

The effectiveness of theory-based WhatsApp reminders on oral hygiene status and practices among adolescents

A eficácia de notificações baseadas em teoria enviadas pelo WhatsApp no status e nas práticas de higiene bucal entre adolescentes

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ABSTRACT

Objective: This study aimed to evaluate the effectiveness of a theory-based WhatsApp reminder intervention on oral hygiene behavior and plaque index among adolescents. **Material and Methods:** Employing a quasi-experimental pretest-posttest control-group design, the study involved 111 senior high school students in Jember District, Indonesia, divided into an intervention group (n=54) and a control group (n=57). The intervention consisted of sending educational and motivational messages three times a week at 8:00 p.m. for four weeks to target pre-sleep routines, while outcomes, including the Plaque Index (PI), observed brushing skills, and self-reported oral health knowledge, attitude, and practice (KAP), were analyzed using ANCOVA and binary logistic regression. **Results:** The intervention group achieved a significantly lower adjusted PI (0.52) compared to the control group (0.74, $p < 0.001$) and a significantly higher adjusted mean practice score ($p < 0.001$). Students in the intervention group were 6.84 times more likely to adopt the correct brushing method compared to the control group ($p = 0.006$). The statistical analysis revealed no significant differences between groups in terms of oral health knowledge, attitude, brushing duration, and completeness of brushing area ($p > 0.05$). **Conclusion:** WhatsApp-based reminders serve as effective, scalable cues to action that successfully bridge the gap between knowledge and practice, significantly improving clinical oral hygiene status and brushing method.

KEYWORDS

Adolescent; Health behavior; Mobile applications; Oral health; Oral hygiene.

RESUMO

Objetivo: Avaliar a eficácia de uma intervenção baseada em teoria, por meio de notificações no WhatsApp, sobre o comportamento de higiene bucal e o índice de placa dentária em adolescentes. **Material e Métodos:** Utilizando um desenho quase-experimental de pré- e pós-teste com grupo de controle, o estudo envolveu 111 alunos do último ano do ensino médio no distrito de Jember, na Indonésia, divididos em um grupo de intervenção (n = 54) e um grupo de controle (n = 57). A intervenção consistiu no envio de mensagens educativas e motivacionais três vezes por semana, às 20h, durante quatro semanas, com foco nas rotinas antes de dormir; enquanto os desfechos, incluindo o Índice de Placa (IP), as habilidades observadas na escovação e o conhecimento, atitude e prática (KAP) em saúde bucal autorrelatados, foram analisados por meio de ANCOVA e de regressão logística binária. **Resultados:** O grupo de intervenção apresentou IP ajustado significativamente menor (0,52) em comparação com o grupo controle (0,74, $p < 0,001$) e pontuação média ajustada de prática significativamente maior ($p < 0,001$). Os alunos do grupo de intervenção tiveram 6,84 vezes mais chances de adotar o método correto de escovação em comparação com o grupo controle ($p = 0,006$). A análise estatística não revelou diferenças significativas entre os grupos em relação a conhecimento, atitude e prática de saúde bucal, duração da escovação e abrangência da área escovada ($p > 0,05$). **Conclusão:** Notificações via WhatsApp funcionam como estímulos à ações eficazes e escalonáveis, que preenchem com sucesso a lacuna entre o conhecimento e a prática, melhorando significativamente o status clínico de higiene bucal e o método de escovação.

PALAVRAS-CHAVE

Adolescentes; Comportamento de saúde; Aplicativos para dispositivos móveis; Saúde bucal; Higiene bucal.

INTRODUCTION

Adolescent oral health is a persistent global public health challenge, particularly in developing countries. This stage of life is a crucial time for developing lifelong health behaviors, while it is also characterized by a high prevalence of preventable oral diseases such as dental caries and gingivitis [1,2]. This high burden persists nationally; for example, the recent Indonesia Health Survey (SKI) 2023 reported that 56.9% of the population experiences oral health problems [3]. The absence of adequate oral hygiene practices during adolescence can predispose individuals to persistent oral health problems in adulthood [4,5]. These outcomes adversely affect the quality of life [6] and contribute to increasing economic burdens on healthcare systems [7].

For decades, interventions have primarily focused on improving health literacy through conventional school-based education programs. Many studies underscore the presence of a “knowledge-practice gap”, where adolescents often demonstrate a sufficient understanding of oral hygiene principles but struggle to translate this knowledge into consistent behavioral adherence [8-10]. The primary challenge, therefore, is not a lack of information but inadequate habit formation and behavioral implementation, particularly regarding oral hygiene practices such as toothbrushing.

The growing literature suggests that conventional educational strategies alone may be insufficient to sustain daily oral hygiene practices, underscoring the need for supplementary behavioral interventions that provide continuous reminders and reinforcement [8,10,11]. The widespread use of mobile technology among adolescents offers an opportunity for health promotion [12,13]. Mobile health (mHealth) initiatives have emerged as a promising strategy, offering scalable, cost-effective, and highly engaging health promotion tools [14,15]. In contrast to traditional static media, mobile platforms provide dynamic and real-time cues to action that can effectively bridge the gap between intention and behavior [13,16,17].

However, the potential of mHealth is often hindered by complexity. Many interventions focus on developing sophisticated, multifaceted applications that are resource-intensive, require new user training, and face challenges with long-term user engagement [18,19]. In contrast, interventions that utilize widely accessible and

familiar digital platforms offer considerable potential for sustainable public health impacts. WhatsApp, for example, is an ideal tool in this context. It is widely adopted by adolescents, requires minimal new training, and provides a cost-effective and scalable implementation [20-22].

Furthermore, a critical gap exists in the assessment of outcomes. Many studies rely solely on subjective measures, such as self-reported behavior [23,24], which are susceptible to social desirability and recall bias [25]. Although these measures are valuable for exploring underlying mechanisms, such as the knowledge-practice relationships, they fail to demonstrate actual clinical improvement. To establish true efficacy, it is crucial to demonstrate that an intervention leads to measurable changes in observable oral health practices and objective clinical outcomes, such as plaque accumulation, which provides the most robust evidence of improved oral hygiene status [26]. Therefore, this study aimed to evaluate the effectiveness of a WhatsApp-based reminders intervention on oral hygiene behavior and plaque index among adolescents.

MATERIAL AND METHODS

Study design and setting

This study employed a quasi-experimental, pretest-post-test control-group design to evaluate a WhatsApp-based reminder intervention for adolescent oral hygiene. This study was conducted in two public senior high schools located within Jember District, East Java, Indonesia. The schools were purposively selected, with one designed as the intervention site and the other as the control. The intervention period lasted four weeks, with outcome assessment conducted at baseline (pretest) and one week after the intervention was completed (post-test).

Participants and sampling

The study population consisted of senior high school students at the selected schools. A purposive sampling method was utilized to recruit participants based on inclusion and exclusion criteria. The inclusion criteria required students to be in the 10th grade, provide informed consent (with parental permission), have active access to the WhatsApp application, and be free from systemic health conditions that affect oral health.

Exclusion criteria included chronic illnesses that affected oral health, inability to use WhatsApp, or failure to complete the study procedures.

The sample size was calculated a priori using a power analysis to compare two independent groups, with $\alpha = 0.05$ and power $(1-\beta) = 0.80$. The effect size of Cohen's $d=0.70$ was assumed based on prior similar interventions and practical considerations [27]. This yielded a minimum of 45 participants in each group. To account for possible attrition, the target sample size was increased. The final enrolled sample comprised 54 students in the intervention group and 57 students in the control group.

Intervention procedure

The intervention group participated in a WhatsApp Reminder program conducted over four weeks. Grounded in the Theory of Planned Behaviour [28], this intervention involved the delivery of educational messages and motivational prompts to enhance oral hygiene practices. Before implementation, the intervention content underwent a content validation process by a panel of three experts: a dental public health specialist, a public health behavioral scientist, and a senior high school teacher. The experts evaluated the 12 draft messages for relevance, representativeness, clarity, and suitability for adolescents. Feedback from this panel was incorporated to refine the messages, ensuring they were engaging and age appropriate.

The finalized intervention consisted of sending these 12 messages through a dedicated WhatsApp Group. The messages were sent three times a week (Monday, Wednesday, and Friday) at 8:00 p.m. local time. This timing was selected to align with the adolescent pre-sleep routine, maximizing the likelihood of the message serving as a cue to action for night-time tooth brushing.

The content of the messages was curated to comprehensive oral health topics, arranged sequentially:

- Weeks 1-2: Focused on basic habit formation (brushing after breakfast and before sleep), understanding dental plaque, and the systemic link between oral health and general health.
- Week 3-4: Emphasized technical skills and specific knowledge, including proper brushing techniques with video demonstration, comprehensive cleaning of all tooth surfaces, and dietary advice. The final messages

emphasized the importance of routine dental check-ups and the need for sustained behavioral maintenance.

The control group did not receive these specific reminders during the study period but was provided with standard oral health education after the study was completed, for ethical considerations.

Pilot study and instrument validation

Before the main study, a pilot study was conducted involving 30 students who were excluded from the final analysis to calibrate the examiners and validate the research instruments. Inter-examiner reliability for the plaque index was excellent ($Kappa = 0.82$). Similarly, the oral health knowledge, attitude, and practice questionnaire items were valid (> 0.361 , $p < 0.05$) and demonstrated good internal consistency (Cronbach's $\alpha = 0.78$).

Data collection and outcome measures

Data collection was conducted at two points: baseline (pre-test) and immediately after the 4-week intervention (post-test). The assessment was divided into three specific domains: clinical status, practical brushing skills, oral health knowledge, attitude, and practices.

1. Clinical outcome: The primary outcome was oral hygiene status measured using the Plaque Index by Silness & Loe (1964) [29]. Plaque accumulation was visually examined without disclosing agents on six index teeth (16,12,24,36,32,44) or substitute on four surfaces (mesial, distal, buccal, lingual) by two calibrated dentists who were blinded to the group allocations. Scores of 0-3 were assigned per surface and averaged to yield a subject-level plaque index. Examiners were trained and calibrated before data collection.
2. Brushing skills: Practical skills were assessed using a standardized observation checklist. Participants were asked to demonstrate their brushing routine while trained observers recorded:
 - Technique: the dominant motion of the brush (Horizontal, Vertical, or Circular)
 - Surface coverage: The completeness of cleaning was assessed based on the surfaces reached (buccal, lingual, occlusal) and specific locations (anterior vs posterior teeth).

- Duration: The total duration time measured in seconds using a stopwatch.
3. Oral health Knowledge, Attitude and Practice (KAP): Nine questions for each domain were given to the students via Google Forms to assess knowledge (e.g., caries etiology, fluoride function), attitude, and self-reported practices (e.g., toothbrushing frequency and timing, eating habits, dental floss use).

Statistical analysis

Data was analyzed using SPSS version 27.0 (IBM Corp.). Descriptive statistics, including frequencies, percentages, means, and standard deviation (SD), were used to summarize the demographic characteristics and baseline data. Normality and homogeneity were assessed using the Shapiro-Wilk and Levene's tests. Baseline comparisons for continuous variables were conducted using an independent t-test for normally distributed data and a Mann-Whitney U test for non-normal data. In contrast, categorical variables were compared using a Chi-square test or Fisher's exact test.

To evaluate changes within each group (pretest–posttest), paired sample t-tests were employed for normally distributed variables, and the Wilcoxon signed-rank test was used for non-normal data, while McNemar's test was used to analyze changes in paired categorical variables. For the primary analysis of intervention effectiveness on continuous outcomes, Analysis of Covariance (ANCOVA) was utilized to compare post-test scores between groups, adjusting for baseline scores and maternal occupation as covariates, with assumptions verified before analysis. Maternal occupation was included as a covariate because it was the only baseline characteristic that differed significantly between groups ($p=0.024$). Baseline values of each outcome variable were also included in the ANCOVA models to control for initial between-group differences and improve the precision of the estimated intervention effect.

Changes in binary outcomes were examined using binary logistic regression and reported as odds ratios with 95% CI. Statistical significance was set at two-tailed $p < 0.05$, and effect sizes (partial η^2 or Cohen's d) were reported for primary outcomes.

Ethical considerations

The study protocol was reviewed and approved by the Ethical Committee of Medical Research, Faculty of Dentistry, University of Jember. The approval code for this study is: 3065/UN25.8/KEPK/DL/2025. All participants provided informed consent, and parental permission was obtained for those under 18 years of age.

RESULT

A total of 111 tenth-grade students participated in this study, consisting of 54 students in the intervention group and 57 students in the control group. As shown in Table I, the overall baseline characteristics were comparable between groups ($p > 0.05$), including age, sex, parental education, family income, access to technology, and exposure to oral health information. The only characteristic that differed significantly between groups was maternal occupation ($p = 0.024$), which was treated as a covariate in the final analysis to control for potential confounding effects.

Baseline measurements, as presented in Table II, indicated that both groups were comparable in terms of oral health knowledge, attitude, and practice scores, as well as toothbrushing skills (method and area) before the intervention ($p > 0.05$). Notably, the intervention group initially presented with significantly higher Plaque Index scores ($p = 0.035$) and shorter tooth-brushing durations ($p < 0.001$) compared to the control group.

Following the four-week WhatsApp reminder intervention, paired analyses indicated significant improvements within the intervention group. Table III reveals that the mean oral health knowledge score in the intervention group increased significantly from 5.52 at baseline to 6.09 at post-test ($p < 0.001$). Oral health practices score increased from 16.63 to 18.43 ($p < 0.001$), and plaque index significantly decreased from 0.76 to 0.55 ($p < 0.001$). Furthermore, the proportion of students practicing the correct tooth-brushing method improved significantly from 50.0% to 66.7% ($p = 0.012$). No significant changes were observed in attitude scores, brushing duration, or completeness of brushing areas.

Table I - Characteristics of respondents in intervention and control groups

Characteristics	Intervention (n=54)	Control (n=57)	Total (n=111)	p-value
Age, mean $\pm$ SD	16.1 $\pm$ 0.5	16.4 $\pm$ 0.5	16.2 $\pm$ 0.5	0.973
Sex, n(%)				0.991
• Male	17(31.5)	18(31.8)	35(31.5)	
• Female	37(68.5)	39(68.4)	76(68.5)	
Maternal education, n(%)				0.238
• Primary school	17(31.5)	27(47.4)	44(39.6)	
• Junior high	9(16.7)	9(15.8)	18(16.2)	
• Senior high	16(29.6)	15(26.3)	31(27.9)	
• University	12(22.2)	6(10.5)	18(16.2)	
Paternal education, n(%)				0.817
• Primary school	14(25.9)	19(33.3)	33(29.7)	
• Junior high	10(18.5)	11(19.3)	21(18.9)	
• Senior high	23(42.6)	20(35.1)	43(38.7)	
• University	7(13.0)	7(12.3)	14(12.6)	
Paternal occupation, n(%)				0.765
• Unemployed	5(9.3)	4(7.0)	9(8.1)	
• Farmers	13(24.1)	14(24.6)	27(24.3)	
• Employee	13(24.1)	10(17.5)	23(20.7)	
• Self-employed	23(42.6)	29(50.9)	52(46.8)	
Maternal occupation, n(%)				0.024*
• Housewife	30(55.6)	45(78.9)	75(67.6)	
• Self-employed, farmers, etc.	15(27.8)	9 (15.8)	24(21.6)	
• Employee	9(16.7)	3(5.3)	12(10.8)	
Family income (IDR), n(%)				0.844
• 0-2,5 million/month	36(66.7)	39(68.4)	75(67.6)	
• > 2,5 million/month	18(33.3)	18(31.6)	36(32.4)	
Ownership of personal phone, n(%)				
• Yes	54(100)	57(100)	111(100)	
• No	0	0	0	
Main internet sources:				0.789
• Personal data	7(13.0)	9(15.8)	16(14.4)	
• Home Wi-Fi	47(87.0)	47(82.5)	94(84.7)	
• Public Wi-Fi/tethering	0	1(1.8)	1(0.9)	
Social media exposure to oral health information (1 month)				0.900
• 0-2 times	45(83.3)	48(84.2)	93(83.8)	
• > 2 times	9(16.7)	9(15.8)	18(16.2)	

*p<0.05, the respondents' characteristics were included as covariates in adjusted analyses.

Table II - Baseline comparison of study variables

Variables	Intervention (n=54) Mean $\pm$ SD	Control (n=57) Mean $\pm$ SD	p-value
Oral health knowledge score	5.52 $\pm$ 2.21	4.79 $\pm$ 1.94	0.059
Oral health attitude score	31.50 $\pm$ 5.91	32.56 $\pm$ 4.43	0.285
Oral health practice score (self-reported)	16.63 $\pm$ 3.44	16.30 $\pm$ 3.56	0.587
Plaque Index	0.76 $\pm$ 0.37	0.65 $\pm$ 0.45	0.035*
Brushing duration (seconds)	69.52 $\pm$ 23.09	94.53 $\pm$ 31.99	<0.001*
	n (%)	n (%)	
Correct brushing method	27(50)	24(42.1)	0.404
Complete brushing area	8(14.8)	4(7.0)	0.186

*Significant at p<0.05.

In contrast, the control group showed no significant improvements in any oral health behavioural variable. Instead of the plaque index worsening, it increased from 0.65 to 0.70 ($p = 0.040$), while brushing duration decreased from 94.53 to 86.46 seconds ($p < 0.001$). No significant improvement was observed in the brushing method and the brushing area completeness.

To evaluate the effectiveness of the WhatsApp reminder intervention, an Analysis of Covariance (ANCOVA) was conducted, controlling for baseline scores and maternal occupation.

The results, presented in Table IV, showed that the intervention group achieved a significantly higher adjusted mean practice score (18.71) compared to the control group (16.34) at the post-test ($p < 0.001$). The effect size of 0.111 indicates that the intervention accounted for 11.1% of the variance in practice scores. Clinically, the intervention resulted in a significant reduction in the Plaque Index. Despite starting with higher baseline scores, the intervention group exhibited a significantly lower adjusted mean Plaque Index (0.52) compared to the control group (0.74) after the intervention ($p < 0.001$).

Table III - Comparison of pretest and post-test scores (paired analysis)

Variables	Group	Pretest (Mean $\pm$ SD)	Post-test (Mean $\pm$ SD)	p-value
Knowledge score	Intervention (n=54)	5.52 $\pm$ 2.21	6.09 $\pm$ 1.94	<0.001**
	Control (n=57)	4.79 $\pm$ 1.94	4.95 $\pm$ 2.20	0.541
Attitude score	Intervention (n=54)	31.50 $\pm$ 5.91	32.5 $\pm$ 5.20	0.375
	Control (n=57)	32.56 $\pm$ 4.43	32.61 $\pm$ 5.29	0.541
Practice score	Intervention (n=54)	16.63 $\pm$ 3.44	18.43 $\pm$ 3.06	<0.001**
	Control (n=57)	16.30 $\pm$ 3.56	16.09 $\pm$ 2.95	0.398
Plaque Index	Intervention (n=54)	0.76 $\pm$ 0.37	0.55 $\pm$ 0.35	<0.001**
	Control (n=57)	0.65 $\pm$ 0.45	0.70 $\pm$ 0.41	0.040*
Brushing duration	Intervention (n=54)	69.52 $\pm$ 23.09	73.13 $\pm$ 24.73	0.337
	Control (n=57)	94.53 $\pm$ 31.99	86.46 $\pm$ 25.48	<0.001**
		Pretest n (%)	Post-test n (%)	
Correct brushing method	Intervention (n=54)	27 (50.0)	36 (66.7)	0.012*
	Control (n=57)	24 (42.1)	23 (40.4)	1.000
Complete brushing area	Intervention (n=54)	8 (14.8)	13 (24.1)	0.063
	Control (n=57)	4 (7.0)	9 (15.8)	0.227

*Significant at $p < 0.05$. **Significant at $p < 0.001$.

Table IV - Comparison of post-intervention outcomes between groups (ANCOVA) adjusted for baseline scores and maternal occupation

Variables	Group	Adjusted Mean $\pm$ SE	p-value (Intervention effect)	Partial η^2 (Effect Size)
Knowledge score	Intervention	5.83 $\pm$ 0.219	0.137	0.021
	Control	5.22 $\pm$ 0.331		
Attitude score	Intervention	32.39 $\pm$ 0.721	0.744	0.001
	Control	32.81 $\pm$ 1.072		
Practice score	Intervention	18.71 $\pm$ 0.365	<0.001**	0.111
	Control	16.34 $\pm$ 0.545		
Plaque Index	Intervention	0.52 $\pm$ 0.024	<0.001**	0.201
	Control	0.74 $\pm$ 0.035		
Brushing duration	Intervention	80.80 $\pm$ 2.980	0.738	0.001
	Control	82.53 $\pm$ 4.301		

**Significant at $p < 0.001$.

Table V - Binary logistic regression analysis predicting the likelihood of adopting correct brushing skills post-intervention, controlling for baseline category and maternal occupation

Variables	Odds Ratio (OR)	95% (CI) for OR	p-value
Correct brushing method	6.84	1.75-25.77	0.006*
Complete brushing area	1.29	0.43-3.89	0.655

*Significant at $p < 0.05$.

Interestingly, the analysis revealed no significant difference between the intervention and control groups regarding oral health knowledge scores after adjustment for covariates ($p = 0.502$). Although the intervention group showed significant within-group improvements over time, as seen in Table III, no significant between-group differences were observed after adjustment for covariates. No significant differences were found for oral health attitude scores ($p = 0.399$) and brushing duration at the end of the study.

Binary logistic regression analysis was performed to determine the likelihood of participants adopting the correct brushing skills. As presented in Table V, students in the intervention group were 6.84 times more likely to adopt the correct tooth-brushing method compared to the control group ($p = 0.006$). However, the intervention did not show a significant impact on the completeness of the brushing area ($p = 0.655$).

DISCUSSION

The present study demonstrated that a four-week WhatsApp-based reminder intervention significantly improved adolescents' clinical plaque status and oral hygiene practices, despite producing only modest improvements in knowledge and no significant improvement in attitudes. These findings reinforce the growing evidence that mobile-based behavioral cues can meaningfully influence health routines by bridging the gap between intention and action, particularly among adolescents who often possess adequate knowledge but struggle with behavioral implementation [30].

The most significant finding of this study was the improvement in clinical outcomes. Adolescents in the intervention group exhibited a significant reduction in Plaque Index scores (from 0.76 to 0.55). In contrast, the control group experienced a deterioration in oral hygiene status (from 0.65 to 0.70) over the same period.

These findings align with recent systematic reviews suggesting that mHealth interventions improve clinical outcomes by providing timely cues to action [31]. The deterioration observed in the control group further underscores the knowledge-practice gap described in previous literature, where standard school-based education alone is insufficient to sustain daily hygiene habits without reinforcement [8-10].

However, at baseline, the intervention group demonstrated a significantly higher Plaque Index ($p = 0.035$) and shorter tooth-brushing duration ($p < 0.001$) compared to the control group. While these initial differences were statistically controlled using ANCOVA, participants with poorer initial oral hygiene may have had a greater potential for clinical improvement. Therefore, although the intervention group successfully achieved a significantly lower adjusted mean Plaque Index at the post-test (0.52 vs 0.74, $p < 0.001$), the magnitude of these observed effects should be interpreted with appropriate caution.

This clinical improvement was accompanied by a significant increase in oral health practice score. The strong concordance between the objective reduction in plaque and the improvement in self-reported practice scores validated that the students did not merely report "better practice" to please examiners (social desirability bias) [25], but genuinely translated the WhatsApp reminders into consistent daily practices. This finding aligns with previous studies, which indicate that digital reminders significantly improve adherence to oral hygiene routines among adolescents [14,20,32]. While the control group's decline highlights the natural decay of hygiene habits in the absence of reinforcement [33]. The intervention group's success confirms that mHealth prompts can effectively sustain and improve daily routines.

Our analysis revealed that the improvement in oral hygiene status was also likely driven by the adoption of correct brushing techniques.

The intervention group was nearly seven times more likely to adopt the correct brushing method compared to the control group. This suggests that the quality of the mechanical removal (technique) is critical for plaque control [34]. By using video demonstrations via WhatsApp, the intervention may have shifted participants from horizontal scrubbing to vertical or circular motions, supporting previous evidence that digital visual aids are highly effective for skills acquisition in toothbrushing practice [35].

The success of this intervention highlights the utility of WhatsApp as a cue to action. By timing messages at 8 pm, the intervention targeted the pre-sleep routine, a critical window for oral habit formation [36]. Unlike complex, standalone health apps that suffer from high attrition rates and require user training [19], WhatsApp is already an integral part of the daily lives of adolescents [20,21]. This high acceptability may have contributed to the favorable behavioral outcomes observed in this study.

Despite improvements in oral health practice and clinical status, the intervention did not result in significantly higher oral health knowledge or attitude scores compared to the control group in the adjusted analysis, although within-group knowledge scores showed improvement. This lack of between-group disparity may be attributed to the high baseline knowledge prevalent among adolescents in school settings. It reinforces the Theory of Planned Behavior's assertion that knowledge is a necessary but insufficient prerequisite for behavior change [28]. Similarly, the stability of attitude scores suggests that four weeks may be too brief to alter deep-seated psychological attitudes, even if immediate behaviors are modified through prompts [37].

Furthermore, the intervention did not significantly improve the completeness of brushing coverage ($p > 0.05$). This outcome is likely explained by the insufficient brushing duration, which is also insignificantly improved in the analysis. Although students adopted correct brushing methods, their average brushing duration at the post-test remained approximately 73 seconds, which is below the standard recommendation of two minutes [38]. The school-based data collection setting may have influenced the students' psychological state, causing them to rush during the brushing session [39]. Consequently, while the intervention successfully corrected how participants brushed in the correct method,

it failed to extend the duration of brushing to ensure comprehensive coverage.

Several limitations should be considered. First, the four-week duration, while sufficient to observe changes in plaque accumulation, limits the assessment of long-term behavioral maintenance. Therefore, the findings should be interpreted as evidence of short-term effectiveness rather than sustained behavioral change. Second, participant engagement with the WhatsApp reminders was not objectively monitored, which may have influenced the intervention effect. Third, while the plaque index offered an objective outcome, data on brushing frequency and dietary habits remained self-reported. Fourth, the quasi-experimental design restricts randomization and may have introduced selection bias because participants were recruited from purposively selected schools, although ANCOVA was used to adjust for baseline confounders such as maternal occupation. Nevertheless, residual confounding cannot be completely excluded. Future studies should employ randomized controlled trials with more extended follow-up periods and incorporate objective measures of intervention adherence to determine if these digital nudges sustain oral health habits into early adulthood.

CONCLUSION

A WhatsApp-based reminder intervention is a practical, scalable, and low-cost strategy that improved oral hygiene practices and significantly reduced dental plaque among adolescents during the four-week intervention period. By leveraging familiar technology to provide timely behavioral cues, this approach has the potential to help bridge the gap between oral health knowledge and actual oral hygiene practice. Further studies with longer follow-up are warranted to evaluate the sustainability of these behavioral improvements.

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Data availability

The datasets analyzed in this study are available from the corresponding author on request.

Author's Contributions

EAAM, ATWH, HH: Conceptualization . EAAM, ATWH: Methodology. HH, EAAM: Formal Analysis. EAAM, ATWH, HH: Investigation. EAAM, ATWH: Data Curation. EAAM, ATWH, HH: Validation. EAAM: Writing Original Draft Preparation. EAAM, ATWH, HH: Writing – Review & Editing. HH: Visualization. EAAM, ATWH, HH: Supervision. EAAM, HH: Project Administration. EAAM: Funding Acquisition.

Conflict of Interest

No conflicts of interest declared concerning the publication of this article.

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Regulatory Statement

This study was conducted in accordance with all the provisions of the local human subjects oversight committee guidelines and policies of Faculty of Dentistry, Universitas Jember. This study protocol was reviewed and approved by The Ethical Committee of Medical Research, Faculty of Dentistry, University of Jember, approval number 3065/UN25.8/KEPK/DL/2025.

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