



# Theory-Guided Reminder Strategy for Promoting Oral Health in Adolescents

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## Abstract

**Objective:** Dental caries is one of the most common chronic diseases in children and adolescents; therefore, they are at high risk for caries. The study examined whether mobile-based applications and reminders can improve oral lifestyle in adolescents.

**Materials and Methods:** Forty-three adolescents (ages 11-14) participated. Oral health education via reminder strategy was guided by the principles of the health belief model. Oral health knowledge and oral self-care skills were assessed at the baseline (prior to education), 5 weeks (1<sup>st</sup> follow-up), and 6 months (2<sup>nd</sup> follow-up) after the education.

**Results:** Complete data were available for all students (follow-up rate 100%). A significant improvement ( $p < 0.001$ ) was observed in the mean (SD) toothbrushing skill scores, increasing from 7.0 (1.9) (baseline) to 14.4 (2.6) (1<sup>st</sup> follow-up) and then to 14.2 (2.7) (2<sup>nd</sup> follow-up). The toothbrushing time also significantly ( $p < 0.001$ ) increased from the mean time of 51.5 (24.4) at the baseline to 112.7 (30.1) seconds at the 1<sup>st</sup> and to 107.2 (22.2) at the 2<sup>nd</sup> follow-up. Diet knowledge scores increased from the baseline mean of 14.6 (4.1) to 28.0 (2.7) at the 1<sup>st</sup> and to 25.0 (3.1) at the 2<sup>nd</sup> follow-ups. The mean sugar intake frequency scores reduced from 12.6 (2.2) at the baseline to 11.9 (1.9) and 11.5 (1.9) at the 1<sup>st</sup> and 2<sup>nd</sup> follow-ups, respectively.

**Conclusion:** Oral health education via the reminder strategy was efficient in improving children's oral self-care skills and oral health-related knowledge. Improvements in oral self-care and knowledge were maintained for six months after the discontinued dental education.

**Keywords:** Adolescents, health behavior, mhealth, oral health, text messages

## Introduction

Oral health plays a crucial role in maintaining children and adolescents' general health and well-being. However, dental caries is one of the most common chronic diseases in children, impacting 60-90% of school-aged children worldwide.[1,2] About 2.26 million school days are missed annually in Canada due to dental-related diseases.[3] The tendency to neglect oral care during adolescence was identified in previous studies.[4]

Apart from the hormonal changes, intellectual and emotional growth, and the establishment of interpersonal relationships are critical milestones at this developmental stage when adolescents also need to take personal responsibility for maintaining their health, including oral health.[5] The Health Canada study reported that 39% of 12-year-olds had one or more permanent teeth already impacted by dental caries.[3] Also, school-aged children who suffered from poor oral health were 12 times more likely to have restricted-ac-

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tivity days compared to those who were in good oral health.[3] These findings emphasize the need to promote oral health in children and adolescents.

The individual one-to-one approach in oral health education was successful in improving oral hygiene[6] but is time-consuming; thus, it is impractical from the population health perspective. Different platforms such as dental offices, primary health care centers, hospitals, and schools may provide opportunities for population-based oral health promotion.

Nowadays, mobile technologies are growing rapidly and have been used to facilitate health improvements in different types of patients. A recent systematic review by Mohammadzadeh et al[7] showed that mobile health (a term used to denote health promotion via mobile means) can be delivered via different strategies such as games, stories, videos, alarms, etc. However, there is limited evidence regarding the effectiveness of oral health messages to promote oral health in adolescents through short messaging service (SMS).[7]

Text messaging could be a medium to reach out to specific population groups. With the development of technology, mobile phone usage has increased globally. The current number of mobile phone users is 7.26 billion globally, which makes up almost 92% of the world's population. Therefore, health information can be delivered to people via affordable and accessible communication platforms like short message services.[8] Besides, among all the other means of communication, text messages have the advantage of instant transmission, a lower chance of being lost, and being less intrusive compared with other information reminder channels, like telephone calls.[9] Previous studies reported the effectiveness of text messages to reinforce health-promoting lifestyles such as smoking cessation,[10] adherence to treatment guidelines, facilitation of healthy diet, and exercise.[11] However, such text messaging interventions targeted only parents,[12] or college students.[8]

Also, the science of health behavior recommends designing theory-based interventions as it is necessary for health messages to target the key motivational factors that may underlie specific health behaviors. Evidence shows that previous theory-based interventions were more effective than conventional simple verbal dental instructions in modifying oral self-care behavior in adolescents.[13,14]

The Health Belief Model (HBM)[15] is a cognition model that was originally designed in response to an in-

effective free tuberculosis health screening program. Currently, the HBM is one of the most widely employed theories used to design health behavior modifying interventions.[16] The model's ability to explain/predict several health-related behaviors made it relevant for many successful health interventions such as voluntary screening for cervical cancer, undergoing Pap test,[17] breast cancer screening, mammography,[18] breast self-examination,[19] smoking cessation,[20] contraceptive use,[21] osteoporosis prevention,[22] dental care,[23] and promotion of healthy eating.[24]

To promote children's oral health, we designed an intervention applying a reminder strategy guided by the main concepts of the HBM, the main constructs of which are perceived susceptibility/severity, perceived benefits/barriers, self-efficacy, and cues to action.[15] To the best of our knowledge, the benefits of the reminder strategy in promoting oral health in adolescents guided by the principles of HBM has not been previously tested. Thus, the objective of the current study is to assess the effectiveness of a reminder strategy using a short messaging service (SMS) for improving adolescents' oral self-care skills, diet knowledge, and diet behavior. The study tested the following hypotheses:

**H1:** Oral health education via the reminder strategy is efficient in improving children's oral self-care skills, diet knowledge, and decreasing sugar intake frequency and amount.

**H2:** After the discontinued dental education, improvement in oral self-care skills, diet knowledge, and decrease in sugar intake will be maintained for six months.

## Materials and Methods

### Study design

The current non-controlled interventional study was approved by the University of British Columbia Clinical Research Ethics Board (H17-02569) and was conducted during the 2020-2021 school year. Some of the main principles of the Health Belief Model (HBM)[15] (self-efficacy, cues to action, perceived susceptibility, and severity) were used to design the oral health education program and to develop the content of the text messages for children and adolescents.

### Participants

A letter of initial contact informing about the study was provided to three program coordinators of community centers in Metro Vancouver. This letter included a summary of the project written in lay terms, but only one coordinator supported the study, who

received a more detailed description of the project. The study included adolescents between 11 and 14 years (grades 6-8) who attended the Westbrook Community Center in Vancouver, British Columbia, Canada. Recruitment posters indicating the aim of the project, the intervention period, inclusion criteria, the summary of the project, and the contact details of the principal and co-principal investigators were placed at the main entrance and a few other spots in close proximity to the community center. Interested parents were invited to send emails to the research coordinator. Following that, copies of parental consent forms and letters of initial contact were distributed to parents/caregivers of all eligible adolescents. All participants with parental consent were also asked to review an assent form and sign it before the study. Only those with signed parental consent and assent forms were included in the study.

### Study measurements

Once the activity room at the Westbrook Community Center was booked, the invitation letters (including the date, address, and estimated duration of the study) were emailed to the parents of the eligible children. At the beginning of the first (baseline) session, participants were given a unique study ID number to use throughout the study period. Study measurements were taken at the baseline, within 4-5 weeks (1<sup>st</sup> follow-up), and 6 months (2<sup>nd</sup> follow-up) after the discontinued education. The study included the following assessments: the self-administered questionnaire inquiring about sociodemographic factors (age, sex, parental education), and other factors corresponding to the HBM theoretical constructs adopted from Solhi et al[25] including Perceived susceptibility (7 items), Perceived severity (3 items), Perceived benefits (2 items), Perceived barriers (2 items), Motivation (7 items), Self-efficacy (2 items), and Cues to action (1 item).

A diet knowledge assessment form included 15 items (food products), and students were asked to define if a specific food/drink item was “tooth-friendly” or not, as well as assessing the frequency of having three main meals, snacking between main meals, eating vegetables/fruits, drinking carbonated beverages, drinking juices, and eating sugar-containing products such as cakes, cookies, candies, chocolates, ice creams, etc.

The oral self-care-related outcomes were: A) the quality of tooth brushing skills’ scores based on a toothbrush observation form (theoretical range: 0-20), and B) the total tooth brushing time (in seconds).

### Oral health educational intervention

(OHEI) The first orientation session was held in fall 2020 after the completion of all baseline assessments. During this session, adolescents received a 15-minute interactive presentation, where they were educated about oral health followed by an orientation about the SMS-reminder setting for oral health intervention (i.e., timing, frequency, and duration of receiving oral health messages and how to confirm the receipt of the message), as well as how to mark the “setting-goal card” each week with new goals (a total of four settings of individual goals). Following that, each participant received an oral self-care kit that included a toothbrush and sample toothpaste and was asked to demonstrate his/her best tooth brushing while an examiner (a dentist) observed tooth brushing skills by filling out the tooth brushing observation (TBO) form.

Our oral self-care skills assessment was based on participants demonstrating their best oral self-care skills. This assessment included two measures: the total tooth brushing time in seconds and the total oral self-care skills (OSCS) scores. OSCS scores were based on the sum concerning 10 oral self-care skills-related aspects, where each of these aspects was scored as 0 (absent), 1 (partially present), or 2 (completely present). The theoretical range of the OSCS measure was from 0 to 20. The following oral self-care skills aspects were assessed: 1) frequency of tooth brushing; 2) brushing systematically (brushing starts from one side then follows to the other side); 3) teeth are brushed slowly (1-2 teeth at a time); 4) tooth brushing reaches gums; 5) labial/buccal surfaces are brushed with rotation movements; 6) lingual surfaces are brushed with sweeping (up and down) motions; 7) occlusal surfaces are brushed with rotation movements; and 8) brushing the tongue.

After that, the TRACE solution disclosing agent was used for each participant to identify the areas of remaining dental plaque. Each child’s ID was photographed first, and then photos of teeth with disclosed plaque (no personal identifiers) were taken. Once photos were taken, each adolescent received a mirror and an individualized explanation about the disclosed pink-color tooth areas indicating his/her deficient oral self-care. At the end of the session, a short visual summary of the best tooth brushing techniques was given to each adolescent.

### Sending oral health-promoting text messages

The modification of oral self-care and dietary habits in this group was facilitated through digital commu-

nication, including several reminders. Oral health messages were sent to everyone through the Mobile Short Messaging Service (SMS). One month of intervention included sending a total of eight educational messages (two messages each week), each containing advice about a healthy diet and how to improve oral self-care. These SMS messages were sent to children's cell phones. Oral health-promoting messages were designed based on the recommendations of the Canadian Dental Association. To increase participants' intrinsic motivation, a clinical psychologist was consulted to help with preparing the content and the sequencing of the oral health messages. The weekly messages were titled "Healthy Teeth & Beautiful Smile" and contained visuals, reinforcing the previous oral health messages and adding new messages about oral self-care and a healthy diet (copies of these messages can be provided upon request). To facilitate the participants' adherence to the intervention, messages were sent on Mondays and Fridays at 7:00 p.m. This timing was chosen based on the participants' preference and to not interfere with their other daily activities. Moreover, messages were cues encouraging them to brush their teeth closer to bedtime, and participants were also asked to reply with "1" to confirm the receipt of the messages.

### Study outcomes

The follow-up was conducted within 4-5 weeks after text messages ceased to evaluate the efficacy of the educational intervention (children's improvement in oral health knowledge, diet behavior, and oral self-care skills). Two oral self-care measures: the quality of oral self-care skills (score range: 0-20) and the total tooth brushing time (in seconds), were chosen as oral self-care outcomes.

### Data analyses

The IBM SPSS Version 28.0 software was used for all quantitative analyses, and the threshold for significance was set at  $p < 0.050$ . The paired sample t-test compared the study outcomes (means of diet knowledge and oral self-care skills) between the baseline and the two follow-ups.

## Results

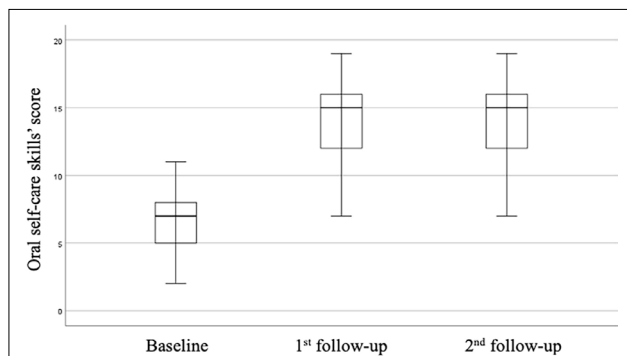
The current study included a total of 43 adolescents between 11-14 years of age. The participation rate at the 1<sup>st</sup> (to assess the efficiency of the intervention) and the 2<sup>nd</sup> follow-ups (to assess the sustainability of the intervention) was 100%.

For the sample size calculations, we used the online calculator from the following website: <https://www.stat.ubc.ca/~rollin/stats/ssize/n2.html>. We calculated the minimal sample size regarding two outcomes, namely the total knowledge scores and oral self-care skills scores. This calculation is based on the minimum 20% improvement from the baseline mean scores. For the knowledge assessment, we input the following parameters:  $\alpha = 0.05$ , desired power = 0.80, mean 1 (baseline knowledge) of 14.4, mean 2 of 17.2 (expected minimum post-educational improvement), and  $\sigma = 4.1$  (common variation). This calculation showed that we need a minimum of 36 participants with complete baseline and follow-up knowledge-related data. For a similar calculation for the 2<sup>nd</sup> outcome of oral self-care skills, we used the following parameters:  $\alpha = 0.05$ , desired power = 0.85, mean 1: 7.0 (baseline value), mean 2: 8.4 (expected post-educational minimal improvement), and  $\sigma = 1.9$  (common variation). This calculation showed that we need a minimum of 34 participants with complete baseline and follow-up data. As we expected some attrition at the follow-up, we decided to recruit 40+ participants.

In our study, all participating children received the same standardized text messages. To increase participant compliance and their active learning, we asked each participant to send us a confirmation that he/she received and read each of the text messages. Also, we encouraged our participants to pose questions or share ideas via text messages with the study's coordinator.

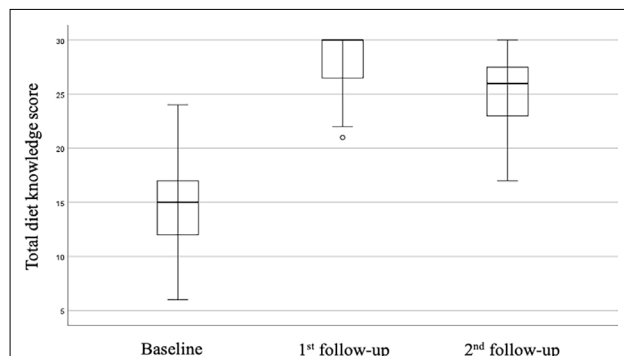
Testing hypothesis 1 (efficiency of the education) and hypothesis 2 (sustainability of the improvement). The distribution of the study outcome-related scores is visualized in Figures 1-4. In Figure 1, one can see that there was an overall improvement in oral self-care skills from the baseline, and the scores' distribution was rather similar at both follow-ups. Data analyses (paired sample t-test) showed that there was a significant ( $p < 0.001$ ) increase in the mean (SD) individual oral self-care skills score (score range: 0-20) from the baseline of 7.0 (1.9) to the 1<sup>st</sup> follow-up 14.4 (2.6) and remained almost the same 14.2 (2.7) at the 2<sup>nd</sup> follow-up.

In regard to the second oral self-care skills-related outcome, a similar distributional pattern was observed (Fig. 2). This trend was also reflected in findings of the analyses. The mean (SD) of the tooth brushing time (in seconds) significantly ( $p < 0.001$ ) increased from 51.5 (24.4) at the baseline to 112.7 (30.1) at the 1<sup>st</sup> follow-up and then it slightly decreased to 107.2 (22.2) at the second follow-up.



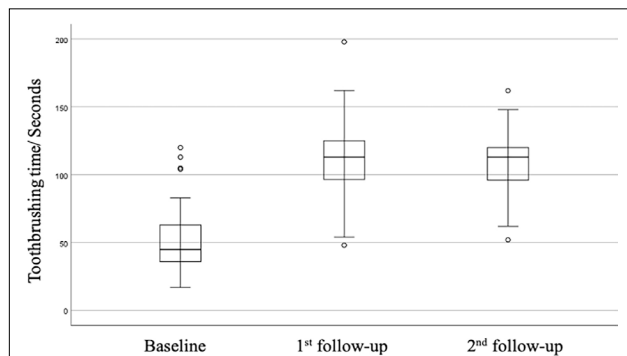
**Figure 1.** Distribution of Oral Self-Care Skill Scores at the baseline and 2 follow-ups

The mean (SD) of oral self-care skill's score (range: 0-20): Baseline: 7.0 (1.9); 1<sup>st</sup> follow-up: 14.4 (2.6); 2<sup>nd</sup> follow-up: 14.2 (2.7)



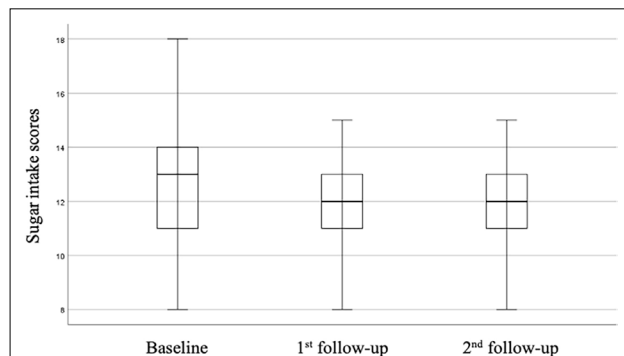
**Figure 3.** Total diet knowledge scores at the baseline and 2 follow-ups

The mean (SD) of the total diet knowledge scores (range: 0-30): Baseline: 14.6 (4.1); 1<sup>st</sup> follow-up: 28.0 (2.7); 2<sup>nd</sup> follow-up: 25.0 (3.1)



**Figure 2.** Distribution of tooth brushing time at the baseline and 2 follow-ups

The mean (SD) of the tooth brushing time (in seconds): Baseline: 51.5 (24.4); 1<sup>st</sup> follow-up: 112.7 (30.1); 2<sup>nd</sup> follow-up: 107.2 (22.2)



**Figure 4.** Distribution of sugar intake scores at the baseline and 2 follow-ups

The mean (SD) of sugar intake scores (range:0-18): Baseline: 12.6 (2.2); 1<sup>st</sup> follow-up: 11.9 (1.9); 2<sup>nd</sup> follow-up: 11.5 (1.9)

The distribution of total diet knowledge scores and sugar intake scores at three observation times is presented in Figures 3 and 4. The mean (SD) of the total diet knowledge scores (range: 0-30) increased significantly ( $p < 0.001$ ) from 14.6 (4.1) at the baseline to 28.0 (2.7) at the 1<sup>st</sup> follow-up and then slightly decreased to 25.0 (3.1) at the 2<sup>nd</sup> follow-up.

Overall, there was a substantial variation among adolescents in diet knowledge scores at all observation periods, especially at the baseline. This variation decreased at the 1<sup>st</sup> and 2<sup>nd</sup> follow-up. The considerable improvement in diet knowledge scores (Fig. 3) occurred from the baseline to the 1<sup>st</sup> follow-up, except for one adolescent who had the lowest score in a group (a lower outlier). The sugar intake scores ranged from 0-18, and the mean (SD) reduced from 12.6 (2.2) at the baseline to 11.9 (1.9) at the 1<sup>st</sup> follow-up, and the mean (SD) slightly reduced to 11.5 (1.9) at the 2<sup>nd</sup> follow-up. The time-related changes from the baseline

were non-significant at either the 1<sup>st</sup> ( $p = 0.110$ ) or 2<sup>nd</sup> ( $p = 0.810$ ) follow-ups. A comparison of the mean (SD) of different outcomes at different observational periods is provided in Table 1.

## Discussion

Nowadays, adolescents spend a great amount of time on their mobile devices, mainly playing games or chatting with friends. Reflecting on our study findings, it seems they often do not allocate sufficient time for their oral self-care.

In our study, we educated the school-aged children about their oral health and healthy eating using mobile phone SMS reminders. The content of each message focused on delivering new oral health & eating-related messages, reinforcing the previous messages, and yet being short enough not to discourage the children. Also, to make the messages more visually appealing, we

**Table 1.** Comparisons of study outcomes: The baseline and follow-ups (n=43)

Outcome measures	Observation times		
	Baseline Mean (SD)	1 <sup>st</sup> follow-up Mean (SD)	2 <sup>nd</sup> follow-up Mean (SD)
Oral self-care skills (total scores)	7.0 (1.9)	14.4 (2.6)	14.2 (2.7)
	*Baseline to 1 <sup>st</sup> follow-up p<0.001; baseline to 2 <sup>nd</sup> follow-up p<0.001		
Toothbrushing time (in seconds)	51.4 (24.4)	112.7 (30.1)	107.2 (22.2)
	*Baseline to 1 <sup>st</sup> follow-up p<0.001; baseline to 2 <sup>nd</sup> follow-up p<0.001		
Diet knowledge (total scores)	14.6 (4.1)	28.0 (2.7)	25.0 (3.1)
	*Baseline to 1 <sup>st</sup> follow-up p<0.001; baseline to 2 <sup>nd</sup> follow-up p<0.001		
Sugar intake frequency (total scores)	12.6 (2.2)	11.9 (1.9)	11.5 (1.9)
	*Baseline to 1 <sup>st</sup> follow-up p<0.001; baseline to 2 <sup>nd</sup> follow-up p<0.001		

\*: Paired sample t-test. SD: Standard deviation

used color-coded messages with relevant pictures added to them. Our study demonstrated that our reminder strategy intervention resulted in significant improvement in oral self-care skills and oral health-related knowledge of our target school-aged children.

Consistent with our current findings, previous studies showed that mobile phone applications were effective in promoting oral health and oral health behavior in children.[26,27] Different mobile-based strategies were used in previous research. Scheerman et al[28] study used the WhiteTeeth app to promote oral health behaviors in Dutch adolescents, while Zotti et al[26] study used the WhatsApp platform to promote oral health in their target group. Both studies presented significant improvements.

A recent 2023 systematic review by Mohammadzadeh et al[7] included 23 studies which focused on mobile health applications for children's oral health (OH) improvement and showed that irrespective of the strategy used, improvement in OH-related outcomes was observed in all studies. Also, a randomized control 2020 study by Arias et al[29] showed that sending reminder text messages improved oral health in highly anxious, dental-phobic patients.

Most of the previous studies either targeted only parents[12] or their interventions involved both parents and their children.[30] However, there were only a few studies that sent reminder text messages.[31,32] To the best of our knowledge, there was only one study by Sheerman et al[27] that tested the efficacy of the theory-based intervention (Health Action Process Approach model) using the social media platform (Telegram) and sent reminder text messages to adolescents. This study was a three-arm randomized control trial,

and their reminder strategy was successful in modifying children/adolescents' oral hygiene. In addition to the text messages, other reinforcement adjuncts such as photographs, videos, audio, and data files were used; therefore, it's hard to distinguish the independent effect of the SMS reminder strategy in promoting oral health in their target children. Our results are also in line with the results of the Alkadhi et al[33] study, which assessed the effectiveness of the text messages reminder strategy in promoting oral health among 12-year-old adolescents. Although their outcome measurements were different than ours (plaque index and gingival index), their results showed that sending text messages resulted in significant improvement in children's oral health compared to those who only received verbal instructions.

### Study limitations and future directions

One of the limitations of the current study was the lack of a control group, not allowing for the definition of the adjusted impact of the intervention. For future studies, we recommend a longer length of follow-up, including a control group, recruiting larger samples, and randomly allocating participants into the control and study groups.

### Conclusion

Oral health education via the reminder strategy was efficient in improving children's oral self-care skills and OH-related knowledge. The improvement in oral self-care skills and knowledge was maintained for six months after the discontinuation of dental education.

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**Conflict of Interest:** None declared.

**Use of AI for Writing Assistance:** Not declared.

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