Journal of Dental Sciences 18 (2023) 1338–1346

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.e-jds.com

Original Article

Morbidity and mortality of oral cancer in Taiwan: Trends from 2000 to 2021

Feng-Chou Cheng [a,b,c†], **Ling-Hsia Wang** [d†], **Hung-Pin Lin** [e,f,g,h**], **Chun-Pin Chiang** [i,j,k,l*]

[a] *Chia-Te Dental Clinic, New Taipei City, Taiwan*
[b] *School of Life Science, National Taiwan Normal University, Taipei, Taiwan*
[c] *Science Education Center, National Taiwan Normal University, Taipei, Taiwan*
[d] *Center for the Literature and Art, Hsin Sheng Junior College of Medical Care and Management, Taoyuan, Taiwan*
[e] *Department of Stomatology, MacKay Memorial Hospital, Taipei, Taiwan*
[f] *Department of Cosmetic Application and Management, MacKay Junior College of Medicine, Nursing and Management, Taipei, Taiwan*
[g] *Department of Medicine, MacKay Medical College, New Taipei City, Taiwan*
[h] *Department of Nursing, School of Nursing, National Taipei University of Nursing and Health Sciences, Taipei, Taiwan*
[i] *Department of Dentistry, Hualien Tzu Chi Hospital, Buddhist Tzu Chi Medical Foundation, Hualien, Taiwan*
[j] *Graduate Institute of Clinical Dentistry, School of Dentistry, National Taiwan University, Taipei, Taiwan*
[k] *Graduate Institute of Oral Biology, School of Dentistry, National Taiwan University, Taipei, Taiwan*
[l] *Department of Dentistry, National Taiwan University Hospital, College of Medicine, National Taiwan University, Taipei, Taiwan*

Received 15 April 2023
Available online 2 May 2023

KEYWORDS
Oral cancer;
Morbidity;
Mortality;
Oral cancer screening;

Background/purpose: Oral cancer is a major cause of cancer morbidity and mortality worldwide, especially in Taiwan. This study investigated the morbidity and mortality of oral cancer in Taiwan from 2000 to 2021.
Materials and methods: The population data and the records of cancer registry were obtained from the websites of the Ministry of the Interior and the Ministry of Health and Welfare, respectively. The numbers of oral cancer cases and deaths were analyzed from 2000 to 2021.
Results: The numbers of oral cancer cases and deaths increased from 3378 to 1494 in 2000

* 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. Department of Stomatology, MacKay Memorial Hospital, No. 92, Section 2, Zhongshan North Road, Taipei 10449, Taiwan.
E-mail addresses: hungpin@gmail.com (H.-P. Lin), cpchiang@ntu.edu.tw (C.-P. Chiang).
† These two authors contributed equally to this work.

https://doi.org/10.1016/j.jds.2023.04.019

Oral mucosal examination

—8277 in 2020 and 3395 in 2021, respectively. The total increase of oral cancer cases was 4899 with a total increase rate of 145.03%, while the total increase of oral cancer deaths was 1901 with a total increase rate of 127.24%. The changes in the numbers of all cancer cases and deaths, as well as the morbidity and mortality of oral cancer or all cancers also showed similar trends. Furthermore, the death-to-case ratio of oral cancers decreased from 44.23% in 2000 to 40.84% in 2020. The total decrease was 3.39% with a total decrease rate of 7.66%.

Conclusion: In Taiwan, people's awareness of oral mucosal health is still inadequate. Obviously, there is still much room for improvement in the oral mucosal health education for our people. With the expertise and responsibility for taking good care of oral health of our people, the dental personnel should take active roles in the prevention and screening for oral cancers.

Introduction

Oral cancer, consisting of the cancers of the lip, oral cavity, oropharynx, and hypopharynx, is a major cause of cancer morbidity and mortality worldwide, especially in Asia.[1] According to cancer registry annual report, oral cancer ranks the 6th in cancer morbidity and mortality in Taiwan in 2020.[2] It also ranks the 3rd and the 4th in cancer morbidity and mortality among the male population, respectively. The median age of all cancer deaths is 69 years old for males, and 71 years old for females. In contrast to that, the median age of deaths from oral cancer is 60 years old for males, and 71 years old for females.[2] Moreover, the number of deaths from oral cancer ranks the second among the age group of 45—54 years in the year of 2020, indicating that oral cancer patients in Taiwan are getting younger.[3] Since 2018, the numbers of cases and deaths from oral cancer in Taiwan have exceeded 8000 and 3000, respectively.[4]

Notably, oral habits of alcohol drinking, betel quid chewing, and cigarette smoking are significant risk factors for the development of oral cancer in Taiwan,[5] especially among the males.[6] The majority of oral cancers in Taiwan are cancers of the tongue and buccal mucosa. Although surgical resection, chemotherapy, radiation therapy, or a combination of any two or three of these methods can be used for treatment of oral cancer, the five-year survival rate of oral cancers in Taiwan is only about 53.9%.[7]

Oral cancer can develop from the oral potentially malignant disorders (OPMDs, also known as oral precancerous lesions), including oral leukoplakia, oral erythroplakia, oral erythroleukoplakia, oral verrucous hyperplasia, oral submucous fibrosis, and oral lichen planus.[8] If oral cancer can be detected and treated in the oral precancerous stage, these lesions can be further prevented from transformation into their malignant counterparts.[9] The inclusion of oral cancer screening in the Taiwanese National Cancer Screening Program can be traced back as early as to 1999 in the mode as outreach services. The development of national screening database started in 2004. The policy of oral cancer screening was modified in 2010. Indigenous Taiwanese people who are 18—29 years old, or all Taiwanese people who are more than 30 years old, with the status of current smokers and/or the current/ex-betel quid chewers, are eligible for the biennial oral cancer screening.[1] However, there are limited literature focused on oral screening policy in Taiwan.[1,10,11]

In the world, Taiwan is the only country that provides a long-term nationwide and organized oral cancer screenings for betel quid chewers and smokers who are considered to be the high-risk subjects of oral cancer. However, there are few analytical reports on the epidemiology of oral cancer and oral cancer screenings in Taiwan. In the current study, we provided a comprehensive overview of the changes in the morbidities and mortalities of oral cancer in the years from 2000 to 2021. We also explored the changes in oral cancer screening in the past years from 2010 to 2021 in Taiwan.

Materials and methods

This study adopted the secondary data analysis. The population data of Taiwan from 2000 to 2021 were obtained from the official website of the Ministry of the Interior. For oral cancer and all cancers, the records of cancer registry, including the numbers of the cases and deaths from oral cancer and all cancers were obtained from the official website of the Ministry of Health and Welfare. It should be noted that the data retrieved for the Ministry of Health and Welfare in the current study, the category of oral cancer include the malignant tumors from the oral cavity, oropharynx, and hypopharynx. This study investigated and analyzed records of oral cancer and all cancers registered from 2000 to 2021.

The number of oral cancer screenings (oral mucosal examinations) was also obtained from the official website of the Ministry of Health and Welfare. Due to the beginning of the policy for comprehensive oral cancer screenings in 2010, this study investigated and analyzed the number of oral cancer screenings from 2010 to 2021. Based on the collected data, we calculated various indicators, including the numbers of cancer cases and deaths per 100,000 people, which are equivalent to the morbidities (crude incidence rates) and mortalities (crude death rates), the death-to-case ratios for oral cancers and all cancers, the ratios of the number of oral cancer cases/deaths to the number of all cancer cases/deaths, the number of oral cancer screenings per 1000 people, and the ratios of the number of oral cancer cases to the number of oral cancer

screenings. For statistical analysis, descriptive statistics was used to compare the changes in the aforementioned indicators related to oral cancer, all cancers, and oral cancer screenings. In addition, the coefficient of correlation was calculated and used for comparisons between the numbers of oral cancer screenings and oral cancer screenings per 1000 people and the numbers of oral cancer deaths and oral cancer deaths per 100,000 people. All the data were recorded and analyzed by Microsoft Excel for MAC (version 16.64).

Results

The numbers of the population, oral cancer cases and deaths, all cancer cases and deaths, and numbers of cancer cases and deaths per 100,000 people (morbidity and mortality) in Taiwan from 2000 to 2021 are shown in Table 1. To take the data of 2000 as the baseline, the changing trends of these parameters are shown in Fig. 1. The total population of Taiwan increased from 22.28 million in 2000 to 23.38 million in 2021. The total increased population was 1.10 million with a total increase rate of 4.93%. Taiwan's population growth was slow, and there was a negative population growth for the first time in 2020 (Table 1).

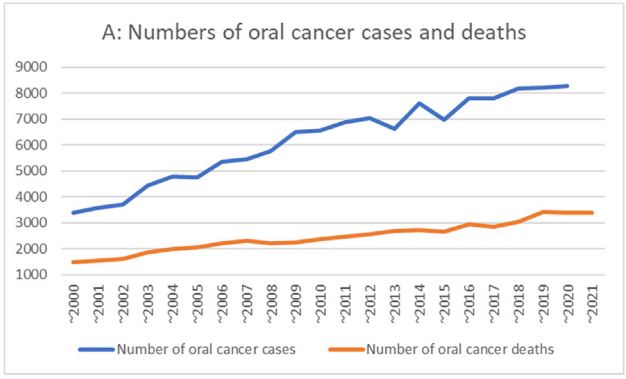
The numbers of oral cancer cases and deaths increased from 3378 to 1494 in 2000—8277 in 2020 and 3395 in 2021, respectively. The total increase of oral cancer cases was 4899 with a total increase rate of 145.03%, while the total increase of oral cancer deaths was 1901 with a total increase rate of 127.24%. The one-year increase of oral cancer cases was 245 with a one-year increase rate of 7.25%, while the one-year increase of oral cancer deaths was 91 with a one-year increase rate of 6.06% (Table 1 and Fig. 1A). In addition, the numbers of all cancer cases and deaths increased from 59,116 to 31,554 in 2000 to 121,979 in 2020 and 51,656 in 2021, respectively. The total increase of all cancer cases was 62,863 with a total increase rate of 106.34%, while the total increase of all cancer deaths was 20,102 with a total increase rate of 63.71%. The one-year increase of all cancer cases was 3143 with a one-year increase rate of 5.32%, while the one-year increase of all cancer deaths was 957 with a one-year increase rate of 3.03% (Table 1 and Fig. 1B). The numbers of oral cancer and all cancer deaths showed a decrease in 2020 in comparison to that in 2019. Furthermore, the changes in the numbers of

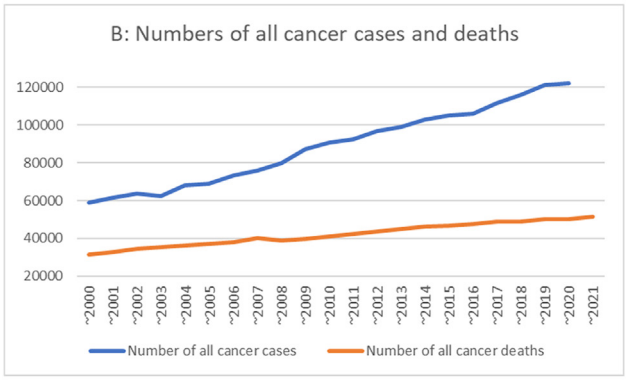
Table 1 The numbers of the population, oral cancer cases and deaths, all cancer cases and deaths, and numbers of cancer cases and deaths per 100,000 people in Taiwan from 2000 to 2021.

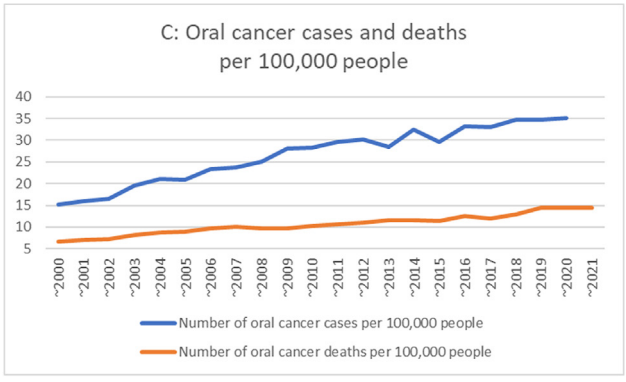
Year	Population	Numbers of cancer cases and deaths				Numbers of cancer cases and deaths per 100,000 people[a]			
		Oral cancer		All cancers		Oral cancer		All cancers	
		Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths
2000	22,276,672	3378	1494	59,116	31,554	15.16	6.71	265.37	141.65
2001	22,405,568	3591	1560	61,606	32,993	16.03	6.96	274.96	147.25
2002	22,520,776	3709	1613	63,736	34,342	16.47	7.16	283.01	152.49
2003	22,604,550	4435	1860	62,542	35,201	19.62	8.23	276.68	155.73
2004	22,689,122	4783	1993	67,895	36,357	21.08	8.78	299.24	160.24
2005	22,770,383	4743	2041	68,907	37,222	20.83	8.96	302.62	163.47
2006	22,876,527	5352	2202	73,293	37,998	23.40	9.63	320.39	166.10
2007	22,958,360	5458	2312	75,769	40,306	23.77	10.07	330.03	175.56
2008	23,037,031	5781	2218	79,818	38,913	25.09	9.63	346.48	168.91
2009	23,119,772	6480	2249	87,189	39,917	28.03	9.73	377.12	172.65
2010	23,162,123	6560	2370	90,649	41,046	28.32	10.23	391.37	177.21
2011	23,224,912	6890	2463	92,682	42,559	29.67	10.60	399.06	183.25
2012	23,315,822	7047	2566	96,694	43,665	30.22	11.01	414.71	187.28
2013	23,373,517	6633	2694	99,143	44,791	28.38	11.53	424.17	191.63
2014	23,433,753	7606	2717	103,148	46,093	32.46	11.59	440.17	196.69
2015	23,492,074	6965	2667	105,156	46,829	29.65	11.35	447.62	199.34
2016	23,539,816	7805	2936	105,832	47,760	33.16	12.47	449.59	202.89
2017	23,571,227	7797	2842	111,684	48,784	33.08	12.06	473.81	206.96
2018	23,588,932	8170	3027	116,131	48,784	34.63	12.83	492.31	206.81
2019	23,603,121	8204	3425	121,254	50,232	34.76	14.51	513.72	212.82
2020	23,561,236	8277	3380	121,979	50,161	35.13	14.35	517.71	212.90
2021	23,375,314	N/A	3395	N/A	51,656	N/A	14.52	N/A	220.99
Total increase	1,098,642	4899	1901	62,863	20,102	19.97	7.81	252.34	79.34
Total increase rate (%)	4.93	145.03	127.24	106.34	63.71	131.73	116.39	95.09	56.01
One-year increase	52,316	245	91	3143	957	1.00	0.37	12.62	3.78
One-year increase rate (%)	0.23	7.25	6.06	5.32	3.03	6.59	5.54	4.75	2.67

N/A: not available.

[a] Equivalent to the morbidities (crude incidence rates) and mortalities (crude death rates).







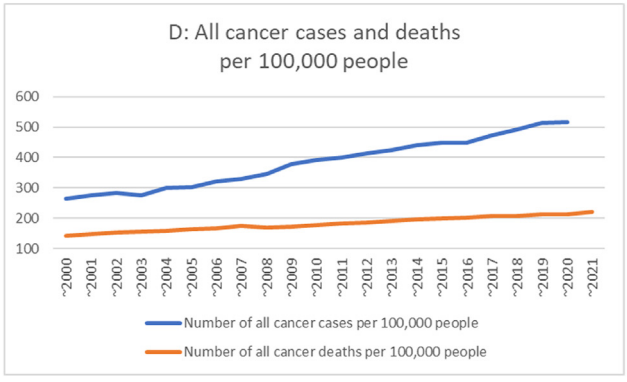


Figure 1 The changing trends of the numbers of oral cancer cases and deaths (A), the numbers of all cancer cases and deaths (B), the numbers of oral cancer cases and deaths per 100,000 people (C), and the numbers of all cancer cases and deaths per 100,000 people (D) in Taiwan from 2000 to 2021.

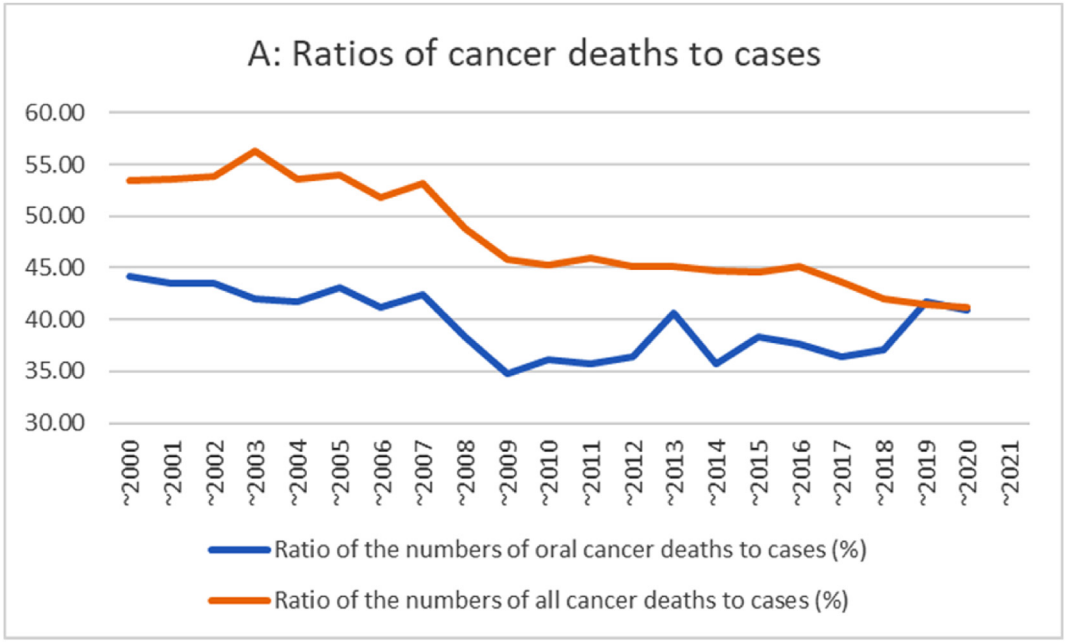
the oral cancer cases and deaths per 100,000 people and the changes in the numbers of all cancer cases and deaths per 100,000 people all showed similar trends as mentioned above (Table 1, Fig. 1C and D).

The death-to-case ratios for oral cancers and for all cancers, as well as the ratios of the number of oral cancer cases to the number of all cancer cases and the number of oral cancer deaths to the number of all cancer deaths in Taiwan from 2000 to 2021 are shown in Table 2. To take the data of 2000 as the baseline, the changing trends of these parameters are shown in Fig. 2. The death-to-case ratio for

Table 2 The ratios of the numbers of oral/all cancer deaths to the number of oral/all cancer cases and ratios of the numbers of oral cancer cases/deaths to all cancer cases/deaths in Taiwan from 2000 to 2021.

Year	Ratios of the numbers of oral/all cancer deaths to oral/all cancer cases (%)[a]		Ratios of the numbers of oral cancer cases/deaths to all cancer cases/deaths (%)	
	Oral cancer	All cancers	Cases	Deaths
2000	44.23	53.38	5.71	4.73
2001	43.44	53.55	5.83	4.73
2002	43.49	53.88	5.82	4.70
2003	41.94	56.28	7.09	5.28
2004	41.67	53.55	7.04	5.48
2005	43.03	54.02	6.88	5.48
2006	41.14	51.84	7.30	5.80
2007	42.36	53.20	7.20	5.74
2008	38.37	48.75	7.24	5.70
2009	34.71	45.78	7.43	5.63
2010	36.13	45.28	7.24	5.77
2011	35.75	45.92	7.43	5.79
2012	36.41	45.16	7.29	5.88
2013	40.62	45.18	6.69	6.01
2014	35.72	44.69	7.37	5.89
2015	38.29	44.53	6.62	5.70
2016	37.62	45.13	7.37	6.15
2017	36.45	43.68	6.98	5.83
2018	37.05	42.01	7.04	6.20
2019	41.75	41.43	6.77	6.82
2020	40.84	41.12	6.79	6.74
2021	N/A	N/A	N/A	6.57
Total increase	−3.39	−12.26	1.08	1.84
Total increase rate (%)	−7.66	−22.97	18.91	38.90
One-year increase	−0.17	−0.61	0.05	0.09
One-year increase rate (%)	−0.38	−1.15	0.95	1.85

N/A: not available.
[a] Equivalent to the death-to-case ratios for oral cancers and for all cancers.



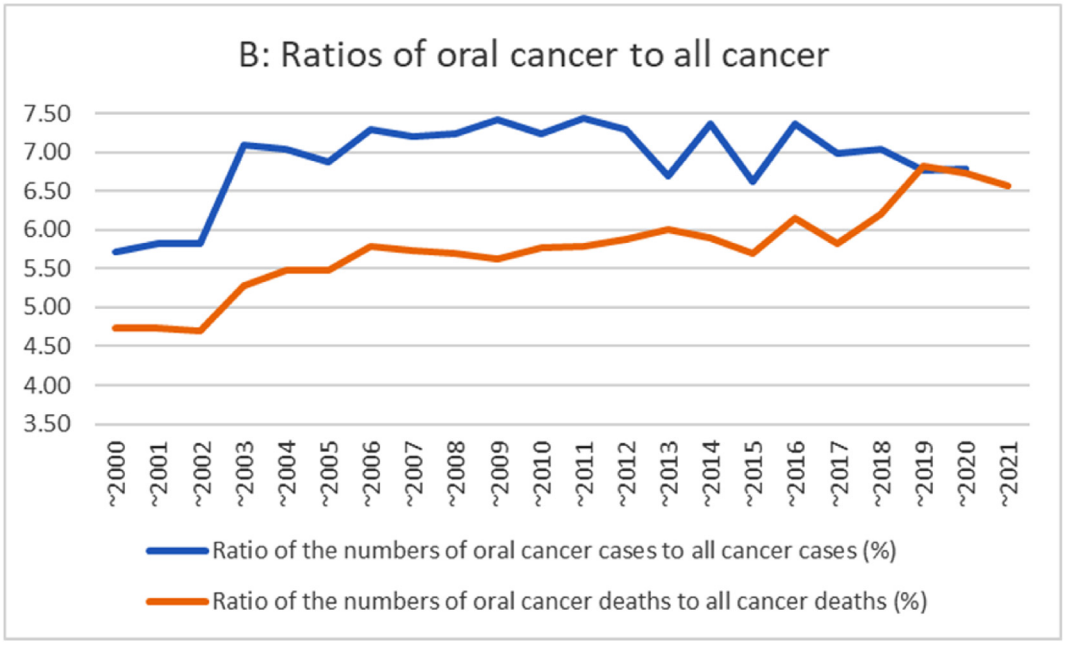


Figure 2 The changing trends of the ratios of the numbers of oral/all cancer deaths to oral/all cancer cases (A), and the ratios of the numbers of oral cancer cases/deaths to all cancer cases/deaths (B) in Taiwan from 2000 to 2021.

oral cancers decreased from 44.23% in 2000 to 40.84% in 2020. The total decrease was 3.39% with a total decrease rate of 7.66%, while the one-year decrease was 0.17% with a one-year decrease rate of 0.38% (Table 2 and Fig. 2A). It should be noted that the death-to-case ratio for oral cancers dropped to its lowest point (34.71%) in 2009, and then fluctuated up and down to 40.84% in 2020. In addition, the death-to-case ratio for all cancers also decreased from 53.38% in 2000 to 41.12% in 2020. The total decrease was 12.26% with a total decrease rate of 22.97%, while the one-year decrease was 0.61% with a one-year decrease rate of 1.15% (Table 2 and Fig. 2A). The death-to-case ratios for oral cancers and for all cancers were comparable to each other in 2019 and 2020 (Table 2 and Fig. 2A).

The ratio of the number of oral cancer cases to the number of all cancer cases increased from 5.71% in 2000 to 6.79% in 2020. The total increase was 1.08% with a total increase rate of 18.91%, while the one-year increase was 0.05% with a one-year increase rate of 0.95% (Table 2 and Fig. 2B). In addition, the ratio of the number of oral cancer deaths to the number of all cancer deaths increased from 4.73% in 2000 to 6.57% in 2021. The total increase was 1.84% with a total increase rate of 38.90%, while the one-year increase was 0.09% with a one-year increase rate of 1.85%

(Table 2 and Fig. 2B). The ratios of the numbers of oral cancer cases/deaths to the numbers of all cancer cases/deaths were close to each other in 2019 and 2020 (Table 2 and Fig. 2B).

Furthermore, the number of oral cancer screenings (oral mucosal examinations), the number of oral cancer screenings per 1000 people, and the ratio of the number of oral cancer cases to the number of oral cancer screenings in Taiwan from 2010 to 2021 are shown in Table 3. To take the data of 2010 as the baseline, the changing trends of these parameters are shown in Fig. 3. The number of oral cancer screenings increased from 782,160 in 2010 to its highest point (1,145,053) in 2012, and then decreased to its lowest point (401,559) in 2021. The total decrease was 380,601 with a total decrease rate of 48.66%, while the one-year decrease was 34,600 with a one-year decrease rate of 4.42% (Table 3 and Fig. 3). The changes in the number of oral cancer screenings per 1000 people showed similar trends as mentioned above (Table 3 and Fig. 3). On the contrary, the ratio of the number of oral cancer cases to the number of oral cancer screenings decreased from 8.39‰ in 2010 to its lowest point (6.01‰) in 2013, and then increased to its highest point (16.73‰) in 2020. However, the total increase was 8.34‰ with a total increase rate of 99.40%, while the one-year increase was 0.83‰ with a one-year increase rate of 9.94% (Table 3 and Fig. 3). In addition, the numbers of oral cancer screenings and oral cancer screenings per 1000 people all showed a negative correlation with the numbers of oral cancer deaths and oral cancer deaths per 100,000 people. The correlation coefficients were between −0.741 and −0.762, suggesting a highly negative correlation (Table 3).

Discussion

The study investigated the trends of oral cancers of the Taiwanese patients in the year from 2000 to 2021. According to the statistics presented above, the numbers of oral cancer cases and deaths as well as the ratios of the numbers of oral cancer cases/deaths to all cancer cases/deaths increased during these years. In contrast to that, the death-to-case ratios for oral cancers and for all cancers decreased during these years.

The occurrence of oral cancer increased gradually. During the oral carcinogenesis process, oral precancerous lesions, such as oral leukoplakia, oral erythroplakia, oral erythroleukoplakia, oral verrucous hyperplasia, oral submucous fibrosis, and oral lichen planus may be discovered and subsequently develop into oral cancers.[8] Oral cancer affects not only the patients' own health, but also their physical (such as facial defects, pain, and discomfort after treatment) and psychological aspects (such as defective appearance, inability to continue working, and financial burden). Similar to cancers in any other regions of the body, oral cancer affects patients both physically and psychologically. The financial burden is one of the important but relatively less discussed issues for the patients and the society.[12,13]

According to the annual statistics of the medical expenditure of the top 10 cancers in the year of 2021 published by the National Health Insurance (NHI) Administration, the medical expenditure of oral cancer ranks the fifth.[14] In 2021, the medical expenditure of the NHI system for the oral cancer treatment was a total of about 12 billion NT dollars (including 9.89 billion NT dollars for medical care

Table 3 The number of oral cancer screenings (oral mucosal examinations), the number of oral cancer screenings per 1000 people, and the ratio of the number of oral cancer cases to the number of oral cancer screenings in Taiwan from 2010 to 2021.

Year	Number of oral cancer screenings	Number of oral cancer screenings per 1000 people	Ratio of the numbers of oral cancer cases to oral cancer screenings (‰)
2010	782,160	33.77	8.39
2011	874,998	37.67	7.87
2012	1,145,053	49.11	6.15
2013	1,104,000	47.23	6.01
2014	1,062,983	45.36	7.16
2015	997,850	42.48	6.98
2016	944,528	40.12	8.26
2017	784,305	33.27	9.94
2018	796,794	33.78	10.25
2019	651,294	27.59	12.60
2020	494,689	21.00	16.73
2021	401,559	17.18	N/A
Total increase	−380,601	−16.59	8.34
Total increase rate (%)	−48.66	−49.13	99.40
One-year increase	−34,600	−1.51	0.83
One-year increase rate (%)	−4.42	−4.47	9.94
Correlation coefficient A	−0.741	−0.751	–
Correlation coefficient B	−0.752	−0.762	–

Correlation coefficient A: correlation coefficient with the number of oral cancer deaths.
Correlation coefficient B: correlation coefficient with the number of oral cancer deaths per 100,000 people.
N/A: not available.

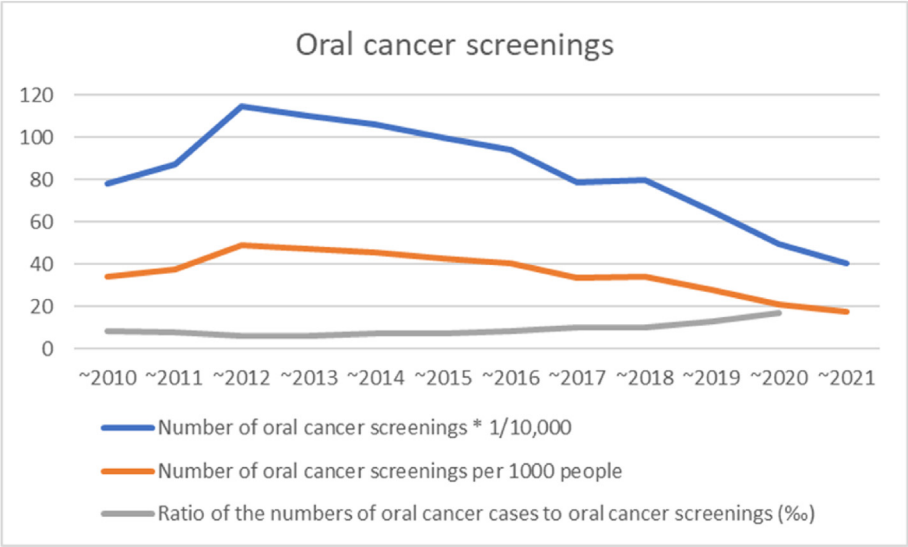


Figure 3 The changing trends of the number of oral cancer screenings (oral mucosal examinations), the number of oral cancer screenings per 1000 people, and the ratios of the numbers of oral cancer cases to oral cancer screenings in Taiwan from 2010 to 2021.

costs and 2.11 billion NT dollars for prescription drug costs) for 53,424 oral cancer patients. On average, the NHI system paid about 225,000 NT dollars (US$ 7500) for each oral cancer patient. Although the average annual growth rate of the number of oral cancer patients in the past five years (2017—2021) is only 2.55%, those for medical care costs and prescription drug costs are as high as 5.05% and 8.38%, respectively.[14] This obviously means that the financial burden of the NHI system caused by oral cancers is growing rapidly. Not only that, a study also pointed out that the hospitalization costs of five major cancers (including liver, lung, colon/rectum, stomach, and oral cavity cancers) are positively correlated with surviving years, and the treatment expenditures for the patients aged 45—64 years are higher than those of other age groups. The out-of-pocket expenditure accounts for about 20% of NHI payments that may cost up to one million NT dollars, which is obviously a great financial burden unaffordable for most of families or people.[15]

In addition to the direct medical costs, the financial burden for the society also consists of the indirect medical costs related to the loss of productivity due to disease morbidity (morbidity cost) and premature death (mortality cost).[13] Among the top 10 high-expenditure cancers in Taiwan, the estimated median morbidity cost (for 2007 to 2017) was highest for oral cancer (US$ 937) in the first three years after diagnosis.[13] A recent study revealed that the direct medical costs for male patients with head and neck cancers (HNC) were 11.54 times higher than female patients with HNC. The indirect costs (productivity loss) for 9306 male patients with HNC in the year of 2014—2015 was estimated to be 9 billion NT dollars.[16] Therefore, the national health promotion policy shall promote cancer screening measures. If the cancer can be detected and treated in the early stage, it can reduce high medical expenses and further reduce the financial burden on the society, families, or individuals.

In this study, we found that the numbers of cases and deaths of oral cancer or all cancers in Taiwan continued to rise over the past 20 years. Moreover, the increase rates of oral cancer cases and deaths are higher than those of all cancers, indicating that the morbidity and mortality of oral cancer in Taiwan show a continuous deterioration. In addition, the proportions of cases and deaths of oral cancer to those of all cancers also showed a continuous and gradual rise. Thus, the deterioration of oral cancer was worse than the average for all cancers. From the superficial data, the intervention of the oral cancer screening policy seems not to prevent the increase in the number of oral cancer deaths in Taiwan. Even the number of oral cancer deaths in 2020 was slightly lower than that in 2019, it was very likely that some cancer patients died from complications of COVID-19 infection, rather than from the cancer-related destructions or complications.

Based on the relatively accessibility for clinical inspection of the oral cavity and the presence of OPMD prior to oral cancer, oral cancer screening for high-risk groups may provide an effective way for cancer prevention.[9,10] A previous study evaluated the efficacy of the nationwide oral cancer screening program with targeted groups in Taiwan in the year between 2004 and 2009. With the comparisons between the screening and non-screening groups, the study revealed that the program contributed to the reductions of a significant 17% for the incidence of overall oral cancers (after adjustment for self-selection bias), 21% for advanced stages (stage III or IV), and 26% for mortality of oral cancers in males with betel quid chewing and smoking habits,[10] compared to another study demonstrating that visual inspection for oral cancer screening contributed to a significant 34% reduction in mortality for males with tobacco or/and alcohol use.[9] Incorporating the risk fraction method with interrupted time-series analysis, a recent study revealed that the national wide oral cancer screening program may contribute to a statistically significant

reduction in oral cancer mortality in men between 30 and 54 years old in Taiwan.[1] In reference to the data regarding the cancer of oral cavity in the year of 2012–2015, a retrospective study also demonstrated that the oral cancer screening programs are able to provide the participants with superior survival rates and better chances for detection of early-stage oral cancers in the subsequent oral cancer screening.[11]

In addition, Taiwan began to promote oral cancer screenings in 2004. Since 2010, it has comprehensively expanded the implementation of oral cancer screening program for over 30-year-old people who chew betel quids or smoke. Among the 454,000 oral cancer screenings completed in 2020, 3270 patients with oral precancerous lesions and 1095 patients with oral cancers were found. From 2014 to 2018, the 5-year relative survival rate of stage-0 oral cancer (excluding oropharynx and hypopharynx) patients registered by the hospitals is 89.7%, and that of stage-4 oral cancer patients is 40.8%.[17] This means that early detection and treatment of oral cancer patients can help to improve the 5-year survival rate for oral cancer patients and reduce the financial treatment burden for the country and individuals.

A 2015 to 2016 oral health survey for adults over 18 years old and elderly in Taiwan showed that the oral mucosal abnormality rate is 6.1% among the participant subjects. Some subjects were diagnosed as having oral cancers or OPMD lesions including oral leukoplakia, oral erythroplakia, oral erythroleukoplakia, oral verrucous hyperplasia, oral submucous fibrosis, and oral lichen planus.[8] Those subjects with betel quid chewing and cigarette smoking habits are 8.80 and 1.73 times more likely to be diagnosed as having oral cancer when compared to non-chewers and non-smokers, respectively. Therefore, betel quid chewing is the highest risk factor for contracting oral cancer or OPMD lesions in Taiwan. In the world, Taiwan is the only country that provides a long-term nationwide and organized oral cancer screening for high-risk subjects (betel quid chewers and cigarette smokers). The overall oral cancer screening rate in 2020 is 55.1%. The relative risk of death from oral cancer is 0.53 in the oral cancer screening group compared to the non-screening group. The relative risk of advanced oral cancer is 0.62 in the screening group compared to the non-screening group.[10] Studies have confirmed and supported oral visual screening for high-risk groups in areas with a high incidence of oral cancer as an effective oral cancer prevention strategy.

One of the limitations in this study is that the numbers of oral cancer cases and deaths investigated were the overall summaries consisting of both the screening and non-screening group. We cannot explore the effects brought by the different groups. A superficial analysis of the data may lead to a misinterpretation that the oral cancer screening program is not helpful for the reduction of the crude mortality and morbidity of oral cancers in Taiwan. However, previous studies have had confirmed about the efficacy of the current oral cancer screening program.[9–11] According to the various indicators in the study, the crude incidence rate and crude death rate of oral cancers grow gradually in these years in Taiwan.

The oral cancer screening program has the effect of early detection and treatment of oral cancer for the patients in the screening group, and improves the survival rate of these oral cancer patients. The increase in the incidence and death of oral cancer in Taiwan may be due to the fact that people's oral habits of betel quid chewing and cigarette smoking cannot be effectively quitted for a long period of time. The results of this study indicate that the proportion of oral cancer deaths to oral cancer cases has decreased for a long period of time, although this proportion did not improve much since 2010 (Table 2). This finding suggests that there are still many oral cancer patients in the non-screening group, who may fail to detect their oral cancers early and miss the best opportunity for treatment of oral cancers. One of the possible explanations is the decreased numbers of oral cancer screenings after 2012 (Table 3). In addition, the time lag effect or the temporal relationship between the exposure of the risk factors and oral cancers, may also be one of the reasons for increasing trends of oral cancers.[1] However, in this study, the numbers of oral cancer screenings and oral cancer screenings per 1000 people (with the correlation coefficients being between −0.741 and −0.762) all presented a highly negative correlation with the numbers of oral cancer deaths and oral cancer deaths per 100,000 people (Table 3), indicating that the decrease in the number of oral cancer screenings may be related to the increase of oral cancer deaths. After the COVID-19 pandemic, the number of oral cancer screenings further decreased significantly, and the number of oral cancer screenings (401,559) in 2021 was only one-third of that (1,145,053) in 2012 (Table 3). This may be a warning sign ever since the implementation of the current oral cancer screening program.

The exposure to the risk factors, predominately betel quid and tobacco, is one of the major causes of oral cancers. The Health Promotion Administration in Taiwan has taken actions for the prevention and control of both hazards.[18] Among the adults (over age 18), the smoking rate decreased from 21.9% in 2008 to 13.1% in 2020. Notably, there is a mild increase of the electronic cigarette use rate for people over age 18 (0.6% in 2018 and 1.7% in 2020).[18] In contrast to that, the rate of betel quid chewing in adults decreased ever since after 2007 with a mild increase from 2017 (6.1%) to 2018 (6.2%).[18,19]

Dentists are the professionals for taking good care of oral health of the people. In Taiwan, however, people's awareness of oral mucosal health might still be inadequate. Obviously, there is still room for improvement in the oral health education for Taiwanese. In fact, the number of dentists in Taiwan has doubled over the past 20 years, and hospital dentistry has also made remarkable progress.[20,21] A recent study concluded that the idea of early detection of oral cancers by private practicing dentists in the settings of everyday condition can be accomplished in a satisfactory manner.[22] We believe that under the intensive education and clinical training, dentists in Taiwan should play a more active role in the oral cancer screening program.

According to the results of this study, there are several ways we can work on to assist the prevention and control of OPMDs and oral cancers. First, the important of oral health and the hazards of betel quid and tobacco should be emphasized and illustrated clearly through our education system. Second, we should take advantages of the top-rated dental clinics for the collaboration of oral cancer

screening. Since the implementation of the NHI system in 1995, the insurance coverage rate has reached 99.9%, but the dental use rate has not yet reached 50%.[23] The appropriate use of the NHI resources regarding the oral health should be encouraged. The importance of regular oral health checkups and dental cleanings should be stressed. Meanwhile, as the professional personnel of oral health, dentists should recognize that the prevention and detection of oral cancers are the responsibilities of dentists. Third, the policy of oral cancer screening should continue to be strengthened, hoping to detect OPMD or oral cancer in the early stage with appropriate management in time.

Declaration of competing interest

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

Acknowledgments

None.

References

1. Su SY. Evaluation of nationwide oral mucosal screening program for oral cancer mortality among men in Taiwan. *Int J Environ Res Publ Health* 2022;19:14329.
2. Health Promotion Administration. *Cancer registry annual report, 2020 taiwan*. Taiwan: Health Promotion Administration, Ministry of Health and Welfare, 2022 [In Chinese].
3. Ministry of Health and Welfare. *Results of 2020 cause of death statistics*. Taiwan: Ministry of Health and Welfare, 2021 [In Chinese].
4. Health Promotion Administration. *Cancer registry annual report, 2018 taiwan*. Taiwan: Health Promotion Administration, Ministry of Health and Welfare, 2020 [In Chinese].
5. Ko YC, Huang YL, Lee CH, Chen MJ, Lin LM, Tsai CC. Betel quid chewing, cigarette smoking and alcohol consumption related to oral cancer in Taiwan. *J Oral Pathol Med* 1995;24:450—3.
6. Su SY, Chen WT, Chiang CJ, Yang YW, Lee WC. Oral cancer incidence rates from 1997 to 2016 among men in Taiwan: association between birth cohort trends and betel nut consumption. *Oral Oncol* 2020;107:104798.
7. *Five-year survival rate of the top 10 newly diagnosed cancers in Taiwan (2016—2020)*. Available at: https://twcr.tw/wp-content/uploads/2023/01/Survival_105_109.pdf; 2022 [Date accessed: 0327, 2023].
8. Warnakulasuriya S, Kujan O, Aguirre-Urizar JM, et al. Oral potentially malignant disorders: a consensus report from an international seminar on nomenclature and classification, convened by the WHO Collaborating Centre for Oral Cancer. *Oral Dis* 2021;27:1862—80.
9. Sankaranarayanan R, Ramadas K, Thomas G, et al. Effect of screening on oral cancer mortality in Kerala, India: a cluster-randomised controlled trial. *Lancet* 2005;365:1927—33.
10. Chuang SL, Su WW, Chen SL, et al. Population-based screening program for reducing oral cancer mortality in 2,334,299 Taiwanese cigarette smokers and/or betel quid chewers. *Cancer* 2017;123:1597—609.
11. Ho PS, Wang WC, Huang YT, Yang YH. Finding an oral potentially malignant disorder in screening program is related to early diagnosis of oral cavity cancer - experience from real world evidence. *Oral Oncol* 2019;89:107—14.
12. Ribeiro-Rotta RF, Rosa EA, Milani V, et al. The cost of oral cancer: a systematic review. *PLoS One* 2022;17:e0266346.
13. Huang SY, Chen HM, Liao KH, Ko BS, Hsiao FY. Economic burden of cancers in Taiwan: a direct and indirect cost estimate for 2007-2017. *BMJ Open* 2020;10:e036341.
14. National Health Insurance Administration. *Medical expenditure of top 10 cancers, 2021*. Taipei, Taiwan: National Health Insurance Administration, 2022 [In Chinese].
15. Liu WC. *Hospitalization costs and financial protection of cancer patients in Taiwan*. Master thesis. Taichung: Asia University, 2005 [In Chinese, English abstract].
16. Wu YH, Lai CH, Chien L, et al. Economic burden of cervical and head and neck cancer in Taiwan from a societal perspective. *Int J Environ Res Publ Health* 2023;20:3717.
17. Yuan Executive. *National oral health promotion plan phase II (2022～2026)*. Taipei, Taiwan: Executive Yuan, 2022 [In Chinese].
18. Health Promotion Administration. The 2022 health promotion administration annual report. Taipei, Taiwan, Health Promotion Administration, Ministry of Health and Welfare, Taiwan. [In Chinese].
19. Yang YH, Warnakulasuriya S, Yang HF, Lin LJ, Wang YW. Public health measures to reduce areca nut and betel quid use for control of oral cancer in Taiwan. *Oral Oncol* 2020;108:104915.
20. Cheng FC, Chang JYF, Lin TC, Chang WC, Chang YT, Chiang CP. Dentist manpower development and geographical distribution of dentists in Taiwan. *J Dent Sci* 2020;15:121—31.
21. Cheng FC, Chang JYF, Lin TC, Tsai PF, Chang YT, Chiang CP. The status of hospital dentistry in Taiwan in October 2019. *J Dent Sci* 2020;15:505—12.
22. Hertrampf K, Jurgensen M, Wahl S, et al. Early detection of oral cancer: a key role for dentists? *J Cancer Res Clin Oncol* 2022;148:1375—87.
23. Cheng FC, Wang YL, Chiang CP. The dental use for dental caries under the National Health Insurance system in Taiwan in 2020. *J Dent Sci* 2023;18:330—7.