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Original Article

The impact of integrating oral health education into a microbiology curriculum for students of department of life science

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Abstract *Background/purpose:* Good oral health is important for general health of the body. This study aimed to evaluate an innovative design incorporating oral health education related to oral pathogenic bacteria into a microbiology laboratory curriculum for students of department of life science by evaluating the students' perspectives on the oral health curriculum. *Materials and methods:* Twenty-six students who took the elective course entitled "Microbiology Laboratory" in the National Taiwan Normal University in 2022 were invited to fill out the questionnaire for a presurvey regarding their familiarity with basic oral health concepts, and a postsurvey in which the students answered the same presurvey questions after finishing the class. *Results:* Of the 26 students, 25 (96.15%) participated in both the presurvey and postsurvey. The results showed that the learning unit of oral health education related to oral pathogenic bacteria helped students in raising their concepts of oral health. To the questions asking that I understand the bacteria that cause dental caries and the pathogenic mechanism and I understand

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the bacteria that cause periodontal diseases and the pathogenic mechanism, the numbers of students who agreed both questions increased from 2 (8%) to 25 (100%), respectively. Moreover, the mean scores increased from 2.64 to 4.32 ($P < 0.001$) and from 2.68 to 4.32 ($P < 0.001$) for the two corresponding questions, respectively.

Conclusion: The learning unit of oral health education in the microbiology laboratory curriculum helped the students of department of life science to increase their awareness and understanding of oral health.

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Introduction

The advent of oral microbiological investigation originated from the initial observations of oral bacteria within the dental plaque by Antony van Leeuwenhoek (1632–1723) using his primitive microscopes in 1680. Oral microbiology has gone through stages of reductionism and holism. In the modern era, oral microbiology knowledge has developed rapidly because oral researchers adopt new concepts of system thinking, such as interspecies interactions, microbial communities, biofilms, polymicrobial diseases. This knowledge has dramatically changed how we think about the oral microbial communities, commonly known as the dental plaque, which is one of the most complex floras associated with the human body.¹ So far, more than 700 different bacterial species have been identified from the human oral cavity, and most of them are associated with the dental plaque.^{2–4} Extensive animal and clinical studies have shown that the oral microbial flora is responsible for two major oral diseases in humans: dental caries (tooth decay) and periodontitis (gum disease).^{5–7} The results of oral microbiological researches also provide valuable insights into the etiology of dental and periodontal diseases, and for the development of new therapeutic and preventive tools to combat oral polymicrobial diseases.¹

Oral microbiology has been developed for more than 300 years, and after the first dental college (Baltimore College of Dental Surgery) was established in the United States in 1840, it accompanied the development path of dentistry to an independent profession and became an important basic discipline in dentistry.⁸ In the modern era, however, the teaching and research of oral microbiology seems to be confined to dental schools and dental research institutions. Oral microbiology should not be independent of microbiology. In fact, microbiology is widely taught in biology, medicine and other fields, and the number of students who study microbiology is large. We think that the introduction of the pathogenic bacteria and their pathogenic mechanisms of two major oral diseases through the course of microbiology is not only the teaching of microbiology knowledge, but also may have the effect of improving students' oral health concepts. Moreover, previous studies have proved that dental students have better oral health concepts than those students of other majors.^{9–11}

We also think it would be beneficial to incorporate oral microbiology content into the general microbiology curriculum. This study designed a learning unit of oral

microbiology in a general microbiology course in the National Taiwan Normal University. The goal of this curriculum design was to hopefully prepare students to obtain a more comprehensive consideration of oral health by understanding the pathogenic bacteria of oral diseases. This study aimed to evaluate an innovative design incorporating oral health education related to oral pathogenic bacteria into a microbiology laboratory curriculum for students of department of life science by evaluating the students' perspectives on the oral health curriculum.

Materials and methods

Participants

A total of 26 students who took the elective course entitled "Microbiology Laboratory" in the National Taiwan Normal University in 2022 were included in this study.

Teaching process

The course was a general laboratory subject mainly for the students in the second semester of the second academic year of the Department of Life Science, School of Life Science, which was a one-credit (3 hours per week) subject and was taught in the multiple teaching modes by lectures, discussion, cooperative learning, experiment/hands-on, and media (computer animation or video) integrated into teaching, etc. This course was mainly taught by the teacher of the School of Life Science who specialized in the field of Zoology, and students from different fields were also welcome to take this course.

Microorganisms exist widely in the environment, including the human oral and digestive tract environments. Microbiology laboratory is a course to introduce students to learn the microorganisms in the environment, and to understand the physical, chemical, and biological characteristics of these microorganisms, hoping that students can learn the commonly used methods of microorganism detection. The objectives of this course are described as follows: to lead students to understand the basic principles of life science experiments and to understand the microorganisms in the environment, to teach students to correctly operate microscopes and other related experimental instruments, and to enable them to learn the commonly used microorganism detection

methods for assessing whether food and drinking water are contaminated.

In this study, this course was designed to add the content of oral pathogenic bacteria, which introduced the main etiological microorganisms of dental caries (*Streptococcus mutans*) and periodontal diseases (anaerobes such as *Treponema denticola* and *Porphyromonas gingivalis*), and the pathogenic mechanisms of these bacteria causing the common oral diseases, hoping to enhance the students' concepts of oral health.

Survey tool

Before the class of oral health education, all students who took this course were invited to fill out the questionnaire for a presurvey. Furthermore, the same students were invited again to fill out the questionnaire for a postsurvey after finishing the class. The questions in both the presurvey and postsurvey were the same for analyzing the changes of students' concepts of oral health before and after the class. All students were invited to join in these surveys at their free will to fill out the questionnaires without the pressure from the investigators.

A structured questionnaire through paper was used as the survey tool. The investigated questions included the self-assessment of students' cognition for concepts of oral health. In the investigated questions, the answer was designed to let the participants to raise a score ranging from 1 to 5. If the intensity or response for each question was extremely agreed, the score was 5. If the intensity or response for each question was neutral, the score was 3. In contrast, if the intensity or response for each question was extremely disagreed, the score was 1. If the mean score was 3 or more, it meant that on average answerers agreed the investigated questions, and the higher the score, the higher the degree of their agreement. In addition, a score equal to 4 or more demonstrated that the participants agreed with the investigated questions. The participants were suggested to fill the score in fresh memory.

Statistical analysis

All data obtained from the questionnaires were stored in excel files and used for statistical analysis. The differences in the mean scores (the degree of agreement) of various investigated items, which represented the changes of students' concepts of oral health before and after the class, were compared by paired sample *t*-test. The gender differences were compared by Mann–Whitney U test. The result was considered to be significant if the *P*-value was less than 0.05.

Results

Demographic data

A total of 26 students who took the elective course entitled "Microbiology Laboratory" in the National Taiwan Normal University in 2022 were included in this study. They were from different departments including 24 students from the

Department of Life Science and 2 students from other departments. Of these 26 students, 12 were males and 14 were females. Moreover, 16 were second-year students, 9 were third-year students, and one was fourth-year student with an average age of 20 years. Seven of them have no career plan to become a teacher in the future (Table 1). Of the 26 questionnaires, 25 valid questionnaires were recovered. Thus, the response rate was 96.15%.

The investigated items

There were seven items being investigated in the surveys by the self-assessment of students' cognition for concepts of oral health before and after the class (Table 2). These investigated items all were required for multiple choice. There were question 1: I understand the bacteria that cause dental caries and the pathogenic mechanism; question 2: I understand the bacteria that cause periodontal diseases and the pathogenic mechanism; question 3: I understand how to properly clean (brush) my teeth and how important it is; question 4: In order to maintain oral health, I will consider carrying a cleaning (brushing) tool with me, so that I can clean (brush) my teeth at any time after eating; question 5: I think that it is important to have regular oral health checks; question 6: I think that oral health is important for overall health; and question 7: After becoming a teacher, I will explain the importance of oral health to my students in the class (Table 2).

The changes of students' concepts of oral health before and after the class

There were seven investigated items for analyzing students' cognition for the concepts of oral health related to knowledge, behavior, and attitude before and after the class (Table 2). Based on the postsurvey results, all respondents regardless of gender found the learning unit of oral health to be helpful in raising their concepts of oral health. The degree of agreement for each item was high, and all the mean scores for each item were between 3.84 and 4.72. Moreover, all 25 (100%) respondents agreed that I understand the bacteria that cause dental caries and the

Table 1 Distribution of students who took the elective course entitled "Microbiology Laboratory" in the National Taiwan Normal University in 2022.

Category	Number of students (N = 26)		
Department	Department of Life Science		Other departments
	24		2
Grade	Second-year	Third-year	Fourth-year
	16	9	1
Gender	Male		Female
	12		14
Career plan to become a teacher	Yes		No
	19		7

Table 2 Question content and question type used in the surveys by the self-assessment of students' cognition for the concepts of oral health before and after the class.

Question content	Question type
1. I understand the bacteria that cause dental caries and the pathogenic mechanism.	For knowledge, multiple choice
2. I understand the bacteria that cause periodontal diseases and the pathogenic mechanism.	For knowledge, multiple choice
3. I understand how to properly clean (brush) my teeth and how important it is.	For behavior, multiple choice
4. In order to maintain oral health, I will consider carrying a cleaning (brushing) tool with me, so that I can clean (brush) my teeth at any time after eating.	For behavior, multiple choice
5. I think that it is important to have regular oral health checks.	For attitude, multiple choice
6. I think that oral health is important for overall health.	For attitude, multiple choice
7. After becoming a teacher, I will explain the importance of oral health to my students in class.	For attitude, multiple choice

pathogenic mechanism, and I understand the bacteria that cause periodontal diseases and the pathogenic mechanism. Regarding carrying a cleaning (brushing) tool for cleaning (brushing) my teeth at any time after eating, just 18 (72%) of the 25 respondents agreed. Other concepts of oral health were all well agreed. The data for questions on the concepts of oral health in both the presurvey and postsurvey are shown in Table 3.

For the concepts of oral health related to knowledge, before the class, only 2 (8%) students agreed both questions that I understand the bacteria that cause dental caries and the pathogenic mechanism, and I understand the bacteria that cause periodontal diseases and the pathogenic mechanism, and the agreed students increased to 25 (100%) for both questions after finishing the class. The mean scores

increased from 2.64 ± 0.70 and 2.68 ± 0.63 to 4.32 ± 0.48 and 4.32 ± 0.48 (both P -values < 0.001), respectively.

For the concepts of oral health related to behavior, before the class, 17 (68%) students agreed that I understand how to properly clean (brush) my teeth and how important it is, and the agreed students increased to 22 (88%) after finishing the class. The mean score increased from 3.88 ± 0.83 to 4.56 ± 0.71 ($P < 0.01$). Furthermore, before the class, no student agreed that in order to maintain oral health, I will consider carrying a cleaning (brushing) tool with me, so that I can clean (brush) my teeth at any time after eating, and the agreed students increased to 18 (72%) after finishing the class. The mean score increased from 2.28 ± 0.74 to 3.84 ± 0.85 ($P < 0.001$) (Table 3).

For the concepts of oral health related to attitude, before the class, 15 (60%) students agreed both questions that I think that it is important to have regular oral health checks, and after becoming a teacher, I will explain the importance of oral health to my students in the class, and the agreed students increased to 24 (96%) for both questions after finishing the class. The mean scores increased from 3.88 ± 1.20 and 3.72 ± 0.79 to 4.72 ± 0.54 and 4.56 ± 0.58 (both P -values < 0.001), respectively. Also, before the class, 19 (76%) students agreed that I think that oral health is important for overall health, and the agreed students increased to 23 (92%) after finishing the class. The mean score increased from 4.08 ± 0.86 to 4.64 ± 0.64 ($P < 0.01$). Furthermore, for overall concepts of oral health, the mean score increased from 3.31 ± 0.60 before the class to 4.42 ± 0.47 after finishing the class ($P < 0.001$) (Table 3).

The gender differences of the changes of students' concepts of oral health before and after the class

Based on the postsurvey results, all students regardless of gender found the learning unit of oral health to be helpful in raising their concepts of oral health. Moreover, regardless of the presurvey and postsurvey by assessing students' perceptions, the oral health concepts related to knowledge of male students were better than those of female students (Table 4). Conversely, the oral health concepts related to behavior and attitude of female students were superior to

Table 3 Presurvey and postsurvey results of repeated questions for students' cognition for the concepts of oral health before and after the class (N = 25).

Questions	Presurvey		Postsurvey		Significance
	Mean \pm SD	Number (rate) of respondents who answered as agree	Mean \pm SD	Number (rate) of respondents who answered as agree	t-value
Question 1	2.64 ± 0.70	2 (8%)	4.32 ± 0.48	25 (100%)	-10.47***
Question 2	2.68 ± 0.63	2 (8%)	4.32 ± 0.48	25 (100%)	-11.71***
Question 3	3.88 ± 0.83	17 (68%)	4.56 ± 0.71	22 (88%)	-3.78**
Question 4	2.28 ± 0.74	0	3.84 ± 0.85	18 (72%)	-8.97***
Question 5	3.88 ± 1.20	15 (60%)	4.72 ± 0.54	24 (96%)	-4.26***
Question 6	4.08 ± 0.86	19 (76%)	4.64 ± 0.64	23 (92%)	-3.93**
Question 7	3.72 ± 0.79	15 (60%)	4.56 ± 0.58	24 (96%)	-5.63***
Overall	3.31 ± 0.60		4.42 ± 0.47		-9.73***

** $P < 0.01$; *** $P < 0.001$.

Table 4 Gender differences of presurvey and postsurvey results by Mann–Whitney U test.

	Presurvey			Postsurvey		
	Male (N = 12)	Female (N = 13)	Significance	Male (N = 12)	Female (N = 13)	Significance
	Median (mean)	Median (mean)	U-test	Median (mean)	Median (mean)	U-test
Question 1	3 (2.75)	2 (2.54)	95.50	4 (4.33)	4 (4.31)	80.00
Question 2	3 (2.83)	2 (2.54)	99.00	4 (4.33)	4 (4.31)	80.00
Question 3	4 (3.83)	4 (3.92)	75.50	4.5 (4.25)	5 (4.85)	48.00
Question 4	2 (2.17)	3 (2.38)	64.00	4 (3.58)	4 (4.08)	56.00
Question 5	3.5 (3.58)	5 (4.15)	58.50	4.5 (4.42)	5 (5)	39.00*
Question 6	4 (4)	4 (4.15)	74.50	5 (4.42)	5 (4.85)	55.50
Question 7	4 (3.75)	4 (3.69)	84.00	4.5 (4.42)	5 (4.69)	61.00
Overall	23.5	24	77.00	29.5	32	52.50

* $P < 0.05$.

those of male students. Overall, oral health concepts of female students were better than those of male students. In addition, for question 5 of postsurvey, the median (mean) score of female students was significantly better than that of male students ($P < 0.01$) (Table 4).

Discussion

Although the birth of microbiology is associated with the observations of oral microbes within the dental plaque, modern microbiology courses rarely discuss this historical development. Around 1680, Antony van Leeuwenhoek (1632–1723) observed and described the first microorganisms in tartar from his teeth using his primitive microscope.¹² He recorded “I didn’t clean my teeth for three days and then took the material that has lodged in small amounts on the gums above my front teeth ... I found a few living animalcules” in his notebook. These oral microbes sketched in his notebook are now known as the most abundant bacteria in the oral cavity, including cocci, spirochetes, and fusiform bacteria. These fascinating observations at the birth of microbiology have shown the complexity of the oral microbial community.¹

After more than 300 years of development, due to the improvement of microscopy technology and the advancement of research methods in biochemistry and molecular biology, microbiology has accumulated a large number of research outcomes, and has become a huge knowledge system in the modern era. Microbiology knowledge is also widely used in medicine, industry, and agriculture. In addition to specialized and advanced microbiology courses, undergraduate students who major in science are almost always required to study general microbiology. It is a pity that the teaching of oral microbiology knowledge seems to be limited to dental students or graduate students in dental schools, while the learning unit of oral microbiology knowledge does not seem to be arranged for science students in general universities. As a result, these numerous students miss the opportunity to learn oral microbiology knowledge, which can further enhance their oral health knowledge.

Although students can obtain a lot of knowledge about microbiology in traditional microbiology courses, including

the physiological and biochemical characteristics of microorganisms, the utilization of microorganisms, and the roles of pathogenic microorganisms. Especially in the experimental courses, microorganisms can be directly observed under a microscope, and the presence of microorganisms can be detected through specific detection methods. However, the traditional microbiology courses pay little attention to the introduction of oral disease-causing bacteria. As a result, students have learned a lot of microbiological knowledge, but they do not know that oral pathogenic bacteria actually exist in their mouths, and are undergoing the pathogenic process of dental caries and periodontal diseases. That is the “real world” in their mouths, neither the world under the microscopes nor the reaction under the test reagents. We think that letting students know this truth will help to improve their oral health concepts, not only the acquisition of oral health knowledge, but also the changes of oral health behaviors and attitudes.

Oral health education has been not only historically lacking in medical school curricula, but also severely lacking in other professions.^{13,14} However, the separation of oral health education and other professional education has serious negative implications for the raising of oral health awareness among the general public. Therefore, the educational process should include a learning environment that encourages interprofessional learning by applying basic biomedical fundamentals and interdisciplinary clinical knowledge to promote students’ health awareness, including oral health.¹⁵ The results of this study confirmed the possibility of this thoughts. To the best of our knowledge, our study is a rare one focusing on oral health education for non-medical professional students in a normal university in Taiwan. The presurvey and postsurvey results showed that the learning unit of oral health education in the microbiology curriculum could result in an increase in students’ cognition for the oral health concepts related to knowledge, behavior, and attitude. It was also observed that students expressed interest in understanding the importance of oral health. This new initiative let the second-year students of department of life science obtain the basic knowledge of oral pathogenic bacteria, which are related to the certain common oral diseases such as dental caries and periodontal diseases. Moreover, these oral

diseases do cause the deterioration of oral health due to the role of oral pathogenic bacteria for causing the impairment of the structure and physiological function of the oral cavity.

In this study, the interprofessional oral health learning related to oral pathogenic bacteria helped the students of department of life science to acquire some basic knowledge of oral health. To the questions asking that I understand the bacteria that cause dental caries and the pathogenic mechanism, and I understand the bacteria that cause periodontal diseases and the pathogenic mechanism, all 25 (100%) students responded positively for both questions after finishing the class, compared to only 2 (8%) of the 25 students having the corresponding knowledge before the class, respectively. Considering the reported effectiveness of the interprofessional learning for improving students' basic knowledge of oral health, this model shows a good outcome for further use in other institutions. Furthermore, to the question asking that after becoming a teacher, I will explain the importance of oral health to my students in the class, 24 (96%) of the 25 students responded positively after the class, compared to 15 (60%) of the 25 students showing the same attitude before the class (Table 3). In this study, 19 (73.08%) of the 26 students had a career plan to become a teacher in the future. In fact, they have a very high chance of becoming a high school teacher in the future. After the class of oral microbiology learning unit, the number of participants who are willing to explain the importance of oral health to their students in the future has increased. If they pass the correct oral health knowledge to their students, it will have a positive impact on raising public awareness of oral health. Considering the reported effectiveness that will have spillover benefits in the future, this model shows a more valuable promise for further use in other institutions of the teacher education.

In the previous studies in Taiwan, males were found to pay more frequent emergency dental visits than females. The common reasons for emergency dental visits in children and adolescents are pulp and periapical diseases, gingivitis and periodontal diseases, and dental trauma.^{16–18} In addition, adult males have higher prevalence of periodontitis than adult females,¹⁹ because it is possible that the males tend to be unaware of their oral health. However, our study also had interesting findings. According to students' self-assessment, the cognition for the concepts of oral health related to knowledge was better in male students than in female students, while the cognition for the concepts of oral health related to behavior and attitude was indeed worse in male students than in female students. These results were consistent with the results of other dental clinical studies.^{16–20} Therefore, it is necessary to give young students, especially male students, oral health education in various ways as early as possible to enhance their awareness of oral health.

It is the real occasion that high school teachers can play an important role for oral health care of their students. The integration of oral health education related to oral pathogenic bacteria into the general microbiology curriculum has the advantage of enhancing students' oral health concepts related to knowledge, behavior, and attitude, and therefore increases their oral health. In addition, the students in

this study are likely to become high school teachers in the future. They can play an active role in the workplace in the future, including implementing oral health education for their students, assisting students in oral health care, promoting the implementation of oral health checks for students, and urging students to receive oral treatment, thereby reducing future oral disease problems, promoting the overall health, and reducing future dental expenses and overall medical expenses. Therefore, it is of great benefit to promote the integration of oral health education related to oral pathogenic bacteria into the general microbiology curriculum or related courses in the long run.

This study does not try to develop an independent oral health education course in the normal university, but merely to add the learning unit of oral health education to the relevant existing basic courses, which is considered to be an innovative beginning. The results of this study will be used as a reference for the development of future courses or educational activities for oral health education. Furthermore, in this study, the learning unit of oral health education related to oral pathogenic bacteria in the general microbiology curriculum for students of department of life science helped to increase their awareness and understanding of oral health. The future curricular directions for students of department of life science should explore an education model that incorporates oral health education into their related curricula.

Declaration of competing interest

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

References

1. He XS, Zhou XD, Shi WY. Oral microbiology: past, present and future. *Int J Oral Sci* 2009;1:47–58.
2. Aas JA, Paster BJ, Stokes LN, Olsen I, Dewhirst FE. Defining the normal bacterial flora of the oral cavity. *J Clin Microbiol* 2005; 43:5721–32.
3. Paster BJ, Boches SK, Galvin JL, et al. Bacterial diversity in human subgingival plaque. *J Bacteriol* 2001;183:3770–83.
4. Paster BJ, Olsen I, Aas JA, Dewhirst FE. The breadth of bacterial diversity in the human periodontal pocket and other oral sites. *Periodontol 2000* 2006;42:80–7.
5. Socransky SS. Criteria for the infectious agents in dental caries and periodontal disease. *J Clin Periodontol* 1979;6:16–21.
6. Dahlen G. Role of suspected periodontopathogens in microbiological monitoring of periodontitis. *Adv Dent Res* 1993;7: 163–74.
7. Loe H, Theilade E, Jensen S. Experimental gingivitis in man. *J Periodontol* 1965;36:177–87.
8. Henry JL, Sinkford JC. The development of education in dental public health in the United States of America. *J Natl Med Assoc* 1975;67:345–410.
9. Cortes FJ, Nevot C, Ramon JM, Cuenca E. The evolution of dental health in dental students at the University of Barcelona. *J Dent Educ* 2002;66:1203–8.
10. Polychronopoulou A, Kawamura M, Athanasouli T. Oral selfcare behavior among dental school students in Greece. *J Oral Sci* 2002;44:73–8.
11. Kawas SA, Fakhruddin KS, Rehman BU. A comparative study of oral health attitudes and behavior between dental and medical

- students; the impact of dental education in United Arab Emirates. *J Int Dent Med Res* 2010;3:6–10.
12. Gest H. *The discovery of microorganisms by robert hooke and Antoni van Leeuwenhoek, fellows of the royal Society*, vol. 58. Notes and Records of the Royal Society of London, 2004: 187–201.
 13. Krol DM. Educating pediatricians on children's oral health: past, present, and future. *Pediatrics* 2004;113:e487–92.
 14. Mouradian WE, Reeves A, Kim S, et al. A new oral health elective for medical students at the University of Washington. *Teach Learn Med* 2006;18:336–42.
 15. Park SE, Donoff RB, Saldana F. The impact of integrating oral health education into a medical curriculum. *Med Princ Pract* 2017;26:61–5.
 16. Huang SM, Huang JY, Yu HC, Su NY, Chang YC. Trends, demographics, and conditions of emergency dental visits in Taiwan 1997–2013: a nationwide population-based retrospective study. *J Formos Med Assoc* 2019;118:582–7.
 17. Huang JY, Yu HC, Chen YT, Chiu YW, Huang SM, Chang YC. Analysis of emergency dental revisits in Taiwan (1999–2012) from Taiwanese National health Insurance research Database (NHIRD). *J Dent Sci* 2019;14:395–400.
 18. Cheng FC, Chiang CP. Analysis of emergency dental visits of pediatric patients in the National Health Insurance of Taiwan in 2020. *J Dent Sci* 2022;17:942–50.
 19. Tsai KZ, Su FY, Cheng WC, Huang RY, Lin YP, Lin GM. Associations of decayed and filled teeth with localized stage II/III periodontitis in young adults: the CHIEF oral health study. *J Dent Sci* 2022;17:1018–23.
 20. Chang CS, Chang FM, Nakagaki H, et al. Comparison of the oral health and self-rated general health status of undergraduate students in Taiwan and Japan. *J Dent Sci* 2010;5:221–8.