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Effectiveness of oral health education intervention among 9–12-year-old school children

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Abstract

Purpose: This study evaluated the effectiveness of a school-based oral health education (OHE) program in improving oral hygiene knowledge, attitudes, and practices (KAP), as well as plaque control and gingival health, among elementary school students in Yogyakarta, Indonesia. **Methods:** A randomized controlled trial was conducted involving 202 students aged 9 to 12 years. The intervention group received a 30-minute OHE session with reinforcements at the third and sixth months, while the control group received no initial education. Outcomes were measured using a validated KAP questionnaire and clinical indices, including the Plaque Index (PI), Gingival Index (GI), and Decayed, Missing, and Filled Teeth (DMFT) scores at baseline, three months, and six months. **Results:** All participants completed the six-month follow-up. Baseline characteristics between groups were comparable ($p > 0.05$). The intervention group showed significant improvements in knowledge, attitude, and practice scores at 3 and 6 months compared with the control group ($p < 0.001$). Significant reductions in plaque and gingival index scores were also observed in the intervention arm, whereas the control group demonstrated minimal changes. DMFT scores remained statistically unchanged in both groups. **Conclusion:** Changes in DMFT scores were not statistically significant in either group. These findings suggest that a structured, repeated school-based OHE program can effectively promote oral health behavior and improve periodontal status in children. The results support the integration of regular oral health education into the primary school curriculum as a sustainable approach to oral disease prevention in developing country settings.

Keywords: gingival health; oral health education; plaque index; school children

INTRODUCTION

The global prevalence of dental diseases is a persistent indication of the essential need for comprehensive and effective oral health education programs [1]. A systematic review of studies among 5–6-year-old children in Southeast Asia found caries prevalence ranging from 25% to 95%, with a median prevalence of 79% [2]. Health education plays a vital role in developing behaviors that support and sustain overall health. Mastrantonio and Garcia emphasize that education can be a powerful tool for shifting negative attitudes toward positive, health-promoting habits in the population [3]. Recent research notes that oral health remains a fundamental component of general health and well-being, despite the ongoing global burden of oral diseases [4]. It encompasses multiple functions, including speaking, smiling, smelling, tasting, touching, chewing, swallowing, and expressing emotions through facial expressions—all performed confidently and free of pain, discomfort, or craniofacial disorders [5].

Among the few areas of health that individuals can directly influence, oral hygiene can be enhanced through simple behavioral changes. Oral Health Education (OHE) programs aim to raise awareness and improve oral hygiene practices among participants, leading to clear benefits. Positive outcomes from OHE include reported improvements in oral health behaviors and practices, as well as clinical indicators such as better oral hygiene, healthier gums, and reduced dental caries [6]. In advanced stages, many oral diseases can result in significant pain, discomfort, and functional limitations. According to the 2018 Basic Health Research (Riskesdas), the prevalence of dental caries among Indonesian children aged 5–9 years was 92.6%, while it decreased to 73.4% among those aged 10–14 years [7].

The Net Enrollment Rate for primary education in Indonesia reached 97.9% in 2023, meaning that nearly all children aged 7–12 years are enrolled in elementary school [8]. Despite this extensive school coverage, the 2018 Basic Health Research (Riskesdas) still recorded a very high prevalence of dental caries, 92.6% among children aged 5–9 years and 73.4% among those aged 10–14 years [7]. Similar regional data confirm the persistent burden of dental caries among Indonesian children, with a recent systematic review reporting an overall caries prevalence of approximately 76% across multiple observational studies of school-aged children in Indonesia [9]. The disparity between the high access to primary education and the persistently heavy caries burden underscores the urgent need for community- or school-based oral health interventions to cultivate proper oral care behaviors from an early age [10].

Oral health education and promotion initiatives can be implemented across a variety of settings, including hospitals, primary healthcare centers, private dental practices, and schools[6]. Among these, schools are considered the most strategic venue for advancing oral health, as they provide a highly effective and efficient platform for reaching over 1 billion children globally. Indirectly, their families and wider communities [6,11]. Compared to community-based strategies, school-based approaches have demonstrated greater effectiveness in delivering both preventive and therapeutic oral health services. Research indicates that children with poor oral health are up to 12 times more likely to experience limitations in daily activities, including school absenteeism, than their peers with good oral health [6,11]. Consequently, more than 50 million hours of schooling are lost annually, which may significantly hinder children's long-term academic performance and future success [6,11].

In recent years, there has been growing interest in evaluating the impact and effectiveness of oral health education programs. This trend aligns with the broader movement toward evidence-based policymaking, offering valuable insights to guide resource allocation decisions. Several systematic reviews of existing evidence have been conducted [12], indicating that oral health education interventions are generally effective in enhancing knowledge in the short term and, to some extent, in influencing behaviors such as regular tooth brushing and healthy dietary choices [12,13].

In a country such as Indonesia, where a large portion of the population lacks adequate awareness of and access to oral and dental care services, there is a critical, immediate need for oral health education interventions to reduce oral health–related morbidity and mortality. This study aimed to evaluate the effectiveness of an oral health education program in improving knowledge, attitudes, and practices (KAP) related to oral hygiene, as well as enhancing plaque control and gingival health among schoolchildren aged 9 to 12 years in Yogyakarta, Indonesia.

Although numerous school-based oral health education (OHE) interventions have been reported globally, evidence from low- and middle-income countries, including Indonesia, remains limited, particularly studies that simultaneously evaluate behavioral outcomes and clinical oral health indicators over multiple follow-up periods. Moreover, many existing interventions focus predominantly on short-term knowledge improvement, with less attention to the sustainability of behavior change and its translation into measurable clinical outcomes.

METHODS

Study design and participants

This study used a cluster-randomized controlled trial design, with schools as the unit of randomization. Cluster randomization was applied to minimize contamination between students within the same school. Eligible schools were randomly assigned to the experimental or control group, and outcome assessments were conducted at the individual-student level between December 2024 and May 2025 in the Special Region of Yogyakarta, Indonesia. In a concurrent parallel design, two groups are randomly assigned: one receives the intervention, while the other serves as the control. The study population comprises children aged 9–12 years enrolled in grades 4–6 in public and private elementary schools in Yogyakarta City. Yogyakarta occupies approximately 32.8 km² and, according to the 2020 Population Census, has about 422,732 inhabitants with a literacy rate exceeding 97 percent. The city hosts more than 200 elementary schools, providing a suitable framework for school-based sampling.

Elementary schools practicing coeducation (boys and girls in the same classes) will be eligible. Participants aged 9–12 years whose parents or guardians provide written informed consent and who themselves provide verbal assent will be included. Children with systemic diseases, those requiring emergency dental treatment, or those wearing fixed orthodontic appliances will be excluded.

Following approval from each school principal, 50 eligible public and private elementary schools were identified and included in the sampling frame. Twenty per cent of these schools (n = 10) were then selected using simple random sampling (lottery method) by an independent assistant not involved in field activities. A total of 10 elementary schools (five intervention schools and five control schools) were selected from the eligible sampling frame. The selection proportion was determined using sample size calculations for a cluster-randomized controlled trial, ensuring sufficient statistical power (≥80%) and accounting for the design effect inherent in cluster sampling.

A biostatistician will generate a master randomization list with computer-produced random numbers and assign each selected school to either Group 1 or Group 2. Allocation concealment will be maintained using sequentially numbered opaque sealed envelopes. Within each selected school, systematic random sampling will be used to recruit participants until the required sample size for that school is reached, while maintaining proportional representation of public and private institutions. To maintain blinding in this study, during data entry and analysis, the two groups will be coded as 1 and 2 without revealing their status. The codes will be disclosed as control or intervention only after all analyses are completed.

This study considered 95% CI and 80% power to estimate the sample size. For this purpose, the mean ± SD (gingival index) value for the intervention group (2A), 0.78 ± 0.42, and the mean ± SD value for the control group (1B), 0.94 ± 0.3822, were used. Therefore, mean of control group ($\mu 1$) = 0.94, mean of intervention group ($\mu 2$) = 0.78, and average standard deviation of control and intervention group (σ) = 0.40 (Shenoy et al, 2010). Using following formula, Sample Size (n) = $(2\ \sigma 2\ (z\alpha/2 + z\beta/2)2)/(\mu 1 - \mu 2)2$, the sample size was calculated as 98. Given a 20% attrition rate, the total sample size was increased to 101 per group.

Data collection

Questionnaire

A structured, closed-ended questionnaire comprising 23 items was adapted from previously published instruments on school-age oral health knowledge, attitudes, and practices. Face and content validity appraisal was undertaken independently by three Indonesian experts in paediatric dentistry and dental public health. The English source items were forward-translated into Bahasa Indonesia, reconciled, and back-translated to ensure semantic equivalence. Test–retest reliability on a sub-sample of 30 students, two weeks apart, produced a Cronbach's alpha of 0.81, indicating good internal consistency.

Each item had a single correct response; correct answers were coded 1, and incorrect answers were coded 0. The maximum attainable scores were 11 for knowledge, 8 for practice, and 4 for attitude, giving a composite KAP ceiling of 23. Mean scores for each domain were calculated for both groups at baseline, three months, and six months, and percentage change was computed as 100 × (post-test – pre-test)/pre-test. Face-to-face interviews with the participants were conducted by the single investigator (KS). Each interview lasted 4–5 min. Demographic variables included age, sex, grade, school type (public or private), and socioeconomic status (SES). SES was calculated using the Kuppuswamy scale and classified according to the 2009 modifications (Ghosh A, Ghosh, 2009).

Clinical examination

Clinical assessments followed the World Health Organization Basic Oral Health Survey methodology. Prior to baseline data collection, a pilot study involving 25 students from a neighbouring elementary school (not included in the main sample) was conducted to calibrate the examiner and test field logistics. All children were examined at their schools, lying on a bench with the examiner seated behind the child's head under artificial light. Sterile mouth mirrors, a WHO probe, and disposable gloves were used for the examinations.

Oral conditions were recorded using the Turesky–Gilmore–Glickman modification of the Quigley–Hein Plaque Index, the Löe and Silness Gingival Index, and the WHO criteria for dentition status and treatment needs at baseline and at the third and sixth months of the study. DMFT scores were derived from data on dentition status and treatment needs. Duplicate examinations were carried out on 10 percent of the students (n = 20) to assess inter-examiner reliability; the intra- class correlation coefficient exceeded 0.85 for all indices.

Intervention description

The OHE intervention covered key topics such as the importance of teeth, types of dentition, proper toothbrushing and flossing techniques, the etiology, signs, symptoms, complications, and prevention of dental caries, the role of fluoride, and the impact of

plaque and calculus on gingival and periodontal health. Additional content included guidance on diet and nutrition, as well as the relevance of oral health to overall health.

Prior to implementation in the main study, the OHE materials were pilot-tested and validated in one school not included in the sample. The intervention was delivered using visual aids, including dental models and a PowerPoint presentation. Although PowerPoint is sometimes considered less engaging for children when used in a text-heavy format, this study designed it as an interactive visual tool rather than a lecture-based medium. The slides emphasized colorful illustrations, animations, and minimal text, consistent with multimedia learning principles appropriate for late-childhood children. The format also ensured standardized content delivery across multiple schools, thereby maintaining intervention fidelity.

The dental model used in the intervention was a three-dimensional, oversized jaw model with detachable teeth, specifically designed for educational demonstrations. It was used to visually demonstrate proper toothbrushing techniques (modified Bass technique), flossing methods, and areas of plaque accumulation. Students were invited to observe closely and to practice brushing movements voluntarily under supervision.

The PowerPoint presentation included age-appropriate visual materials, such as colorful illustrations, simplified anatomical diagrams, real clinical photographs adjusted for sensitivity, and short animated sequences demonstrating caries progression and plaque formation. Minimal text was used to maintain attention, and key messages were delivered verbally in simple, interactive language suitable for children aged 9–12 years. Interactive questioning and short quizzes were incorporated to enhance engagement. The visual design incorporated bright yet balanced color schemes, child-friendly graphics, and step-by-step pictorial demonstrations to align with the cognitive development of late childhood learners. The educational materials were adapted to the local cultural context and validated during pilot testing.

The intervention was administered to students aged 9–12 years in the experimental group via a single 30-minute interactive session at each follow-up. The sessions were delivered by a licensed dentist with experience in pediatric oral health education, who served as the principal investigator. Prior to the study, the investigator underwent standardized training to ensure uniform delivery of the educational content, including rehearsal of presentation flow, demonstration techniques using dental models, and calibration of oral health messages according to the study protocol. The training process was supervised by a senior academic in preventive dentistry to ensure the intervention's consistency and fidelity. Throughout the study, the research team periodically monitored adherence to the intervention protocol.

It was administered to students in the experimental group aged 9–12 years during a single 30-minute interactive session at each follow-up, conducted by a trained investigator and supervised by the research team. No oral health education was provided to the control group during the study period. Reinforcement of the intervention in the experimental group was carried out at the third and sixth months. To prevent contamination between study arms, only one group (either experimental or control) was selected from each school. Upon completion of the six-month study period, the same OHE module was provided to students in the control group.

During each follow-up period, up to three visits per school were conducted to ensure maximum student participation. Students who were absent during follow-up examinations were considered missing data. Potential adverse events such as discomfort or gingival irritation were monitored during the intervention. No adverse events were reported or observed. Photographs of the dental models and selected slides from the educational materials are provided as supplementary material to enhance transparency and reproducibility.

Evaluation of intervention

Baseline assessment was conducted in December 2024–January 2025. The second and third follow-ups were carried out in March–April and May 2025, respectively. During each visit, the intervention group received the oral health education session. The effectiveness of the intervention was evaluated by measuring improvements in oral hygiene knowledge, attitudes, and practices (KAP) scores, along with reductions in plaque and gingival index scores in the experimental group, and comparing them with those of the control group. The primary outcome measures included changes in the mean scores for oral hygiene KAP, plaque control, gingival health, and DMFT at 3 and 6 months following the intervention, assessed in both the experimental and control groups.

Data analysis

Following the completion of the intervention trial, all collected data were entered into Microsoft Excel (version 2007) and analyzed using the Statistical Package for the Social Sciences (SPSS) version 25.0. Statistical significance was determined at a p-value less than 0.05. To assess intra-examiner reliability in

clinical coding, the intraclass correlation coefficient (ICC) was calculated. Descriptive analyses were conducted to summarize the baseline clinical and socio-demographic characteristics of participants in both the experimental and control groups, ensuring comparability between groups at the start of the study. Descriptive statistics included means, medians, and standard deviations for oral hygiene knowledge, attitudes, and practices (KAP), plaque index (PI), gingival index (GI), and DMFT scores.

The chi-square test was applied to evaluate associations between categorical variables. Before conducting parametric analyses, the normality of continuous variables (oral hygiene KAP scores, plaque index, and gingival index) was assessed using the Shapiro–Wilk test. The results indicated that the data were approximately normally distributed ($p > 0.05$), supporting the use of parametric tests. In addition, given the relatively large sample size (N = 202), the application of repeated-measures ANOVA was considered robust under the Central Limit Theorem.

To analyze differences in repeated measures of oral hygiene, KAP, plaque index, and gingival index over the study period (baseline, 3 months, and 6 months), repeated-measures analysis of variance (ANOVA) was conducted. Where significant differences were found, post hoc analysis using Tukey's test was performed. Independent t-tests were used to compare the experimental and control groups for oral hygiene KAP, PI, and GI scores at each time point. The Mann–Whitney U test was used to assess differences in mean DMFT scores between the two groups because the data did not meet the assumptions of parametric testing.

RESULTS

The flow of clusters and participants through the trial is presented in Figure 1. A total of 50 elementary schools were assessed for eligibility. Of these, 40 schools were excluded because they were not selected during the random sampling procedure. The remaining 10 schools were randomized at the cluster level, with 5 allocated to the experimental group and 5 to the control group. Students were then recruited from the selected schools, resulting in a total of 202 eligible participants, with 101 students in the experimental group and 101 students in the control group. No participants were lost to follow-up at either the 3-month or 6-month assessment. All enrolled participants were therefore included in the final analysis.

Intra-examiner reproducibility was assessed in a random sub-sample of 20 students (≈10 percent of the total) by duplicate examinations. The intraclass correlation coefficient was 0.94 for the Gingival Index (GI) and 0.88 for the Plaque Index (PI), indicating excellent repeatability. The questionnaire showed good internal consistency: Cronbach's α was 0.87 for the knowledge domain, 0.90 for the attitude domain, and 0.92 for the practice domain. All 202 students—101 in the experimental arm and 101 in the control arm—completed the six-month follow-up. The sample comprised 50.5 percent boys and 49.5 percent girls. Mean age was 10.6 ± 0.8 years in the experimental group and 10.5 ± 0.7 years in the control group. There were no significant baseline differences between groups for sex ($p = 0.82$), grade level ($p = 0.55$), or school type (public versus private, $p = 0.63$). A larger proportion of students in the experimental arm fell into the middle socioeconomic category ($p = 0.01$).

Table 1 summarizes the baseline characteristics of 202 elementary school students aged 9–12 years who participated in the study. The distribution between the experimental and control groups was relatively balanced with respect to age, sex, grade level, and school type, with no statistically significant differences observed ($p > 0.05$ for all variables). The mean age in the experimental group was 10.6 ± 0.8 years, and 10.5 ± 0.7 years in the control group. Gender distribution was nearly equal between the two groups.

However, a significant difference in socioeconomic status (SES) was found between groups ($p = 0.009$), with a higher proportion of students from middle-income backgrounds in the control group than in the experimental group. Despite this discrepancy, the overall demographic and academic variables were sufficiently comparable to support valid group comparisons for intervention outcomes.

The Shapiro–Wilk test indicated that all continuous variables, including knowledge, attitude, practice, plaque index, and gingival index scores at baseline, 3 months, and 6 months, were normally distributed (all $p > 0.05$). These findings confirm that the assumption of normality was satisfied for all outcome measures. Therefore, the use of parametric statistical tests, including independent samples t-tests and repeated-measures ANOVA, was considered appropriate for subsequent analyses (Table 2).

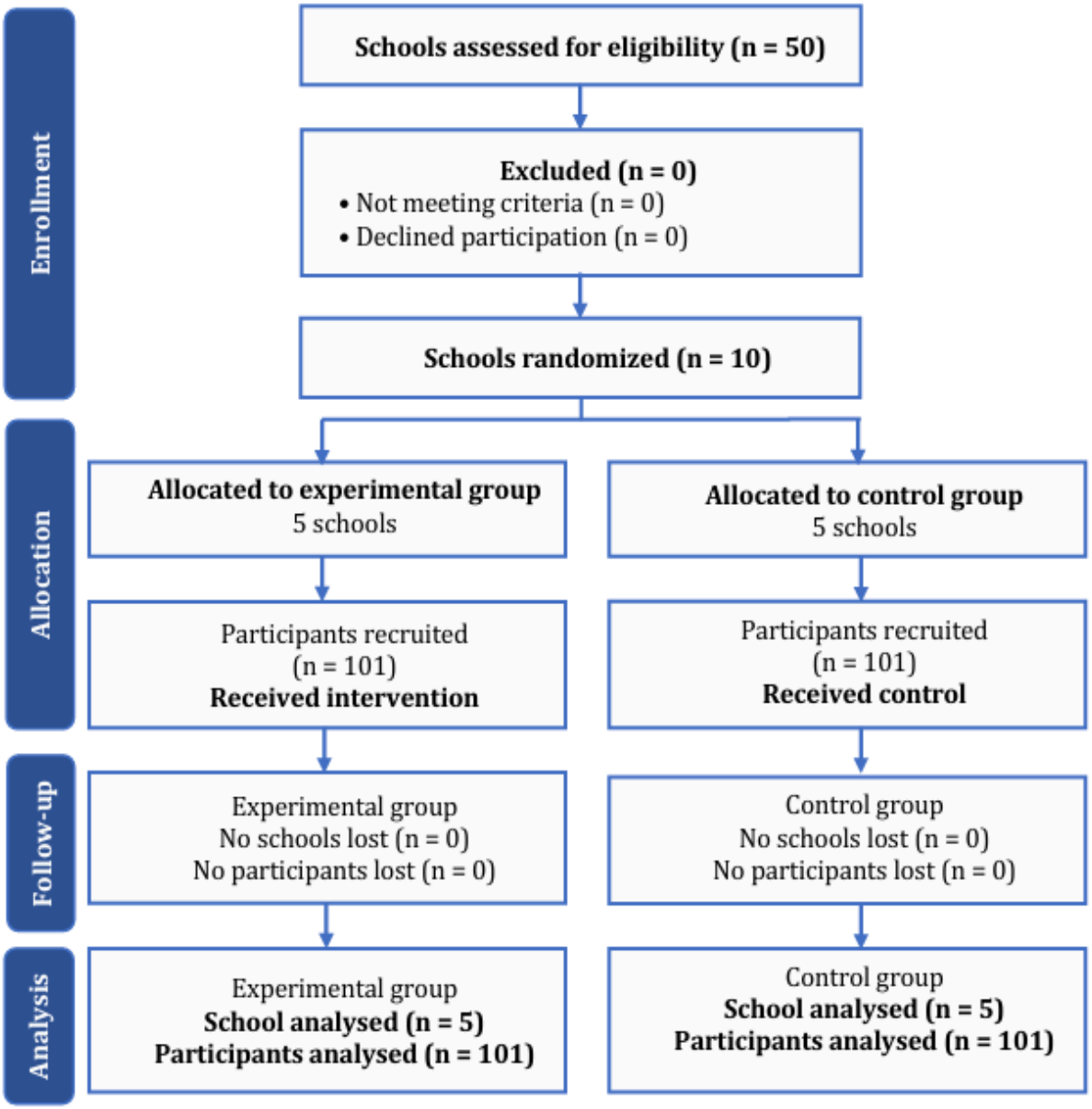


Figure 1. CONSORT flow diagram

Table 1. Distribution of a sample of 9–12 year old students in Yogyakarta, Indonesia (n = 202)

Variable	Category	Experimental group (n = 101) n (%)	Control group (n = 101) n (%)	χ^2	p-value
Age (years)	9–10	50 (49.5)	48 (47.5)	0.12	0.73
	11–12	51 (50.5)	53 (52.5)		
Sex	Male	51 (50.5)	50 (49.5)	0.01	0.92
	Female	50 (49.5)	51 (50.5)		
Grade	4	36 (35.6)	38 (37.6)	0.99	0.61
	5	34 (33.7)	32 (31.7)		
	6	31 (30.7)	31 (30.7)		
Socio-economic status	Low	30 (29.7)	26 (25.7)	6.80	0.009
	Middle	60 (59.4)	70 (69.3)		
	High	11 (10.9)	5 (5.0)		
Type of school	Public	42 (41.6)	44 (43.6)	0.18	0.67
	Private	59 (58.4)	57 (56.4)		
Mean age (years ± SD)	—	10.6 ± 0.8	10.5 ± 0.7	t = 1.05	0.29

Note: Categorical variables were compared using the chi-square (χ^2) test. Continuous variables were compared using an independent-samples t-test. A p-value < 0.05 was considered statistically significant. SD, standard deviation.

Table 2. Shapiro–Wilk test of normality for continuous outcome variables at baseline, 3 months, and 6 months (n = 202)

Variable	Baseline (W, p)	3 months (W, p)	6 months (W, p)	Interpretation
Knowledge	0.988, 0.182	0.985, 0.109	0.983, 0.087	Normally distributed
Practice	0.987, 0.165	0.984, 0.094	0.982, 0.071	Normally distributed
Attitude	0.990, 0.241	0.986, 0.121	0.984, 0.093	Normally distributed
Plaque Index	0.989, 0.214	0.986, 0.127	0.984, 0.089	Normally distributed
Gingival Index	0.991, 0.301	0.987, 0.156	0.985, 0.094	Normally distributed

Note: W (Shapiro–Wilk statistic), p (significance value), p > 0.05 indicates a normal distribution. Time points: Baseline = before intervention, 3 months = 3 months after intervention, 6 months = 6 months after intervention. Normality was assessed using the Shapiro–Wilk test. Based on these results, parametric tests (independent t-test and repeated-measures ANOVA) were deemed appropriate.

Table 3. Intragroup and intergroup comparisons of oral hygiene knowledge, attitude and practice (KAP) at baseline, 3 months and 6 months (n = 202)

Measure	Time point	Experimental group (mean ± SD)	Control group (mean ± SD)	t-value	p-value	F value (time)	pΔ value	% change (Exp)	% change (Ctrl)
Oral-hygiene knowledge (max = 11)	Baseline	5.20 ± 1.70	5.30 ± 1.80	0.35	0.73	247.801	0.001	—	—
	3 months	8.10 ± 1.50	5.90 ± 1.60	9.65	< 0.001				
	6 months	9.50 ± 1.00	6.10 ± 1.50	16.84	< 0.001			82.7	15.1
Oral-hygiene practice (max = 8)	Baseline	3.40 ± 1.20	3.45 ± 1.15	0.27	0.79	29.833	0.001	—	—
	3 months	4.35 ± 1.30	3.50 ± 1.10	5.28	< 0.001				
	6 months	4.45 ± 1.05	3.18 ± 1.25	7.11	< 0.001			30.9	–7.8
Oral-hygiene attitude (max = 4)	Baseline	2.10 ± 0.90	2.05 ± 0.95	0.38	0.70	35.917	0.001	—	—
	3 months	2.70 ± 0.85	2.15 ± 0.90	4.42	< 0.001				
	6 months	2.85 ± 0.80	1.95 ± 0.85	7.02	< 0.001			35.7	–4.9
Composite KAP (max = 23)	Baseline	10.70 ± 3.30	10.80 ± 3.20	0.21	0.83	192.654	0.001	—	—
	3 months	15.15 ± 2.85	11.55 ± 3.10	9.38	< 0.001				
	6 months	16.35 ± 2.40	11.90 ± 2.95	14.68	< 0.001			52.7	10.2

Note: Data are presented as mean ± SD. Between-group comparisons at each time point were analyzed using an independent-samples t-test. Intragroup changes over time were assessed using repeated-measures ANOVA.
A p-value < 0.05 was considered statistically significant. SD, standard deviation; KAP, knowledge, attitude, and practice.

Table 3 presents the outcomes related to oral hygiene knowledge, practices, attitude, and the composite KAP scores at baseline, 3 months, and 6 months. At baseline, no statistically significant differences were observed between the experimental and control groups across all KAP domains (p > 0.05), indicating comparable starting points. By the third month, the experimental group showed significant improvements in oral hygiene knowledge and practice scores, while the increase in attitude score, although positive, was not statistically significant (p = 0.12). At the six-month follow-up, however, all three domains—including attitude—showed highly significant improvements in the experimental group (p < 0.001 for all).

Compared to baseline, knowledge scores increased by 82.7% in the experimental group, while the control group saw a modest increase of 15.1%. Oral hygiene practices improved by 30.9% in the experimental group but declined by 7.8% in the control group. Attitude scores improved by 35.7% in the experimental group and decreased by 4.9% in the control group. The overall composite KAP score rose by 52.7% in the experimental group, whereas the control group exhibited only a marginal improvement of 10.2%. These findings indicate that the oral health education intervention significantly enhanced students' knowledge, behavior, and attitudes toward oral hygiene over the study period.

Table 4 shows that repeated-measures ANOVA followed by post hoc Tukey's test detected significant time-by-group interactions for oral hygiene knowledge, practice, attitude, and the overall KAP scores (p < 0.001 for all comparisons, except for practice between 3 and 6 months, which was not significant). These findings confirm that the improvements observed in the experimental group were attributable to the school-based oral health education intervention. In contrast, no statistically significant differences in mean or median DMFT scores were found between the experimental and control groups at baseline, 3 months, or 6 months (Mann–Whitney U test, p > 0.05).

Table 5 shows that the mean baseline plaque index scores did not differ significantly between the experimental and control groups. However, intergroup comparisons revealed a statistically significant reduction in plaque scores in the experimental group at

both the 3 and 6 month follow-ups. Intragroup analysis further confirmed a significant improvement in plaque control over time in both groups. However, the reduction was substantially greater in the experimental group (57.67%) compared to the control group (4.56%) at six months. Table 6 demonstrates that there is no significant difference in baseline gingival index (GI) scores observed between the two groups. By the 3rd and 6th months, the experimental group showed significantly lower GI scores than the control group. Within the experimental group, GI scores demonstrated a marked improvement at six months, with a 40.90% reduction, compared to a minimal 0.7% improvement observed in the control group. As shown in Table 7, both plaque index and GI scores improved significantly at the 3- and 6-month intervals in the experimental group. In contrast, significant improvements in the control group were observed only between the 3rd and 6th months. Table 8 indicates that there were no statistically significant differences in the mean or median DMFT scores between the experimental and control groups at any time point—baseline, 3 months, or 6 months.

Table 4. Comparison of mean knowledge, attitude, and practice (KAP) scores at different time intervals using post hoc Tukey's test among 9–12-year-old students in Yogyakarta, Indonesia (n = 202)

Variable	Time interval	Mean difference ± SE	p-value	95% CI (Lower–Upper Bound)
Oral hygiene knowledge	Baseline vs 3 months	3.00 ± 0.20	< 0.001	2.58 – 3.41
	Baseline vs 6 months	4.23 ± 0.19	< 0.001	3.84 – 4.61
	3 months vs 6 months	1.23 ± 0.17	< 0.001	0.88 – 1.58
Oral hygiene practice	Baseline vs 3 months	0.91 ± 0.14	< 0.001	0.64 – 1.19
	Baseline vs 6 months	1.08 ± 0.15	< 0.001	0.78 – 1.37
	3 months vs 6 months	0.16 ± 0.14	0.27	–0.12 – 0.45
Oral hygiene attitude	Baseline vs 3 months	0.33 ± 0.09	0.001	0.14 – 0.52
	Baseline vs 6 months	0.92 ± 0.10	< 0.001	0.72 – 1.13
	3 months vs 6 months	0.59 ± 0.09	< 0.001	0.41 – 0.77
Overall KAP	Baseline vs 3 months	4.26 ± 0.26	< 0.001	3.74 – 4.78
	Baseline vs 6 months	6.24 ± 0.27	< 0.001	5.69 – 6.78
	3 months vs 6 months	1.98 ± 0.26	< 0.001	1.46 – 2.49

Note: Post hoc pairwise comparisons were performed using Tukey's test following repeated-measures ANOVA. Data are presented as mean difference ± standard error (SE). A p-value < 0.05 was considered statistically significant. CI, confidence interval; KAP, knowledge, attitude, and practice; SE, standard error.

Table 5. Intragroup and intergroup comparisons of mean plaque index scores in experimental and control groups (n = 202)

Time point			Experimental group (Mean ± SD)	Control group (Mean ± SD)	t-value	p-value
Baseline			2.15 ± 0.52	2.19 ± 0.41	0.493	0.622
3 months			1.44 ± 0.46	2.23 ± 0.49	11.687	0.001
6 months			0.91 ± 0.40	2.09 ± 0.53	17.558	0.001
Group	**F-value**	**pΔ-value**	**% Change**			
Experimental	275.518	0.001	57.67			
Control	3.732	0.026	4.56			

Note: Data are presented as mean ± standard deviation (SD). Independent t-tests were used to compare groups at each time point. Intragroup comparisons across time (baseline, 3 months, and 6 months) were analyzed using repeated-measures ANOVA. A p-value < 0.05 was considered statistically significant. % Change represents the percentage reduction in mean plaque index from baseline to 6 months. SD, standard deviation.

Table 6. Intragroup and intergroup comparisons of mean gingival index scores in experimental and control groups (n = 202)

Time point			Experimental group (Mean ± SD)	Control group (Mean ± SD)	t-value	p-value
Baseline			1.32 ± 0.25	1.36 ± 0.21	1.192	0.235
3 months			0.86 ± 0.30	1.30 ± 0.26	11.123	0.001
6 months			0.78 ± 0.31	1.35 ± 0.22	14.793	0.001
Group	**F-value**	**pΔ-value**	**% Change**			
Experimental	190.801	0.001	40.90			
Control	2.948	0.05	0.70			

Note: Data are presented as mean ± standard deviation (SD). Between-group comparisons at each time point were analyzed using an independent-samples t-test. Intragroup changes over time were assessed using repeated-measures ANOVA. A p-value < 0.05 was considered statistically significant. % Change represents the percentage reduction in mean gingival index from baseline to 6 months. SD, standard deviation.

Table 7. Comparison of mean plaque scores and gingival scores at different time intervals using post hoc Tukey's test among a sample of 12–15-year-old students in Yogyakarta, Indonesia (n = 202)

Group / time interval	Mean difference ± SE	p-value	95% Confidence Interval	
			Lower bound	Upper bound
Plaque scores – Experimental				
Baseline – 3 months	0.71 ± 0.05	<0.001	0.60	0.82
Baseline – 6 months	1.24 ± 0.05	<0.001	1.13	1.34
3 months – 6 months	0.52 ± 0.05	<0.001	0.42	0.63
Plaque scores – Control				
Baseline – 3 months	-0.04 ± 0.05	0.36	-0.15	0.05
Baseline – 6 months	0.101 ± 0.05	0.06	-0.006	0.20
3 months – 6 months	0.073 ± 0.03	0.02	0.007	0.13
Gingival scores – Experimental				
Baseline – 3 months	0.46 ± 0.02	<0.001	0.40	0.52
Baseline – 6 months	0.53 ± 0.02	<0.001	0.48	0.59
3 months – 6 months	0.07 ± 0.03	0.02	0.007	0.13

Note: Post hoc pairwise comparisons were performed using Tukey's test following repeated-measures ANOVA. Data are presented as mean difference ± standard error (SE). A p-value < 0.05 was considered statistically significant—CI, confidence interval; SE, standard error.

Table 8. Mean, median and IQR of DMFT at baseline, 3 months and 6 months after intervention in control and experimental group (n = 202)

Group	Baseline			3 months			6 months			% change
	Mean ± SD	Median	IQR	Mean ± SD	Median	IQR	Mean ± SD	Median	IQR	
Experimental group	0.78 ± 1.41	0	1	1.41 ± 2.45	1	2	1.55 ± 2.87	1	2	98.71
Control (n = 103)	0.92 ± 1.52	0	1	1.80 ± 3.55	1	2	2.23 ± 4.27	1	3	142.39
U value	4792			4906			4633.5			
Pγ	0.413			0.623			0.237			

Note: Data are presented as mean ± standard deviation (SD), median, and interquartile range (IQR). Between-group comparisons were performed using the Mann–Whitney U test because DMFT scores were non-normally distributed. A p-value < 0.05 was considered statistically significant. % Change represents the relative change from baseline to 6 months. SD, standard deviation; IQR, interquartile range; DMFT, decayed, missing, and filled teeth.

DISCUSSION

The present study adds to the existing literature by demonstrating that a structured, school-based oral health education program with periodic reinforcement can significantly improve oral hygiene knowledge, attitudes, practices, plaque control, and gingival health among Indonesian schoolchildren aged 9–12 years. Importantly, these improvements were sustained over a six-month follow-up period, highlighting the value of reinforcement in maintaining positive oral health behaviors. The present findings demonstrate that a single-session, school-based oral health education intervention, reinforced at 3 and 6 months, was highly effective in enhancing oral hygiene knowledge, attitudes, and practices (KAP) and in reducing plaque and gingival inflammation among Indonesian elementary school students aged 9–12 years.

The 9–12-year age range was selected because, during this period, nearly all permanent teeth—except the third molars—have erupted, and oral self-care abilities are undergoing significant development. Furthermore, the World Health Organization has designated 12 years as the global index age for monitoring oral health trends [14]. Children in late childhood possess progressively refined motor coordination, which supports their capacity to master toothbrushing techniques and engage more effectively in oral self-care practices [15]. Because health-related beliefs and habits adopted at this stage tend to persist, intervening early offers long-term benefits [16].

Consistent with pedagogical considerations, our findings align with recent evidence demonstrating significant increases in oral health knowledge following school-based educational interventions among adolescents and primary school children, compared with control conditions [17,18]. Attitudinal change is often more difficult to achieve than knowledge gain, yet this programme boosted positive attitudes by 35.7%, while attitudes declined by 4.9 % in the control group. Practice scores followed a similar pattern, rising 30.9 %t in the intervention cohort but falling 7.8 % among controls. These magnitudes closely mirror the 43.1 % and 36.2 % improvements in attitude and practice, respectively, reported after a fisher community inter- vention in India [19].

Biological outcomes corroborated the questionnaire data. Plaque scores fell by 57.67 % in the experimental arm versus only 4.56 % in controls, while mean gingival index scores decreased by 40.9 % compared with a negligible 0.7 % change in controls. These reductions are clinically meaningful and underline the value of simple, skills-based demonstrations reinforced over time. As in earlier research [12], dentinal health,

as measured by DMFT, did not change significantly during the six-month window—an expected finding, because caries progression or arrest generally requires longer follow-up intervals.

Taken together, the current results indicate that a brief, culturally tailored oral health education module delivered within the school setting can yield rapid and substantial improvements in children's self-reported behaviours and in objective periodontal parameters. They also highlight the importance of periodic reinforcement to consolidate gains. Future studies with longer follow-up are warranted to determine whether these behavioural and periodontal improvements translate into sustained reductions in caries. There was a striking reduction in mean plaque index scores in the intervention cohort (57.67 %), whereas the control cohort showed only a modest decline (4.56 %). These findings echo those of earlier school-based trials, which also documented substantial reductions in plaque accumulation after the intervention [20].

Parallel changes were observed in gingival health: the experimental group experienced a 40.90 percent reduction in mean Gingival Index (GI), whereas the control group showed a negligible 0.7 percent decline. Similar post-intervention improvements in gingival status have been reported in Brazil, India, and Pakistan [20]. Conversely, a recent randomized controlled trial found that traditional oral health instruction without structured, skills-based reinforcement did not result in significant changes in knowledge, attitudes, self-efficacy, or oral hygiene practices in the control group, highlighting the importance of interactive, skills-based educational sessions for meaningful behavioural change [17].

No statistically significant difference in mean DMFT was observed between groups during shorter follow-up periods [21,22]. However, some studies reported smaller caries increments in the intervention arms than in the control arms. These findings support the view that altering the caries trajectory often demands longer follow-up or adjunct preventive measures [23]. It is worth noting that modest improvements in oral hygiene and plaque scores were observed even in control groups of recent clinical trials, a pattern likely influenced by participants' awareness of being examined and repeated contact with study personnel — phenomena similar to the Hawthorne effect [24]. Such responses may reflect increased motivation to seek information and adopt better self-care practices independent of formal instruction.

Despite the promising findings, several limitations should be acknowledged. First, the follow-up period was limited to six months, which may not be sufficient to detect long-term changes in caries progression as measured by DMFT. Second, although cluster randomization was implemented at the school level to minimize contamination, residual information exchange between students outside the school environment cannot be entirely ruled out. Third, self-reported components of KAP are subject to social desirability bias, particularly in school-based settings, where children may respond in ways they perceive as favorable. Finally, the study was conducted in a single urban district, which may limit the generalizability of the findings to rural populations or regions with different socioeconomic characteristics.

From a public health perspective, the findings underscore the feasibility and effectiveness of integrating structured oral health education with periodic reinforcement into school health programs. Given the relatively low cost, scalability, and ease of implementation, such interventions could serve as a practical strategy to improve oral hygiene behaviors and periodontal health among school-aged children in similar middle-income settings. The incorporation of skill-based demonstrations and reinforcement sessions appears particularly critical for sustaining behavioral change. Policymakers and school health authorities may consider adopting standardized, culturally tailored oral health modules as part of routine school-based preventive services to reduce the long-term burden of preventable dental diseases.

CONCLUSION

This study found that implementing oral health education in the school setting effectively enhances students' knowledge, attitudes, and practices regarding oral hygiene, thereby improving plaque control and promoting healthier gingival conditions. The repetition and reinforcement of educational interventions are essential for maintaining long-term positive oral health behaviors.

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Authors' Contribution

P.O.K: Conceptualization, Methodology, Formal analysis, Writing – Original Draft, Supervision, Final approval.
A.O: Data curation, Investigation, Validation, Resources, Writing – Review & Editing, Visualization, Project administration, Final approval. All authors have read and agreed to the published version of the manuscript.

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Data Availability
The datasets generated and analyzed during this study are available from the corresponding author upon reasonable request and subject to necessary ethical approvals. Data sharing complies with institutional guidelines and protects participant confidentiality.

Ethics statement
This study was conducted in accordance with the Declaration of Helsinki. Ethical approval was obtained from the Ethics Committee of the Faculty of Dentistry, Universitas Muhammadiyah Yogyakarta (approval number: 244/EC-KEPK FKIK UMY/VII/2025). Written informed consent was obtained from parents or legal guardians of all participating children, and verbal assent was obtained from the students prior to data collection. Participation was voluntary, and confidentiality of all data was strictly maintained.

Conflicts of interest
All authors declare that they have no conflicts of interest that could have influenced the design, execution, interpretation, or reporting of this study.

Use of artificial intelligence (AI)
During the preparation of this manuscript, the authors used ChatGPT-3 as an auxiliary tool for brainstorming, initial idea structuring, and language refinement to enhance clarity and grammatical accuracy. All generated content was carefully reviewed, critically evaluated, and substantively revised by the authors. The authors take full responsibility for the integrity, accuracy, and originality of the final manuscript.

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