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Original Article

Regional distributions of overall dentists and institutional dentists in Taiwan in 2019



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Received 4 January 2021

Available online 18 January 2021

KEYWORDS

Urban-rural gap;
Uneven distribution
of dentists;
Postgraduate year
training program
for dentists;
Dental training
institutions

Abstract *Background/purpose:* Taiwan is facing a huge urban-rural gap in the human resources of dentists between cities and counties. Although the postgraduate year training program for dentists (PGYD) was implemented in Taiwan in 2010, the uneven distribution of dentists is still a serious problem. The purpose of this study was to evaluate the distributions of overall dentists and dental training institutions and their dentists (so-called institutional dentists) in each city and county in 2019 to further analyze the regional distributions of overall dentists and institutional dentists in Taiwan.

Materials and methods: This study collected the numbers of dentists, dental training institutions, and institutional dentists in each city and county in 2019 for evaluating the regional distributions of dentists and institutional dentists in Taiwan.

Results: The numbers of dentists and institutional dentists in municipalities were significantly higher than those in non-municipalities in Taiwan, respectively. The coefficient of variation

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<https://doi.org/10.1016/j.jds.2021.01.001>

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was greatest for dentists in the single-system institutions (1.72) and program-management institutions (1.87). The coefficients of correlation between the dentist index and institutional dentist index were $R^2 = 0.9805$ ($P < 0.001$) for municipalities, $R^2 = 0.4523$ ($P < 0.01$) for non-municipalities, and $R^2 = 0.7691$ ($P < 0.001$) for nationwide.

Conclusion: The dentist manpower and dental training institutions are concentrated in municipalities of Taiwan. The quantitative and qualitative improvement of collaborating institutions in the PGYD system may have an influence on the distribution of new-entry dentists and contribute to establishment of an effective regional dental health care service.

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Introduction

In Taiwan, there are three major dentist occupation problems: a surplus of dentists, an uneven distribution of dentists, and a concentration of dentists in the metropolitan areas.¹ Some studies considered that the number of dentists per 100,000 people reaches 50 as a standard of enough dentists for dental care services, which means that the dentist manpower can meet the needs of dental care services in Taiwan. In fact, this standard was reached as early as at the end of 2010, and was exceeded 14.09 in 2019. Furthermore, Taiwan is facing a huge difference in the human resources of dentists between cities and counties. In 2019, the number of dentists per 100,000 people in all 9 cities was more than 50. However, the corresponding value in 12 out of 13 counties was less than 50, and their population accounted for 25.94% of the total population.^{1–5}

During the period from 2010 to 2019, there were a total number of 4473 newly-registered dentists and a total number of 3471 additional practicing dentists, in which there was a difference of 1002 dentists. Therefore, there were 447 newly-registered dentists and 100 resigned dentists on average each year, and there were 347 practicing dentists added per year in the past ten years.^{6,7} Moreover, the annual increase of practicing dentists in Taiwan has already met the demand, and there has been no shortage of dentists in Taiwan. However, every year newly-registered dentists who are concentrated in the metropolitan areas may cause the uneven distribution of dentists to become a serious problem. Thus, to obtain effective dental services in the whole Taiwan region, it is necessary to maintain a balance between the numbers of dentists or dental clinics and the population through resolution of regional differences and urban concentrations of dentists. Every year, many dental students graduate from 7 domestic dental schools or departments in Taiwan (the newly-established 8th dental department still has no graduate students currently) and this has a particularly significant impact on the number of dentists in cities with dental schools or departments.^{7–10} In addition, increased dental students graduated from foreign dental schools or departments also have a significant impact on the total number of dentists in Taiwan.⁵ All dental schools or departments are located in the metropolitan areas of the municipalities in Taiwan. Therefore, many new dentists graduated from these dental schools gather in municipalities with dental schools in

Taiwan every year and this also has a particularly significant impact on the number of dentists in municipalities. Taiwan's postgraduate year training program for dentists (PGYD) is not mandatory. Unless the dentists want to become the owner of a dental clinic or enter the dental specialist training programs, they do not need to participate in the PGYD program. Moreover, the training content also includes participation in dental services in remote areas of Taiwan, trying to resolve regional differences in distribution of dentists.^{1,2} Therefore, evaluation of the associations among distributions of dentists and dental training institutions in cities and counties was very important for assessing uneven regional distributions of dentists and the need of dentists in those counties without enough dentists.

In Taiwan, the PGYD system was implemented in 2010. However, there was no detailed analysis on the associations among distributions of dentists and dental training institutions in cities and counties. Therefore, in this study, we examined the distributions of overall dentists, PGYD clinical training institutions and their dentists (so-called institutional dentists in the following text) in each city and county of Taiwan in 2019 to further analyze the regional distributions of overall dentists and institutional dentists in Taiwan.

Materials and methods

This study used the method of secondary data analysis to collect the information about the population and the numbers of overall dentists and institutional dentists in Taiwan in 2019. This information was open to access and could be collected from the related websites.

We obtained the population data including the total population in cities and counties at the end of 2019 from the website of the Ministry of the Interior. In addition, the information of overall dentists in cities and counties at the end of 2019 was available at the website of the Ministry of Health and Welfare. We also obtained the PGYD program name list that was effective in 2018 from the website of the Joint Committee of Taiwan. The information in the list 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 collaborating institution), and the

administrative regions in Taiwan. Therefore, through exploiting the institution and staff searching system of the Ministry of Health and Welfare by the time of November 2019, the numbers of dentists registered in the PGYD training institutions were realized and recorded.

The whole area of Taiwan was divided into two groups: municipalities and non-municipalities. Taiwan currently has 9 cities (including 6 municipalities and 3 non-municipalities) and 13 counties (including 10 in Taiwan and 3 in offshore islands). For statistical analysis, coefficient of variation (CV) was determined for comparisons of variability. Mann–Whitney *U* test was used for comparisons between two subgroups, and Kruskal–Wallis test was used for comparisons among three or more subgroups. Furthermore, we defined the dentist index or the institutional dentist index as the ratio of dentists per 100,000 people or the ratio of institutional dentists per 100,000 people to their corresponding values in the whole area of Taiwan, respectively. Then, the coefficient of correlation was used for comparisons between the dentist index and the institutional dentist index.

Results

The numbers of dental training institutions and institutional dentists in three types of dental training institution and the number of overall dentists in 22 cities and counties in Taiwan in 2019

The numbers of dental training institutions and institutional dentists in three types of dental training institution and the number of overall dentists in 22 cities and counties in Taiwan in 2019 were obtained and shown in Table 1. In Taiwan, the total number of practicing dentists was 15,127 in 2019. Meanwhile, there was a total number of 4129 institutional dentists in 481 dental training institutions. Of these 4129 institutional dentists (27.30% of the overall dentists), 2473 were in 155 single-system institutions, 422 in 32 program-management institutions, and 2828 in 385 collaborating institutions (Table 1). Therefore, there was an average number of 8.58 (4129/481) dentists per institution. Moreover, the average numbers of institutional dentists were 15.95 (2473/155) for single-system institutions, 13.19 (422/32) for program-management institutions, and 7.35 (2828/385) for collaborating institutions (Table 1).

Taipei City was the city with the largest number of institutional dentists (1,105, 26.76% of 4129), and Taitung County was the county with the smallest non-zero number of institutional dentists (11, 0.27% of 4129) among all cities and counties in Taiwan (Table 1). It should be noted that there was none of dental training institution in Kinmen County and Lienchiang County. The mean number of institutional dentists per city or county of Taiwan was 187.68 (4129/22). There were 16 of the 22 cities and counties with 176 or fewer institutional dentists that were below the mean number of 187.68 institutional dentists per city or county of Taiwan. Besides, Taipei City was also the city with the largest mean number of institutional dentists per institution (13.81 or 1105/80), and Taitung County was also the county with the smallest mean non-zero number of

institutional dentists per institution (3.67 or 11/3) among all cities and counties in Taiwan (Table 1). There were 17 of the 22 cities and counties with 8.40 or fewer institutional dentists per institution that were below the average number of 8.58 institutional dentists per institution for the overall 481 dental training institutions in Taiwan.

Furthermore, 2473 institutional dentists were in 155 single-system institutions. Taipei City was the city with the largest number of institutional dentists (815, 32.96%) in single-system institutions, and Penghu County was the county with the smallest non-zero number of institutional dentists (8, 0.32%) in single-system institutions among all cities and counties in Taiwan (Table 1). It should be noted that there were 3 counties without any single-system institution. The mean number of institutional dentists in single-system institutions per city or county of Taiwan was 112.41 (2473/22). There were 16 of the 22 cities and counties with 93 or fewer institutional dentists in single-system institutions that were below the mean number of 112.41 institutional dentists in single-system institutions per city or county of Taiwan (Table 1). Besides, Taipei City was also the city with the largest average number of institutional dentists (31.35 or 815/26) in single-system institutions, and Yunlin County was the county with the smallest average non-zero number of institutional dentists (5.50 or 11/2) in single-system institutions among all cities and counties in Taiwan (Table 1). There were 17 of the 22 cities and counties with 13.29 or fewer institutional dentists per single-system institution that were below the average number of 15.95 (2473/155) institutional dentists per single-system institution (Table 1).

A total of 422 dentists were in 32 program-management institutions. Kaohsiung City was the city with the largest number of institutional dentists (144, 34.12%) in program-management institutions, and Chiayi City was the city with the smallest non-zero number of institutional dentists (4, 0.95%) in program-management institutions among all cities and counties in Taiwan (Table 1). It should be noted that there were 10 cities or counties without any program-management institution. The mean number of institutional dentists in program-management institutions per city or county in Taiwan was 19.18 (422/22). There were 16 of the 22 cities and counties with 14 or fewer institutional dentists in program-management institutions that were below the mean number of 19.18 institutional dentists in program-management institutions per city or county in Taiwan (Table 1). Besides, Kaohsiung City was also the city with the largest average number of institutional dentists per program-management institution (48.00 or 144/3), and Chiayi City was also the city with the smallest average non-zero number of institutional dentists per program-management institution (4.00 or 4/1) among all cities and counties in Taiwan (Table 1). There were 20 of the 22 cities and counties with 13.00 or fewer institutional dentists per program-management institution that were below the average number of 13.19 institutional dentists per program-management institution (Table 1).

A total of 2828 dentists were in 385 collaborating institutions. Taipei City was the city with the largest number of institutional dentists (766, 27.09%) in collaborating institutions, and Yunlin County was the county with the smallest non-zero number of institutional dentists (7,

Table 1 The numbers of dental training institutions and dentists in three different types of dental training institution and the number of overall dentists in 22 cities and counties in Taiwan in 2019.

*City or county	Single-system		Program-management		Collaborating		#All training institutions		Overall dentists
	Institutions	Dentists	Institutions	Dentists	Institutions	Dentists	Institutions	Dentists	
Taipei City	26	815	9	99	62	766	80	1105	3325
New Taipei City	38	419	4	38	85	528	102	723	2712
Taoyuan City	12	197	2	14	41	308	47	362	1237
Taichung City	25	314	3	23	57	331	70	494	1963
Tainan City	6	176	3	35	28	266	31	293	1131
Kaohsiung City	14	186	3	144	42	308	52	503	1862
Municipalities	121	2107	24	353	315	2507	382	3480	12,230
Mean	20.17	351.17	4.00	58.83	52.50	417.83	63.67	580.00	2038.33
Standard deviation	11.67	246.11	2.53	51.31	20.05	193.95	25.52	296.41	849.88
Coefficient of variation	0.58	0.70	0.63	0.87	0.38	0.46	0.40	0.51	0.42
Keelung City	2	24	0	0	4	16	6	40	194
Hsinchu City	4	43	2	11	11	48	14	82	335
Chiayi City	2	38	1	4	4	44	5	48	229
Hsinchu County	2	15	0	0	5	15	7	30	251
Miaoli County	3	17	0	0	6	27	8	38	176
Changhua County	5	93	2	31	15	61	20	176	588
Nantou County	2	20	0	0	2	10	4	30	161
Yunlin County	2	11	1	5	3	7	6	23	181
Chiayi County	4	31	0	0	3	12	6	35	108
Pingtung County	2	12	0	0	4	17	6	29	213
Penghu County	1	8	0	0	2	10	3	18	38
Yilan County	2	24	1	13	4	23	5	42	182
Hualien County	3	30	1	5	4	20	6	47	150
Taitung County	0	0	0	0	3	11	3	11	66
Kinmen County	0	0	0	0	0	0	0	0	18
Lienchiang County	0	0	0	0	0	0	0	0	7
Non-municipalities	34	366	8	69	70	321	99	649	2897
Mean	2.13	22.88	0.50	4.31	4.38	20.06	6.19	40.56	181.06
Standard deviation	1.45	22.84	0.73	8.24	3.79	17.25	4.90	41.26	140.24
Coefficient of variation	0.68	1.00	1.46	1.91	0.87	0.86	0.79	1.02	0.77
Nationwide	155	2473	32	422	385	2828	481	4129	15,127
Mean	7.05	112.41	1.45	19.18	17.50	128.55	21.86	187.68	687.59
Standard deviation	10.08	192.85	2.11	35.96	24.23	205.05	29.31	287.40	950.15
Coefficient of variation	1.43	1.72	1.45	1.87	1.38	1.60	1.34	1.53	1.38

*The first six items are municipalities.

#Some dental training institutions have both the roles of main and collaborating institutions. The repeated calculation of the numbers of dental training institutions and dentists has been deducted.

0.25%) in collaborating institutions among all cities and counties in Taiwan (Table 1). It should be noted that there were 2 counties without any collaborating institution. The mean number of institutional dentists in collaborating institutions per city or county in Taiwan was 128.55 (2828/22). There were 16 of the 22 cities and counties with 61 or fewer institutional dentists in collaborating institutions that were below the mean number of 128.55 institutional dentists in collaborating institutions per city or county in Taiwan (Table 1). Besides, Taipei City was also the city with the largest average number of institutional dentists per collaborating institution (12.35 or 766/62), and Yunlin County was also the county with the smallest average non-zero number of institutional dentists per collaborating institution (2.33 or 7/3) among all cities and counties in Taiwan (Table 1). There were 18 of the 22 cities and

counties with 7.33 or fewer institutional dentists per collaborating institution that were below the average number of 7.35 institutional dentists per collaborating institution (Table 1).

The coefficient of variation (CV) of institutional dentists for single-system institutions (1.72), program-management institutions (1.87), and collaborating institutions (1.60) were higher than that (1.38) of overall dentists, and some counties lacking single-system, program-management and collaborating institutions were recognized. However, the CV of institutional dentists for all dental training institutions (1.53) was close to that (1.38) of overall dentists (Table 1).

When comparing the institutional dentists between municipalities and non-municipalities, the total numbers of dentists were 12,230 in municipalities and 2897 in non-

municipalities. Meanwhile, there was a total number of 3480 institutional dentists in municipalities, accounted for 28.45% of all dentists in municipalities. Moreover, there was a total number of 649 institutional dentists in non-municipalities, accounted for 22.40% of all dentists in non-municipalities. The number of institutional dentists (3,480, 84.28%) in municipalities was significantly higher than that (649, 15.72%) in non-municipalities ($P < 0.001$). Moreover, 2,107, 353, and 2507 institutional dentists in municipalities and 366, 69, and 321 institutional dentists in non-municipalities were registered in the single-system, program-management, and collaborating institutions, respectively. As stated above, the numbers of institutional dentists registered in single-system, program-management, and collaborating institutions in municipalities were all significantly higher than the corresponding numbers of institutional dentists registered in single-system, program-management, and collaborating institutions in non-municipalities of Taiwan, respectively ($P < 0.001$) (Table 1).

In addition, we also found that the nationwide average number of institutional dentists per institution was 8.58 (4129/481). However, this average number of institutional dentists per institution was highest for single-system institutions (15.95 or 2473/155), followed by program-management institutions (13.19 or 422/32) and collaborating institutions (7.35 or 2828/385) (Table 1). Moreover, this average number of institutional dentists per institution in municipalities was 9.11 (3480/382) for all dental training institutions, of which it was also highest for single-system institutions (17.41 or 2107/121), followed by program-management institutions (14.71 or 353/24), and collaborating institutions (7.96 or 2507/315). The corresponding number of institutional dentists per institution in non-municipalities was 6.56 (649/99) for all dental training institutions, of which it was also highest for single-system institutions (10.76 or 366/34), followed by program-management institutions (8.63 or 69/8), and collaborating institutions (4.59 or 321/70) (Table 1).

We also found that the mean numbers of institutional dentists per institution for each type of institution in municipalities were all significantly higher than the corresponding mean numbers of institutional dentists per institution for each type of institution in non-municipalities, respectively (all P -values < 0.01). The mean number of institutional dentists per institution for all institutions in municipalities was also significantly higher than that in non-municipalities ($P < 0.05$). Moreover, the mean number of institutional dentists per institution for single-system institutions was significantly higher than that for program-management institutions and that for collaborating institutions, respectively (both P -values < 0.01).

The distributions of dentist index and institutional dentist index in 22 cities and counties in Taiwan in 2019

Because a larger population might need a larger number of dentists and institutional dentists for providing dental services, we used the population of December 2019 to calculate the number of dentists per 100,000 people and the number of institutional dentists per 100,000 people in each

city or county of Taiwan. We found that there were 64.09 dentists per 100,000 people nationwide in Taiwan in 2019 (Table 2). Taipei City was the city with the largest number (125.71) of dentists per 100,000 people, and Kinmen County was the county with the smallest number (12.84) of dentists per 100,000 people among 22 cities and counties of Taiwan. However, Lienchiang County had a very sparse population, so its number of dentists per 100,000 people (53.48) was higher than 13 cities and counties of non-municipalities in Taiwan. There were 16 of the 22 cities and counties with 60.13 or fewer dentists per 100,000 people that were below the number of 64.09 dentists per 100,000 people nationwide in Taiwan (Table 2).

Furthermore, there were 17.49 institutional dentists per 100,000 people nationwide in Taiwan in 2019 (Table 2). Taipei City was also the city with the largest number (41.78) of institutional dentists per 100,000 people, and Yunlin County was the county with the smallest non-zero number (3.38) of institutional dentists per 100,000 people among 22 cities and counties of Taiwan. There were 16 of the 22 cities and counties with 17.11 or fewer institutional dentists per 100,000 people that were below the number of 17.49 institutional dentists per 100,000 people nationwide in Taiwan (Table 2). The coefficient of variation (CV) of institutional dentists per 100,000 people (0.76) was wider than that (0.50) of dentists per 100,000 people (Table 2).

The mean numbers of dentists per 100,000 people were 74.20 in municipalities and 41.33 in non-municipalities. Meanwhile, the mean numbers of institutional dentists per 100,000 people were 21.19 in municipalities and 8.68 in non-municipalities (Table 2). We discovered that the mean number of dentists per 100,000 people (74.20) and the mean number of institutional dentists per 100,000 people (21.19) in municipalities were both significantly higher than the corresponding mean numbers (41.33 and 8.68, respectively) in non-municipalities (both P -values < 0.01) (Table 2).

Each value of dentists per 100,000 people and each value of institutional dentists per 100,000 people was calculated with an index of 100. The coefficient of correlation between the dentist index and the institutional dentist index was $R^2 = 0.7691$ ($P < 0.001$) with a slope of 1.1612 for nationwide. Moreover, the coefficients of correlation between the dentist index and the institutional dentist index were $R^2 = 0.9805$ ($P < 0.001$) with a slope of 1.4243 for municipalities ($n = 6$) and $R^2 = 0.4523$ ($P < 0.01$) with a slope of 0.7929 for non-municipalities ($n = 16$) (Fig. 1).

Discussion

In Taiwan, the Medical Care Act was enacted and announced in November 1986, and Article 15 of which has regulations on the postgraduate training for more than two years for dentists and physicians. Since the government does not further regulate the training content afterwards, as long as dentists and physicians have worked in a hospital or a clinic for two years, they meet the requirements of the Medical Care Act for the postgraduate training. As late as 2010, the Department of Health (after 2013, Department of Health was renamed as the Ministry of Health and Welfare)

Table 2 The distributions of dentist index and institutional dentist index in 22 cities and counties in Taiwan in 2019.

	Number of dentists per 100,000 people	Dentist index (%)	Number of institutional dentists per 100,000 people	Institutional dentist index (%)
Taipei City	125.71	196.15	41.78	238.88
New Taipei City	67.48	105.29	17.99	102.86
Taoyuan City	55.00	85.82	16.10	92.05
Taichung City	69.73	108.80	17.55	100.34
Tainan City	60.13	93.82	15.58	89.08
Kaohsiung City	67.14	104.76	18.14	103.72
Municipalities	74.65	116.48	21.24	121.44
Mean	74.20	—	21.19	—
Standard deviation	25.82	—	10.14	—
Coefficient of variation	0.35	—	0.48	—
Keelung City	52.59	82.06	10.84	61.98
Hsinchu City	74.64	116.46	18.27	104.46
Chiayi City	85.55	133.48	17.93	102.52
Hsinchu County	44.51	69.45	5.32	30.42
Miaoli County	32.27	50.35	6.97	39.85
Changhua County	46.20	72.09	13.83	79.07
Nantou County	32.58	50.83	6.07	34.71
Yunlin County	26.57	41.46	3.38	19.33
Chiayi County	21.47	33.50	6.96	39.79
Pingtung County	26.00	40.57	3.54	20.24
Penghu County	36.12	56.36	17.11	97.83
Yilan County	40.07	62.52	9.25	52.89
Hualien County	45.98	71.74	14.41	82.39
Taitung County	30.45	47.51	5.07	28.99
Kinmen County	12.84	20.03	0.00	0
Lienchiang County	53.48	83.45	0.00	0
Non-municipalities	40.12	62.60	8.99	51.40
Mean	41.33	—	8.68	—
Standard deviation	18.90	—	6.08	—
Coefficient of variation	0.46	—	0.70	—
Nationwide	64.09	100	17.49	100
Mean	50.30	—	12.09	—
Standard deviation	25.27	—	9.13	—
Coefficient of variation	0.50	—	0.76	—

announced to confirm the implementation of postgraduate year training program for dentists (PGYD) in 2010. Then, in 2017, it announced to confirm the implementation of postgraduate year training program for physicians in 2019. Both training programs last for two years, and they are not mandatory.¹¹ On the other hand, in Japan, the Medical Practitioners Law and Dental Practitioners Law were both revised in 2000 to make the postgraduate clinical training compulsory for physicians in 2004 and for dentists in 2006.¹²

Postgraduate clinical training institutions are classified into single-system, program-management, and collaborating institutions. Clinical training can only be completed in a single-system institution under a single-system program, but can also be implemented in more than 2 group institutions under a joint training group program, which combines the clinical training in program-management and collaborating institutions. Moreover, it requires both at least one hospital and one dental clinic to participate in the training program.^{11,13} The Japan's postgraduate clinical training for dentists is similar to ours. Their postgraduate clinical training facilities are classified into single-type,

management-type, and cooperative-type facilities.¹² In Taiwan, PGYD has been implemented for 10 years. The postgraduate clinical training program has already been implemented in many dental institutions, including hospitals with dental departments and dental clinics. The distribution of such training institutions is considered to have a certain effect on the choice of practice location by new-entry dentists after the completion of PGYD. In Taiwan, the clinical training institutions for medical postgraduate clinical training program are required to be located in the teaching hospitals joint training system. In Japan, clinical training facilities for physicians are required to be located in the second-grade medical care areas. However, there is no such stipulation for PGYD in Taiwan.¹¹

Japan's postgraduate clinical training for dentists started only a few years earlier than that of Taiwan, but they quickly discovered that the groups of management-type clinical training facilities for dentistry differ considerably from those for medicine, and many straddle prefectures have formed groups with cooperative-type facilities. They also concluded that the presence or absence of a dental

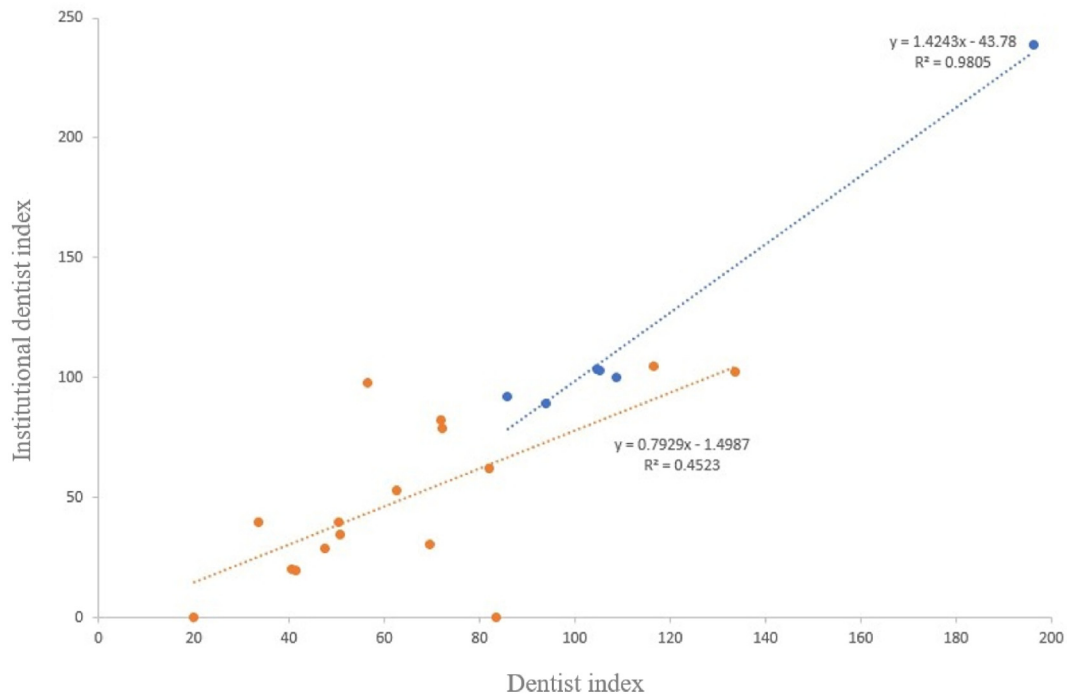


Figure 1 Correlation of dentist index and institutional dentist index according to municipalities and non-municipalities in Taiwan in 2019. ●: The group of municipalities. ●: The group of non-municipalities. The regression for municipalities: $y = 1.4243x - 43.78$, $R^2 = 0.9805$ ($P < 0.001$). The regression for non-municipalities: $y = 0.7929x - 1.4987$, $R^2 = 0.4523$ ($P < 0.01$). The regression for nationwide: $y = 1.1612x - 21.996$, $R^2 = 0.7691$ ($P < 0.001$).

school or college has a large effect on the number of dental residents in a particular area. Transfer of dental residents and enhancement of cooperative-type clinical training facilities in regions with a small percentage of dentists are considered to help in alleviating uneven regional distributions of dentists.¹²

Different from the Japanese viewpoint, we further investigated the number of dentists in dental training institutions and discovered the impact of the PGYD system on the distribution of dentists. In 2019, the number of dental training institutions accounted for only 6.80% (481/7077) of all dental institutions, but the number of institutional dentists in dental training institutions accounted for as much as 27.30% (4129/15,127) of overall dentists.^{6,14} This indicates that more than a quarter of dentists who work in dental training institutions. Therefore, the influence of the PGYD system on the distribution of dentists cannot be ignored.

In 2019, the average numbers of practicing dentists per dental institution were 10.77 (2186/203) for hospitals with dental departments, 1.88 (12,941/6874) for dental clinics, and 2.14 (15,127/7077) for all dental institutions, respectively.^{6,14} However, this average number was 8.58 for all dental training institutions, of which it was highest for single-system institutions (15.95), followed by program-management institutions (13.19) and collaborating institutions (7.35). Obviously, the human resources of dentists in dental training institutions were much more than those in general institutions.

For each type of dental training institution and all dental training institutions, the CVs of institutional dentists of

three different types of dental training institution were wider than that of all dental training institutions. Therefore, the dispersion of the distributions of institutional dentists was wider than that of all dental training institutions. The CV of institutional dentists (1.60) in collaborating institutions was lower than those of institutional dentists in single-system (1.72) and program-management (1.87) institutions, but was still higher than that of overall dentists (1.38). Therefore, it can only be said that the collaborating institutions have the effect of reducing uneven regional distributions of dentists within the PGYD system, especially in counties with few dentists, to avoid excessive uneven regional distributions of dentists due to the PGYD system, but it cannot be stated that collaborating institutions have the effect on reducing nationwide uneven regional distributions of dentists. On the other hand, the training institutions can attract new-entry dentists to come for training. Because training institutions provide better resources, they can also attract dentists to work in the training institutions. However, in recent years the number of dentists grew rapidly. Therefore, the PGYD system might also result in an increase in the average number of dentists per dental training institution and the development of large-scale dental departments in hospitals. The current situation was also conducive to the development of large-scale dental institutions and chain dental clinics, but not conducive to reducing uneven regional distributions of dentists.^{11,15}

In Japan, the number of dentists per 100,000 people continued to increase in the past. However, the gap due to the presence or absence of dental schools or colleges has

not improved, and it has increased with a clear difference in absolute numbers in fact.¹² In Taiwan, all dental schools and most medical centers are concentrated in municipalities. The increase of the number of dentists per 100,000 people after the implementation of PGYD was faster than that before the implementation of PGYD. However, the gap between municipalities and non-municipalities has continued to expand, and it has also increased with a clear difference in absolute numbers of dentists between municipalities and non-municipalities in Taiwan.^{11,14}

When the population gathers in municipalities, more medical and educational training resources are gathered there. In 2019, there was 69.41% population in municipalities of Taiwan. However, there were 12,230 dentists (80.85% of a total of 15,127 dentists in Taiwan), 382 dental training institutions (79.42% of a total of 481 dental training institutions in Taiwan), and 3480 institutional dentists (84.28% of a total of 4129 institutional dentists in Taiwan) in municipalities of Taiwan. Of 3480 institutional dentists in municipalities of Taiwan, 2107 (85.20% of a total of 2473) were in single-system institutions, 353 (83.65% of a total of 422) in program-management institutions, and 2507 (88.65% of a total of 2828) in collaborating institutions. In addition, Taipei City's population accounted for 11.21% of the total population in Taiwan. However, there were 3325 dentists (21.98% of a total of 15,127 dentists in Taiwan), 80 dental training institutions (16.63% of a total of 481 dental training institutions in Taiwan), and 1105 institutional dentists (26.76% of a total of 4129 institutional dentists in Taiwan) in Taipei City. Therefore, there was a serious urban-rural gap of dentist manpower and dental training resources between municipalities and non-municipalities of Taiwan. Moreover, the gap of dental training resources was wider than that of dentist manpower. Furthermore, the quality and quantity of required dental care vary as the population of a city or a country rises and falls, but any regional gap is likely to increase subsequently, depending on differences in the numbers of new-entry dentists, which may be affected by the PGYD system.¹²

In 2019, the correlation between the dentist index and the institutional dentist index was very close ($R^2 = 0.7691$) with a slope of 1.1612 among all cities and counties in Taiwan. This indicates that an increase in the dentist index by one unit may increase the institutional dentist index by 1.1612 units. Moreover, the correlation between the dentist index and the institutional dentist index was also very intimate ($R^2 = 0.9805$) with a slope of 1.4243 for municipalities, and was moderate ($R^2 = 0.4523$) with a slope of 0.7929 for non-municipalities (Fig. 1). This means that when the number of dentists in municipalities increases, more institutional dentists increase in proportion, which also indicates that it is possible to attract more new-entry dentists to municipalities in Taiwan.

Although the effect of the presence of a dental school or a medical center in municipalities on the number of dentists and new-entry dentists in a particular area of Taiwan can be verified through comparison of data for medicine,¹² in Taiwan we currently do not have enough relevant data to evaluate the effect of the presence of a medical school or a medical center in municipalities on the number of physicians and new-entry physicians in a particular area of Taiwan due to that the implementation

of postgraduate year training program for physicians was as late as in 2019.

Empirical findings from the implementation of postgraduate clinical training for physicians in Japan indicate that physicians tend to select clinical training hospitals over medical university hospitals for postgraduate clinical training due to the implementation of new postgraduate clinical training program. Increased separation of physicians from medical university hospitals led to a decrease in the supply of physicians from these hospitals in prefectures with few practitioners. However, this is now accelerating the shortage of physicians in certain regions and widening regional differences in medical services. The proportion of dental trainees in dental university hospitals is 85.3% in 2006, but since many of them become dental practitioners in dental clinics after the completion of their dental clinical training, the percentage of trained dentists remaining in university hospitals is not large. Thus, it is considered that the increasing trend of regional gap seen in medicine is not connected to dentistry because of the difference in the system for dispatching practitioners from university hospitals.¹²

In addition, according to the survey in Taiwan in 2018, the proportion of dental trainees in hospitals was about 60% since the implementation of PGYD. However, because 85.55% (12,941/15,127) of total practicing dentists work in dental clinics in 2019, the proportion of dentists working in hospitals is not large. Thus, the increasing trend of regional gap seen in medicine in Japan is also not connected to Taiwan's dentistry because of the difference in the system for dispatching dental trainees among hospitals and dental clinics and a high percentage of clinic dentists in total practicing dentists.^{6,11}

Since the implementation of Japan's postgraduate clinical training for dentists in 2006, dental school hospitals have been actively conducting training programs under the group system and have acquired a large number of cooperative-type facilities. The prefectures with high numbers of cooperative clinical training facilities were the prefectures with dental schools or colleges, but not the areas with few dentists.¹² Therefore, more and more dental clinics have participated in clinical training programs, which have been mainly in the group system collaborating with the hospitals to serve as the training facilities.¹⁶ Some studies found that dental clinics designated as cooperative-type facilities have little effect on recruiting new-entry dentists to dental clinics for training. Thus, an increase in the number of dental clinics associated with single-type/management-type facility is needed to promote clinical training in dental clinics. However, these dental clinical training facilities are not necessarily designated in areas with few new-entry dentists. If they are intensively designated in urban areas in clinical training programs, uneven regional distribution of dentists may further expand.¹⁷

In Taiwan, more and more dental clinics have participated in the PGYD system, and they have been mainly in the group system collaborating with other dental clinics and hospitals to serve as the training institutions. There have been also many dental clinics designated as single-system institutions or program-management institutions. However, they are mainly in the metropolitan areas of municipalities, not in the areas with few dentists. Moreover, university hospitals and medical centers almost only propose single-

system programs, and do not contribute to the quantitative and qualitative improvement of collaborating institutions.¹¹

In this study, we conclude that the dentist manpower and dental training resources are concentrated in municipalities of Taiwan, and these resources are especially concentrated in Taipei City. Although the implementation of PGYD has the expectation of balancing the distribution of dentists, the results of the implementation of PGYD show that the distribution of dentists in the three different types of institutions is more uneven than that of overall dentists. Moreover, although collaborating institutions have the effect on reducing this uneven distribution in the PGYD system, they tend to concentrate in municipalities instead of in non-municipalities. This indicates that dental clinics in municipalities are actually more capable of joining the PGYD system as collaborating institutions.

Because the quantitative and qualitative improvement of collaborating institutions in the PGYD system may have an influence on the distribution of new-entry dentists and contribute to establishment of an effective regional dental health care service,¹² it is suitable for university hospitals and medical centers to propose joint training group programs to assist dental clinics to join as their collaborating institutions. Thus, the government should also consider how to promote dental clinics in the areas with few dentists to participate in the PGYD system, not just as collaborating institutions, but also as single-system institutions or program-management institutions. In addition, we also consider that it is necessary to examine and analyze the practice location of new-entry dentists after the completion of PGYD training, to improve regular numbers and distributions of dental postgraduate training programs and dental trainees, and to analyze the correlation between the numbers of dental clinics or dental expenditure and the numbers of patients.

Declaration of competing interest

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

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