Original Article

Imbalance in the geographical distribution of practicing dentists in postgraduate dental training institutions in Taiwan

Feng-Chou Cheng [a,b], Julia Yu-Fong Chang [c,d,e],
Tzu-Chiang Lin [f], Wen-Chiung Chang [g], Yung-Ta Chang [a*],
Chun-Pin Chiang [b,c,d,e,h**]

[a] School of Life Science, National Taiwan Normal University, Taipei, Taiwan
[b] Department of Dentistry, Far Eastern Memorial Hospital, New Taipei City, Taiwan
[c] Department of Dentistry, National Taiwan University Hospital, College of Medicine, National Taiwan University, Taipei, Taiwan
[d] Graduate Institute of Oral Biology, School of Dentistry, National Taiwan University, Taipei, Taiwan
[e] Graduate Institute of Clinical Dentistry, School of Dentistry, National Taiwan University, Taipei, Taiwan
[f] Center for the Liberal Arts, National Kaohsiung University of Science and Technology, Kaohsiung, Taiwan
[g] National Institute of Infectious Diseases and Vaccinology, National Health Research Institutes, Miaoli County, Taiwan
[h] Department of Dentistry, Hualien Tzu Chi Hospital, Buddhist Tzu Chi Medical Foundation, Hualien, Taiwan

Abstract *Background/purpose:* Postgraduate year training program for dentists (PGYD) in Taiwan started since 2010. This study tried to assess the geographical distribution of practicing dentists in postgraduate dental training institutions in Taiwan.
Materials and methods: This study utilized the secondary data analysis to measure and compare the numbers of practicing dentists in each type of dental training institution and the numbers of overall practicing dentists among different cities and counties in Taiwan.
Results: Our results found that the practicing dentists in each type of dental training institution showed a significantly greater imbalance in geographical distribution than the overall practicing dentists. It meant that the practicing dentists in postgraduate dental training institutions were more concentrated in northern part of Taiwan than in other parts of Taiwan,

* Corresponding author. School of Life Science, National Taiwan Normal University, No. 88, Sec. 4, Ting-Chou Road, Taipei, 11677, Taiwan.
** Corresponding author. Department of Dentistry, Hualien Tzu Chi Hospital, Buddhist Tzu Chi Medical Foundation, No. 707, Section 3, Chung-Yang Road, Hualien, 970, Taiwan.
    E-mail addresses: biofv031@ntnu.edu.tw (Y.-T. Chang), cpchiang@ntu.edu.tw (C.-P. Chiang).

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compared to the number of overall practicing dentists in different cities or counties in Taiwan. However, the disparities in the number of practicing dentists in dental training institutions could be compensated by cross-regional collaborating institutions under the joint training group system.

Conclusion: Because continuation of the current PGYD system may accelerate the imbalance in geographical distribution of practicing dentists in dental training institutions in Taiwan. To prevent this, further studies on yearly changes in the geographical distribution of dentists in postgraduate dental training institutions by city or county should be taken to monitor whether we should further modify the currently used PGYD system toward a better one to solve the problem of imbalance in the geographical distribution of dentists in postgraduate dental training institutions in Taiwan.

Introduction

Postgraduate year training program for dentists (PGYD) in Taiwan started on September, 2010, according to an announcement by the Department of Health (after 2013, Department of Health was renamed as the Ministry of Health and Welfare) in 2010.[1] Postgraduate clinical training for dentists in Japan has been mandatory since 2006. It has been criticized that the PGYD system accelerates the imbalance in geographical distribution of dentists in Japan.[2] There were few studies on the impact of dental PGY system on geographical distribution of dentists in Taiwan. However, this system was generally considered to accelerate the imbalance in geographical distribution of dentists in Taiwan.[1,3] Therefore, it is necessary to investigate the geographical distribution of practicing dentists in postgraduate dental training institutions in Taiwan.

A Japanese study assumed that the number of clinical training programs for dentists in each prefecture reflects its ability to offer such training, and reported that prefectures with more dentists or dental clinics have a greater ability to offer postgraduate clinical training for dentists.[4] As 85.3% of the 2006 postgraduate dental trainees are enrolled in the clinical training programs in dental university/school-affiliated hospitals, the imbalance in geographical distribution of dentists in Japan is expected to become severe under the currently used PGYD system in Japan.[2]

Similar to the Japanese mode, the PGYD system in Taiwan is composed of clinical training programs as its basic units. There are two types of clinical training program: single-system and joint training group programs.[2,3] Under the single-system program, dental trainees receive training in a single dental institution (single-system institution). Under the joint training group program, dental trainees make rounds among a dental institution that manages the program (program-management institution) and the other dental institutions (collaborating institutions). In general, the single-system and program-management institutions are hospitals, whereas the collaborating institutions are dental clinics in Japan.[2] However, there are more dental clinics than hospitals in number as the single-system and program-management institutions, whereas the collaborating institutions are mainly dental clinics in Taiwan.[3]

Under the joint training group program, dental trainees can receive training in any collaborating institutions located in a city or a county other than the location of the program-management institution. Dental trainees are redistributed among cities or counties as a result of their movement across city and county boundaries, and disparities in their number among cities and counties may be corrected.[2,3]

Because each senior dentist can guide one dental trainee who is also a practicing dentist, in this study the number of practicing dentists in each type of dental training institution is used as the analysis objects. This study presented the findings focusing on the number of dentists who actually registered in each type of postgraduate dental training institution.

Materials and methods

This study used the method of secondary data analysis as the research method. From the Joint Committee of Taiwan's website, we found the name list of dental training institutions qualified for the PGYD in 2018 with the program span of 2 years. The data revealed the types of programs (single-system or joint training group program), the titles of the medical institutions (the name of the certain hospital or dental clinic), the types of the institutions (single-system, program-management, or collaborating 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 numbers of the dentists registered in the above institutions were realized.

We adopted the statistical methods of a Japanese study described as follows.[2] The number of practicing dentists registered in individual postgraduate dental training institutions was summed by city or county, and the result was defined as the number of practicing dentists in dental training institutions in a city or a county. On the other hand, according to the types of the institutions, the numbers of practicing dentists who registered in different types of postgraduate dental training institutions were divided into three categories and summed by city or county, which were defined as the number of practicing dentists in single-

system institutions, the number of practicing dentists in program-management institutions, and the number of practicing dentists in collaborating institutions in a city or a county in Taiwan. Using these numbers as indices, this study compared disparities in the number of overall practicing dentists among cities and counties in Taiwan. As the control index, the number of overall practicing dentists was determined by city or county, based on data from the Ministry of Health and Welfare survey involving the population and the number of overall practicing dentists in 2018.[5]

For each of the numbers of practicing dentists in single-system institutions, those in program-management institutions, those in collaborating institutions, those in any training institutions, and the overall practicing dentists, the ratio of the maximum to minimum number (non-zero) and coefficient of variation were calculated as indicators of the maximum gap and relative dispersion, respectively. Then, as indicators of equality of geographical distribution of practicing dentists, Lorenz curves and Gini coefficients were used. In this study, the X axis of the Lorenz curve represented the cumulative percentages of the population sequentially from the city or county with the fewest practicing dentists per population. The Y axis represented the cumulative percentages of practicing dentists in single-system institutions, those in program-management

institutions, those in collaborating institutions, those in any training institutions, and the overall practicing dentists. The Gini coefficients were derived from the Lorenz curves.

Based on the data and information collected from the methodologies that just mentioned above, these data were stored in excel files and then put into analysis. We hoped that the results of this study could help us to understand the current geographical distribution of practicing dentists in postgraduate dental training institutions in Taiwan. Moreover, these data could become an important reference for the development of training programs for the PGYD.

Results

In this study, a list of 194 clinical training programs in 2018 was collected. Because 5 branches belonging to the Taipei City Hospital proposed training programs and all these 5 branches were also hospitals belong to the same institution administratively, there were 194 clinical training programs that were proposed by 190 institutions. Table 1 shows the numbers of practicing dentists in single-system institutions, program-management institutions, collaborating institutions, any training institutions, and the numbers of overall practicing dentists in 20 cities and counties in Taiwan in 2018.

Table 1 The numbers of dental training institutions and practicing dentists in each type of dental training institution and the numbers of overall practicing dentists in 20 cities and counties in Taiwan in 2018.

City or county[a]	Single-system		Program-management		Collaborating		[b]Dentists in any institutions	Overall dentists
	institutions	dentists	institutions	dentists	institutions	dentists		
Taipei City	27	823	9	98	63	764	1154	3269
New Taipei City	39	402	4	39	88	521	711	2616
Taoyuan City	12	187	2	17	43	305	358	1189
Taichung City	25	313	3	20	59	331	486	1922
Tainan City	6	171	3	33	29	273	360	1103
Kaohsiung City	14	177	3	143	42	299	474	1778
Keeling City	2	27	0	0	4	15	42	186
Hsinchu City	5	51	2	15	12	47	92	322
Chiayi City	2	38	1	4	4	45	49	226
Hsinchu County	2	11	0	0	5	11	22	243
Miaoli County	3	15	0	0	7	25	35	170
Changhua County	5	89	2	32	16	64	173	584
Nantou County	2	20	0	0	2	11	26	169
Yunlin County	2	15	1	5	3	8	28	174
Chiayi County	4	31	0	0	3	15	37	108
Pingtung County	2	12	0	0	4	17	24	210
Penghu County	1	6	0	0	2	7	7	36
Yilan County	2	23	1	11	4	21	38	172
Hualien County	3	29	1	5	4	18	44	149
Taitung County	0	0	0	0	3	12	12	67
Total	158	2440	32	422	406	2809	4172	14,693
Maximum gap	>39	>137.17	>9	>35.75	44	109.14	164.86	90.81
Coefficient of variation	1.34	1.63	1.35	1.75	1.28	1.50	1.45	1.29
Gini coefficient	—	0.420	—	0.496	—	0.351	0.353	0.329

[a] The first six items are municipalities.
[b] Some training institutions have both the statuses of main and collaborating institutions. The repeated calculation of the number of practicing dentists has been deducted.

Practicing dentists in single-system institutions

The total number of practicing dentists in 158 single-system institutions in Taiwan was 2440. Taipei City was the city with the largest number of practicing dentists (823, 33.73%), and Penghu County was the county with the smallest number of practicing dentists (6, 0.25%) in single-system institutions among all cities and counties in Taiwan. There was one area, Taitung County, without any single-system institution. The mean number of practicing dentists in single-system institutions in one city or county in Taiwan was 122. There were 14 of the 20 cities and counties with 89 or fewer practicing dentists in single-system institutions that were below the mean number of 122 practicing dentists in single-system institutions in one city or county in Taiwan. The maximum gap was >137.17 times, the coefficient of variation was 1.63, and the Gini coefficient was 0.420, as shown in Table 1 and Fig. 1 (A).

Practicing dentists in program-management institutions

The total number of practicing dentists in 32 program-management institutions was 422. Kaohsiung City was the city with the largest number of practicing dentists (143, 33.89%), and Chiayi City was the city with the smallest number of practicing dentists (4, 0.95%) in program-management institutions among all cities and counties in Taiwan. It should be noted that there were eight areas without any program-management institution. The mean number of practicing dentists in program-management institutions in a city or county in Taiwan was 21.1. There were 15 of the 20 cities and counties with 20 or fewer practicing dentists that were below the mean number of 21.1 practicing dentists in program-management institutions in a city or county in Taiwan. The maximum gap was >35.75 times, the coefficient of variation was 1.75, and the Gini coefficient was 0.496, as shown in Table 1 and Fig. 1 (B.)

Practicing dentists in main training institutions

The single-system and program-management institutions are the managers of training programs, also known as main training institutions in PGYD. Therefore, the statistics of the two types of institutions were combined. The total number of practicing dentists in 190 main training institutions was 2862. Taipei City was the city with the largest number of practicing dentists (921, 32.18%), and Penghu County was the county with the smallest number of practicing dentists (6, 0.21%) in main training institutions among all cities and counties in Taiwan. There was one area, Taitung County, without any main training institution. The mean number of practicing dentists in main training institutions in a city or county in Taiwan was 143.1. There were 14 of the 20 cities and counties with 121 or fewer practicing dentists that were below the mean number of 143.1 practicing dentists in main training institutions in a city or county in Taiwan. The maximum gap was >153.5 times, the coefficient of variation was 1.57.

Practicing dentists in collaborating institutions

The total number of practicing dentists in 406 collaborating institutions was 2809. Taipei City was the city with the largest number of practicing dentists (764, 27.20%), and Penghu County was the county with the smallest number of practicing dentists (7, 0.25%) in collaborating institutions among all cities and counties in Taiwan. The mean number of practicing dentists in collaborating institutions in a city or county in Taiwan was 140.45. There were 14 of the 20 cities and counties with 64 or fewer practicing dentists that were below the mean number of 140.45 practicing dentists in collaborating institutions in a city or county in Taiwan. The maximum gap was 109.14 times, the coefficient of variation was 1.50, and the Gini coefficient was 0.351, as shown in Table 1 and Fig. 1 (C).
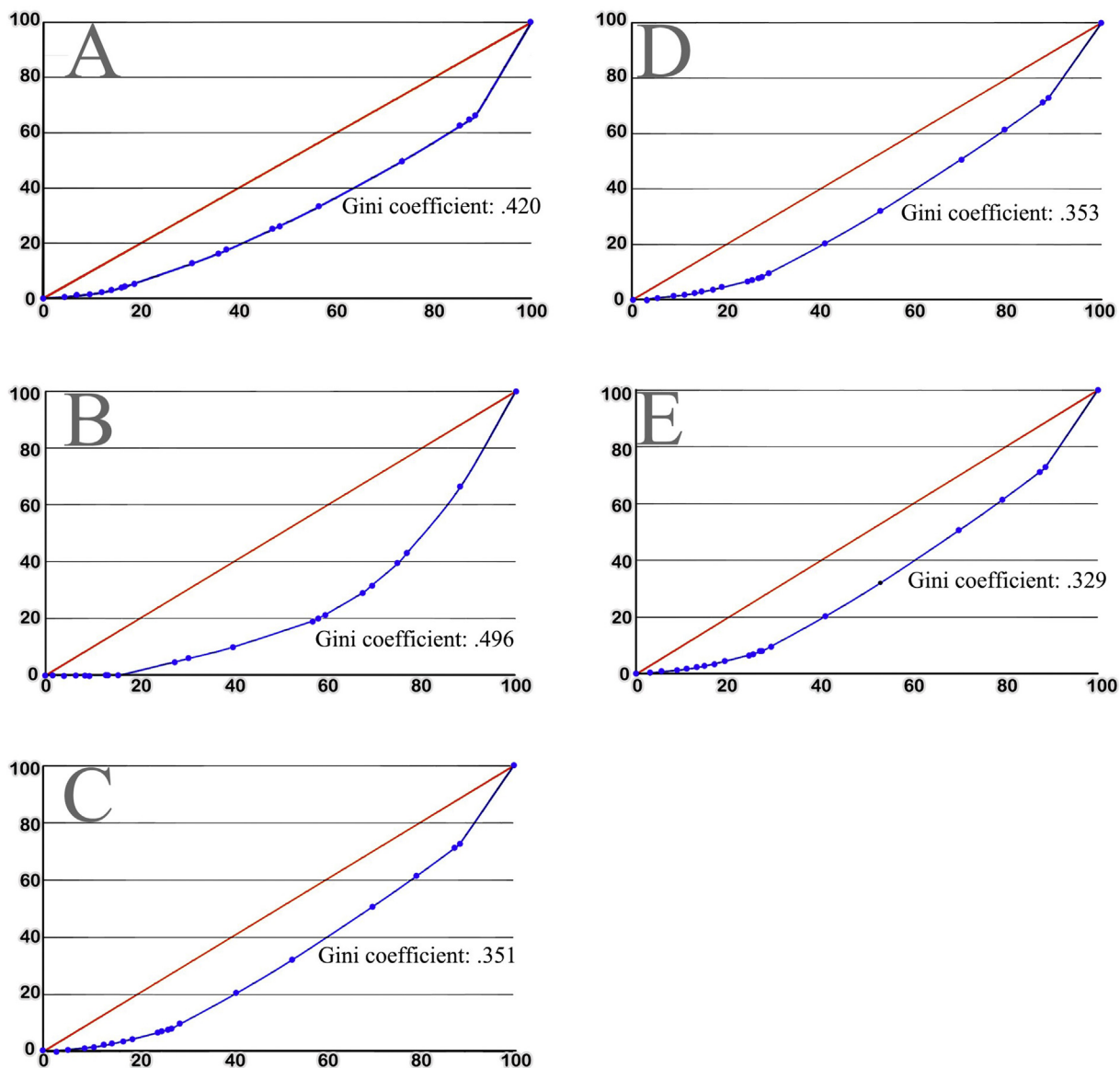
Practicing dentists in any training institutions

The total number of practicing dentists in all training institutions was 4172. Taipei City was the city with the greatest number of practicing dentists (1,154, 27.66%), and Penghu County was the county with the smallest number of practicing dentists in any training institutions (7, 0.17%) among all cities and counties in Taiwan. The mean number of practicing dentists in any training institutions in a city or county in Taiwan was 208.6. There were 14 of the 20 cities and counties with 173 or fewer practicing dentists that were below the mean number of 208.6 practicing dentists in any training institutions in a city or county in Taiwan. The maximum gap was 164.86 times, the coefficient of variation was 1.45, and the Gini coefficient was 0.353, as shown in Table 1 and Fig. 1 (D).

Overall practicing dentists

The total number of practicing dentists in Taiwan (excluding Kinmen and Lienchiang Counties) was 14,693. Taipei City was the city with the largest number of practicing dentists (3,269, 22.25%), and Penghu County was the county with the smallest number of practicing dentists (36, 0.25%) among all cities and counties in Taiwan. The mean number of practicing dentists in a city or county in Taiwan was 734.65. The maximum gap was 90.81 times, the coefficient of variation was 1.29, and the Gini coefficient was 0.329, as shown in Table 1 and Fig. 1 (E).

Comparison among the numbers of practicing dentists in main training institutions, and those in collaborating institutions revealed that the Taipei City had the maximum numbers of practicing dentists in main training institutions (921 practicing dentists) or in collaborating institutions (764 practicing dentists), and the Penghu County had the minimum numbers of practicing dentists in main training institutions (6 practicing dentists) or in collaborating institutions (7 practicing dentists). Moreover, the maximum gap in the number of practicing dentists in any training institutions was 164.86 times, which was larger than the maximum gap in the number of overall practicing dentists (90.81 times). However, the maximum gap in the number of practicing dentists in collaborating institutions (109.14

Figure 1 Lorenz curves of practicing dentists in each type of dental training institution and overall practicing dentists by city and county in Taiwan.

times) was closer to that (90.81 times) in the number of overall practicing dentists in all cities and counties.

The coefficient of variation for the number of overall practicing dentists was 1.29, which was smaller than that (1.63) for the number of practicing dentists in single-system institutions, that (1.75) for the number of practicing dentists in program-management institutions, and that (1.50) for the number of practicing dentists in collaborating

institutions, indicating that the geographical distribution of practicing dentists in each type of institution is more widely dispersed than that of overall practicing dentists. However, the coefficient of variation (1.50) for the number of practicing dentists in collaborating institutions was closer to that (1.45) for the number of practicing dentists in any training institutions.

The Lorenz curve for the number of practicing dentists in collaborating institutions was closer to the perfect equality line than that for the numbers of practicing dentists in single-system institutions and program-management institutions. Moreover, the Gini coefficient for the former was 0.351, which was lower than the values of 0.420 and 0.496 for the latter, respectively. For the number of overall practicing dentists, however, the Lorenz curve was closer to the perfect equality line, and the Gini coefficient was 0.329. This means that the disparities in the number of practicing dentists in any training institutions in cities and counties were compensated by cross-regional collaborating institutions under the joint training group system.

Discussion

The number of dental trainees belonging to a clinical training program or a facility indicates level of acceptance in the prefecture where the training resources are available.[2] Although this study used practicing dentists in each type of dental training institution as the analysis object, all statistical parameters were ratios or proportions, and the number of full-time dentists with 5 years of practice experience in the training institutions was the training capacity, which was also a proportional relationship. Thus, the statistical parameters calculated by the practicing dentists in a training institution were close to those calculated by dental trainees belonging to a training institution, assuming that the recruitment rate of dental trainees in each training institution is the same. Therefore, it can be inferred from the geographical distribution of practicing dentists in a training institution to those of dental trainees belonging to a training institution.

On the other hand, a clinical training facility group, in principle, must be formed within the same secondary medical-care area or the same prefecture under the system of postgraduate clinical training for physicians in Japan.[2] However, a joint training group can be composed of teaching hospitals in different cities and counties in Taiwan.[1] Similar to the Japanese system, the PGYD system in Taiwan allows a program-management institution to form a clinical training institution group with several collaborating institutions located in cities and counties other than the location of the program-management institution. Given the resulting movement of dental trainees across administrative boundaries under this join training group system, the number of dental trainees in each city or county should be counted on an institution basis, not on a program basis in the Japanese research.[2] In other words, the geographical distribution of overall practicing dentists was more accurately reflected to the number of practicing dentists in a training institution, rather than a program. Therefore, we didn't calculate the number of practicing dentists belonging to a training program in this study.

In Taipei, the city with the largest numbers of practicing dentists in training institutions, the numbers of practicing dentists were 921 for the main training institutions and 764 for the collaborating institutions. In Penghu, the county with the fewest numbers of practicing dentists in training institutions, the numbers of practicing dentists were 6 for the main training institutions and 7 for the collaborating institutions. It should be noted that one area, Taitung County, had none of main training institution. Therefore, the maximum gap was >153.5 times for the main training institutions and 109.14 times for the collaborating institutions. There were 14 of the 20 cities and counties with 121 or fewer practicing dentists that were below the mean number of 143.1 practicing dentists in main training institutions in a city or county in Taiwan, or with 64 or fewer practicing dentists that were below the mean number of 140.45 practicing dentists in collaborating institutions in a city or county in Taiwan. Because the geographical distribution of practicing dentists in training institutions can be inferred to the numbers of dental trainees belonging to different training institutions, these changes may illustrate the fact that main training institutions are the training places, where most of the dental trainees are accepted. Under the joint training group, it is likely that the resulting movement of dental trainees to cities and counties with fewer dental trainees may lead to redistribution of practicing dentists, which in turn reduces disparities in the number of practicing dentists in different cities and counties in Taiwan.

The Gini coefficient for practicing dentists in any training institutions was 0.353, however, those in single-system institutions and program-management institutions were 0.420 and 0.496, respectively, with the Lorenz curves having no intersecting. In contrast, the Gini coefficient for practicing dentists in collaborating institutions decreased from 0.353 to 0.351 with the Lorenz curves having no intersecting. This finding indicates that the disparities in the number of practicing dentists in any training institutions in cities and counties can be partially corrected by the redistribution of practicing dentists in the collaborating institutions.

The Lorenz curve, expressing the equality level of distribution, is mainly utilized to analyze the imbalance of income. If the distribution is completely equal, it is a straight diagonal line passing the points of origin. On the other hand, if the curve falls below the diagonal line indicating that the distribution becomes unequal. Therefore, the Gini coefficient is primarily utilized as an indicator of inequality in the allocation of resources such as income or manpower. The value of the Gini coefficient is only between 0 and 1. A value close to 1 means a more uneven distribution, and a value close to 0 means a more even distribution. Some foreign researches on the geographical distribution of physicians or dentists already utilized the Lorenz curve and Gini coefficient as indicators to analyze the imbalance of these resources. Thus, it seems reasonable to utilize them as indicators of the geographical distribution of practicing dentists.[2,6,7] The Gini coefficient has been reported to be 0.340 for the distribution of physicians by municipality in Japan in 1990,[6] and 0.129 for the distribution of overall physicians by state in the USA in 1992.[7] However, it is not easy to find different groups that are

suitable under various conditions and can be compared with each other using the Gini coefficient.[8] On the other hand, for income inequality internationally, the warning point of the Gini coefficient is set at 0.4, which can also be used as a reference for medical resource allocation research.[9]

In fact, it is also difficult to directly compare these Gini coefficient values in this study. However, this coefficient is still useful in relative comparison on the geographical distribution of dentists. For example, a Japanese study has reported the Gini coefficient to be 0.405 and 0.335 for the distributions of dental trainees belonging to a program or a facility, respectively. This Japanese study demonstrated that disparities in the number of dental trainees among prefectures are partly corrected by the redistribution of dental trainees under the facilities-group system,[2] similar to the results of our study. As mentioned earlier, the results of our study can be inferred from the geographical distribution of practicing dentists in a training institution to the number of dental trainees belonging to a training institution.

Both the maximum gap and coefficient of variation for the number of overall practicing dentists were smaller than those of the number of practicing dentists in each type of dental training institution, indicating that the current distribution of practicing dentists in the dental training institutions has a wider disparity than that of overall practicing dentists. Meanwhile, the Gini coefficient for the number of practicing dentists in each type of dental training institution was greater than that of the number of overall practicing dentists, indicating that the current distribution of practicing dentists in the dental training institutions by city or county was more imbalanced than that of overall practicing dentists.

While the basic purposes of the PGYD are described as the realization of community oral health development work, the operation of hospital-clinic referral, the understanding of patient safety and infection control in clinics, the practice of clinic management, and so on, it is recommended that dental clinics themselves can act as single-system or program-management institutions, and even university hospitals or medical centers, conduct clinical training programs with dental clinics under the system of joint training group.[1,10] As the importance of the roles of dental clinics as clinical training institutions has been recognized among the broader population, dental clinics not only have been just designated as collaborating institutions, but some of them also have been designated as single-system or program-management institutions.[2,3] These dental clinics designated as single-system or program-management institutions and medical centers, however, are usually concentrated in northern or urban areas.[3,11] If dental trainees prefer to continue their practice in or near the original training institution after training, regional disparities in the number of practicing dentists may further expand. However, a previous study did find that dental trainees have this tendency when they choose the location of practice, and believe that the current system may result in a more uneven geographical distribution of dentists.[1] In fact, under the system of postgraduate clinical training for physicians in Japan, practical measures have been discussed against the concentration of medical interns in urban areas.[2]

Another Japanese study reported that prefectures with more dentists or dental clinics have a greater ability to offer the postgraduate clinical training for dentists on the assumption that the number of clinical training programs for dentists in each prefecture reflects its ability to offer such training.[4] In our study, there were more training institutions and practicing dentists in Taiwan's municipalities, especially in Taipei City and New Taipei City. On the other hand, a comparison between the numbers of practicing dentists in single-system or program-management institutions and those in collaborating institutions demonstrated that disparities in the number of practicing dentists among cities and counties can be partially corrected under the joint training group system. Meanwhile, a comparison of the above numbers with the number of overall practicing dentists suggests that the imbalanced geographical distribution of dentists in postgraduate dental training institutions in Taiwan may become severe under the currently used PGYD system.

In Japan, clinical training in a remote area or an isolated island is only available in the form of a short-term dispatch within a month or a business trip to the training facility, therefore, the currently used PGYD system is less likely to serve as the driving force to preferentially allocate dentists to areas with fewer dentists.[2] Similar to the situation in Japan, our study found that there were very few training institutions and practicing dentists in a remote area (like Taitung) or an isolated island (like Penghu) in Taiwan, thus in the currently used PGYD system it is less likely to balance the geographical distribution of dentists by pushing dental trainees to areas with fewer dentists.

At present, all university hospitals and medical centers in Taiwan have proposed training programs of a single-system institution. Thus, according to the findings in this and other studies, in order to solve the problem mentioned above, university hospitals and medical centers should integrate local dental clinics to be collaborating institutions across cities and counties for joint implementation of PGYD. Besides, it is necessary to encourage dental clinics to participate in PGYD system and this in turn increases the number of collaborating institutions in those areas.[1—3]

Finally, this study found that the practicing dentists in each type of dental training institution showed a significantly greater imbalance in geographical distribution than the overall practicing dentists. This finding suggests that the currently used PGYD system may accelerate the imbalance in the geographical distribution of dentists in postgraduate dental training institutions in Taiwan. However, our study also found that this imbalance in the geographical distribution of practicing dentists in each type of training institution could be partially compensated by the adoption of cross-regional collaborating institutions under the joint training group system. Therefore, further studies on yearly changes in the geographical distribution of dentists in postgraduate dental training institutions by city or county should be taken to monitor whether we should further modify the currently used PGYD system toward a better one to solve the problem of imbalance in the

geographical distribution of dentists in postgraduate dental training institutions in Taiwan.

Declaration of Competing Interest

The authors have no conflicts of interest relevant to this article.

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