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Original Article

Does postgraduate year training program for dentists worsen the imbalance of geographical distribution of dentists in Taiwan?

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Abstract *Background/purpose:* Taiwan implemented the non-compulsory postgraduate year training program for dentists (PGYD) in 2010. Previous studies found that training institutions for dentists are mostly distributed in metropolitan areas. This study explored whether the PGYD system might worsen the imbalance of geographical distribution of dentists in Taiwan.
Materials and methods: This study collected the data of population, the number of practicing dentists from 2010 to 2018, and the number of practicing dentists in the training institutions in 2018 to draw the Lorenz curve and to calculate the Gini coefficient for evaluating whether the PGYD system might worsen the imbalance of geographical distribution of dentists in Taiwan.

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Dentist policies

Results: Our results showed that the uneven geographical distribution of overall practicing dentists did not deteriorate after the implementation of the PGYD system. However, the uneven geographical distribution of practicing dentists in training institutions was more serious than the uneven geographical distribution of overall practicing dentists.
Conclusion: Because the PGYD system is not mandatory, dentists engage in training program and select training institutions as driven by the market factors. After completion of the PGYD training, dentists choose the practice location as driven by the market factors again and this in turn redistributes the dentists to different regions of Taiwan. In addition, major dentist policies may also result in the movement of dentists to various regions of Taiwan. Thus, the market-driven redistribution of dentists to different regions of Taiwan finally reduces the imbalance of geographical distribution of dentists in Taiwan caused by the PGYD system.

Introduction

Postgraduate clinical training for dentists has been implemented in Japan since 2006. Slightly later, postgraduate year training program for dentists (PGYD) also implemented in Taiwan in 2010. However, there are some differences between the dentist training systems in Japan and in Taiwan. In Japan, the dentist training system is mandatory for one year. New dentists need to complete the training program before they can practice freely. On the contrary, the PGYD system in Taiwan lasts for two years and is not mandatory. New dentists can practice freely in different regions of Taiwan without the PGYD training. However, if they want to become the owner of a dental clinic, they need to complete the PGYD training first. After the implementation of the comprehensive dental specialist system at the end of 2017, dentists need to complete the PGYD training before they can enter the dental specialist training programs. Furthermore, there are some similarities between the dentist training systems in Japan and in Taiwan. Dental institutions participate in the postgraduate training in two ways: a single system and a group system. In a single system, there is only one hospital or dental clinic that works as the main training institution and handles all the dentist training matters. In the group system, a main hospital or dental clinic is the main training institution that works as the manager of the whole training group. Besides, a number of other clinical training institutions join the group as cooperative training institutions.[1–3]

A few years after the implementation of the Japanese postgraduate clinical training for dentists, some studies began to explore whether this dentist training system worsened the uneven geographical distribution of dentists in Japan. These Japanese studies found that the uneven geographical distribution of dental trainees was indeed significantly more serious than that of overall practicing dentists. Because the uneven geographical distribution of dentists is affected by many factors, such as the clinical training system based on a one-year employment contract, the subsequent relocation of dentists as driven by the market after training, and the geographical distribution of dentists worsened as a result of the merger of municipalities (known as shichōson in Japan, shichōson refers to the cities, towns, and villages in Japan).[2,3] Therefore, there is no consensus on whether the postgraduate clinical training system deteriorates the uneven geographical distribution of dentists in Japan.

This study used the Lorenz curve and Gini coefficient to analyze the geographical distribution of overall practicing dentists in Taiwan from 2010 to 2018 and the geographical distribution of practicing dentists in training institutions in 2018 to assess the impact of the PGYD system on the geographical distribution of practicing dentists in Taiwan.

Materials and methods

This study used the method of secondary data analysis to collect the information about the population and the number of overall practicing dentists in Taiwan from 2010 to 2018 and the number of practicing dentists in the PGYD training institutions in 2018. This information was open to access and could be collected from the related websites.

We obtained the population data including the total population at the end of each year in cities/counties and districts/townships from 2010 to 2018 from the website of the Ministry of the Interior. In addition, the information of practicing dentists from 2010 to 2018 was available on the website of the Ministry of Health and Welfare. This information included the number of practicing dentists in cities/counties and districts/townships at the end of each year, and the numbers of dentists and dental institutions (such as the hospitals with dental departments and dental clinics) issued each year. Although the city/county merger was implemented in 2010, the statistical data were the total population and the number of practicing dentists at the end of the current year, which belonged to the scope of the merged administrative region. Taoyuan County alone was upgraded to a municipality in 2014, without affecting the scope of the administrative region. Therefore, the administrative regions of the statistical interval were consistent.

We also obtained the name list of the PGYD programs in 2018 from the website of the Joint Committee of Taiwan, which included the types of programs (single-system or joint training group program), the titles of the dental institutions (the name of the certain hospital or dental clinic), the types of the institutions (single-system,

program-management, or cooperative institution), and the administrative region in Taiwan. In addition, through exploiting the institution and staff searching system of the Ministry of Health and Welfare by the time of November 2018, the institutional level and the district/township location of the above institutions, and the numbers of dentists registered in these institutions were realized and recorded.

Based on the number of overall practicing dentists in Taiwan from 2010 to 2018 and the number of practicing dentists in the training institutions in 2018, we drew the Lorenz curve and calculated the Gini coefficient to understand the changes of the geographical distribution of overall practicing dentists from 2010 to 2018. Moreover, based on the geographical distribution of practicing dentists in the training institutions in 2018, we could also discuss the impact of the PGYD system on the geographical distribution of overall practicing dentists in Taiwan.

First, in each year, it was grouped by city and county, and each group was ranked from low to high according to the number of dentists per 100,000 persons. Then, we drew the Lorenz curve with the abscissa (X axis) as the cumulative population and the ordinate (Y axis) as the cumulative number of dentists. In addition, it was grouped by district and township to draw the Lorenz curve and calculate the Gini coefficient for 2018.

When the number of dentists per population in each administrative region was completely even, the Lorenz curve was a diagonal line through the origin, called the equal distribution line. However, the more uneven was the geographical distribution of dentists, the more the Lorenz curve deviated from the equal distribution line. The Gini coefficient was calculated based on the area between the equal distribution line and the Lorenz curve as the numerator and the total area below the equal distribution line as the denominator. The actual value of the Gini coefficient was only between 0 and 1. The larger was the Gini coefficient (closer to 1), the more uneven was the distribution. On the contrary, the smaller was the Gini coefficient (closer to 0), the more even was the distribution.[4–6]

Finally, based on the Gini coefficient of overall practicing dentists from 2010 to 2018, we analyzed the changes in the geographical distribution of overall practicing dentists, and further explored the impact of the PGYD system on the geographical distribution of overall practicing dentists according to the Gini coefficient of practicing dentists in the training institutions in 2018. The data collected by the above methods were filed in excel and analyzed statistically.

Results

Taiwan currently has 22 cities and counties (including offshore islands) with 368 districts and townships. There are 6 municipalities (directly under the central government) in 22 cities and counties, which are different from Japanese cities, towns and villages. In 2010, Taichung City and County, Tainan City and County, as well as Kaohsiung City and County were merged to become municipalities, so three counties were reduced. The statistics were based on the values at the end of the year, so the values belonged to the combined administrative regions. In 2014, Taoyuan County alone was upgraded to a municipality, without affecting the scope of the administrative region. In addition, there was no change in the districts and townships. Therefore, the number and scope of the administrative regions were consistent throughout the period of this study.

The PGYD system implemented in 2010. From 2010 to 2018, the population and the number of practicing dentists increased year by year in Taiwan (Table 1). The population increased from 23.16 million to 23.59 million, and the number of practicing dentists increased by 3,061 from 11,656 to 14,717. It was estimated that the number of practicing dentists per 100,000 persons increased from 50 to 62. This showed that through the consideration of the population, the number of practicing dentists also increased. Therefore, the overall quality and quantity of dental services could be improved. In addition, during this period, the average number of dental graduates who obtained the dentist license through the national dentist examination was 445 per year, resulting in an increase of a total number of 4,002 dentists from 2010 to 2018. Therefore, it could be estimated that there were 941 dentists who resigned during this period.

From 2010 to 2018, the Lorentz curve of the geographical distribution of practicing dentists by cities and counties produced a Gini coefficient varied from 0.316 to 0.334 in each year (Table 1). From 2010 to 2017, however, there was a year-by-year decline, but in 2018, the Gini coefficient rose to the level of 2010 (0.334). Overall, the uneven geographical distribution of practicing dentists did not deteriorate. Taking 2018 as an example, the Gini coefficient of practicing dentists by districts and townships was 0.453, which was higher than that (0.334) by cities and counties in the same year (Table 1). It indicates that the calculation of the Gini coefficient by a more subdivision of administrative region can more truly reflect the uneven geographical distribution of practicing dentists. We also used Mann–Kendall test for trend analysis to evaluate the various trends. The results demonstrated that the growth in the numbers of Taiwan's population, practicing dentists, and dentists per 100,000 persons from 2010 to 2018 was significantly different ($P < 0.001$). The increased numbers per year of above items were 57,707, 385 and 1.52, respectively. In addition, the decline in the Gini coefficient of practicing dentists by cities and counties also had a significant difference ($P < 0.05$). The decreased value of the Gini coefficient per year was 0.002 (Table 1).

In 2018, there were 4,172 practicing dentists in the training institutions, accounting for 28.35% of the total number of practicing dentists. The Lorenz curve of practicing dentists in the training institutions was more deviated from the equal distribution line than that of overall practicing dentists. The Gini coefficient of practicing dentists in total training institutions was 0.353 (Table 2). We further analyzed the Lorenz curve of practicing dentists in the different types of training institutions (including main training institutions of the single system, main training institutions of the group system, and cooperative training institutions of the group system). We found that all of them were more deviated from the equal distribution line than the Lorenz curve of overall practicing dentists (Table 2). Among them, the Lorenz curve of practicing dentists in

Table 1 The population as well as the number and Gini coefficient of practicing dentists in Taiwan from 2010 to 2018.

Years	Population at the end of the year	Number of practicing dentists	Number of practicing dentists per 100,000 persons	Number of new dentists issued	Gini coefficient of practicing dentists by cities and counties
2010	23,162,123	11,656	50.324	471	0.334
2011	23,224,912	11,992	51.634	461	0.330
2012	23,315,822	12,391	53.144	495	0.329
2013	23,373,517	12,794	54.737	477	0.325
2014	23,433,753	13,178	56.235	448	0.324
2015	23,492,074	13,502	57.475	434	0.319
2016	23,539,816	13,912	59.100	430	0.318
2017	23,571,227	14,379	61.002	403	0.316
2018	23,588,932	14,717	62.389	383	0.334 (0.453)[a]
Sen's slope of Mann–Kendall test	57,707.083	384.675	1.518	–	−0.002
Significance	$P < 0.001$	$P < 0.001$	$P < 0.001$	–	$P < 0.05$

[a] This value was the Gini coefficient of practicing dentists by districts and townships.

Table 2 The number and Gini coefficient of practicing dentists in different types and levels of training institutions in Taiwan in 2018.

	Number of practicing dentists	Gini coefficient of practicing dentists by cities and counties
Main training institutions of the single system	2,440	0.415
Main training institutions of the group system	422	0.404
Cooperative training institutions of the group system	2,809	0.351
Medical center training institutions	1,271	0.464
Regional hospital training institutions	723	0.241
District hospital training institutions	158	0.487
Dental clinic training institutions	2,020	0.431
Total training institutions	4,172[a]	0.353
Overall practicing dentists	14,717	0.334

[a] Some training institutions had both the statuses of main and cooperative training institutions. The repeated calculation of the number of practicing dentists had been deducted.

main training institutions of the single system (Gini coefficient, 0.415) deviated most from the equal distribution line, followed by main training institutions of the group system (Gini coefficient, 0.404), and then cooperative training institutions of the group system (Gini coefficient, 0.351), indicating that the uneven geographical distribution of practicing dentists is more serious in main training institutions, especially the main training institutions of the single system (Table 2).

Furthermore, we further analyzed the Lorenz curve of practicing dentists in different levels of training institutions (including medical centers, regional hospitals, district hospitals, and dental clinics). We also discovered that the Lorenz curves of practicing dentists in all of them (except regional hospitals) were more deviated from the equal distribution line than the Lorenz curve of overall practicing dentists (Gini coefficient, 0.334) (Table 2). Among them, the Lorenz curve of practicing dentists in training institutions of district hospitals (Gini coefficient, 0.487) deviated most from the equal distribution line, followed by that of medical centers (Gini coefficient, 0.464) and that of dental clinics (Gini coefficient, 0.431). These findings indicate that the uneven geographical distribution of practicing dentists in training institutions of medical centers and district hospitals are more serious. However, the Lorenz curve of practicing dentists in regional hospitals (Gini coefficient, 0.241) was closer to the equal distribution line than the Lorenz curve of overall practicing dentists (Gini coefficient, 0.334, Table 2).

In this study, we also collected the data of the numbers of dental institutions (including dental clinics and hospitals with dental departments), PGYD training institutions and hospitals in Taiwan from 2010 to 2018 (Table 3). Although the numbers of hospitals and hospitals with dental departments showed a decrease, due to the large growth of dental clinics year by year, the number of overall dental institutions increased year by year from 6,519 in 2010 to 7,039 in 2018 (Table 3). In terms of PGYD training institutions, the number of dental clinic training institutions increased from 211 in 2010 to 467 in 2018, and the number

Table 3 The numbers of dental institutions (including dental clinics and hospitals with dental departments), PGYD training institutions, and hospitals in Taiwan from 2010 to 2018.

Years	2010	2011	2012	2013	2014	2015	2016	2017	2018
Dental clinics	6,295	6,399	6,476	6,565	6,630	6,665	6,727	6,791	6,836
Hospitals with dental departments	224	218	216	215	213	206	209	206	203
Total	6,519	6,617	6,692	6,780	6,843	6,871	6,936	6,997	7,039
Training institutions (clinics)[a]	211	—	210	—	347	—	389	—	467
Training institutions (hospitals)[a]	116	—	102	—	110	—	121	—	131
Total[a]	327	—	312	—	457	—	510	—	598
Hospitals	492	491	488	482	486	486	485	478	478

[a] The duration of being a training institution was 2 years. The number of training institutions was the total of main and cooperative training institutions. Some training institutions had both the statuses of main and cooperative training institutions.

of hospital training institutions also increased from 116 in 2010 to 131 in 2018 (Table 3). These findings indicate that the number of dental clinic and hospital training institutions have a marked growth, especially the number of dental clinic training institutions.[1]

Discussion

The Lorenz curve and Gini coefficient are first used to measure the degree of income inequality, and later are used as indicators for measuring the geographical distribution of medical human resources.[7–12] Therefore, they were also suitable to be used as indicators for measuring the degree of uneven geographical distribution of dentists in Taiwan in this study.

In Taiwan, the PGYD is a two-year training program and is not mandatory. New dentists can practice freely without the PGYD training. However, to become the owner of a dental clinic or to enter the dental specialist training program, they must first complete the PGYD training. There are two types of training program: a single training institution and a joint training group. In a single system, only one hospital or one dental clinic handles the dentist training program as the main training institution. The joint training group consists of one hospital or one dental clinic as the manager of the training program, where is also the main training institution, and a number of other clinical training institutions join as the cooperative training institutions. Therefore, the types of training institutions in Taiwan are similar to those in Japan.[1] In addition, there are a total number of 8 universities with dental schools in Taiwan. However, like Japan, there is a large regional deviation in geographical distribution of the dentist training institutions. Among 22 cities and counties, they are concentrated in only 4 cities, including Taipei City, Taichung City, Tainan City, and Kaohsiung City.

In this study, the number of practicing dentists in training institutions was used to analyze the uneven geographical distribution of practicing dentists, but the number of dental trainees was not used for analysis. This is because there are no publicly available data about the trainees of PGYD. In addition, the training institutions have the qualification to recruit dental trainees and other advantages, so these training institutions are easy to attract dentists for employment. Therefore, when discussing the impact of the PGYD system on the geographical distribution of dentists, it is more appropriate to use the number of practicing dentists in the training institutions as the subjects of analysis.

During the nine-year period from 2010 to 2018, the total number of new dentists who passed the national dentist examination was 4,002, and the total number of increased practicing dentists during this period was 3,061. Thus, an estimated number of dentists who resigned during this period was 941. Furthermore, these new dentists had to apply for the PYGD training program since 2010, accounting for 27.19% of the total number of practicing dentists in 2018. The impact of them on the geographical distribution of practicing dentists could not be ignored. A Japanese study on the geographical distribution of practicing dentists pointed out that if the resignation of dentists is not taken into consideration, the geographical distribution of practicing dentists in 2006 can be used as a benchmark, and all dental trainees are assumed to stay in the original training institutions, the Gini coefficient of practicing dentists should increase steadily in 2008 and in 2010. This indicates that under this premise, the PGYD has a high potential to worsen the uneven geographical distribution of dentists.[4]

Different from the perspective of dental trainees in the Japanese study, our study was from the perspective of training institutions. This study found that the Gini coefficient of practicing dentists in training institutions in 2018 was greater than that of overall practicing dentists, indicating that the geographical distribution is more uneven for the practicing dentists in training institutions than for the overall practicing dentists. However, the PGYD trainees in training institutions are also practicing dentists. If the same assumption is made that the PGYD trainees will stay in the original training institutions, it can be predicted that the Gini coefficient of practicing dentists will also increase.

From 2010 to 2018, the number of PGYD training institutions accounted for 4.6% to 8.5% of the total number of dental institutions. This finding indicates an increased tendency for the number of PGYD training institutions in Taiwan. The number of practicing dentists in training institutions accounted for 28.35% of the total number of practicing dentists in 2018. It is obvious that the dentist manpower is concentrated in the dental institutions qualified as the training institutions. Thus, it can be predicted that the implementation of the PGYD system may affect the geographical distribution of dentists. However, this study

found that since the implementation of the PGYD system, the geographical distribution of practicing dentists did not deteriorate. From 2008 to 2017, the Gini coefficient decreased from 0.334 to 0.316, but in 2018 the Gini coefficient rose back to 0.334 (Table 1). A trend analysis using the Mann—Kendall test showed that there was a significant difference in the decrease in the Gini coefficient of practicing dentists, which decreased by 0.002 per year. Overall, our study demonstrated a similar finding to that of a Japanese study, in which the Gini coefficient of practicing dentists also had a decline from 2006 to 2010.[4]

In Japan, dental school hospitals are only concentrated in 19 prefectures and 28 municipalities (known as shichōson in Japan, shichōson refers to the cities, towns, and villages in Japan), but nearly 80% of dental trainees belong to the training programs of these dental school hospitals. However, the Japanese study also found that the geographical distribution of practicing dentists does not deteriorate from 2006 to 2010, and the Gini coefficient decreases from 0.232 to 0.222.[4] The reason is that the dentist training programs in Japan mainly use dental school hospitals as the managers of the training programs in the group system, and a large number of cooperative training institutions join the group system. Due to government policy support, dental clinics joined the training programs as cooperative training institutions increase year by year. In addition, there are many dental clinics that join the group system of dental school hospitals across prefectures to further disperse the geographical distribution of dental trainees.[3]

Although the geographical distribution of dental trainees in Japan is indeed more uneven than that of overall practicing dentists, some studies propose a spreading-out hypothesis. Due to the principle of competition, the geographical distribution of physician tends to be balanced. The premise is that when the number of dentists per 100,000 persons is high (such as 74.4 dentists in Japan in 2006 and 50.3 dentists in Taiwan in 2010), the geographical distribution of dentists may be consistent with the spreading-out hypothesis, even after the implementation of the mandatory postgraduate clinical training system.[13—15] Since approximately 85% of overall practicing dentists in Japan work in dental clinics, and most of them are general practitioners. It is further noted that dentists are free to choose to open a new dental clinic anywhere in Japan, and the selection of clinic location is affected by the market mechanism.[10] This indicates that the geographical distribution of practicing dentists in Japan is assumed to follow the spreading-out hypothesis.[4] The situation in Taiwan is similar to that in Japan. More than 85% of practicing dentists work in dental clinics. Most of them are also general practitioners.[16] Dentists who have completed the PGYD training can also choose to open a new dental clinic anywhere in Taiwan.

The PGYD system in Taiwan is not mandatory, so new dentists can choose to practice freely without participating in the PGYD training. However, at the end of 2017, the comprehensive dental specialist system was implemented. Under this system. The dentists require to complete the PGYD training before entering the dental specialist training.[17] The implementation of this major dentist policy may lead to all dentists who have not participated in the PGYD training to reconsider to join the PGYD training program. Thus, dentists are moved to the training institutions and this makes the geographical distribution of practicing dentists more uneven. It could also explain why the Gini coefficient of practicing dentists increased in 2018. However, it still needs further studies to evaluate the changes in the geographical distribution of dentists in Taiwan in the future.

In 2018, the numbers of practicing dentists in main training institutions and cooperative training institutions were 2,862 and 2,809, respectively (Table 2). The Gini coefficient of practicing dentists in cooperative training institutions (0.351) was closer to that of overall practicing dentists (0.334). Meanwhile, the numbers of practicing dentists in hospital training institutions and dental clinic training institutions were 2,152 and 2,020, respectively (Table 2). The Gini coefficient of practicing dentists in dental clinic training institutions (0.431) was closer to that of overall practicing dentists (0.334). Previous study on the development trend of the PGYD training institutions found that a large number of dental clinics join the PGYD programs in the form of cooperative training institutions, and the dental clinics are characterized by a smaller scale and a wider geographical distribution. These dental clinics can reach remote areas and in turn result in a balanced redistribution of the practicing dentists in different regions of Taiwan.[1]

The Gini coefficient of practicing dentists in regional hospital training institutions (0.241) was lower than that of overall practicing dentists (0.334) (Table 2). The possible reason was that the geographical distribution of regional hospitals in all cities and counties is already relatively even. The Gini coefficients of practicing dentists in medical center (0.464) and district hospital (0.487) training institutions were much higher than that of overall practicing dentists (0.334) (Table 2). It may be due to that medical centers and district hospitals with dental departments are mostly concentrated in the metropolitan areas of municipalities (different from Japanese cities, towns, and villages). Since most hospitals are training institutions, the geographical distribution of hospitals directly affects the geographical distribution of practicing dentists in training institutions. Further studies are needed to verify this explanation in the future.

In addition, although only 15% of overall practicing dentists work in hospitals, 52% of practicing dentists in training institutions work in hospitals. This means that the PGYD system may cause the geographical distribution of dentists to shift in a more uneven direction. The results of this study showed that the uneven geographical distribution of dentists in Taiwan did not deteriorate, indicating that the changes in the geographical distribution of dentists in Taiwan is also assumed to follow the spreading-out hypothesis.

By the training institutions that belong to medical centers or university hospitals, it can explain the phenomenon of the spreading-out hypothesis. Taking the National Taiwan University Hospital as an example, the PGYD trainees and dentists in the dental specialist training programs are recruited every year, and there are 20 and 10, respectively. The PGYD training lasts for 2 years, and the dental specialist training takes 2—3.5 years, in which oral and maxillofacial surgery specialist training requires 3.5

years. Excluding other types of training programs, there are at least 60 dentists who have received dentist trainings in the National Taiwan University Hospital in the same period. After completing these trainings, these dentists usually have to leave the National Taiwan University Hospital. Due to the market factors, they choose a new practice location and further spread out to different regions of Taiwan.

A previous study found that the types of training programs proposed by medical centers or university hospitals in Taiwan are mainly based on a single training institution.[1] This is different from the situation in Japan. Japanese dental school hospitals play the role of management institutions in joint training groups. A large number of cooperative training institutions join their training groups, and the number of dental clinics joining the training groups in the form of cooperative training institutions also increase year by year.[3] In Taiwan, the possible reason is that the medical centers have the task of dental specialist training. The managers of the dental departments may think that it is not easy to arrange for the trainees to rotate from the main training institution (usually a hospital) to the cooperative training institution (mainly a dental clinic), or they do not trust the training quality of the dental clinics. In the future, the implementation of the PGYD system should encourage medical centers or university hospitals to propose joint training groups and accept more dental clinics across cities and counties to join as cooperative training institutions, which in turn may help to balance the geographical distribution of dentists.

Other possible explanation is that the PGYD system in Taiwan is not mandatory. Thus, the dentists who do not intend to open a new dental clinic or to enter the dental specialist training do not need to receive the PGYD training. They can also choose to enter the PGYD training at any time with the adjustment of their life plans. Moreover, the cumulative training period is 24 months, calculated in units of months. During the training, they can switch training institutions or training programs, and they can also interrupt and then connect the training programs after the interruption. The dentists who have completed the PGYD training are also expected to choose the next practice location. Therefore, the phenomenon of spreading-out hypothesis occurs. However, the PGYD system may influence the geographical distribution of dentists in two ways: one is that the practice location of dentists during the training period is restricted to the training institutions and the other is whether the dentists stay in the original training institutions after completing the training. More importantly, the type and location of the training institutions may also influence the choice of the dentists' career plans. A previous study also found that dentists who have completed the training often choose the same areas of their training institutions as the next practice location in the future.[18] Further studies are needed to assess how training institutions affect training dentists' choice of practice location and their career plans.

The Japanese study found that due to the merger policy of municipalities (known as shichōson in Japan, shichōson refers to the cities, towns, and villages in Japan), the number of municipalities decrease, and the scope and population of municipalities increase. This results in a decrease in the Gini coefficient in the municipalities level.[4] The number and scope of administrative regions were the same during our studying period, so there was no such situation that the calculated Gini coefficients were changed due to the merger of administrative regions.

A previous study found that the Lorenz curve of practicing dentists in main training institutions, that of practicing dentists in cooperative training institutions, and that of overall practicing dentists by districts and townships are more curved than those by cities and counties.[18] Since there are urban-rural gaps between districts/townships and cities/counties, the uneven geographical distribution of dentists from the perspective of the districts/townships level may be more obvious and closer to the real situation. Therefore, in the future, the studies on the uneven geographical distribution of dental or medical resources should be viewed from the perspective of the districts/townships level.

During the period from 2010 to 2018, there were a total number of 4,002 new dentists and a total number of 3,061 additional practicing dentists, in which there was a difference of 941 dentists. It might be due to the dentists who resigned and no longer provided dental services. The other possible reasons included retirement, death, studying abroad, and other factors. In 2018, the number of new dentists who applied for the PGYD program accounted for 27.19% of overall practicing dentists. Furthermore, the number of resigned dentists was 23.51% of the number of new dentists, accounting for 6.39% of overall practicing dentists in 2018. The impact of these resigned dentists on the geographical distribution of dentists cannot be ignored, and further studies are needed to clarify this issue.

In addition, from 2010 to 2018, the dental school graduates who passed the national dentist examination to obtain a dentist license maintained an average of approximately 445 dentists per year. According to a recent press release from the Ministry of Health and Welfare, there are approximately 420 graduates of dental schools in Taiwan every year.[17] Thus, it could be estimated that there were at least approximately 25 foreign dental school graduates who obtained the dentist license through the national dentist examination every year. However, it was also estimated that there were at least approximately 225 dentists graduated from foreign dental schools who also had to apply for the PGYD training program. For a long time, Taiwan implemented the control mechanism for the total number of dentists and physicians by controlling the number of the students enrolling into the domestic dental and medical schools, but the foreign dental school graduates were exempted from this control mechanism. Thus, further studies are needed to monitor the statuses of these dentists graduated from foreign dental schools. These include whether they participate in the PGYD training program, whether they practice in Taiwan after the PGYD training, and whether they affect the geographical distribution of dentists in Taiwan.

In short, the degree of uneven geographical distribution of practicing dentists in training institutions was more serious than that of overall practicing dentists in 2018. In particular, the geographical distribution of practicing dentists in main training institutions, in medical center, or in district hospital training institutions was the most uneven. We conclude that the PGYD system is one of the factors that

worsen the uneven geographical distribution of dentists in Taiwan. However, the choice of the dentist's practice location is affected by the market factors. In addition, the decision of a training institution to participate in the PGYD program, the selection of training institutions by the new dentists, and the choice of the next practice location after the completion of training are also driven by market factors. Furthermore, the withdrawal of resigned dentists and the addition of dentists graduated from foreign dental schools are both possible influencing factors on the geographical distribution of practicing dentists in Taiwan. Therefore, the PGYD system itself alone cannot be the only one factor that contributes to the deterioration of the uneven geographical distribution of dentists. Other factors should also be considered. Because dentists who completed the PGYD training often spread out to various regions of Taiwan as driven by the market factors, the geographical distribution of dentists after the implementation of the Taiwan PGYD system does not continue to deteriorate. Besides, major dentist policies may also result in the movement of dentists to different regions of Taiwan. Thus, the market-driven redistribution of dentists to different regions of Taiwan finally reduces the imbalance of geographical distribution of dentists in Taiwan caused by the PGYD system. In the future, we should continue to evaluate the changes in the geographical distribution of dentists and explore the possible reasons for the changes.

Declaration of Competing Interest

None declared.

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