนวนประชากร และนำมาคำนวณค่าสัมประสิทธิ์จีนี ค่าสัมประสิทธิ์สเปียร์แมนระหว่างความหนาแน่นของประชากร และสัดส่วนของแพทย์และประชากรระหว่างปี 2008 และ 2018 รวมทั้งยังมีการวิเคราะห์ในกลุ่มย่อยของ 76 จังหวัดในประเทศไทยและ 335 เขตการรักษาพยาบาลของประเทศญี่ปุ่น โดยแบ่งเป็น 4 กลุ่มย่อยตามนิยาม เมืองใหญ่-เมืองในเขตชนบท และจำนวนแพทย์ในพื้นที่เหล่านั้น นอกจากนี้ยังมีการศึกษาเปรียบเทียบในเรื่องนโยบายการศึกษาและนโยบายการให้บริการทางการแพทย์และสาธารณสุขในทั้งสองประเทศด้วย

ผลการศึกษา: ในช่วงระยะเวลา 10 ปีที่ผ่านมา สัมประสิทธิ์จีนีของประเทศไทยเพิ่มขึ้นจาก 0.372 เป็น 0.319 ในขณะที่ญี่ปุ่นเพิ่มขึ้นจาก 0.217 เป็น 0.211 ในส่วนของสัมประสิทธิ์สเปียร์แมนประเทศไทยเพิ่มขึ้นจาก 0.168 เป็น 0.181 อย่างไม่มีนัยยะสำคัญทางสถิติ ในขณะที่ประเทศญี่ปุ่นสัมประสิทธิ์สเปียร์แมนเพิ่มขึ้นจาก 0.368 เป็น 0.405 อย่างมีนัยยะสำคัญทางสถิติ ในการวิเคราะห์กลุ่มย่อย จะเห็นได้ว่าในระยะเวลาสิบปีที่ผ่านมา จำนวนแพทย์ในประเทศไทยเพิ่มขึ้น 1.97-1.99 เท่าของกลุ่มในเขตเมือง และ เพิ่มขึ้น 1.55-1.74 เท่าของกลุ่มในเขตชนบท ในขณะที่ประเทศญี่ปุ่น จำนวนแพทย์เพิ่มขึ้น 1.10-1.17 เท่าของกลุ่มในเขตเมือง และ เพิ่มขึ้น 0.99-1.00 เท่าของกลุ่มในเขตชนบท ทั้งนี้ความแตกต่างของทั้งสองประเทศอาจเกิดจากนโยบายการผลิตแพทย์ของไทยที่กำหนดไว้ว่าแพทย์จบใหม่ต้องใช้ทุนในเขตชนบทก่อนจะย้ายไปทำงานที่อื่น

สรุป: การศึกษาเปรียบเทียบนี้พบว่าประเทศไทยค่อนข้างประสบความสำเร็จในการจัดสรรแพทย์ไปยังพื้นที่ขาดแคลนแพทย์ ยังเสนอแนะด้วยว่า ระบบการศึกษาเพื่อผลิตแพทย์ของไทยอาจมีประสิทธิภาพในการบรรเทาปัญหาการจำหน่ายแพทย์ที่ไม่เหมาะสมตามพื้นที่ภูมิศาสตร์ได้ ในขณะที่ระบบจัดสรรแพทย์ของญี่ปุ่นในภาพรวมอาจจะมีประสิทธิภาพมากกว่า ในบางครั้งอาจจำเป็นที่จะต้องใช้การเมืองเข้า

สาขาวิชา	สาธารณสุขศาสตร์	ลายมือชื่อนิสิต ....
ปีการศึกษา	2564	ลายมือชื่อ อ.ที่ปรึกษาหลัก ....

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KEYWORD: Geographical maldistribution of physician, Healthcare accessibility, Health policy, Gini coefficient

Hiromichi Takahashi : GEOGRAPHICAL DISTRIBUTION IMPROVEMENT OF PHYSICIANS IN THAILAND AND JAPAN: A COMPARATIVE LONGITUDINAL SECONDARY DATA ANALYSIS. Advisor: Prof. SATHIRAKORN PONGPANICH, Ph.D.

Background: The equitable distribution of healthcare workforces to all citizens is necessary to achieve health for all, and has been discussed and addressed in all countries including Thailand and Japan. The objective of this study was to longitudinally examine the change in the geographical distribution of physicians and related policies between 2008 and 2018 through a comparison between Thailand and Japan.

Methodology: This research was a longitudinal comparative descriptive study. All data is open secondary data that can be downloaded in the government website. The number of physicians, the physician-population ratio, the Gini coefficient and the Spearman's correlation coefficient between population density and physician-population ratio in 2008 and 2018 were calculated and compared among Thailand and Japan. As a subgroup analysis, all 76 provinces in Thailand and 335 secondary medical areas in Japan were divided into four groups according to two criteria: urban-rural and higher-lower initial physician supply classification. Related educational and healthcare policies were also compared.

Result: During the decade, the Gini coefficient was improved from 0.372 to 0.319, and from 0.217 to 0.211 in Thailand and Japan, respectively. The correlation coefficient in Thailand was 0.168 and 0.181 in 2008 and 2018, respectively with no statistical significance. In Japan, the correlation coefficient was 0.368 and 0.405 in 2008 and 2018, respectively with statistical significance. As for the subgroup analyses, the number of physicians in Thailand was increased by 1.97-1.99 and 1.55-1.74 times for the groups with higher and lower initial physician supply, respectively. While one in Japan was increased by 1.10-1.17 and 0.99-1.00 times for the urban and rural groups, respectively. The existence of mandatory rural service for all medical school graduates was one of the biggest differences among countries.

Conclusion: This comparative study revealed that Thailand relatively successfully allocated physicians to physician shortage areas. It was also suggested that Thai educational system may be more effective in mitigating the geographic

Field of Study:	Public Health	Student's Signature ....
Academic Year:	2021	Advisor's Signature ....

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Hiromichi Takahashi

TABLE OF CONTENTS

Page

LIST OF TABLES

Page

LIST OF FIGURES

Page

CHAPTER 1: INTRODUCTION

1 Background and Rationale

Regional maldistribution of healthcare resources has been a topic of great interest and debate in various countries [1]. The geographical maldistribution of healthcare workers, especially in physicians both within and between countries, is a long-standing and important problem worldwide. In many countries, the number of physicians per capita is on the rise, but their distribution is actually concentrated in urban centers and wealthy areas. All countries, rich and poor, report that urban and wealthy areas have a higher proportion of healthcare workers [2]. Several countries, including the United States [3, 4], the United Kingdom [5, 6], Canada [7], European regions [8], China [9], and India [10] have reported disparities in healthcare delivery due to maldistribution of physicians. Not only developed countries, but also developing countries have also reported that urban and wealthy areas have more healthcare workers while there is a shortage in rural areas. In Nicaragua, about half of the entire healthcare workforce is concentrated in Managua, the capital city, which has only 20 percent of the country's population [11]. In spite of this apparent state of surplus, posts in rural areas are not being filled. In Indonesia, vast landmass and difficult terrain pose a major obstacle to the provision of health services and a balanced distribution of healthcare workers. Healthcare workers including physicians are not willing to move to forest and remote islands or mountainous areas where communication with the other areas of the country is poor and there is little comfort for healthcare workers and their families [12].

Factors that are likely to play an important role in when physicians decide where to practice and live are attractive of the locational environment, mode of employment, income potential, working conditions a physician faces, issues of prestige and recognition, expectations [13].

The maldistribution of physicians has a variety of effects. For example, a maldistribution of healthcare workforce can lead to large disparities in health status between rural and urban populations. In Mexico, the average life expectancy of people in rural areas is 55 years, compared to 71 years in urban areas. The infant mortality rate is 20/1,000 in the wealthier northern regions, compared to 50/1,000 in the poorer southern regions [14]. Geographical maldistribution of physicians also causes inequities in access. It has been reported that some citizens have limited access to healthcare due to lack of resources. For instance, people living in areas with few physicians may have to travel farther to see a physician or face long waiting times [15]. In Ghana, access to healthcare is poor in some rural areas, and about 30% of the population is forced to travel long distances to receive secondary or higher levels of care [16].

In Thailand, there is a geographical maldistribution of physicians as Nishiura reported [17]. Since Thailand's population is expected to age rapidly and its demographics will change dramatically in the future, it is necessary to improve regional distribution of physicians. Introducing financial incentives and improvement of the entrance criteria for medical students, for example, are recommended.

In order to consider what to do next to eliminate the geographical maldistribution of physicians in Thailand, it is needed to review what kinds of countermeasures have been implemented, and whether the geographical maldistribution of physicians has been mitigated or not so far. Furthermore, reviewing the degree of improvement of the geographical maldistribution of physicians along with related policies in other country is also helpful, in spite of several differences in health systems and policies among countries. Japan is one of the most aged countries and has implemented many policies to improve people’s health, including ones related to the geographical maldistribution of physicians. Comparing the two countries would be helpful not only for Thailand but also for Japan. Japan has the problem in the geographical maldistribution of physicians as well as Thailand and other countries. In Japan, the geographical maldistribution of physicians is discussed for a long time. In Japan, where the population is aging rapidly and declining, areas with small and declining populations are less likely to be selected. Several studies pointed that the geographical maldistribution in Japan has not been improved so far [18-20]. The population in Japan is expected to decline and be aging afterwards. Reviewing countermeasures implemented in Thailand would be useful for Japan as well.

Both Thailand and Japan have implemented several kinds of policies to eliminate the geographical maldistribution of physicians so far. Thailand and Japan have increased their physician-population ratio as well as a lot of other countries done as mentioned earlier. Increasing the number of physicians itself increases the likelihood of contributing to the health of the country as a whole, but there is the question of whether increasing the number of physicians is eliminating geographical maldistribution or not. When the overall number of physicians increase, there are two different ideas of the impact on the geographic distribution of physicians: the first one is that an increase in the number of physicians will not address regional maldistribution, and the other is that it will correct [21]. The former view is that an increase in the number of physicians will not correct geographical maldistribution. The reason is based on the fact that physicians prefer urban life for career, lifestyle, and family reasons that have been addressed earlier. The other view is that an increase in the number of physicians will eliminate geographical maldistribution as Newhouse advocated [22]. The hypothesis behind the latter is that in areas where there are already many physicians, especially in urban areas, there will be competition for patients because there are so many physicians. Therefore, it would be difficult to earn descent income working in that location because physicians would have to compete for patients. Physicians who are considering where to practice are expected to choose places that are less competitive. As a result, theoretically, this would increase the absolute number of physicians in less populated areas and equalize regional differences in the number of physicians relative to the population. This theory is based on the premise that many medical facilities are run by the private sector and that physicians are free to choose where they practice. However, it is reported that this trickledown has not been found both in Thailand and Japan [17, 20, 21, 23].

In both Thailand and Japan, the government is not only increasing the number of physicians but also taking various policies to correct the maldistribution of physicians [24-26]. Thailand and Japan have different population and other sociological factors, as well as different healthcare systems and policies against maldistribution. Thus, comparing not only the number of physicians and their distribution, but also related policies is significantly important.

However, there are a few studies comparing geographical distribution of physician and policies between Thailand and Japan, though some studies have been conducted about geographical distribution of physician in each country.

Hence, this study shall compare the geographical maldistribution of physicians in Thailand and Japan, as well as the policies that have been implemented to eliminate the geographical maldistribution of physicians.

2 Research question

In this study, four questions are set as followings:

1) How has the number of physicians in each Thailand and Japan changed over the past 10 years?
2) How has the geographical distribution of physicians changed over the past 10 years in each Thailand and Japan?
3) What are the related systems and policies that may have affected the geographical distribution of physicians in each Thailand and Japan?
4) What are the differences and similarities between Thailand and Japan in the geographical distribution of physicians and related systems and policies?

3 Research objective

In response to the research question, one general objective and two specific objectives are set as follows.

a) General objective

To compare the change in the geographical distribution of physician and related policy between Thailand and Japan.

b) Specific objective

1. To identify the incremental number of physicians from 2008 to 2018 both in Thailand and Japan

2. To identify the change in the geographical maldistribution from 2008 to 2018 both in Thailand and Japan
3. To examine the differences and similarities in the geographical distribution from 2008 to 2018 among Thailand and Japan
4. To examine the differences and similarities in the related policy of the geographical distribution of physicians both in Thailand and Japan

4 Conceptual framework

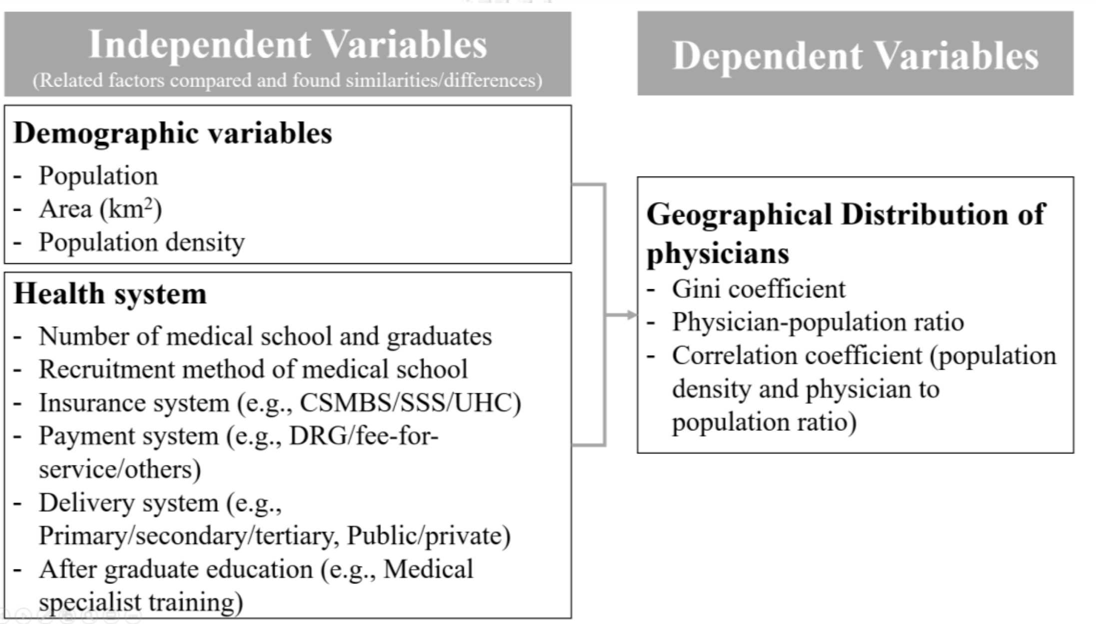


Figure 1. Conceptual framework

5 Expected benefit

This study would be able to provide beneficial information in terms of whether policies and health systems implemented in each country relatively address the geographical maldistribution or not. In addition, comparing results among countries with different healthcare systems is important, because the impact of one country's healthcare system on results can only be observed by comparing it with the systems of other countries. Moreover, proposing an effective policy to improve the geographical distribution of physicians to both Thailand and Japan is possible. Japan would be able to gain information about how Thailand improved the physician distribution. Similarly, Thailand, which will experience rapid aging in the future, would acquire precedent information that Japan has faced and how to these problems have been solved

6 Operational definition

Physician is a person graduated from medical school and qualified to practice medicine. In this study, the number is calculated by the census.

Geographical distribution is the natural arrangement and apportionment of physicians in the different regions.

Geographical maldistribution is undesirable inequality or unevenness of placement over an area.

Population is the number of people living in a certain country or region.

Population density is a number defined by the number of people living per square kilometer (km2) of unit area.

Physician-population ratio is a ratio that shows how many physicians exist every 1,000 population. It can be calculated by followings

$$Physician - population\ ratio\ = \frac{\text{(The number of physicians)}}{1{,}000\ population}$$

Gini coefficient is used to measure inequality of a distribution. The Gini coefficient ranges between 0 and 1. It is defined as a ratio: the denominator is the area of the triangle that is under the perfect equality distribution line; and the numerator is the area between the Lorenz curve of the distribution and the perfect equality distribution line. A higher Gini coefficient indicates a more unequal distribution and 0 Gini coefficient describes perfectly equal [27].

Province is part of the government of Thailand that is divided into 76 provinces and one special administrative area, representing the capital Bangkok as of 2022. They are the primary local government units and are divided into amphoes (districts). Each province is led by a governor, who is appointed by the central government.

Secondary Medical Area (SMA) is area from the 47 prefectures of Japan and consist of several municipalities. Each SMA is considered to provide general impatient care including emergency medical care for regional residents. Plans for the number of physicians and hospital beds are based on SMA, which are the basic units of regional medical care.

Urban is province or SMA with population densities above the median value.

Rural is province or SMA with population densities below the median value.

CHAPTER 2: LITERATURE REVIEW

1 Geographical distribution of physician (in general)

1.1 Causes of issue

As shown in Figure 2, Wibulpolprasert identified multiple influencing factors of physician maldistribution, including general social and economic inequities, the medical education system, payment incentives, the development of public and private healthcare systems, and social movements for reform [28]. Followings are factors identified by Ono that were likely to play an important role in when physicians decide where to practice and live [13].

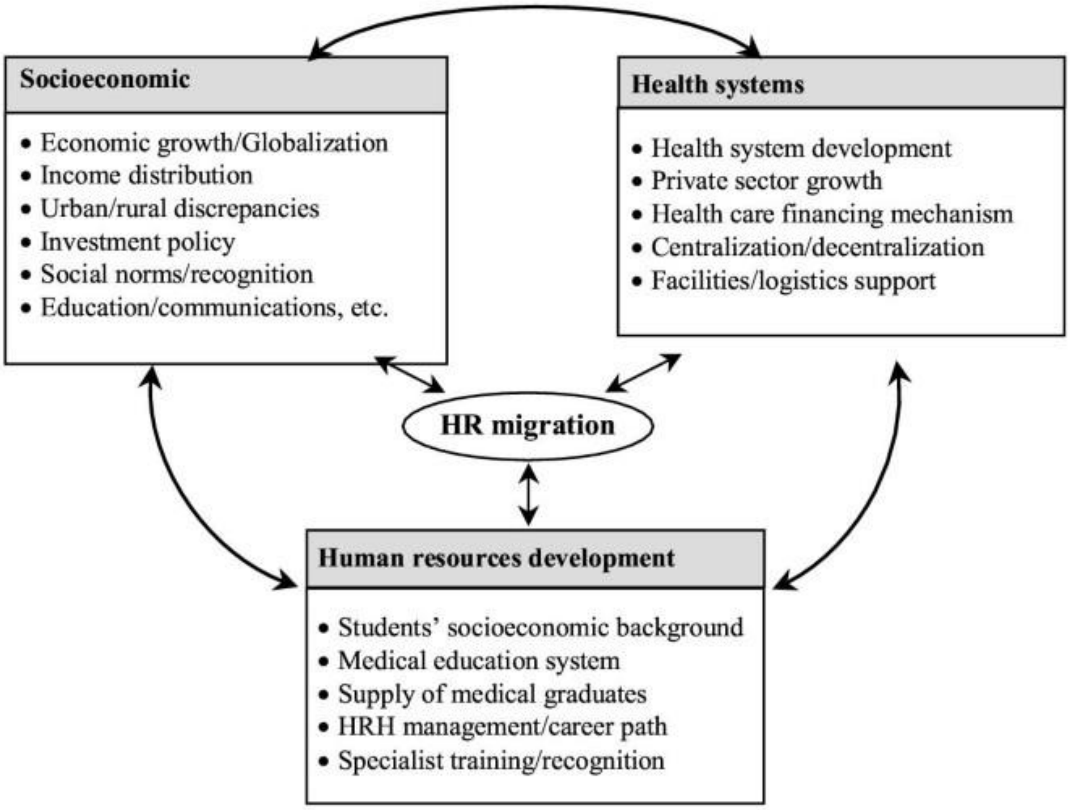


Figure 2. Factors determining the distribution of physicians

Source: Adopted from Wibulpolprasert S [28, 29]

Attractive of the locational environment

It is included infrastructure, vocational opportunities for spouses, educational choices for children as well as housing, personal safety concerns, access to cultural activities and leisure activity.

A qualitative study in Germany reported that "expected workload," "recreational opportunities," "work-life balance," and "family compatibility" were major barriers for students in deciding to specialize in GP [30]. Even in urban areas, physicians might have difficulty selecting socioeconomically disadvantaged areas, and factors such as unsafe neighborhoods and school environments might affect the desirability of a location [13]. In a qualitative study among Canadian medical students, many residents initially planned to practice in an urban area to gain experience. In addition, they considered practicing in an urban area in the long term due to lifestyle and family issues. Practicing in rural areas was not considered by many and was attributed to workload, lifestar entry, family issues, and lack of medical support in the community [31]. In a study conducted in Germany in which 16 practitioners were interviewed, they reported that less competition and a more diverse job description made working in rural areas more attractive. On the other hand, income and lack of leisure facilities were negative aspects. Group practices, for example, made rural practice more attractive, and financial incentives were reported to be insufficient to attract young physicians to practice in rural areas [32]. On the other hand, some physicians reported that being rural was an attraction in itself. A survey of physicians working in rural Colorado, USA, rated various lifestyle factors as determinants of their choice and satisfaction with rural work. They most commonly cited were recreational and leisure activities (70 percent); suitability for raising children (55 percent); and professional independence (44 percent). The physicians had the highest satisfaction levels with: the community (84 percent); their ability to provide quality care (84 percent); and work-life balance (60 percent). [33]

Mode of employment

To be a salaried employee, publicly employed, or self-employed. To be employed by someone, whether an employer allow physicians to hold two or more jobs was concerned. The employment status of physicians influenced policy options to attract them to areas with physician shortages. If physicians were salaried employees, their choice of practice location depends on the availability of positions in the area. Economic incentives also depend on the type of employment. If the physician is a salaried physician, his or her salary can vary depending on where he or she works, but if he or she is self-employed and on a per capita basis or fee-for service (FFS), the incentive may not work based on where he or she works [13]. Several countries also permit physicians to work two jobs. In many cases, they work part-time while employed. Opportunities to earn income from part-time work are more common in densely populated urban areas, and this may influence the choice of work location.

Income potential

If the system is FFS or capitation system, physicians in rural areas have less patients and earn less income than colleagues who practice in urban. Otherwise, physicians in rural have to work longer than ones in urban in order to earn descent wage.

Studies in the United States showed that rural primary care physicians earned slightly more per year than their urban counterparts. However, to earn this income, primary care physicians working in rural areas tended to work longer hours, visit more patients, and have a higher percentage of Medicaid patients. Adjusting for those efforts also showed that physicians in urban areas earned higher salaries [34]. A study in Germany argues that economically disadvantaged areas in urban areas have less potential to gain sufficient financial benefit due to the small percentage of patients with private insurance with large benefit coverage and amounts [35].

Working conditions a physician faces

Working hours, extensive on-call duties, different language and culture, security concerns, access to high-quality medical equipment and support services, opportunities to have a desirable career and to develop professional knowledge and skills. Working conditions are important for physicians when choosing where to work. Many medical students and new graduates emphasize the importance of balancing work and family life.

In an Internet survey targeting all medical students in Germany, almost all respondents emphasized the importance of balancing work and family life. General practice was not preferred, especially in rural areas [36]. In a study targeting a group of Norwegian physicians, those choosing surgery and internal medicine were motivated by medical challenges and career possibilities, while those choosing psychiatry and general practice were motivated by diversity, variety, and having time with family [37]. A survey in Switzerland showed that future family physicians, both women and men, are less career oriented. Compared to specialists, family physicians are more likely to be married and have children. They have lower internal and external career motivation, greater non-specialty interests, and lower objective and subjective evaluations of career success. Part-time oriented models of work-family and work-life balance are preferred, respectively [38]. In a survey of rural New Zealand practitioners, concerns about overwork, excessive on-call, bureaucratic demands, and general practitioners (GPs) shortages were equally important to both men and women. Female GPs, on the other hand, mentioned issues of security, accreditation, and balancing work and family [39]. In Australia, physicians prefer to work in the public sector, while those unwilling to take career or clinical risks prefer the private sector [40]. According to a survey of rural women physicians in Victoria, Australia, 36% of rural women practitioners and 56% of rural women specialists wanted to reduce their work hours. Female practitioners with children were more likely to work as employees than female practitioners without children. The study indicated that attracting and retaining women in rural practices requires a place for the physician's entire family, a flexible practice structure, mentoring by a female physician, and financial and personal recognition [41]. Workload in public hospitals affiliated other than the Ministry of Public Health (MoPH) and private hospitals is less for the physicians rather than the hospitals affiliated by the MoPH [42].

Issues of prestige and recognition

The relative prestige, status and work locations can be an important factor influencing physicians' choice of practice location. Working in a rural area and focusing on primary care may be seen as inferior to working in an urban area and working as a surgeon or specialist.

The Australian survey showed that Surgery, Internal Medicine, and Intensive Care Medicine had the highest prestige rankings, while Public Health, Occupational Medicine, and Non-Specialty Hospital Medicine had the lowest. Additionally, dermatology, general practice, and public health were high in lifestyle [43]. In addition, other studies in Australia have shown that physicians who pursue lifestyle, prestige, and academic pursuits are more interested in urban settings, while rural settings offer more opportunities for service and autonomy. Less value placed on prestige was associated with the experience of working in rural areas, and a high value for service was also a predictor of the intention to work in rural areas [44].

Expectations

Medical students' expectations of work in rural areas. Physician who origin from rural often choose to work in rural area. Various studies have shown that a physician's rural birthplace is associated with a greater likelihood of practicing in rural areas in the future [45-48]. For example, an Australian study showed that being from a rural area during childhood was associated with practicing in a rural area. In particular, those who spent more than 6 years of their childhood in a rural area were significantly more likely to open a business in a rural area than those who spent 0-5 years.[49] However, it is not known why rural background or origin increases the likelihood of selecting a rural practice location [50]. Studies in the United States, Australia, Canada, Japan, and South Africa have each shown that people from rural areas choose to practice in rural areas in the future [47-49, 51, 52], and training physicians from rural areas has been advocated as a way to solve the regional maldistribution of physicians.

1.2 Solution that countries have taken in general

The health sector policymakers have mainly three strategies for addressing the maldistribution of physicians; to target future physicians, to target current physicians, and to do with less [13].

1.2.1 Targeting future physicians: medical education policies

Intervening at different stages of medical education, policies can address and influence future physicians who would decide where to practice after graduation. A physician's career starts with admission to medical school and the associated selection of candidates. Similarly, participation in clinical training is also a point at which the government may influence the location choice. It is said that both recruiting appropriate students and providing them with the curriculum and experience needed to succeed in primary care in rural settings during their formal training are effective policies for placing primary care physicians in rural areas [53].

Various policies have been implemented in various countries to encourage medical students to practice in underserved areas. The goal of these policies is to encourage those interested in serving their communities to choose a career in medicine and to reduce or eliminate negative expectations that students have about practicing in rural and other underserved areas. Some policies also emphasize an element of community involvement and support by providing training and subsequent medical care in underserved areas. There are two major approaches that can make it easier for future physicians to choose underserved areas. First, when medical schools recruit students, recruit students who are more likely to choose underserved areas. Second, the educational process should make it easier for students to choose underserved areas.

1.2.1.1 Student recruitment

Interventions in medical school admission process can influence the number of medical school graduates who choose underserved areas in the future. Students from rural areas or who have expressed an interest in rural service prior to entering college are more likely to choose underserved areas, and medical schools can increase the number of physicians working in underserved areas by prioritizing these candidates. The advantage of this approach is that it is a relatively low-cost intervention but because of the long duration of medical training, there is a considerable time lag before it takes effect. The effect may not be created if students prefer to stay in urban areas during their training [54]

In Australia, three medical school admission schemes are offered by the federal government: the Commonwealth Supported Places (CSP) Scheme, the Bonded Medical Places (BMP) Scheme and the Medical Rural Bonded Scholarship (MRBS) Scheme. Under the CSP scheme, students pay a portion of their tuition fees and the government subsidizes the rest. There is no work place requirement in this scheme. The other two schemes (BMP Scheme and MRBS Scheme) offer scholarships but with a requirement to work in a physician shortage area. Under the BMP Scheme, the Australian government provides placements for medical training. Medical students are required to sign a contract with the Australian government to work in a physician shortage area for the same period of time as their medical training, and if they break the contract, they will be required to repay the cost of their education. The BMP system does not provide financial aid. According to a recent review [55], more than 4,500 participants in the BMP system have reached agreements with the Australian government, but only one participant has begun work obligations in a physician shortage district, and three have decided to reimburse the fees for their medical education. On the other hand, students in the MRBS scheme are provided with considerable financial support and a commitment from the Australian government to work in rural and remote areas for a continuous period of six years after the completion of their specialty training. If students in the MRBS scheme break the contract, the physician will not be allowed to practice in his or her private clinic and will not be allowed to access the Medicare codes for up to 12 years. The scheme has been operated since 2001, with 100 places provided every year. A cumulative total of over 1,200 applicants have participated in this scheme so far, and 50 beneficiaries have started their mandatory return-to-work period.

1.2.1.2 Training institutions

Training in underserved areas early in their education can promote a proper understanding of the realities and working conditions in those areas. If students are attracted to the area, it may influence their future choice of work location. There are two method that let students experience in underserved areas: by establishing training institutions or parts of them in underserved areas, or by making internships or rotations in underserved areas mandatory.

The first method is establishing training institutions or parts of them in underserved areas. For example, the Medical School of the University of Tromsø in Norway was established in 1972 to solve the chronic shortage of physicians in northern Norway. In its early years, 25% of the admission quota was reserved for students from northern Norway, but this was raised to 50% and 60% in 1979 and 1998, respectively [56]. In Brazil, the number of physicians per population of 1,000 and the number of medical facilities per inhabitant increased in municipalities with new medical schools, indicating the possibility of recruiting more physicians and strengthening the medical infrastructure [57]. Previous studies have shown that the graduates from northern Norway are particularly likely to stay there. Among students who graduated between 1996 and 2001, 75.4% of those from Northern Norway preferred to practice in Northern Norway, while those from Southern Norway were only 19.3% likely to stay in Northern Norway [56].

The second method is making internships or rotations in underserved areas mandatory. This initiative is taking place in Canada, Norway, Australia, and Scotland, for example. In Canada, several medical schools are providing medical students with an underserved area experience by using satellite campuses and multiple clinical training facilities. The Northern Ontario School of Medicine (NOSM) places its main campus in a rural area. NOSM has a social responsibility to enhance access to and quality of healthcare in Northern Ontario and admitted its first class of medical students in 2005. Students from Northern Ontario, rural, remote, Aboriginal and French-speaking communities are actively recruited. Students train at 70 teaching and research facilities located throughout Northern Ontario. Additional financial assistance is available to students who choose rural areas after completing their training. Because the program is relatively new and the large majority of graduates of NOSM are still undergoing clinical training, it is not possible to verify whether the maldistribution of physicians has been eliminated, but it has been shown that approximately 70% of NOSM graduates undergo training in family medicine, primarily in rural areas. In the province of Finnmark in northern Norway and the state of New South Wales in Australia, local governments have developed programs to recruit physicians, contracting them for two to three years of training in the region in return for scholarships and social support. In both cases, physicians who chose this program have been shown to have higher retention rates in the region [58].

Although both establishing training institutions and training systems is expensive, it is expected to be effective. However, as with student recruitment, it will take time for the effects to emerge [59, 60].

1.2.2 Targeting current physicians: Regulation and Financial incentives

Second, when the government tries to address and influence current physicians, there are mainly two strategies: regulation and financial incentives. The government can regulate what types of physicians can work where. As for the former strategy, the government can intervene in participation in specialty training, for example, by making it a condition for physicians to work in rural areas when choosing a specialty. It can also implicitly or explicitly regulate the location of a physician's practice when they open a clinic. As for the latter strategy, the government can give incentives.

1.2.2.1 Regulation

The regulation may promote the elimination of the regional maldistribution of physicians. It restricts the choice of location for physicians to open clinics. For example, the policy could prevent new clinics from opening in areas with high density of physicians. The majority of OECD countries, with the exception of eight countries, do not restrict the choice of location when opening a clinic [13].

In Germany, one of the eight countries that do regulate, the state sets a cap on the number of services provided and limits the number of clinics in a given area. Physicians must obtain a practice permit in order to practice and take advantage of court-ordered health insurance. This permit is not issued if the physician-population ratio exceeds a certain percentage in each of the 395 planned areas, and physicians who have contracts with the statutory health insurance funds are effectively unable to practice in the relevant locations.

In Denmark, the number of physicians allowed to be reimbursed by the public tax-based healthcare system is set by region. This number is based on the number of patients in the region, the turnover rate, the number of patients assigned to one physician, and the geographical distance to the patient's clinic. The goal is to ensure that every patient in the country has the freedom to choose at least two clinics within 15 kilometers of each other, and once the number of patients in a region exceeds a certain level, physicians will not be able to assign patients to them.

One of the advantages of a regulatory approach is that the direct financial costs to the system are low and generally limited to administrative costs. However, a disadvantage is that it is very difficult to evaluate because of the lack of evidence in efforts to set physician density thresholds.

Some countries are attempting to eliminate regional maldistribution by making agreements with foreign-trained physicians that restrict where they can practice when they wish to practice in that country.

Australia requires foreign-trained physicians to work in areas with labor shortages for at least 10 years. This program was implemented in

1997, and since then the number of GPs in rural and remote areas has increased substantially [61].

In Canada, physicians who have not received post-graduate medical training in North America are required to serve in designated underserved areas in order to practice. Each state sets the specific requirements and length of service, but usually they are required to serve for the same length of time as their clinical training. Those who do not meet this requirement will be obligated to repay the funds in full, with interest. While this policy seems to be effective in reducing the regional maldistribution of physicians, it has also been shown that 70.1% of physicians funded in Newfoundland and Labrador and who signed a return-to-work agreement did not meet the service requirement [62].

Furthermore, the World Health Organization (WHO) has warned that directing foreign-trained physicians to a specific location in this way may violate an article of the WHO Global Code of Practice on International Recruitment of Health Professionals [63].

1.2.2.2 Financial incentives

Many physicians feel disadvantaged in terms of income due to relatively long working hours and smaller number of patients when they choose to practice in rural areas and other areas. Many countries have introduced various forms of financial incentives to address this. While financial incentives can equalize the financial disadvantages faced by physicians in rural areas, their high cost is a demerit. Incentives are often paired with restrictions, making it difficult to evaluate the effectiveness of incentives on their own. Most of the evaluations of incentives have been conducted in the U.S., but the U.S. has a particularly high percentage of investment in medical education among OECD countries, so care must be taken in interpretation. There are two major approaches to incentives: wage payments and non-wage incentives.

Financial incentives may be available for physicians working in underserved areas to cover their disadvantageous working conditions compared to those working in urban areas. The incentives compensate for the low patient volume and long working hours that physicians working in underserved areas face, and may be based on the location and duration of their practice. The institutions where physicians practice vary from clinics to government health centers, and their employment status can be employed as salaried workers or self-employed. Payments may be made to the medical institution, directly to the individual physician who provides the service, or to both. Payment can be based on duration, on the number of patients enrolled, on the volume of services provided, or on the achievement of other specific goals. Some reports indicate that financial incentives are effective in motivating physicians in underserved areas, but not in attracting new recruits to these areas.

France and Denmark offer income guarantees to GPs for the first two years of practice. 200 GPs take advantage of this scheme every year since it was introduced in France in 2013, with a guaranteed income of €55,000 per year for two years [13]. In Denmark, North Jutland and the capital region pay DKK 1,500 per shortage for up to two years if the number of registered patients is less than 1,600 per GP. In the Capital Region, GPs who are using this policy will be obligated to provide services for five years [13].

In Denmark, another incentive is available. Incentives are paid when a clinic closes and takes over patients who have lost their family physician. In the case of the North Jutland region, higher rewards are offered if the GP is responsible for more than 1,760 patients as a result of the handover. New Zealand has a similar policy. The standard is 1,600 patients per GP, and if a GP contracts 5%-20%, 20%-30%, or more than 30% beyond this standard, the revenue factors for the additional patients are 2, 2.5, and 3, respectively. The scheme is limited to two years and is primarily intended to smooth the transition period when a GP retires and is replaced [13].

The province of British Columbia, Canada, offers incentives designed to compensate for difficult working conditions in underserved areas. “Isolation points" are decided based on the number of physicians and geographic characteristics of the community, and this program provides CAD 6,000 to CAD 30,000. In 2008, there were 144 communities qualified to pay this incentive, and in 2007-2008, a total of 1,568 physicians received this incentive [13].

There are also incentives to encourage post-op physicians to stay in practice. Some provinces in Canada pay bonuses to GPs when they reach a certain number of years in practice. For example, in rural Alberta, physicians are paid an annual bonus of CAD 4,000 and CAD 10,000 after five and 26 years of practice, respectively [64]. In Thuringia, Germany, there is an incentive for physicians to delay their retirement. GPs aged 65 and older who apply and continue to work in a designated area can get EUR 1,500 per quarter in addition to their regular income [13].

Several countries offer incentives in the form of non-wage payments targeted at different stages of a physician's career. Many policies target first-time practitioners, encouraging them to open clinics in underserved areas. There are also incentives for physicians who are already practicing in such areas, aimed at keeping them in the area or postponing their retirement. The amount of the incentives is often set by each region depending on the severity of the shortage of physicians, and may be conditional on meeting criteria such as the size of the clinic and the amount of activity.

The financial support offered by the 11 federal states in Germany is targeted at GPs who are opening a practice for the first time. A one-time payment is available to GPs who open clinics in designated shortage areas. The amount of the subsidy ranges from EUR 15,000 to EUR 60,000 and is determined by the state, the extent of the shortage, the size of the municipality where the clinic will be located, and the type of services the physician will provide. In return for the incentive, some provinces require that the services be provided for five to ten years. Similar policies are being implemented in the Canadian provinces. Ontario, for example, provides financial incentives ranging from CAD 80,000 to CAD117,600 for opening rural clinics [64].

Besides opening clinics, other types of financial support are intended to improve working conditions. Various provinces in Canada provide financial support for hiring temporary GPs, which can be utilized when a GP is not present due to holidays or other reasons. The amount of support varies from province to province and ranges from CAD 510 (Nova Scotia) to CAD 1,200 (Northwestern Territories). Financial assistance, offered in some regions of Denmark, is available for GPs to hire additional staff. The duration varies from region to region, and in some areas there is no time limit. In the case of North Jutland, the GP is provided DKK 110,000 per quarter for hiring a nurse [13].

There are also incentives aimed at encouraging people who are considering retirement to postpone it. In Southern Denmark, GPs over the age of 63 can receive a payment range from DKK 320,000 to DKK 1,080,000, based on their age, the size of their patient list, and the length of their subsequent commitment. In North Jutland, GPs between the ages of 62 and 65 receive DKK 55,000 per quarter [13].

1.2.3 Doing with less: service delivery reorientation

The methods presented in this section are not directly methods of luring physicians to underserved areas, but methods of doing well with fewer physicians. In an environment where these methods are well established, it is expected that physicians will be less hesitant to choose an area with a shortage of physicians when choosing a practice location. There are various method to improve work environment: group practice among physicians, collaboration between physicians and other healthcare professionals, performing some of the physician's functions by other professionals, and introducing a new process. These will eliminate the burden on physicians and improve the working environment, as physicians will not have to do everything by themselves.

Group practices can contribute to improving physicians' working conditions. In countries such as Canada [65], and Switzerland [38], medical students have a preference for group practice. The benefits of group practice include the ability to share work, share resources, and improve cooperation with other physicians.

In 2007, France introduced the Maisons de Santé Pluridisciplinaires (MSPs), which allow healthcare professionals to run a group practice with other healthcare professionals while continuing to run their own business. As of 2012, there were 235 MSPs (80% of them in rural areas), with plans to create 450 more in the future. According to a survey covering 71 GPs in nine MSPs, the workload per week for GPs belonging to MSPs was 46 hours, whereas for other GPs it ranged from 52 to 60 hours. While the work environment has improved, MSPs provide healthcare for longer hours than other clinics [66].

In Germany in 2004, a system of community health centers (MVZs) was launched to coincide with changes in the health insurance payment system. MVZs have two or more medical specialties and are owned by a hospital or one or more physicians. Both salaried and self-employed physicians are eligible to work in MVZs. In 2011, there were 1,750 MVZs. A total of 9,571 physicians worked there, the majority of them were GPs and internists. it is reported that physicians belonging to MVZs have better working conditions and are more satisfied than those working in other forms. It is also reported that MVZ in rural areas have better improved working conditions, larger financial benefits, and higher patient satisfaction than MVZ urban areas [67].

In countries where the typical way for physicians to work is through employment rather than self-employment, employers sometimes create networks to cover practices in underserved areas. Ireland's policy is to create hospital groups where physicians working or training there are transferred to hospitals in underserved areas within the group to gain new experience. Similarly, in Japan, hospital groups and prefectures set up satellite clinics in underserved areas, and physicians work there in shifts to support community healthcare.

Non-physician healthcare professionals may take on some of the roles previously performed by physicians. In some countries, pharmacists and nurse practitioners have been given broader roles and authority, and such regulatory reforms can contribute to reducing the burden on physicians. For example, the 2009 health reform law ("Hôpital, Patients, Santé, Territoires") launched in France expanded the role of pharmacists. For example, they can now update medication doses for chronic patients, reducing the burden on physicians by taking on some of their work [13].

The medical treatment process is becoming more and more efficient every day. While ingenuity can reduce the burden, the use of technology can also dramatically improve the process. Telemedicine is one of them, and it can be a way to reduce the burden as well as the access imbalance between rural and urban areas. It is expensive to implement, and more difficult or even more expensive to implement in areas lacking communication infrastructure.

2 Impact of increase of the number of physician on dispersal pattern of physician

There are two views: one is that an increase in the number of physicians will not address regional maldistribution, and the other is that it would correct [21]. The former view is that an increase in the number of physicians would not correct geographical maldistribution. The reason why urban areas tend to be favored was as mentioned earlier. The other view was that an increase in the number of physicians will eliminate geographical maldistribution. The hypothesis behind this was that in areas where there are already many physicians, especially in urban areas, there would be competition for patients because there are so many physicians, and as a result, it would be difficult to earn descent income working in that location because physicians would have to compete for patients. This theory was based on the premise that many medical facilities were run by the private sector and that physicians were free to choose where they practice [21]. Eliminating the regional maldistribution of physicians by increasing the supply of physicians is considered to be very time-consuming and costly. Furthermore, studies in other countries suggested that increasing the supply of physicians alone would not improve distribution; rather, it would cause an oversupply of physicians [68, 69].

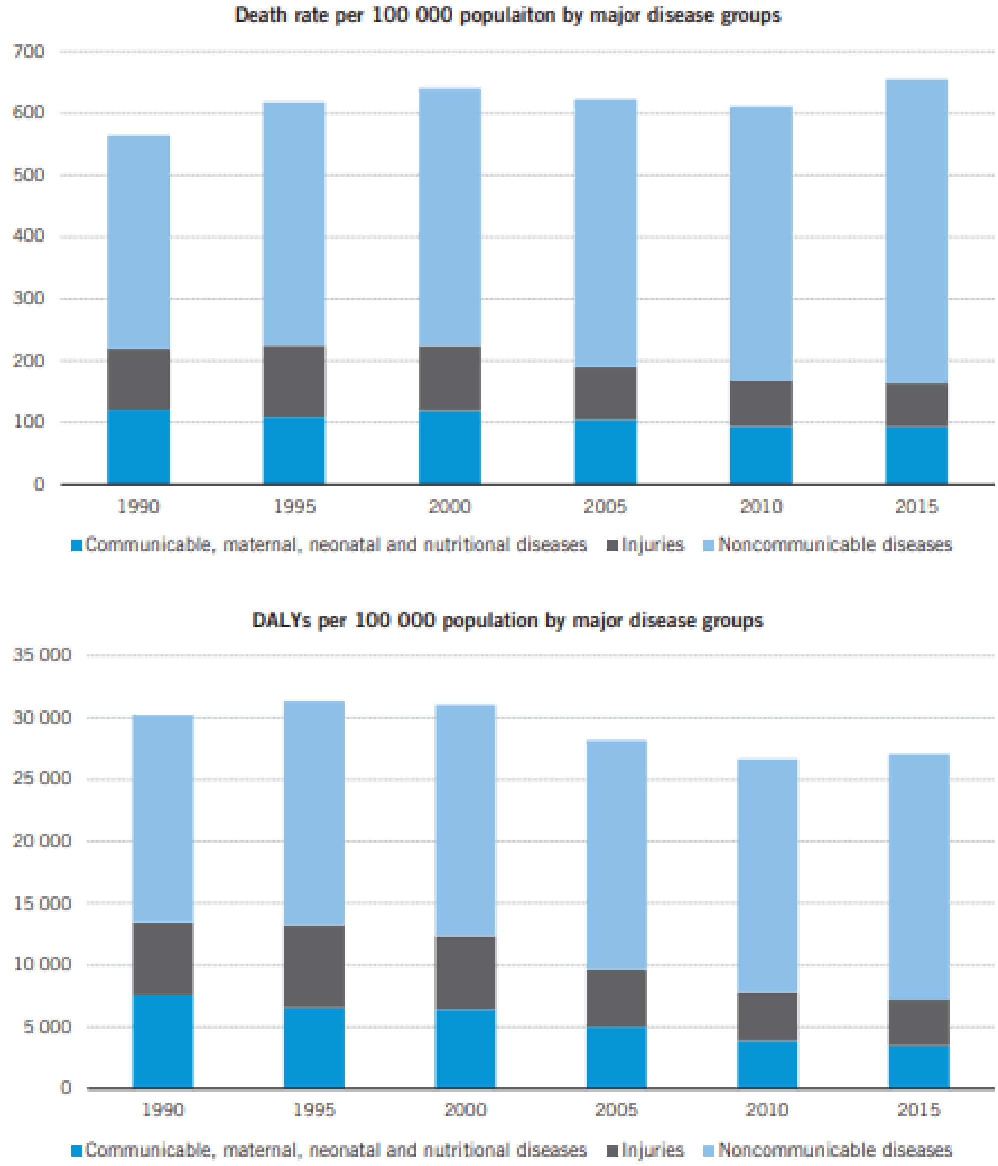
3 Situation in Thailand

3.1 Demographics

Thailand is a lower middle-income developing country and is divided into 77 provinces including Bangkok, 878 districts, 7,255 subdistricts called Tambons [70]. According to the United Nations, a population is 69.63 million in 2019. The United Nations projections for the future population estimate that it would be 70.34 million in 2030, but would decline to 65.94 million in 2050 and 46.01 million in 2100. In 2019, 16.8%, 13.4%, 57.4%, and 12.4% of the population was under 15 years old, between 15 and 25 years old, between 25 and 65 years old, over 65 years old, respectively. Thailand is in the process of aging and has the highest percentage of population over 65 years old in ASEAN. This is expected to reach about 20% by 2030 (aging society) and about 30% by 2050 (super-aging society) [71].

The overall health of the Thai population has improved over the years. Between 1990 and 2020, it was shown by the World Development Indicators that life expectancy at birth had increased from 67.2 to 73.6 years for males and from 73.4 to 81.1 years for females [72]. In the same period, the overall male and female adult mortality rate had decreased, although the male mortality rate increased from 1990 to 2000 due to HIV/AIDS. According to the WHO, in 2019, healthy life expectancy at birth in Thailand was 68.3 years, for males 65.9 years and for females 70.6 years [73].

According to WHO, the total number of deaths in Thailand in 2016 was approximately 539,000, and NCDs accounted for an estimated 74% of total deaths. While this proportion has remained stable over the past 25 years, the aging of the population has led to an increase in mortality rates and a gradual shift in causes of death, with injuries becoming the second leading cause of Disability-adjusted life years (DALYs) as shown in Figure. 3 [74].

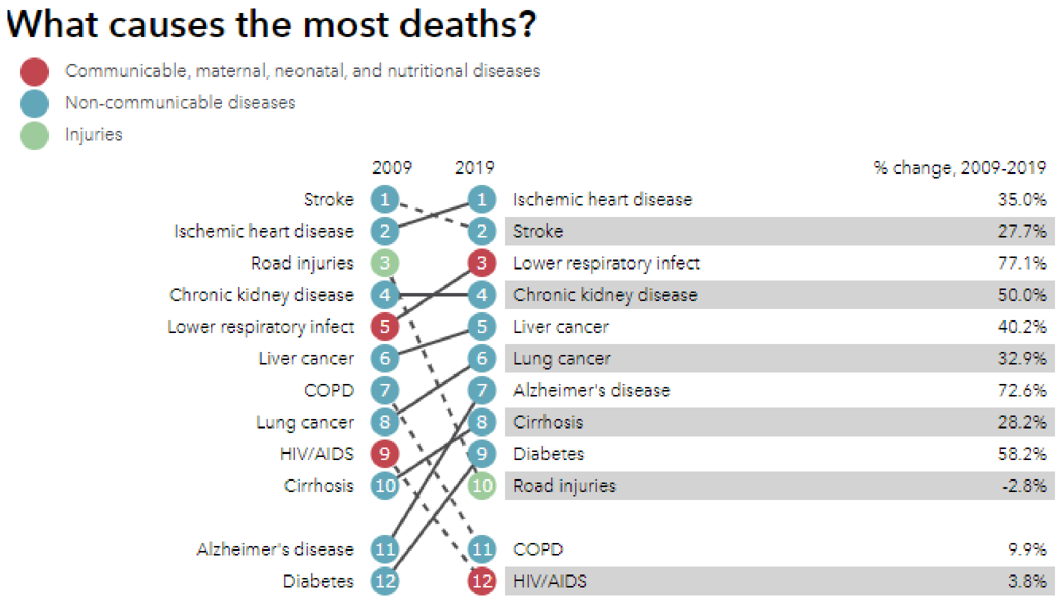


Source: Institute for Health Metrics and Evaluation, 2017

Figure 3. Thailand: Deaths and DALYs per 100 000 populations by major disease groups, 1990–2015

Source: Adopted from Legido-Quigley H [74]

HIV/AIDS was a factor that slowed the decline in mortality from infectious diseases until universal access to ART began in 2004 [75]. As of 2009, while HIV/AIDS was still the primary cause of death in Thailand, it was ranked 12th in 2019, with a change from 2009 to 2019 of -96.2% [76]. Thailand was one of the six upper-middle-income countries with the slowest decline in adult mortality between 1990 and 2015, largely due to male deaths from traffic accidents [77].



Top 10 causes of total number of deaths in 2019 and percent change 2009-2019, all ages combined

Figure 4. Causes the most death

Source: Adopted from Vos T [78]

3.2 Current number of physician

During 1960-1975, 25% of physicians trained in Thailand are estimated to have emigrated, mainly to the US and UK [79]. Because of this migration, there was a shortage of physicians throughout Thailand, with a growing disparity in rural areas. In this period, the National Health Development Plan stated that the government's agenda was directed towards the rapid development of health and education [79]. After 1972, the government imposed a requirement on graduates of public medical schools to serve in the Thai public sector for three years, or pay a considerable penalty. This brought the number of rural hospitals from 200 in 1976 to 425 in 1985. Also, the number of rural physicians increased from 300 in 1976 to 1,162 in 1985, a four-fold increase in rural physicians in 10 years [29].

The measures focused on rural areas, but due to rapid economic growth and a government investment policy that began in the late 1980s, private hospitals with free access to low-interest foreign loans became a target for investment. This brought about rapid growth in the private healthcare sector from 1988-1997, and physicians concentrated in urban private medical facilities. Prior to the economic upturn, in 1986 private hospitals accounted for about 10% of all hospital beds and physicians, but by 1995 the ratio had risen to 25% [80]. Since 1990, the number of beds in rural hospitals has continued to increase, while the number of physicians has either not increased or sometimes decreased. In contrast, the number of beds in private hospitals increased along with the number of physicians. The number of physicians in private hospitals increased 3.3 times in 10 years, from 1,000 in 1985 to 3,300 in 1995 [29]. The outflow of physicians from MoPH to new private hospitals increased to 30% in 1997 from 8% in 1994. The internal brain drain was quite significant: as of April 1997, three months before the economic crisis, twenty-one district hospitals lacked a single full-time physician [81]. The ratio of beds to physicians in district hospitals was 7.1:1 as of 1989 and increased to 15.3:1 in 1998 [80].

However, a severe economic crisis began in mid-1997, which rapidly reduced demand for private hospital services [81].. Almost all private hospitals decreased the number of beds and physicians, and some closed altogether. The number of physicians in district hospitals in 2001 was 2,725, compared to 1,653 in 1997, and the ratio of beds to physicians decreased from 15.3 in 1998 to 10.6 in 2000 [29].

There are 36,472 physicians in Thailand as of 2020 [82]. There are 23 medical schools in Thailand, two of them is private and others are operated by public [25]. The average number of graduates from medical school per year between 2000 and 2009 was 1,423 [83]. The increase in the number of graduates has been accompanied by an improvement in the distribution of workers: in 1979, the number of physicians in Bangkok was 1 for every 1,210 residents, and in northeastern Thailand, there was 1 physician for every 25,713 residents. This 21-fold gap had narrowed to five times by 2009 [84].

3.3 Related systems of physician education, training, and incentives

As shown in Figure 5, there are several factors influencing the geographical distribution of physicians in Thailand. Moreover, the Thai government has implemented several countermeasures to tackle to the geographical maldistribution in Thailand [29].

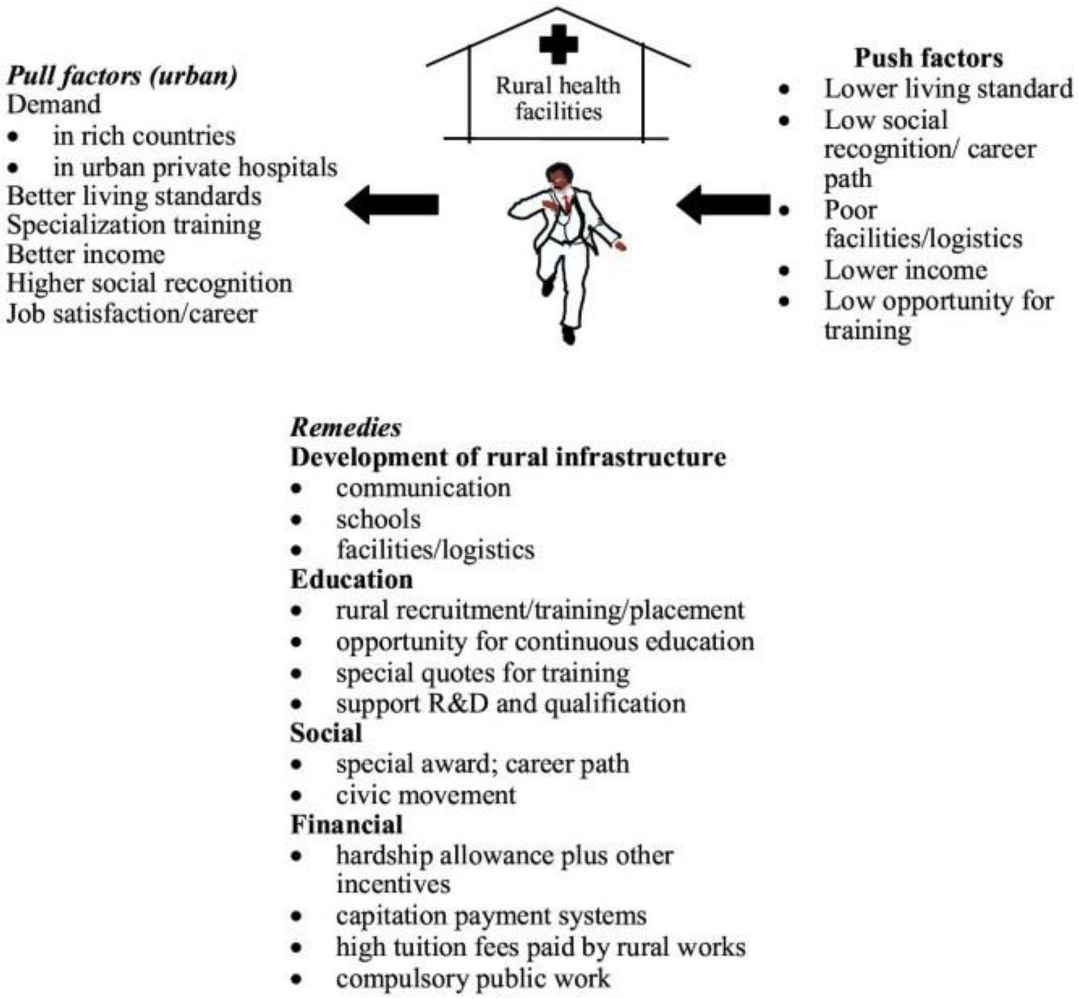


Figure 5. Push and pull factors and strategies used

Source: Adopted from Wibulpolprasert S [29]

3.3.1 Recruitment of medical school

In Thailand, there are two types of recruit tracks for medical students: normal tack and special truck. In addition, two types program are ongoing: the Collaborative Project to Increase Rural Doctors (CPIRD, 1995-2004) and One District, One Doctor (ODOD, 2005-2014). The difference between the normal track and the special track is mainly the recruit and education process, and obligation after their graduation [85].

As for the recruitment process, all twelfes-grade students are eligible to apply for medical school's admission examination under the normal track. 19 Medical schools affiliated by the Ministry of Education recruit students based on the student's achievement. With respect to the education process, education duration is six years for all track students (one year basic science, two years preclinical, and three years clinical). Finally, about their obligation after the graduation, graduates from all tracks have to be engaged in rural mandatory service [29, 86, 87]. This mandatory service was enacted in 1968 and physicians started to work mandatorily in 1972 [29]. Normal track and CPIRD graduates have to work for a district hospital for three years after graduation, otherwise, the government impose physicians to pay 13,000 USD as a fine. As for the difference about the location selection, normal track graduates can choose places more flexible depending on the availability of vacant post. During the first three years of assignments in rural areas, physicians were moved to community and provincial hospitals, most of them within the same province [88].

Under the special track, CPIRD offers more opportunities for medical education to people from rural areas; twelfes-grade students living in a specified rural province were eligible to take an examination under the special track [84]. Special track students who passed the examination study together with normal track students only for the first three years. However, for the last three years, special track students are trained in the 34 regional and provincial hospitals affiliated by the MoPH where the teaching was conducted by medical staff. Medial students from all tracks experience services in rural area in their clinical education. After that, they are eligible to take physician license examination. Special track graduates are assigned to severe underserved places in or near the graduate origin.

Students who live in a given rural "districts" are eligible for ODOD program while CPIRD students have to live in a given "province". The only one entrance examination is offered by 19 medical schools jointly. Students are recruited depending on their achievement. ODOD program impose participants to work longer in a given district as a resident and pay more if they break the contract than CPIRD. Graduates using ODOD program must practice for 12 years in their hometown, otherwise, they have to pay 65,000 USD as fine.

The CPIRD program was started to distribute annually 300 physicians to rural areas, and recruited 30 students in 1995 that increased by 293 in 2002 [29]. The CPIRD program has been successful, with a 14.9% incidence of physicians to leave rural areas over 11 years, in comparison to 17.6% of physicians who did not participate in the CPIRD program [86]. Through 2009, more than 2,700 CPIRD physicians made additional contributions to the public service in rural and remote hospitals [89], and the physician-population ratio in rural and urban areas has increased from 1 in 10 in 2001 to 1 in 5 in 2009 since then [26]. Other studies have also shown that CPIRD physicians are 51.6% less likely to retire from a MoPH hospital each year when compared to normal track physicians. Furthermore, CPIRD graduates are 138.9% more likely than normal track physicians to complete three years of rural service [89, 90]. However, finding long-term success is still difficult. Only 51% of CPIRD physicians and 44% of non-participating physicians stayed on by the fourth year of the recommended MoPH rural service [86]. Most of those CPIRD graduates did not remain at the district hospital beyond what was required, and after three years, nearly three out of four had retired to pursue their professional training. This proportion was also true for graduates who were recruited through regular courses. Although mandatory service through CPIRD is fulfilled, it is a minor proportion that is kept for longer periods. In addition, there is not always an improvement in retention rates after the mandatory service period, even with financial incentives [84].

As for the difference between CPIRD and ODOD, there is no evidence of a difference in drop-out rates between CPIRD and ODOD program students during 2005-2010 [26]. In addition, one study confirmed the outcomes of high retention rates in rural areas for the ODOD program, showing that ODOD graduates are 71.7% and 36.6% less likely to leave rural practice than normal track physicians and CPIRD physicians, respectively. In addition, ODOD graduates had a 2.36 times higher probability of completing a three-year rural assignment at a MoPH hospital than their Normal Track cohorts. However, no statistically significant difference in the completion of three years of rural work between CPIRD and ODOD physicians [89].

Despite the success of the ODOD program, several problems have arisen. These problems are due to low admission rates, limited professional development of ODOD physicians, relatively high penalties for non-adherence, and the detrimental effects of extensive mandatory service for ODOD physicians. As for admission criteria, all ODOD candidates are required to pass an entrance examination equivalent to the National Entrance Examination. However, it was found that remote rural residents were less likely to achieve the lowest requirement than students residing in urban areas. As a result, in the 2005-2016 period, the ODOD students enrolled less than 80% of expectations, and in fewer years, less than half. The number of students passing the entrance exam was lower than expected, which resulted in the underachievement of ODOD production numbers. As a result, in the 2005-2016 period, the ODOD students enrolled less than 80% of expectations, and in fewer years, less than half. The number of students passing the entrance exam was lower than expected, which resulted in the underachievement of ODOD production numbers. In response to the low admission rate, the Cabinet approved a four-year extension of the ODOD program in 2013, allowing student enrollment from 2013 to 2016, in order to achieve the additional production goal of 3,232 physicians [26]. In addition, restriction of specialist training for ODOD graduates is argued. In the ODOD program, graduates are assigned to mandatory rural service as a generalist for 12 years. Physicians who graduated from the ODOD program and wished to be medical specialists have had stress. In 2013, the MoPH administrators decided to eliminate this restriction by allowing ODOD physicians to be trained of almost all medical specialists after completing 4 years of service in rural areas, except for physicians under the training in family medicine that can be participated after graduation. However, this policy relaxation allowed to ODOD physicians to work not for primary care as a specialist and also raised concern to undermine the major objective of the ODOD program. In response to this problem, the revision announcement in 2016 limited the choice of medical specialists for ODOD physicians to several major domains allowing physicians to work in rural community hospitals such as internal medicine, general surgery, pediatrics, and orthopedics.

To overcome the problems of ODOD program, the inclusive track was introduced as a replacement of the ODOD program in 2017. The recruitment strategy is similar to ODOD that is from remote rural areas. However, the inclusive track has less duration of compulsory service as well as penalty fine than those of the normal track and CPIRD. Instead of the less duration of compulsory service and penalty fine, no subsidized education in return for service that was paid for ODOD students [26].

3.3.2 After graduate education and training

Graduates of medical schools in the country are required to complete a six-year program, pass a graduation examination administered by each school, and then take and pass a national licensing examination administered by the Medical Council of Thailand to obtain a license to practice medicine in Thailand [88]. The National Licensing Examination for Physicians is divided into three parts: basic science, preclinical, and clinical, and students must pass all three parts. The physician's license is valid for life and does not need to be renewed. At the initiative of the Thai Medical Association, there was an attempt to mandate Continuing Professional Development to ensure medical competence as a requirement for reacquisition of a medical license. However, there was resistance from the medical community, which had not reached a consensus on mandatory license renewal.

As a response, in order to encourage physicians to practice in rural hospitals, the government established a system of financing to supplement physicians' earnings with a monthly allowance. 60-88 USD per month as hardship allowance was introduced in 1975 and amended in 1997. Now the rate is 250 USD per month for physicians who work in remote districts, and 500 USD per month (almost three times of their base salary) for those who work in the most remote districts (69 districts are designated). In addition, physicians who do not work privately can receive 400 USD per month [29]. As such, newly graduated physicians working in rural hospitals earned 1,900 USD per month, that is 10-15% more than new physicians in non-private urban hospitals in 2008 [86], but another research described that rural physicians still earn lower than new graduates in private practice in an urban areas [29]. It is said that when all allowances are added together, the monthly salary is 5-10 times the base salary [91]. These incentives implemented with the mandatory service is said to be the one of the most important contributor [91].

Non-monetary incentives are also available, such as special allowances for rural workers, social recognition, free housing, and social recognition of the annual Best Rural Physician Award [74, 91]. Each year, a "Hardship Award" is presented to the best rural physician in the most remote area. In addition, some medical schools specially recognize graduates who have done outstanding work in rural areas. Many rural physicians are invited to serve as adjunct or full-time lecturers in medical schools, primarily in the Department of Community Medicine. Some also receive honorary degrees from the university. Some rural physicians are honored at the national level as "Model Thais of the Year. [29]"

The career paths of public sector physicians are similar to those of other professions in the public service. Most public hospital clinicians are civil servants and usually begin their career path from level 4 of the position classification (PC) system (11 levels in all) [28]. To be promoted to higher PC levels, academic or administrative performance must be approved and evaluated by the hospital director. The evaluation framework is competency-based, administered by the Office of Public Sector Development Commission (OPDC). Since physicians are generally recognized universally as leaders of health professional teams in Thailand, physicians are usually promoted within 10-12 years to at least PC level 7 or 8, equal to the head of the department at the MoPH central headquarters [28]. Furthermore, the MoPH employed a strategy to address the internal exodus of rural physicians since October 1996. Physicians who have worked in rural areas for an extended period of time are promoted to PC level 9, which is considered the equivalent of a provincial medical chief or deputy director of a central department in the MoPH [29]. In addition, the 2008 civil service reform replaced the traditional PC system with a new career advancement mechanism: the PC was renamed and positions were now classified according to the type of work, such as academic and technical clusters, administrative clusters, support clusters, and so on. This was intended to improve the effectiveness of civil servants' performance. In reality, however, there were no significant changes to this system.

Although most physicians are GPs, it is noted that the ratio of specialists is increasing due to their social prestige and economic benefits

[88]. Graduates desiring to continue their specialty training must follow the regulations of the Medical Council of Thailand. The number of postgraduate training of specialist physicians exceeds that of family physicians in some years. General physicians work in district hospitals, while specialists work in general hospitals and regional hospitals. The proportion of specialist physicians in the country grew from 3% in 1971 to 85% in 2009. According to a 2011 survey, 13-18% of newly graduated physicians wanted to pursue specialist training after one year (out of three years) of mandatory rural service, and 61-73% planned to pursue specialist training after three years of rural service [86]. Most residency programs, such as general surgery, internal medicine, and pediatrics, require a minimum of three years of rural practice experience, with exceptions such as psychiatry, forensic medicine, and pathology, which the MoPH intends to rapidly expand in size due to a shortage of personnel in these areas. The length of study in residency training programs varies between 3 years for some specialties (internal medicine, obstetrics and gynecology, psychiatry, pediatrics, etc.) and 5 years for others (neurosurgery, thoracic surgery, urology, etc.). Physicians who complete five or more years of work in a rural district hospital can apply for qualifying board examination, and they get a Thai Board certificate from the Medical Council of Thailand if they pass the exam. Those who have this certificate is considered as equivalent to a Doctor of Public Health or Doctor of Philosophy degree [29]. This is offered in the specialty of preventive medicine, general practice and family medicine. In contrast to undergraduate education, which is handled by medical schools, residency training programs can be offered by public and private tertiary hospitals, but must be certified and accredited by the Medical Council of Thailand and the relevant specialty royal university. The participation of many healthcare providers in residency training programs has resulted in a significant increase in the number of specialists trained between 1990 and 2010, from approximately 500 to over 1,500 per year.

3.4 Related health system, policy and regulation

3.4.1 Infrastructure development

In the 1960s, there are no district hospitals in Thailand. Only a few large district had health centers, and health centers provided primary healthcare (PHC) services. Other districts without health centers relied on mobile health teams providing healthcare services several times among a year [84]. Along with the National Health Development Plan, the District Health System Development Project was initiated in 1977 in order to ensure that all districts were provided with complete geographical coverage of district hospitals and health centers over the next 20 years. In addition, the expansion of rural hospitals was completely suspended between 1982 and 1986 because there are limited resources [29]. Moreover, the Fifth National Medical Education Seminar in 1986 decided that "there should be no new medical schools in the capital and vicinity provinces [29]." As a result, there were 728 district hospitals with 10 to 120 beds in 2001, and more than 95 of rural districts were covered [29]. By the late 1990s, the targeted coverage had been attained in districts and subdistricts. In 2010 there were 9,758 health centers in the 7,255 subdistricts; 731 district hospitals in the 801 districts; and 68 provincial and 25 regional hospitals in the 76 provinces outside Bangkok [84] . Every district hospital must be staffed by physicians and nurses [92]. Only 2,725 physicians worked there, however, the number of estimated required physicians is 4,700 [29].

Following the improvement in infrastructure, more healthcare professionals have been engaged. The number of physicians has increased significantly, especially with the establishment of medical schools outside Bangkok, which has greatly improved the country's ability to produce physicians. The number of physicians has increased fivefold in about 30 years, from 8,000 in 1985 to more than 40,000 in 2013 [91, 93]. Furthermore, the number of rural physicians quadrupled from 300 to 1,162 by the middle of the 1990s because Thai government allocate physicians to rural areas [29].

The establishment of a private, for-profit medical school in 1989 was met with strong opposition from rural physicians' associations. Two of the Medical Council members resigned and held a press conference to express their opposition. Finally, the Medical Council made the decision to admit only private, non-profit medical schools. Since then, no new private medical schools have been established. Graduates of private medical schools are required to pass a licensing examination, compared to graduates of public medical schools, who are automatically licensed [29].

3.4.2 Insurance system

Currently, Thailand has three major insurance systems: Civil Servant Medical Benefit Scheme (CSMBS), Social Security Scheme (SSS), and Universal Healthcare Coverage Scheme (UCS). CSMBS was introduced in 1978 and is administered by the Comptroller Generals Department of the Ministry of Finance. Legally, the basis for CSMBS is the Royal Decree on the Disbursement of Medical Benefits, B.E. 2523), last amended in 2007 (B.E. 2550). It covers Thai civil servants, their dependents (parents, spouse and up to two children), and the retirees from the public sector. Services are funded by taxation to compensate for the low salaries of government officials, and the package includes pension, housing benefit, and child allowance. It is the most comprehensive of the three insurance schemes in terms of benefits provided. It covers about 4.4 million people (about 9% of the Thai population) [94] and is financed by the general tax, with no contribution by the insured. There are no restrictions on the choice of medical facilities, including emergency and inpatient care, and the insured can choose any medical facility. No conditions are excluded, including childbirth and annual physical examinations. Furthermore, treatment is paid directly by the insurer to the medical facility, and the insured's out-of-pocket expenses are free, except for admissions to private hospitals. Private beds and services provided by special nurses are not covered, but this is also the case for SSS and UCS. Payment is FFS for outpatient and based on Diagnosis Related Group (DRG) for inpatient. As of 2016, the expenditure was 37.7 billion baht [94].

The SSS was introduced in 1990. In that year, Thailand enacted the Social Security Act and established the Social Security Office. The scheme covered private-sector full-time employees, and in 1991 the self-employed were also allowed to join the scheme on a voluntary basis. SSS is a component of a comprehensive social security system including pension, disability compensation, and funeral grants. Under the SSS, employers, employees, and the government contribute to the fund, with each contributing 1.5% of the insured's salary. Self-employed persons are required to contribute to the fund as employers and employees. The hospitals available are those contracted by the insured among registered public and private healthcare providers, including for hospitalization and emergency cases, and work-related injuries and illnesses are not covered. Payment is made on a per capita basis, although some treatments are FFS. The program features cash benefits in the event of illness or maternity leave, but does not include annual medical check-ups. As of 2016, it covers 10.6 million people and the expenditure was 37.7 billion baht [94].

Although there were much effort, 30% of the population was still uninsured by 2001 [77]. The most recent introduction is the UCS, introduced in 2002, which covers all citizens not covered by CSMBS or SSS and includes about 48 million people (about 75% of the total population) [94]. With this introduction, universal coverage has been achieved. It was implemented in April 2002, based on the "30 baht universal coverage" policy pledged by the Thai Rak Thai Party. The UCS is administered by the National Health Security Office (NHSO) of the MoPH, and is financed by a general tax with no contribution from beneficiaries. 30 baht per visit or hospitalization is paid by the public. 30 baht payment was removed in November 2006, making the UCS completely free. Covers about 47 million people, which is about 75% of the total population of Thailand [95]. The healthcare provider is a contracted healthcare provider in the insured's district. Beneficiaries are required to receive medical services at PHC facilities, which are gatekeepers to secondary and tertiary care, and are required to pay 100% co-pay if they are seen at other facilities [96]. When hospitalized, the patient will be referred to a district hospital by the PHC facility. The payment method is per capita for outpatient and DRG for inpatient. Medical checkups are not included. As of 2016, the expenditure was 37.7 billion baht [94].

Prior to the introduction of the UCS in 2002, the Medical Welfare Scheme (MWS, also known as the Low-Income Card Scheme), and the Voluntary Health Card Scheme (VHCS), along with CSMBS and SSS. While CSMBS and SSS were for people in formal employment, MWS and VHCS were for people in informal employment. The MWS was introduced in 1975 as a government subsidized program for the poor and later expanded to cover the elderly in 1992 and other vulnerable groups (e.g., children under 12 years old) in 1994. The VHCS was a voluntary health insurance program for those not covered by the other three programs. Each household could purchase VHCS coverage for one year for 500 baht (about US$15) [97]. Although these four insurance schemes attempted to cover the entire population, the MWS and VHCS had operational problems, and it is estimated that about 30% of the population was uninsured [98]. The MWS had been criticized for its eligibility criteria (Means Test), card administration, and coverage of the noncovered population. The program failed to reach all of the eligible population [99, 100]. In the VHCS, the program resulted in a loss of revenue for healthcare facilities because there was no formal budget allocation. In addition, the VHCS had a reverse selection problem: since the VHCS was a voluntary program, the presence of an illness was positively correlated with the purchase and use of the VHCS [99].

3.4.3 Payment system

General information

In recent years, healthcare expenses have been increasing in most countries [101]; during the period 2000-2015, the average annual growth rate of the global economy was 2.8%, while the average annual growth rate of global healthcare expenses was 4.0% [102]. Controlling costs has therefore become a significant global concern. Since hospitalization costs are the largest component of healthcare expenses, controlling costs incurred from hospitalized patients is an important key to healthcare cost containment [103]. Payment system is one of the methods to control, and there are several kinds of payment system [104, 105]. The major payment methods adopted in Thailand include FFS based on cost, per capita method, and DRG payment. Which payment methods are applicable depends on the insurance systems that individuals are in and whether patient is hospitalized or outpatient.

One of the most common methods of cost-based payment is FFS. It has been argued that healthcare providers have an incentives to perform more for patients to increase their revenue [106]. Traditionally, physicians and healthcare providers charged patients medical fee in a case-by-case manner without any common rule. As a result, medical fees were not consistence and standardized, and differed by patient. The first DRG was introduced in the United States in 1983 in order to overcome this challenge. Since the 1990s, DRG-based payment has been becoming the major method of healthcare service fee reimbursement for acute hospitalized care in most high-income countries instead of FFS. The most common reason that healthcare providers and the governments implement DRG-based payment is improving efficiency and cost control [106-111]. One research examined slight evidence related to impact of DRG-based payment system in various high-income

European countries [112]. The results suggested that DRG is useful in term of improving hospitals' efficacy by shortening their average length of stay (LOS), however, DRG also increases the number of patients.

Under the DRG-based reimbursement system, healthcare providers receive fixed payment for each hospitalization depending on the DRG classification. DRG classification is determined by the main and secondary diagnosis, age and gender of the patient, comorbidities, and complication [106, 111]. Basically, it is assumed that patients with the same DRG have the same LOS and consume the same level of medical resources. Introducing the DRG lets healthcare provider know the amount they will be reimbursed for caring each disease. From the healthcare providers' perspective, medical fees per hospitalization for each disease is fixed, healthcare providers have an incentive to save medical resources for patients and to improve efficiency. Theoretically, healthcare providers may reduce LOS and level of healthcare service to decrease costs as Annear and Huntington mentioned [113]. To increase the number of patients, unintended results, for example, unnecessary hospitalization to increase the number of patients, too early discharge with planned rehospitalization to increase revenue, and hospitalization only low-risk and low-cost patients to make financial risk minimum [114].

DRG in Thailand

In Thailand, the FFS payment system was applied prior to introduction of DRG. Before DRG system, FFS provided the opportunity for physicians to serve unnecessary care, and increased the Thai healthcare expenditure like those experienced by other countries. In order to change this situation, the DRG study began in 1993 with the drafting of a blueprint for healthcare reform. The first DRG was introduced in order to allocate resources in the context of the Low-Income Card scheme, a welfare system for the poor. Developed as a key mechanism for inpatient hospital payments, Thai DRG version 2, based on the U.S. Medicare DRG, was implemented nationwide under Thailand's UCS in 2002. In 2003, the third DRG, including 1,200 DRGs, was introduced and payments by the National Health Security Office to all hospitals were executed for inpatient medical services within the global budget of the UCS. The fourth DRG was introduced when CSMBS started to adopt DRG in 2007. In 2010, the fifth DRG for acute, subacute, and psychiatric services was announced, which has 2,700 case groups in acute cases [111]. Later, when all teaching hospitals joined the UCS, the Thai DRGs were changed to be in line with the Australian DRGs. After 2012, the common Thai-DRGs with 2,450 classification based on ICD-10 and a risk adjustment factor to reflect additional funding for teaching hospitals or regional difference are specifically tailored for implementation in the three major government health insurance schemes, CSMBS, SSS and UCS [115, 116]. There are several changes in the Thai DRG version 6.2. The main change is that a workshop of medical experts was held to examine the relationship between the level of medical resource use and diagnostic complexity in the existing claims data, and then the classification methodology was re-examined. Based on the evidence and through expert consultation, a high correlation between patient classification and hospital resource consumption was achieved. A new relative weight (RW) was established in Thai DRG version 6.2. For the insured patients under Thai health security schemes, the RW was adjusted for a patient's LOS (adj. RW) determined remuneration to the hospital for inpatient care [117]. Thanks to the new RW, even though DRG version 6.2 has fewer disease clusters (603 vs. 726) and fewer DRGs (1,541 vs. 2,451 DRGs, 910 fewer) than DRG version 5, most statistical results show improved performance in DRG version 6.2 and suggested that DRG version 6.2 is able to classify more accurately than DRG version 5. Moreover, the RW of DRG version 6.2 was able to explain nearly 60% of the total hospital resource use. In conclusion, Thai DRG version 6.2 was able to classify patients into the same groups better than TDRG version 5.1 and showed a higher correlation with hospital resource use [116]. A RW was assigned to each Thai-DRG group, indicating the amount of resources used in treating patients in that group relative to the reference group.

Payment system of each insurance system

Since establishment of CSMBS, open-ended payment system (opposite of closed-end meaning decided budget) has been adopted. Healthcare providers of CSMBS are paid outpatient medical fees based on FFS. On the first of July, 2007, the Thail government changed CSMBS hospitalization payment system from the FFS based payment system to DRG based payment system in order to restrain increasing healthcare expenditure. It means that all impatient healthcare expenditure paid by all patients were imbursed from the Comptroller General's Department before reform. After reform, healthcare providers are able to be reimbursed based on DRG [114].

Since its inception in 1991, SSS has paid healthcare providers using a comprehensive, flat-rate closed-end method (fixed per capita payment) for both outpatient and inpatient care. The closed-ended payment method specifically refers to the gross budget system (Glabal Budget). Since medical treatment is provided within a predetermined budget, it is said to be easier to control healthcare expenditures. However, since there were concerns about the lack of services under the closed-end system, the DRG-based payment system was adopted for inpatient care in 2005 [114].

UCS uses a closed-end system for both outpatient and inpatient care. For inpatients, DRG-based payments with global budgeting have been used since the inception of the UCS system in 2003. For outpatients, capitation payment system is applied. People resister with a hospital and hospitals gain a flat rate of USD 30 per capita per year. The capitation system is believed to create strong incentives for a more equitable redistribution of human resources. After its introduction, some large hospitals in the city that were previously overstaffed now refuse to accept new graduates. In addition, hospitals in heavily populated and poor areas, previously understaffed, now say they have enough money to hire more staff [29].

A study using nationally representative data from Thailand showed that reforming CSMBS healthcare expenditures to DRG-based payments in Thailand reduced the number of hospitalizations by 0.6-1.1% and had no significant effect on hospitalization frequency or LOS [114]. It is suggested that the overall decrease in the number of hospital admissions was the result of hospitals' selection of which patients to hospitalize. This author suggests that hospitals may have attempted to prepare for financial risk by choosing to hospitalize patients with relatively less complex treatment (i.e., lower costs) rather than by changing the intensity of care (i.e., reducing LOS) as a result of payment reform. The study also found that after the reform, CSMBS beneficiaries were 10% more likely to be hospitalized at community hospitals, which are considered the lowest level of public healthcare facilities for inpatients in Thailand, and 7%, 2%, and 1% less likely to be hospitalized at general hospitals, other public hospitals, and hospitals affiliated with medical schools, which are higher level public healthcare facilities, respectively. In Thailand's public healthcare facility system, patients are usually first seen at community hospitals, which have the lowest medical intensity. If the patient is in bad condition, the community hospital physician will refer the patient to a higher medical intensity hospital based on the patient's condition and each hospital's ability to treat the patient. In most cases, referrals are made to community hospitals that can provide secondary care, while more complex cases are referred to general hospitals that provide tertiary care. High-level referral hospitals are those with advanced medical technology and the highest level of care. There are two types of referrals: to hospitals that provide a higher level of care and vice versa, possibly reflecting the fact that after the CSMBS transition to the DRG system, referrals to the former have decreased and those to the latter have increased [114]. This suggests that the DRG payment reforms reduced the demand for higher-level hospitals, which are often located in urban centers, and increased the demand for rural hospitals, which may have affected the distribution of physicians.

3.4.4 Delivery system

In Thailand, the MoPH is responsible for formulating health policies and strategies and implementing regulations. It is the main health service provider at the national, provincial, district, and sub-district levels, and the MoPH plays a particularly important role in rural areas where private health services are infrequent [94]. The Provincial Health Office (PHO) is in charge of provincial health administration, supervising and supporting the regional or general hospitals, district hospitals, and district health offices within each province. District health offices, supervised by the PHO, supervise all health centers in their districts and manage the district health system in collaboration with the district hospitals [88]. There are three levels of medical care: health centers under the jurisdiction of the district health center provide PHC services; district hospitals under the jurisdiction of the PHO are responsible for PHC and secondary care (all district hospitals have the clinical capacity to have inpatient services and have 10 to 120 beds); tertiary care is provided by the regional/general hospitals depending on their size and capacity medical care and other specialized care. There are both public and private medical facilities in Thailand. As shown in the Figure 6, they are divided into hospitals operated by the MoPH, those operated by government agencies other than the MoPH, and those operated by the private sector. As of 2014, MoPH facilities accounted for 67% of the 161,000 hospital beds in Thailand, non-MoPH public facilities accounted for 14%, and private hospitals accounted for 19% [77]. The majority of hospitals are public, accounting for 79% of all inpatients, while private hospitals cover 14% of total outpatients and 11% of total inpatients [94]. MoPH hospitals have the highest bed occupancy rates (>80%), while private hospitals have lower rates

(50-60%) [88]. As of 2009, 53.5% of all physicians worked in the MoPH, while 22.7%, 4.3%, 17.1%, and 2.4% worked in ministries other than the MoPH, local government hospitals, private companies, and state-owned companies, respectively [88]. Physicians affiliated with public healthcare providers are legally allowed to practice privately after hours.

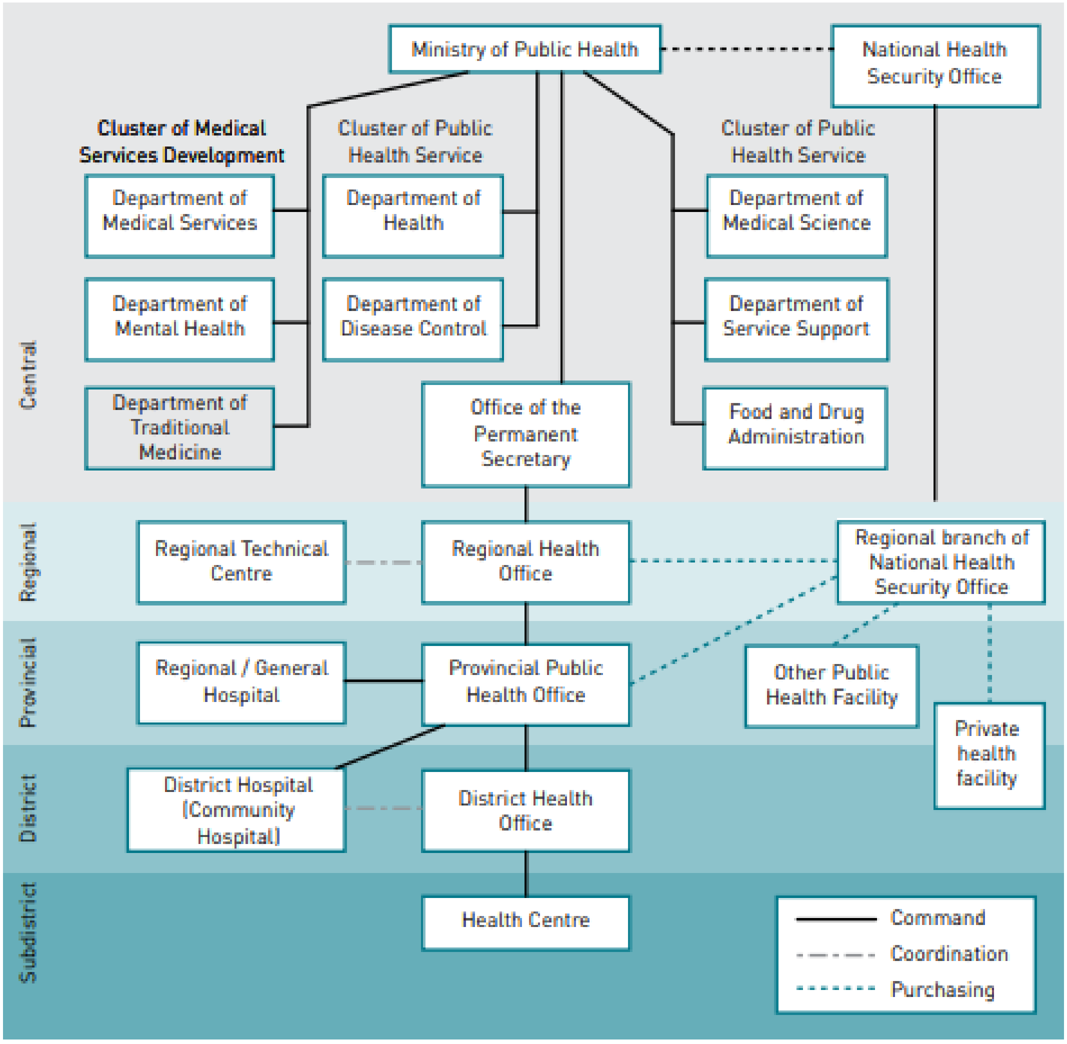
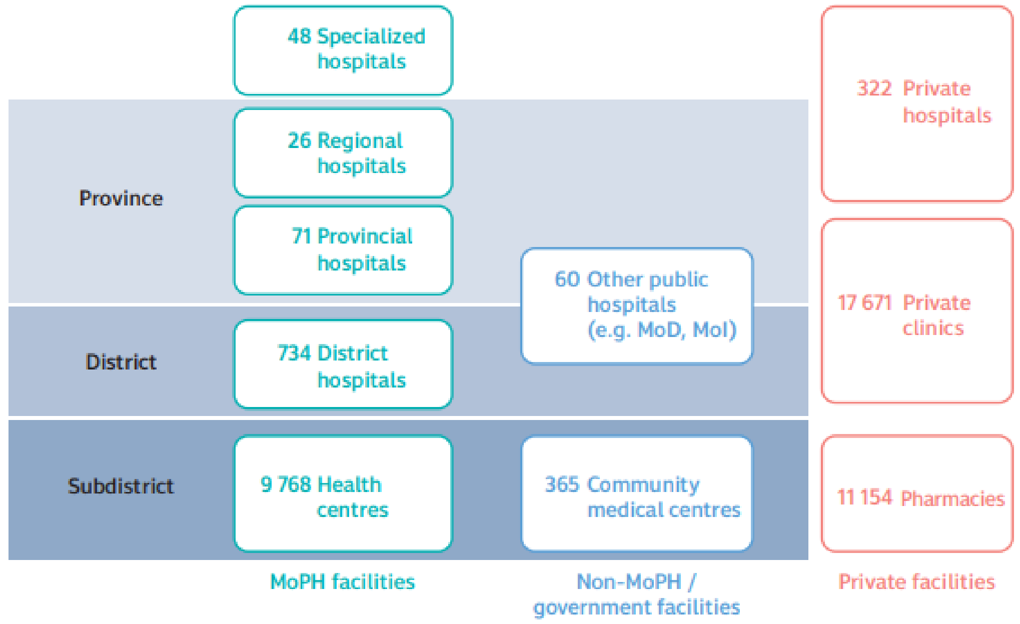


Figure 6. Organizational structure and interlinkages between MoPH and NHSO
Source: Adopted from WHO [88]



Note: MoD: Ministry of Defence; MoI: Ministry of Interior
Source: Legido-Quigley H, Asgari-Jirhandeh N, editors. Resilient and people-centred health systems: progress, challenges and future directions in Asia. New Delhi: World Health Organization, Regional Office for South-East Asia; 2018.

Figure 7. Healthcare facilities in Thailand, 2015
Source: Adopted from WHO [94]

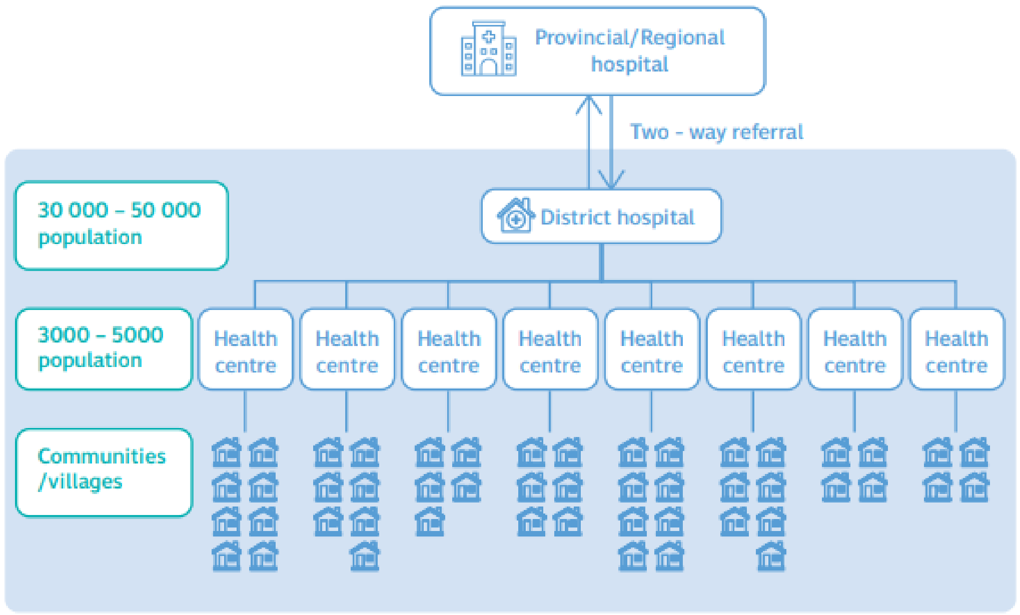


Figure 8. PHC infrastructure of the MoPH at district level
Source: Adopted from WHO [94]

Hospitals operated by MoPH are provided by regional or provincial hospitals, district hospitals, and health centers at the provincial, district, and subdistrict levels, respectively. Since 1977, the Fourth National Socio-Economic Development Plan has led to the establishment of PHC systems in the regions and major investments in district health infrastructure and provincial referral hospitals. By 1990, all districts had district hospitals. Subsequently, health promoting hospitals were established in subdistricts, and by the 2000s, all subdistricts were fully equipped.

At the subdistrict (tambon) level, 9,768 health centers and 734 district hospitals are the main healthcare providers. Each subdistrict has at least one health center that serves for each population of 3,000 to 5,000 people and requires a team of about 3-5 nurses and paramedics. However, in many of these health centers' physicians attend on a rotation basis only for one or two clinic sessions of 3–6 hours per month. In addition, physicians may also be moved frequently between different facilities with negative consequences for continuity of care [92]. They mainly provide PHC and are the first point of contact for residents to receive various services such as prevention and treatment. Basically, it does not have inpatient facilities and provides services on an outpatient basis.

Each district has one district hospital that has an inpatient facility for every 30,000 to 50,000 people and primarily provides PHC. District hospitals have 30 to 150 beds, depending on the size of the population. District hospitals provide comprehensive preventive and curative services and refer patients to higher level hospitals depending on the patient's condition. Typically, a 30-bed district hospital is staffed by about 100-300 staff including 3-4 general physicians, 30 nurses, 2-3 pharmacists, 1-2 dentists, 20+ paramedics, and other administrative staff, while larger district hospitals may also have specialists in obstetrics, surgery, pediatrics, etc. [92]. Although there are some differences, each regional hospital is linked to 8-12 health centers, which receive referrals.

Each province has a provincial hospital with more than 150 beds. The largest regional hospitals have more than 1,000 beds [88]. Regional hospitals also serve as referral points to provincial hospitals [74]. Other government hospitals include 64 military hospitals, 11 university hospitals, 61 specialized hospitals, 8 hospitals under other ministries, 12 hospitals under local government (municipalities and Bangkok Metropolitan Authority) and a few state enterprises.

The number of private hospitals is 322, and 30% of these are located in Bangkok. Private clinics and hospitals are primarily responsible for offering curative services to meet the needs of the affluent population who choose to pay even though they are covered by CSMBS, SSS, or UCS [88]. Most private hospitals are small, with less than 100 beds. Large private hospitals are located in Bangkok and primarily serve foreign patients.

The percentage of private hospitals increased sharply between 1989 and 1997, as the number of private hospitals. After the 1997 economic crisis, there was a migration of physicians from private hospitals to public MoPH hospitals, which coincided with the closure of a significant number of private hospitals due to a downturn in household demand and the financial difficulties of private hospitals. The Medical Resource Survey for the seven-year period from 2002 to 2009 shows that physicians at district hospitals had the highest workload, followed by physicians at general hospitals, and physicians at university hospitals had the lowest workload. Physicians at private hospitals had about the same workload as physicians at regional hospitals. The workload of physicians at district hospitals is declining, while that of physicians at other institutions remains unchanged [88].

At the village level, which is even smaller than the subdistrict level, each village has about 10 Village Health Volunteers (VHVs) who provide health information and education to the community and assist health center staff in conducting community-based screenings and other activities. VHVs also assist patients and health center staff in conducting community-based screenings and other activities. VHVs also support patients and families and provide long-term care.

3.4.5 Other policies

In Thailand, the government introduced the VHVs to expand the PHC work force in rural areas. To further expand the PHC workforce in rural areas, Thailand has introduced VHVs who work closely with local people. The VHVs are responsible for promoting PHC throughout the country, managing communicable diseases, and providing local communities with basic care services. VHVs visit homes to provide follow-up care and serve as a link between clinical care and community resources. Home visits include blood pressure monitoring, emotional support through family counseling and conversation, and providing relevant advice on healthy lifestyles. They also assist with a range of community projects and introduce residents to traditional healthcare resources. VHVs are composed of people from the local community, so they fully comprehend the cultural context of the community's medical needs and are able to provide individuals and families with appropriate physical and emotional support. Currently, about 700,000 trained volunteers are available throughout the country [118]. VHVs in Thailand have been shown to be effective in the successful implementation of public health activities such as HIV prevention and control, avian influenza monitoring, and children's oral hygiene, and the WHO has recognized the program as a global model of community-based public health [83].

3.5 Related research (Geographical distribution of physician)

The inequitable physician distribution among rural and urban areas has changed from the 1970s. The number of physicians working for rural hospitals is 300, 1,162, 1,874 in 1976, 1985, 1998, respectively. The number is increasing, but the required number of physicians in 1998 is 3,161. The difference in physician-population ratio between the poorest north-eastern area and Bangkok was 21 times, 8.6 times,13.8 times, and 10.5 times in 1979, 1986, 1996, and 2001, respectively. One of the reason why the difference in 1996 increased is the emergence of the private sector, which served mainly wealth and urban areas [29].

The density of physicians in Bangkok in 2007 was 10 times as high as in the country's most rural areas [86]. The number of populations per physician in Bangkok was 1,210 in 1970, while the number of physicians was 25,713. It was 21 times in 1970, however, the significant difference was reduced to 5 times in 2009 [84].

In the study of Daniel et al. in 1994, the geographical distribution of the number of physicians in developed and developing countries was compared. Data were obtained from annual country surveys conducted by the WHO, national statistical summaries, and published information on national policies and programs. In Thailand, the overall number of physicians per 1,000 population was 1.59, with a large gap between urban and rural areas of 8.54 and 0.35, respectively. In developing countries, the level of urbanization and the economic disparity between rural areas were considered to be the most important factors determining the level of geographic imbalance [119].

Nishiura et al. used the Lorenz curve and the Gini coefficient to analyze the regional characteristics and geographic distribution of the population and physicians in each province of Thailand in 2000. As a result, a clear geographical maldistribution of physicians in each province was confirmed (Gini coefficient = 0.433). 39.6% of physicians are concentrated in Bangkok while 10% of the population is there [17].

While countries are suggested to have 1 physician per 1,000 population by the WHO [120]. The MoPH set a target ratio for the number of physician per population at 1,800:1. In 2018, the ratio in the Bangkok Metropolitan area is 630:1, while the mean ratio in rural areas is 2,373:1 [87]. In addition, WHO sets the minimum threshold for the number of physicians, nurses, and maternity nurses per 1,000 population at 2.28 [121]. Thailand has 2.8 physicians, nurses, and maternity nurses per 1,000 population, which is slightly above the minimum standard required by WHO. However, given that the number of physicians is lower than the standard, it can be inferred that a large area is covered by the number of nurses and maternity nurses.

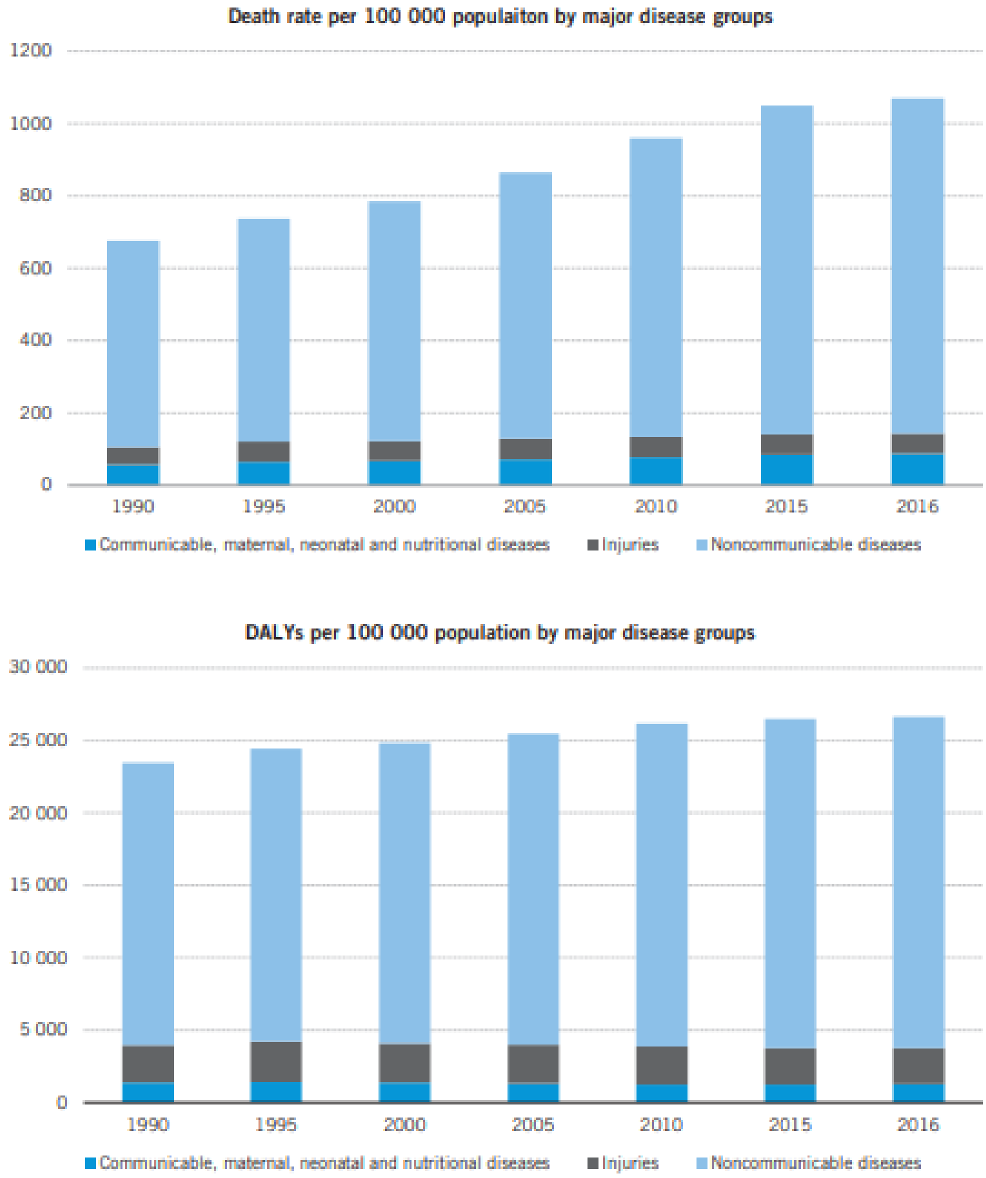
Woranan Witthayapipopsakul et al. assessed the equity of physician distribution in public hospitals affiliated to the MoPH by using “concentration index (CI)” that is advocated by the World Bank to represent the equity. In the CI and Spearman's correlation analyses, it was found that there is a correlation between the density of physicians and the wealth of the region compared to other healthcare providers. Nevertheless, the degree of concentration of medical resources in Thailand is considered to be very equitable. The exclusion of Bangkok and private hospitals was considered to be one reason, but the development of rural medical infrastructure since the 1970s, the mandatory rural work requirement for all physicians enacted in 1972, and financial incentives for rural work were also considered to have contributed to this [91].

4 Situation in Japan

4.1 Demographics

According to the United Nations, the population in 2019 is 126.86 million. The United Nations projections for the future population estimate that it will be 120.76 million in 2030, and will decline to 105.80 million in 2050 and 74.96 million in 2100. In 2019, 12.6%, 9.3%, 50.1%, and 28.0% of the population is under 15 years old, between 15 and 25 years old, between 25 and 65 years old, over 65 years old, respectively [71]. In Japan, the proportion of elderly people aged 65 and above is currently the highest in the world, and Japan entered the "super-aged society" in 2007 when the proportion exceeded 21% for the first time [122]. Moreover, the percentage of elderly people in Japan is expected to rise to 33.4% and 39.4% by 2035 and 2060, respectively [123]. Japan's population is still changing rapidly.

The overall health of the Thai population has improved over the years. Between 1990 and 2020, it is shown by the World Development Indicators that life expectancy at birth has increased from 75.9 to 81.6 years for males and from 81.9 to 87.8 years for females [72]. According to the WHO, in 2019, healthy life expectancy at birth in Thailand was 74.1 years, for males 72.6 years and for females 75.5 years [73].



Source: Institute for Health Metrics and Evaluation, 2018

Figure 9. Japan: Deaths and DALYs per 100 000 population by major disease groups, 1990–2016

Source: Adopted from Legido-Quigley H [74]

According to WHO, NCDs are a leading cause of death and morbidity in Japan, as in many other high-income countries; the top three causes of death in 2015 were cerebrovascular disease, ischemic heart disease, and lower respiratory tract infections. With the increase in life expectancy, the Japanese are suffering from more chronic and age-related diseases [74].

Leading causes in 2005	Leading causes in 2015	Change in age-standardized death rate (%), 2005–2015
1 Cerebrovascular disease	1 Cerebrovascular disease	–19.3
2 Ischaemic heart disease	2 Ischaemic heart disease	–11.6
3 Lower respiratory infection	3 Lower respiratory infection	–6.5
4 Alzheimer's disease	4 Alzheimer's disease	3.7
5 Lung cancer	5 Lung cancer	–8.7
6 Stomach cancer	6 Stomach cancer	–5.9
7 Colorectal cancer	7 Colorectal cancer	–6.4
8 Liver cancer	8 Chronic kidney disease	–11.2
9 Self-harm	9 Liver cancer	4.1
10 Chronic kidney disease	10 COPD	–16.0
11 COPD	11 Pancreatic cancer	6.5
12 Pancreatic cancer	12 Self-harm	–2.3
13 Gallbladder cancer	13 Gallbladder cancer	5.1
14 Aortic aneurysm	14 Aortic aneurysm	2.1
15 Oesophageal cancer	15 Other cardiovascular disease	–8.7
16 Breast cancer	16 Interstitial lung disease	0.7
17 Other cardiovascular disease	17 Breast cancer	0.0
18 Cirrhosis hepatitis C	18 Oesophageal cancer	–14.4
19 Road injuries	19 Lymphoma	–6.6
20 Interstitial lung disease	20 Other neoplasms	–18.8

Key: COPD: chronic obstructive pulmonary disease; CVD: cardiovascular disease
Note: The ranking is based on the number of deaths from each cause
Source: Nomura et al., 2017

Figure 10. Japan: Causes of death, both sexes, 2005 and 2015
Source: Adopted from Legido-Quigley H [74]

4.2 Current number of physician

In Japan, the problem of the number of physicians has shifted from a shortage to a surplus. Japan first experienced a physician shortage in the 1960s and 1970s [23]. The government at the time set a goal of securing at least 150 physicians per 100,000 people, the same level of other developed countries, and in the 1970s doubled the number of medical school enrollments to strengthen the supply of physicians. In order to achieve this goal, the government established 34 new medical schools including 18 national and 16 privates in the 1970s [20]. In 1984, the number of physicians reached the target. As Japan's population is aging and is expected to decline, the possibility of a surplus of physicians has become a problem. In 1982, a decision was made to " consider the establishment of a rational training plan for physicians to ensure that they are assigned in a proper level and that there is not an overall excess of physicians," and the number of physicians began to be curtailed [124]. A possible way to control the number of physicians has been proposed as a government-sanctioned reduction in medical school enrollment, but this measure is controversial and has been resisted by several interest groups [125].

Japan has issued the following several policies regarding the increase of medical school capacity [126]. (i) Based on the "New Comprehensive Measures for Securing Physicians" (agreed on August 31, 2006), the number of physicians can be increased up to 10 in each of the 10 prefectures where the shortage of physicians is recognized as particularly serious during the period from FY 2008 to FY 2009. In addition, Jichi Medical University will also be able to increase the number of physicians by 10. As a result, the number of enrollment of medical schools increased from 7,793 in 2008 to 8,486 in 2009 [127]. (ii) Based on the "Emergency Measures to Secure Physicians" (decided by the government and the ruling party on May 31, 2007), the number of physicians may be increased by up to 5 per prefecture (up to 15 in Hokkaido) from FY2009 to FY2019 in principle, in order to secure and assign physicians to regions and departments in need of physicians. (iii) Based on the "Basic Policies for Economic and Fiscal Reform 2009" (approved by the Cabinet on June 23, 2009) and the "New Growth Strategy" (approved by the Cabinet on June 18, 2010), the number of students can be increased up to 10 per prefecture each year in principle through the regional quota from FY2010 to FY2011. This increase shall be based on the regional medical revitalization plans, etc., which are to be established by prefectures from FY2009. (iv) Based on the "Basic Policies for Economic and Fiscal Management and Reform 2018" (Cabinet Decision on June 15, 2018), the current capacity of medical schools will be generally maintained for FY2020 and FY2021. (v) Based on the "Basic Policies for Economic and Fiscal Management and Reform 2019" (Cabinet decision on June 21, 2018), promote effective measures against uneven distribution of physicians in regions and medical specialties by utilizing the physician uneven distribution index and taking into account the career path of physicians including clinical training and specialized training.

The number of physicians in Japan is 339,623 and 280,431 as of 2020 and 2010, respectively [128]. However, around 17% of them practice in Tokyo. Although prefectures nearby Tokyo increased the number of physicians, the increase of population remained the physician-population ratio [127].

4.3 Related systems of physician education, training, and incentives

4.3.1 Recruitment of medical school

In general, medical schools accept applicants who have graduated from high school. The entrance examination process differs between public and private universities. At most public universities, acceptance or rejection is determined by the results of the national standardized Center Test and a secondary examination conducted by each university on the same day. The second examination is held twice, but the number of accepted applicants is smaller and the difficulty level is higher in the second session. Private universities may or may not use the Center Test, and the schedule of the second examination depends on the university. Many applicants apply to both public and private universities or several private universities at the same time. 6-year tuition differs between public and private universities, and is approximately 3.5 million yen and 20 million yen for public and private universities, respectively. The curriculum during the school year consists of basic and clinical medicine in the first through fourth years, and clinical training in the fifth and sixth years. After that, in February of the sixth year, the National Qualifying Examination for Medical Practitioners is held, and if the student passes the exam, he or she is granted a medical license. There are no restrictions on the area of employment after graduation or the department of medical treatment, and students are free to choose any of these areas.

In addition to the general quota, there is a "regional quota" for medical school applicants. The regional quota is about 10% of the total number of accepted applicants to the medical school, and is basically open to those who reside in the prefecture where the university is located or those who attended high school in the prefecture. They are exempted from tuition and admission fees, but are required to work in the prefecture for 9 years after graduation. If a student leaves the program while still in school or during the nine-year obligation period, the total scholarship amount, plus interest, must be repaid in a lump sum. If a physician leaves the regional quota and then begins specialist training without the consent of the prefectural government, he or she will not be certified as a specialist [126]. Especially in unserved areas, medical schools are considered to have the role of stabilizing the provision of medical care in the prefecture, and in order to increase the number of physicians practicing in that prefecture, more medical schools have set regional quotas when selecting students. The regional quota system differs slightly among medical schools, but basically it provides scholarships. The regional quota system has three main methods: 1) selection of medical school students from within the same prefecture where the medical school is located, 2) selection of medical school students who are willing to engage in local healthcare services no matter where they are from, and 3) provision of scholarships or conditional scholarships to those who are already enrolled in medical school. In 1997, there were only two medical schools that offered regional quotas, with a total of 11 students; in 2010, there are 67 out of 79 medical schools that have regional quotas, with a total of 1,172 students [13]. In FY2020, the total admission capacity of medical schools was 9,207 (excluding Jichi Medical University), of which 1,679 were for regional quotas [126]. Each medical school indicated that it was increasing the percentage of students recruited from among high school graduates in the prefecture (2003: 30.1%, 2010: 36.7%). Since many of these quota systems are relatively new and not many students have graduated so far, their evaluation has been incomplete so far. A survey conducted by the MEXT of six schools that graduated medical students with regional quotas found that 89% of students who graduated with regional quotas stayed in the prefecture, while 54% of students who graduated with general quotas stayed in the prefecture [129]. While this statistic is comparatively encouraging, a long-term follow-up study on the impact is necessary to solidify this first impression.

In 1972, Jichi Medical University was established for that single purpose: to train physicians in areas where there is a shortage of medical professionals. Although Jichi Medical University is a private university strictly speaking, it operates with a scheme of unique management and funding. It is operated by a educational foundation, which is jointly funded by the national government and 47 prefectures. The recruitment and selection process takes place first in each prefecture (2 or 3 local high school graduates are selected by each prefecture for admission), followed by a second selection process by the university. all students are required to practice back in their home prefecture after 6 years of medical training. Students obtain loans while in medical school and are exempted from reimbursement if they work for a certain period of time at a public hospital designated by the prefectural governor (9 years with 2-3 years of clinical training as a primary care generalist and then 6-7 years in rural services). 97% of the physicians who graduated from Jichi Medical University (2,962 in total) had fulfilled their service obligation by 2006. Seventy percent of graduates remained in their home prefectures beyond their service obligation period [130]. Compared to graduates of other medical schools, graduates of the Jichi Medical University who have completed their service obligation are more likely to practice in rural areas. In a study by Inoue, Matsumoto, and Sawada, a significantly higher percentage of graduates of Jichi Medical University practiced in rural areas even after fulfilling their service obligation [131]. Moreover, even among graduates of Jichi Medical University (who deliberately chose to work in rural areas), those who grew up in rural areas and those who chose primary care/general practice as their specialty are likely to remain in rural areas after 9 years of service obligation [52].

4.3.2 After graduate education and training

In 2004, the Ministry of Health, Labor and Welfare (MHLW) implemented a new training system for fresh physicians. It requires all new graduates of medical schools to rotate work in all related specialties over a two-year period of post-graduate clinical training [132]. Prior to the introduction of the new system, the majority of medical school graduates received their post-graduate medical training directly at an academic hospital affiliated with the medical school, where they graduated from the program. Nomura reports that approximately 75-80 percent of graduates were belonging to universities where they graduated from the program [133]. The new system requires residents to rotate through a number of specialties, whereas most prior training programs were biased toward a single specialty. The new system has dramatically changed the career patterns of Japanese residents, with more training programs outside university hospitals and a system that matches applicants' needs with training sites on a national level. After the new program was introduced, there was a significant increase in the number of non-university hospitals and in the number of residents choosing non-university hospitals as their training destination. Between 1999 and 2005, the number of non-university hospitals for training nearly doubled, and no new university hospitals have opened since 1979 except for Tohoku Medical and Pharmaceutical University and International University of Health and Welfare. In the year 2003, just before the introduction of the new program, the number of residents choosing a university hospital was 5,923 (73%), while 2,243 residents chose a non-university hospital. In contrast, in the year 2004, after the introduction of the new program, 3,262 residents (44%) preferred university hospitals and 4,110 residents chose non-university hospitals [133]. This transfer of residents from university hospitals to non-university hospitals is causing a significant physician shortage in rural areas, as university hospitals are important in allocating physicians to rural areas. As a result, a number of rural hospitals have no choice but to terminate some specialty services. This has the potential to threaten Japanese regional healthcare. After the change of the training system, it is revealed that residents tend to prefer urban general hospitals to local university hospitals. Residents' manpower as physicians and their concentration in urban areas can not be ignored considering a lot of graduates (approximately 7,500 annually) are employed in hospitals as physicians. As a matter of fact, according to the research by Toyabe, although indices of physicians distribution as a whole got worse after 2004, it was improved if residents were excluded from the calculation [134].

Prior to 2019, the national government set the recruitment capacity for clinical interns by medical institution, but after 2019, the national government will set the capacity for each prefecture, and prefectures will be able to set the capacity for each medical institution within their prefecture. Until now, the capacity was set based on the population and the number of medical students, so the number of capacity in urban areas was high, but with the change in the calculation method, the number of capacity in non-urban prefectures increased. [135].

Recently, in 2018, a new policy was implemented that requires physicians seeking specialty certification after a two-year postgraduate program to undertake their training at hospitals that are designated by the Japanese Medical Specialists Board. This new system of standardized medical specialist training resulted in a 20% increase in the number of trainees, but most of the trainees stayed in prefectures with a high population density, a national aging rate lower than 27%, or a high density of physicians (i.e., 250 physicians per 100,000 population), further exacerbating the inequality between urban and rural areas in the distribution of physicians [136]. As for specialist training, the Japan Medical Specialists Board has set the ceiling number of recruits by prefecture for each medical specialty [135, 137]. For example, if applicants actually want to work in internal medicine in the popular Tokyo metropolitan area, they can expect to face a narrow recruitment process. Therefore, if applicants are not recruited, they will have to choose a training location in a prefecture where sealing is not required.

4.4 Related health system, policy and regulation

4.4.1 Infrastructure development

Over the past 50 years, several policies have been implemented in Japan to address the maldistribution of physicians. In the 1970s, 34 new medical schools were established to increase the nationwide physician-population ratio to 150 per 100,000 people [23]. This policy resulted in an effective doubling of physician-population ratio (per 100,000 people) from 114.7 in 1970 to 258.8 in 2018. However, it but has not improved inequalities in physician distribution [138].

In Japan, at least one medical school has been established in all 47 prefectures based on the policy of "one medical school per prefecture" announced in 1973. Especially in underserved areas, medical schools are established to satisfy the demand for physicians in each prefecture. The number of medical schools and the total number of medical students are managed by the MHLW and the Ministry of Education, Culture, Sports, Science and Technology (MEXT), and have remained almost unchanged for the past 30 years except for a few examples. In 2016 and 2017, Tohoku Medical and Pharmaceutical University and International University of Health and Welfare established medical schools, respectively. The capacity was 100 for Tohoku Medical and Pharmaceutical University and 140 for International University of Health and Welfare. As for 2022, the number of medical schools and the capacity were 81 and 9,374. Compared to 2008, before the increase plan in the number of physicians, the number of enrollment increased by 1,581 because of the establishment of new medical schools and the expansion of the number of enrollments as mentioned in section 4.2 [139].

4.4.2 Insurance system

Overview of insurance

The Constitution of Japan, which was enacted in May 1947, clearly states that the people have the right to health and that the improvement of social welfare, social security, and public health is the responsibility of the government. In Japan, government-led social security policies brought about the achievement of universal health coverage in 1961. The features of Japanese universal health insurance are: (1) all persons, regardless of whether they are Japanese or foreign nationals, who are permitted to stay in Japan for more than three months are obliged to join the public medical insurance system, and (2) which public medical insurance system they join is determined by their occupation, age, and area of residence, and they are not free to choose any one of them. (3) Regardless of which healthcare insurance system a citizen belongs to, "free access" which allows the citizen to freely choose the healthcare provider and frequency of visits at his/her own discretion is guaranteed. Thanks to the free access system, citizens can receive necessary medical services with a certain level of co-payment if they have an insurance card when they become ill, etc. On the other hand, however, one problem pointed out is the casual visit to the nighttime outpatient clinic of secondary emergency healthcare providers for patients who require hospitalization or surgery, even though they have minor illnesses.

Benefits

In principle, the benefits are the same regardless of which public medical insurance plan an individual enrolls in. While there are some differences in disease prevention and health promotion plans among insurers, these differences in benefits are minor because public health insurance is not a choice for enrollees. Under both systems, benefits cover hospitalization, outpatient visits, psychiatric outpatient visits, prescription drugs, home nursing care, dental care, and other expenses. The co-payment ratio for healthcare expenditures is the same across the systems, with those under 70 years of age paying 30% of the total cost, and children under 6 years of age (before compulsory schooling) paying 20%. Those aged 70 to 74 pay 20%, those aged 75 and over with low income pay 10%, and those aged 70 and over with income equal to that of the working-age population pay 30%, etc. The co-payment ratio is determined according to age and income. The co-payment ratio ranges from 10-30%, but if the co-payment amount is still too high and exceeds a certain monthly limit, a high-cost medical care benefit system is available to pay the amount in excess of the monthly limit. The maximum co-payment amount depends on the insured person's age and income, as shown in the Table below [140].

<table>
<tr><th colspan="2" rowspan="3">Category</th><th rowspan="3">Income
(JPY)</th><th colspan="3">Monthly maximum healthcare expenditure</th></tr>
<tr><th colspan="2">Age 70 and above</th><th rowspan="2">Age 69 and below
(by household)</th></tr>
<tr><th>Outpatient
(by individual)</th><th>Impatient
(by household)</th></tr>
<tr><td colspan="2" rowspan="3">Equivalent to young people</td><td>11.60 Mil-</td><td colspan="3">252,600 + (Actual Healthcare expanse – 842,000) × 1%</td></tr>
<tr><td>7.70-11.60 Mil</td><td colspan="3">167,400 + (Actual Healthcare expanse – 558,000) × 1%</td></tr>
<tr><td>3.70-7.70 Mil</td><td colspan="3">80,100 + (Actual Healthcare expanse – 267,000) × 1%</td></tr>
<tr><td colspan="2">Ordinarily</td><td>1.56-3.70 Mil</td><td>18,000</td><td colspan="2">57,600</td></tr>
<tr><td rowspan="2">Resident tax exemption</td><td>Cat 2</td><td></td><td rowspan="2">8,000</td><td>24,600</td><td rowspan="2">35,400</td></tr>
<tr><td>Cat 1</td><td>0.8 Mil of pension income and below</td><td>15,000</td></tr>
</table>

Table 1 Monthly maximum healthcare co-payment amount

Source: Adopted from MLHW [140]

For example, assume that the age of an insured person is under 69 and the income ranges from 3.7 to 7.7 million JPY, the maximum monthly amount of co-payment is calculated as 80,100 JPY + (medical expense – 267,000) * 1%. The high-cost medical care benefits system plays an important role in preventing individuals from financial risk [140]. The total paid amount of the high-cost medical care benefits system in 2013 was 1,677.2 billion JPY for people aged under 75 years old, and 542.9 billion JPY for those aged 75 and older. From 2004 to 2013, the amount for those under 75 years old increased 1.56 times, while the amount for those aged 75 and older increased 1.65 times [141].

Mainly three kinds of insurer

There are more than 3,000 insurers in Japan, which can be categorized mainly into three: (A) vocational insurance, (B) National Health Insurance (community insurance), and (C) the latter-stage elderly healthcare system (for people aged 75 and older.) The latter-stage elderly healthcare system is supported by public expense and support fund from vocational insurance and National Health Insurance. The insurance premium that insured people pay depends on the insurance system because the calculation method of an insurance premium depends on the insurance system.

A) Vocational insurance

Vocational insurance is categorized into three, and one of which is by a Health Insurance Association, mainly for large companies. The Health Insurance Association is consisted of more than 1,300 insurers and is eligible for public subsidies in case of financial difficulties of the insurers. As of April 1, 2017, there were 1,357 Health Insurance Associations, all of which are public corporations established under the Health Insurance Law [142]. There are associations organized by a single company (single association) and associations organized by employers in the same industry (general association), with 29.17 million members as of August 31, 2016.

The second one is insurance by mutual aid associations for civil servants, which can not be available for public subsidies. Mutual aid associations are insurers established under the Mutual Aid Associations Law to cover national public servants and others. As of the end of March 2014, there were 85 such associations, with 8.91 million members as of the end of March 2014. As with health insurance societies, the level of premiums varies depending on the mutual aid association to which the insured person belongs.

The third one is Kyokai Kenpo insurance operated by Japan Health Insurance Association for employees of small and medium-sized enterprises. In addition to insured people's premium, the main fund resource of Japan Health Insurance Association is support subsidies consisted of public fund and insurance premium from Health Insurance Association. Based on the Health Insurance Law, the Kyokai Kenpo is an insurer established so that employees and dependents of small and medium-sized companies, for whom it is difficult to establish a Health Insurance Association, can enroll in the plan. The number of enrollees is 37.18 million as of the end of August 2016, and the premium level differs for each branch established in each prefecture. In the event that a Health Insurance Association becomes unable to operate due to financial difficulties or other reasons and is dissolved, the insured who had been a member of the association will be enrolled in the Kyokai Kenpo. Under these circumstances, the Kyokai Kenpo plays a role as a safety net for employee insurance. In the case of the Health Insurance Association and the Kyokai Kenpo, the company where the employee works pays half of the insurance premiums. The calculation of premiums is made by multiplying the monthly standard wage (the monthly salary and other remuneration received by the insured person from the employer, divided into a series of intervals) by the premium rate.

B) National Health Insurance (community insurance)

National Health Insurance is a medical insurance system for the self-employed, unemployed, and retired persons under 75 years old. In other words, it plays a role as a medical safety net supporting the nation's health in that it is a system that insures residents who are not covered by any other medical insurance. Until 2017, municipalities were responsible for the operation of National Health Insurance, but in 2018 it was transferred to prefectural jurisdiction. In the current National Health Insurance system, enrollees pay premiums, but about 50% of the actual benefit expenditures are covered by public funds. The method of calculating premiums for National Health Insurance differs from municipality to municipality. The premiums are calculated based on a combination of the following four categories: income premiums (calculated based on the insured's income of last year), asset premiums (calculated based on the insured's assets (land and house)), per capita premiums (imposed per individual), and per household premiums (imposed per household). The system is financially unstable due to structural problems such as the high age structure of the insured, low income levels, and low premium (tax) collection rates.

C) **The latter-stage elderly healthcare system**

The latter-stage elderly healthcare system was introduced in 2008 by divided from National Health Insurance, covering all those aged 75 and older without distinction between the main person and dependents. It is operated by prefectures and municipalities. Under this system, premiums are paid by deducting from insured people's pension that is calculated on a prefectural basis based on the healthcare expenditures of the past two years. Because the co-payment of insured people is less than 10% of healthcare expenditure, this system is supported by public funds and other two insurance systems mentioned earlier [143].

Approximately 50% of the financial resources of the latter-stage elderly healthcare system are public fund (national government: prefecture: municipalities = 4:1:1), about 40% are subsidies from each insurer, and about 10% are the insurance premiums from insured people. The total healthcare expenditure of the latter-stage elderly healthcare system in 2017 is 16,800 billion yen consisted of 15,400 billion yen of expense of benefits and 1,300 billion yen of patients' out-of-pocket [143]. In principle, support payments from premiums of the working-age population are allocated proportionally by the number of enrollees (aged 0-74) in each insurer, and the burden is heavy on insurers with weak financial strength.

4.4.3 Payment system

As mentioned earlier, under the universal health insurance system, all citizens are covered by one of the public medical insurance plans. Healthcare expenditures for visits to healthcare providers are based on the medical service reimbursement system. Medical service reimbursement is the compensation received by healthcare providers and pharmacies for medical services and medicines covered by public insurance [144]. Healthcare providers claim the payment agency for the calculated amount excluding patients' co-payments. Medical service reimbursement is determined by the Minister of Health, Labor and Welfare based on discussions at the Chuikyo (Central Council of Medical Examiners) and is revised every two years. The reimbursement is based on a point system, and each point is valued at 10 yen. According to the medical service reimbursement table, hospitals may charge additional points if they staff above a certain staffing level. Each hospital tries to attract personnel in order to increase revenue.

When a patient visits a healthcare provider with an insured person's card, the patient pays a copayment (10-30%) to the provider based on age and income for the medical services received. The 70-90% of the healthcare expenditure, excluding the copayment, is covered by public funds such as insurance premiums and taxes paid by the citizens. Healthcare providers claim this 70-90% portion to the payment organizations (the Social Insurance Medical Fee Payment Fund and the Federation of National Health Insurance Associations). The payment organizations examine the appropriateness of the claims and bill the medical insurers for the medical service reimbursement to be paid to healthcare providers, etc. In other words, the role of the payment organization is to examine the medical service reimbursement statements (receipts) billed by healthcare providers, etc., and to pay the reimbursement based on the results of the examination. The payment organization examines whether or not the medical treatment provided to the patient by the healthcare provider complies with the rules for medical treatment (e.g., rules in charge of medical treatment and related notices).

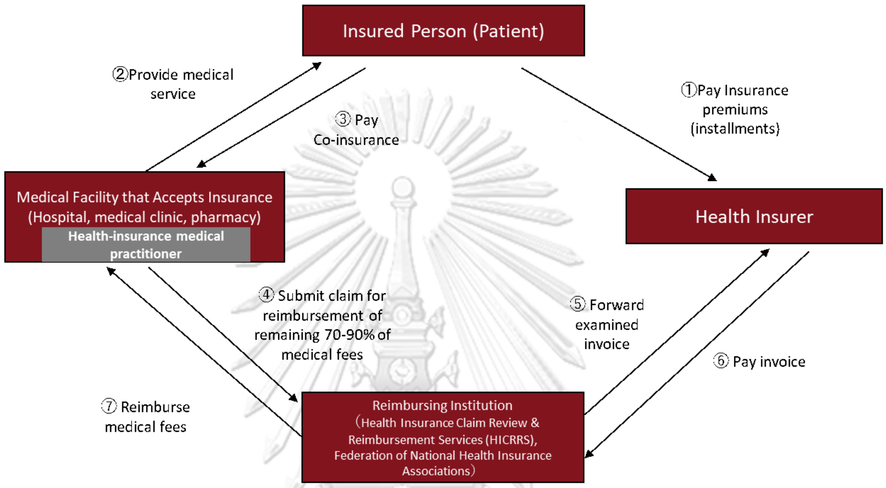


Figure 11. Flow of charges and payments for publicly insured medical services

Source: Adopted from Health and Global Policy Institute [145]

Medical service reimbursement means the fee that healthcare providers and pharmacies receive in exchange for providing medical services and drugs covered by medical insurance. Medical service reimbursement is quantified in terms of points, and each point is valued at 10 yen. The MHLW has set medical service reimbursement points and calculation requirements for medical services, medical devices, and pharmaceuticals, and all domestic healthcare providers must comply with these regulations. In addition, it is prohibited to charge higher healthcare expenditure than the reimbursement points specified, and in principle, the combination of insured and uninsured medical treatment (mixed treatment) is not allowed. However, there are already some cases in which combined uninsured and insured medical treatment is allowed as part of the uninsured combined medical care cost system. The uninsured combined medical care cost system includes evaluation medical care and patient-directed medical care.

Medical service reimbursement system (FFS and Diagnosis Procedure Combination (DPC))

Since the foundation of the current medical insurance system was established in 1961, the reimbursement system has been based on FFS payment. Under the reimbursement system, reimbursement is calculated based on the number of points set individually for medical services, drugs, and medical equipment covered by insurance, and each healthcare provider receives reimbursement from the insurer based on the number of reimbursement points.

Currently, FFS system is basically adopted in the outpatient setting. Medical fees are calculated based on the amount of defined medical treatment performed. In the case of hospitalization, as described below, some acute care hospitals or hospital beds have adopted DPC, and when a patient is hospitalized in a hospital or hospital bed that is not subject to DPC, FFS payment system is adopted. When hospitalized not in DPC hospitals or hospital beds, reimbursement differs depending on the function of the hospital or hospital beds. Basically, if a high level of outcome is achieved through the provision of extensive medical care by a large number of medical personnel, a higher score can be calculated.

Introduction of DPC

DPC is a unique Japanese reimbursement system that was introduced in the early 2000s in response to growing concern about healthcare expenditure, LOS, and demand for medical services as the population rapidly ages.

From 1998 to 2004, a comprehensive payment system for acute stage inpatient care was introduced at 10 national hospitals as a trial. The trial showed that although the LOS varied greatly from patient to patient, even for the same disease, the difference between the comprehensive reimbursement per day and the actual treatment cost was smaller under the comprehensive reimbursement per hospital stay system than under the comprehensive reimbursement per day system, and that there were incentives to lower the per diem price. The current DPC system, which calculates a fixed fee per day based on the LOS, was introduced. The main purpose of DPC is to promote standardization and transparency of medical care. By establishing an objective medical information database, it is hoped that the results of medical care and areas for improvement will be clarified, and the disparities in the quality of medical care between hospitals will be corrected, thereby improving overall quality. At the same time, patients will benefit from being able to refer to standard treatment and pricing information with objective data. It is also expected to reduce the average LOS. As of April 1, 2016, an estimated 1,667 hospitals with approximately 490,000 beds, or about 55% of all general hospital beds in Japan, are subject to DPC operations [146]. It is a flat-rate payment system similar to the DRG/PPS (Prospective Payment System) system introduced in the United States, and uses DPC codes that are structured primarily based on disease codes and procedures (as of April 2016 As of April 2016, there were a total of 4,244 classifications) [146].

The DPC system is characterized by its comprehensive evaluation on a per day basis and by its partial incorporation of FFS payment methods. The amount of the medical reimbursement fee is the sum of the comprehensive evaluation portion set for each DPC and the FFS evaluation portion, which is not subject to DPC. The comprehensive evaluation portion is calculated by multiplying the amount per day (set in three steps) by the number of days spent in the hospital and a coefficient set for each medical institution (coefficient for each medical institution) [147]. Basic inpatient charges, medical tests (including diagnostic imaging), injections, medicines, and medical treatments that cost less than 1,000 points are subject to the comprehensive evaluation portion, which is calculated based on the number of points per day by DPC classification, the number of days spent in the hospital, and a predetermined coefficient for each healthcare provider. Surgery, radiotherapy, anesthesia, and medical treatments that cost more than 1,000 points are not subject to comprehensive evaluation, and are calculated on a FFS basis.

The institution-specific coefficients consist of three elements: basic coefficient, functional evaluation coefficient I, and functional evaluation coefficient II. Basic coefficient is a coefficient that evaluates the basic medical functions of medical institutions. In order to reflect the characteristics of the facilities, DPC hospitals are classified into three groups of medical facilities: (1) the headquarters of university hospitals, (2) DPC specialized hospitals, and (3) DPC standard hospitals (hospitals other than Group I and Group II). Functional evaluation coefficient I is a coefficient that evaluates the structure of the hospital, such as staffing and the system of the facility as a whole. Functional evaluation coefficient II is a coefficient that evaluates incentives to improve the efficiency of the healthcare provider system as a whole through participation in DPC/PDPS (incentives for the roles and functions that healthcare providers should play).

The calculation method differs depending on the stage of hospitalization, and three hospitalization periods are set. The fixed fee per day for hospitalization period I is set higher than that for hospitalization periods II and III. Hospitalization Period II refers to the period from the first day to the average LOS in Hospitalization Period II. The fixed fee for this period varies according to the diagnosis group classification, but is set lower than that for Hospitalization Period I after taking into account the average input of medical resources per day. Hospitalization Period III is the last period of specified hospitalization, and the flat fee per day is lower than that of Hospitalization Period II [148]. Exceptionally, reimbursement for patients who stay longer than Hospitalization Period III is calculated on a FFS basis.

4.4.4 Delivery system

The MHLW is the central leadership organization in the Japanese healthcare system. The MHLW actively cooperates and collaborates with a wide variety of organizations including the Cabinet, Ministry of Finance, MEXT, Ministry of Agriculture, Forestry and Fisheries, Ministry of Economy, Trade and Industry, Japan Medical Association, Japan Nurses Association, and many others. Since 2016, then-Prime Minister Shinzo Abe has considered healthcare to be a major industry in Japan, and the Cabinet Office, along with the Ministry of Economy, Trade, and Industry, has taken the lead on much of Japan's healthcare policy [74].

Japan's healthcare delivery system is based on a universal health insurance system and a free access system, which allows patients to receive medical care at any medical institution.

Medical facilities in Japan can be divided into general clinics (with or without beds), dental clinics, and hospitals, most of which are clinics. As of 2019, there were 8,300 hospitals, 6,644 bedded clinics, 95,972 non-bedded clinics, and 68,500 dental clinics. Looking at the change in the number of medical institutions between 1987 and 2019, the number of hospitals has decreased by a factor of 0.86, while the number of clinics without beds has increased by a factor of 1.7 [149].

Hospitals and clinics can be broadly classified into the following categories: national, public medical institutions, social insurance-related organizations, corporations, and individuals. In Japan, the medical care delivery system is mainly private, and while most clinics used to be private, recently the number of clinics established by corporations has been increasing. This situation is one of the characteristics of the Japanese healthcare delivery system, as the majority of hospitals in countries such as the United Kingdom and France are public institutions [150]. Individuals and private medical institutions (medical corporations) account for 70% of hospitals and more than 50% of hospital beds, making the private sector-centered healthcare delivery system one of the characteristics of the healthcare delivery system in Japan [151]. In addition, from an international perspective, Japan has a large number of hospital beds per population, a long average LOS, and a low number of medical personnel per bed. For example, although the average LOS has been shortened, it is still long compared to other countries.

Medical facilities in Japan are also categorized into primary medical facilities (clinics), secondary medical facilities (community hospitals), and tertiary medical facilities (specialized hospitals). Patients are expected (but not required) to visit a primary medical facility and are referred to a secondary or tertiary medical facility if necessary. Regional public health centres or community health centres provide with public health services. However, he Japanese healthcare system does not clearly distinguish between primary, secondary, and tertiary care, and there is no gatekeeper system. If a certain amount of money is paid, it is also possible to be related to a medical institution that provides advanced medical care without a referral from a primary medical institution [74].

Hospital beds in Japan include general hospital beds, sanatorium beds, psychiatric beds, infectious disease beds, and tuberculosis beds, with general hospital beds being the most common [152]. It has been pointed out that the baby boom generation (born between 1947 and 1949) will all be 75 years old or older by around 2025, and social security costs, including nursing care and medical expenses, are expected to increase rapidly. With the further aging of society expected in the future, it is necessary to make efficient use of limited healthcare resources. In order to functionally specialize medical institution beds according to the nature of medical needs and to enable patients to receive appropriate medical care according to their conditions, the government plans to reduce the number of hospital beds to about 1,150,000 by 2025 [153].

4.4.5 Other policies

In Japan, the MHLW has launched a study group on the supply and demand of medical personnel to address the regional maldistribution of physicians, and discussions are underway. An interim report on the results of the study was issued in March 2019 [154, 155]. The report stated that, as measures to address physician maldistribution, each prefecture should formulate a plan for securing physicians and include it in its medical plan, utilizing the physician maldistribution index, and that a certification system should be established to evaluate work in areas with a small number of physicians.

The physician maldistribution index was established as an indicator of physician maldistribution that enables objective comparison and evaluation of the number of physicians in each region on a nationwide basis. The index includes the following three dimensions [155]. First, the index includes age- and gender-adjusted consultation rates to account for differences in medical needs due to demographic changes. Second, the index reflects population inflows and outflows during the day and at night to more accurately reflect medical demand. Third, it takes into account the gender and age structure of physicians to adjust for physician performance. The top third of the physician maldistribution index is defined as physician-majority prefectures, while the bottom third is defined as physician-minority prefectures. As with the plan for securing physicians, the plan is based on a three-year cycle, with each cycle being repeated as the SMAs or prefectures belonging to the physician-minority prefectures move out of this category. In order to normalize the uneven distribution of physicians, each prefecture will consider establishing regional quotas for medical schools and various other measures to secure physicians, and the MHLW plans to limit the number of physicians and restrict the movement of physicians on a prefectural basis based on the criteria for physician majority/minority prefectures [154-156].

The plan for securing physicians to be established at the prefectural level shall be based on the physician maldistribution index. In securing physicians on a prefectural basis, prefectures with a small number of physicians shall secure physicians from prefectures with a large number of physicians, and prefectures with a large number of physicians shall not secure physicians from other prefectures. Prefectures with neither a small number of physicians nor a large number of physicians shall be able to secure physicians from tertiary medical regions (prefectures) with a large number of physicians, if necessary, when there are areas with a small number of physicians within the prefecture. The plan for securing physicians in each SMA is basically the same as that for each prefecture [154, 157, 158].

The certification system for evaluating work in physician-majority areas requires that physicians work in a physician-majority area for a defined duty for a minimum of six months. Physicians who are certified will be able to become administrators of certain hospitals (under consideration). Incentives for individual physicians who become administrators, as well as tax, subsidy, loan, and reimbursement evaluations for such healthcare providers are to be considered [135, 154, 159, 160].

The Comprehensive Medical Care Fund is used to eliminate the uneven distribution of physicians [161]. The national government provides the fund to prefectures, which in turn pass it on to municipalities and operators. The fund can be used for measures to secure physicians, but the specific use and amount of the fund vary from prefecture to prefecture. It may be used to pay allowances for physicians or to pay for training, but the allowances are not as expensive as in Thailand [162].

Although it has not been implemented, the government and prefectures are also considering interventions to ease the anxiety of physicians as they work in low-physician areas. For example, support is being considered for group practice, making it easier for physicians to take vacations by allowing the government to dispatch replacement physicians, allowing remote consultations among physicians, and allowing joint use of medical facilities. Financial incentives are also being considered for medical institutions that send out physicians in response to requests from regions where there is a shortage of physicians [135].

4.5 Related research (Geographical distribution of physician)

Kobayashi examined the change in geographical distribution of physicians between 1980 and 1990. During this period, at least one medical school has been established in each of 47 prefectures. The authors tried to describe how improve the number and distribution of physicians. The increase in the number of physicians was about 37%, with an increase in the number of physicians per 100,000 population from 127 to 165 nationwide. However, the Lorenz curve and Gini coefficient analysis did not show any improvement in the inequality of physician distribution. The number of physicians increased proportionally in municipalities with a population of 30,000 or more, but hardly increased in areas with a population of less than 10,000 [23].

Toyabe conducted a study that aimed to identify trends in the distribution of physicians by comparing the number of physicians in Japan in 1996 and 2006. Time series trends in the number of physicians and physician distribution from 1996 to 2006 were analyzed. The indexes used to show the maldistribution of the number of physicians compared to the population were the Gini coefficient, the Atkinson index, and the Theil index. From 1996 to 2006, the number of physicians increased annually, but was still below the international level. After 2004, all three physician unevenness indices showed a worsening trend, with the maldistribution of hospital-employed physicians being the most pronounced. The number of hospital-employed physicians has increased substantially in urban areas, but not in less densely populated areas. Excluding residents from the calculations improved the measure of maldistribution. The author concluded that the problem of a shortage of physicians in Japan is related to both a shortage in the absolute number of physicians and the unequal distribution of hospital-employed physicians. The introduction of a post-graduate training system may exacerbate this situation [134].

Tanihara et al. analyze data covering six time points, across a decade: 1998, 2000, 2002, 2004, 2006, and 2008. Secondary tiers of medical care (STM), as defined by the Medical Service Law and related regulations, are the spatial units of analysis. The trends of geographic disparities in the distribution of population and physicians in the 348 secondary tiers of healthcare in Japan were examined. In addition, the population and the number of physicians per 100,000 population in each STM were compared. To quantitatively evaluate the maldistribution, the Gini coefficient for the distribution of physicians was calculated. During the period 1998-2008, there was an increase of 0.95% in the total population and an increase of 13.6% in the number of practicing physicians per 100,000 population. However, the ratio of the number of physicians to the population increased in smaller, predominantly rural areas, although the inequality of physician distribution remained unchanged. On the other hand, the Gini coefficient of population increased as the maldistribution of population became more severe during the same period. Although there was a decrease in the absolute number of practicing physicians in the smaller STMs, the number of practicing physicians per population increased in the STMs located in rural areas because the population, the denominator of the STM, decreased. Between 1998 and 2008, policies to increase the number of physicians and the physician-population ratio in all regions of Japan, regardless of size, did not lead to an equalization of the geographic distribution of physicians. The increase in the physician-population ratio in small rural STMs was due to concurrent urbanization, not to an increase in the number of practicing physicians [18].

Hara et al. conducted a study aimed at examining the longitudinal geographic distribution of physicians in Japan, adjusting the demand for healthcare according to changes in the population age structure. The trends in the number of physicians per 100,000 population in the Japanese SMA were examined between 2000 and 2014. Healthcare demand was reconciled with per capita healthcare expenditure. The trends in the Gini coefficient and the number of SMAs with low physician supply were analyzed. In addition, authors performed a subgroup analysis by dividing SMAs into four groups according to their urban-rural classification and initial physician supply. Trends in the Gini coefficient and the number of SMAs with low physician supply over time indicated that the distribution of physicians got worse in terms of equity over the study period. There was an increase of 22.9% in the number of physicians per 100,000 population in urban areas with high initial physician supply and 34.5% in urban areas with low initial physician supply, which appeared to increase for all groups. However, after adjustment for healthcare demand, there was a 1.3 percent decrease in physician supply in the former group and a 3.5 percent increase in the latter. In rural areas, the number of physicians also decreased, by 4.4% in the group with the highest initial physician supply and by 7.6% in the group with the lowest initial physician supply. In Japan, although there was an increase in the total number of physicians, there was a decrease in the demand-adjusted supply of physicians in recent years in all regions except for urban areas with low initial physician supply. In addition, the distribution of physicians had consistently deteriorated in fairness since 2000 [19].

Inoue's study evaluated changes in the geographic distribution of physicians over a 22-year period between 1980 and 2002 and the characteristics of physicians in 1980 that predicted practice in rural areas in 2002. Data on the approximately 93,000 physicians recorded in the censuses for both years revealed that in both years the rural physician-population ratio was about half that of the urban area, with no improvement in maldistribution. 92.7% of physicians who were in urban areas in 1980 were still in urban areas in 2002. On the other hand, 55.9% of physicians who were in rural areas in 1980 remained in rural areas in 2002. Being in primary care in 1980 and practicing in rural areas both predicted practicing in rural areas in 2002 (OR [95% CI]: 1.28 [1.23-1.35], 16.18], respectively [15.43-16.95]) [20].

5 The ways to show maldistribution

Both the Lorenz curve and the Gini coefficient were originally developed in the economic field to assess inequality in the distribution of income, but their application have gone beyond socioeconomics to include use in the field of public health. They have also been widely used as an indicator of the maldistribution of medical resources in a region [23, 163-167].

5.1 Lorenz curve

The Lorenz curve is a figure that shows inequity and concentration of income, wealth, or health resource developed by American economist Max Lorenz in 1905 [168]. In the graph, the horizontal axis describes the cumulative population ranked by income, wealth, or health resource, while the vertical axis describes the cumulative income, wealth, or health resource. For example, if an x and y value is 40 and 15, respectively, it explains that 40% of the population has 15% of the overall income, wealth, or health resource. The straight line with 45 degrees slope crossing the origin and the point where x and y is 100% is usually depicted with the Lorenz curve in a figure of the Lorenz curve. That is the perfect distribution line and describes all of the population have income, wealth, or health resource equally. The Lorenz curve ordinarily lies under the perfect distribution line and represents the actual distribution. The more the Lorenz curve is apart from the perfect distribution line, the more the unevenness exists. Because the Lorenz curve is one of the best, simplest and the most understandable way to explain the degree of unevenness, it is recognized and used worldwide.

To show the Lorenz curve, the population and number of physicians per unit area are used. First, the number of physicians per unit area is divided by the population to obtain the physician-population ratio per unit area, and then the unit areas are sorted in ascending order of the physician-population ratio [18, 21, 23, 134]. The cumulative population percentage and the cumulative number of physicians percentage are obtained. Plot the cumulative population percentage and cumulative number of physicians percentage on a graph and connect each point with a line to complete the Lorenz curve. At the same time, a line is drawn connecting the origin and the vertex (the point where the cumulative population percentage and cumulative number of physicians percentage are each 1). This represents the perfect distribution.

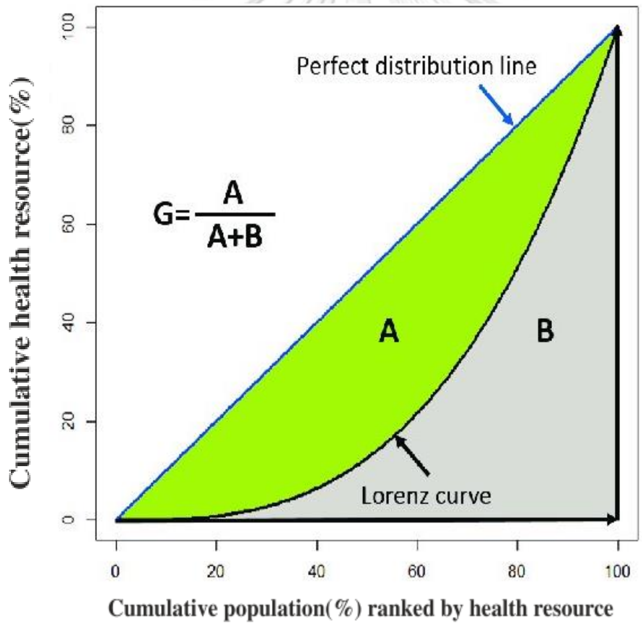


Figure 12. Example of the Lorenz curve and the Gini coefficient

5.2 Gini coefficient

The Gini coefficient was invented by an Italian statistician named Corrado Gini in 1912 [169]. It was derived from the Lorenz curve. The Gini coefficient is calculated as the ratio of the area A (between the perfect equality distribution line and the Lorenz curve) divided by A+B (the total area under the perfect equality distribution line). The closer Gini coefficient is to one (the smaller the area A), the closer the equal distribution is. The closer Gini coefficient is to zero (the larger the area A), the closer the unequal distribution is.

To compute the Gini coefficient, the Lorenz curve is used. First, the area below the Lorenz curve (part B in the Figure 12) is calculated. To calculate the Gini coefficient, the Lorenz curve with plotted unit areas is used. The first point is the origin, the second is the point of the unit area closest to the origin, and the third is the intersection of the line drawn from the second point to the x-axis and x-axis. The triangle area enclosed by these three points is calculated. Thereafter, four points are used: the first and second points are the second and third points used to calculate the area of the previous triangle; the third point is the point in unit area of the second nearest the origin; the fourth point is the intersection of the line drawn from the third point to the x-axis with the x-axis. The area of the trapezoidal area enclosed by these four points is calculated. The area below the Lorenz curve is calculated by repeating this process and adding up all the areas. The area between the Lorenz curve and the perfect distribution line (part A in the Figure 12) can be calculated by subtracting the area of part B obtained earlier from 0.5. The Gini coefficient is defined by Brown as follows [170]:

$$G = 1 - \sum_{i=0}^{n-1} \{Y_{i+1} + Y_1\}\{X_{i+1} - X_i\}$$

There are three characteristics of the Gini coefficient. The first one is anonymous. The coefficient does not disclose individual information. Just looking the Gini coefficient, we can’t comprehend who possess high and low part of the health resources. The second one is scale of independence. The Gini coefficient does not depend on how wealthy a country is. For example, both rich and poor countries may show the same coefficient due to similar income distribution. The final characteristic is that the Gini coefficient does not depend on the size of the population. Thus, it is comparable among countries.

Ordinarily, the interpretation of the coefficient is usually done in comparative terms, by contrasting the calculated value to that of other geographic units and population groups [171]. As for the one of the criteria, the Gini coefficient 0.4 is usually considered as a "guard line" for the gap in the allocation of medical and health resources. The Gini coefficient <0.2 means highly fair distribution of health resources; between 0.2 and 0.3 means relatively fair; between 0.3 and 0.4 means more reasonable; between 0.4 and 0.5 indicates a large gap; and >0.5 indicates a high degree of unfairness [172]

In the Algerian study, geographical maldistribution of private physicians and its transition was analyzed by using the Gini coefficient. The results that 0.47 of the Gini coefficient in 1998 rose to 0.50 in 2017 concluded that the entire disparities had increased [173]. A U.S. study used the Gini coefficient to measure variation in the distribution of physicians and hospital beds over a 30-year period, covering 46 states and ranking the distribution of physicians and hospital beds within each state based on the Gini coefficient of fairness [174].

While examining the Gini coefficient is convenient to grasp the distribution of health resource, there are some limitations in using it. The first limitation is sampling bias. Its validity depends on the sample size. Small countries or countries with less diversity frequently tend to show the low Gini coefficients. On the other hand, large countries or countries with diversity usually demonstrate the high Gini coefficients. The second shortcoming of the Gini coefficient is that demographic structure is not took into account. For example, elder people generally need more healthcare resource than young people, but calculation in the Gini coefficient doesn’t consider this aspect. In order to overcome this problem, calculation the Gini coefficient by adjusting the healthcare demand is needed. Thirdly, it is also a merit of the Gini coefficient, the Gini coefficient doesn’t tell us individual information. Just reviewing the Gini coefficient, we can’t identify who struggle in poor in a population. Thus, additional research is needed to make policies. Finally, the Gini coefficient does not reflect the quality of life. In general, people living in urban areas tend to have a higher income and health resource than those who live in rural areas. Nevertheless, people in urban areas have more difficulties to keep their health, for example, they tend to exercise less and sometimes have to spend more to gain healthier food.

5.3 Atkinson index

The Gini concentration coefficients complemented the defect in the Lorenz curve regarding the display of distributional bias, but even this has a weakness latent in it. Suppose there were two distributions with the same Gini coefficient. Distribution 1, in which inequality is high in the low-income group and low in the high-income group, and Distribution 2, in which inequality is low in the low-income group and high in the high-income group, but the Gini coefficient is the same. In a sense, the Gini coefficient is value-neutral and does not take into account social welfare. The Atkinson scale has been proposed as a complement to the Gini coefficient.

$$A_g = 1 - \left\{ \sum_{i=1}^{n} \left(\frac{Y_i}{\overline{\overline{Y}}} \right)^{1-\varepsilon} \; P_i \right\}^{\frac{1}{1-\varepsilon}}$$

The ratio of the population in the i-th income bracket to the total population is pi, its income level is Yi, and the overall average income is Y~. ε is a parameter that indicates the weight given to poverty in the low-income bracket, and this parameter should be increased if you want to strongly express its severity. The larger the value of ε, the relatively more weight is given to inequality at the lower end of the distribution and the relatively less to inequality at the upper end. If ε is quite high, inequality is sensitive only to transfers among the bottom tiers; if ε is zero, transfers of health services have zero weight and the distribution is ranked only in terms of total level of health services [175].

A research conducted by Toyabe, the geographical maldistribution of physician was examined by using the Gini coefficients, the Atkinson index, and the Theil index. All three indices changed similarly [134]. Moreover, Mark examined the maldistribution of GPs in England and Wales from 1974 to 2003 using the Gini coefficient and the Atkinson index. The study showed that the trend of the Gini coefficient and the Atkinson index was similar, but their degree of change was different. The change in the Atkinson index was more significant than the one in the Gini coefficient. In this study, the change in the Atkinson index is more sensitive than the Gini coefficient change [6].

5.4 Theil index

The Theil index was proposed by Dutch economist H. Theil, using entropy to calculate income inequality. The Theil index is primarily used to analyze differences in the contribution of resource allocation among regions, but it can also be used to break down overall differences. The Theil index ranges from 0 to 1, with smaller values indicating greater inequity among regions. The Theil index was originally proposed as a measure of income inequity, but because it can be decomposed by group, can import group-level data, and is especially useful for smoothing effects in hierarchical data sets, it is now being used as a measure of inequity in health surveys [134, 175-177]. The formula for calculating the Theil Index can be expressed as follows [178].

$$T = \sum_{i=1}^{n} P_i \log\left(\frac{P_i}{Y_i}\right)$$

In the formula, Pi is the ratio of the population of a location to the total population and Yi is the ratio of the health resources owned by a location to the total number of health resources. The characteristic of the Theil index is inequality decomposable into within- and between-group inequality [179]. There are two components: an “within-group" component, which is a weighted sum of inter-unit inequality within each group, and an "between-group" component, which measures inequality solely due to variations in health resource density between groups. The decomposition equation is;

$$T = T_{intra\ class} + T_{inter\ class}$$

$$T_{intra\ class} = \sum_{g=1}^{k} P_g P_g$$

$$T_{inter\ class} = \sum_{g=1}^{k} P_g \ \log \frac{P_g}{Y_g}$$

In the equations above, "intra-class" represents the difference in health resource allocation within a region, "inter-class" represents the difference in health resource allocation between regions, Pg is the ratio of the population of a location to the total population, and Yg is the ratio of the health resources held by a location to the total number of health resources. The contribution of each part of the difference to the total Theil index can be calculated by decomposing the total Theil index. In the case of health resource allocation, a TI = 0 implies equity in allocation, with smaller values indicating greater equity in allocation and vice versa.

Another characteristic of the Theil index is less intuitive and not directly comparable across populations with different sizes or group structures [179].

CHAPTER 3: RESEARCH METHODOLOGY

1 Study Design

In this study, longitudinal comparative descriptive study was conducted, using secondary data.

Comparing two countries, Thailand and Japan, this study showed how two countries were similar or different. Thailand and Japan are classified as upper-middle-income economies (4,096 USD to 12,695 USD in GNI per capita) and high-income economies (12,696 USD or more in GNI per capita), respectively [180]. There are a lot of differences in healthcare system, population composition, human behavior and so on. Comparative studies allow for the sharing of knowledge and practices about the healthcare systems of both countries. Comparisons can contextualize the current situation of physician maldistribution and how it has been addressed. Moreover, it can identify systems and practices that have been effective in each country. Since laws and other regulations are different in each country, it may not be possible to directly apply the systems of one country to the other, but it may be possible to utilize the principles of the other country.

Longitudinal method is to compare two or more time points. In this study, data in 2008 and 2018 were employed. Both in Thailand and Japan, the government implemented several policies to address the geographical maldistribution in long term as mentioned in the literature review section. Comparing indicators and policies in this period in each country would describe how improve the country's geographical distribution and policy that was effective.

2 Study Area

The setting of this study was nationwide, which included all the provinces of Thailand and all the SMA derived from the 47 prefectures of Japan. To show the number of physicians and their maldistribution over the past 10 years in a given region, it was sufficient to show the change between the present and 10 years ago. However, if the region had been restructured, it was difficult to simply calculate the number of physicians, and a simple comparison between 10 years ago and the present was not possible because of the possibility of erroneous interpretations. Therefore, the provinces/SMAs with the larger number of provinces/SMAs among 2008 and 2018 were modified based on the year with the smaller number of provinces/SMAs, and various indicators such as population, area, and number of physicians were calculated after the modification. Specifically, Bung Kan province was carved out from Nong Khai province as the 77th province in Thailand in 2011 [181]. This brought the number of provinces from 76 Province as of 2008 to 77 provinces in 2018. In this study, each variable was calculated based on the lesser number, 76 provinces in 2008. This was based on the assumption that Bung Kan province and Nong Khai province as of 2018 were combined and considered the same area as Nong Khai province in 2008. Thus, it was assumed that Thailand had 76 Province in both 2008 and 2018. Similarly, in Japan, there were 348 SMAs in 2008 [182], but since then many municipalities had been merged [183], and the number of SMAs had been reorganized to 335 as of 2018 [184]. It was common practice to recognize the number of SMAs in Japan as of December 31 of each year [138, 185]. Since the year with the smaller number was used as the base year, each variable was calculated based on 335 SMAs in Japan. Variables such as population and number of physicians by municipality for both 2008 and 2018 were aggregated by SMA as of 2018. Population and number of physicians by municipality in 2008 were also aggregated by SMA as of 2018, assuming that the same 335 medical regions continued from 2008 to 2018. This matching of ranges to a single point for multiple-year health resource maldistribution comparisons to remove the effects of regional reorganization had been done in past studies [18, 21, 23, 134, 186]. The reason for matching the year with the smaller number of provinces and SMAs was because it was not possible to match the year with the larger number of provinces and SMAs. For example, in Thailand, Nong Khai province was one province in 2008, meaning that this could not be divided into Nong Khai province and Bung Kan province as of 2018.

3 Study Period

The study period was from 2008 to 2018 both in Thailand and Japan.

4 Operational Framework

In this study, there were three kinds of outcome variables to be compared: the Gini coefficient; Physician-population ratio; Correlation coefficient (population density and physician-population ratio). In addition, demographic variables, population, area, and population density were compared as premise of the outcome variables. Moreover, health system, including, current number of physician, infrastructure development, recruitment of medical school, insurance system, payment system, delivery system, after graduate education and training and policies in each country were described and compared as background and context of each results.

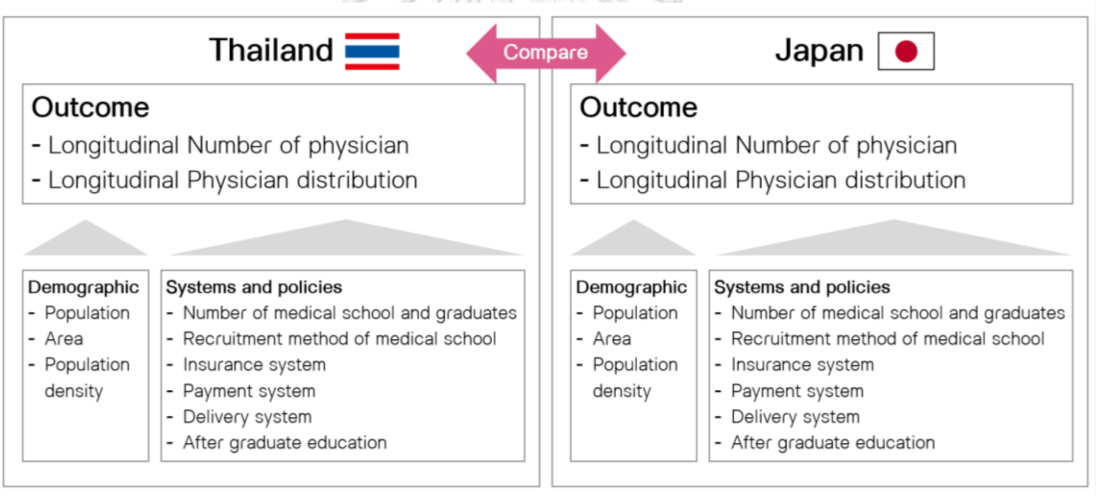


Figure 13. Operational Framework

5 Source of data

All data was open secondary data that could be downloaded in the government website. The variables list that to be analyses was as follow:

Table 2. Source of variables

Variables	Data source
Gini coefficient	Calculated from the collected variables (Population and the number of physicians. See section 7.2.2 (Gini coefficient))

Physician-population retio	Calculated by dividing the number of physicians by 1000 population (see section 6 (Variables))
Correlation coefficient	Calculated from the collected variables (Population density (from population and area) and physician-population ratio (population and the number of physicians)) See section 7.3
Population	Collected from the following source (see section 5.1.1 and 5.2.1)
Area	Collected from the following source (see section 5.1.2 and 5.2.2)
Population density	Calculated by dividing population by area (see section 6 (Variables))
Number of physician	Collected from the following source (see section 5.1.2 and 5.2.3)

5.1 Thailand

5.1.1 Population, Area

The population and area data of Thailand in 2018 could be downloaded from the Thai National Statistical Office (NSO) website [187]. The data named " Number of Population from Registration by Sex, Area, Density, House, Region and Province: 2011-2020" was downloaded. The data was arranged by the bureau of Registration Administration, Ministry of Interior. Data on population and area by province for 2008 were also downloaded from the Thai NSO website [188]. In the "Tables compiled by other agencies" tab, select Ministry of Interior, The Bureau of Registration Administration, 2008 for Ministry, Department, and Data year, respectively. Did not select any country/region. Then a list of data would be displayed, and select "POPULATION FROM REGISTRATION, AREA, DENSITY AND HOUSE BY PROVINCE: 2008" for each area (Bangkok, central region, northern region, northeastern region, southern region).

5.1.2 Number of physician

The number of physician data of Thailand in 2018 could be downloaded from the Thai NSO website as well [189]. The data named "Number of Health Personnel by Region and Province: 2016 - 2020" was downloaded. The data was arranged by the Office of the Permanent Secretary for Public Health, MoPH. Data on the number of physicians by province for 2008 were also downloaded from the Thai NSO website [188]. In the "Tables compiled by other agencies" tab, select MoPH, Office of the Permanent Secretary, 2008 for Ministry, Department, and Data year, respectively. Did not select any country/region. Then a list of data would be displayed, and select "NUMBER MEDICAL AND HEALTH PERSONNELS BY PROVINCE: 2008" for each area (Bangkok, central region, northern region, northeastern region, southern region).

5.2 Japan

5.2.1 Population

The Japanese population data was cited from "Counts of population, vital events and households derived from Basic Resident Registration [190]", and could be downloaded from the website of the Portal Site of Official Statistics [191]. The data is arranged by the Ministry of Internal Affairs and Communications, Counts of population. In this study, the number of Japanese population registered in the Basic Resident Registration Book was used. The Basic Resident Registration Act was amended (effective July 9, 2012) to include foreign nationals. To enable comparisons between years, only the Japanese population was used in this study. The Basic Resident Registration population here refers to the number of Japanese citizens who have a fixed address in a municipality in Japan and are listed in the Basic Resident Registration of that municipality as of March 31 of each year.

5.2.2 Area

The Japanese area data was cited from "Municipalities Area Statistics of Japan", and could be downloaded from the website of the Ministry of Land, Infrastructure, Transport and Tourism, Geospatial Information Authority of Japan [192]. The data is arranged by the Ministry of Land, Infrastructure, Transport and Tourism, Geospatial Information Authority of Japan. This refers to the "area" as used in the National Area Survey by Prefecture, Town, Village, and Village. This area includes the Northern Territories (the Habomai Islands, Shikotan Island, Kunashiri Island, and Etorofu Island) and Takeshima Island. The area is as of October 1 of each year.

5.2.3 Number of physician

The Japanese number of physicians data was cited from "Statistics of Physicians, Dentists and Pharmacists [193]", and could be downloaded from the website of the Portal Site of Official Statistics [194]. The data is arranged by the MHLW of Japan. Physicians with an address in Japan are required by Article 6, Section 3 of the Medical Practitioners Law to participate in this survey. Physicians report their address, gender, date of birth, and location of their workplace as of December 31 of the survey year. A physician is defined as a person who has passed the national medical examination based on the Medical Practitioners Law and is licensed by the Minister of Health, Labor and Welfare, and is required to notify the Minister of Health, Labor and Welfare via the prefectural governor of his/her address every two years thereafter based on the Medical Practitioners Law.

6 Variables

Variables were population, area, population density, number of physicians, physician-population ratio, Gini coefficient, and correlation coefficient between population density and physician-population ratio. Population, area, and number of physicians were the numbers recognized by national surveys, as described in "5

Sources of data". Population and number of physicians were discrete variables, while area was a continuous variable. Population density was calculated by dividing population by area and represents the number of people per square kilometer. Physician-population ratio was calculated by dividing the number of physicians by the population in units of 1000 and represents the number of physicians per 1000 population. The Gini coefficient was explained in the literature review and the calculation method was described in detail in "7 Data analyses." The Correlation coefficient was also explained in detail in "7 Data analyses". The Gini coefficient and Correlation coefficient were continuous variables.

Table 3. List of variables

Variable name	Detail
Population	- Discrete variable - Obtained from census
Area	- Continuous variable - Obtained from census
Population density	- Continuous variable - Calculated by dividing population by area of each province
Number of physicians	- Discrete variable - Obtained from census
Physicians-population ratio	- Continuous variable - Calculated by dividing the number of physicians by 1,000 population
Gini coefficient	- Continuous variable - If the area between the line of perfect equality and Lorenz curve is A, and the area under the Lorenz curve is B, then the Gini coefficient is A/(A+B)
Correlation coefficient	- Continuous variable

7 Data Analysis

7.1 Descriptive statistics

Mean and standard deviation or median and quartile for population, area, population density, number of physicians, physician-population ratio of all provinces/SMAs in both 2008 and 2018 would be shown. Basically, continuous variables and discrete variables can use both of mean (standard deviation) and median (quartile). Which to use (mean (standard deviation) or median (quartile)) depends on the distribution of the variables. To determine whether each variable follows the normal distribution or not, both Shapiro-Wilk test and Kolmogorov–Smirnov test were conducted for each variable. Sample size in Thailand and Japan were 76 provinces and 335 SMAs, respectively. Kolmogorov-Smirnov test is more appropriate in this case because the Shapiro–Wilk test is more appropriate method for small sample sizes (<50 samples) although it can also be handling on larger sample size while Kolmogorov–Smirnov test is used for n ≥50 [195]. If a variable followed the normal distribution, mean/standard deviation would be used to show the descriptive statistics, on the other hand, if a variable was not normal distribution, median/quartile would be used. As mentioned in the study area section, the number of provinces was 76 and the number of SMAs was 335. That was based on the smaller number of provinces/SMAs compared to the number of provinces/SMAs in 2008 and 2018. In addition, to examine the differences between 2008 and 2018, Wilcoxon signed rank test was conducted for each variable.

Then, all provinces/SMAs were divided into 4 groups according to two criteria in 2008: urban/rural, and had a higher/lower initial physician supply as shown in Figure 14. First, the median population density for Thailand in 2008 was determined. Using the median population density as a reference, the 76 provinces were divided into two groups: high and low. Provinces higher than the median were considered urban, and those lower than the median were considered rural. Similarly, the median physician-population ratio was calculated. The median value was used as the basis for dividing the 76 provinces into high and low. Provinces above the median were considered to have a high initial physician supply, and provinces below the median were considered to have a low physician supply. The group with urban and high initial physician supply was group 1, the group with urban and low initial physician supply was group 2, the group with rural and high initial physician supply was group 3, and rural and low initial physician supply was group 4. The 335 SMAs in Japan were also divided into four groups based on the median population density and physician-population ratio in 2008. This dividing method was based on the previous research [19, 196]. For the provinces/SMAs included in each group, descriptive statistics for area, population, population density, number of physicians, physician-population ratio were shown. Mean and standard deviation or median and quartile for area, population, population density, number of physicians, physician-population ratio was shown as well. Which to be described (Mean/standard deviation or median/quartile) was based on the distribution of each variable as mentioned in the previous section (7.1.1). As mentioned in the study area section, the number of provinces is 76 and the number of SMAs was 335. That was based on the smaller number of provinces/SMAs compared to the number of provinces/SMAs in 2008 and 2018. It meant that each of the 76 provinces and 335 SMAs were divided into four groups. Thus, by reviewing how each indicator for each group changed between 2008 and 2018, it was possible to confirm whether the regional maldistribution had been eliminated as more physicians were allocated to areas where there were initially low numbers of physicians.

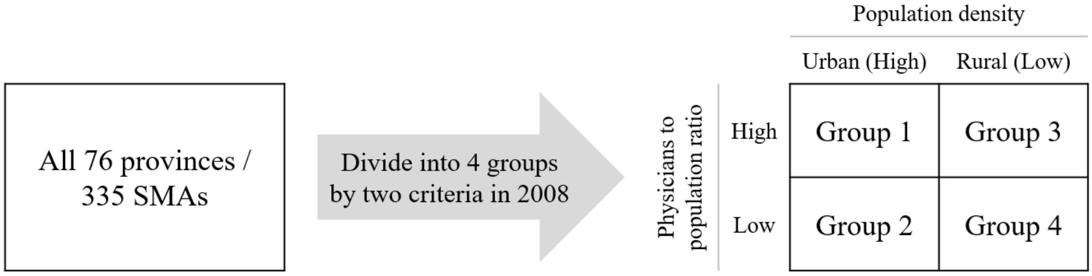


Figure 14. Way of dividing provinces/SMAs into four groups

* High and low indicate higher or lower than the overall median

7.2 Lorenz curve and Gini coefficient

7.2.1 Lorenz curve

Thai and Japanese Lorenz curve and Gini coefficient in both 2008 and 2018 were shown to examine how physicians distribute and how geographical maldistribution was redressed from 2008 to 2018. Lorenz curves and Gini coefficients for both 2008 and 2018 were also calculated based on 76 provinces for Thailand and 335 SMAs for Japan. To show the Lorenz curve as of 2008 for Thailand, the population and number of physicians per province in 2008 were used. First, the number of physicians per province was divided by the population to obtain the physician-population ratio per province, and then the provinces were sorted in ascending order of the physician-population ratio. This sorting method was based on previous studies [18, 21, 23, 134]. Next, the cumulative population percentage and the cumulative number of physicians percentage were obtained. Plotted the cumulative population percentage and cumulative number of physicians percentage on a graph and connected each point with a line to complete the Lorenz curve. At the same time, a line was drawn connecting the origin and the vertex (the point where the cumulative population percentage and cumulative number of physicians percentage were each 1). This represents the perfect distribution. Thus, Lorenz curves for 2008 and 2018 for Japan and Thailand were created.

7.2.2 Gini coefficient

To compute the Gini coefficient, the Lorenz curve is used. First, the area below the Lorenz curve (part B in the Figure 15) was calculated. To calculate the Gini coefficient for Thailand, the Lorenz curve with 76 plotted provinces in Thailand was used. The first point was the origin, the second was the point of the province closest to the origin, and the third was the intersection of the line drawn from the second point to the x-axis and x-axis. The triangle area enclosed by these three points was calculated. Thereafter, four points are used: the first and second points were the second and third points used to calculate the area of the previous triangle; the third point was the point in province of the second nearest the origin; the fourth point was the intersection of the line drawn from the third point to the x-axis with the x-axis. The area of the trapezoidal area enclosed by these four points was calculated. The area below the Lorenz curve was calculated by repeating this process and adding up all the areas. The area between the Lorenz curve and the perfect distribution line (part A in the Figure 15) could be calculated by subtracting the area of part B obtained earlier from 0.5.

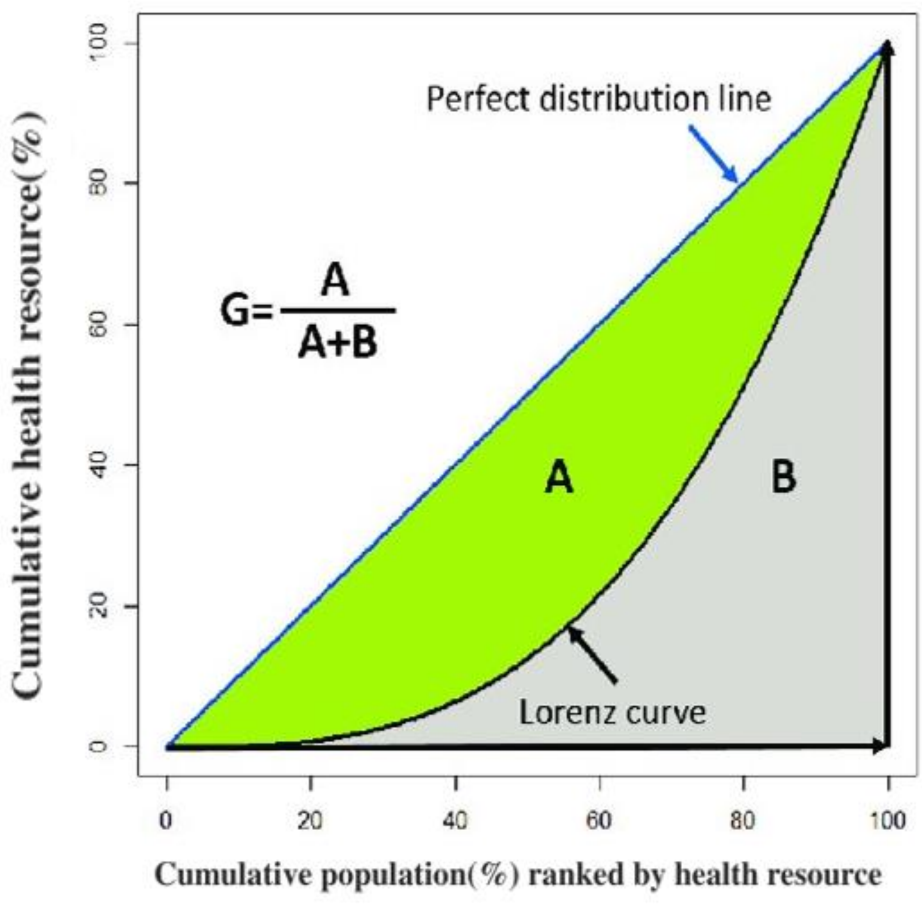


Figure 15. Explanation of the Lorenz curve and the Gini coefficient

The reason why the Gini coefficient was used and other indicators were declined is following. The Atkinson index needs to set a parameter that indicates the weight given to areas with lesser physicians. However, setting the weight may cause a bias, especially in comparison among countries. Thus, the Atkinson index was not appropriate to use. As for the Theil index, one of its characteristics is less intuitive and not directly comparable across populations with different sizes or group structures. The sizes and group structures were different between Thailand and Japan. As such, the Theil index was also not appropriate in this comparative study. On the other hand, the Gini coefficient is comparable even if the size and structure of the population vary among the countries. As a conclusion, the Gini coefficient was considered the most suitable in this study.

7.3 Relation between population density and physician-population ratio

To examine the degree of concentration of physicians in urban areas, a univariate analysis of population density and physician-population ratio was performed. Spearman's correlation coefficient was calculated for both 2008 and 2018 for Thailand and Japan, respectively, and changes over time were checked. Since the distributions of both population density and physician-population ratio were considered skewed rather than following a normal distribution, the correlation coefficient was calculated as Spearman's correlation coefficient. This method was based on a previous study by Matsumoto [21].

8 Software

All analyses was performed using Python 3.7.11 (Python Software Foundation, https://www.python.org/).

9 Ethical Consideration

This study " GEOGRAPHICAL DISTRIBUTION IMPROVEMENT OF PHYSICIANS IN THAILAND AND JAPAN: A COMPARATIVE LONGITUDINAL SECONDARY DATA ANALYSIS." was reviewed and approved by The Research Ethics Review Committee for Research Involving Human Research Participants, Group I, Chulalongkorn University (COA No. 112/65).

In this study, all data was open access secondary data without any individual data, and downloaded from NSO of Thailand and Japan. As such, this research was exempted for ethics review in compliance with the Office for Human Research Protections (OHRP Exempt Categories) 45 CFR part 46.101(b).

CHAPTER 4: RESULTS

1 Demographic Changes in Both Countries

As shown in Table 4 and 5, the population was increasing in Thailand while it in Japan was decreasing. In Thailand, the population grew 1.05 times in the 10 years between 2008 and 2018. On the other hand, Japan's population had decreased by 0.98 times. The number of physicians in Thailand increased 1.73-fold from 21,354 in 2008 to 36,938 in 2018, an increase of 15,584. The number of physicians had increased in both countries, but the number of physicians in Thailand had increased 1.73 times over the past 10 years, whereas the number of physicians in Japan had increased 1.14 times. In Japan, the numbers were 286,699 and 327,210 in 2008 and 2018, respectively, a 1.14-fold increase. The resulting physician-population ratio improved 1.65-fold in Thailand, from 0.34 (2008) to 0.56 (2018). In Japan, the ratios were 2.26 and 2.62 in 2008 and 2018, respectively, a 1.16-fold improvement. While the number of physicians in Thailand has increased significantly, the physician-population ratio in 2018 was still about one-fifth that of Japan.

Table 4. Descriptive statistics of entire Thailand

	Thailand		
	2008	2018	Ratio 2018/2008
Number of Population	63,389,730	66,413,979	1.05
Area (sq.km.)	513,119.54	513,139.54	1.00
Population Density (/sq.km)	123.54	129.43	1.05
Number of Physician	21,354	36,938	1.73
Physician population ratio	0.34	0.56	1.65

Table 5. Descriptive statistics of entire Japan

	Japan		
	2008	2018	Ratio 2018/2008
Number of Population	127,076,183	124,776,364	0.98
Area (sq.km.)	372,077.02	372,953.07	1.00
Population Density (/sq.km)	341.53	334.56	0.98
Number of Physician	286,699	327,210	1.14
Physician population ratio	2.26	2.62	1.16

Next, variables for each province/SMAs were identified. First, the distribution of each variable was reviewed. Both in Thailand and Japan, it was found that all variables in 2008 and 2018 didn't follow the normal distribution as the results of Kolmogorov-Smirnov test and Shapiro-wilk test shown in Table 6 and 7, respectively. Population, area, population density, number of physicians, and physician-population ratio for Thailand were distributed as shown in Figures 16 (2008) and 17 (2018), respectively. In addition, Figure 18 showed variables both in 2008 and 2018 in one graph with blue graph showed variables in 2008 while orange graph represented variables in 2018. In a similar manner, those for Japan were distributed as shown in Figures 19 (2008), 20 (2018), and 21 (both 2018 and 2018) respectively. The dashed line in the figures represented the median of each variable.

Table 6. P-value of Kolmogorov-Smirnov test of each variable

	Thailand		Japan	
	2008	2018	2008	2018
Number of Population	<0.001*	<0.001*	<0.001*	<0.001*
Area (sq.km.)	<0.001*	<0.001*	<0.001*	<0.001*
Population Density (/sq.km)	<0.001*	<0.001*	<0.001*	<0.001*
Number of Physician	<0.001*	<0.001*	<0.001*	<0.001*
Physician population ratio	<0.001*	<0.001*	<0.001*	<0.001*

* Statistically significant at p-value < 0.05

Table 7. P-value of Shapiro-wilk test of each variable

	Thailand		Japan	
	2008	2018	2008	2018
Number of Population	<0.001*	<0.001*	<0.001*	<0.001*
Area (sq.km.)	<0.001*	<0.001*	<0.001*	<0.001*
Population Density (/sq.km)	<0.001*	<0.001*	<0.001*	<0.001*
Number of Physician	<0.001*	<0.001*	<0.001*	<0.001*
Physician population ratio	<0.001*	<0.001*	<0.001*	<0.001*

* Statistically significant at p-value < 0.05

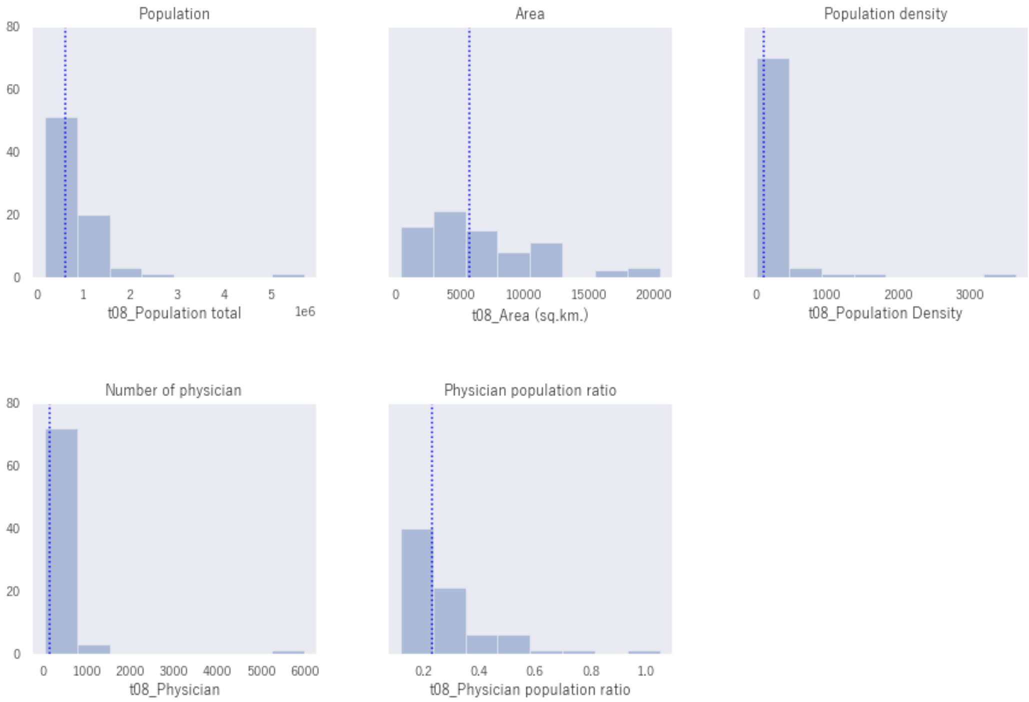


Figure 16. Distribution of each variable of Thailand in 2008

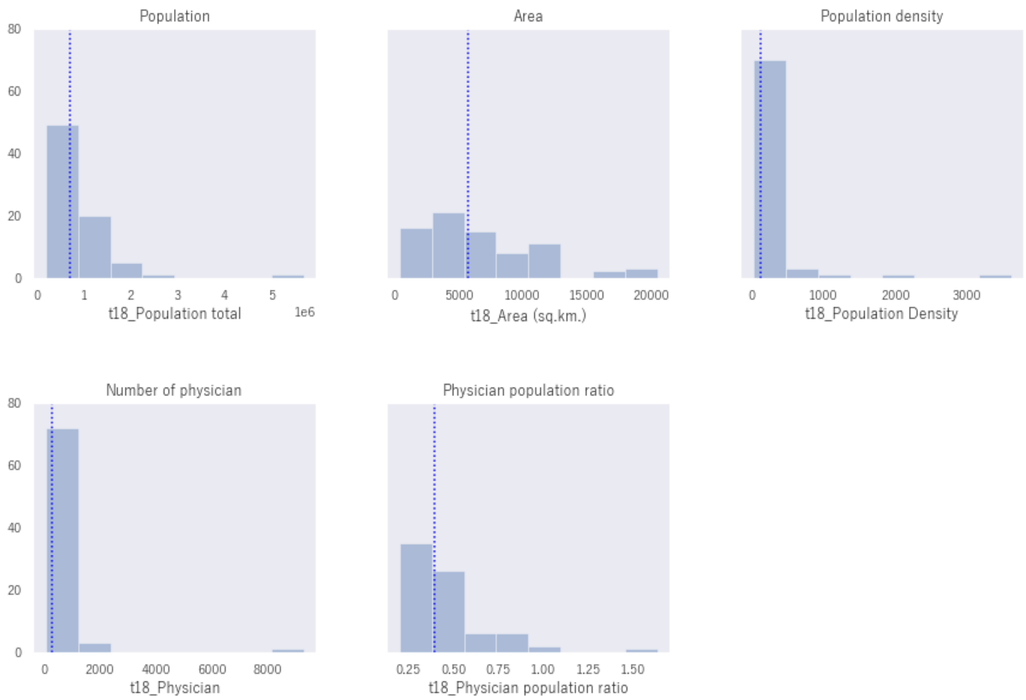


Figure 17. Distribution of each variable of Thailand in 2018

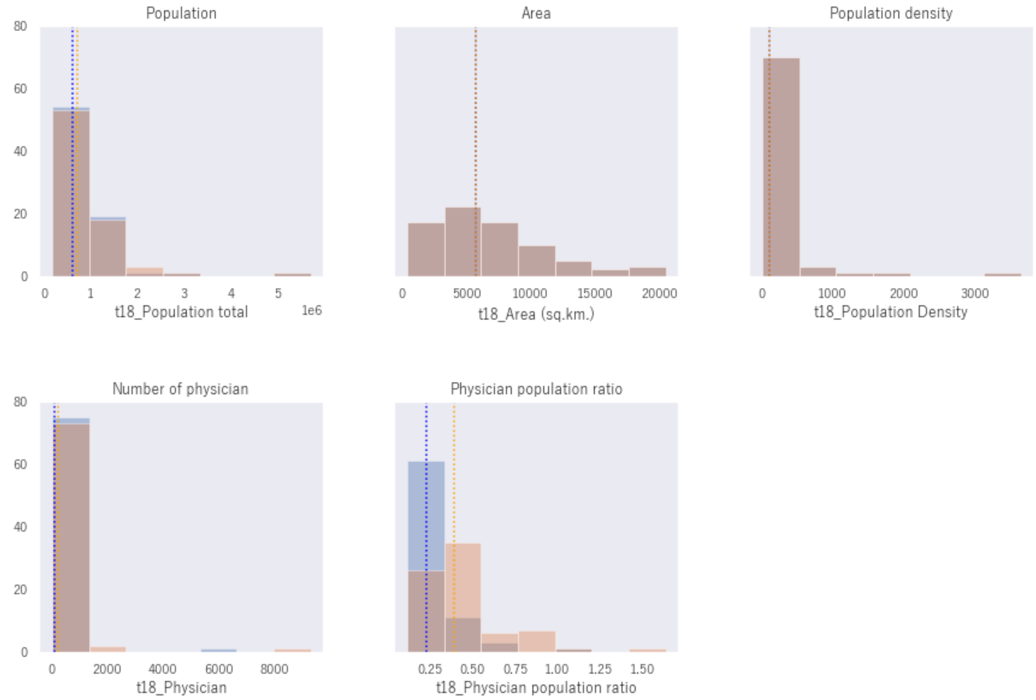


Figure 18. Distribution comparison of each variable of Thailand between 2008 and 2018

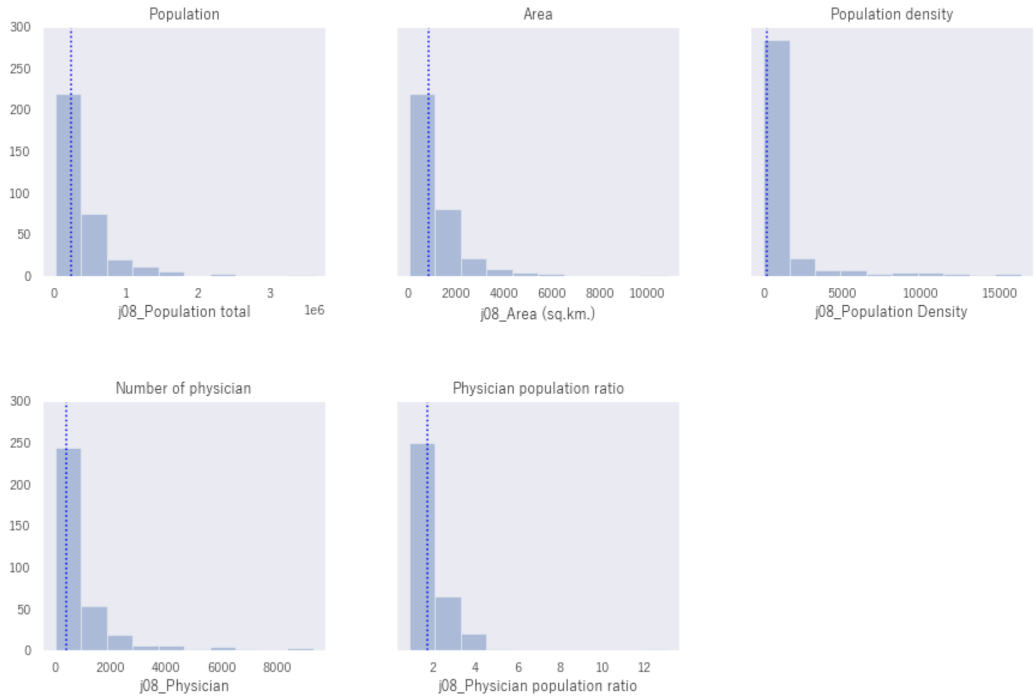


Figure 19. Distribution of each variable of Japan in 2008

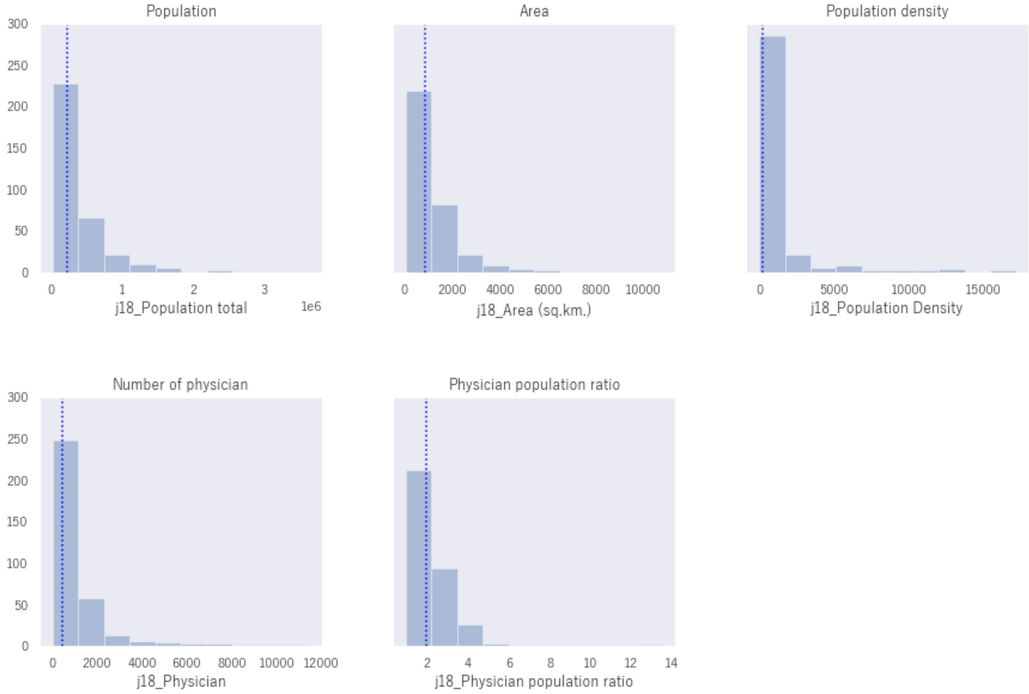


Figure 20. Distribution of each variable of Japan in 2018

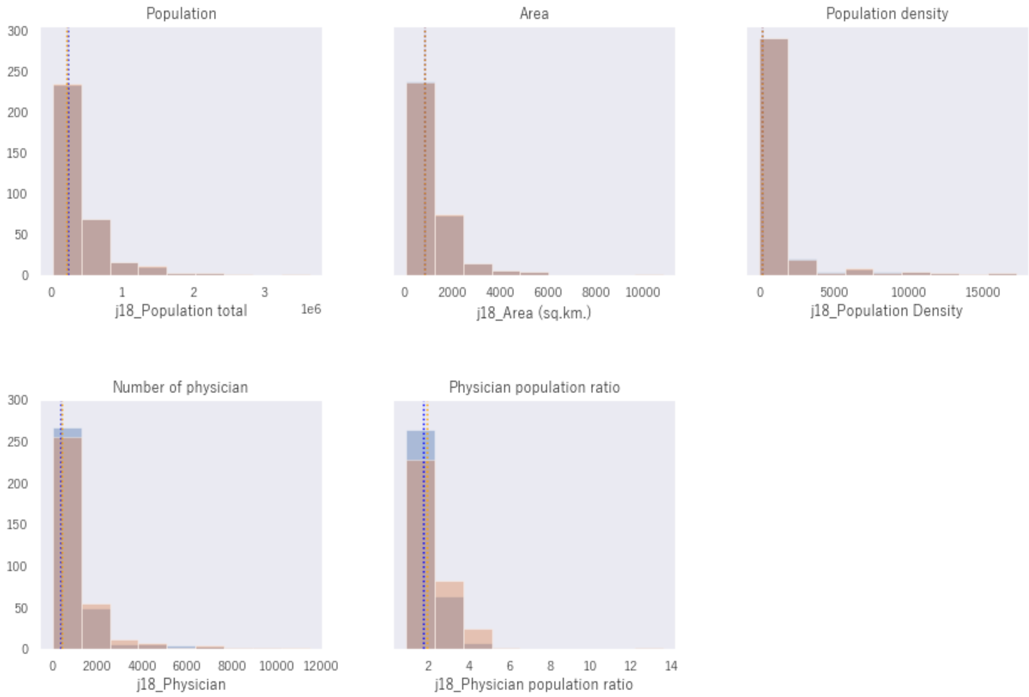


Figure 21. Distribution comparison of each variable of Japan between 2008 and 2018

Table 8. Descriptive statistics of Thai provinces

		Thailand			
		2008	2018	Ratio 2018/2008	P-Value [a]
Number of Population	Mean	834,075	873,868	1.05	<0.001*
	SD	728,155	735,530	1.01	
	Median	631,905	716,543	1.13	
	Q1	464,023	478,046	1.03	
	Q3	1,010,321	1,082,667	1.07	
Area (sq.km.)	Mean	6,751.57	6,751.84	1.00	0.317
	SD	4,670.32	4,670.29	1.00	
	Median	5,760.84	5,760.84	1.00	
	Q1	3,520.12	3,520.12	1.00	
	Q3	9,599.70	9,599.70	1.00	
Population Density (/sq.km.)	Mean	227.75	244.67	1.07	<0.001*
	SD	463.91	485.45	1.05	
	Median	121.94	125.80	1.03	
	Q1	78.68	84.04	1.07	
	Q3	161.75	169.09	1.05	
Number of Physician	Mean	281	486	1.73	<0.001*
	SD	689	1,067	1.55	
	Median	140	273	1.95	
	Q1	95	179	1.87	
	Q3	252	449	1.78	
Physician population ratio	Mean	0.27	0.46	1.67	<0.001*
	SD	0.16	0.23	1.45	
	Median	0.23	0.39	1.71	
	Q1	0.16	0.30	1.81	
	Q3	0.31	0.48	1.57	

* Statistically significant at p-value < 0.05

a. Wilcoxon signed rank test. Comparison between 2008 and 2018.

Table 9. Descriptive statistics of Japanese SMAs

		Japan			
		2008	2018	Ratio 2018/2008	P-Value [a]
Number of Population	Mean	379,332	372,467	0.98	<0.001*
	SD	427,314	439,261	1.03	
	Median	235,406	218,094	0.93	
	Q1	112,132	101,762	0.91	
	Q3	480,542	465,834	0.97	
Area (sq.km.)	Mean	1,110.68	1,113.29	1.00	0.010*
	SD	1,103.01	1,102.85	1.00	
	Median	855.27	855.67	1.00	
	Q1	434.03	434.46	1.00	
	Q3	1,402.09	1,405.51	1.00	
Population Density (/sq.km.)	Mean	1,135.02	1,154.81	1.02	<0.001*
	SD	2,536.58	2,667.36	1.05	
	Median	258.65	243.56	0.94	
	Q1	99.78	91.31	0.92	
	Q3	675.60	676.70	1.00	
Number of Physician	Mean	856	977	1.14	<0.001*
	SD	1,244	1,468	1.18	
	Median	407	435	1.07	
	Q1	186	188	1.01	
	Q3	1,054	1,239	1.18	
Physician population ratio	Mean	1.95	2.24	1.15	<0.001*
	SD	0.92	1.01	1.10	
	Median	1.75	1.98	1.13	
	Q1	1.46	1.70	1.16	
	Q3	2.16	2.46	1.14	

* Statistically significant at p-value < 0.05

a. Wilcoxon signed rank test. Comparison between 2008 and 2018.

Table 10 and 11 showed how the province/SMAs, divided into four groups according to population density and physician-population ratio as of 2008, had changed between 2008 and 2018. Groups 1 and 2 were groups that include provinces/SMAs with population densities above the median in the 2008 data, while groups 3 and 4 were groups that included provinces with population densities below the median. Similarly, Groups 1 and 3 included provinces/SMAs with a physician-population ratio above the median in the 2008 data, while Groups 2 and 4 included provinces/SMAs with a physician-population ratio below the median. Thus, Group 1 was relatively urban and initially had an abundance of physicians. Group 2 was relatively urban and had a low initial physician staffing. Group 3 was relatively rural and had a large initial physician allocation. Group 4 was relatively rural and had a small initial physician allocation.

Table 10. Changes in variables for the four groups of Thailand

	Group	2008 Median (IQR)	2018 Median (IQR)	P-value [a]	Ratio
Number of Population	1	835,861 (606767 - 1099908)	848,720 (644070 - 1286452)	<0.001 *	1.02
	2	906,877 (546698 - 1408486)	946,043 (539052 - 1435434)	<0.001 *	1.04
	3	484,722 (432252 - 805805)	532,326 (425523 - 812812)	0.005 *	1.10
	4	538,330 (394091 - 783559)	564,092 (426180 - 810479)	<0.001 *	1.05
Area (sq.km.)	1	2,556.64 (986.23 - 5056.99)	2,556.64 (986.23 - 5056.99)	1.000	1.00
	2	5,512.67 (4010.38 - 8569.71)	5,512.67 (4010.38 - 8569.71)	1.000	1.00
	3	6,367.62 (4641.72 - 11247.11)	6,367.62 (4641.72 - 11247.11)	1.000	1.00
	4	7,195.14 (5466.83 - 12070.24)	7,195.14 (5466.83 - 12070.24)	0.317	1.00
Population Density (/㎢)	1	289.87 (164.93 - 575.15)	290.01 (174.22 - 706.83)	0.001 *	1.00
	2	147.51 (129.51 - 161.96)	153.32 (131.55 - 169.35)	0.001 *	1.04
	3	80.15 (73.59 - 100.78)	85.03 (74.11 - 106.94)	0.001 *	1.06
	4	77.77 (54.77 - 90.23)	78.51 (57.22 - 95.58)	<0.001 *	1.01
Number of Physician	1	255 (185 - 362)	443 (331 - 809)	<0.001 *	1.74
	2	134 (95 - 198)	264 (159 - 406)	<0.001 *	1.97
	3	144 (114 - 282)	223 (192 - 469)	<0.001 *	1.55
	4	99 (67 - 119)	197 (130 - 244)	<0.001 *	1.99
Physician population ratio	1	0.35 (0.29 - 0.45)	0.57 (0.46 - 0.81)	<0.001 *	1.64
	2	0.16 (0.14 - 0.18)	0.29 (0.27 - 0.36)	<0.001 *	1.82
	3	0.30 (0.26 - 0.34)	0.47 (0.41 - 0.57)	<0.001 *	1.56
	4	0.18 (0.16 - 0.21)	0.31 (0.28 - 0.35)	<0.001 *	1.70

* Statistically significant at p-value < 0.05

a. Wilcoxon signed rank test. Comparison between 2008 and 2018.

Table 11. Changes in variables for the four groups of Japan

	Group	2008 Median (IQR)	2018 Median (IQR)	P-value [a]	Ratio
Number of Population	1	543,379 (306371 - 813566)	517,062 (306245 - 824962)	0.066	0.95
	2	391,870 (249206 - 668884)	381,742 (233341 - 677183)	0.273	0.97
	3	142,225 (97415 - 212101)	129,351 (85998 - 202279)	<0.001 *	0.91
	4	92,103 (64144 - 186681)	80,553 (55473 - 166199)	<0.001 *	0.87
Area (sq.km.)	1	557.23 (276.84 - 929.13)	559.15 (276.94 - 929.95)	0.002 *	1.00
	2	432.64 (254.79 - 671.73)	432.68 (254.75 - 686.51)	0.050	1.00
	3	1,101.99 (767.64 - 1569.21)	1,102.05 (767.64 - 1568.78)	0.972	1.00
	4	1,259.31 (943.44 - 2157.19)	1,293.90 (946.04 - 2157.65)	0.783	1.03
Population Density (/㎢)	1	656.62 (424.33 - 2101.74)	667.06 (414.25 - 2011.61)	0.114	1.02
	2	749.72 (404.73 - 2028.89)	705.04 (377.13 - 2001.43)	0.589	0.94
	3	148.53 (99.04 - 194.54)	132.65 (89.01 - 178.34)	<0.001 *	0.89
	4	82.36 (55.69 - 125.59)	70.36 (48.02 - 112.78)	<0.001 *	0.85
Number of Physician	1	1,362 (760 - 2030)	1,589 (834 - 2311)	<0.001 *	1.17
	2	578 (320 - 928)	633 (360 - 1120)	<0.001 *	1.10
	3	283 (189 - 449)	284 (188 - 505)	0.001 *	1.00
	4	137 (87 - 245)	136 (84 - 265)	0.320	0.99
Physician population ratio	1	2.46 (1.98 - 3.09)	2.82 (2.31 - 3.44)	<0.001 *	1.14
	2	1.49 (1.33 - 1.6)	1.77 (1.55 - 1.88)	<0.001 *	1.19
	3	1.99 (1.88 - 2.18)	2.26 (2.07 - 2.52)	<0.001 *	1.13
	4	1.45 (1.27 - 1.59)	1.65 (1.4 - 1.79)	<0.001 *	1.14

* Statistically significant at p-value < 0.05

a. Wilcoxon signed rank test. Comparison between 2008 and 2018.

2 Lorenz curve and Gini coefficient

The Lorenz curves for Thailand were shown in Figure 22, both for 2008 and for 2018, and Figure 23 showed both 2008 and 2018 plotted on one graph. Lorenz curves for Japan were shown in Figure 24 and Figure 25.

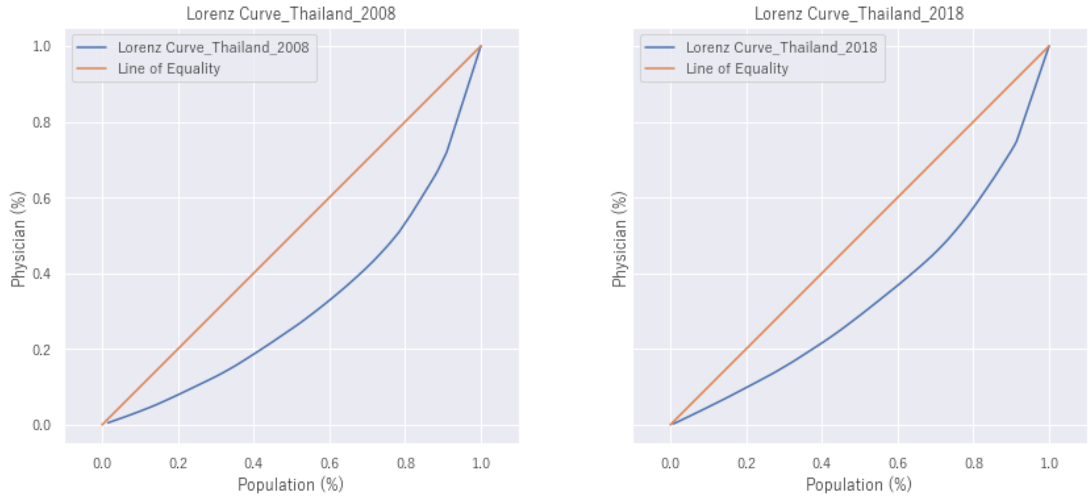


Figure 22. Lorenz curve for Thailand

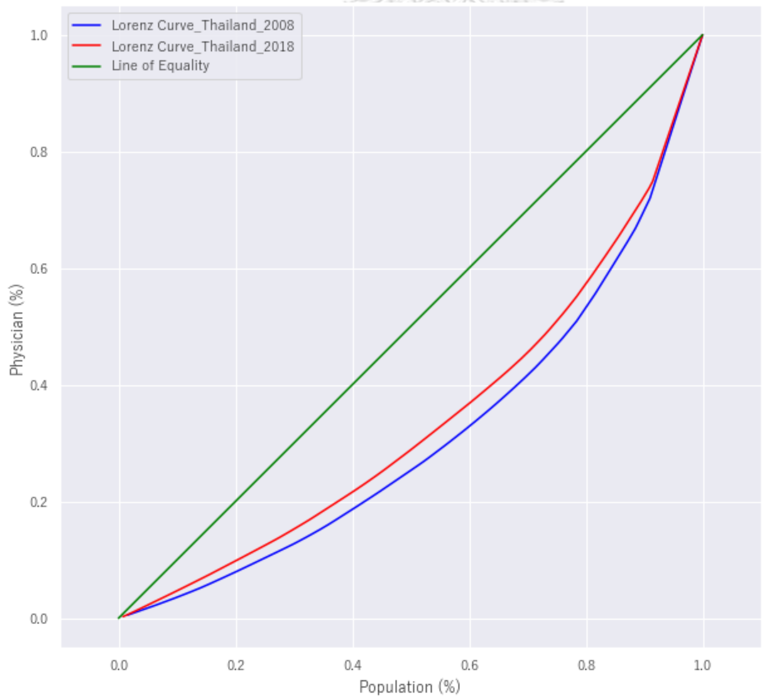


Figure 23. Lorenz curve for Thailand (plotted on one graph)

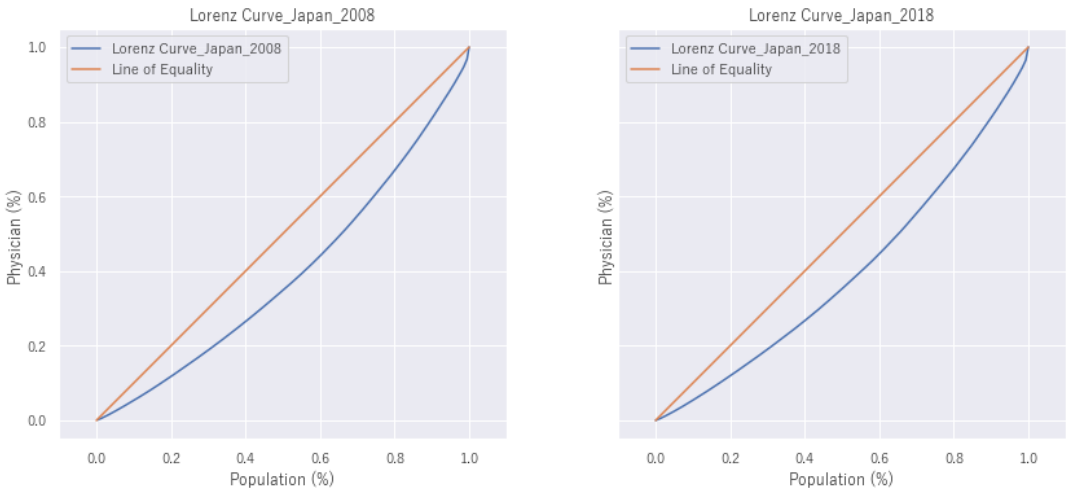


Figure 24. Lorenz curve for Japan

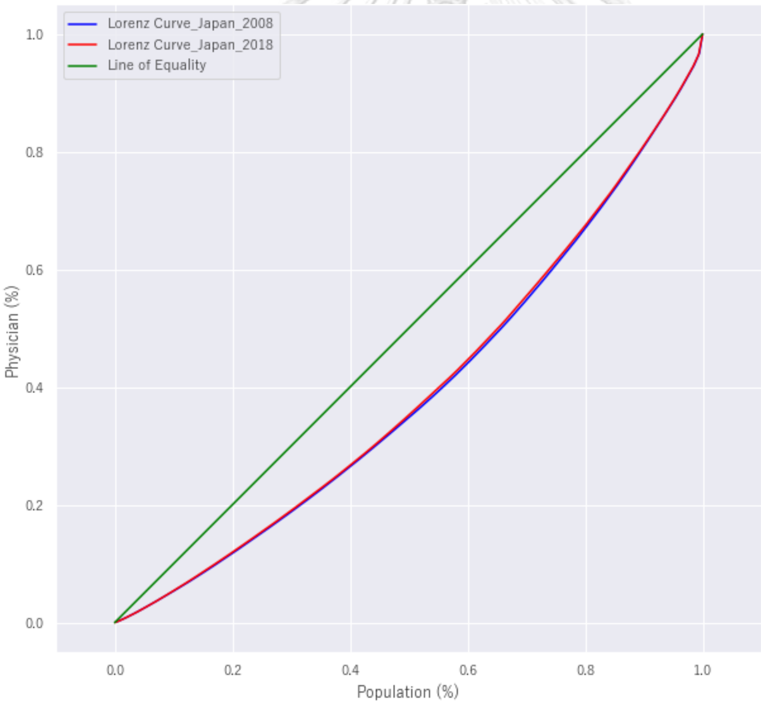


Figure 25. Lorenz curve for Japan (plotted on one graph)

The Gini coefficient was 0.372 in 2008 and 0.319 in 2018 in Thailand, as shown in Table 12. The Gini coefficient for Japan was 0.217 and 0.211 in 2008 and 2018, respectively.

Table 12. Gini coefficient in Thailand

	Thailand		
	2008	2018	Ratio 2018/2008
Gini coefficient	0.372	0.319	0.86

Table 13. Gini coefficient in Japan

	Japan		
	2008	2018	Ratio 2018/2008
Gini coefficient	0.217	0.211	0.97

3 Relation between population density and physician-population ratio

The population density and physician-population ratio for each province were plotted; Figures 26 and 27 showed the plotted figures for Thailand and Japan, respectively.

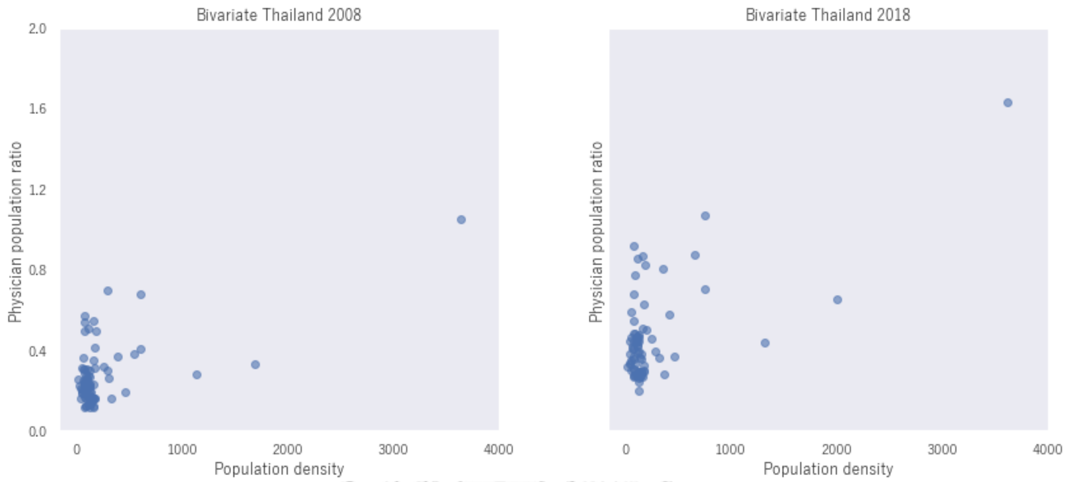


Figure 26. Bivariate plot between population density and physician-population ratio in Thailand

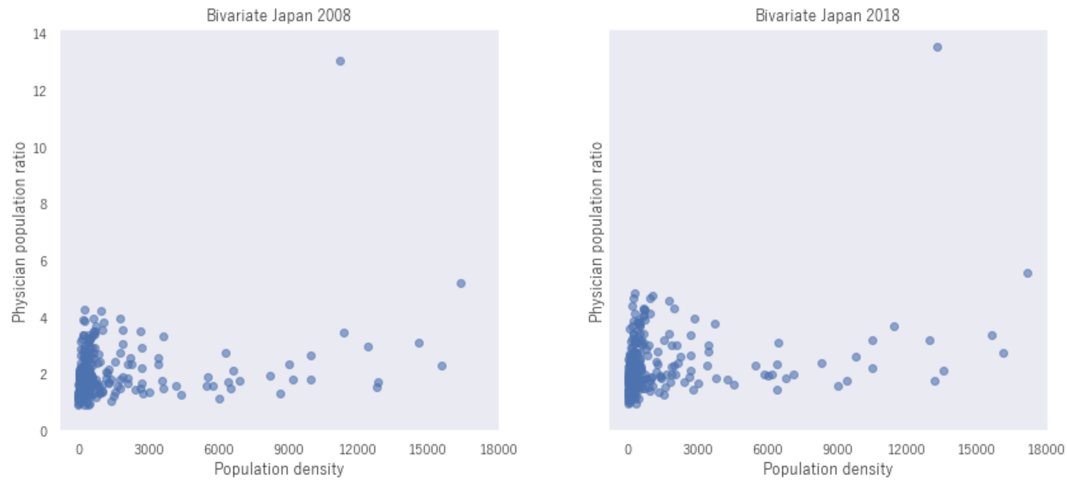


Figure 27. Bivariate plot between population density and physician-population ratio in Japan

In addition, Spearman's correlation coefficients between population density and physician-population ratio were calculated. As shown in Table 14, the correlation coefficients in Thailand were 0.168 and 0.181 in 2008 and 2018, respectively. However, the high p-value was found. The correlation coefficients in Japan were 0.368 and 0.405 in 2008 and 2018 with statistically significant, respectively.

Table 14. Relation between population density and physician-population ratio in Thailand

	Thailand		
	2008	2018	Ratio 2018/2008
Spearman's correlation coefficient	0.168	0.181	1.07
P-value	0.146	0.119	

* Statistically significant at p-value < 0.05

Table 15. Relation between population density and physician-population ratio in Japan

	Japan		
	2008	2018	Ratio 2018/2008
Spearman's correlation coefficient	0.368	0.405	1.10
P-value	<0.001*	<0.001*	

* Statistically significant at p-value < 0.05

4 Related educational policies

In Thailand, there are two types of recruit tracks for medical students: normal tack and special truck. Regarding the special track, there have been two types of special tracks: the Collaborative Project to Increase Rural Doctors (CPIRD, 1995-2004) and One District, One Doctor (ODOD, 2005-2014). The difference between the normal track and the special track is mainly the recruit and education process, and obligation after their graduation. Characteristics of both tracks were followings.

Table 16. Characteristics of physician educational system in Thailand

	Normal Track	**Special Track**	
		CPIRD	**ODOD**
Recruitment	- Eligible all 12th grades students - Examination is offered by individual medical school	- 12th grade willing students who live in rural province areas are eligible - One exam offered jointly	- 12th grade willing students who live in rural district and urban are also eligible - One exam offered jointly
Education	- Regular six years course (1-year basic science, 2 years preclinical, and 3 years clinical)	- The first three years are the same as the normal track - The latter 3 years are in the 34 regional and provincial hospitals affiliated by MoPH	
After Graduate obligation	- 3 years obligation - Choose places flexible depending on the availability of vacant post - Fine: 13,000 USD	- 3 years obligation - assigned to severe underserved places in or near the graduate origin - Fine: 13,000 USD	- 12 years obligation - assigned to severe underserved places in or near the graduate origin - Fine: 65,000 USD

On the other hand, at least one medical school has been established in all 47 prefectures based on the policy "One medical school per prefecture." Japanese educational system has normal track and regional quota. In addition, Jichi Medical University was established in 1972 for single purpose: to train physicians in areas where there is a shortage of medical professionals. Jichi Medical University has unique characteristics. Characteristics of Japanese medical school were following.

Table 17. Characteristics of physician educational system in Japan

	Jichi Medical School	**Other medical school**	
		Normal track	**Regional quota**
Recruitment	- Eligible all students - 2-3 students from each prefecture are selected	- Eligible all students	- Residents and high school students in the prefecture are also eligible - Relatively low minimum score
Education	- Complete basic and clinical medicine studies by the 3rd year - Begin clinical practice in the 4th year	- Basic medicine and clinical medicine (1st – 4th year) - Pre-clinical training (5th – 6th year)	
After Graduate obligation	- 9 years obligation - Become a public official (physician) in own home prefecture and contribute to local healthcare -	- No restriction	- Most universities require 9 years - If leaving the program, the scholarship with interest is returned - Practice in areas designated by the university - Basically, remote islands and remote areas within the prefecture where the university is located

As for the career incentive in rural experience, clinicians typically start at level 4 out of 11 and are promoted to level 7 or 8 (equal to the head of the department at the MOPH central headquarters) after about 10-12 years. Nevertheless, physicians who have worked in rural areas for an extended period of time are promoted to level 9 (the equivalent of a provincial medical chief or deputy director of a central department in the MOPH). In Japan, more than 6 month practice in the designated area allows physicians to be an administrator of certain hospitals. The individual and entity merit is under considering.

Regarding the specialties training, most residency programs in Thailand, such as general surgery, internal medicine, and pediatrics, require a minimum of three years of rural practice experience. In the specialty of preventive medicine, general practice and family medicine, five years experience allow physicians to take specialist exam. In contrary in Japan, the new specialists training system was introduced in 2018. The Japanese Medical Specialists Board set ceiling number of specialists by prefecture for each medical specialty.

Finally, with respect to the financial incentives, for example, rural Thai physicians would receive rural service allowance. It ranges 250 USD (for physicians who work in remote districts) to 500 USD (69 most remote districts) per month. In addition, physicians who do not work privately would receive 400 USD. On the other hand, in Japan, Comprehensive Medical Care Fund is used to eliminate the maldistribution of physicians, but the amount of allowance is not high.

5 Related healthcare policies

5.1 Insurance system

Currently, Thailand has three major insurance systems: Civil Servant Medical Benefit Scheme (CSMBS), Social Security Scheme (SSS), and Universal Healthcare Coverage Scheme (UCS). The following table shows the characteristics of each scheme.

Table 18. Characteristics of Thai insurance system

		Civil Servant Medical Benefit Scheme (CSMBS)	Social Security Scheme (SSS)	Universal Coverage Scheme (UCS)
Financing body		Comptroller General's Department, Ministry of Finance	Social Security Office, Ministry of Labour	National Health Security Office, Ministry of Public Health
Population groups covered		Government employees, public sector workers and Dependents (Covered even after retirement)	Private sector employees	To whom which not covered by CSMBS nor SSS
Choice of provider		Free choice	Contracted hospital or referral line, registration required	Contracted hospital or referral line, registration required (notably district health system)
Funding		General tax	One-third each from the employee, employer and government	General tax and co-payment
Copayment		inpatient at private hospital only	Maternity, emergency services	30-baht/visit
Payment to health facilities	Outpatient	Fee for service		Capitation
	inpatient	Diagnosis-Related Grouping (DRG) based payments		
Number of insured(2016)		4.4 Mil	10.6 Mil	48.0 Mil
Expenditure (2016)		71.0 Bil THB	37.7 Bil THB	109.3 Bil THB

In Japan, government-led social security policies brought about the achievement of universal health coverage in 1961. The features of Japanese universal health insurance are: (1) all persons, regardless of whether they are Japanese or foreign nationals, who are permitted to stay in Japan for more than three months are obliged to join the public medical insurance system, and (2) which public medical insurance system they join is determined by their occupation, age, and area of residence, and they are not free to choose any one of them. (3) Regardless of which healthcare insurance system a citizen belongs to, "free access" which allows the citizen to freely choose the healthcare provider and frequency of visits at his/her own discretion is guaranteed. There are more than 3,000 insurers in Japan, which can be categorized mainly into three: (A) vocational insurance, (B) National Health Insurance (community insurance), and

(C) the latter-stage elderly healthcare system (for people aged 75 and older). In principle, the benefits and co-payment ratio are the same regardless of which public medical insurance plan an individual enrolls in. The co-payment ratio is determined according to age and income. The co-payment ratio ranges from 10-30%. The following table shows the characteristics of each scheme.

Table 19. Characteristics of Japanese insurance system

	Vocational insurance			National health insurance	Latter-stage elderly healthcare system
Financing body (Numbers as of 2015.3)	Health insurance association (HIA) (1,409)	Mutual aid associations (85)	Kyokai Kenpo (1)	Prefectures (47)	
Population groups covered	Employees and dependents for large companies	Civil servants	Employees of small and medium-sized enterprises	Self-employed, unemployed, retired persons under 75 yrs.	Aged 75 and older
Choice of provider	Free choice				
Funding	Premiums from the company and the employee (Rates depend on the association, but are generally split 50-50)		Premiums from the company and the employee, support subsidies from public fund and HIA	Premiums from enrollees, and public funds.	50% public funds, 40% support subsidies from other insurance systems, 10% premiums
Copayment	Under 70 yrs.: 30%, Children under 6 yrs and aged 70 to 74 yrs: 20%				10%
	If the co-payment amount is still too high and exceeds a certain monthly limit, a high-cost medical care benefit system is available				
Payment to health facilities: Outpatient	Fee for service				
Payment to health facilities: inpatient	Depends on hospital and bed (No difference among insurance systems)				
Number of insured(2015.3)	29.13 Mil	8.84 Mil	36.39 Mil	33.03 Mil	15.77 Mil
Expenditure (2014)	4,340 Bil JPY	1,344 Bil JPY	6,077 Bil JPY	10,999 Bil JPY	14,698 Bil JPY

5.2 Payment system

The major payment methods adopted in Thailand include FFS based on cost, per capita method, and DRG payment. Which payment methods are applicable depends on the insurance systems that individuals are in and whether patient is hospitalized or outpatient as shown in the previous section in this chapter.

As for Japan, healthcare expenditures for visits to healthcare providers are based on the medical service reimbursement system determined by the Minister of Health, Labor and Welfare based on discussions at the Chuikyo (Central Council of Medical Examiners) and is revised every two years. Medical service reimbursement is the compensation received by healthcare providers and pharmacies for medical services and medicines covered by public insurance. FFS system is basically adopted in the outpatient setting. Medical fees are calculated based on the amount of defined medical treatment performed. In the case of hospitalization, as described below, some acute care hospitals or hospital beds have adopted DPC, and when a patient is hospitalized in a hospital or hospital bed that is not subject to DPC, FFS payment system is adopted. When hospitalized not in DPC hospitals or hospital beds, reimbursement differs depending on the function of the hospital or hospital beds. Basically, if a high level of outcome is achieved through the provision of extensive medical care by a large number of medical personnel, a higher score can be calculated.

5.3 Delivery system

There are three levels of medical care: health centers under the jurisdiction of the district health center provide PHC services; district hospitals under the jurisdiction of the PHO are responsible for PHC and secondary care (all district hospitals have the clinical capacity to have inpatient services and have 10 to 120 beds); tertiary care is provided by the regional/general hospitals depending on their size and capacity medical care and other specialized care. There are both public and private medical facilities in Thailand. There are several kinds of operators as shown in the following figure.

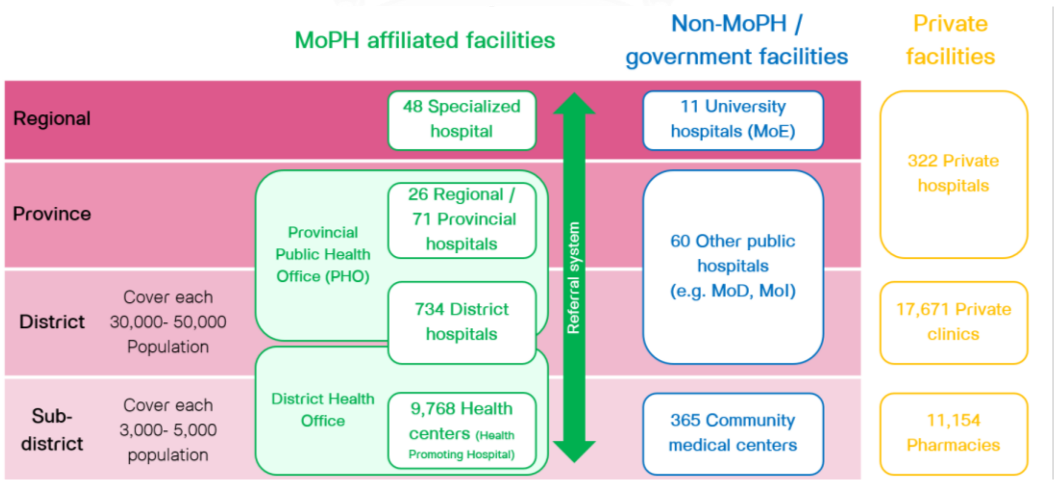


Figure 28. Delivery system in Thailand (as of 2015)

Medical facilities in Japan can be divided into general clinics (with or without beds), dental clinics, and hospitals, most of which are clinics. As of 2019, there were 8,300 hospitals, 6,644 bedded clinics, 95,972 non-bedded clinics. Hospitals and clinics can be broadly classified into the following categories: national, public medical institutions, social insurance-related organizations, corporations, and individuals. In Japan, the medical care delivery system is mainly private, and while most clinics used to be private. The following table shows the distribution of Japanese healthcare providers by operator types.

Table 20. Distribution of Japanese healthcare providers by operator types

Establishing Organization		Hospital		Clinic	
		Number	Percentage	Number	Percentage
Overall		**8,300**	**100.0%**	**102,616**	**100.0%**
Public bodies	National government	322	3.9%	537	0.5%
	Public organizations	1,202	14.5%	3,522	3.4%
	Social insurance bodies	51	0.6%	450	0.4%
Private bodies	Medical corporations	5,720	68.9%	43,593	42.5%
	Individuals	174	2.1%	41,073	40.0%
Others		831	10.0%	13,441	13.1%

CHAPTER 5: DISCUSSION, CONCLUSION, AND RECOMMENDATIONS

1 Interpretation of the results

This study used open secondary data from Thailand and Japan to examine the number of physicians and the physician-population ratio in each province in Thailand and in each SMAs in Japan. In addition, the Gini coefficient, which indicates physician maldistribution in the country as a whole, and the correlation between population density, which indicates physician preference, and the number of physicians per population were examined.

First, the number of physicians and physician-population ratio in Thailand was increased more than that in Japan from 2008 to 2018. Although the improvement in Thailand was larger than Japan, physician-population ratio in Thailand had not reached the WHO-recommended 1 in 1,000 standard yet. In addition, it was still about one-fifth of Japan's physician-population ratio. Even though the number of physicians in Japan was higher than in Thailand, the number of physicians in Japan was not enough. Among 38 OECD countries, physician-population ratio of Japan was ranked eleven counting from the last as of 2019 [197]. In Thailand, the number of physicians in Groups 2 and 4, i.e., areas with relatively few physicians in 2008, had approximately doubled, while Groups 1 and 3, which had a relatively abundant supply of physicians in 2008, had approximately 1.55-1.74 times as many. This means that Thailand had been able to focus on allocating physicians to areas where there were few physicians over the past 10 years. On the other hand, in Japan, the number of physicians in urban Groups 1 and 2 increased 1.17 and 1.10 times, respectively, while those in Groups 3 and 4 increased only 1.00 and 0.99 times, respectively, suggesting that physicians were concentrated in urban areas rather than in the high and low number of physicians as of 2008. If Newhouse's trickle-down theory existed in Japan, an increase in the number of physicians encouraged physicians to move from saturated urban markets into rural areas where jobs and profits were more easily obtain [22]. However, as Kobayashi, Matsumoto, and Inoue had pointed out [20, 21, 23], the trickledown advocated by Newhouse had not been found in Japan [22].

The change in the Gini coefficient, which represented physician maldistribution, had improved significantly in Thailand from 0.372 in 2008 to 0.319 in 2018, while in Japan there had been little improvement, 0.217 and 0.211 in 2008 and 2018, respectively. While previous studies had noted the inequitable distribution of physicians in Japan and had reported little improvement over the years [18-21, 23, 134], this comparative study describes that the distribution of physicians in Japan was found to be significantly more equitable than in Thailand. There have been very few studies using the Gini coefficient regarding the regional distribution of physicians in Thailand, but the Gini coefficient remained high and the regional distribution was significant, which was consistent with previous studies [17]. Although one previous study had shown that the distribution of physicians in Thailand was generally equitable [91], the study didn't include physicians working in Bangkok or private sector. On the other hand, this study used physician registry database, which showed that registered physicians, including those in Bangkok and private hospitals, were unevenly distributed.

The correlation coefficients can describe the change in the number of physicians and the Gini coefficient from 2008 to 2018 in both countries. In Thailand, there was no correlation between population density and the physician-population ratio, and no statistical significance was found. In other words, the degree to which physicians in Thailand were concentrated in populated urban areas was small, but the large Gini coefficient suggested that they were unevenly distributed by factors other than whether or not they were in urban areas. In Japan, on the other hand, the correlation coefficient was high with statistical significance. This means that the physician-population ratio was higher in urban areas. Furthermore, this trend had become stronger between 2008 and 2018. Thus, the Gini coefficient had improved in Japan despite the greater allocation of physicians to central city areas, a seeming contradiction. This may be interpreted as an improvement in the Gini coefficient, perhaps because the decline in the rural population was more significant and thus the number of physicians per population in the rural areas appeared to improve. Suppose it is true that physicians who have worked in urban areas are not likely to migrate to rural areas, as Inoue pointed out [20]. In that case, it can be inferred that the geographical maldistribution of physicians in Japan is not expected to extinguish in the future unless effective countermeasures are put in place because there are a lot of physicians in urban areas now.

In the 10-year period from 2008 to 2018, the improvement in the regional maldistribution of physicians in Japan was considerably smaller than in Thailand. However, a hypothesis can be made that this was the result of improvements already made in Japan. Research on the regional maldistribution of physicians in Japan had been widely conducted since Kobayashi's study in the 1990s. Although the subject of the study was slightly different, the Gini coefficient as of 1990 was 0.340 [23], which was close to the current Gini coefficient in Thailand. In Japan, more than one medical school was established in each prefecture in the 1970s, suggesting that the regional maldistribution of physicians might had been considerably eliminated by the time of Kobayashi's study. Based on this hypothesis, it is suggested that establishing medical schools in a wide geographical area might contribute significantly to improving the regional maldistribution of physicians.

2 Comparison and effects of each health system on the physician distribution

Healthcare systems that are thought to influence the regional maldistribution of physicians was compared. The first was the insurance system. In general, the higher the number of people with private insurance, the higher the density of physicians is likely to be [198]. It had been shown in the US. that physicians were more concentrated in wealthier areas [199]. In Thailand, CSMBS coverage is more extensive, while in Japan, there is little difference in benefits depending on the type of insurance one has. Therefore, it is assumed that the type of insurance had relatively less effect on the regional selection of physicians in Japan, and the insurance system in Thailand was more likely to accelerate the regional maldistribution of physicians. Studies in Taiwan had also shown that universal health insurance equalizes the regional maldistribution of medical personnel [200]. Both countries have universal health insurance, but Thailand's universal health insurance was established relatively recently, in 2002. If the trend toward equalization had accelerated since then, it was possible that the physician maldistribution had been corrected during the 10 years of this study.

Matsumoto and other researchers proposed that in a healthcare system where physicians can choose where to practice without regulation and where the majority of healthcare providers are privately owned, the concentration gap between surplus and shortage areas decrease as the physician-population ratio increase [21, 22, 201]. While in Japan, the choice of location for medical treatment is generally free, in Thailand, graduates are required to serve medical treatment in a designated area for a certain period of time. Furthermore, the majority of healthcare providers in Japan are private, whereas in Thailand, most are public. This suggests that the maldistribution of physicians in Japan was relatively easier to eliminate by increasing the number of physicians.

A capitation payment system has the potential to address equity issues in the distribution of healthcare human resources by providing incentives for health facility managers to maintain optimal staffing levels to reduce costs and thereby redistribute "excess" personnel to underserved areas [202, 203]. This suggests that in Thailand, where the capitation system was applied to outpatients of the UCS, an incentive was in place for the regional maldistribution of physicians to be easily eliminated. In Japan, the capitation system has not been introduced, and this incentive was not likely to work.

3 Comparison and effects of education and training system on the physician distribution

As discussed earlier, there were differences in health insurance, healthcare delivery systems, and payment methods that may have a variety of impacts on the regional maldistribution of physicians. While these can affect the regional maldistribution of physicians, they were not designed with the goal of eliminating regional maldistribution. Those that likely directly affect the regional maldistribution are systems of medical schools’ recruitment, education, and post-graduation training.

As Matsumoto and other researchers had shown, physicians preferred urban living and tended to pursue highly specialized clinical fields that required the resources of urban hospitals [21, 53, 204-206]. Therefore, although policies to increase the number of physicians alone would result in rapid growth in urban areas, they would not correct the existing maldistribution, so interventions such as special education and scholarship programs, as well as increasing the number of physicians, had been shown to be effective [52, 53, 207-209]. In Japan, medical school graduates in general are not required to do clinical practice in designated areas. Students through the regional quota system are often required to practice in remote areas during their clinical training from the fourth year, and are obliged to practice clinically in designated areas for approximately nine years after graduation. In Japan, the place of work after graduation from medical school is based on a matching system, and physicians can choose any region, whether they are hired or not. The fact that regional maldistribution had not been eliminated in the past decade suggests that these policies had not been effective in eliminating physician maldistribution, or that there were adverse forces working to offset this effect. On the other hand, all physicians in Thailand are required to work in rural areas for three years after graduation, and failure to do so means the payment of a fine. This is a direct policy to eliminate the regional maldistribution of physicians, and it is suggested that it was working effectively. In addition, the special programs, CPIRD and ODOD programs, add three years during school and nine years after graduation, respectively, to the three years of mandatory rural service after graduation in the normal track. In return for these obligations, students are motivated by the accessibility of medical school and scholarships, and students who participate in these programs contributed to the elimination of regional segregation through further regional service.

The regional quota in Japan can be considered the equivalent of the special track in Thailand. In Japan, the obligation is about 9 years, whereas in Thailand, the obligation of CPIRD and ODOD is 3 and 12 years, respectively, but the conditions for recruiting and scholarships are similar. The major difference in education system is whether all physicians are required to work in rural areas or not. In Thailand, the 3-

year obligation is also imposed on all graduates in the normal track, while in Japan this kind of obligation do not exist.

In addition, the economic incentives for working in physician shortage areas in Thailand and Japan were very different. In Thailand, physicians working in the rural areas received an allowance of 250 USD to 500 USD per month, depending on the region, and 400 USD if they worked only in public services [29]. As such, rural physicians earned 10-15% more per month than new physicians in non-private urban hospitals in 2008 [86]. In Japan, on the other hand, there was no standardized, high-value allowance like in Thailand; the amount varied from prefecture to prefecture and was relatively small.

4 Answers to research questions

Research questions for this study can be answered as follows. As for the first research question, *"How has the number of physicians in each Thailand and Japan changed over the past 10 years? "*, the answer is that the number of physicians in Thai had increased by 15,584, from 21,354 as of 2008 to 36,938 as of 2018, and the incremental ratio was 1.73 times. Thai population had increased from 63,389,730 in 2008 to 66,413,979 in 2018, a 1.05-fold increase. As a result, the physician-population ratio in Thailand had improved from 0.34 in 2008 to 0.56 in 2018, a 1.65-fold improvement. On the other hand, The number of physicians had been increased from 286,699 to 327,210 in 2008 and 2018, respectively, the number in 2018 was 1.14 times of that in 2008. In contrast, the Japanese population had declined from 127,076,183 to 124,77,364 during the same period, the decline ratio was 0.98. Consequently, the physician-population ratio had improved from 2.26 in 2008 to 2.62 in 2018, a 1.16-fold improvement was found.

The second research question, *"How has the geographical distribution of physicians changed over the past 10 years in each Thailand and Japan? "* In Thailand, the Gini coefficient had been improved from 0.372 in 2008 to 0.319 in 2018. In contrast the Japanese Gini coefficient in 2008 was 0.217 while the one in 2018 was 0.211. Geographical maldistribution of physicians in Thailand improved more than that in Japan, comparing 2008 and 2018. It is because the Gini coefficient that shows the geographical maldistribution improved in Thailand, while that in Japan improved very little. Thailand could successfully distribute physicians to areas with a low physician-population ratio rather than rural or urban during this decade even though there was still a big maldistribution of physicians. The physician maldistribution in Thailand was not a concentration in populated urban areas. However, Japan relatively couldn't distribute physicians to shortage areas. Moreover, the trend that physicians prefer populated urban areas to rural areas had been strengthening. Despite the fact that the distribution of physicians to rural areas was insufficient compared to urban areas, the decrease in the population in rural areas led to the improvement of the physician-population ratio in rural areas.

As for the third question, *"What are the related systems and policies that may have affected the geographical distribution of physicians in each Thailand and Japan?"* The answer is physician education system, especially mandatory rural services for all medical school graduates may be effective to improve the geographical distribution of physicians in Thailand. On the other hand, in Japan, because the degree of maldistribution had been low since the past, background systems may prevent the geographic maldistribution of physicians from occurring.

Finally, as for the last question, *"What are the differences and similarities between Thailand and Japan in the geographical distribution of physicians and related systems and policies? "* Mandatory service system in Thailand is one of the most significant differences among two countries. All graduates of medical schools must contribute to rural services for three years while there is no mandatory service for all graduates of medical schools in Japan. In addition, differences in financial incentives among two countries were also remarkable. There were more variety and amount in Thai financial incentives than ones in Japan. Moreover, there were some differences in insurance system, payment system, and delivery system that may affect physician distribution as discussed in section 2 and 3 of chapter 5.

5 Limitation

There were some limitations in this study. This study used data from an aggregated regional registry of physicians. However, it was possible that there were several physicians who did not participate in the census, and this might cause sampling bias. Furthermore, the data covered all registered physicians and did not distinguish between clinical and non-clinical physicians. In the Japanese census data, the number of clinical physicians could be identified, but in the Thai data, it was currently difficult to determine the number of clinical physicians only. This might overestimate the number of physicians in both countries. In particular, because of the high ratio of non-clinicians in Thailand [93], the number of physicians or physician-population ratio might be assessed as relatively low. One possible way to conduct an analysis targeting the number of clinicians in Thailand would be to assume the number of clinicians by multiplying a certain percentage by the total number of physicians, based on previous studies [93].

A further limitation of this study is that it did not take into account the specialty of the physician. The ideal distribution should be evaluated within each specialty of the physician. This is because each specialty has its own distribution pattern. Research on specific medical departments is needed in subsequent years.

Population adjustment is another limitation. Although it is usually known that people need more medical care as they get older [210-214], this study did not take this into account and was based on the assumption that all ages needed medical care equally. This might underestimate the demand for medical care, especially in Japan, where the population is aging rapidly. To overcome this limitation, it is possible to calculate, for example, the physician-population ratio and Gini coefficient based on the adjusted population calculated using age- and gender-specific medical care utilization rates [19, 215].

Another limitation is that differences in geographic units between the two countries might complicate the interpretation of the results of this study. In Thailand, the analysis was based on the province as the targeted unit, while in Japan, the analysis was based on the SMA. The median population of province in Thailand in 2008 was 631,905 (interquartile range [IQR]: 464,023-1,010,321), while the median population of SMA in Japan was 235,406 (IQR: 112,132-480,542). The median land area was 5760.84 (IQR: 3520.12-9599.70) square kilometers for the Thai province and 855.27 (IQR: 434.03-1402.09) square kilometers for the Japanese SMA. Thus, the smaller the area, the easier it is for rural Japanese residents to cross the border and access physicians in other areas. Therefore, in a simple comparison of the inequity of physician distribution relative to population (Gini coefficient) between Japan and Thailand, it could be considered more equitable for Japan as a country as a whole, but when considering access to healthcare for rural residents, access to healthcare for rural residents in Thailand was considered more severe.

6 Conclusion and recommendation

In spite of constant growth of physician numbers, physicians did not diffuse according to population distribution in both countries. Rather, Japanese physicians seemed to diffuse according to population distribution. In order to reverse the continuing maldistribution of physicians, political intervention is required in both countries.

Thailand had greatly improved the regional maldistribution of physicians, which might be contributed to by requiring graduating physicians to work in rural areas and by special track systems such as CPIRD and ODOD. However, the low physician-population ratio was still considered problematic. Policies to increase the number of physicians, such as the establishment of more medical schools and an increase in enrollment, may be necessary. Furthermore, although there were 23 medical schools in Thailand, some provinces did not have medical schools [25]. Since the number of physicians in provinces without medical schools is extremely low, there is an urgent need to establish medical schools or clinical sites, especially in these areas. It may also be useful to establish and calculate the physicians distribution indicators across the country, as is currently developed in Japan. In Thailand, where the average age and life expectancy are expanding and the population is aging, healthcare needs is expected to change significantly in the future. To measure the degree of physician maldistribution taking into account healthcare needs by age and gender, as well as physicians' specialty and age may be useful. Although this measurement has been just started in Japan, efforts to grasp healthcare demand and supply that is different from the past will be required in the future as the population ages.

On the other hand, Japan had more physicians than Thailand, but the problem was that the regional maldistribution of physicians had hardly been resolved. Strong policies such as those implemented in Thailand may be effective, for example, requiring all graduates to work in the countryside or requiring work in the countryside as a prerequisite for opening a practice. In addition, another option would be to make rural work experience a requirement for the training of medical specialists, especially in PHC, as is put in place in Thailand. In Japan, since the medical specialists are certified not by the government but by the Japanese Medical Specialty Board, detailed reconciliation to solve conflicts would be required with some related party. Moreover, it would be helpful to let medical students experience rural practices during their clinical training. As many researchers mentioned, encouraging medical students and young physicians to be experts in PHC by letting them experience rural practice is supposed to be effective [20, 131, 132, 208, 216, 217]. Financial incentives should be considered with countermeasures having mandatory obligations. In Japan, financial incentives for rural physicians are not expensive and there are only a few merits. Expanding financial and other incentives paralleling compulsory service may contribute to improving the geographical maldistribution of physicians and satisfy physicians more.

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APPENDIX 1 – SCHEDULE OF ACTIVITIES

Process	Time schedule									
	2021			2022						
	10	11	12	1	2	3	4	5	6	7
Literature reviews										
Proposal development										
Ethical committee consideration										
Data collection										
Data analysis										
Conclusion										
Report writing										

APPENDIX 2 – ETHICAL APPROVAL

The Research Ethics Review Committee for Reseach Involving Human Research Participants, Group I, Chulalongkorn University
Chamchuri 1 Building, 2nd Floor, 254 Phayathai Road, Pathumwan, Bangkok 10330 Thailand
Telephone: 02-218-3202, 02-218-3049 Email: eccu@chula.ac.th

COA No. 112/65

Certificate of Approval

Examption for Ethics Review

Study Title No. 650062	:	GEOGRAPHICAL DISTRIBUTION IMPROVEMENT OF PHYSICIANS IN THAILAND AND JAPAN: A COMPARATIVE LONGITUDINAL SECONDARY DATA ANALYSIS.
Principal Investigator	:	Mr. Hiromichi Takahashi
Place of Proposed Study/Institution	:	College of Public Health Sciences, Chulalongkorn University

This Research proposal is exempted for ethics review in compliance with the Office for Human Research Protections (OHRP Exempt Categories) 45 CFR part 46.101(b).

Certified under condition: To conduct this research project, the researcher (s) must strictly adhere to research proposal approved by the committee. If there is any amendment, it must be sent to the committee for review before carrying on the project.

Signature Prida Tasanapradit	Signature Raveenan Mingpakanee
(Associate Prof. Prida Tasanapradit)	(Assistant Prof. Dr. Raveenan Mingpakanee)
Chairman	Secretary

Date of Approval : 26 May 2022

Remarks

Final report (AF 01-15) and abstract is required for a one year (or less) research/project and report within 30 days after the completion of the research/project.

Digital Certificate

Study Title No. 650062
Date of Approval 26 May 2022
Approval Expire date 25 May 2023

APPENDIX 3 – CORRESPONDENCE TABLE OF THE GROUPS TO WHICH EACH PROVINCE BELONGS

No	Area	Province	PPR	Group [2]	
			2018 [1]	2018	(2008)
1	Bangkok	Bangkok	1.634	1	1
2	Central Region	Samut Prakan	0.439	1	1
3	Central Region	Nonthaburi	0.652	1	1
4	Central Region	Pathum Thani	0.702	1	1
5	Central Region	Phra Nakhon Si Ayutthaya	0.362	2	1
6	Central Region	Ang Thong	0.392	2	1
7	Central Region	Lop Buri	0.423	3	3
8	Central Region	Sing Buri	0.459	1	1
9	Central Region	Chai Nat	0.393	1	2
10	Central Region	Saraburi	0.629	1	1
11	Central Region	Chon Buri	0.804	1	1
12	Central Region	Rayong	0.503	1	1
13	Central Region	Chanthaburi	0.677	3	3
14	Central Region	Trat	0.483	3	3
15	Central Region	Chachoengsao	0.477	1	1
16	Central Region	Prachin Buri	0.466	3	3
17	Central Region	Nakhon Nayok	0.857	3	3
18	Central Region	Sa Kaeo	0.303	4	4
19	Central Region	Ratchaburi	0.507	1	1
20	Central Region	Kanchanaburi	0.331	4	4
21	Central Region	Suphan Buri	0.378	2	1
22	Central Region	Nakhon Pathom	0.575	1	1
23	Central Region	Samut Sakhon	0.874	1	1
24	Central Region	Samut Songkhram	0.366	2	2
25	Central Region	Phetchaburi	0.353	4	4
26	Central Region	Prachuap Khiri Khan	0.406	3	3
27	Northern Region	Chiang Mai	0.772	3	3
28	Northern Region	Lamphun	0.483	3	3
29	Northern Region	Lampang	0.590	3	3

No	Area	Province	PPR 2018 [1]	Group [2]	
				2018	(2008)
30	Northern Region	Uttaradit	0.461	3	3
31	Northern Region	Phrae	0.404	3	3
32	Northern Region	Nan	0.443	3	4
33	Northern Region	Phayao	0.444	3	4
34	Northern Region	Chiang Rai	0.436	3	3
35	Northern Region	Mae Hong Son	0.319	4	3
36	Northern Region	Nakhon Sawan	0.470	3	3
37	Northern Region	Uthai Thani	0.382	4	4
38	Northern Region	Kamphaeng Phet	0.275	4	4
39	Northern Region	Tak	0.338	4	4
40	Northern Region	Sukhothai	0.330	4	4
41	Northern Region	Phitsanulok	0.918	3	3
42	Northern Region	Phichit	0.443	3	2
43	Northern Region	Phetchabun	0.268	4	4
44	Northeastern Region	Nakhon Ratchasima	0.446	1	2
45	Northeastern Region	Buri Ram	0.292	2	2
46	Northeastern Region	Surin	0.296	2	2
47	Northeastern Region	Si Sa Ket	0.270	2	2
48	Northeastern Region	Ubon Ratchathani	0.420	3	4
49	Northeastern Region	Yasothon	0.264	2	2
50	Northeastern Region	Chaiyaphum	0.277	4	4
51	Northeastern Region	Amnat Charoen	0.272	4	4
52	Northeastern Region	Nong Bua Lam Phu	0.201	2	2
53	Northeastern Region	Khon Kaen	0.868	1	1
54	Northeastern Region	Udon Thani	0.359	2	2
55	Northeastern Region	Loei	0.299	4	4
56	Northeastern Region	Nong Khai	0.294	2	2
57	Northeastern Region	Maha Sarakham	0.323	2	2
58	Northeastern Region	Roi Et	0.291	2	2
59	Northeastern Region	Kalasin	0.268	2	2
60	Northeastern Region	Sakon Nakhon	0.280	4	4

No	Area	Province	PPR 2018 [1]	Group [2]	
				2018	(2008)
61	Northeastern Region	Nakhon Phanom	0.242	2	2
62	Northeastern Region	Mukdahan	0.307	4	4
63	Southern Region	Nakhon Si Thammarat	0.359	2	2
64	Southern Region	Krabi	0.281	4	4
65	Southern Region	Phangnga	0.418	3	3
66	Southern Region	Phuket	1.070	1	1
67	Southern Region	Surat Thani	0.543	3	3
68	Southern Region	Ranong	0.349	4	4
69	Southern Region	Chumphon	0.366	4	3
70	Southern Region	Songkhla	0.821	1	1
71	Southern Region	Satun	0.292	2	4
72	Southern Region	Trang	0.465	1	1
73	Southern Region	Phattalung	0.272	2	2
74	Southern Region	Pattani	0.279	2	2
75	Southern Region	Yala	0.389	4	3
76	Southern Region	Narathiwat	0.293	2	2

1. Represents physician-population ratio in 2018.
2. Group that each province belongs to as of each year by applying the dividing method mentioned in chapter 3.
   Note that each province was divided into four groups by using data in 2008 in this paper. Group number in 2018 was not used in this research but shown to let readers utilize the latest information.

APPENDIX 4 – CORRESPONDENCE TABLE OF THE GROUPS TO WHICH EACH SMA BELONGS

No	Prefecture	SMA	PPR	Group [2]	
			2018 [1]	2018	(2008)
1	北海道	南渡島	2.381	3	3
2	北海道	南檜山	1.230	4	4
3	北海道	北渡島檜山	1.225	4	4
4	北海道	札幌	3.099	1	1
5	北海道	後志	2.214	3	3
6	北海道	南空知	1.795	4	4
7	北海道	中空知	2.433	3	3
8	北海道	北空知	1.899	4	3
9	北海道	西胆振	2.221	3	3
10	北海道	東胆振	1.698	4	4
11	北海道	日高	1.029	4	4
12	北海道	上川中部	3.582	3	3
13	北海道	上川北部	1.991	3	4
14	北海道	富良野	1.292	4	4
15	北海道	留萌	1.386	4	4
16	北海道	宗谷	1.094	4	4
17	北海道	北網	1.652	4	4
18	北海道	遠紋	1.478	4	4
19	北海道	十勝	1.896	4	4
20	北海道	釧路	1.787	4	4
21	北海道	根室	0.956	4	4
22	青森県	津軽地域	3.233	3	3
23	青森県	八戸地域	1.842	4	4
24	青森県	青森地域	2.316	3	3
25	青森県	西北五地域	1.320	4	4
26	青森県	上十三地域	1.282	4	4
27	青森県	下北地域	1.385	4	4
28	岩手県	盛岡	3.164	3	3
29	岩手県	岩手中部	1.533	4	4

No	Prefecture	SMA	PPR 2018 [1]	Group [2]	
				2018	(2008)
30	岩手県	胆江	1.701	4	4
31	岩手県	両磐	1.706	4	4
32	岩手県	気仙	1.647	4	4
33	岩手県	釜石	1.320	4	4
34	岩手県	宮古	1.233	4	4
35	岩手県	久慈	1.364	4	4
36	岩手県	二戸	1.550	4	4
37	宮城県	仙南	1.626	4	4
38	宮城県	仙台	3.003	1	1
39	宮城県	大崎・栗原	1.722	4	4
40	宮城県	石巻・登米・気仙沼	1.611	4	4
41	秋田県	大館・鹿角	1.717	4	4
42	秋田県	北秋田	1.223	4	4
43	秋田県	能代・山本	1.998	3	4
44	秋田県	秋田周辺	3.440	3	3
45	秋田県	由利本荘・にかほ	1.948	4	3
46	秋田県	大仙・仙北	1.639	4	4
47	秋田県	横手	2.169	3	3
48	秋田県	湯沢・雄勝	1.198	4	4
49	山形県	村山	2.935	3	3
50	山形県	最上	1.394	4	4
51	山形県	置賜	1.903	4	4
52	山形県	庄内	2.002	3	4
53	福島県	県北	3.053	1	1
54	福島県	県中	2.065	3	3
55	福島県	県南	1.496	4	4
56	福島県	相双	0.986	4	4
57	福島県	いわき	1.850	2	2
58	福島県	会津・南会津	1.955	4	4
59	茨城県	水戸	2.458	1	1
60	茨城県	日立	1.646	2	2

No	Prefecture	SMA	PPR 2018 [1]	Group [2]	
				2018	(2008)
61	茨城県	常陸太田・ひたちなか	1.143	2	2
62	茨城県	鹿行	0.975	2	2
63	茨城県	土浦	2.235	1	1
64	茨城県	つくば	4.312	1	1
65	茨城県	取手・竜ヶ崎	1.787	2	2
66	茨城県	筑西・下妻	1.133	2	2
67	茨城県	古河・坂東	1.512	2	2
68	栃木県	県北	1.593	4	4
69	栃木県	県西	1.486	4	4
70	栃木県	宇都宮	2.058	1	1
71	栃木県	県東	1.301	2	2
72	栃木県	県南	4.274	1	1
73	栃木県	両毛	1.838	2	2
74	群馬県	前橋	4.770	1	1
75	群馬県	渋川	2.337	1	1
76	群馬県	伊勢崎	1.839	2	1
77	群馬県	高崎・安中	2.113	1	1
78	群馬県	藤岡	2.428	3	3
79	群馬県	富岡	2.270	3	3
80	群馬県	吾妻	1.401	4	4
81	群馬県	沼田	1.876	4	4
82	群馬県	桐生	1.942	2	1
83	群馬県	太田・館林	1.593	2	2
84	埼玉県	南部	1.597	2	2
85	埼玉県	南西部	1.458	2	2
86	埼玉県	東部	1.623	2	2
87	埼玉県	さいたま	1.969	2	2
88	埼玉県	県央	1.671	2	2
89	埼玉県	川越比企	2.438	1	1
90	埼玉県	西部	2.274	1	1
91	埼玉県	利根	1.357	2	2

No	Prefecture	SMA	PPR 2018[1]	Group[2]	
				2018	(2008)
92	埼玉県	北部	1.543	2	2
93	埼玉県	秩父	1.485	4	4
94	千葉県	千葉	3.027	1	1
95	千葉県	東葛南部	1.864	2	2
96	千葉県	東葛北部	1.836	2	2
97	千葉県	印旛	1.905	2	2
98	千葉県	香取海匝	1.948	2	2
99	千葉県	山武長生夷隅	1.242	2	2
100	千葉県	安房	4.673	3	3
101	千葉県	君津	1.626	2	2
102	千葉県	市原	1.815	2	1
103	東京都	区中央部	13.550	1	1
104	東京都	区南部	3.195	1	1
105	東京都	区西南部	3.390	1	1
106	東京都	区西部	5.547	1	1
107	東京都	区西北部	2.738	1	1
108	東京都	区東北部	1.767	2	2
109	東京都	区東部	2.129	1	2
110	東京都	西多摩	1.800	2	2
111	東京都	南多摩	1.796	2	2
112	東京都	北多摩西部	1.972	2	1
113	東京都	北多摩南部	3.195	1	1
114	東京都	北多摩北部	1.754	2	1
115	東京都	島しょ	1.376	4	4
116	神奈川県	川崎北部	2.220	1	1
117	神奈川県	川崎南部	2.618	1	1
118	神奈川県	横須賀・三浦	2.292	1	1
119	神奈川県	湘南東部	1.922	2	2
120	神奈川県	湘南西部	2.612	1	1
121	神奈川県	県央	1.464	2	2
122	神奈川県	相模原	2.385	1	1

No	Prefecture	SMA	PPR 2018 [1]	Group [2]	
				2018	(2008)
123	神奈川県	県西	1.767	2	2
124	神奈川県	横浜	2.406	1	1
125	新潟県	下越	1.688	4	4
126	新潟県	新潟	2.745	1	1
127	新潟県	県央	1.353	2	2
128	新潟県	中越	1.872	2	2
129	新潟県	魚沼	1.422	4	4
130	新潟県	上越	1.842	4	4
131	新潟県	佐渡	1.633	4	4
132	富山県	新川	2.208	3	3
133	富山県	富山	3.231	1	1
134	富山県	高岡	2.168	1	1
135	富山県	砺波	2.285	3	3
136	石川県	南加賀	1.796	2	2
137	石川県	石川中央	3.738	1	1
138	石川県	能登中部	2.031	3	3
139	石川県	能登北部	1.620	4	4
140	福井県	福井・坂井	3.814	1	1
141	福井県	奥越	1.283	4	4
142	福井県	丹南	1.286	4	4
143	福井県	嶺南	1.735	4	4
144	山梨県	中北	3.102	1	1
145	山梨県	峡東	1.992	3	3
146	山梨県	峡南	1.169	4	4
147	山梨県	富士・東部	1.580	4	4
148	長野県	佐久	2.527	3	3
149	長野県	上小	1.720	4	4
150	長野県	諏訪	2.467	1	1
151	長野県	上伊那	1.652	4	4
152	長野県	飯伊	1.999	3	4
153	長野県	木曽	1.411	4	4

No	Prefecture	SMA	PPR 2018 [1]	Group [2]	
				2018	(2008)
154	長野県	松本	3.852	3	3
155	長野県	大北	2.332	3	4
156	長野県	長野	2.104	1	1
157	長野県	北信	1.788	4	4
158	岐阜県	岐阜	2.864	1	1
159	岐阜県	西濃	1.710	2	2
160	岐阜県	中濃	1.755	4	4
161	岐阜県	東濃	1.904	4	4
162	岐阜県	飛騨	1.847	4	4
163	静岡県	賀茂	1.616	4	4
164	静岡県	熱海伊東	2.263	1	1
165	静岡県	駿東田方	2.309	1	1
166	静岡県	富士	1.495	2	2
167	静岡県	静岡	2.505	1	1
168	静岡県	志太榛原	1.694	2	2
169	静岡県	中東遠	1.592	2	2
170	静岡県	西部	2.761	1	1
171	愛知県	海部	1.277	2	2
172	愛知県	尾張東部	4.307	1	1
173	愛知県	尾張西部	1.905	2	2
174	愛知県	尾張北部	1.730	2	2
175	愛知県	知多半島	1.554	2	2
176	愛知県	西三河北部	1.728	2	2
177	愛知県	西三河南部西	1.707	2	2
178	愛知県	西三河南部東	1.384	2	2
179	愛知県	東三河北部	1.384	4	4
180	愛知県	東三河南部	1.845	2	2
181	愛知県	名古屋・尾張中部	3.126	1	1
182	三重県	北勢	1.974	2	2
183	三重県	中勢伊賀	3.137	1	1
184	三重県	南勢志摩	2.381	3	3

No	Prefecture	SMA	PPR 2018 [1]	Group [2]	
				2018	(2008)
185	三重県	東紀州	1.525	4	4
186	滋賀県	大津	3.927	1	1
187	滋賀県	湖南	2.343	1	1
188	滋賀県	甲賀	1.509	2	2
189	滋賀県	東近江	1.939	2	2
190	滋賀県	湖東	1.559	2	2
191	滋賀県	湖北	1.975	4	3
192	滋賀県	湖西	1.818	4	4
193	京都府	丹後	1.755	4	4
194	京都府	中丹	2.265	3	3
195	京都府	南丹	1.964	4	4
196	京都府	京都・乙訓	4.574	1	1
197	京都府	山城北	1.982	1	2
198	京都府	山城南	1.437	2	2
199	大阪府	豊能	3.757	1	1
200	大阪府	三島	2.772	1	1
201	大阪府	北河内	2.356	1	1
202	大阪府	中河内	1.974	2	2
203	大阪府	南河内	3.032	1	1
204	大阪府	堺市	2.313	1	1
205	大阪府	泉州	2.300	1	1
206	大阪府	大阪市	3.709	1	1
207	兵庫県	神戸	3.391	1	1
208	兵庫県	東播磨	2.140	1	2
209	兵庫県	北播磨	2.411	1	2
210	兵庫県	但馬	2.132	3	4
211	兵庫県	丹波	2.023	3	4
212	兵庫県	淡路	2.191	3	3
213	兵庫県	阪神	2.638	1	1
214	兵庫県	播磨姫路	2.103	1	1
215	奈良県	奈良	2.804	1	1

No	Prefecture	SMA	PPR 2018 [1]	Group [2]	
				2018	(2008)
216	奈良県	東和	2.815	1	1
217	奈良県	西和	1.987	1	2
218	奈良県	中和	3.206	1	1
219	奈良県	南和	1.752	4	4
220	和歌山県	和歌山	4.126	1	1
221	和歌山県	那賀	1.830	2	2
222	和歌山県	橋本	2.139	3	3
223	和歌山県	有田	1.820	4	4
224	和歌山県	御坊	2.639	3	3
225	和歌山県	田辺	2.459	3	3
226	和歌山県	新宮	2.264	3	3
227	鳥取県	東部	2.556	3	3
228	鳥取県	中部	2.143	3	3
229	鳥取県	西部	4.424	3	3
230	島根県	松江	2.711	3	3
231	島根県	雲南	1.471	4	4
232	島根県	出雲	4.874	1	1
233	島根県	大田	2.010	3	3
234	島根県	浜田	2.659	3	3
235	島根県	益田	2.267	3	3
236	島根県	隠岐	1.753	4	4
237	岡山県	県南東部	3.831	1	1
238	岡山県	県南西部	3.013	1	1
239	岡山県	高梁・新見	1.672	4	4
240	岡山県	真庭	1.641	4	4
241	岡山県	津山・英田	2.016	3	3
242	広島県	広島	3.042	1	1
243	広島県	広島西	2.776	1	1
244	広島県	呉	3.196	1	1
245	広島県	広島中央	2.150	1	1
246	広島県	尾三	2.396	3	1

No	Prefecture	SMA	PPR 2018[1]	Group[2]	
				2018	(2008)
247	広島県	福山・府中	2.104	1	1
248	広島県	備北	2.537	3	3
249	山口県	岩国	2.252	3	3
250	山口県	柳井	2.256	3	3
251	山口県	周南	2.136	1	1
252	山口県	山口・防府	2.444	1	3
253	山口県	宇部・小野田	4.157	1	1
254	山口県	下関	2.739	1	1
255	山口県	長門	1.772	4	3
256	山口県	萩	1.862	4	4
257	徳島県	東部	3.825	1	1
258	徳島県	南部	2.715	3	3
259	徳島県	西部	2.119	3	3
260	香川県	小豆	1.579	4	4
261	香川県	東部	3.417	1	1
262	香川県	西部	2.382	1	1
263	愛媛県	宇摩	1.777	4	4
264	愛媛県	新居浜・西条	1.999	1	1
265	愛媛県	今治	2.035	1	1
266	愛媛県	松山	3.560	1	1
267	愛媛県	八幡浜・大洲	1.976	4	3
268	愛媛県	宇和島	2.458	3	3
269	高知県	安芸	2.101	3	4
270	高知県	中央	3.702	3	3
271	高知県	高幡	1.679	4	4
272	高知県	幡多	2.019	3	3
273	福岡県	福岡・糸島	3.964	1	1
274	福岡県	粕屋	1.881	2	2
275	福岡県	宗像	1.778	2	2
276	福岡県	筑紫	1.974	2	1
277	福岡県	朝倉	1.954	4	4

No	Prefecture	SMA	PPR 2018[1]	Group[2]	
				2018	(2008)
278	福岡県	久留米	4.696	1	1
279	福岡県	八女・筑後	2.424	3	3
280	福岡県	有明	2.664	1	1
281	福岡県	飯塚	3.433	1	1
282	福岡県	直方・鞍手	1.860	2	2
283	福岡県	田川	2.081	1	1
284	福岡県	北九州	3.436	1	1
285	福岡県	京築	1.522	2	2
286	佐賀県	中部	3.932	1	1
287	佐賀県	東部	1.862	2	2
288	佐賀県	北部	2.251	3	1
289	佐賀県	西部	1.706	4	4
290	佐賀県	南部	2.534	3	1
291	長崎県	長崎	4.257	1	1
292	長崎県	佐世保県北	2.449	1	1
293	長崎県	県央	3.162	1	1
294	長崎県	県南	1.914	2	2
295	長崎県	五島	2.136	3	3
296	長崎県	上五島	1.519	4	4
297	長崎県	壱岐	1.608	4	4
298	長崎県	対馬	1.820	4	4
299	熊本県	宇城	1.780	2	2
300	熊本県	有明	2.096	1	2
301	熊本県	鹿本	2.081	3	3
302	熊本県	菊池	1.839	2	2
303	熊本県	阿蘇	1.367	4	4
304	熊本県	八代	2.519	3	3
305	熊本県	芦北	2.938	3	3
306	熊本県	球磨	2.220	3	3
307	熊本県	天草	2.202	3	3
308	熊本県	熊本・上益城	4.087	1	1

No	Prefecture	SMA	PPR 2018 [1]	Group [2]	
				2018	(2008)
309	大分県	東部	3.400	1	1
310	大分県	中部	3.283	1	1
311	大分県	南部	1.905	4	3
312	大分県	豊肥	2.054	3	4
313	大分県	西部	1.732	4	4
314	大分県	北部	2.049	3	3
315	宮崎県	宮崎東諸県	3.682	1	1
316	宮崎県	都城北諸県	2.057	1	3
317	宮崎県	延岡西臼杵	1.813	4	3
318	宮崎県	日南串間	2.302	3	3
319	宮崎県	西諸	1.738	4	4
320	宮崎県	西都児湯	1.360	4	4
321	宮崎県	日向入郷	1.711	4	4
322	鹿児島県	鹿児島	4.051	1	1
323	鹿児島県	南薩	2.208	3	3
324	鹿児島県	川薩	2.248	3	3
325	鹿児島県	出水	1.703	4	4
326	鹿児島県	姶良・伊佐	1.907	4	4
327	鹿児島県	曽於	1.088	4	4
328	鹿児島県	肝属	1.981	4	3
329	鹿児島県	熊毛	1.324	4	4
330	鹿児島県	奄美	1.826	4	4
331	沖縄県	北部	1.934	4	3
332	沖縄県	中部	1.954	2	2
333	沖縄県	南部	3.002	1	1
334	沖縄県	宮古	1.607	2	4
335	沖縄県	八重山	1.726	4	4

1. Represents physician-population ratio in 2018.
2. Group that each SMA belongs to as of each year by applying the dividing method mentioned in chapter 3.

Note that each province was divided into four groups by using data in 2008 in this paper. Group number in 2018 was not used in this research but shown to let readers utilize the latest information.

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