

Effectiveness of an oral hygiene promoting program for elementary school students using a smartphone endomicroscope in Thailand

Jintana Sarayuthpitak and Sarinya Rodpipat

Faculty of Education, Curriculum and Instruction, Chulalongkorn University, Bangkok, Thailand

Sanong Ekgasit

Faculty of Science, Chulalongkorn University, Bangkok, Thailand, and

Dean M. Ravizza

Department of Secondary and Physical Education, Salisbury University, Salisbury, Maryland, USA

Abstract

Purpose – The purpose of this paper is to examine the effectiveness of oral hygiene promoting program (OHPP) using a smartphone endomicroscope among students in elementary schools in Bangkok, Thailand, to enable their oral hygiene maintenance and to compare oral health outcomes in the intervention program between the experimental and control groups.

Design/methodology/approach – This is a quasi-experimental research study consisting of two groups, a pretest, a posttest and a follow-up design. The student sample consisted of 59 fifth graders who matched the study criteria on medium and low levels of teeth brushing skills. There were 29 experimental group participants who completed the six-week OHPP using a smartphone endomicroscope. Another 30 participants formed the control group involved in the ordinary oral health education program. The comparison data for oral health behaviors (knowledge, attitude and practice (KAP)) and oral hygiene were statistically analyzed by using multivariate analysis of variance (MANOVA).

Findings – Results indicated that the experimental group exhibited higher oral health behaviors regarding KAPs and oral hygiene related to teeth cleanliness and gum health than the control group in the postexperimental and follow-up phases. However, there were no statistically significant differences between the two groups with regard to tongue cleanliness.

Originality/value – The students maintain their own oral hygiene due to a provision of activities related to KAP concerns. The instrument helped the students to find tooth decay and dental plaque associated with teeth cleanliness after brushing their teeth.

Keywords School-based dental program, Oral health, Smartphone endomicroscope, Children's oral health, Thailand

Paper type Research paper



Introduction

Oral hygiene problems affect the physical, mental and emotional health influencing in childhood, which is associated with cardiovascular risk factors and subclinical atherosclerosis in adulthood [1]. The 8th National Oral Health Survey, Thailand, in 2017 found 52% of 12-year-old students were affected by dental caries and gingivitis (66.3%). Additionally, brushing rates after lunch decreased to 44.7%, and risk behavior in soft-drink candy and snack increased to 13.4%. In Bangkok, first graders had a high level of caries in primary teeth (55%) while gingivitis also affected the main group of children (76.8%) [2, 3]. These incidences devastated the overall mental health of students exerting an influence on students' daily life in terms of social skills and self-confidence as the main factor impacting long-term quality of life [4].

According to a prior study in Thailand, 66.4% of students aged 11–12 years old were exposed to cavity problems (mean DMFT = 2.17). Students in this age group brushed daily in the morning at a rate of 75.3%, after school lunch at 51.0%, and 44.4% brushed before bedtime. Over 80% of students consumed cariogenic snacks and drinks some days during the past week [5]. Another study revealed that the student's oral health-related behaviors, notably knowledge and attitude, were important prerequisites for oral health-related behaviors. This study found that most of the existing educational programs on oral health in schools were not effective and sufficient. Thus, other models of education should be considered based on the psychology or social learning theories, which can change the individual behaviors and sustain them for a longer period [6].

In Thailand, programs aimed at preventing and solving oral health problems in schoolchildren have been conducted by schools and the Ministry of Public Health where the highest priority was given to oral hygiene care and protection through the provision of knowledge and teeth cleanliness in dimensions of social and environmental conditions with a continuous process. Some interventions included policies related to promoting access to dental services, dental care, children's oral health promotion project, parent and community involvement, integration of health-promoting schools and oral hygiene promotion brushing technique as well as setting a cavity-free target for every child born after 2026 [7, 8].

From implementation to school practice, various studies mentioned activities influencing the improvement of students' oral hygiene that identified the relationship between knowledge, attitudes and practices (KAPs) on oral care in students as the result of a tooth decay prevention program comprising dental cavity prevention, oral diseases, oral cancer and the importance of healthy tooth brushing. The postexperiment demonstrated better oral hygiene in students. However, promoting suitable oral health behaviors may not enable students to realize the clear results in the corner of the mouth by themselves causing obstacles for improving teeth brushing skills and oral hygiene for students [9]. Tooth brushing given in prevention programs exists to help children understand which factors impede adoption of tooth brushing recommendations and which efforts are necessary to improve their tooth brushing abilities [10].

The evaluation of cleanliness after brushing teeth with the images in school found that an oral health education program based on the use of quantitative light-induced fluorescence (QLF technology) could be used in the clinical setting for plaque assessment by detecting mature plaque as red fluorescence in photograph [11]. These can improve the oral hygiene status. This visualization can help students to improve their brushing skills just like the smartphone microscope, which can link images from a camera while in the mouth and display results via a smartphone.

Nevertheless, most of the existing implementations for promoting oral hygiene for students starting at the kindergarten level to secondary education only emphasized promoting students' knowledge and practices [12]. Health education services and oral health promotion at school can improve oral hygiene practices in the children. In this regard, the

improvement of children's brushing skills is necessary to be able to study KAP, teeth cleanliness, gum health and tongue cleanliness, and to be able to see the results of brushing immediately [9–11, 13]. There are studies in Thailand regarding the use of an endomicroscope on students in primary school. The objective of this research was to examine the effectiveness of the oral hygiene promoting program (OHPP) using a smartphone endomicroscope among students in elementary schools in Bangkok to enable their oral hygiene maintenance and to compare oral health outcomes in the intervention program between the experimental and control groups. We hypothesized that students who receive OHPP using the smartphone endomicroscope are more likely to exhibit improved oral hygiene and oral health KAP.

Methods

Study design and setting

This is a quasi-experimental research study consisting of two groups – a pretest and posttest – with a follow-up design. Data were collected three times between December 2018 and February 2019. This research was conducted at one elementary school in Bangkok. The school was located quite far from the city center. The sample size was calculated from a previous study [14] and included achieving 80 power at a 5% significant level (effect size: 0.5), and the pooled variance was 7.19. The entire sample size was increased to 60 participants due to the 20% increase in attrition and refusal. One week after having the postexperiment, one student left the program. The experimental groups contained a total of 29 people including 9 male participants and 20 female participants. The control group contained 9 male participants and 21 female participants. The intervention group received the developed oral health education program, whereas the control group received the ordinary oral health education program. The researchers had the experimental group participate in the program after school while the control group returned home to prevent contamination between the two groups. Students in both groups were asked not to discuss the activities during the trial period.

Study population

The study population included upper elementary students in schools under the jurisdiction of the Bangkok metropolitan administration.

Inclusion criteria

The study involved upper elementary students who (1) obtained medium to low brushing skills according to the debris index (DI) [15] after brushing teeth and (2) had no plan to make an appointment with the dentist for dental care within 10 weeks.

Exclusion criteria

Students were excluded if they were involuntarily committed to the activities due to the feeling of being unsatisfied or unsafe or having impacts on students' health.

Sampling procedure

This study applied purposive sampling to select a sample at a school under the jurisdiction of the Bangkok metropolitan administration. The school conducted a health-promoting school program for students in addition to having collaborative support from school administrators. Inclusion and exclusion criteria for recruiting 60 samples were brought into consideration. We used the method of simple sampling by drawing plots so that we can prevent the contamination bias.

Materials and instruments

The intervention program

The intervention program was revised from the protection motivation theory [16], a theory that contained content relevance in motivating students to perceive information about oral hygiene issues and oral health behaviors through various patterns of learning activities. The program also applied the theory of self-efficacy [17] since its contexts promoted perception of the risk of oral diseases and disease severity, as well as an expectation of responsiveness in oral disease prevention. Additionally, promoting dental health in schools was a primary concept that could induce more effectiveness in oral health behavior promotion. In this respect, the researchers developed ten activities: (1) exploration oral health, (2) plaque index examination, (3) dental checkup, (4) amiling children, (5) information on dental health, (6) perception of oral risk, (7) how to properly clean teeth, (8) questions and answers, (9) communication among home, school and dentist and (10) sharing information. The ten activities were completed in one visit. The researchers conducted and oversaw the training of the participants. The event happened twice a week for 50 min to include all ten activities.

Healthy teeth

The healthy teeth have been approved by the dentists and are used by the researchers to help carry out the project. The researchers with the help of dentists graded the participants based on the pictures taken from the smartphone endomicroscope (Figure 1). The instrument was developed from the assembly of a mini-camera with 10x magnification lens [18] together with the design of a handle and exploration component. The smartphone endomicroscope contained four parts: (1) camera (2) lens (3) handle and (4) smartphone link. The equipment provided the illustration of dental plaque and cavities in students and was brought into the exploration of oral health activity. The study used the recorded images in the perception of oral risk and communication among home, school and dentist activities. The next step involved scoring and examining the validity of the instrument through interrater reliability among three inspectors, including the school health teacher, health education teacher and dentist. The correlation was found by specifying the validity value above 0.80. An obtained value based on the validity test was 0.92.

Health knowledge, attitude and practice questionnaire

The researchers decided the score given to the participant by the data collection instrument consisting of a measurement form relating to oral health behaviors concerning oral hygiene care, food choice, oral cleaning, self-teeth checking and oral diseases. In measuring the knowledge aspect component, the form included 20 items with four possible answers. IOC (Item objective congruence) was between 0.68 and 1.00, and reliability was 0.87, and items of knowledge difficulty index (b) were in a range between 0.30 and 0.73, while item discrimination index (r) ranged from 0.20 to 0.80. Regarding attitude measurement that represented perceived self-efficacy, feeling, belief, opinion, responsiveness and decision, the form was a 20-item measure specifying both positive and negative statements by dividing into a three-level score scale in which three points referred to students who agreed with the statement, two points meant that the students who were uncertain with the statement while a score of 0 indicated student disagreement with the statement. This form received an IOC of 0.90–1.00, a reliability of 0.88 and discrimination in the range of 0.20–0.87. According to the practice aspect, a 20-item form was used in measurement with both positive and negative question wordings, which consisted of a four-level classification: four points denoted regular practice with 6–7 days per week, three points remarked frequent practice with 3–5 days per week, two points addressed occasional practice with 1–2 days per week and zero point



- 1 Mini-camera with 20X magnification lens installed inside
- 2 1 Luminous point
- 3 Length of exploring part at signal side
- 4 2 parts of articulated arm: (left-right)
- 5 Control switch for turning on and off
- 6 Handle used in oral check-up
- 7 Hole for battery charger

Figure 1.
Smartphone
endomicroscope

indicated no practice. This form received IOC of 0.90–1.00, the reliability of 0.80 and discrimination in the range of 0.33–1.00.

Oral hygiene status was evaluated by a dental plaque score range developed from the Community Periodontal Index (CPI) as a measure used by this research, in accordance with the World Health Organization (WHO) survey manual. The study applied a blunt explorer conformed to the periodontal probe as stated by the WHO specification manual. In total, six teeth numbers of 16, 11, 26, 36, 31 and 46 [19] were examined using a scoring method that ranges from 0 to 2 modified by Greene and Vermillion [15] (0 = more than 1/2 of anterior teeth with observable plaque, 1 = less than 1/2 of anterior teeth with observable plaque and 2 = no observable plaque). This instrument attained an IOC of 0.97. Simultaneously, Gum health was modified from gingivitis index (GI) [20] score in the range of 0–2 (0 = moderate gingivitis with swollen, inflamed and receding gums, 1 = slight gingivitis with inflamed and bleeding gums and 2 = healthy gingiva), so the IOC was 1.00. The area of tongue coating was visually investigated using the score in the range of 0–2 (0 = 1–1/2 tongue dorsum with coating, 1 = less than 1/3 of tongue dorsum with coating, 2 = no observable tongue coating) [21] where the test gained IOC of 1.00.

Methodology

The intervention group participated in the 50-min program twice a week for six weeks continuously led by the research staff. The main purpose of the program was to enable students to perceive their own oral health problems via the smartphone endomicroscope and then to record the results. For this experiment, the researchers worked with schools upon mutual agreement. Each study participant joined willingly and with parental consent.

No participants were injured during the study, and no private information including participants' names was shared. The kit can be utilized for hygiene self-checking after brushing to provide immediate feedback. A photo was displayed on a mobile phone or tablet screen for keeping a record. With regard to knowledge enabling students to comprehend the scope of oral hygiene care, food choice and oral cleaning, their teeth could be checked with the mobile phone or tablet screen provided by the research team. Oral diseases and their relation with attitudes on risk perception and oral hygiene mindfulness were demonstrated through photos taken from the smartphone endomicroscope by students representing their oral health problems. On the other hand, the control group received dental health education that was provided as part of the elementary school health curriculum to encourage students to brush their teeth during lunchtime and to learn about dental care and oral diseases in-class sessions, which included a school oral checkup by the dentist once per semester.

Statistical analysis

Data on oral health outcomes were collected three times to include (1) before the experiment in November 2018; (2) following the six-week experiment period in January 2019 and (3) after a ten-week experiment period in February 2019. The researcher conducts the examination three times before, after and follow-up on the examination. There are three ways to measure the dental health: the tongue, the teeth and the gums. Three levels of cleanliness include poor, average and good. For teeth, the researchers used the DI. The measuring tool was taken and improved for the tongue and gums.

Descriptive analysis results on mean and standard deviation of the scores of oral health behaviors, such as KAP related to oral hygiene, teeth cleanliness, gum health and tongue cleanliness, were compared between the experimental group and control group among three periods by mean, standard deviation *t*-test and MANOVA with repeated measures at a significance level of 0.05.

Ethical approval statement

This research protocol, number 246.1/61 was approved by the Ethics Review Committee for Research Involving Human Research Subjects, Health Science Group at Chulalongkorn University in Bangkok, Thailand.

Results

Table 1 shows the characteristics collected from the 59 students at baseline. Table 2 summarizes the basic statistics of oral health behaviors in aspects of KAP and oral hygiene regarding teeth cleanliness, gum health and tongue cleanliness of students participating in

Characteristic		Experimental group (n = 29)	Control group (n = 30)	Total (n = 59)
Age, years (%)	10	2 (6.9)	2 (6.7)	4 (6.8)
	11	25 (86.2)	24 (80.0)	49 (83.0)
	12	2 (6.9)	4 (13.3)	6 (10.2)
Gender (%)	Male	9 (31.0)	9 (30.0)	18 (30.5)
	Female	20 (69.0)	21 (70.0)	41 (69.5)
Living arrangement of student (%)	With both father and mother	24 (82.8)	25 (83.3)	49 (83.0)
	Father or mother	2 (6.9)	3 (10.0)	4 (6.8)
	Other (Aunt, uncle)	3 (10.3)	2 (6.7)	6 (10.2)
Having toothache (%)	Yes	3 (10.3)	2 (6.7)	5 (8.5)
	No	26 (89.7)	28 (93.3)	54 (91.5)

Table 1.
Baseline characteristics

Item	Experimental group		Control group		<i>t</i>	<i>p</i> -value
	Mean	SD	Mean	SD		
<i>Preexperimental phase</i>						
Knowledge	9.03	2.04	9.07	3.11	-0.05	0.965
Attitude	2.27	0.17	2.27	0.19	-0.10	0.924
Practice	2.74	0.32	2.70	0.26	0.52	0.608
Teeth cleanliness	0.86	0.33	0.87	0.38	-0.12	0.915
Gum health	1.78	0.35	1.74	0.42	0.46	0.646
Tongue cleanliness	1.17	0.54	1.17	0.46	0.04	0.965
<i>Postexperimental phase</i>						
Knowledge	13.55	2.18	10.17	2.78	5.19	<0.001*
Attitude	2.50	0.19	2.26	0.27	4.01	<0.001*
Practice	2.91	0.20	2.63	0.33	3.93	<0.001*
Teeth cleanliness	1.36	0.21	1.04	0.32	4.51	<0.001*
Gum health	1.95	0.11	1.65	0.49	3.23	<0.001*
Tongue cleanliness	1.94	0.20	1.83	0.38	1.32	0.195
<i>Follow-up phase</i>						
Knowledge	13.69	1.85	10.63	2.28	5.64	<0.001*
Attitude	2.55	0.13	2.18	0.22	7.74	<0.001*
Practice	2.98	0.21	2.70	0.30	4.26	<0.001*
Teeth cleanliness	1.50	0.34	1.14	0.37	3.91	<0.001*
Gum health	1.95	0.08	1.62	0.42	4.22	<0.001*
Tongue cleanliness	1.97	0.07	1.70	0.47	3.15	<0.001*

Table 2.
Basic statistics of oral health behaviors

Note(s): Significant at *p*-value < 0.05

the experimental group and control group among three phases, including independent *t*-test. There were no statistically significant differences of baseline conditions between the experimental and the control groups at baseline (see Table 3).

Six weeks after the conclusion of the experiments, researchers conducted a postexperimental measurement. The follow-up process started four weeks after the experiments were completed in order to study the duration of oral health behaviors. Results from independent *t*-test and one-way MANOVA repeated regarding the preliminary agreement test found that statistical values of Mauchly's sphericity test indicated variation within the experimental and control groups for each measurement of the mean scores of oral health behaviors concerning knowledge (*p* < 0.001*), attitude (*p* = 0.045*), practice (*p* < 0.001*), teeth cleanliness (*p* < 0.001*), gum health (*p* < 0.001*) and tongue cleanliness (*p* = 0.010*). So, all *p*-values were less than the specified significance level of 0.05, which can

Source of variation of experimental and control groups	Wilk' Lambda		<i>p</i> -value
	Statistical values	Multivariate <i>F</i> test	
Knowledge	0.51	27.11	<0.001*
Attitude	0.85	4.96	0.010*
Practice	0.87	4.18	0.020*
Teeth cleanliness	0.54	24.54	<0.001*
Gum health	0.99	0.17	<0.001*
Tongue cleanliness	0.38	46.10	0.852

Table 3.
Effectiveness of the intervention program

Note(s): Significant at *p*-value < 0.05

be concluded as the differences among mean scores of all factors for each measurement at a significance level of 0.05. Hence, the outputs achieved a preliminary agreement responding to the repeated measures ANOVA test.

The effectiveness of the intervention program was measured by experimental and control group students' scores on oral health behaviors regarding knowledge (Wilk' Lambda = 0.51, $F = 27.11$, $p < 0.001^*$), attitude (Wilk' Lambda = 0.85, $F = 4.96$, $p = 0.010^*$), practice (Wilk' Lambda = 0.87, $F = 4.18$, $p = 0.020^*$), teeth cleanliness (Wilk' Lambda = 0.54, $F = 24.54$, $p < 0.001^*$) and gum health (Wilk' Lambda = 0.99, $F = 0.17$, $p < 0.001^*$). This results in p -values of less than 0.05 indicated that the developed program had an influence on both oral health behaviors KAP and oral hygiene of the experimental and control groups as the statistically significant differences at the 0.05 level. For tongue cleanliness (Wilk' Lambda = 0.38, $F = 46.10$, $p = 0.852$) at $p > 0.05$, it can be concluded that the influence of the developed program on oral hygiene concerning tongue cleanliness showed no statistically significant difference between experimental and control groups at the level of significance 0.05.

Discussion

This *OHPP* was purposely provided for fifth-grade elementary students in order to improve oral health behaviors and oral hygiene regarding KAP on avoiding dental plaque, gingivitis and tongue coating compared to the control group who received an ordinary oral health education program. Outcomes exemplified success in changing students' oral health behaviors between the experimental and control groups in aspects of KAP as well as oral hygiene regarding teeth and gum cleanliness [12], while the results on tongue cleanliness showed no statistically significant difference at a significance level of 0.05 [21].

This program has an effect on oral health behavior change of students in both the experimental and control groups compared to before the experiment. As the outcomes on oral health behaviors eventuated in oral hygiene of students concerning teeth cleanliness and gum health, parents should be included in the oral health program so that they can help guide students at home when it comes to oral activities [10, 13], whereas results related to tongue cleanliness indicated no statistically significant difference in oral health outcome changes. These findings suggest that a provision of activities created opportunities for students to independently improve teeth brushing skills by checking for teeth cleanliness after brushing, which could shape their self-perception and self-improvement from the recorded performance [8, 16, 17].

Students' oral health behaviors regarding KAP arose from the intervention program associated with the use of photos taken by smartphone endomicroscope, video media and experiment-based activity provision through students' self-observation and self-analysis of causes and effects in relation to their own oral health behaviors and oral hygiene problems [11, 22]. Students see the pictures and understand where they have not cleaned thoroughly. Furthermore, using the images of students' oral hygiene from the smartphone endomicroscope device could enable students to perceive problems seen by the camera, thus informing them on issues of dental plaque and caries process [11, 23]. This information transferring can be useful to dentists.

Oral care in relation to teeth cleaning can be performed by the use of a smartphone endomicroscope to explore dental plaque built up on teeth, so this method enabled students to improve their own brushing skills. Moreover, image visibility on the smartphone showed not only dental plaque but also other oral health problems, including decayed, chipped or crowded teeth and gingivitis that affected students' psychological anxiety resulting in oral health self-care practices [24]. Environmental management could help promote oral care in

students, for example, sinks and washroom accessories seemed to offer more opportunities for students to brush their teeth at school.

Students in the experimental group exhibited better improvement of oral health behaviors, which had an effect on students' oral health hygiene development associated with teeth cleanliness and gum health. Both components have a direct relationship to each other in that healthy teeth lead to healthy gums. The oral health program should consist of both gum and teeth care [14]. The plaque load in students was caused by bacteria accumulation without cleaning for a long time. Likewise, the daily routine of students (i.e. chatting and drinking water) would reduce plaque concentration [25].

Limitations

First, the school was located far from the city center. In fact, even under the care of a dentist, students received dental care only once per semester. This study did not define inclusion criteria on oral disease consideration that might cause differences of students' oral hygiene status in relation to outcomes that found incomplete crowns in tooth position of some students; therefore, neighboring teeth must be used instead. Second, consideration of oral health behaviors and oral hygiene to study the change encompassed mean examination through a comparison between the value before and after the experiment and any follow-up period by neglecting to focus on the number of people who were improved at various levels in the future. Therefore, if a specified number of people with improved oral hygiene are diagnosed, effectiveness of the intervention program will be more noticeable. Third, the results of the present study could not represent every school child due to purposive sampling.

Conclusions

This study focuses on improving students' teeth brushing skills and enhancing them to discover and perceive their own oral health problems from the device usage. This effort could increase student interest toward caring for teeth and tongue cleanliness, including gum health checkups.

Conflict of Interest: None

References

1. Pussinen PJ, Paju S, Koponen J, Viikari JSA, Taittonen L, Laitinen T, *et al.* Association of childhood oral infections with cardiovascular risk factors and subclinical atherosclerosis in adulthood. *JAMA Netw Open.* 2019; 2(4): e192523. doi: [10.1001/jamanetworkopen.2019.2523](https://doi.org/10.1001/jamanetworkopen.2019.2523).
2. Thailand Ministry of Public Health. The 8th national oral health survey in Thailand 2017. Nonthaburi: Department of Health, Ministry of Public Health; 2018; 1: 15–16.
3. Lukssamijarulkul N, Panza A. Oral health problems among children in selected primary schools in Bangkok, Thailand. *J Health Res.* 2016; 30(Suppl.1): S17–25. doi: [10.14456/jhr.2016.63](https://doi.org/10.14456/jhr.2016.63).
4. Alsumait A, ElSalhy M, Amin M. Long-term effects of school-based oral health program on oral health knowledge and practices and oral health-related quality of life. *Med Princ Pract.* 2015; 24(4): 362-368. doi: [10.1159/000430096](https://doi.org/10.1159/000430096).
5. Vichayanrat T, Gaewkhiew P, Kasetsuwan R, Kaewsringam H, Lapauthaya K, Khawiboonchai P, *et al.* Oral health status, behaviors and oral health related quality of life among pupils in Border Patrol Police Schools, Thailand. *Mahidol Dental J.* 2016; 36(1): 31-8.
6. Rad M, Shahrvan A, Haghdoost AA. Effective factors on oral health behaviors of 12-year-old children in cities and villages of Iran: a path analysis. *J Dent (Shiraz).* 2018; 19(3): 225-31.
7. Thailand, Ministry of Public Health, Department of Health, Bureau of Dental Health. A community-based model development to move forward a cavity free future in Thailand. ACFE-

- Thailand Chapter Project. [cited 2020 Dec]. Available from: http://dental2.anamai.moph.go.th/ewt_dl_link.php?nid=1926.
8. Munsil J, Kengganpanich T, Kengganpanich M, Benjakul S. The effects of dental health promotion program applying social cognitive theory to prevent dental caries among grade 4 students, Phra Nakhon Si Ayutthaya province. *J Health Education*. 2019; 42(1): 13-28. (in Thai).
 9. Haque SE, Rahman M, Itsuko K, Mutahara M, Kayako S, Tsutsumi A, *et al*. Effect of a school-based oral health education in preventing untreated dental caries and increasing knowledge, attitude, and practices among adolescents in Bangladesh. *BMC Oral Health*. 2016; 16: 44. doi: [10.1186/s12903-016-0202-3](https://doi.org/10.1186/s12903-016-0202-3).
 10. Deinzer R, Cordes O, Weber J, Hassebrauck L, Weik U, Krämer N, *et al*. Toothbrushing behavior in children - an observational study of toothbrushing performance in 12 year olds. *BMC Oral Health*. 2019; 19(1): 68. doi: [10.1186/s12903-019-0755-z](https://doi.org/10.1186/s12903-019-0755-z).
 11. Khudanov B, Jung HI, Kahharova D, Lee JW, Hamidov I, Lee ES, *et al*. Effect of an oral health education program based on the use of quantitative light-induced fluorescence technology in Uzbekistan adolescents. *Photodiagnosis Photodyn Ther*. 2018; 21: 379-84. doi: [10.1016/j.pdpdt.2018.01.012](https://doi.org/10.1016/j.pdpdt.2018.01.012).
 12. Samosir R, Yusof ZYM, Mohamed NH, Shoaib LA. Oral health knowledge, attitudes and practices of 11-12 year old Orang Asli children in Cameron Highland, Malaysia. *Southeast Asian J Trop Med Public Health*. 2018; 49(5): 894-908.
 13. Jasmine Sharmila MK, Umadevi R, Anantha Eashwar VM. Knowledge, attitude and practice on oral hygiene among primary school children in an urban area of Kancheepuram district, Tamil Nadu. *Int J Community Med Public Health*. 2020; 7(1): 311-6. doi: [10.18203/2394-6040.ijcmph20195873](https://doi.org/10.18203/2394-6040.ijcmph20195873).
 14. Tumkaew Y, Duangsong R. Effects of dental health education program for behavioral modification on gingivitis prevention among Prathomsuksa VI primary school students, Wiangkao district, Khon Kaen province. *Thai Dental Nurse J*. 2018; 29(1): 36-48. (in Thai).
 15. Greene JC, Vermillion JR. The simplified oral hygiene index. *J Am Dent Assoc* 1964; 68: 7-13. doi: [10.14219/jada.archive.1964.0034](https://doi.org/10.14219/jada.archive.1964.0034).
 16. Rogers RW. A protection motivation theory of fear appeals and attitude change. *J Psychol*. 1975; 91(1): 93-114. doi: [10.1080/00223980.1975.9915803](https://doi.org/10.1080/00223980.1975.9915803).
 17. Bandura A. Self-efficacy: toward a unifying theory of behavioral change. *Psychol Rev* 1977; 84(2): 191-215. doi: [10.1037//0033-295x.84.2.191](https://doi.org/10.1037//0033-295x.84.2.191).
 18. Ekgasit S, Kaewmanee N, Jangtawee P, Thammacharoen C, Donphoongpri M. Elastomeric PDMS planoconvex lenses fabricated by a confined sessile drop technique. *ACS Appl Mater Inter*. 2016; 8(31): 20474-82. doi: [10.1021/acsami.6b06305](https://doi.org/10.1021/acsami.6b06305).
 19. World Health Organization [WHO]. Oral health surveys: basic methods. Geneva: WHO; 1997.
 20. Schwartz SB, Christensen JR, Fields H. Examination, diagnosis, and treatment planning. In: Nowak AJ, Christensen JR, Mabry TR, Townsend JA, Wells MH, (Eds). *Pediatric dentistry: infancy through adolescence*. 6th ed.. Philadelphia, PA: Elsevier; 2019. p. 419-54.
 21. Van Gils LM, Slot DE, Van der Sluijs E, Hennequin-Hoenderdos NL, Van der Weijden FG. Tongue coating in relationship to gender, plaque, gingivitis and tongue cleaning behaviour in systemically healthy young adults. *Int J Dent Hyg*. 2020; 18(1): 62-72. doi: [10.1111/idh.12416](https://doi.org/10.1111/idh.12416).
 22. Ueno M, Zaitzu T, Ohnuki M, Takayama A, Adiatman M, Kawaguchi Y. Association of a visual oral health literacy instrument with perceived and clinical oral health status in Japanese adolescents. *Int J Health Promot Educ*. 2015; 53(6): 303-14. doi: [10.1080/14635240.2015.1030034](https://doi.org/10.1080/14635240.2015.1030034).
 23. Blake H, Dawett B, Leighton P, Rose-Brady L, Deery C. School-based educational intervention to improve children's oral health-related knowledge. *Health Promot Pract*. 2015; 16(4): 571-82. doi: [10.1177/1524839914560568](https://doi.org/10.1177/1524839914560568).

24. Albright DL, Godfrey K, McDaniel JT, Fletcher KL, Thomas KH, Bertram J, *et al.* Oral health among student veterans: effects on mental and physical health. *J Am Coll Health.* 2020; 68(3): 263-70. doi: [10.1080/07448481.2018.1540985](https://doi.org/10.1080/07448481.2018.1540985).
25. Bashirian S, Seyedzadeh-Sabounchi S, Shirahmadi S, Soltanian AR, Karimi-Shahanjarini A, Vahdatinia F. Socio-demographic determinants as predictors of oral hygiene status and gingivitis in schoolchildren aged 7-12 years old: a cross-sectional study. *PLoS One.* 2018; 13(12): e0208886. doi: [10.1371/journal.pone.0208886](https://doi.org/10.1371/journal.pone.0208886).

Corresponding author

Jintana Sarayuthpitak can be contacted at: Jintana.S@Chula.ac.th