



Available online at [www.sciencedirect.com](http://www.sciencedirect.com)

ScienceDirect

journal homepage: [www.e-jds.com](http://www.e-jds.com)



Original Article

# The changes of the number and regional distribution of dentists and dental institutions 9 years after the implementation of postgraduate year training program for dentists in Taiwan



Feng-Chou Cheng<sup>a,b</sup>, Julia Yu-Fong Chang<sup>c,d,e</sup>,  
Tzu-Chiang Lin<sup>f</sup>, Po-Fang Tsai<sup>g</sup>, Yung-Ta Chang<sup>a\*</sup>,  
Chun-Pin Chiang<sup>b,c,d,e,h\*\*</sup>

<sup>a</sup> School of Life Science, National Taiwan Normal University, Taipei, Taiwan

<sup>b</sup> Department of Dentistry, Far Eastern Memorial Hospital, New Taipei City, Taiwan

<sup>c</sup> Department of Dentistry, National Taiwan University Hospital, College of Medicine, National Taiwan University, Taipei, Taiwan

<sup>d</sup> Graduate Institute of Oral Biology, School of Dentistry, National Taiwan University, Taipei, Taiwan

<sup>e</sup> Graduate Institute of Clinical Dentistry, School of Dentistry, National Taiwan University, Taipei, Taiwan

<sup>f</sup> Center for the Liberal Arts, National Kaohsiung University of Science and Technology, Kaohsiung, Taiwan

<sup>g</sup> Graduate Institute of Humanities in Medicine, College of Humanities and Social Sciences, Taipei Medical University, Taipei, Taiwan

<sup>h</sup> Department of Dentistry, Hualien Tzu Chi Hospital, Buddhist Tzu Chi Medical Foundation, Hualien, Taiwan

Received 10 October 2020

Available online 23 October 2020

## KEYWORDS

Surplus of dentists;  
Uneven regional  
distribution;

**Abstract** *Background/purpose:* In Taiwan, there are three major dentist occupation problems: a surplus of dentists, an uneven regional distribution of dentists, and a concentration of dentists in the metropolitan areas. The purpose of this study was to evaluate the distributions of the population and dentists in each city or county in 2001, 2010 and 2019 to further

\* Corresponding author. School of Life Science, National Taiwan Normal University, No. 88, Section 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](mailto:biofv031@ntnu.edu.tw) (Y.-T. Chang), [cpchiang@ntu.edu.tw](mailto:cpchiang@ntu.edu.tw) (C.-P. Chiang).

<https://doi.org/10.1016/j.jds.2020.10.006>

1991-7902/© 2020 Association for Dental Sciences of the Republic of China. Publishing services by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

### Postgraduate year training program for dentists

analyze the changes of regional distributions of dentists 9 years after the implementation of postgraduate year training program for dentists (PGYD) in 2010 in Taiwan.

*Materials and methods:* This study collected the data of population, the number of dentists in each city or county in 2001, 2010 and 2019, and the numbers of dentists and dental institutions from 2001 to 2019 for evaluating the changes of regional distributions of dentists 9 years after the PGYD implementation in Taiwan.

*Results:* Nine years after the PGYD implementation, the uneven distribution of dentists persisted. The number of dentists still increased and dentists were more concentrated in municipalities than in non-municipalities in Taiwan. Moreover, the number of dental institutions increased slowly, but dental institutions tended to become larger.

*Conclusion:* Because the PGYD system is not mandatory, dentists choose their practice locations as driven by the market factors. The increase in the average number of dentists in dental institutions is also driven by the market factors. The market-driven movement of dentists to the people-concentrated municipalities finally persist the imbalance of dentist distribution in Taiwan. This situation also enables the development of large-scale dental institutions in municipalities in Taiwan.

© 2020 Association for Dental Sciences of the Republic of China. Publishing services by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

## Introduction

In Taiwan, there are problems of regional differences and urban concentrations of dentists. Thus, to obtain effective dental services, it is necessary to maintain a balance between the numbers of dentists or dental clinics and the population.<sup>1–3</sup> In Japan, many dental students graduate from 29 dental universities and schools (colleges) every year and this causes a very significant impact on the number of dentists in prefectures with dental universities or schools.<sup>1</sup> In Taiwan, there are six municipalities (cities directly under the control of central government) and eight universities with dental schools. Of these 8 dental schools, four are in Taipei City, two in Taichung City, one in Tainan City, and one in Kaohsiung City. Although the other two municipalities do not have dental schools, there are also universities with medical schools (colleges) and medical centers with dental institutions. Therefore, similar to the situation in Japan, many new dentists who graduate from dental schools every year also tend to gather and practice in the municipalities, resulting in a concentration of dentist in the municipalities of Taiwan. For resolving regional differences in dental health services, the Japanese government tries to set a mandatory postgraduate clinical training policy for dentists to normalize and correct the uneven regional distribution of dentists and dental clinics.<sup>2,3</sup> Although Taiwan's postgraduate year training program for dentists (PGYD) is not mandatory, the training content also includes a participation in dental services in remote areas.<sup>4</sup> Moreover, if the dentists want to become the owner of a dental clinic or enter a dental specialist training program, they should finish the PGYD training program. Therefore, evaluation of the changes of distributions of increasing dentists in different cities and counties is very important for assessing uneven regional distributions of dentists in Taiwan and for knowing the places where need dentists urgently.

In Taiwan, there are three major problems of the dentist occupation: a surplus of dentists, an uneven regional distribution of dentists, and a concentration of dentists in the metropolitan areas.<sup>5</sup> The PGYD system was implemented in 2010. In the website of the Ministry of Health and Welfare, there are records of the number of dentists from 1992 to 2019. However, no detailed analysis of these data was performed to compare the changes of the numbers of dentists in different cities and counties before and after the PGYD implementation. Therefore, in this study, we examined the distributions of the population and dentists in each city or county in 2001, 2010 and 2019 to further analyze the changes of regional distributions of dentists 9 years after the PGYD implementation in Taiwan.

## Materials and methods

This study used the secondary data analysis to collect the information about the population and the number of overall practicing dentists in Taiwan from 2001 to 2019. 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 different cities and counties in 2001, 2010 and 2019 from the website of the Ministry of the Interior. In addition, the information of practicing dentists in 2001, 2010 and 2019 was available from the website of the Ministry of Health and Welfare. This information included the number of practicing dentists in different cities and counties in Taiwan at the end of 2001, 2010 and 2019, and the numbers of dentists and dental institutions (such as dental clinics and hospitals with dental departments) from 2001 to 2019. 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. The data before 2009

was also combined. 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. The whole area of Taiwan was divided into two groups: municipalities and non-municipalities. For statistical analysis, coefficient of variation (CV) was determined for comparisons of variability. Mann–Kendall test was used for trend analysis to evaluate the various trends. Wilcoxon signed-rank test was used for comparisons between two sub-groups.

## Results

Taiwan currently has 22 cities and counties (including offshore islands). There are 6 municipalities (directly under the control of central government) in 22 cities and counties. In 2010, Taichung City and County, Tainan City and County, as well as Kaohsiung City and County were merged to become municipalities. In 2014, Taoyuan County alone was upgraded to a municipality, without affecting the scope of the administrative region. The statistics were based on the current administrative regions. Therefore, the number and scope of the administrative regions were consistent throughout the period of this study.

### The change of the total numbers of dentists from 2001 to 2019

The numbers of total population and dentists in 22 cities and counties in Taiwan in 2001, 2010 and 2019 are shown in Table 1. In Taiwan, the total population increased from 22.41 million in 2001 to 23.16 million in 2010 and further to 23.60 million in 2019 (Table 1). Meanwhile, the total number of dentists increased from 8944 in 2001 to 11,656 in 2010 and further to 15,127 in 2019. Taiwan's PGYD was implemented in 2010. Thus, during the nine-year intervals before and after the PGYD implementation, the population increased by 756 thousand and 441 thousand, respectively. Meanwhile, the number of dentists increased by 2712 and 3471 in these two 9-year intervals, respectively. In addition, the ratio of the population of the municipalities to the total population increased from 67.27% in 2001 to 68.27% in 2010 and further to 69.41% in 2019. The population increases in municipalities from 2001 to 2010 and from 2010 to 2019 were both significantly different ( $P < 0.05$ ). Meanwhile, the corresponding ratio of dentists increased from 79.51% in 2001 to 79.92% in 2010 and further to 80.85% in 2019 (Table 1). On the contrary, the corresponding ratio of the population (from 32.73% in 2001 to 31.73% in 2010 and further to 30.59% in 2019) and dentists (from 20.49% in 2001 to 20.08% in 2010 and further to 19.15% in 2019) in non-municipalities showed a decrease (Table 1). Furthermore, the increases of dentists in municipalities, non-municipalities, and the whole Taiwan area from 2001 to 2010 ( $P < 0.05$ ,  $P < 0.001$ , and  $P < 0.001$ , respectively) and from 2010 to 2019 ( $P < 0.05$ ,  $P < 0.01$ , and  $P < 0.001$ , respectively) were also all significantly different.

Therefore, our findings indicate that both population and dentists concentrate in municipalities, especially the Taipei City where has the maximal number of dentists and

the New Taipei City where has the maximal number of population (Table 1).

### The change of the numbers of dentists per 100,000 people from 2001 to 2019

We analyzed the tendencies by calculating the numbers of dentists per 100,000 people in 2001, 2010 and 2019, respectively. The differences of the corresponding values from 2001 to 2010 and from 2010 to 2019 to estimate the increasing number of dentists per 100,000 people of these periods are shown in Table 2. The numbers of dentists per 100,000 population increased from 39.92 in 2001 to 50.32 in 2010 and further to 64.09 in 2019 (Table 2). Thus, during the nine-year intervals before and after the PGYD implementation, the numbers of dentists per 100,000 people increased by 10.40 and 13.77, respectively. To view municipalities and non-municipalities separately, the numbers of dentists per 100,000 people in municipalities increased from 47.18 in 2001 to 58.90 in 2010 and further to 74.65 in 2019. On the other hand, the numbers of dentists per 100,000 people in non-municipalities increased from 25.00 in 2001 to 31.86 in 2010 and further to 40.12 in 2019. Thus, during the nine-year intervals before and after the PGYD implementation, the increasing number of dentists per 100,000 people in municipalities were 11.72 and 15.75, respectively. The increasing number of dentists per 100,000 people in municipalities 9 years after the PGYD implementation was significantly higher than that 9 years before the PGYD implementation ( $P < 0.05$ ). Besides, the increasing number of dentists per 100,000 people in non-municipalities were 6.86 from 2001 to 2010 and 8.26 from 2010 to 2019, respectively (Table 2).

The coefficient of variance (CV) of the number of dentists per 100,000 people were greatest for nationwide, which were 50.22% in 2001, 52.77% in 2010, and 50.24% in 2019, respectively. The corresponding CV values for municipalities were 39.56%, 36.14%, and 34.80%, respectively. Meanwhile, the corresponding CV values for non-municipalities were 42.80%, 55.71%, and 45.73%, respectively. These results indicate that the numbers of dentists per 100,000 people are more dispersed for the whole Taiwan area than for municipalities or for non-municipalities in Taiwan. However, the numbers of dentists per 100,000 people were less dispersed for municipalities than for non-municipalities (Table 2).

### The change of the numbers of dental clinics and hospitals with dental departments from 2001 to 2019

The numbers of dentists and dental institutions (including dental clinics and hospitals with dental departments) in Taiwan from 2001 to 2019 were collected. Then, the average numbers of dentists per dental institution were calculated and shown in Table 3. As mentioned above, the total number of dentists increased from 8944 in 2001 to 11,656 in 2010 and further to 15,127 in 2019 (Tables 1 and 3). Meanwhile, the total numbers of dental institutions (including dental clinics and hospitals with dental departments) increased from 5891 in 2001 to 6519 in 2010 and

**Table 1** The numbers of total population and dentists in 22 cities and counties in Taiwan in 2001, 2010 and 2019.

	Total population			Overall dentists		
	2001	2010	2019	2001	2010	2019
Taipei City	2,633,802	2,618,772	2,645,041	2142	2604	3325
New Taipei City	3,610,252	3,897,367	4,018,696	1342	1922	2712
Taoyuan City	1,762,963	2,002,060	2,249,037	591	847	1237
Taichung City	2,485,968	2,648,419	2,815,261	1289	1615	1963
Tainan City	1,848,243	1,873,794	1,880,906	623	848	1131
Kaohsiung City	2,731,415	2,773,483	2,773,198	1124	1479	1862
Municipalities	15,072,643	15,813,895	16,382,139	7111	9315	12,230
Percentage	67.27%	68.27%	69.41%	79.51%	79.92%	80.85%
Keelung City	390,966	384,134	368,893	125	138	194
Hsinchu City	373,296	415,344	448,803	170	246	335
Chiayi City	267,993	272,390	267,690	149	193	229
Hsinchu County	446,300	513,015	563,933	85	165	251
Miaoli County	560,640	560,968	545,459	104	147	176
Changhua County	1,313,994	1,307,286	1,272,802	380	487	588
Nantou County	541,818	526,491	494,112	138	151	161
Yunlin County	743,562	717,653	681,306	127	153	181
Chiayi County	563,365	543,248	503,113	76	92	108
Pingtung County	909,364	873,509	819,184	188	199	213
Penghu County	92,268	96,918	105,207	23	30	38
Yilan County	465,799	460,486	454,178	107	127	182
Hualien County	353,139	338,805	326,247	97	127	150
Taitung County	244,612	230,673	216,781	53	59	66
Kinmen County	56,958	97,364	140,185	8	18	18
Lienchiang County	8851	9944	13,089	3	9	7
Non-municipalities	7,332,925	7,348,228	7,220,982	1833	2341	2897
Percentage	32.73%	31.73%	30.59%	20.49%	20.08%	19.15%
Total	22,405,568	23,162,123	23,603,121	8944	11,656	15,127

further to 7077 in 2019 (Table 3). Therefore, the average number of dentists per dental institution increased from 1.518 in 2001 to 1.788 in 2010 and further to 2.137 in 2019. Consequently, during the nine-year intervals before and after the PGYD implementation, the number of dental institutions increased by 628 and 558, respectively. Meanwhile, the average number of dentists per dental institution increased by 0.270 and 0.349 in these two nine-year intervals, respectively. We also used Mann–Kendall test for trend analysis to evaluate the various trends. The growth in the numbers of dentists, dental institutions, and dentists per dental institution from 2001 to 2019 was all significantly different (all  $P$ -values < 0.001). The increasing numbers per year of above corresponding three items were 340.500, 64.333 and 0.034, respectively (Table 3).

To view dental clinics and hospitals with dental departments separately, the total number of dental clinic dentists increased from 7649 in 2001 to 10,147 in 2010 and further to 12,941 in 2019. Meanwhile, the total numbers of dental clinics increased from 5659 in 2001 to 6295 in 2010 and further to 6874 in 2019. Therefore, the average number of dentists per dental clinic increased from 1.352 in 2001 to 1.612 in 2010 and further to 1.883 in 2019. Consequently,

during the nine-year intervals before and after the PGYD implementation, the number of dental clinic dentists increased by 2498 and 2794, respectively. Moreover, the number of dental clinics increased by 636 and 579, respectively. Meanwhile, the average number of dentists per dental clinic increased by 0.260 and 0.271, respectively. According to Mann–Kendall test, the growth in the numbers of dental clinic dentists, dental clinics, and dentists per dental clinic from 2001 to 2019 was all significantly different ( $P < 0.001$ ). The increasing numbers per year of above corresponding items were 285.667, 66.300 and 0.029, respectively, by Mann–Kendall test (Table 3).

The total number of hospital dentists increased from 1295 in 2001 to 1509 in 2010 and further to 2186 in 2019. Meanwhile, the total numbers of hospitals with dental departments decreased from 232 in 2001 to 224 in 2010 and further to 203 in 2019. Therefore, the average number of dentists per hospital increased from 5.582 in 2001 to 6.737 in 2010 and further to 10.768 in 2019. Consequently, during the nine-year intervals before and after the PGYD implementation, the number of hospital dentists increased by 214 and 677, respectively. Moreover, the number of hospitals decreased by 8 and 21 in these two nine-year intervals,

**Table 2** Distributions of dentists per 100,000 people in 22 cities and counties in Taiwan from 2001 to 2019.

	Number of dentists per 100,000 population			Increasing number of dentists per 100,000 population	
	2001	2010	2019	2001–2010	2010–2019
Taipei City	81.33	99.44	125.71	18.11	26.27
New Taipei City	37.17	49.32	67.48	12.14	18.17
Taoyuan City	33.52	42.31	55.00	8.78	12.69
Taichung City	51.85	60.98	69.73	9.13	8.75
Tainan City	33.71	45.26	60.13	11.55	14.87
Kaohsiung City	41.15	53.33	67.14	12.18	13.82
Municipalities	47.18	58.90	74.65	11.72	15.75
Mean ± SD	46.46 ± 18.38	58.44 ± 21.12	74.20 ± 25.82	–	–
CV	39.56%	36.14%	34.80%	–	–
Keelung City	31.97	35.92	52.59	3.95	16.66
Hsinchu City	45.54	59.23	74.64	13.69	15.41
Chiayi City	55.60	70.85	85.55	15.26	14.69
Hsinchu County	19.05	32.16	44.51	13.12	12.35
Miaoli County	18.55	26.20	32.27	7.65	6.06
Changhua County	28.92	37.25	46.20	8.33	8.94
Nantou County	25.47	28.68	32.58	3.21	3.90
Yunlin County	17.08	21.32	26.57	4.24	5.25
Chiayi County	13.49	16.94	21.47	3.44	4.53
Pingtung County	20.67	22.78	26.00	2.11	3.22
Penghu County	24.93	30.95	36.12	6.03	5.17
Yilan County	22.97	27.58	40.07	4.61	12.49
Hualien County	27.47	37.48	45.98	10.02	8.49
Taitung County	21.67	25.58	30.45	3.91	4.87
Kinmen County	14.05	18.49	12.84	4.44	–5.65
Lienchiang County	33.89	90.51	53.48	56.61	–37.03
Non-municipalities	25.00	31.86	40.12	6.86	8.26
Mean ± SD	26.33 ± 11.27	36.37 ± 20.26	41.33 ± 18.90	–	–
CV	42.80%	55.71%	45.73%	–	–
Nationwide	39.92	50.32	64.09	10.40	13.77
Mean ± SD	31.82 ± 15.98	42.39 ± 22.37	50.30 ± 25.27	–	–
CV	50.22%	52.77%	50.24%	–	–

Mean ± SD = Mean ± standard deviation; CV = coefficient of variance.

respectively. Meanwhile, the average number of dentists per hospital increased by 1.155 and 4.031 in these two nine-year intervals, respectively. According to Mann–Kendall test, the change in the numbers of hospital dentists, hospitals with dental departments, and dentists per hospital from 2001 to 2019 was all significantly different ( $P < 0.001$ ). The increased numbers of hospital dentists and dentists per hospital were 55.875 and 0.322, respectively, by Mann–Kendall test. In contrast, the decreased number of hospitals with dental departments was 1.727 by Mann–Kendall test (Table 3).

## Discussion

In the past, there were only few studies reporting the human resources of dentists in Taiwan.<sup>5–9</sup> These studies considered that when the number of dentists per 100,000

people reaches 50, the dentist manpower is enough to meet the needs of dental care services in Taiwan. Thus, it is estimated that the supply of dentists in Taiwan can meet this standard, and there may be a surplus of dentists and uneven geographical distribution of dentists in Taiwan.<sup>5–9</sup> In fact, this standard had been reached as early as at the end of 2010. However, the later study confirmed that the supply of dentists has already exceeded the originally estimated demand. Moreover, the geographical distribution of dentists shows a significant imbalance in Taiwan, especially in the northern region of Taiwan where more than half of dentists concentrate in this particular region. Therefore, the previous study concluded that the problem of dentist oversupply and geographical imbalance of dentist distribution may continue to deteriorate.<sup>5,9</sup>

However, an important reason for the concentration of dentists in the northern region is that three of the six municipalities in Taiwan are in the northern region. The

**Table 3** The numbers of dentists and dental institutions (including dental clinics and hospitals with dental departments) as well as the average number of dentists per institution in Taiwan from 2001 to 2019.

Year	Dental clinics			Hospitals with dental departments			Total		
	Dentists	Institutions	Average (Dentists per institution)	Dentists	Institutions	Average (Dentists per institution)	Dentists	Institutions	Average (Dentists per institution)
2001	7649	5659	1.352	1295	232	5.582	8944	5891	1.518
2002	7880	5730	1.375	1326	208	6.375	9206	5938	1.550
2003	8259	5889	1.402	1292	230	5.617	9551	6119	1.561
2004	8559	5979	1.432	1309	234	5.594	9868	6213	1.588
2005	8824	6029	1.464	1316	230	5.722	10,140	6259	1.620
2006	9077	6065	1.497	1335	225	5.933	10,412	6290	1.655
2007	9372	6104	1.535	1368	222	6.162	10,740	6326	1.698
2008	9672	6173	1.567	1421	223	6.372	11,093	6396	1.734
2009	9893	6214	1.592	1458	228	6.395	11,351	6442	1.762
2010	10,147	6295	1.612	1509	224	6.737	11,656	6519	1.788
2011	10,424	6399	1.629	1568	218	7.193	11,992	6617	1.812
2012	10,744	6476	1.659	1647	216	7.625	12,391	6692	1.852
2013	11,030	6565	1.680	1764	215	8.205	12,794	6780	1.887
2014	11,308	6630	1.706	1870	213	8.779	13,178	6843	1.926
2015	11,584	6665	1.738	1918	206	9.311	13,502	6871	1.965
2016	11,930	6727	1.773	1982	209	9.483	13,912	6936	2.006
2017	12,264	6791	1.806	2115	206	10.267	14,379	6997	2.055
2018	12,596	6836	1.843	2121	203	10.448	14,717	7039	2.091
2019	12,941	6874	1.883	2186	203	10.768	15,127	7077	2.137
Sen's slope of Mann-Kendall test	285.667	66.300	0.029	55.875	-1.727	0.322	340.500	64.333	0.034
Significance	$P < 0.001$	$P < 0.001$	$P < 0.001$	$P < 0.001$	$P < 0.001$	$P < 0.001$	$P < 0.001$	$P < 0.001$	$P < 0.001$

municipality itself is an administrative unit with concentrated population. Furthermore, the eight universities with dental schools in Taiwan are all located in municipalities. Of the 8 dental schools, four are in Taipei City, two in Taichung City, one in Tainan City, and one in Kaohsiung City. Although the quality and quantity of required dental care vary with the increased and decreased population of a city or a country, any regional imbalance of dentist distribution tends to increase continuously, depending on differences in the numbers of new-entry dentists. Therefore, the presence or absence of a dental school has a certain effect on the number of dentists and new-entry dentists in a particular region.<sup>10</sup>

Before the PGYD implementation in Taiwan, the National Health Research Institutes discussed the manpower requirements of dentists and proposed that the PGYD system should balance the distribution of dentists and promote dental care in remote areas.<sup>6</sup> The PGYD system has been implemented for more than 9 years, and the changes in the human resources of dentists in Taiwan 9 years after the PGYD implementation are worth discussing. Therefore, our study compared the human resources of dentists for 9 years before and after the PGYD implementation, and it was also appropriate to analyze the differences in human resources of dentists in municipalities and non-municipalities. In Taiwan, from 2001 to 2010, the population increased by

756,555 with an increase rate of 3.38%, and dentists increased by 2712 with an increase rate of 30.23%. However, from 2010 to 2019, the population increased by 440,998 with an increase rate of 1.90%, and dentists increased by 3471 with an increase rate of 29.78%. These findings indicate that after the PGYD implementation, the population growth tends to be slow, but the increase in the number of dentists accelerates. Moreover, regardless of the intervals 9 years before and after the PGYD implementation, the proportion of the increase in the number of dentists was much greater than that in the number of population.

The PGYD system is related to the qualification of a dentist to become the owner of a dental clinic, and is also the basic clinical training before the specialist training. Thus, it has no relationship with the growth of the dentist manpower. Since the implementation of the national health insurance in 1995 in Taiwan, the domestic department of dentistry becomes a popular department of choice by the freshman in the universities, and those students who enter the departments of dentistry have a very low re-examination rate.<sup>11</sup> The number of dental students who graduated from foreign departments of dentistry, returned to Taiwan after graduation, and passed the national dentist examination gradually increased. This resulted in an unexpected increase in the number of dentists in Taiwan.<sup>9</sup> In

addition, the increase in the number of dentists per 100,000 population accelerated significantly due to the differences in the growth rate of population and dentists before and after the PGYD implementation. After the PGYD implementation, the population of non-municipalities had a negative growth, which was theoretically beneficial to the increase of the number of dentists per 100,000 people. However, dentists tended to be concentrated in municipalities rather than non-municipalities. By the year of 2019, the number of dentists in municipalities exceeded 80% of the overall dentists. Therefore, the gap in the number of dentists per 100,000 people between municipalities and non-municipalities was widened.

The higher is the CV value, and the greater is the dispersion of the parameter. In our study, the CV was greatest for the number of dentists per 100,000 people of all cities and counties in Taiwan. Among the municipalities, the dispersion of the number of dentists per 100,000 people was relatively small. However, after the PGYD implementation, population growth slowed down, but dentists continued to increase and were concentrated in the municipalities, leading to a significant rise in the number of dentists per 100,000 people in the municipalities, especially the Taipei City. In 2006, the number of dentists per 100,000 people in Japan was 74.0, and the CV was 19%. However, in Tokyo the number of dentists per 100,000 people was 1.58 times of the national value.<sup>10</sup> From 2001 to 2019, the number of dentists per 100,000 people in the whole Taiwan area increased from 39.92 to 64.09, and the CV was around 50–53%. In 2019, the number of dentists per 100,000 people in the Taipei City (125.71) was 1.96 times of the national value (64.09). Moreover, the number of dentists per 100,000 people in municipalities (74.65) was also 1.16 times of the national value (64.09). These results indicate that Taiwan is facing a huge difference in the human resources of dentists between municipalities and non-municipalities. Furthermore, in 2019, the number of dentists per 100,000 people in 13 counties out of 16 non-municipalities in Taiwan was less than 50, and their population accounted for 25.94% of the total population in Taiwan. This result also shows the great uneven distribution of the human resources of dentists in Taiwan.

After the PGYD implementation, the growth rate of the number of dental clinics slowed down, and the number of hospitals with dental departments decreased. As the PGYD is a system that raises the threshold for dentists to open new dental clinics, it may slow down the growth rate of dental clinics. However, the decline in hospitals with dental departments is due to the fact that small hospitals such as district hospitals have no competitive advantages in dentistry. First, they do not have sufficient resources like medical centers and regional hospitals. Second, it is not as convenient for dental patients to seek dental treatment in hospitals with dental departments as in dental clinics. Therefore, some district hospitals abandon the operation of dental department due to insufficient number of dental patient or the dental department which is not a profitable unit. Finally, this leads to a decrease in the number of hospitals with dental departments. However, the number of dentists grew rapidly, which resulted in an increase in the average number of dentists in dental clinics and the development of large-scale dental departments in

hospitals. Thus, the current situation was conducive to the development of large-scale dental institutions and chain dental clinics.

Although after the PGYD implementation, the structure of Taiwan's dental institutions developed as described above, the PGYD system was only one of the possible factors that influenced the development of dental institutions and dentist distribution, and the overall situation was still affected by the market factors. For example, municipalities have the advantages of good living functions and convenient transportation. There are more populations and more dental services needed. On average, urban residents are more capable to afford a high payment for dental care. This attracts dentists to gather in the metropolitan areas, resulting in the establishment of large dental clinics. In addition, all eight universities with dental schools are located in municipalities and this also has some effects on gathering dentists in the metropolitan areas. After the PGYD implementation, dental institutions above a certain level (such as hospitals and large dental clinics) are eligible to become training institutions, and most of these institutions are concentrated in municipalities, which in turn encourages dentists to gather in municipalities. Furthermore, the raise in the cost for operating dental clinics slowed down the increase in the number of small dental clinics. As a result, large dental institutions (especially those in medical centers and regional hospitals, specialist dental clinics, and chain dental clinics) were promoted to establish.

A large number of dental clinics and a high proportion of total dentists working in these dental clinics are two characteristic features of Taiwan's dental environment. In Taiwan, by the end of 2019, there were 6874 dental clinics, and by June 2020, there were 5828 7-Eleven convenience stores. Obviously, the number of dental clinics surpasses the number of 7-Eleven convenience stores by more than 1000 in Taiwan. Basically, Taiwan's laws and regulations are loose regarding a dentist to open a new dental clinic. In addition, the national health insurance is beneficial to the operation of a dental clinic. Therefore, the number of dental clinics is very high, and it is very easy to acquire dental services when patients have oral diseases in Taiwan. However, there is still a large urban–rural gap in dental resources. Because the quality and quantity of required dental care vary as the population of a city or a county rises and falls, the distribution of dental resources in Taiwan still do not reach effective dental services which require maintenance of a balance between the number of dentists or dental clinics and the population through resolution of regional differences and urban concentrations of dentists and dental clinics.<sup>1–3</sup> Since small dental clinics are easy to operate and also easy to distribute in rural areas, the PGYD system can raise a proposal which considers to use rural dental clinics as training institutions to increase the number of dentists in remote areas where dentists are lacking. This policy may have some effects on balancing the urban–rural gap in dental resources.<sup>12</sup>

Our conclusions about the changes in the dentist resources 9 years after the PGYD implementation are that the accelerated increase in the number of dentists and the continuous concentration of dentists in municipalities caused the expansion of the gap in dentist resources between urban and rural areas. The reason is that the PGYD

system is not mandatory, dentists freely choose practice locations in Taiwan area as driven by the market factors. In addition, the changes in dental institutions are that the number of dental clinics grows slowly, and the number of hospitals with dental departments decreases. Thus, the average number of dentists in dental clinics increases slightly, and that in hospitals with dental departments also increases. Moreover, such change is also driven by the market factors. Thus, the market-driven movement of dentists to be concentrated in municipalities of Taiwan finally persist the imbalance of regional distribution of dentists in Taiwan. At the same time, it also enables the development of the large-scale dental institutions. Because dental clinics are small, widely distributed, easy to operate and manage, small dental clinics are easy to develop in remote areas. Therefore, it is recommended that future dental policy planning should not only continue to control the growth of the number of dentists, but also encourage dentists to work or open new dental clinics in remote areas with insufficient dental resources in Taiwan.

### Declaration of competing interest

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

### References

1. Okada M, Yamada Y, Okawa Y, et al. An analysis of regional differences in dental care facilities and in dental care expenditure. Part 2. According to the presence/absence of a dental college. *Nihon Shika Iryou Kanri Gakkai Zasshi* 2004;38:310–20 [in Japanese].
2. Hirata SI. The general representation of dental postgraduate clinical training program. *Nihon Shika Ishikai Zasshi* 2006;58:1067–73 [in Japanese].
3. Hirata SI, Hidaka K. Postgraduate clinical training program for dentists in Japan. *Dent Jpn* 2006;42:191–4.
4. Cheng FC. *The research of practicing PGY system in dental institutions*. PhD thesis. Taipei: National Taiwan Normal University School of Life Science, 2019 [in Chinese, English abstract].
5. Cheng FC, Chang JYF, Lin TC, et al. Imbalance in the geographical distribution of practicing dentists in postgraduate dental training institutions in Taiwan. *J Dent Sci* 2020;15:249–56.
6. National Health Research Institutes. *Dental workforce 2020: education, supply and demand*. Miaoli County, Taiwan: National Health Research Institutes, 2010 [in Chinese].
7. Huang CS, Cher TL, Lin CP, et al. Projection of the dental workforce from 2011 to 2020, based on the actual workload of 6762 dentists in 2010 in Taiwan. *J Formos Med Assoc* 2013;112:527–36.
8. Cher TL, Lai HH, Huang CS, et al. Field survey of dental manpower in Taiwan's hospitals. *J Formos Med Assoc* 2012;111:305–14.
9. Cheng FC, Chang JYF, Lin TC, et al. Dentist manpower development and geographical distribution of dentists in Taiwan. *J Dent Sci* 2020;15:121–31.
10. Gotouda H, Kasai K, Kaneda T, et al. Associations among distributions of dental postgraduate residents, dentists and clinical training facilities in Japan. *J Oral Sci* 2009;51:635–9.
11. Shiau YY, Chang CS, Chiu CH, et al. Manpower and education of dentists in Taiwan. *J Med Educ* 2001;5:3–12 [in Chinese, English abstract].
12. Cheng FC, Chiang CP, Lin TC, et al. Trends of participation of post-graduate year training program for dentists in Taiwan dental training institutions from 2010 to 2018. *J Dent Sci* 2019;14:47–53.