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Original Article

Correlation between the beverage serving activities and the dental use of health care resources of National Health Insurance for common oral diseases



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Abstract *Background/purpose:* Taiwanese get use to drinking hand-shaken beverages. However, excessive sugar intake is strongly associated with the occurrence of dental caries. This study evaluated the correlation between the beverage serving activities and the dental use of National Health Insurance (NHI) for common oral diseases in 2016.

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intake;
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Materials and methods: Data on the population, the beverage serving activities, and the dental records of NHI were obtained from the related websites of government. These data were divided by cities and counties to investigate the beverage serving activities and the dental use of NHI for common oral diseases in 2016.

Results: In Taiwan, the value of beverage consumption per person had a moderate to high positive correlation with the dental use rate, the number of out-patient visits per 1,000 people, and the medical expenses per person for common oral diseases. For dental caries, diseases of pulp & periapical tissues, and gingivitis & periodontal diseases, their Pearson's *r* values were 0.52–0.61, 0.18–0.40, and 0.58–0.65, respectively. These results indicate that the higher the beverage consumption per capita, the higher the dental use per capita.

Conclusion: There is a long-term benefit for oral health and systemic health through reducing or avoiding unnecessary excessive sugar intake. Therefore, from a cost-effectiveness viewpoint, Taiwan government should develop a better oral health care policy including a health education strategy of appropriate sugar intake to prevent dental caries and other non-communicable diseases in Taiwanese people.

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Introduction

In the long evolutionary history of human beings, carbohydrate intake has evolved from the meaning of physiological needs to the meaning of psychological needs. It has changed from providing a source of human energy to satisfying human pursuit of sweetness. Human beings love sweet tastes as a result of evolution. In today's life, it is easy to obtain sugar. However, excessive sugar intake is strongly associated with the occurrence of dental caries.

Dental caries is a human oral disease with a long history. Archaeological evidence shows that tooth decay is an ancient disease dating far back to prehistory.¹ In the 1960s, the World Health Organization (WHO) survey found that the prevalence of dental caries in industrialized countries is quite high, while it is generally low in developing countries. Actually, the severity of dental caries increases with the progress of industrialization. In the late 1970s, the development trend of dental caries in schoolchildren around the world was polarized. In industrialized countries, the prevalence of dental caries showed a gradual downward trend, while the prevalence of dental caries in developing countries became more and more serious.²

Factors related to the occurrence of dental caries are multi-layered and interlocked. Among them, the availability and accessibility of sugar-sweetened diets are one of the important factors that promote the occurrence of dental caries in children and adolescents. According to the 2019/2020 survey of oral health of children and adolescents aged 6 to 18 by the Ministry of Health and Welfare, the impact of hand-shaken beverages on schoolchildren's dental caries was included for the first time. Statistics show that the average value of the decayed, extracted, and filled permanent teeth (DMFT) index of schoolchildren who drink more than 3 cups of hand-shaken beverages per day is 3.65, which is more than twice that (1.68) of schoolchildren who do not drink hand-shaken beverages.³ This shows that the DMFT index of schoolchildren who drink hand-shaken beverages and favor high sweetness is significantly higher than

schoolchildren who do not drink or tend to use less sugar. The possible reasons are that the fructose or high fructose syrup used in hand-shaken beverages can effectively promote the growth of bacterial biofilms, and the beverage ingredients are sticky foods, which cause the sugar to stay on the surface of the teeth for a longer time, making the teeth more vulnerable to cariogenic bacteria.

In fact, the effects of excessive sugar intake are gaining increasing attention, especially considering their impact on both oral and systemic health, which means that excessive sugar intake causes not only tooth decay, but also obesity, type 2 diabetes mellitus, and cardiometabolic diseases.⁴ Excessive sugar intake-induced oral and systemic diseases also increase the needs for oral and systemic health care. Therefore, effectively reducing unnecessary sugar intake may promote oral and systemic health, which also means the reduction of future medical expenses for oral and systemic health care. While dental caries and periodontal diseases are associated with each other and with increased sugar consumption, obesity, and systemic inflammation, this reinforces the WHO's guidance that any approach intended to prevent non-communicable diseases should target common risk factors.⁵

This study aimed to collect statistical data on the beverage serving activities in Taiwan's Industry and Service Census and statistical data on the dental use of health care resources of National Health Insurance (NHI) for common oral diseases, and to analyze the correlation between these two groups of data. The results can be used as a reference for planning future oral health care strategies.

Materials and methods

This study adopted the methods of the secondary data analysis. The statistical data of beverage serving activities in Taiwan's Industry and Service Census were obtained from the website of the Directorate-General of Budget, Accounting and Statistics. Since the census is conducted every 5 years, the most recent census that has been published

online is the 2016 census. Therefore, this study used the statistical data of 2016 for analysis. Due to the Industry and Services Census excluded street vendors, the beverage serving activities only included beverage serving activities via shops. The data included the number of beverage shops and their value of beverage production by cities and counties of Taiwan. The population data of Taiwan in the end of 2016 were obtained from the website of the Ministry of the Interior. The dental treatment records were obtained from the website of the NHI Administration. These records included the numbers of patients, the numbers of out-patient visits and their medical expenses, and disease classifications.

In addition, according to the population and beverage serving activities via shops in 2016, the value of beverage production per shop and the value of beverage consumption per person were calculated and analyzed by cities and counties. According to the population and dental patients who received NHI services in 2016, dental use indicators of NHI such as dental use rate, the mean numbers of out-patient visits per 1,000 people, and the mean medical expense NHI points per person, as well as the mean numbers of out-patient visits per patient, the mean medical expense NHI points per patient, and the mean medical expense NHI points per out-patient visit were calculated and analyzed by cities and counties based on three groups of common oral-related diseases (dental caries, diseases of pulp & periapical tissues, and gingivitis & periodontal diseases) by the International Statistical Classification of Diseases and Related Health Problems 10th Revision (ICD-10). It should be noted that the value of one NHI point is settled quarterly, and one NHI point fluctuates around 0.8–1.2 NT dollars. The dental use rate of each oral-related diseases was calculated by dividing the number of patients of each oral-related diseases to the total population.

Furthermore, the data of New Taipei City and Taipei City were combined into a group of Greater Taipei in this study as people in both cities share a common living environment. Then, the coefficient of correlation was used for comparisons between the beverage serving activities and the dental use indicators of NHI. This study did not include Kinmen County and Lienchiang County, so the cities and counties of the whole area of Taiwan were divided into 19 groups for Pearson's correlation and regression analysis.

Results

The beverage serving activities and beverage consumption in Taiwan in 2016

The number of beverage shops and the total value of beverage production by cities and counties of Taiwan in 2016 are shown in [Table 1](#). In Taiwan, the total value of production of beverages via shops was 85.57 billion NT dollars in 2016. Meanwhile, there were a total number of 22,472 beverage shops and a total population of 23.39 million people. Therefore, there were an average value of beverage production per shop of 3.81 million NT dollars and an average value of beverage consumption per person of 3658 NT dollars ([Table 1](#)). Taipei City was the city with the largest value of production of beverages (23.02 billion,

26.90% of 85.57 billion), followed in a descending order by Taichung City (15.95 billion, 18.64% of 85.57 billion) and Kaohsiung City (10.98 billion, 12.83% of 85.57 billion). Penghu County was the county with the smallest value of production of beverages (0.26 billion, 0.30% of 85.57 billion) among all cities and counties in Taiwan ([Table 1](#)).

Besides, Kaohsiung City was the city with the largest number of beverage shops (3989, 17.75% of 22,472), followed in a descending order by Tainan City (3121, 13.89% of 22,472) and Taichung City (2865, 12.75% of 22,472). However, Penghu County was also the county with the smallest number of beverage shops (133, 0.59% of 22,472) among all cities and counties in Taiwan ([Table 1](#)).

Furthermore, Taipei City was the city with the largest value of beverage production per shop (8.90 million), followed in a descending order by Hsinchu County (5.73 million) and Taichung City (5.57 million). The group of Greater Taipei also had a very high value of beverage production per shop (6.41 million). However, Taitung County was the county with the smallest value of beverage production per shop (1.74 million) among all cities and counties in Taiwan ([Table 1](#)).

In addition, Taipei City was the city with the largest value of beverage consumption per person (8538 NT dollars), followed in a descending order by Taichung City (5764 NT dollars) and Chiayi City (4262 NT dollars). The group of Greater Taipei also had a very high value of beverage consumption per person (4535 NT dollars). However, Miaoli County was the county with the smallest value of beverage consumption per person (1467 NT dollars) among all cities and counties in Taiwan ([Table 1](#)). These results indicate that southern cities have a larger number of beverage shops, while northern and central cities have higher amounts of beverage production and consumption. However, in the eastern region and the outlying islands, both the number of beverage shops and the amounts of beverage production and consumption are relatively low ([Table 1](#)).

The dental use indicators of National Health Insurance for common oral-related diseases in Taiwan in 2016

The dental use indicators of NHI for three groups of common oral-related diseases (dental caries, diseases of pulp & periapical tissues, and gingivitis & periodontal diseases) by cities and counties of Taiwan in 2016 are shown in [Tables 2-4](#). For dental caries, the number of patients, the number of out-patient visits, and the medical expenses were 6.33 million patients, 12.84 million visits, and 16.03 billion NHI points, respectively, in 2016. Moreover, based on the corresponding value per person, the dental use rate, the number of out-patient visits per 1,000 people, and the medical expenses per person were 27.05%, 550 visits, and 685 NHI points, respectively. Meanwhile, based on the corresponding value per patient, the number of out-patient visits per patient, the medical expenses per patient, and the medical expenses per out-patient visit were 2.03 visits, 2534 NHI points, and 1248 NHI points, respectively ([Table 2](#)).

For diseases of pulp & periapical tissues, the number of patients, the number of out-patient visits, and the medical expenses were 1.84 million patients, 3.40 million visits, and 5.80 billion NHI points, respectively, in 2016. Based on the corresponding value per person, the dental use rate, the number of out-patient visits per 1,000 people, and the

Table 1 The number of beverage shops and the total value of beverage production by cities and counties of Taiwan in 2016.

	Total value of beverage production (1,000 NT dollars)	Number of beverage shops	Population	Value of beverage production per shop (1,000 NT dollars)	Value of beverage consumption per person (NT dollars)
New Taipei City	7,255,146	2136	3,979,208	3397	1823
Taipei City	23,015,341	2586	2,695,704	8900	8538
(Greater Taipei)	(30,270,487)	(4722)	(6,674,912)	(6411)	(4535)
Taoyuan City	4,019,837	1339	2,147,763	3002	1872
Taichung City	15,949,293	2865	2,767,239	5567	5764
Tainan City	7,435,075	3121	1,886,033	2382	3942
Kaohsiung City	10,980,840	3989	2,779,371	2753	3951
Ilan County	985,016	427	457,538	2307	2153
Hsinchu County	2,005,969	350	547,481	5731	3664
Miaoli County	820,170	332	559,189	2470	1467
Changhua County	2,892,501	847	1,287,146	3415	2247
Nantou County	845,079	440	505,163	1921	1673
Yunlin County	1,208,962	551	694,873	2194	1740
Chiayi County	867,793	434	515,320	2000	1684
Pingtung County	2,319,783	1077	835,792	2154	2776
Taitung County	417,461	240	220,802	1739	1891
Hualien County	699,144	339	330,911	2062	2113
Penghu County	255,320	133	103,263	1920	2473
Keelung City	893,891	236	372,100	3788	2402
Hsinchu City	1,551,438	490	437,337	3166	3547
Chiayi City	1,150,230	540	269,874	2130	4262
Overall	85,568,289	22,472	23,392,107	3808	3658

medical expenses per person were 7.88%, 145 visits, and 248 NHI points, respectively. Meanwhile, based on the corresponding value per patient, the number of out-patient visits per patient, the medical expenses per patient, and the medical expenses per out-patient visit were 1.84 visits, 3146 NHI points, and 1706 NHI points, respectively (Table 3).

For gingivitis & periodontal diseases, the number of patients, the number of out-patient visits, and the medical expenses were 8.34 million patients, 15.87 million visits, and 13.83 billion NHI points, respectively, in 2016. Based on the corresponding value per person, the dental use rate, the number of out-patient visits per 1,000 people, and the medical expenses per person were 35.65%, 679 visits, and 591 NHI points, respectively. Meanwhile, based on the corresponding value per patient, the number of out-patient visits per patient, the medical expenses per patient, and the medical expenses per out-patient visit were 1.90 visits, 1658 NHI points, and 871 NHI points, respectively (Table 4).

Among three groups of common oral-related diseases, gingivitis & periodontal diseases had the highest values in the number of patients (8.34 million patients), the number of out-patient visits (15.87 million visits), the dental use rate (35.65%), and the number of out-patient visits per 1,000 people (679 visits), followed in a descending order by dental caries (6.33 million patients, 12.84 million visits, 27.05%, and 550 visits, respectively) and diseases of pulp & periapical tissues (1.84 million patients, 3.40 million visits, 7.88%, and 145 visits, respectively) (Tables 2-4).

Dental caries had the highest values in medical expenses (16.03 billion NHI points), the medical expenses per person

(685 NHI points), and the number of out-patient visits per patient (2.03 visits), followed in a descending order by gingivitis & periodontal diseases (13.83 billion NHI points, 591 NHI points, and 1.90 visits, respectively) and diseases of pulp & periapical tissues (5.80 billion NHI points, 248 NHI points, and 1.84 visits, respectively) (Tables 2-4).

Moreover, diseases of pulp & periapical tissues had the highest values in medical expenses per patient (3146 NHI points) and the medical expenses per out-patient visit (1706 NHI points), followed in a descending order by dental caries (2534 and 1248 NHI points, respectively) and gingivitis & periodontal diseases (1658 and 871 NHI points, respectively) (Tables 2-4). These results indicate that among three common oral-related diseases, dental caries consumes more medical expenses, and patients with dental caries also have higher average number of dental visits. The number of patients with gingivitis and periodontal diseases is the largest among the three groups of patients, and the total number of dental visits is also the largest among the three, which reflects a higher dental use rate. Although the number of patients, the number of dental visits, and the medical expenses consumed by diseases of pulp and periapical tissues are lower, the average medical expenses per patient or per dental visits are higher (Table 3).

Comparison of various dental use indicators by cities and counties, New Taipei City had the highest values in the number of patients, the number of out-patient visits, and the medical expenses for three groups of common oral-related diseases, while Penghu County had the lowest corresponding values (Tables 2-4). This was all about the size of the population. For dental caries, Penghu County

Table 2 The dental use indicators of National Health Insurance for dental caries by cities and counties of Taiwan in 2016.

	Number of patients	Number of out-patient visits	Medical expenses (1,000 NHI points)	Dental use rate (%)	Number of out-patient visits per 1,000 people	Medical expenses per person (NHI points)	Number of out-patient visits per patient	Medical expenses per patient (NHI points)	Medical expenses per out-patient visit (NHI points)
New Taipei City	1,076,893	2,173,330	2,645,740	27.06	546	665	2.02	2457	1217
Taipei City	799,346	1,630,980	1,924,538	29.65	605	714	2.04	2408	1180
(Greater Taipei)	(1,876,239)	(3,804,310)	(4,570,278)	(28.11)	(570)	(685)	(2.03)	(2436)	(1201)
Taoyuan City	562,077	1,131,482	1,485,365	26.17	527	692	2.01	2643	1313
Taichung City	809,045	1,595,967	2,039,276	29.24	577	737	1.97	2521	1278
Tainan City	518,042	1,106,038	1,390,527	27.47	586	737	2.14	2684	1257
Kaohsiung City	785,145	1,638,589	2,115,333	28.25	590	761	2.09	2694	1291
Ilan County	110,496	220,554	257,618	24.15	482	563	2.00	2331	1168
Hsinchu County	142,536	286,067	358,636	26.03	523	655	2.01	2516	1254
Miaoli County	135,698	274,105	350,937	24.27	490	628	2.02	2586	1280
Changhua County	341,722	669,396	834,717	26.55	520	649	1.96	2443	1247
Nantou County	125,714	242,568	307,431	24.89	480	609	1.93	2445	1267
Yunlin County	154,814	307,997	388,255	22.28	443	559	1.99	2508	1261
Chiayi County	121,266	240,369	299,345	23.53	466	581	1.98	2469	1245
Pingtung County	173,713	350,243	447,078	20.78	419	535	2.02	2574	1276
Taitung County	48,110	95,758	118,599	21.79	434	537	1.99	2465	1239
Hualien County	86,201	186,082	223,278	26.05	562	675	2.16	2590	1200
Penghu County	32,472	73,105	90,951	31.45	708	881	2.25	2801	1244
Keelung City	93,871	190,608	219,955	25.23	512	591	2.03	2343	1154
Hsinchu City	130,580	271,341	334,015	29.86	620	764	2.08	2558	1231
Chiayi City	79,347	159,824	198,232	29.40	592	735	2.01	2498	1240
Overall	6,327,088	12,844,403	16,029,826	27.05	550	685	2.03	2534	1248

had the highest values in dental use rate (31.45%), the number of out-patient visits per 1,000 people (708 visits), the medical expenses per person (881 NHI points), the number of out-patient visits per patient (2.25 visits), and the medical expenses per patient (2801 NHI points). Moreover, Taoyuan City had the highest value in medical expenses per out-patient visit (1313 NHI points) (Table 2).

For diseases of pulp & periapical tissues, Penghu County had the highest values in dental use rate (9.02%) and the medical expenses per person (275 NHI points). Hualien County had the highest values in the number of out-patient visits per 1,000 people (174 visits) and the number of out-patient visits per patient (2.01 visits). Moreover, Hsinchu County had the highest values in the medical expenses per patient (3324 NHI points) and the medical expenses per out-patient visit (1838 NHI points) (Table 3).

Furthermore, for gingivitis & periodontal diseases, Taipei City had the highest values in the dental use rate (42.00%) and the medical expenses per person (1730 NHI points). Penghu County had the highest value in the number of out-patient visits per 1,000 people (880 visits). Kaohsiung City and Penghu County had the highest value in the number of out-patient visits per patient (2.11 visits). Furthermore, Miaoli County had the highest values in medical expenses per patient (1768 NHI points) and the medical expenses per out-patient visit (956 NHI points) (Table 4). These results indicate that based on the dental use per population or per patient as an indicator, a city or a county with a large population may not necessarily have a high dental use rate.

The coefficient of correlation between the beverage serving activities and the dental use indicators of National Health Insurance for common oral-related diseases in Taiwan in 2016

The coefficient of correlation (Pearson's r) between the beverage serving activities and the dental use indicators of NHI for three groups of common oral-related diseases (dental caries, diseases of pulp & periapical tissues, and gingivitis & periodontal diseases) in Taiwan in 2016 are shown in Table 5. Among the three groups of common oral-related diseases, the total value of beverage production had a very high positive correlation with the number of patients, the number of out-patient visits, and the medical expenses for all three groups of common oral-related diseases, and all Pearson's r values were 0.96–0.97 (Table 5).

In addition, the number of beverage shops also had a very high positive correlation with the number of patients, the number of out-patient visits, and the medical expenses, and their Pearson's r values were 0.89–0.92. Furthermore, the value of beverage production per shop also had a high positive correlation with the same dental use indicators, and their Pearson's r values were 0.66–0.68 (Table 5). Because a city or a county with more population will inevitably respond to more beverage serving activities (such as the total value of beverage production, the number of beverage shops, and the value of beverage production per shop) and high dental use indicators (such as the number of patients, the number of out-patient visits, and the medical expenses), it is also inevitable that the above parameters are highly positively correlated (Table 5).

Table 3 The dental use indicators of National Health Insurance for diseases of pulp & periapical tissues by cities and counties of Taiwan in 2016.

	Number of patients	Number of out-patient visits	Medical expenses (1,000 NHI points)	Dental use rate (%)	Number of out-patient visits per 1,000 people	Medical expenses per person (NHI points)	Number of out-patient visits per patient	Medical expenses per patient (NHI points)	Medical expenses per out-patient visit (NHI points)
New Taipei City	327,111	622,223	1,049,877	8.22	156	264	1.90	3210	1687
Taipei City (Greater Taipei)	219,692 (546,803)	435,387 (1,057,610)	705,862 (1,755,739)	8.15 (8.19)	162 (158)	262 (263)	1.98 (1.93)	3213 (3211)	1621 (1660)
Taoyuan City	159,508	291,518	510,024	7.43	136	237	1.83	3197	1750
Taichung City	230,293	394,935	724,489	8.32	143	262	1.71	3146	1834
Tainan City	153,105	288,713	501,032	8.12	153	266	1.89	3272	1735
Kaohsiung City	209,406	385,436	657,923	7.53	139	237	1.84	3142	1707
Ilan County	36,208	68,675	105,333	7.91	150	230	1.90	2909	1534
Hsinchu County	37,732	68,250	125,436	6.89	125	229	1.81	3324	1838
Miaoli County	41,481	70,896	125,672	7.42	127	225	1.71	3030	1773
Changhua County	103,143	180,535	304,211	8.01	140	236	1.75	2949	1685
Nantou County	41,059	71,692	125,299	8.13	142	248	1.75	3052	1748
Yunlin County	49,205	88,484	149,543	7.08	127	215	1.80	3039	1690
Chiayi County	40,076	71,793	125,765	7.78	139	244	1.79	3138	1752
Pingtung County	55,429	98,372	158,418	6.63	118	190	1.77	2858	1610
Taitung County	14,894	27,172	42,818	6.75	123	194	1.82	2875	1576
Hualien County	28,667	57,536	90,005	8.66	174	272	2.01	3140	1564
Penghu County	9,312	16,766	28,443	9.02	162	275	1.80	3054	1696
Keelung City	29,768	56,598	86,437	8.00	152	232	1.90	2904	1527
Hsinchu City	34,809	64,631	112,371	7.96	148	257	1.86	3228	1739
Chiayi City	21,517	38,717	67,991	7.97	143	252	1.80	3160	1756
Overall	1,842,415	3,398,329	5,796,948	7.88	145	248	1.84	3146	1706

Therefore, we also used the value of beverage consumption per person and the dental use per person as indicators (such as the dental use rate, the number of out-patient visits per 1,000 people, and the medical expenses per person) to analyze their correlation. The results showed that there was a high positive correlation between the value of beverage consumption per person and the dental use indicators (the number of patients, the number of out-patient visits, and the medical expenses) for all three groups of common oral-related diseases, of which their Pearson's *r* values were 0.55–0.59 (Table 5).

In addition, the value of beverage consumption per person also had a high positive correlation with the dental use rate, the number of out-patient visits per 1,000 people, and the medical expenses per person for dental caries and for gingivitis & periodontal diseases, and their Pearson's *r* values were 0.52–0.65 (Table 5).

For diseases of pulp & periapical tissues, however, the above parameters also showed at least a moderate positive correlation, and their Pearson's *r* values were 0.18–0.40 (Table 5). For gingivitis & periodontal diseases, the total value of beverage production and the number of beverage shops also had a high positive correlation with the above parameters, and their Pearson's *r* values were 0.44–0.51 (Table 5). This result indicates that the higher the beverage consumption per capita, the higher the dental use per capita.

Discussion

In Taiwan, the market for hand-shaken beverages is huge, and there are a lot of hand-shaken beverage shops. This indicates the fact that many Taiwanese like to drink hand-shaken beverages. Taiwan has now become a beverage kingdom, and beverage manufacturers from Taiwan can be found all over the world. Since the early 1980s, Taiwan's economy has grown rapidly, and bubble tea has evolved into an explosively growing takeaway hand-shaken beverage.⁶ The invention of pearl milk tea has brought about an innovation in the taste of beverages. In Taiwan, "drinking hand-shaken beverages" has long become a life culture that meets psychological needs. However, due to most hand-shaken beverages containing a lot of sugar and energy, drinking too much hand-shaken beverages does not seem to be very healthy, especially for those containing too much sugar which may cause dental caries. To the best of our knowledge, this study is the first one focusing on the correlation between the beverage serving activities and the dental use of health care resources of NHI in Taiwan. This may be the first study of dental public health focusing on the relationship between beverage consumption and common oral diseases such as dental caries, diseases of pulp & periapical tissues, and gingivitis & periodontal diseases.

By government regulations, the beverage serving activities refer to shops and vendors engaged in preparing

Table 4 The dental use indicators of National Health Insurance for gingivitis & periodontal diseases by cities and counties of Taiwan in 2016.

	Number of patients	Number of out-patient visits	Medical expenses (1,000 NHI points)	Dental use rate (%)	Number of out-patient visits per 1,000 people	Medical expenses per person (NHI points)	Number of out-patient visits per patient	Medical expenses per patient (NHI points)	Medical expenses per out-patient visit (NHI points)
New Taipei City	1,471,139	2,747,209	2,515,869	36.97	690	632	1.87	1710	916
Taipei City	1,132,140	2,169,883	1,959,099	42.00	805	727	1.92	1730	903
(Greater Taipei)	(2,603,279)	(4,917,092)	(4,474,968)	(39.00)	(737)	(670)	(1.89)	(1719)	(910)
Taoyuan City	695,769	1,240,901	1,103,964	32.40	578	514	1.78	1587	890
Taichung City	1,065,632	1,995,451	1,680,716	38.51	721	607	1.87	1577	842
Tainan City	660,311	1,306,113	1,117,338	35.01	693	592	1.98	1692	855
Kaohsiung City	1,058,754	2,230,384	1,779,657	38.09	802	640	2.11	1681	798
Ilan County	137,675	242,890	207,362	30.09	531	453	1.76	1506	854
Hsinchu County	171,551	301,605	281,662	31.33	551	514	1.76	1642	934
Miaoli County	163,561	302,422	289,129	29.25	541	517	1.85	1768	956
Changhua County	435,505	802,568	689,245	33.83	624	535	1.84	1583	859
Nantou County	163,842	294,924	256,073	32.43	584	507	1.80	1563	868
Yunlin County	203,622	372,198	321,659	29.30	536	463	1.83	1580	864
Chiayi County	156,175	298,955	259,841	30.31	580	504	1.91	1664	869
Pingtung County	228,950	434,494	355,841	27.39	520	426	1.90	1554	819
Taitung County	59,206	111,377	102,752	26.81	504	465	1.88	1735	923
Hualien County	105,296	203,136	183,353	31.82	614	554	1.93	1741	903
Penghu County	42,996	90,908	73,968	41.64	880	716	2.11	1720	814
Keelung City	126,406	234,548	206,302	33.97	630	554	1.86	1632	880
Hsinchu City	160,164	297,582	271,468	36.62	680	621	1.86	1695	912
Chiayi City	100,685	194,758	175,316	37.31	722	650	1.93	1741	900
Overall	8,339,379	15,872,306	13,830,613	35.65	679	591	1.90	1658	871

beverages for immediate drinking, which can be subdivided into beverage shops and beverage vendors. However, the official statistics do not cover street vendors. It can be expected that the actual beverage consumption is much higher than the statistical data. According to the statistics of the Ministry of Finance, the number of beverage shops increased from 21,346 in 2017 to 25,625 in 2020, showing a total increase of 4,279 beverage shops by 3 years with a mean annual growth rate of 6.7%. On the other hand, the beverage shops were generally denser in the southern region than in the northern and central regions of Taiwan, reflecting that the beverage serving activities were more severely affected by factors such as rental costs and climate.⁷ Our study also showed a similar result, but in terms of beverage consumption per person, a higher consumption was shown in the central region of Taiwan.

Furthermore, according to the statistics of the Ministry of Economic Affairs, the total production of beverages via shops increased from 93.88 billion NT dollars in 2017 to a recent highest point of 99.42 billion NT dollars in 2019, and then decreased to 97.83 billion NT dollars in 2020. Due to the global outbreak of COVID-19, the total production of beverages dropped in 2020, and this was the first decline in recent years. On the other hand, according to the statistics of the NHI Administration, the total medical expenses for dental out-patient clinics increased from 404.0 billion NHI points in 2016 to 453.6 billion NHI points in 2019 and further

to 457.5 billion NHI points in 2020. It indicates that the dental health care cost does not decrease due to the COVID-19 pandemic. However, the medical expenses for dental caries and diseases of pulp & periapical tissues showed the same trend as the total production of beverages. The medical expenses for dental caries and diseases of pulp & periapical tissues increased from 161.3 to 58.4 billion NHI points in 2016 to 163.0 and 66.0 billion NHI points in 2019, and then decreased to 159.5 and 65.7 billion NHI points in 2020, respectively. Conversely, the medical expenses for gingivitis & periodontal diseases showed the same trend as the total dental expenses. The medical expenses for gingivitis & periodontal diseases increased from 139.3 billion NHI points in 2016 to 173.5 billion NHI points in 2019 and further to 180.8 billion NHI points in 2020. This may be due to the fact that in recent years, the health policy tends to encourage people to receive regular scaling and early treatment of periodontal diseases. In fact, diseases of pulp & periapical tissues are the results of further deterioration of dental caries. In recent years, the expenditure of medical expenses for these two dental diseases has shown the same development trend as the total production of beverages. Therefore, this forces us not to ignore the correlations among the beverage consumption, excessive sugar intake, and dental caries-related diseases.

This study found that although diseases of pulp & periapical tissues consumed less NHI costs overall, the average

Table 5 The coefficient of correlation (Pearson's *r*) between the beverage serving activities and the dental use indicators of National Health Insurance for three groups of common oral-related diseases in Taiwan in 2016.

	Number of patients	Number of out-patient visits	Medical expenses	Dental use rate	Number of out-patient visits per 1,000 people	Medical expenses per person	Number of out-patient visits per patient	Medical expenses per patient	Medical expenses per out-patient visit
Dental caries									
Total value of beverage production	0.96*	0.96*	0.96*	0.34	0.26	0.24	-0.02	-0.04	-0.03
Number of beverage shops	0.91*	0.92*	0.92*	0.33	0.28	0.32	0.08	0.20	0.19
Value of beverage production per shop	0.68**	0.67**	0.66**	0.33	0.20	0.17	-0.19	-0.23	-0.10
Value of beverage consumption per person	0.58**	0.58**	0.59**	0.61**	0.52*	0.52*	0.11	0.12	-0.05
Diseases of pulp & periapical tissues									
Total value of beverage production	0.96*	0.96*	0.96*	0.20	0.23	0.32	0.84*	0.33	0.13
Number of beverage shops	0.90*	0.89*	0.90*	0.12	0.17	0.28	0.61**	0.39	0.18
Value of beverage production per shop	0.67**	0.67**	0.67**	0.05	0.06	0.21	0.59**	0.42	0.31
Value of beverage consumption per person	0.56*	0.55*	0.57*	0.21	0.18	0.40	0.34	0.51*	0.37
Gingivitis & periodontal diseases									
Total value of beverage production	0.97*	0.97*	0.97*	0.51*	0.44*	0.47*	0.84*	0.10	-0.08
Number of beverage shops	0.90*	0.92*	0.90*	0.49*	0.48*	0.45*	0.61**	0.06	-0.29
Value of beverage production per shop	0.68**	0.66**	0.67**	0.38	0.20	0.30	0.59**	-0.07	0.22
Value of beverage consumption per person	0.57*	0.58**	0.57*	0.65**	0.58**	0.60**	0.34	0.11	0.17

* < 0.001; ***P* < 0.01; **P* < 0.05.

NHI costs per patient were higher, which means that the sequelae of dental caries in patients may in turn cause more medical expenses. Moreover, the self-payment for further prosthesis fabrication after endodontic treatment may cause the financial burden of the patients themselves or their families. This also highlights the importance of preventing dental caries and avoiding the deterioration of dental caries in the early stage. In addition to correcting adverse oral health behavior, reducing the excessive sugar intake is also a key factor to reduce dental caries and diseases of pulp & periapical tissues.

A 2019-2020 survey of Taiwan shows that the mean DMFT of schoolchildren who drink more than 3 cups of hand-shaken beverages per day is 3.65, which is significantly

higher than that (1.68) of schoolchildren who do not drink. Moreover, the average decayed teeth (DT) and filled permanent teeth (FT) also show the same trend. In terms of sweetness hobby of hand-shaken beverages, it is more related to DT, showing that the mean DT of schoolchildren who like to drink beverages with high sugar is 1.00, which is significantly higher than that (0.71) of schoolchildren who like sugar-free beverages.³ In Taiwan, sugar-sweetened beverages are currently banned in middle schools and elementary schools. Only seven types of beverages, including 100% vegetable juice, fresh milk, long-lasting milk, soy milk, yogurt, packaged drinking water, and mineral water, can be sold in middle schools and elementary schools, and the sugar content is limited. Despite this,

scholars are still concerned that there are many hand-shaken beverage shops outside campuses. The production of beverages and the number of beverage shops have continued to grow in recent years. Such convenience for hand-shaken beverages may cause a negative impact on the oral health of our schoolchildren. Furthermore, scholars speculate that there are two main reasons for the cariogenicity of hand-shaken beverages. The sugar in hand-shaken beverages is mostly fructose or high fructose syrup. Streptococci in the high fructose syrup environment can produce acid and reduce the pH value, and the rate of decline is much faster than in the sucrose environment. This indicates that sugar can effectively produce acidity and promote the growth of biofilms, leading to the occurrence of dental caries. Many ingredients in hand-shaken beverages are sticky foods with high starch content, which may cause sugar to remain on the surface of the teeth for a longer time, and then in turn make the teeth more vulnerable to cariogenic bacteria.³

From a macroscopic viewpoint, the factors related to the occurrence of dental caries are multi-layered and interlocked, including individual congenital factors and oral health care behavior, family socioeconomic status, school support and supervision, individual habits for sugar-sweetened diets, the convenience of obtaining sugar-sweetened foods in life, the availability and accessibility of dental care resources, and the emphasis and implementation of national oral health policies.³ From a microscopic viewpoint, however, there is no doubt that excessive sugar consumption is the main cause of dental caries.⁸ However, it should be noted that the dental use rate in this study refers to the proportion of the number of patients with oral-related diseases who receive dental services from NHI to the population, but the actual number of patients with oral-related diseases should account for a higher proportion of the population. This is because there may be some patients with low oral health awareness, low socioeconomic status or other disadvantaged status who do not seek for dental health care.^{9,10} The possible factors and effects of this phenomenon still need further studies.

The results of this study showed a positive correlation between hand-shaken beverage consumption and the dental use of health care resources of NHI for common oral diseases. In particular, there was a high positive correlation between hand-shaken beverage consumption and the medical expenses for dental caries and gingivitis & periodontal diseases. This study was not intended to demonstrate a causal relationship between high hand-shaken beverage consumption and high dental use of health care resources of NHI for common oral diseases. However, it is undeniable that the high hand-shaken beverage consumption may lead to excessive sugar intake, which is the main cause of dental caries. According to the comparison of past studies, although the dental caries status of adult and schoolchildren in Taiwan has been improving year by year, the expenditure of medical expenses for dental caries-related diseases is still increasing year by year, except for the decrease in 2020 due to the COVID-19 pandemic.^{3,11,12} It is well known that the expenditure of medical expenses is affected by multiple factors. In addition to the incidence of the disease, the relevant factors also include the severity of the diseases, the patients' medical awareness

and behavior, medical waste behavior, and the regulations of the health insurance system. In any case, reducing sugar intake and improving oral health behavior are correct and should be advocated.

Dental caries is highly prevalent and has negative impacts on societies and the quality of life of individuals at all stages.⁸ Excessive sugar consumption and low socioeconomic status are associated with increased chronic oral disease burden values, especially dental caries.⁵ Furthermore, the sugar consumption is associated with other non-communicable conditions and diseases, such as obesity, diabetes, and cardiovascular diseases.⁸ However, dental caries-related diseases are highly preventable, but require interventions which can lead to reduction of their primary causes such as the excessive sugar intake in the diet. Such interventions have the potential to reduce dental caries-related diseases and other non-communicable diseases that are linked to excessive sugar consumption. Future surveys should monitor the long-term impact of different health policies, in order to assess the actual results in reducing sugar consumption. Furthermore, evaluation of health policies should not only be restricted to the assessment of reducing sugar consumption, but also monitor the impact on clinically relevant outcomes such as dental caries-related diseases and other non-communicable diseases.

In addition to maintaining oral health, reducing or avoiding unnecessary excessive sugar intake also has the effect of ruling out primary causes of other non-communicable conditions and diseases. Furthermore, in addition to the correct tooth-cleaning method, the concept of proper sugar intake should also be emphasized in oral health education. Therefore, from a cost-effectiveness viewpoint and a long-term benefit for oral health and systemic health, Taiwan government should develop a better oral health care policy including a health education strategy of appropriate sugar intake to prevent dental caries and other non-communicable diseases in Taiwanese people.

Declaration of competing interest

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

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