

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 impact of the COVID-19 pandemic on the dentist manpower in Taiwan



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

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

<sup>b</sup> Center for the Literature and Art, Hsin Sheng Junior College of Medical Care and Management, Taoyuan, 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 5 March 2021; Final revision received 5 March 2021

Available online 17 March 2021

## KEYWORDS

COVID-19 pandemic;  
 Dentist manpower;  
 Practicing dentists;  
 Dental clinics;  
 Hospital dentists

**Background/purpose:** The dentists are the high-risk group of infectious respiratory diseases during dental treatment. This study investigated the changes of the numbers of overall practicing dentists, dental clinics, and hospital dentists in Taiwan during the COVID-19 pandemic. **Materials and methods:** We collected the data of the numbers of overall practicing dentists, dental clinics, and hospital dentists in each city and county of Taiwan in October 2019, April 2020, and October 2020 for evaluating the impact of the COVID-19 pandemic on the dentist manpower in Taiwan.

**Results:** After the COVID-19 outbreak, the total increased numbers of practicing dentists, dental clinics, and hospital dentists in Taiwan were 408, 14, and –16 from October 2019 to October 2020, respectively. In addition, their increased rates of the corresponding items were

\* Corresponding author. Department of Dentistry, Hualien Tzu Chi Hospital, Buddhist Tzu Chi Medical Foundation, No. 707, Section 3, Chung-Yang Road, Hualien 970, Taiwan.

\*\* Corresponding author. School of Life Science, National Taiwan Normal University, No. 88, Sec. 4, Ting-Chou Road, Taipei 11677, 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).

† Both authors contributed equally to this study.

<https://doi.org/10.1016/j.jds.2021.03.001>

1991-7902/© 2021 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/>).

2.76%, 0.21%, and  $-0.72\%$ , respectively. The increased rate of practicing dentists from October 2019 to April 2020 was significantly higher than that of dental clinics ( $P < 0.001$ ) and that of hospital dentists ( $P < 0.001$ ). Moreover, the increased rate of practicing dentists from October 2019 to October 2020 was significantly higher than that of dental clinics ( $P < 0.01$ ).

**Conclusion:** During the COVID-19 pandemic, the increased number of practicing dentists is not different from that in the past, but the increased numbers and rates of dental clinics and hospital dentists are lower than those in the past. This indicates that the willingness of dentists to open new dental clinics or work in hospitals reduces due to the impact of the COVID-19 pandemic.

© 2021 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

The contents of dental practices are prevention, diagnosis, and treatment of diseases in the oral and maxillofacial region with medical and dental knowledge.<sup>1</sup> During dental treatment, when dentists use scaling machines and high-speed handpieces, splatter, droplets, or aerosols are likely to occur. However, transmission of infections can occur either through direct contact with blood, saliva, splatter, droplets, or aerosols, or through indirect contact with contaminated surfaces.<sup>2</sup> Therefore, healthcare workers who fail to follow proper infection control procedures when providing patient healthcare are more likely to contract infectious diseases.<sup>3</sup> The treatment guidelines must be followed to guide the medical staff to treat and serve the patients.<sup>4</sup>

Although dentists are not direct healthcare workers for respiratory diseases, they must directly face the mouth and nose of patients during dental treatment. This makes the dentists a high-risk group to contract infectious respiratory diseases. In general, the hospital environment may have more patients with respiratory diseases. For dentists, those working in a hospital have a higher risk of contracting respiratory infections than those working in a dental clinic. Thus, the outbreak of a fatal respiratory disease also affects the willingness of a dentist to work in a hospital. In Taiwan, the number of hospital dentists was 21.6% of the overall dentists in 1986, and this value decreased to 14.4% in 2018. When the disease of severe acute respiratory syndrome (SARS) suddenly happened in year 2003, the number of hospital dentists decreased by 34 from 1326 in year 2002 to 1292 in year 2003. In fact, after going through the SARS pandemic, the ratio of hospital dentists to overall dentists continued to decrease to a lowest level of 12.7% in 2007. Then, the ratio increased gradually to 14.5% in 2019.<sup>5,6</sup>

On January 21, 2020, the Taiwan Central Epidemic Command Center (CECC) officially reported the first COVID-19 case in Taiwan. From March to April, the number of confirmed COVID-19 cases in Taiwan rose rapidly from less than 100 to more than 400. On January 12, 2021, the Taiwan CECC officially reported the first confirmed COVID-19 case of a hospital physician.<sup>7</sup> Therefore, the outbreak of COVID-19 may also affect the manpower structure of hospital dentistry in Taiwan. However, there was no study to survey

the difference of the dentist manpower, especially the dentist manpower of hospital dentistry, in Taiwan during the COVID-19 pandemic. Furthermore, this was the first study on the comparison of distributions of overall practicing dentists, dental clinics, and hospital dentists in 20 cities and counties in Taiwan during the COVID-19 pandemic from October 2019 to October 2020. This study aimed to assess the changes of the numbers of overall practicing dentists, dental clinics, and hospital dentists in Taiwan during the COVID-19 pandemic. We particularly focused on studying the changes of hospital dentists in different cities or counties of Taiwan, hospitals of various levels, and hospitals with different COVID-19 tasks for evaluating the impact of the COVID-19 pandemic on the hospital dentistry in Taiwan.

## 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 in hospitals and the overall dentists in Taiwan, and the information regarding to these hospitals with dental departments such as their levels, tasks for COVID-19, and locations in October 2019, April 2020, and October 2020. All of these data are open information that can be collected from the related websites. The total number of overall practicing dentists by city and county could be obtained from the Newsletter of Taiwan Dental Association.<sup>8–10</sup> Besides, in the webpages of the Ministry of Health and Welfare by the time of October 2019, April 2020, and October 2020, the information including the number of the hospitals with dental departments could be obtained. Meanwhile, the hospital information including the city or county location and the number of registered dentists of each hospital mentioned above could be further obtained. Furthermore, we could know what tasks for COVID-19 were assigned to these hospitals from the webpages of the Taiwan Centers for Disease Control (CDC).

All hospitals were classified into three levels: medical centers, regional hospitals, and district hospitals. According to the tasks for COVID-19, hospitals were classified into three types: those where patients with severe COVID-19 were treated, those that were responsible for community inspection, and those that were not assigned COVID-19-related tasks. In addition, the whole area of Taiwan was

divided into four regions: northern, central, southern, and eastern regions. 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; and the eastern region included Yilan County, Hualien County, and Taitung County. The offshore islands (Kinmen County and Lienchiang County) were not included in this study.

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 mainly the impact of the COVID-19 pandemic on the dentist manpower of hospital dentistry in Taiwan, and became an important reference for the development of dentist manpower for hospital dentistry in Taiwan during and after the COVID-19 pandemic.

## Results

### The change of the total numbers of overall practicing dentists from October 2019 to October 2020

Taiwan currently has 9 cities and 11 counties (excluding the Kinmen County and Lienchiang County). There are 6 municipalities (those directly under the control of central government) and 14 non-municipalities among 9 cities and 11 counties. The numbers of practicing dentists in 9 cities and 11 counties in Taiwan in October 2019, April 2020, and October 2020 are shown in [Table 1](#). In Taiwan, the numbers of practicing dentists increased from 14,800 in October 2019, to 15,125 in April 2020, and further to 15,208 in October 2020 ([Table 1](#)). Meanwhile, the numbers of pure dentist members (the dentists with membership of Taiwan Dental Association but without practice registration) increased from 158 in October 2019, to 195 in April 2020, and further to 204 in October 2020. In 2020, the worst period of the COVID-19 pandemic in Taiwan was from March to April, after that period the COVID-19 pandemic gradually subsided. Thus, half a year before and after the worst period of the COVID-19 pandemic, the numbers of practicing dentists increased by 325 and 83, respectively. Meanwhile, the numbers of pure dentist members increased by 37 and 9 in these two periods, respectively.

To view municipalities and non-municipalities separately, the numbers of practicing dentists in 6 municipalities increased from 11,989 in October 2019, to 12,244 in April 2020, and further to 12,293 in October 2020. On the other hand, the numbers of practicing dentists in 14 non-municipalities increased from 2811 in October 2019, to 2881 in April 2020, and further to 2915 in October 2020. Thus, half a year before and after the worst period of the COVID-19 pandemic, the increased numbers of practicing dentists in 6 municipalities were 255 and 49, respectively. Besides, the corresponding increased numbers in 14 non-municipalities were 70 and 34, respectively ([Table 2](#)).

In addition, to view 9 cities and 11 counties separately, the numbers of practicing dentists in 9 cities increased from 12,724 in October 2019, to 13,000 in April 2020, and further to 13,065 in October 2020. On the other hand, the numbers of practicing dentists in 11 counties increased from 2076 in October 2019, to 2125 in April 2020, and further to 2143 in October 2020. Thus, the increased numbers of practicing dentists in 9 cities were 276 and 65, respectively. Besides, the corresponding increased numbers in 11 counties were 49 and 18, respectively ([Table 2](#)).

Furthermore, regarding the geographical distribution, practicing dentists were mainly concentrated in the northern region of Taiwan. The numbers of practicing dentists in the northern region of Taiwan increased from 7829 in October 2019, to 8039 in April 2020, and further to 8100 in October 2020. Thus, the increased numbers of practicing dentists in the northern region were 210 and 61, respectively. The changes of the percentage of practicing dentists showed a similar situation in the central region of Taiwan, but were less in other regions of Taiwan ([Table 2](#)).

Therefore, the practicing dentists were concentrated in 6 municipalities or 9 cities, especially the Taipei City with the maximal number of practicing dentists. The number of practicing dentists was largest in the northern region of Taiwan, followed by the central and southern regions of Taiwan, and lastly the eastern region of Taiwan. Moreover, the number of practicing dentists was still steadily growing during the COVID-19 pandemic.

### The change of the total numbers of dental clinics from October 2019 to October 2020

The numbers of dental clinics in 9 cities and 11 counties in Taiwan in October 2019, April 2020 and October 2020 are shown in [Table 3](#). In Taiwan, the numbers of dental clinics decreased from 6618 in October 2019, to 6616 in April 2020, and further increased to 6632 in October 2020 ([Table 3](#)). Thus, half a year before and after the worst period of the COVID-19 pandemic, the numbers of dental clinics decreased by 2, and then increased by 16, respectively.

To view 6 municipalities and 14 non-municipalities separately, the numbers of dental clinics in 6 municipalities increased from 5150 in October 2019, to 5156 in April 2020, and further to 5166 in October 2020. On the other hand, the numbers of dental clinics in 14 non-municipalities decreased from 1468 in October 2019, to 1460 in April 2020, and further increased to 1466 in October 2020. Thus, the increased numbers of dental clinics in 6 municipalities were 6 and 10 in the two intervals mentioned above, respectively. Besides, the corresponding increased numbers in 14 non-municipalities were -8 and 6, respectively ([Table 4](#)).

In addition, to view 9 cities and 11 counties separately, the numbers of dental clinics in 9 cities increased from 5498 in October 2019, to 5501 in April 2020, and further to 5514 in October 2020. On the other hand, the numbers of dental clinics in 11 counties decreased from 1120 in October 2019, to 1115 in April 2020, and further increased to 1118 in October 2020. Thus, the increased numbers of dental clinics in 9 cities were 3 and 13, respectively. Besides, the corresponding increased numbers in 11 counties were -5 and 3, respectively ([Table 4](#)).

**Table 1** Distributions of overall dentists in 9 cities and 11 counties in Taiwan from October 2019 to October 2020.

	Number (percentage) of overall dentists			Increased number (rate) of overall dentists	
	October 2019	April 2020	October 2020	October 2019 to April 2020	April 2020 to October 2020
Taipei City	3304 (22.32%)	3371 (22.29%)	3378 (22.21%)	67 (2.03%)	7 (0.21%)
New Taipei City	2597 (17.55%)	2669 (17.65%)	2663 (17.51%)	72 (2.77%)	−6 (−0.23%)
Taoyuan City	1178 (7.96%)	1221 (8.07%)	1257 (8.27%)	43 (3.65%)	36 (3.06%)
Taichung City	1947 (13.16%)	1977 (13.07%)	1981 (13.03%)	30 (1.54%)	4 (0.21%)
Tainan City	1127 (7.61%)	1135 (7.50%)	1148 (7.55%)	8 (0.71%)	13 (1.15%)
Kaohsiung City	1836 (12.41%)	1871 (12.37%)	1866 (12.27%)	35 (1.91%)	−5 (−0.27%)
Keelung City	184 (1.24%)	184 (1.22%)	193 (1.27%)	0	9 (4.89%)
Hsinchu City	322 (2.18%)	341 (2.25%)	346 (2.28%)	19 (5.90%)	5 (1.55%)
Chiayi City	229 (1.55%)	231 (1.53%)	233 (1.53%)	2 (0.87%)	2 (0.87%)
Hsinchu County	244 (1.65%)	253 (1.67%)	263 (1.73%)	9 (3.69%)	10 (4.10%)
Miaoli County	175 (1.18%)	183 (1.21%)	187 (1.23%)	8 (4.57%)	4 (2.29%)
Changhua County	574 (3.88%)	588 (3.89%)	588 (3.87%)	14 (2.44%)	0
Nantou County	161 (1.09%)	167 (1.10%)	166 (1.09%)	6 (3.73%)	−1 (−0.62%)
Yunlin County	175 (1.18%)	183 (1.21%)	183 (1.20%)	8 (4.57%)	0
Chiayi County	104 (0.70%)	108 (0.71%)	108 (0.71%)	4 (3.85%)	0
Pingtung County	212 (1.43%)	208 (1.38%)	215 (1.41%)	−4 (−1.89%)	7 (3.30%)
Penghu County	36 (0.24%)	36 (0.24%)	35 (0.23%)	0	−1 (−2.78%)
Yilan County	183 (1.24%)	184 (1.22%)	186 (1.22%)	1 (0.55%)	2 (1.09%)
Hualien County	147 (0.99%)	149 (0.99%)	146 (0.96%)	2 (1.36%)	−3 (−2.04%)
Taitung County	65 (0.44%)	66 (0.44%)	66 (0.43%)	1 (1.54%)	0
Nationwide	14,800 (100%)	15,125 (100%)	15,208 (100%)	325 (2.20%)	83 (0.56%)
Mean ± SD	740.00 ± 954.52	756.25 ± 975.00	760.40 ± 975.60	—	—
CV	128.99%	128.93%	128.30%	—	—
<sup>a</sup> Pure dentist members	158	195	204	37 (23.42%)	9 (5.70%)

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

The first six items are municipalities and the offshore islands outside Taiwan such as Kinmen County and Lienchiang County were not included in this study.

<sup>a</sup> Pure dentist members: The dentists with membership of Taiwan Dental Association but without practice registration.

Furthermore, regarding the geographical distribution, dental clinics were mainly concentrated in the northern region of Taiwan. The numbers of dental clinics in the northern region of Taiwan increased from 3196 in October 2019, to 3206 in April 2020, and further to 3216 in October 2020. Thus, the increased numbers of dental clinics in the northern region were 10 and 10, respectively. On the contrary, the numbers of dental clinics in other regions of Taiwan mostly showed a small number of reduction (Table 4).

Therefore, the dental clinics were concentrated in 6 municipalities or 9 cities, especially the Taipei City with the maximal number of dental clinics. The number of dental clinics was largest in the northern region of Taiwan, followed by the central and southern regions of Taiwan, and lastly the eastern region of Taiwan. In general, the number of dental clinics still showed a small number of increase during the COVID-19 pandemic.

### The change of the total numbers of hospital dentists from October 2019 to October 2020

The numbers of hospital dentists in 9 cities and 11 counties in Taiwan in October 2019, April 2020 and October 2020 are

shown in Table 5. In Taiwan, the numbers of hospital dentists decreased from 2208 in October 2019, to 2194 in April 2020, and further to 2192 in October 2020. However, the numbers of hospital with dental department increased from 175 to 178 during this period (Table 5). Thus, half a year before and after the worst period of the COVID-19 pandemic, the numbers of hospital dentists decreased by 14 and 2, respectively.

According to hospitals of different levels, the numbers of practicing dentists in medical centers and regional hospitals decreased from 1983 in October 2019, to 1969 in April 2020, and further to 1957 in October 2020 by a total decrease of 26. On the contrary, the numbers of practicing dentists in district hospitals increased from 225 in October 2019 to 235 in October 2020 by a total increase of 10.

According to hospitals with different tasks for COVID-19, the numbers of practicing dentists in hospitals with the task of treating severe COVID-19 patients and in hospitals with the task of community inspection decreased from 2129 in October 2019, to 2117 in April 2020, and further to 2110 in October 2020 by a total decrease of 19. On the contrary, the numbers of practicing dentists in hospitals without assigned COVID-19-related task increased from 79 in October 2019 to 82 in October 2020 by a total increase of 3 (Table 6).

**Table 2** Comparisons of overall dentists in 6 municipalities and 14 non-municipalities, in 9 cities and 11 counties, and in 4 different regions in Taiwan from October 2019 to October 2020.

Administrative hierarchy	Number (percentage) of overall dentists			Increased number (rate) of overall dentists	
	October 2019	April 2020	October 2020	October 2019 to April 2020	April 2020 to October 2020
<b>Municipalities (n = 6)</b>	11,989 (81.01%)	12,244 (80.95%)	12,293 (80.84%)	255 (2.13%)	49 (0.41%)
Mean ± SD	1998.17 ± 839.56	2040.67 ± 859.01	2048.83 ± 850.93	—	—
CV	0.42	0.42	0.42	—	—
<b>Non-municipalities (n = 14)</b>	2811 (18.99%)	2881 (19.05%)	2915 (19.17%)	70 (2.49%)	34 (1.21%)
Mean ± SD	200.79 ± 129.54	205.79 ± 133.56	208.21 ± 134.34	—	—
CV	0.65	0.65	0.65	—	—
<b>City or county</b>					
<b>Cities (n = 9)</b>	12,724 (85.97%)	13,000 (85.95%)	13,065 (85.91%)	276 (2.17%)	65 (0.51%)
Mean ± SD	1413.78 ± 1100.08	1444.44 ± 1123.67	1451.67 ± 1120.93	—	—
CV	77.81%	77.79%	77.22%	—	—
<b>Counties (n = 11)</b>	2076 (14.03%)	2125 (14.05%)	2143 (14.03%)	49 (2.36%)	18 (0.87%)
Mean ± SD	188.73 ± 141.69	193.18 ± 145.17	194.82 ± 145.88	—	—
CV	75.08%	75.15%	74.88%	—	—
<b>Region</b>					
<b>Northern region (n = 6)</b>	7829 (52.90%)	8039 (53.15%)	8100 (53.26%)	210 (2.68%)	61 (0.78%)
Mean ± SD	1304.83 ± 1343.88	1339.83 ± 1372.68	1350.00 ± 1369.21	—	—
CV	102.99%	102.45%	101.42%	—	—
<b>Central region (n = 5)</b>	3032 (20.49%)	3098 (20.48%)	3105 (20.42%)	66 (2.18%)	7 (0.23%)
Mean ± SD	606.40 ± 769.55	619.60 ± 779.36	621.00 ± 780.69	—	—
CV	126.90%	125.78%	125.71%	—	—
<b>Southern region (n = 6)</b>	3544 (23.95%)	3589 (23.73%)	3605 (23.70%)	45 (1.27%)	16 (0.45%)
Mean ± SD	590.67 ± 729.00	598.17 ± 741.84	600.83 ± 741.25	—	—
CV	123.42%	124.02%	123.37%	—	—
<b>Eastern region (n = 3)</b>	395 (2.67%)	399 (2.64%)	398 (2.62%)	4 (1.01%)	-1 (-0.25%)
Mean ± SD	131.67 ± 60.48	133.00 ± 60.61	132.67 ± 61.10	—	—
CV	45.93%	45.57%	46.05%	—	—

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

To view 6 municipalities and 14 non-municipalities separately, the numbers of hospital dentists in 6 municipalities decreased from 1799 in October 2019, to 1787 in April 2020, and further to 1769 in October 2020 by a total decrease of 30. On the other hand, the numbers of hospital dentists in 14 non-municipalities increased from 409 in October 2019 to 423 in October 2020 by a total increase of 14 (Table 6). In addition, to view 9 cities and 11 counties separately, the numbers of hospital dentists in 9 cities decreased from 1908 in October 2019, to 1894 in April 2020, and further to 1880 in October 2020 by a total decrease of 28. On the other hand, the numbers of hospital dentists in 11 counties increased from 300 in October 2019 to 312 in October 2020 by a total increase of 12 (Table 6).

Furthermore, regarding the geographical distribution, hospital dentists were also mainly concentrated in the northern region of Taiwan. The numbers of hospital dentists in the northern region of Taiwan decreased from 1162 in October 2019, to 1150 in April 2020, and further to 1128 in October 2020 by a total decrease of 34. On the other hand, the numbers of hospital dentists in the central region of Taiwan increased from 386 in October 2019 to 401 in October 2020 by a total increase of 15.

Therefore, the hospital dentists were concentrated in 6 municipalities or 9 cities, especially the Taipei City with the maximal number of hospital dentists. The number of hospital dentists was largest in the northern region of Taiwan, followed by the central and southern regions of Taiwan, and lastly the eastern region of Taiwan. Moreover, the number of hospital dentists decreased by a small number during the COVID-19 pandemic.

### The comparison of the changes of the total numbers of practicing dentists, dental clinics and hospital dentists from October 2019 to October 2020

After the COVID-19 outbreak, the increased numbers of practicing dentists, dental clinics, and hospital dentists in Taiwan were 325, -2 and -14 from October 2019 to April 2020, respectively. Thus, the increased rates of the corresponding items were 2.20%, -0.03% and -0.63%, respectively. Besides, the increased numbers of practicing dentists, dental clinics, and hospital dentists in Taiwan were 83, 16 and -2 from April 2020 to October 2020, respectively. Thus, the increased rates of the corresponding items were 0.56%, 0.24% and -0.09%, respectively.

**Table 3** Distributions of dental clinics in 9 cities and 11 counties in Taiwan from October 2019 to October 2020.

	Number (percentage) of dental clinics			Increased number (rate) of dental clinics	
	October 2019	April 2020	October 2020	October 2019 to April 2020	April 2020 to October 2020
Taipei City	1358 (20.52%)	1362 (20.59%)	1360 (20.51%)	4 (0.29%)	−2 (−0.15%)
New Taipei City	1055 (15.94%)	1055 (15.95%)	1060 (15.98%)	0	5 (0.47%)
Taoyuan City	446 (6.74%)	453 (6.85%)	459 (6.92%)	7 (1.57%)	6 (1.35%)
Taichung City	945 (14.28%)	943 (14.2%)	939 (14.16%)	−2 (−0.21%)	−4 (−0.42%)
Tainan City	512 (7.74%)	512 (7.74%)	514 (7.75%)	0	2 (0.39%)
Kaohsiung City	834 (12.60%)	831 (12.56%)	834 (12.58%)	−3 (−0.36%)	3 (0.36%)
Keelung City	92 (1.39%)	89 (1.35%)	90 (1.36%)	−3 (−3.26%)	1 (1.09%)
Hsinchu City	140 (2.12%)	141 (2.13%)	142 (2.14%)	1 (0.71%)	1 (0.71%)
Chiayi City	116 (1.75%)	115 (1.74%)	116 (1.75%)	−1 (−0.86%)	1 (0.86%)
Hsinchu County	105 (1.59%)	106 (1.60%)	105 (1.58%)	1 (0.95%)	−1 (−0.95%)
Miaoli County	101 (1.53%)	103 (1.56%)	105 (1.58%)	2 (1.98%)	2 (1.98%)
Changhua County	276 (4.17%)	275 (4.16%)	273 (4.12%)	−1 (−0.36%)	−2 (−0.72%)
Nantou County	97 (1.47%)	97 (1.47%)	97 (1.46%)	0	0
Yunlin County	106 (1.60%)	107 (1.62%)	108 (1.63%)	1 (0.94%)	1 (0.94%)
Chiayi County	54 (0.82%)	53 (0.80%)	54 (0.81%)	−1 (−1.85%)	1 (1.85%)
Pingtung County	144 (2.18%)	141 (2.13%)	144 (2.17%)	−3 (−2.08%)	3 (2.08%)
Penghu County	25 (0.38%)	24 (0.36%)	24 (0.36%)	−1 (−4.00%)	0
Yilan County	100 (1.51%)	99 (1.50%)	100 (1.51%)	−1 (−1.00%)	1 (1.00%)
Hualien County	76 (1.15%)	76 (1.15%)	74 (1.12%)	0	−2 (−2.63%)
Taitung County	36 (0.54%)	34 (0.51%)	34 (0.51%)	−2 (−0.54%)	0
Nationwide	6618 (100%)	6616 (100%)	6632 (100%)	−2 (−0.03%)	16 (0.24%)
Mean ± SD	330.90 ± 398.54	330.80 ± 399.08	331.60 ± 399.11	−	−
CV	120.44%	120.64%	120.36%	−	−

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

In addition, the total increased numbers of practicing dentists, dental clinics, and hospital dentists were 408, 14 and −16 from October 2019 to October 2020, respectively. Thus, the increased rates of the corresponding items were 2.76%, 0.21% and −0.72%, respectively. Therefore, the increased rate of practicing dentists was higher than that of dental clinics and that of hospital dentists. Among them, the number of hospital dentists decreased slightly. We used Kruskal-Wallis test for the comparison of the increased rates of practicing dentists, dental clinics and hospital dentists. The increased rate of practicing dentists from October 2019 to April 2020 was significantly higher than that of dental clinics ( $P < 0.001$ ) and that of hospital dentists ( $P < 0.001$ ). Moreover, the increased rate of practicing dentists from October 2019 to October 2020 was significantly higher than that of dental clinics ( $P < 0.01$ ).

## Discussion

At the end of 2019, a disease broke out in Wuhan, China. The disease was identified as coronavirus disease 2019 (COVID-19) caused by a new type of coronavirus, a severe acute respiratory disease coronavirus 2 (SARS-CoV-2). It is obvious that serious disease outcomes and rapid global spread are the two main characteristics of the disease, both of which represent a serious public health threat posed by the virus.<sup>11</sup> In addition to mainly affecting the respiratory system, the disease is characterized by

symptoms affecting multiple systems of human body. About 20% of patients worldwide have an increased risk of severe COVID-19 disease due to underlying comorbidities.<sup>12</sup>

On April 23, 2020, the COVID-19 pandemic in Taiwan included 428 positive cases, with 6 deaths and 264 who had recovered. Between March and April 2020, the number of the positive COVID-19 cases in Taiwan increased from less than 100 to more than 400.<sup>7</sup> During this period, the entire Taiwan's society was on a high alert regarding the pandemic. However, Taiwan's government learned from its 2003 SARS experience and established a public health response mechanism for enabling rapid actions for the next crisis.<sup>13</sup> The COVID-19 pandemic has gradually subsided after May 2020. At the end of 2020, the COVID-19 pandemic in Taiwan included 799 positive cases (including 56 local cases), with 7 deaths and 671 who had recovered.<sup>7</sup> Therefore, compared with the world under the COVID-19 pandemic, Taiwan still maintains the normal social life. For example, the government, schools, and hospitals all maintain normal operations as usual.

Nevertheless, the dentists are not the first-line medical staff to care for COVID-19 patients. During dental treatment, the dentists usually have close contact with the patients' mouth and nose, so they are at a high-risk for contracting this infectious respiratory disease. During the COVID-19 pandemic, the risk to contract the disease directly influences the willingness of the dentists to work, especially those in hospitals, where may be more patients with this respiratory disease. In addition, patients'

**Table 4** Comparisons of dental clinics in 6 municipalities and 14 non-municipalities, in 9 cities and 11 counties, and in 4 different regions in Taiwan from October 2019 to October 2020.

Administrative hierarchy	Number (percentage) of dental clinics			Increased number (rate) of dental clinics	
	October 2019	April 2020	October 2020	October 2019 to April 2020	April 2020 to October 2020
<b>Municipalities (n = 6)</b>	5150 (77.82%)	5156 (77.93%)	5166 (77.90%)	6 (0.12%)	10 (0.19%)
Mean ± SD	858.33 ± 342.47	859.33 ± 341.91	861.00 ± 339.83	—	—
CV	39.90%	39.79%	39.47%	—	—
<b>Non-municipalities (n = 14)</b>	1468 (22.18%)	1460 (22.07%)	1466 (22.10%)	-8 (-0.54%)	6 (0.41%)
Mean ± SD	104.86 ± 60.12	104.29 ± 60.19	104.71 ± 59.95	—	—
CV	57.33%	57.71%	57.25%	—	—
<b>City or county</b>					
<b>Cities (n = 9)</b>	5498 (83.08%)	5501 (83.15%)	5514 (83.14%)	3 (0.05%)	13 (0.24%)
Mean ± SD	610.89 ± 459.58	611.22 ± 460.15	612.67 ± 459.46	—	—
CV	75.23%	75.28%	74.99%	—	—
<b>Counties (n = 11)</b>	1120 (16.92%)	1115 (16.85%)	1118 (16.86%)	-5 (-0.45%)	3 (0.27%)
Mean ± SD	101.82 ± 67.35	101.36 ± 67.31	101.64 ± 66.99	—	—
CV	66.15%	66.41%	65.91%	—	—
<b>Region</b>					
<b>Northern region (n = 6)</b>	3196 (48.29%)	3206 (48.46%)	3216 (48.49%)	10 (0.31%)	10 (0.31%)
Mean ± SD	532.67 ± 546.40	534.33 ± 547.58	536.00 ± 547.61	—	—
CV	102.58%	102.48%	102.17%	—	—
<b>Central region (n = 5)</b>	1525 (23.04%)	1525 (23.05%)	1522 (22.95%)	0	-3 (-0.20%)
Mean ± SD	305.00 ± 365.69	305.00 ± 364.42	304.40 ± 362.30	—	—
CV	119.90%	119.48%	119.02%	—	—
<b>Southern region (n = 6)</b>	1685 (25.46%)	1676 (25.33%)	1686 (25.42%)	-9 (-0.53%)	10 (0.59%)
Mean ± SD	280.83 ± 323.18	279.33 ± 322.81	281.00 ± 323.63	—	—
CV	115.08%	115.57%	115.17%	—	—
<b>Eastern region (n = 3)</b>	212 (3.20%)	209 (3.16%)	208 (3.14%)	-3 (-1.42%)	-1 (-0.47%)
Mean ± SD	70.67 ± 32.33	69.67 ± 32.96	69.33 ± 33.25	—	—
CV	45.75%	47.31%	47.72%	—	—

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

willingness to go to hospitals or dental clinics for non-urgent dental treatments also decreases during the pandemic.<sup>14</sup> This reduces the number of patients to visit dental departments of hospitals and dental clinics and indirectly affects the willingness of the dentists to work. Therefore, the change of dentist manpower during the COVID-19 pandemic is a topic worthy of further investigation.

This study used the numbers of overall practicing dentists, dental clinics, and hospital dentists in Taiwan in October 2019 as the baseline before the COVID-19 pandemic. We assessed the numbers of overall practicing dentists, dental clinics, and hospital dentists at the end of April 2020 after the worst period of the COVID-19 pandemic in Taiwan, and continued to evaluate the corresponding numbers at the end of October 2020 after the COVID-19 pandemic subsided. Thus, this could further compare the changes in Taiwan's dentist manpower during the severe period (from October 2019 to April 2020) and the relatively stationary period (from April 2020 to October 2020) of the COVID-19 pandemic in 2020.

Many dental schools have been locked down because of the COVID-19 pandemic.<sup>15</sup> Most of the lectures are switched to the online mode to keep on the learning progress for their dental students. Taiwan showed an exception in dental

education during the COVID-19 pandemic. This may be due to some early proper actions taken in Taiwan. The Taiwan Central Epidemic Command Center (CECC) was activated on January 20, 2020. The CECC proposed and controlled strategies in the field of medication. Besides, all schools and universities postponed their new semester by two weeks to reduce social/community interactions. Due to the proper strategies taken by the CECC, the dental education can be carried out as usual, but all the staff and students must wear a surgical mask at all times and check the body temperature before entering their dental schools during the COVID-19 pandemic. Internship including clinical skill training course is carried out in the teaching hospitals as usual, but the number of patients treated are reduced because of delayed treatment asked by some patients.<sup>16</sup> Therefore, the education and graduation of dental students continued as usual, and the national dentist license examinations were held twice a year as usual in Taiwan in 2020.

According to our previous study, the annual increased numbers of overall practicing dentists, dental clinics, and hospital dentists in Taiwan from 2001 to 2019, were 340.50, 66.30 and 55.88, respectively. In addition, the year before the outbreak of COVID-19 (from 2018 to 2019), the increased numbers (rates) of the corresponding items were 410 (2.79%), 38 (0.56%), and 65 (3.06%), respectively.<sup>17</sup> In

**Table 5** Distributions of hospital dentists in 9 cities and 11 counties in Taiwan from October 2019 to October 2020.

	Number (percentage) of hospital dentists/Number of hospitals with dental departments			Increased number (rate) of hospital dentists	
	October 2019	April 2020	October 2020	October 2019 to April 2020	April 2020 to October 2020
Taipei City	728 (32.97%)/27	715 (29.62%)/27	715 (29.55%)/27	−13 (−1.79%)	0
New Taipei City	198 (8.97%)/13	206 (8.53%)/13	190 (7.85%)/13	8 (4.04%)	−16 (−8.08%)
Taoyuan City	162 (7.34%)/13	157 (6.50%)/13	148 (6.12%)/13	−5 (−3.09%)	−9 (−5.56%)
Taichung City	209 (9.47%)/19	212 (8.78%)/19	220 (9.09%)/19	3 (1.44%)	8 (3.83%)
Tainan City	201 (9.10%)/11	201 (8.33%)/11	202 (8.35%)/11	0	1 (0.50%)
Kaohsiung City	301 (13.63%)/21	296 (12.26%)/21	294 (12.15%)/21	−5 (−1.66%)	−2 (−0.66%)
Keelung City	22 (1.00%)/5	20 (0.83%)/5	20 (0.83%)/5	−2 (−9.09%)	0
Hsinchu City	46 (2.08%)/6	46 (1.91%)/6	48 (1.98%)/6	0	2 (4.35%)
Chiayi City	41 (1.86%)/4	41 (1.70%)/5	43 (1.78%)/5	0	2 (4.88%)
Hsinchu County	6 (0.27%)/4	6 (0.25%)/4	7 (0.29%)/5	0	1 (16.67%)
Miaoli County	12 (0.54%)/3	12 (0.50%)/3	12 (0.50%)/3	0	0
Changhua County	122 (5.53%)/11	119 (4.93%)/11	126 (5.21%)/11	−3 (−2.46%)	7 (5.74%)
Nantou County	27 (1.22%)/5	27 (1.12%)/5	24 (0.99%)/5	0	−3 (−11.11%)
Yunlin County	16 (0.72%)/6	16 (0.66%)/6	19 (0.79%)/7	0	3 (18.75%)
Chiayi County	20 (0.91%)/3	23 (0.95%)/4	23 (0.95%)/4	3 (15.00%)	0
Pingtung County	19 (0.86%)/7	19 (0.79%)/7	20 (0.83%)/6	0	1 (5.26%)
Penghu County	1 (0.05%)/1	1 (0.04%)/1	1 (0.04%)/1	0	0
Yilan County	33 (1.49%)/4	34 (1.41%)/4	37 (1.53%)/4	1 (3.03%)	3 (9.09%)
Hualien County	38 (1.72%)/8	36 (1.49%)/8	36 (1.49%)/8	−2 (−5.26%)	0
Taitung County	6 (0.27%)/4	7 (0.29%)/4	7 (0.29%)/4	1 (16.67%)	0
Nationwide	2208 (100%)/175	2194 (100%)/177	2192 (100%)/178	−14 (−0.63%)	−2 (−0.09%)
Mean ± SD	110.40 ± 170.14	109.70 ± 167.57	109.60 ± 166.99	−	−
CV	154.11%	152.89%	152.36%	−	−

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

this study, during the COVID-19 pandemic (from October 2019 to October 2020), the increased numbers (rates) of the corresponding items were 408 (2.76%), 14 (0.21%), and −16 (−0.72%), respectively. However, the situation that practicing dentists, dental clinics or hospital dentists were concentrated in municipalities, cities or the northern region of Taiwan has remained the same as usual during the COVID-19 pandemic.

Furthermore, the increased numbers of practicing dentists were 325 during the severe period (from October 2019 to April 2020) and 83 during the subsided period of COVID-19 (from April 2020 to October 2020), respectively. During this one-year period, the total increased number (rate) of practicing dentists was 408 (2.76%), which was similar to the year before the outbreak of COVID-19. This showed that the increased number of practicing dentists during the COVID-19 pandemic is not different from that in the past. It was also indirectly confirmed that Taiwan's dental education, students' graduation from dental school, and participation in the national dentist license examination by the dental students all remained the same during the COVID-19 pandemic.

On the other hand, during the COVID-19 pandemic the number of dental clinics decreased by 2 during the severe period and increased by 16 during the subsided period. The total increased number (rate) of dental clinics was 14 (0.21%), which was lower than 40% of that before the outbreak of COVID-19. This indicates that the increased number of dental clinics during the pandemic is lower than

that in the past. Moreover, the increased numbers of pure dentist members (dentists with membership of Taiwan Dental Association but without practice registration) were 37 and 9 in the severe and subsided COVID-19 periods, respectively. The increased number (rate) of pure dentist members was 46 (29.11%) during the one-year period from October 2019 to October 2020. Taiwan's regulations on the practice registration of medical personnel do not restrict those who are not in practice or retired. In Taiwan, the practice registration for dentists without practicing may have three situations: (1) maintenance of practice registration; (2) no registration for practice but still maintaining the membership (so-called pure dentist members); (3) no registration for practice and withdrawal from the Dental Association. This indicates that the number of pure dentist members who decide not to practice suddenly increase during the COVID-19 pandemic. In addition, the increased rate of dental clinics from October 2019 to October 2020 was significantly lower than that of practicing dentists ( $P < 0.01$ ). It is also indirectly confirmed that the COVID-19 pandemic may reduce the willingness of dentists to open new dental clinics or delay their plans to open new dental clinics, and may also prompt dentists to stop practicing or retire. However, the above inferences still need the supports from further empirical studies.

During the COVID-19 pandemic, the increased numbers of hospital dentists were −14 during the severe period and −2 during the subsided period. During this one-year period from October 2019 to October 2020, the total increased



**Table 6** Comparisons of hospital dentists in hospitals of different levels, in hospitals with different COVID-19 tasks, in 6 municipalities and 14 non-municipalities, in 9 cities and 11 counties, and in 4 different regions in Taiwan from October 2019 to October 2020.

	Number (percentage) of hospital dentists/Number of hospitals with dental departments			Increased number (rate) of hospital dentists	
	October 2019	April 2020	October 2020	October 2019 to April 2020	April 2020 to October 2020
<b>Hospitals of different levels</b>					
Medical centers	1213 (54.94%)/24	1198 (54.60%)/24	1197 (54.61%)/24	-15 (-1.24%)	-1 (-0.08%)
Mean ± SD	50.54 ± 34.59	49.92 ± 33.23	49.88 ± 33.32	—	—
CV	68.44%	66.57%	66.80%	—	—
Regional hospitals	770 (34.87%)/73	771 (35.14%)/73	760 (34.67%)/72	1 (0.13%)	-11 (-1.43%)
Mean ± SD	10.55 ± 12.12	10.56 ± 12.27	10.56 ± 12.00	—	—
CV	114.88%	116.19%	113.64%	—	—
District hospitals	225 (10.19%)/77	225 (10.26%)/79	235 (10.72%)/81	0	10 (4.44%)
Mean ± SD	2.92 ± 4.71	2.85 ± 4.57	2.95 ± 4.25	—	—
CV	161.30%	160.35%	144.07%	—	—
<b>Hospitals with different tasks</b>					
Treatment of severe COVID-19 cases	1623 (73.51%)	1611 (73.43%)	1612 (73.54%)	-12 (-0.74%)	1 (0.06%)
Mean ± SD	32.46 ± 31.39	32.22 ± 30.65	32.24 ± 30.60	—	—
CV	96.70%	95.13%	94.91%	—	—
Community inspection	506 (22.92%)	506 (23.06%)	498 (22.72%)	0	-8 (-1.58%)
Mean ± SD	5.16 ± 7.11	5.11 ± 6.84	5.03 ± 6.41	—	—
CV	137.79%	133.86%	127.44%	—	—
No task	79 (3.58%)	77 (3.51%)	82 (3.74%)	-2 (-2.53%)	5 (6.33%)
Mean ± SD	3.04 ± 6.94	2.85 ± 6.63	2.93 ± 6.01	—	—
CV	228.29%	232.63%	205.12%	—	—
<b>Administrative hierarchy</b>					
Municipalities (n = 6)	1799 (81.48%)/104	1787 (74.03%)/104	1769 (73.10%)/104	-12 (-0.67%)	-18 (-1.00%)
Mean ± SD	299.83 ± 214.81	297.83 ± 209.30	294.83 ± 211.33	—	—
CV	71.64%	70.27%	71.68%	—	—
Non-municipalities (n = 14)	409 (18.52%)/71	407 (16.86%)/73	423 (17.48%)/74	-2 (-0.49%)	16 (3.91%)
Mean ± SD	29.21 ± 30.02	29.07 ± 29.20	30.21 ± 30.91	—	—
CV	102.77%	100.45%	102.32%	—	—
<b>City or county</b>					
Cities (n = 9)	1908 (86.41%)	1894 (86.33%)	1880 (85.77%)	-14 (-0.73%)	-14 (-0.73%)
Mean ± SD	212.00 ± 215.03	210.44 ± 211.21	208.89 ± 211.16	—	—
CV	101.43%	100.37%	101.09%	—	—
Counties (n = 11)	300 (13.59%)	300 (13.67%)	312 (14.23%)	0	12 (4.00%)
Mean ± SD	27.27 ± 33.46	27.27 ± 32.46	28.36 ± 34.35	—	—
CV	122.70%	119.03%	121.12%	—	—
<b>Region</b>					
Northern region (n = 6)	1162 (52.63%)	1150 (52.42%)	1128 (51.46%)	-12 (-1.03%)	-22 (-1.89%)
Mean ± SD	193.67 ± 273.14	191.67 ± 268.49	188.00 ± 268.30	—	—
CV	141.03%	140.08%	142.71%	—	—
Central region (n = 5)	386 (17.48%)	386 (17.59%)	401 (18.29%)	0	15 (3.89%)
Mean ± SD	77.20 ± 86.45	77.20 ± 87.23	80.20 ± 91.10	—	—
CV	111.98%	112.99%	113.59%	—	—
Southern region (n = 6)	583 (26.40%)	581 (26.48%)	583 (26.60%)	-2 (-0.34%)	2 (0.34%)
Mean ± SD	97.17 ± 123.93	96.83 ± 121.93	97.17 ± 121.14	—	—
CV	127.54%	125.92%	124.67%	—	—
Eastern region (n = 3)	77 (3.49%)	77 (3.51%)	80 (3.65%)	0	3 (3.90%)
Mean ± SD	25.67 ± 17.21	25.67 ± 16.20	26.67 ± 17.04	—	—
CV	67.04%	63.11%	63.89%	—	—

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

number of hospital dentists was –16, which showed a slight decrease. This indicates that the increased number of hospital dentists during the COVID-19 pandemic is lower than that in the past. Furthermore, the number of hospital dentists was 2208 (14.92% of 14,800 overall practicing dentists) in October 2019, and this corresponding number decreased to 2194 (14.51% of 15,125 overall practicing dentists) in April 2020, and further reduced to 2192 (14.41% of 15,208 overall practicing dentists) in October 2020. Thus, the increased rate of hospital dentists from October 2019 to April 2020 was significantly lower than that of practicing dentists ( $P < 0.001$ ). It is also indirectly confirmed that the COVID-19 pandemic may reduce the willingness of dentists to work in hospitals, and may also prompt dentists to work in dental clinics. However, the above inferences still need supports from further empirical studies.

Although the increased number of practicing dentists during the COVID-19 pandemic was the same as those in previous years, the number of hospital dentists decreased during the COVID-19 pandemic. In particular, the reduced number and proportion of practicing dentists in hospitals with the tasks for COVID-19 (such as tasks for treatment of severe COVID-19 patients and tasks for community inspection) was relatively higher than that of practicing dentists in hospitals without the tasks. Similarly, the reduced number and proportion of practicing dentists in medical centers and regional hospitals was also relatively higher than that of practicing dentists in district hospitals. The other possible reason is that the hospitals with the tasks for COVID-19 are usually high-level hospitals (such as medical centers and regional hospitals) that are concentrated in municipalities, cities, and the northern region of Taiwan. Therefore, the reduced number and proportion of practicing dentists in the above-mentioned hospitals is also relatively higher.

When the disease of severe acute respiratory syndrome (SARS) suddenly happened in year 2003, the numbers of overall practicing dentists, dental clinics, and hospital dentists increased by 345 and 159, and decreased by 34, respectively, from 2002 to 2003. After going through SARS pandemic, the ratio of hospital dentists to overall dentists continued to decrease to a lowest level of 12.7% in 2007. However, one year (from 2001 to 2002) before the SARS pandemic, the corresponding numbers of overall practicing dentists, dental clinics, and hospital dentists increased by 262, 71 and 31, respectively.<sup>6,17</sup> The SARS pandemic in Taiwan occurred from March to July 2003. It came suddenly but ended quickly. Therefore, the increased numbers of overall practicing dentists and dental clinics in that year were not affected. Instead, it affected the willingness of a dentist to work in a hospital, and this impact continued from 2003 to 2007.

Unlike the SARS pandemic, Taiwan's government has obtained enough experience to respond to the COVID-19 pandemic, and thus the social life of people in Taiwan is as usual during the pandemic. However, it has been more than one year since the outbreak of COVID-19. Although the current increase in the number of practicing dentists has not been affected, the willingness of dentists to open new dental clinics or work in hospitals may be reduced by the impact of the COVID-19 pandemic. Since the CECC officially reported the first COVID-19 case of a hospital physician on

January 12, 2021, the entire Taiwan's society was on a high alert again regarding the pandemic. Therefore, as the COVID-19 pandemic continues, the changes in the dentist manpower should continue to be monitored.

## Declaration of competing interest

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

## References

- Cheng FC, Chang JYF, Lin TC, et al. Current practice patterns and training project of oral pathology specialists in Taiwan. *J Dent Sci* 2020;15:168–75.
- Cheng HC. The knowledge and attitudes for dental practitioners in Taiwan toward post COVID-19 pandemic. *J Family Dent* 2020;15:37–42.
- de Souza RA, Namen Jr FM, Galan J, Vieira C, Sedano OH. Infection control measures among senior dental students in Rio de Janeiro State, Brazil. *J Publ Health Dent* 2006;66:282–4.
- Jain M, Sawla L, Mathur A, et al. Knowledge, attitude and practice towards droplet and airborne isolation precautions amongst dental health care professionals in India. *Med Oral Patol Oral Cir Bucal* 2010;15:e957–61.
- 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.
- 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.
- Taiwan Centers for Disease Control. *COVID-19 dashboard*. 2021. <https://www.cdc.gov.tw/Category/NewsPage/EmXemth4IT-IRAPrAnyG9A>. [Accessed 12 January 2021].
- Taiwan Dental Association. Statistics on the number of members of dental associations of counties and cities in October 2019. *Newsletter of Taiwan Dental Association* 2019;38:82 [In Chinese].
- Taiwan Dental Association. Statistics on the number of members of dental associations of counties and cities in April 2020. *Newsletter of Taiwan Dental Association* 2019;39:84 [In Chinese].
- Taiwan Dental Association. Statistics on the number of members of dental associations of counties and cities in October 2020. *Newsletter of Taiwan Dental Association* 2019;39:83 [In Chinese].
- Abu Hammad O, Alnazzawi A, Borzangy SS, et al. Factors influencing global variations in COVID-19 cases and fatalities; A review. *Healthcare* 2020;8:216–29.
- Clark A, Jit M, Warren-Gash C, et al. Global, regional, and national estimates of the population at increased risk of severe COVID-19 due to underlying health conditions in 2020: a modelling study. *Lancet Glob Health* 2020;8:e1003–17.
- Wang CJ, Ng CY, Brook HR. Response to COVID-19 in Taiwan: big data analytics, new technology, and proactive testing. *J Formos Med Assoc* 2020;323:1341–2.
- Guo H, Zhou Y, Liu X, et al. The impact of the COVID-19 epidemic on the utilization of emergency dental services. *J Dent Sci* 2020;15:564–7.
- Iyer P, Aziz K, Ojcius DM. Impact of COVID-19 on dental education in the United States. *J Dent Educ* 2020:1–5.
- Chang TY, Hong G, Paganelli C, et al. Innovation of dental education during COVID-19 pandemic. *J Dent Sci* 2021;16:15–20.
- Cheng FC, Chang JYF, Lin TC, et al. 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. *J Dent Sci* 2021;16:437–44.