SYSTEMATIC REVIEW

Effectiveness of mHealth vs. Conventional Oral Health Education Among Adolescents in Periodontal Disease: A Systematic Review and Meta-Analysis

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ABSTRACT

Introduction: This paper aimed to evaluate the effectiveness of mobile health (mHealth) interventions in comparison to conventional health education in improving periodontal health among adolescents. **Methods:** This systematic review was performed according to Cochrane and PRISMA guidelines. Systematic searches were performed in several databases: PubMed, Scopus, Web of Science, Cochrane, ScienceDirect, EBSCO, LILACS, Google Scholar and a manual search for appropriate studies published until December 2022. The inclusion criteria were experimental studies carried out among adolescents aged 10-19 years old with the objective of improving periodontal health using mHealth interventions and conventional health education. Risk of bias assessments were done using the Critical Appraisal Skills Programme Randomized Controlled Trial (CASP-RCT). Meta-analysis, meta-regression and Egger's test were performed to evaluate the impact of mHealth education on periodontal health outcomes. **Results:** Out of 8,061 titles and abstracts screened, three articles met the inclusion criteria. It was found that mHealth interventions demonstrated significant improvements in periodontal health compared to conventional health education. While conventional health education showed higher knowledge scores, mHealth interventions were superior in improving plaque scores and bleeding scores over extended follow-up periods. Subgroup analysis revealed no significant difference in knowledge scores between the two education modalities. **Conclusion:** mHealth interventions show promise in improving periodontal health awareness and outcomes among adolescents. However, variations in study quality, as assessed using the CASP-RCT checklist, limit confidence in the findings. With overall evidence rated as moderate, future research should prioritize high-quality randomized controlled trials.
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INTRODUCTION

Periodontal disease is defined as pathologies affecting all the supporting tissues of the teeth, including gingivitis and periodontitis (1). The global incidence and prevalence of periodontal diseases have increased substantially from 1990 to 2019, where it is estimated that 1.09 billion people worldwide were affected by periodontal diseases (2). Even though only severe periodontitis is considered a major global health issue, finding and treating periodontal diseases early is very important to stop them from becoming long-term problems that can cause tooth loss and other issues. (3, 4) Although epidemiological studies indicate that the prevalence of periodontal disease remains relatively low among adolescents, the incidence within this age group is notably high. This trend can be linked to a few reasons, such as poor oral hygiene habits that are often seen in teenagers and the hormonal changes that come with puberty, which can worsen gum inflammation and make them more prone to periodontal problems. (5-8) Despite concerns of periodontal diseases showing an increasing trend among younger individuals, the periodontal health of adolescents is often overlooked.

The primary objective of health education programs is to enhance health promotion and disease prevention in a targeted population, which ultimately results in behavioural changes (9). Health education encompasses various learning experiences aimed at promoting voluntary actions that support health. Possessing information pertaining to oral health entails that an individual is fully equipped to comprehend the nature and progression of oral disease, in addition to the preventative measures required to preserve optimal oral health. This knowledge may be acquired through experiential learning, media sources, educational institutions, and dental clinics (10). An effective oral health education program should lead to an overall improvement in oral health status and a reduction in the incidence of oral diseases, with periodontal disease and dental caries being particularly prevalent among them (11, 12).

Conventional and mHealth education can substantially influence health and dental health outcomes, yet they diverge in their methodologies and potential results. Conventional health education facilitates direct engagement between dentists and patients, allowing them to pose inquiries, seek elucidation, and participate in doctor-patient communications actively. The efficacy of hands-on training in dental health education, such as the use of printed materials and dental models, is ideal when delivered in a physical environment. Well-established facilities and healthcare experts frequently link the conventional type of health education, conferring credibility to the disseminated material.

The widespread use of mobile phones globally, especially in high-income nations, and the rapid expansion of mobile infrastructure in low- and middle-income countries have led to the emergence of mHealth (13, 14). The World Health Organization defined mHealth as “a term used for medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, Personal Digital Assistants (PDAs), and other wireless devices. Mobile devices are used in mHealth applications to collect community and clinical health data, deliver healthcare information to practitioners, researchers, and patients, monitor patient vital signs in real-time, and provide direct care (15). This field uses mobile technology’s mobility, quick access, and direct communication to spread health information rapidly. With basic apps and advanced features like text messaging and multimedia services, mHealth can revolutionize healthcare delivery worldwide, especially in low- and middle-income countries. The term encompasses both basic applications and sophisticated technologies, such as voice commands, text messaging (SMS), multimedia messaging service, Bluetooth technology, and others (16). Currently, mHealth education commonly utilizes mobile technology, specifically smartphones and tablets, to disseminate health and dental health-related knowledge to individuals (17). However, there is concern that mHealth lacks personal interaction and immediate feedback, which are typically offered by conventional educational methods.

Despite showing enormous potential in improving health, the efficacy of mHealth in improving periodontal health has not been evaluated. With the increasing prevalence of mobile technology use, it is essential to investigate its effectiveness in health education. Thus, the aim of this systematic review is to systematically and critically appraise available literature investigating the efficacy of mHealth compared to conventional health education modalities in improving periodontal health among adolescents.

METHODOLOGY

Protocol and registration

This methodological survey was designed and performed following the recommendations of the Cochrane Handbook for Systematic Reviews of Interventions (18). A study protocol based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Protocols (PRISMA) was created (19), and the study was registered with a registration number (CRD42023402820) at the Prospective Register of Systematic Reviews (PROSPERO), University of York.

The PICO criteria were (1) Population: adolescents aged 10-19 years old; (2) Intervention: have participated in the study using the mHealth; (3) Comparison: In comparison with the conventional method in health education; and (4) Outcome: periodontal status.

The PICO question was “Among adolescents aged 10-19 years old, will mHealth intervention improve the periodontal health status compared to conventional oral health education?” In this context, the World Health Organization defines 'adolescents' as individuals in the 10-19 years age group. mHealth is an abbreviation for mobile health, a term used for the practice of medicine and public health supported by mobile devices. Additionally, conventional health education refers to the teaching of health through face-to-face counselling or through pamphlets/booklets, etc.

Search strategy

An electronic search was conducted independently by three (3) investigators (AFL, AAM, NAAB) using eight (8) electronic databases to identify relevant articles published up to December 2022 in PubMed, Google Scholar, Web of Science, ScienceDirect, Cochrane, Scopus, LILACS and EBSCO. All investigators independently evaluated and appraised the reference lists of relevant papers from the electronic search using computer software (EndNote 20, Mendeley). Keywords such as "adolescence," "adolescent," "schoolchildren," "mHealth," "mobile oral health," "mobile health," "dental

health education," "oral health education", "periodontal" were applied for each database in conjunction with the use of Boolean operators 'AND' and 'OR'. Any disagreement between the investigators will be resolved by discussions with the other two researchers who act as the field experts (NAMR and BAMS).

Inclusion and exclusion criteria and study selection
After discarding duplicate articles using EndNote 20 and Mendeley, the investigators (AFL, AAM, NAAB) separately screened the titles and abstracts of all the articles and performed a full-text assessment to identify studies based on the inclusion and exclusion criteria. Articles that fulfilled the following inclusion criteria were considered in this study:

» mHealth and conventional health education studies;
» Improved periodontal health as outcomes;
» Adolescents aged 10-19 years old;
» Non-randomized trial study;
» Quasi-experimental study;
» Randomized clinical trials;
» No limit to any country;
» English;
» Studies conducted up to 31st December 2022.

Articles that fulfilled the following exclusion criteria were omitted:

» Non-English;
» Observational studies;
» Systematic review;
» Expert opinions, reviews, case reports or case series, letters to the editor, short communications, protocols, conference papers and theses;
» Full text is unavailable.

Data extraction
Each article's parameters were extracted and documented by three investigators (AFL, AAM, NAAB) using a customized Microsoft Excel spreadsheet, which included the following details: article title, authors, year of publication, country, study design, sample size, gender, age, evaluation tool, evaluation criteria, response rate, and overall outcomes. Two additional investigators (GSSL, AAMY) cross-checked the data for accuracy, and any discrepancies were resolved through discussions involving all investigators. When the consensus failed to emerge, two senior researchers (NAMR, BAMS) were consulted. Authors of the included studies were contacted via email to provide any additional data required for qualitative or quantitative analysis.

Risk of bias assessment and level of evidence
Three investigators (AFL, AAM, NAAB) independently assessed the Risk of Bias assessment (19) of the selected articles using the Critical Appraisal Skills Programme Randomized Controlled Trial (CASP-RCT) critical appraisal checklist for randomized controlled trials (20, 21). Either 'yes', 'no,' 'unclear,' or 'not applicable' was assigned for each domain. Subsequently, the studies were categorized as 'include,' 'exclude,' or 'seek further info.' Any persistent disputes were resolved with the assistance of the sixth and seventh researchers (GSSL, AAMY, NAMR, BAMS). The Oxford Centre for Evidence-Based Medicine (OCEBM) guideline was used to establish the level of evidence in each study (22).

Statistical analysis
Based on the DerSimonian-Laird random-effects model, two-arm meta-analyses were performed to compare the effectiveness of mHealth education and conventional health in improving periodontal health. The heterogeneity between the included primary studies was also assessed using the Higgins' I statistic, which has three categories: less than 30% = acceptable heterogeneity, between 30 and 60% = moderate heterogeneity, and more than 60% = severe heterogeneity. Due to the limited number and scarcity of included primary studies, subgroup analysis was unable to be performed. Nevertheless, meta-regression analysis was used to assess the effect of sample size on the overall findings, whereas Egger's test was used to identify publication bias. Statistical analyses were carried out using Review Manager version 5.4 software designed for composing Cochrane Reviews (Cochrane Collaboration, Oxford, UK). The confidence interval (3) was reported at the 95% level, and the significance threshold was chosen at p=0.05.

RESULTS

Study selection
The flowchart in Figure 1 illustrates the procedure for selecting and extracting articles, as outlined in the PRISMA 2020 flow diagram for new systematic reviews. This process includes searching various databases, registries, and other sources, as recommended by PRISMA. A total of 8,434 abstracts and titles were identified, and 388 articles were removed due to duplicated publications, full text not available, or articles written in other languages. Following the removal of duplicate articles utilizing EndNote 20 and Mendeley, the researchers (AFL, AM, NAAB) independently examined the titles and abstracts of all the publications and pursued retrieval. Manual searches were performed from the reference lists of selected studies to screen for relevant articles.

Study characteristics
Three articles have been selected for additional examination and analysis (3, 23, 24). Table I presents comprehensive demographic information for all the selected articles. Study size ranged from 100 to 291 participants, with ages ranging from 12 years old to 19 years old. The studies were conducted in India, the Netherlands and Brazil respectively. Two studies were conducted at schools (3, 23), and one study was conducted in orthodontic clinics (24).

All studies performed clinical examinations at baseline and at follow-ups ranging from four to 12 weeks to

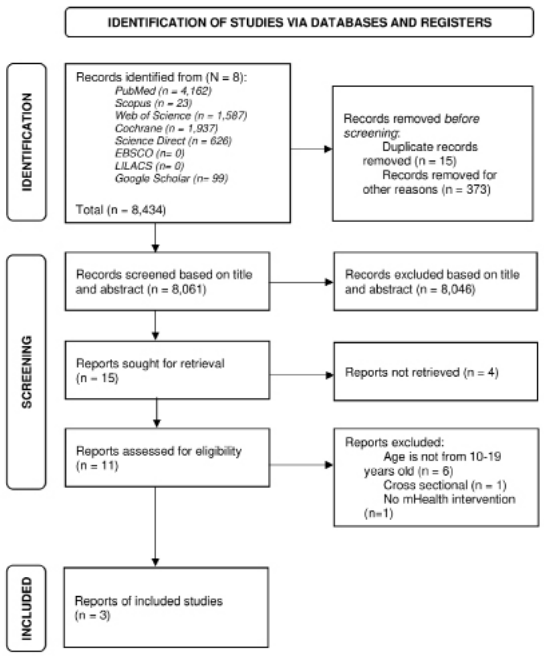

Figure 1: PRISMA 2020 flow diagram for new systematic reviews, which included searches of databases, registers and other sources.

measure periodontal health by evaluating gingival bleeding and the presence of plaque. Knowledge scores and oral health behaviours were evaluated using self-administered questionnaires.

The three studies included in this review employed single-blinded randomized controlled trials with two to four parallel arms. Regarding mHealth interventions, two studies utilized mobile applications (23, 24), while one study implemented an interactive game-based visual performance technique (3). All interventions were specifically developed for their respective study populations. In all studies, the control groups received conventional oral health education.

The attrition rate across the studies ranged from 6% to 17%. One study utilized an intention-to-treat analysis (24), while the other two did not specify their analysis methods for the RCT (3, 23). All studies reported improvements in oral health knowledge, behaviour, gingival bleeding scores, and plaque scores for both the control and intervention groups. However, the intervention groups showed a significant reduction in

Table I: The demographic characteristics of the studies selected

No.	Title	Country	Sample size	Gender	Age (Mean)	Evaluation tool	Evaluation criteria	Main results/outcome
	Effectiveness of a Visual Interactive Game on Oral Hygiene knowledge, practice and clinical parameters among adolescents: a randomised control trial (K et al. 2022)	India	100	Both	13.92 conventional OHE, 13.35 IGVP technique. min=12, max=15	Questionnaire & Clinical examination	1. Knowledge 2. Gingival score 3. Plaque score	**Mean Knowledge score** **Baseline** Baseline knowledge score in both groups was almost equal (control group: 7.30 ± 1.31; test group: 7.29 ± 1.72) and statistically insignificant (p = 0.192). Post-intervention The mean knowledge score post-OHE intervention of the control group (7.88 ± 1.97) and test group (8.94 ± 1.27) indicated a statistically significant difference between the groups, p < 0.001 # Following the OHE intervention, the test group showed a significant increase in the percentage of knowledge gained (22.4%) when compared to the control group (7.8%) using a paired t-test, p < 0.001 **Mean Gingival score** **Baseline** Control group (1.44); test group (1.38) and statistically insignificant (p = 0.775). Post-intervention Control group (1.40); test group (0.57) and statistically significant (p < 0.001). # Greater reduction in the mean gingival score a in the test group after intervention, indicating a 58.7% reduction when compared to the control group, which had a 2.8% (p < 0.001). **Mean Plaque score** **Baseline** Control group (1.52); test group (1.49) and statistically insignificant (p = 0.426). Post-intervention Control group (1.51) and test group (0.45) and statistically significant (p < 0.001). # Greater reduction in the mean plaque score in the test group after intervention, indicating a 63.4% reduction when compared to the control group, which had a 0.7% reduction, respectively (p < 0.001). **Mean and % OH Knowledge Score** **Baseline** Control group (7.30 ± 1.31); test group (7.29 ± 1.72) and statistically insignificant (p = 00.192). Post-intervention Control group (7.88 ± 1.97) and test group (8.94 ± 1.27) and statistically significant (p < 0.001). # Following the OHE intervention, the test group showed a significant increase in the percentage of knowledge gained (22.4%) when compared to the control group (7.8%) using a paired t-test, p < 0.001 **Mean and % OH Practise Score** Did not explain in the results

CONTINUE

Table I: The demographic characteristics of the studies selected (continued)

No.	Title	Country	Sample size	Gender	Age (Mean)	Evaluation tool	Evaluation criteria	Main results/outcome
	Improving adolescents' periodontal health: evaluation of a mobile oral health App associated with conventional educational methods: a cluster randomised trial (Marchetti et al. 2018)	Brazil	291	Both	16.1 years. min=14, max=19	Questionnaire & Oral clinical indexes	1. Knowledge Score (KS). 2. Simplified Oral Hygiene Index (OHI-S) 3. Gingival Bleeding (GBI)	This clinical trial showed that the use of an App associated with conventional methods was effective in improving adolescent's oral health. It showed a significant long-term outcome. Regarding clinical findings, all methods were equally effective.
	The effect of using a mobile application (WhiteTeeth) on improving oral hygiene: A randomized controlled trial (Scheerman et al. 2020)	Netherlands	132	NA	12-16	Clinical examination	Primary outcomes: plaque index and bleeding scores Secondary outcomes: Oral health behaviour-brushing habits and usage of Fluoridated mouth rinse and other dental aids	**At 6-week follow-up** The intervention effect on the total amount of dental plaque (B = -6.86; 95% CI -16.05 to 2.34) and the total sites covered with plaque (B = -4.83; 95% CI -9.69; 0.04) was not significant. **At 12-week follow-up** The reductions in dental plaque accumulation (B = -11.32; 95% CI 20.57 to -2.07) and in the presence of dental plaque (B = -6.77; 95% CI -11.67 to -1.87) were significantly greater in patients in the intervention group than in the controls: while, on average, plaque was present on 62% of teeth in the intervention group, it was present on 73% of teeth in the control group. **Bleeding scores** Had improved more in participants in the intervention group than in controls at 6 weeks of follow-up (B =-3.74; 95% CI -6.84 to -0.65). **At 12 weeks of follow-up** However, the intervention effect was no longer significant (B = -1.89; 95% CI -5.00 to 1.22). The only **significant intervention effect** was for fluoride use at the 6-week follow-up; it favoured the intervention group (B = 1.93; 95% CI 0.36 to 3.50). No significant intervention effects were found for the oral health behaviour score, tooth-brushing (frequency and duration) and interproximal brush usage. Psychosocial factors: significant adjusted effects were found for coping planning regarding tooth-brushing (T1: B = 0.27; 95% CI 0.03 to 0.51; T2: B = 0.27; 95% CI 0.03 to 0.51; P = .028) and intention towards fluoride mouth rinse use (T1B = 0.56; 95% CI 0.15 to 0.96; T2 B = 0.42 95% CI 0.01 to 0.83) at **both 6-week and 12-week follow-up.** Although not significant, the scores on most psychosocial factors at 12-week follow-up were better in the intervention group than in the control group.

bleeding and plaque scores at follow-ups. Additionally, oral health knowledge and behaviour scores were significantly higher in the intervention groups compared to the control groups at follow-ups.

Risk of bias

The CASP-RCT is a tool used to assess the quality of research studies using 11 questions that each focus on a different methodological aspect and validity of a study. Table II summarizes the results of the quality assessment using the CASP-RCT checklist. There were 11 studies assessed for eligibility, but only three reports were included in the study. Based on the CASP checklist, all studies scored well in various domains according to the CASP checklist for RCT, with a total score of 7 for K et al. (2022) (23), a total score of 11 for Scheerman et al. (2020) (24), and a total score of 6 for Marchetti et al. (2018) (3). The level of evidence for all studies was determined to be 3, indicating a moderate quality of evidence. The researchers established a consensus to incorporate articles of both medium and high quality for future evaluation.

The precision of the estimate of the intervention or treatment effect and benefits of the experimental intervention outweighing the harms and costs were not reported in two studies and information was not clear for Scheerman et al. (2020) (24). There were also some areas where two studies did not provide clear information, as in domains 10 and 11, where the results can be applied to the local population and the experimental intervention provided greater value to the people in care, but it was reported thoroughly by Scheerman et al. (2020) (24).

Statistical analysis

The mean and standard deviation of the patient's knowledge scores, plaque scores, and gingival bleeding scores between control (conventional health education)

Table II: CASP Checklist for RCT

No.	Study (Author)	Domains											Total Score	Level of Evidence
		1	2	3	4	5	6	7	8	9	10	11		
	(K et al. 2022)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Can't tell	Can't tell	7	3
	(Marchetti et al. 2018)	Yes	Yes	No	Yes	Yes	Yes	Yes	No	No	Can't tell	Can't tell	6	3
	(Scheerman et al. 2020)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Can't tell	Yes	Yes	11	3

and intervention (mHealth education) were compared. Two-arm meta-analysis in Figure 2 shows the patients' knowledge score on periodontal health after conventional health education and mHealth education intervention. The overall weighted mean difference of knowledge scores was 0.69 (95% CI: 0.47–0.90), with patients in the conventional health education group demonstrating significantly higher knowledge scores regarding their periodontal health ($p < 0.05$) compared to those in the e-health education group. The I2 of the weighted mean differences in knowledge scores was 0%, implying that the included primary studies for quantitative analysis do not possess significant heterogeneity.

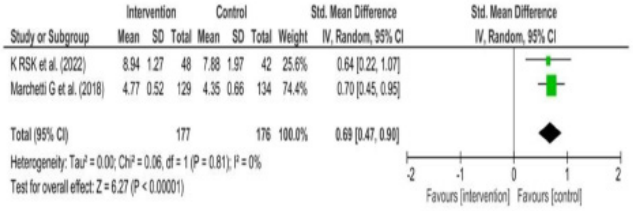

Figure 2: Patients' knowledge score on periodontal health after conventional health education and mHealth education intervention.

The weighted standardized mean difference of plaque scores was -1.78 (95% CI: -5.46 – 1.91) for the group receiving conventional health education and -1.85 (95% CI: -4.71 – 1.01) for the group receiving mHealth education, as shown in Figure 3. No significant difference was found, despite both the conventional health education (p=0.34) and mHealth education (p=0.21) groups' plaque scores demonstrating a slight improvement at the 3-month and above follow-up period. However, there appears to be significant data heterogeneity, as the I of the weighted mean differences of plaque scores was >99%.

Similarly, Figure 4 reveals that the weighted standardized mean difference of bleeding scores was -1.08 (95% CI: -3.07 – 0.92) for the conventional health education group and -1.39 (95% CI: -3.46 – 0.68) for the mHealth education group. Despite showing slight improvement in the bleeding scores at the 3-month and above follow-up period for both control (p=0.29) and intervention (p=0.19) groups, no significant differences were noted, respectively. Nevertheless, the I of the weighted mean differences of bleeding scores was 99%, suggesting

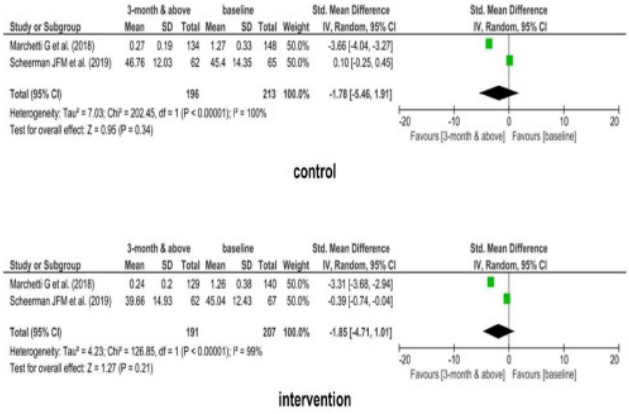

Figure 3: Patients' plaque score on periodontal health after conventional health education and mHealth education intervention.

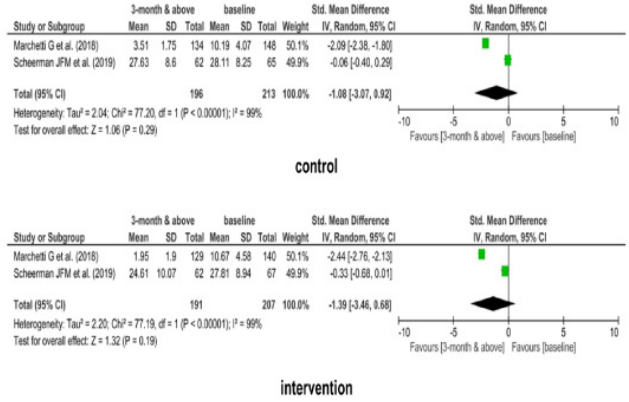

Figure 4: Patients' bleeding score on periodontal health after conventional health education and mHealth education intervention.

substantial data heterogeneity.

When comparing conventional and mHealth education on both plaque and bleeding scores (Figure 5), it is noted that there is a tendency to favor the mHealth education group. The weighted standardized mean difference of the plaque score between the control and intervention groups was -0.31 (CI: -0.67–0.06), but no significant difference (p = 0.10) was noted. However, a significant difference was found (p = 0.02) when looking at the bleeding scores, with a standardized weighted mean difference of -0.60 (CI: -1.12–0.08), indicating that the intervention (mHealth education) worked better for controlling bleeding scores. However, substantial data

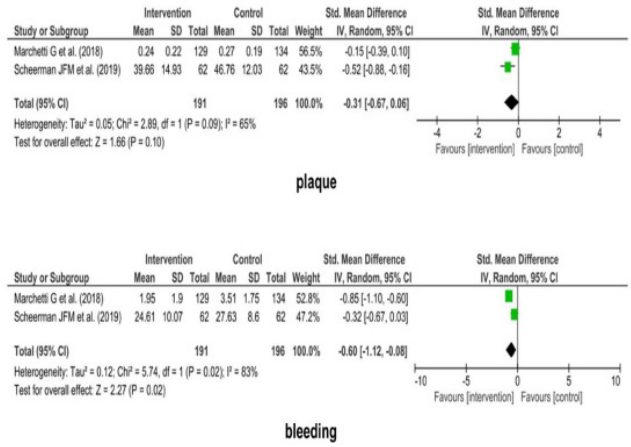

Figure 5: Comparison patients' plaque score on periodontal health after conventional health education and mHealth education intervention .

heterogeneity is observed, ranging from 65% to 83%. The overall substantial heterogeneity can be explained by the different study designs, evaluation tools and patient's demographic details.

Meta-regression was used to assess how the size of each study affected the knowledge scores (p=0.163), plaque scores (p=0.087), and bleeding scores (p=0.06) in both the control and intervention groups. In addition, Egger's test revealed no evidence of significant publication bias among the included primary studies, with an average p-value of 0.081.

DISCUSSION

This systematic review and meta-analysis found that educating adolescents with mHealth led to improved periodontal disease outcomes compared to conventional health methods. It examined periodontal health by comparing patients' knowledge scores, plaque scores, and gingival bleeding scores in control (conventional education of health) and intervention (mHealth education) groups. The utilization of mHealth in dental health education to improve all periodontal health parameters showed sustained improvement at least up to 12 weeks after intervention.

Research suggests that the use of mHealth in oral health education increases participant engagement (25). According to Ram Surath Kumar et al. (2022), the interactive game-based visual performance (IGVP) method worked better than regular oral health education in lowering gum and plaque issues and improving knowledge and its use in managing oral hygiene. They also discovered that adding the IGVP methodology after providing a health education session for schools was a simple, enjoyable, interactive, and cost-efficient approach. Similarly, the clinical trial conducted by Marchetti et al. in 2018 showed that utilizing an app in conjunction with conventional approaches successfully enhanced dental health among adolescents (3). The results also demonstrated a substantial long-term effect. These results are similar to those reported by Borujeni et al. 2021 (26). They discovered that teledentistry is a successful and productive approach to enhancing oral hygiene in patients receiving fixed orthodontic treatment. Adolescents may find it easier to maintain their oral hygiene and improve their tooth-brushing skills with the assistance of mHealth technology.

However, subgroup meta-analysis revealed that patients in the conventional health education group had significantly higher knowledge of periodontal health compared to those in the mHealth education group after the intervention. The limited interaction in mHealth compared to conventional oral health talks or lectures may account for this. Conventional face-to-face education facilitates two-way communication, allowing for immediate feedback and discussion while being adaptable to the patient's attention span and nonverbal cues. Additionally, young adolescents may require guidance for e-learning, as they may lack the cognitive ability for effective self-directed learning (27).

In terms of plaque score and bleeding score, subgroup analyses revealed no significant differences between conventional oral health education and mHealth oral health education at three-month follow-ups. Heterogeneity scores for both parameters were high. These findings may be due to small number of studies included in the meta-analysis, variability in dental indices used to assess plaque score and bleeding score, and demographic differences among study populations.

While conventional oral health education may be more effective for knowledge acquisition, mHealth interventions offer advantages in behavioural improvements, such as reducing plaque and bleeding scores. Overall, the intervention group demonstrated a reduction in plaque score, though the difference was not statistically significant compared to the control group. Interestingly, this review found that mHealth oral health education significantly reduced gingival bleeding compared to conventional oral health education. Gingival bleeding is considered a key indicator of periodontal health, and its reduction suggests improved periodontal health (28). Since gingival bleeding typically develops after one week of plaque accumulation, a reduction in bleeding scores may indicate that patients have been consistently maintaining excellent oral hygiene over time (29).

The findings of this review are consistent with previous studies. mHealth-based education alone has shown limited potential in improving oral health behaviour (30). However, when used as an adjunct to conventional oral health instructions, mobile applications and text messages have been shown to enhance both oral health knowledge and behaviour among adolescents, adults,

and mothers of young children (31). Conventional oral health education offers the advantage of two-way communication, which strengthens the doctor-patient relationship, while mobile apps provide regular reminders and reinforcement of oral health knowledge beyond dental visits (24). A hybrid approach, combining both conventional and mHealth education, may be the most effective strategy for improving both knowledge retention and periodontal health outcomes.

This meta-analysis links the methodological quality of the included studies, as assessed using the CASP-RCT checklist, to the strength of the evidence it presents. Although all three studies selected for analysis were of moderate to high quality, the disparity among studies necessitates caution when interpreting the overall findings. Given that the level of evidence across the studies was rated as Level 3 (moderate), the confidence in the estimated effects is correspondingly moderate.

A major strength of this review is its systematic approach and rigorous methodology following adherence to PRISMA guidelines. The studies included had a low risk of bias, ensuring the reliability of the findings. Additionally, this review focused on adolescents' periodontal health, a crucial yet often overlooked age group in periodontal disease prevention. However, this review has several limitations. The small number of studies included may overestimate or underestimate the effects of mHealth compared to conventional oral health education. The high heterogeneity score shows that the studies vary greatly, which may limit the results' generalizability and accuracy.

This review highlights the need for high-quality, long-term randomized controlled trials to further evaluate the effectiveness of mHealth in improving adolescents' oral health. The impact of mHealth interventions may vary across demographic and socioeconomic groups, and their potential role in widening health inequities should be explored and addressed (32).

CONCLUSION

This review highlights the effectiveness of mHealth interventions in enhancing awareness, knowledge, and oral health status among adolescents, particularly in reducing gingival bleeding. However, as assessed using the CASP-RCT checklist, the certainty of evidence remains moderate. Due to the limited number of high-quality RCTs and the large variability in study designs, more well-designed RCTs are needed to verify the effectiveness of mHealth interventions in improving periodontal health among adolescents. Future research and application development should prioritize evidence-based behavior change techniques and incorporate elements such as gamification to enhance effectiveness and engagement among the target population.

REFERENCES

1. Martens L, De Smet S, Yusof MY, Rajasekharan S. Association between overweight/obesity and periodontal disease in children and adolescents: a systematic review and meta-analysis. Eur Arch Paediatr Dent. 2017;18(2):69-82. doi: 10.1007/s40368-017-0272-1
2. Zhang X, Wang X, Wu J, Wang M, Hu B, Qu H, et al. The global burden of periodontal diseases in 204 countries and territories from 1990 to 2019. Oral Dis. 2024;30(2):754-68. doi: 10.1111/odi.14436
3. Marchetti G, Fraiz FC, Nascimento WMD, Soares GMS, Assunɜro L. Improving adolescents' periodontal health: evaluation of a mobile oral health App associated with conventional educational methods: a cluster randomized trial. Int J Paediatr Dent. 2018;28(4):410-9. doi: 10.1111/ipd.12371
4. World Health Organization. Global oral health status report: Towards universal health coverage for oral health by 2030. Geneva: World Health Organization; 2022 18th December 2022. Available from https://www.who.int/publications/i/item/97892400614840
5. Boyapati R, Cherukuri SA, Bodduru R, Kiranmaye A. Influence of Female Sex Hormones in Different Stages of Women on Periodontium. J Midlife Health. 2021;12(4):263-6. doi: 10.4103/jmh.jmh_142_21
6. Costa SA, Nascimento GG, Colins PMG, Alves CMC, Thomaz EBAF, Carvalho Souza SdF, et al. Investigating oral and systemic pathways between unhealthy and healthy dietary patterns to periodontitis in adolescents: A population-based study. Journal of Clinical Periodontology. 2022;49(6):580-90. doi: https://doi.org/10.1111/jcpe.13625
7. Jurišić S, Vukojević M, Martinović V, Ćubela M, Šarac Z, Ivanković Z, et al. ATTITUDES TOWARDS AND HABITS IN ORAL HEALTH OF ADOLESCENTS IN HERZEGOVINA. Acta Clin Croat. 2021;60(1):96-102. doi: 10.20471/acc.2021.60.01.14
8. Moreira ARO, Batista RFL, Ladeira LLC, Thomaz EBAF, Alves CMC, Saraiva MC, et al. Higher sugar intake is associated with periodontal disease in adolescents. Clinical Oral Investigations. 2021;25(3):983-91. doi: 10.1007/s00784-020-03387-1
9. Ghaffari M, Rakhshanderou S, Ramezankhani A, Noroozi M, Armoon B. Oral health education and promotion programmes: meta-analysis of 17-year intervention. International journal of dental hygiene. 2018;16(1):59-67. doi: 10.1111/idh.12304
10. Tadin A, Poljak Guberina R, Domazet J, Gavic L. Oral Hygiene Practices and Oral Health Knowledge among Students in Split, Croatia. Healthcare (Basel). 2022;10(2). doi: 10.3390/

healthcare10020406
11. Nakre PD, Harikiran AG. Effectiveness of oral health education programs: A systematic review. J Int Soc Prev Community Dent. 2013;3(2):103-15. doi: 10.4103/2231-0762.127810
12. Almabadi ES, Bauman A, Akhter R, Gugusheff J, Van Buskirk J, Sankey M, et al. The Effect of a Personalized Oral Health Education Program on Periodontal Health in an At-Risk Population: A Randomized Controlled Trial. Int J Environ Res Public Health. 2021;18(2). doi: 10.3390/ijerph18020846
13. Donner J. Research Approaches to Mobile Use in the Developing World: A Review of the Literature. The Information Society. 2008;24(3):140-59. doi: 10.1080/01972240802019970
14. Carter A, Liddle J, Hall W, Chenery H. Mobile Phones in Research and Treatment: Ethical Guidelines and Future Directions. JMIR mHealth uHealth. 2015;3(4):e95. doi: 10.2196/mhealth.4538
15. World Health Organization. mHealth programmes are sponsored by government 2024 [Available from: https://www.who.int/data/gho/indicator-metadata-registry/imr-details/4774.
16. Marcolino MS, Oliveira JAQ, D'Agostino M, Ribeiro AL, Alkmim MBM, Novillo-Ortiz D. The Impact of mHealth Interventions: Systematic Review of Systematic Reviews. JMIR Mhealth Uhealth. 2018;6(1):e23. doi: 10.2196/mhealth.8873
17. Mahmood A, Kedia S, Wyant DK, Ahn S, Bhuyan SS. Use of mobile health applications for health-promoting behavior among individuals with chronic medical conditions. Digit Health. 2019;5:2055207619882181. doi: 10.1177/2055207619882181
18. Lasserson TJ, Thomas J, Higgins JP. Starting a review. Cochrane handbook for systematic reviews of interventions. 2019:1-12. doi: https://doi.org/10.1002/9781119536604.ch1
19. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. Bmj. 2021;372:n71. doi: 10.1136/bmj.n71
20. CASP. Critical Appraisal Skills Programme (CASP) for Randomised Controlled Trial Checklist. 2018. Available from: https://casp-uk.net/casp-tools-checklists/
21. Hallas D, Spratling R, Fletcher J. Methodological Analysis: Randomized Controlled Trials for Pfizer and Moderna COVID-19 Vaccines. Journal of Pediatric Health Care. 2021;35(4):443-8. https://doi.org/10.1016/j.pedhc.2021.04.001
22. Durieux N, Vandenput S, Pasleau F. [OCEBM levels of evidence system]. Rev Med Liege. 2013;68(12):644-9. Available from: https://rmlg.uliege.be/article/2479?lang=en
23. K RSK, Deshpande AP, Ankola AV, Sankeshwari RM, Jalihal S, Hampiholi V, et al. Effectiveness of a Visual Interactive Game on Oral Hygiene Knowledge, Practices, and Clinical Parameters among Adolescents: A Randomized Controlled Trial. Children. 2022;9(12):1828. doi: 10.3390/children9121828.
24. Scheerman JFM, van Meijel B, van Empelen P, Verrips GHW, van Loveren C, Twisk JWR, et al. The effect of using a mobile application ("WhiteTeeth") on improving oral hygiene: A randomized controlled trial. International Journal of Dental Hygiene. 2020;18(1):73-83. doi: https://doi.org/10.1111/idh.12415
25. Kaneyasu Y, Shigeishi H, Sugiyama M, Ohta K. Effectiveness of e-learning to promote oral health education: A systematic review and meta-analysis. Medicine (Baltimore). 2023;102(51):e36550. doi: 10.1097/md.0000000000036550
26. Borujeni ES, Sarshar F, Nasiri M, Sarshar S, Jazi L. Effect of teledentistry on the oral health status of patients undergoing fixed orthodontic treatment at the first three follow-up visits. Dent Med Probl. 2021;58(3):299-304. doi: 10.17219/dmp/134750
27. Uus X, Mettis K, VΔljataga T. Cognitive Skills in Adolescents' Self-Directed Learning Efficacy. Creative Education. 2022;13:583-98. doi: 10.4236/ce.2022.132035
28. Chapple ILC, Mealey BL, Van Dyke TE, Bartold PM, Dommisch H, Eickholz P, et al. Periodontal health and gingival diseases and conditions on an intact and a reduced periodontium: Consensus report of workgroup 1 of the 2017 World Workshop on the Classification of Periodontal and Peri-Implant Diseases and Conditions. J Periodontol. 2018;89 Suppl 1:S74-s84. doi: 10.1002/jper.17-0719
29. Rathee M, Jain P. Gingivitis Treasure Island, Florida: StatPearls Publishing; 2023 [updated 27 March 2023. Available from: https://www.ncbi.nlm.nih.gov/books/NBK557422/.
30. Wang K, Yu KF, Liu P, Lee GHM, Wong MCM. Can mHealth promotion for parents help to improve their children's oral health? A systematic review. Journal of Dentistry. 2022;123:104185. doi: https://doi.org/10.1016/j.jdent.2022.104185
31. Toniazzo MP, Nodari D, Muniz FWMG, Weidlich P. Effect of mHealth in improving oral hygiene: A systematic review with meta-analysis. Journal of Clinical Periodontology. 2019;46(3):297-309. doi: https://doi.org/10.1111/jcpe.13083
32. Abdelmalak N, Burns J, Suhlrie L, Laxy M, Stephan A-J. Consideration of inequalities in effectiveness trials of mHealth applications – a systematic assessment of studies from an umbrella review. International Journal for Equity in Health. 2024;23(1):181. doi: 10.1186/s12939-024-02267-4