



Original Article

# The status of hospital dentistry in Taiwan in October 2019



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**Abstract** *Background/purpose:* Dental care has been officially incorporated into the hospital accreditation system in Taiwan since 2015. The geographical distribution of dentist manpower still remains in an unbalanced status as shown by the dentist-to-population ratio. This study tried to assess the dental manpower issue in terms of the status of hospital dentistry, and hence provided two organizational-level suggestions with their policy implications.

*Materials and methods:* This study utilized the secondary data analysis to evaluate the dental manpower in dental departments of medical centers, regional hospitals, and district hospitals in different regions of Taiwan in October 2019.

*Results:* Our results found that the dental manpower including the numbers of general dentists and dental specialists was highest in medical centers, followed by regional hospitals and district hospitals. Moreover, the dental resources and manpower were mostly concentrated in the northern region of Taiwan, followed by the central and southern regions of Taiwan, the

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eastern region of Taiwan, and offshore islands.

**Conclusion:** The hospital dentistry in Taiwan develops toward large-scale and specialization. Both hospital general dentists and dental specialists are concentrated in the medical centers, especially the medical centers in the northern region of Taiwan, indicating the problem of oversupply in the northern Taiwan and unbalanced distribution of dentists among the regions in Taiwan. Therefore, the responsibilities of the hospitals in metropolitan areas are to develop the elderly and disabled dentistry and to assist with oral health promotion and oral disease prevention in remote areas to reduce the urban-rural gap in dental resources in Taiwan.

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## Introduction

Department of Health of Taiwan (Department of Health was renamed as the Ministry of Health and Welfare after 2013) promoted the hospital accreditation system in 1978.<sup>1</sup> After 40 years of development, the hospital's medical quality, manpower training, hospital management, teaching, and research have made a great progress. In 2003, the hospital accreditation reform was carried out and began to focus on patient-centered care and patient safety environment, which had a great impact on medical system of Taiwan. The contents of hospital accreditation include all medical specialties, hospital management, nursing, pharmacy, radiology, medical rehabilitation, and medical technology, etc. Before dental medicine included in the hospital accreditation, there were only 3 recognized dental specialties (oral and maxillofacial surgery, oral pathology, and orthodontics) to participate in hospital accreditation. Other dental specialties and dental care were excluded from hospital accreditation.<sup>2</sup>

As late as 2011, the accreditation criteria for teaching hospitals have been significantly revised, and hospital dentistry including the resident training program, the dental trainee student training program, and the new dentist training program (that is, post-graduate year training program for dentists or PGYD) has been officially incorporated into the teaching hospital accreditation system. By 2015, dental care accreditation standards were integrated into hospital accreditation standards, and dental care (including "improving dental patient safety, improving medical service quality, transforming medical treatment environment, and taking care of vulnerable groups") was officially incorporated into the hospital accreditation system. Due to the lack of emphasis on dentistry in many hospitals in the past, the development of hospital dentistry has been uneven in these hospitals. For example, the number of dentists in the dental department of the medical center varies from 6 to 80. Moreover, there are also many hospitals that have the scale of dental department even smaller than that of a local dental clinic. Therefore, the accreditation objects of dental care are mainly from regional hospitals and above, and district hospitals are exempt from the dental care.<sup>3</sup> Although it starts late that the hospital dentistry is included in the teaching hospital accreditation and hospital accreditation system, it is still very important to

improve the overall quality of dental services in the hospitals.

In addition to the hospital accreditation system, there are other ways to access the dental manpower. A global and crucial indicator from World Health Organization (WHO) is the dentist-to-population ratio, which can assess whether the dental manpower relative to the population is adequate. Although the dentist-to-population is used by comparative viewpoint among different countries, it can also be deployed at the local level, such as different regions within a country.<sup>4</sup> Besides, there are scholar studies on the dental manpower issues with quantitative methods, such as face-to-face interview, telephone survey, or mailed questionnaire.<sup>2,5-7</sup> The data collection by these studies may focus on the hospitals or the dentists as their research objectives, but most of them are one-snap-shot studies which are belonged to the category of cross-sectional study.

The hospital accreditation system, the dentist-to-population ratio, and the quantitative studies with low response rates, however, all have their shortcomings in assessment of dental manpower. The hospital accreditation system covers only the medical centers and regional hospitals, neglecting district hospitals and local clinics. The dentist-to-population indicator cannot be used to measure the status of hospital as institutional filter which may be an important mediating factor. The quantitative studies with different survey tools usually strike a low response rate, which may endanger the reliability and validity. Considering how to overcome these shortcomings, this study analyzed the comprehensive secondary data, trying to examine the dental manpower and resources of the dental departments in medical centers, regional hospitals, and district hospitals to understand the status of hospital dentistry in Taiwan in October 2019.

## Materials and methods

In this study, we adopted the method of the secondary data analysis to collect the information about the numbers of practicing dentists, practicing physicians, total population in Taiwan, and the information regarding to the hospital dentistry in medical centers, regional hospitals, and district hospitals in October 2019. All of these data are open information that can be collected from the related websites. The total number of overall dentists by city and county in

October 2019 could be obtained from the Newsletter of Taiwan Dental Association,<sup>8</sup> and the population data could be obtained from the webpages of the Ministry of the Interior. Besides, in the webpages of the Ministry of Health and Welfare by the time of October 2019, the information including the numbers of medical centers, regional hospitals, and district hospitals as well as the hospitals with dental departments could be obtained. Meanwhile, the hospital information including the city or county location, the numbers of physicians, dentists, dental technicians, dental specialties (oral and maxillofacial surgery, oral pathology, and orthodontics), dental specialists, and dental units of each hospital mentioned above could be further obtained.

All hospitals were classified into three levels: medical centers, regional hospitals, and district hospitals. The whole area of Taiwan was divided into five regions: northern, central, southern, eastern regions, and offshore islands. The northern region included Taipei City, New Taipei City, Keelung City, Taoyuan City, Hsinchu City, and Hsinchu County; the central region included Miaoli County, Taichung City, Changhua County, Nantou County, and Yunlin County; the southern region included Chiayi City, Chiayi County, Tainan City, Kaohsiung City, Pingtung County, and Penghu County; the eastern region included Yilan County, Hualien County, and Taitung County; and the offshore islands included Kinmen County and Lienchiang County.

Based on the data and information collected from the methodologies that just mentioned above, these data were stored in excel files and put into analysis. The results of this study could help us to understand the current status of the hospital dentistry in Taiwan, and became an important reference for the development of training programs for dental students and dentists in Taiwan.

## Results

In this study, the contents of hospital dentistry in Taiwan in October 2019 could be obtained. We compared mainly the dental manpower in medical centers, regional hospitals, and district hospitals in Taiwan in October 2019, as shown in Table 1. Then, we compared dental specialties and dental specialists in medical centers, regional hospitals, and district hospitals in Taiwan in October 2019, as shown in Table 2. Finally, we compared general dentists and dental specialists in medical centers, regional hospitals, and district hospitals in four different regions of Taiwan and offshore islands in October 2019, as shown in Table 3.

### The dental manpower in medical centers, regional hospitals, and district hospitals in Taiwan

We calculated the dental manpower in 474 hospitals including 25 medical centers, 89 regional hospitals, and 360 district hospitals in Taiwan (Table 1). Of the 474 hospitals, 180 including 24 (96%) medical centers, 77 (86.52%) regional hospitals, and 79 (21.94%) district hospitals established dental departments (so-called hospital dentistry). Among 25 medical centers, there were 4 children's hospitals, of which 3 established dental departments. According to our survey, 2211 dentists registered their practice licenses in

**Table 1** The dental and medical manpower in medical centers, regional hospitals, and district hospitals in Taiwan in October 2019.

	Medical center	Regional hospital	District hospital	Total
Total hospitals	25	89	360	474
Hospitals with dental departments	24	77	79	180
Total hospital dentists	1213	770	228	2211
Average	50.54	10.00	2.89	12.28
Total hospital physicians	15,271	11,010	2741	29,022
Average	636.29	142.99	34.70	161.23
Dentist-to-physician ratio	0.08	0.07	0.08	0.08
Hospitals with dental technicians	17	14	4	35
Total hospital dental technicians	56	29	4	89
Average	2.33	0.38	0.05	0.49
Dentist-to-technician ratio	21.66	26.55	57.00	24.84
Total dental units in hospitals <sup>a</sup>	1357	910	458	2511
Average	56.55	11.82	5.80	13.95

<sup>a</sup> Some hospitals did not provide information about the number of dental units. The total number of dental units was an estimate. Therefore, it was not a precise number.

hospitals, and 29,022 physicians registered their practice licenses in these hospitals. The total numbers of dentists in 24 medical centers, 77 regional hospitals, and 79 district hospitals were 1213 (54.86%), 770 (34.83%), and 228 (10.31%), respectively. Thus, the average numbers of dentists in 24 medical centers, 77 regional hospitals, and 79 district hospitals were 50.54, 10.00, and 2.89, respectively. The corresponding physicians in 24 medical centers, 77 regional hospitals, and 79 district hospitals were 15,271 (52.62%), 11,010 (37.94%), and 2741 (9.44%), respectively. Moreover, the average numbers of physicians in 24 medical centers, 77 regional hospitals, and 79 district hospitals were 636.29, 142.99, and 34.70, respectively. Our results indicate that both the total and average numbers of dentists or physicians are highest in medical centers, followed by regional hospitals and district hospitals. The dentist-to-physician ratio in different levels of hospitals was between 0.07 and 0.08 (Table 1).

Among 180 hospitals with dental departments, 35 including 17 medical centers (70.83%), 14 regional hospitals (18.18%), and 4 district hospitals (5.06%) had dental technicians. The total numbers of dental technicians in medical centers, regional hospitals, and district hospitals were 56 (62.92%), 29 (32.58%), and 4 (4.49%), respectively. Thus, the dentist-to-technician ratios for 24 medical centers, 77 regional hospitals, and 79 district hospitals were 21.66, 26.55 and 57.00, respectively. The average numbers of dental units in 24 medical centers, 77 regional hospitals, and 79 district hospitals were 56.55, 11.82, and 5.80, respectively. Our findings indicate that each dentist in

**Table 2** The dental specialties and dental specialists in medical centers, regional hospitals, and district hospitals in Taiwan in October 2019.

	Medical center	Regional hospital	District hospital	Total
Hospitals with department of general dentistry	24	77	79	180
Total hospital general dentists	841	650	208	1699
Average	35.04	8.44	2.63	9.44
Hospitals with dental specialties	21	38	8	67
Hospitals with 1 dental specialty	0	20	7	27
Hospitals with 2 dental specialties	7	14	1	22
Hospitals with 3 dental specialties	14	4	0	18
Total hospital dental specialists	366	116	18	500
Average	15.25	1.51	0.23	2.78
Specialist-to-dentist ratio	0.30	0.15	0.08	0.23
Hospitals with department of oral and maxillofacial surgery	21	38	7	66
Total hospital oral and maxillofacial surgery specialists	159	81	9	249
Average	6.63	1.05	0.11	1.38
Hospitals with department of oral pathology	14	4	1	19
Total hospital oral pathology specialists	31	4	0	35
Average	1.29	0.05	0	0.19
Hospitals with department of orthodontics	21	18	1	40
Total hospital orthodontic specialists	176	31	9	216
Average	7.33	0.40	0.11	1.20

medical centers or regional hospitals can be assigned at least one dental unit and each dentist in district hospitals can be assigned at least 2 dental units. These results point out that the dental resources including dental technicians and dental units was also highest in medical centers, followed by regional hospitals and district hospitals (Table 1).

### The dental specialties and dental specialists in medical centers, regional hospitals, and district hospitals in Taiwan

Although a complete dental specialist system with 10 dental specialists was established in Taiwan in 2017, so far only three dental specialties had the definite qualification

accredited by the Ministry of Health and Welfare. Therefore, this survey only included these three dental specialties that were oral and maxillofacial surgery, oral pathology, and orthodontics (Table 2). Of 180 hospitals with department of general dentistry, 67 including 21 (87.5%) medical centers, 38 (49.35%) regional hospitals, and 8 (10.13%) district hospitals established dental specialties. Of the 21 medical centers with dental specialties, 7 and 14 had two and three dental specialties, respectively. Meanwhile, for the 38 regional hospitals with dental specialties, 20, 14, and 4 had one, two, and three dental specialties, respectively. Of the 8 district hospitals with dental specialties, 7 and one had one and two dental specialties, respectively. Among 3 children's hospitals, none of them had dental specialties. According to our survey, 1699 dentists registered their practice licenses as general dentists in the hospitals, and 500 dentists registered their practice licenses as dental specialists in these hospitals, which was 22.61% (500/2211) of the total dentist population in the hospitals. The total numbers of general dentists in 24 medical centers, 77 regional hospitals, and 79 district hospitals were 841 (49.50%), 650 (38.26%), and 208 (12.24%), respectively. Thus, the average numbers of general dentists in 24 medical centers, 77 regional hospitals, and 79 district hospitals were 35.04, 8.44, and 2.63, respectively. The total numbers of dental specialists in 24 medical centers, 77 regional hospitals, and 79 district hospitals were 366 (73.2%), 116 (23.2%), and 18 (3.6%), respectively. Therefore, the average numbers of dental specialists in 24 medical centers, 77 regional hospitals, and 79 district hospitals were 15.25, 1.51, and 0.23, respectively. These findings indicate that both the total and average numbers of general dentists and dental specialists are highest in medical centers, followed by regional hospitals and district hospitals. The specialist-to-dentist ratios in 24 medical centers, 77 regional hospitals, and 79 district hospitals were 0.30 (366/1213), 0.15 (116/770), and 0.08 (18/228), respectively (Table 2).

To view each specialty separately, 66 hospitals including 21 (87.5%) medical centers, 38 (49.35%) regional hospitals, and 7 (8.86%) district hospitals established department of oral and maxillofacial surgery. Of the 249 oral and maxillofacial surgery specialists registered their practice licenses in the hospitals, 159 worked in medical centers, 81 in regional hospitals, and 9 in district hospitals. Meanwhile, the average numbers of oral and maxillofacial surgery specialists in 24 medical centers, 77 regional hospitals, and 79 district hospitals were 6.63, 1.05, and 0.11, respectively (Table 2).

Besides, 19 hospitals including 14 (58.33%) medical centers, 4 (5.19%) regional hospitals, and one (1.27%) district hospital established department of oral pathology. Of the 35 oral pathology specialists registered their practice licenses in hospitals, 31 worked in medical centers, 4 in regional hospitals, and none in district hospitals. Moreover, the average numbers of oral pathology specialists in 24 medical centers, 77 regional hospitals, and 79 district hospitals were 1.29, 0.05, and 0, respectively (Table 2).

In addition, 40 hospitals including 21 (87.5%) medical centers, 18 (23.38%) regional hospitals, and one (1.27%) district hospitals established department of orthodontics. Of the 216 orthodontic specialists registered their practice



**Table 3** The general dentists and dental specialists in medical centers, regional hospitals, and district hospitals in four different regions of Taiwan and offshore islands in October 2019.

	Northern region	Central region	Southern region	Eastern region	Offshore islands	Total
Total population	10,286,189	5,808,544	6,350,573	997,826	153,134	23,596,266
Total overall dentists	7829	3032	3544	395	25	14,825
Hospitals with dental departments	71	44	47	16	2	180
Total hospital dentists	1162	386	583	77	3	2211
Average	16.37	8.77	12.40	4.81	1.50	12.28
Hospital dentists/overall dentists (%)	14.84	12.73	16.45	19.49	12.00	14.91
Medical center dentists/medical centers	681/12	196/6	314/5	22/1	0	1213/24
Average	56.75	32.67	62.80	22.00	0	50.54
Regional hospital dentists/regional hospitals	382/30	128/19	214/22	46/6	0	770/77
Average	12.73	6.74	9.73	7.67	0	10.00
District hospital dentists/district hospitals	99/29	62/19	55/20	9/9	3/2	228/79
Average	3.41	3.26	2.75	1.00	1.50	2.89
Hospitals with dental technicians	14	11	9	1	0	35
Total hospital dental technicians	45	28	15	1	0	89
Average	0.63	0.64	0.32	0.06	0	0.49
Average of dental units in hospitals	14.75	12.00	15.34	10.33	N/A	13.95
Hospitals with department of general dentistry	71	44	47	16	2	180
Total hospital general dentists	897	288	448	64	2	1699
Average	12.63	6.55	9.53	4.00	1.00	9.44
Hospitals with dental specialties	31	13	18	5	0	67
Hospitals with 1 dental specialty	12	5	8	2	0	27
Hospitals with 2 dental specialties	11	3	6	2	0	22
Hospitals with 3 dental specialties	8	5	4	1	0	18
Total hospital dental specialists	256	97	134	13	0	500
Average	3.61	2.20	2.85	0.81	0	2.78
Hospitals with department of oral and maxillofacial surgery	30	13	18	5	0	66
Total hospital oral and maxillofacial surgery specialists	123	52	66	8	0	249
Average	1.73	1.18	1.40	0.50	0	1.38
Hospitals with department of oral pathology	9	5	4	1	0	19
Total hospital oral pathology specialists	16	9	8	2	0	35
Average	0.23	0.20	0.17	0.13	0	0.19
Hospitals with department of orthodontics	19	8	10	3	0	40
Total hospital orthodontic specialists	117	36	60	3	0	216
Average	1.65	0.82	1.28	0.19	0	1.20

licenses in hospitals, 176 worked in medical centers, 31 in regional hospitals, and 9 in district hospitals. Meanwhile, the average numbers of orthodontic specialists in 24 medical centers, 77 regional hospitals, and 79 district hospitals were 7.33, 0.40, and 0.11, respectively (Table 2).

### The general dentists and dental specialists in medical centers, regional hospitals, and district hospitals in four different regions of Taiwan and offshore islands

Regarding the geographical distribution of dental resources in the hospitals with dental departments, 71 (39.44%) of the

180 hospitals with dental departments concentrated in the northern region of Taiwan. These 71 hospitals included 12 (50%) of 24 medical centers, 30 (38.96%) of 77 regional hospitals, and 29 (36.71%) of 79 district hospitals. Meanwhile, 1162 (52.56%) of 2211 hospital dentists populated in the northern region of Taiwan. These 1162 hospital dentists included 681 (56.14%) of 1213 dentists in the medical centers, 382 (49.61%) of 770 dentists in the regional hospitals, and 99 (43.42%) of 228 dentists in the district hospitals. Besides, 45 (50.56%) of the 89 hospital dental technicians also populated in the northern region of Taiwan (Table 3).

To view general dentistry and each dental specialty separately, 897 (52.80%) of the 1699 hospital general dentists populated in the northern region of Taiwan.

Meanwhile, 256 (51.2%) of 500 hospital dental specialists also populated in the northern region of Taiwan. These 256 hospital dental specialists included 123 (49.40%) of the 249 hospital oral and maxillofacial surgery specialists, 16 (45.71%) of the 35 hospital oral pathology specialists, and 117 (54.17%) of the 216 hospital orthodontic specialists (Table 3).

Furthermore, less than half of dental manpower including hospital dentists, dental specialists, and dental technicians mentioned above populated in the central and southern regions of Taiwan. Moreover, very few hospital dentists, dental specialists, and dental technicians worked in the eastern region of Taiwan and offshore islands. These results indicate that the dental resources and dental manpower are mostly concentrated in the northern region of Taiwan, followed by the central and southern regions of Taiwan, and lastly the eastern region of Taiwan and offshore islands (Table 3).

According to our survey, the total (and average) numbers of hospital dentists in the northern, central, southern, eastern regions of Taiwan and offshore islands were 1162 (16.37), 386 (8.77), 583 (12.40), 77 (4.81) and 3 (1.50), respectively. Thus, the scale of hospital dentistry was largest in the northern region of Taiwan, followed by the central and southern regions of Taiwan, and lastly the eastern region of Taiwan and offshore islands. Moreover, the total (and average) numbers of hospital dental technicians in the northern, central, southern, and eastern regions of Taiwan and offshore islands were 45 (0.63), 28 (0.64), 15 (0.32), 1 (0.06), and 0 (0), respectively. In addition, the average numbers of dental units in hospitals of the northern, central, southern, and eastern regions of Taiwan were 14.75, 12.00, 15.34, and 10.33, respectively (Table 3).

## Discussion

In the past, there were very few studies analyzing the contents of hospital dentistry in Taiwan. There have been relevant studies on the dental manpower, teaching quality, administrative management, and clinical dental care of hospital dentistry in Taiwan through field survey by questionnaires.<sup>2,5-7</sup> Although the preliminary results have been obtained,<sup>2,5-7</sup> for example, questionnaires were mailed to hospitals in 2002, but the response rate was merely 40.5%.<sup>2</sup> In this study, we collected the information about the contents of hospital dentistry in Taiwan from the open information webpages of the Ministry of Health and Welfare. Therefore, this study was focused mainly on the analysis of the human resources in hospital dentistry in Taiwan and could achieve the results of the census to reflect the real status of hospital dentistry in Taiwan in October 2019.

According to the previous studies, the number of hospital dentists was 21.64% of the total number of dentists in Taiwan in 1986, which decreased to 14.41% in 2018. On the contrary, the ratio of dentists in dental clinics to overall dentists increased from 78.36% in 1986 to 85.59% in 2008. After going through severe acute respiratory syndrome (SARS) event, the ratio of hospital dentists to overall dentists once decreased to a lowest point of 12.74% in 2007. Then, the ratio increased gradually to 14.93% in October 2019.<sup>2,9</sup> In this study, we further found that 2211 dentists

registered their practice licenses in hospitals. The total numbers of hospital dentists in medical centers, regional hospitals, and district hospitals were 1213 (54.86%), 770 (34.83%), and 228 (10.31%), respectively (Table 1). This result shows that dentists who serve in hospitals are mainly in large hospitals, like medical centers or regional hospitals. Among all hospitals in Taiwan, 101 (88.60%) of 114 medical centers and regional hospitals established dental departments, and the average number of hospital dentists was 19.63 (1983/101) (Table 1). In contrast, only 21.94% (79/360) of district hospitals established dental departments, and the average number of dentists in district hospitals was only 2.89 (Table 1). The hospital with the largest number of dentists was the National Taiwan University Hospital, where 143 dentists were registered. However, the number of dentists in district hospitals was from 1 to 3. Because the location of dentist practicing was not mainly in the hospitals, the dentist-to-physician ratio in three different levels of hospitals was between 0.07 and 0.08 (Table 1), which was far from the ideal ratio of 0.33 in overall.<sup>10</sup>

We also found that 89 dental technicians registered their practice licenses in the hospitals. The total numbers of dental technicians in medical centers, regional hospitals, and district hospitals were 56 (62.92%), 29 (32.58%), and 4 (4.49%), respectively (Table 1). The average number of hospital dental technicians was 0.49. However, the overall dentist-to-technician ratio in hospitals was 24.84 (Table 1). The dentist-to-technician ratios in medical centers, regional hospitals, and district hospitals were 21.66, 26.55 and 57.00, respectively (Table 1). Compared to the previous study with a response rate of about 50%, the number of hospital dental technicians increased from 77 in 2002 to 98 in 2008, while the average number of hospital dental technicians decreased from 1.17 in 2002 to 0.96 in 2008. Meanwhile, the dentist-to-technician ratio increased from 11.22 in 2002 to 13.49 in 2008.<sup>2</sup> Although the license system for dental technician was implemented in 2009, after 10 years the total and average numbers of hospital dental technicians obviously decreased. The possible reason for the decreased number of dental technicians working in the hospital was that hospitals mainly used outside dental technician manpower to handle most of works of dental technology. However, more studies are needed to explore this phenomenon in the future. In general, among dental manpower in different levels of hospitals, medical centers have the largest dental manpower, followed by regional hospitals and lastly district hospitals.<sup>2</sup> Similar results were found in this study.

The implementation of the dental specialist system in Taiwan started in oral and maxillofacial surgery in 1999, oral pathology in 2001, and orthodontics in 2009.<sup>11</sup> According to the information from the webpages of the Ministry of Health and Welfare, the accumulative numbers of certified specialists for oral and maxillofacial surgery, oral pathology, and orthodontics were 431, 80, and 704 in 2019, respectively. However, according to the webpages of related dental specialty associations, the numbers of valid specialists mentioned above were 384, 68, and 650, respectively. The possible reasons for the reduced numbers of dental specialists are refusal for dental specialist requalification, retirement, and death in a minor number of

dental specialists. Furthermore, we found that there were 249 oral and maxillofacial surgery specialists, 35 oral pathology specialists, and 216 orthodontic specialists registered in the hospitals (Table 2), which accounted for 64.84%, 51.47% and 33.23% of the total number of oral and maxillofacial surgery specialists, oral pathology specialists, and orthodontic specialists, respectively. Overall, 500 (45.37%) of 1102 dental specialists were registered in the hospitals. Comparatively, oral and maxillofacial surgery and oral pathology specialists worked mainly in the hospitals. In contrast, orthodontic specialists practiced mainly in the dental clinics. However, it needs further studies to understand the actual practice patterns of various dental specialists. For example, we previously found that only 8 oral pathology specialists practice both anatomical oral pathology and oral medicine, and all of them are in university hospitals or medical centers.<sup>11</sup> In addition, pediatric dentistry has just been implemented in 2019, and it may be the object of study in the near future.

We also found that the number of hospital general dentists (1,699) plus hospital dental specialists (500) was slightly fewer than the number of overall hospital dentists (2,211) in Taiwan (Table 2). The possible reason was that a small number of dentists obtained the qualification of a medical specialist before 1991 and registered this medical specialty instead of a dental specialty.<sup>11</sup> From the difference between the number of overall dentists and the number of dentists in hospitals, the number of dentists in dental clinics could be calculated.<sup>9</sup> Further analysis of the dental specialist-to-dentist ratio, we calculated and found that the ratios were 22.61% (500/2211) for the hospitals, 4.77% (602/12,614) for the dental clinics, and 7.43% (1102/14,825) for the overall dental institutions in Taiwan. Moreover, the dental specialist-to-dentist ratios were 0.30 (366/1213) for medical centers, 0.15 (116/770) for regional hospitals, and 0.08 (18/228) for district hospitals (Table 2). In the United States, the number of dental specialists has increased during the past 50 years. Less than 10% of the dentists are specialists in 1970, but 22% of the dentists are specialists in 2009. It is predicted that the percentage will increase to 27% in 2022, and most dental specialists are in the urban area.<sup>12</sup> Currently, the proportion of dental specialists in Taiwan was still low and concentrated in the large hospitals. In a previous study, approximately 350–400 dental students graduated from dental schools each year, and approximately 1/4 of the newly-graduated dentists chose to participate in further dental specialty training.<sup>2</sup> Therefore, with the implementation of the comprehensive dental specialist system in 2018, it is also predicted that the number and proportion of dental specialists will continue to grow, especially in large hospitals.<sup>13</sup>

The dentist-to-population ratio is the first core indicator used by the WHO to assess whether the number of health workers relative to the population is adequate. It can be used to monitor the most basic needs of healthcare to be achieved in a country, and can be used for comparative analysis among several countries or several regions of a country.<sup>4</sup> Based on the data of our previous study in October 2019, the total population of Taiwan is approximately 23.59 million, the number of dentists is 14,825, and the number of people served by each dentist is 1,592, equivalent to 62.8 dentists per 100,000 people, which is

better than the datum of 61 dentists per 100,000 people reported in 2009 in the Organization for Economic Cooperation and Development (OECD) countries.<sup>4</sup> Thus, the current dentist manpower in Taiwan is exactly oversupplied.<sup>9</sup> To view each region of Taiwan separately, the numbers of overall dentists were 7829 in the northern region, 3032 in the central region, 3544 in the southern region, 395 in the eastern region, and 25 in the offshore islands (Table 3). We calculated the numbers of people served by each dentist in above regions, which were 1,314, 1,916, 1,792, 2526 and 6,125, respectively. Meanwhile, these numbers were equivalent to 76.1, 52.2, 55.8, 39.6 and 16.3 dentists per 100,000 people, respectively. It is obvious that only the dentist manpower of the northern region of Taiwan is comparable or superior to OECD countries. The dentist manpower of other regions even lags behind that of OECD countries of 10 years ago, especially the dentist manpower of the eastern region of Taiwan and the offshore islands. Unfortunately, this also reflects that the geographical distribution of dentist manpower in Taiwan is in an extremely unbalanced status.

In this study, all aspects of dental resources and manpower including the hospitals with dental departments, dentists, dental technicians, and dental specialists in the hospitals, and overall dentists were mostly concentrated in the northern region of Taiwan, followed by the central and southern regions of Taiwan, the eastern region of Taiwan, and offshore islands. The average numbers of hospital dentists, dental technicians, and dental specialists had a similar geographical distribution as above. We also found that the hospitals in the northern region of Taiwan had the largest hospital dentistry scale compared with hospitals in the other regions of Taiwan. These results were consistent with those in other previous studies.<sup>2,13,14</sup> An unbalanced urban-rural distribution of dentists was noted in Taiwan. Therefore, how to balance the dental manpower resources in different regions of Taiwan will be a vital issue that needs further studies in the future.<sup>2,13,14</sup>

We conclude that the hospital dentistry in Taiwan develops toward large-scale and specialization. Both hospital general dentists and dental specialists are predominantly concentrated in the medical centers, especially the medical centers in the northern region of Taiwan, indicating the problem of oversupply and unbalanced distribution of dentists in the northern region of Taiwan. Although there are less than 15% of total dentists working in the hospitals, the hospital dentistry is still responsible for training of new dentists and dental research, which is important for the cultivation and development of young dentists.<sup>2</sup> With the implementation of the comprehensive dental specialist system, the number and proportion of hospital dentists may continue to increase in the future. When facing the problem of oversupply and unbalanced distribution of dentists, the responsibilities of the hospitals with dental departments are to develop the elderly and disabled dentistry and to provide dental care for these persons. In addition, the administrators of hospitals should reduce the working hours of the hospital dentists, especially the working hours of the training dentists (such as dentists in specialist training program and PGY trainees) and interns to improve their quality of life. The hospitals in metropolitan areas should also assist with oral health promotion and oral

disease prevention in remote areas to reduce the urban-rural gap in dental resources in Taiwan.

Finally, the highest-level hospitals should take the responsibilities of developing the complete dental specialties in all of them. Among the 21 medical centers (excluding children's hospitals) in Taiwan, all of them have dental departments and specialists of oral and maxillofacial surgery and orthodontics, but only 14 have oral pathology specialists. After the implementation of the comprehensive dental specialist system, the medical centers and university hospitals should establish a dental department with complete dental specialties, especially the oral pathology, owing to the fact that these highest-level hospitals have the responsibilities for dental education, training, research, and services. Only in this way can they have complete dental human resources and meet the responsibilities of hospital dentistry mentioned above.

### Declaration of competing interest

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

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