Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Gamification versus Conventional Oral Health Education on kindergarten Children's Oral Hygiene in Al-Ahsa, Saudi Arabia: An experimental study

Hajar Ibrahim Alsuwayi
Eastern Health Cluster
Elwalid Fadul Nasir
mamlakatnoonn@gmail.com

King Faisal University
Areej Jafar Alomran
Riyadh Second Health Cluster
Amany Osama Kassem
Riyadh Elm University
Nada Mohamed Ahmed Suliman
King Faisal University

Research Article

Keywords: game-based education, kindergarten, Oral Hygiene, AL Ahsa

Posted Date: November 18th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-11191635/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: No competing interests reported.

Abstract

Background

Oral hygiene in early childhood is a strong predictor of long-term dental health, yet conventional lecture-based education may be less engaging for preschoolers than interactive, game-based approaches. This study aimed to measure baseline oral hygiene status among preschool children in Al-Ahsa, Saudi Arabia, and to compare the effectiveness of non-conventional (game-based) versus conventional oral health education on children's oral hygiene outcomes.

Materials and Methods

A prospective, double-arm, single-blinded randomized controlled trial was conducted among preschool children aged 5–6 years enrolled in kindergartens across Al-Ahsa. Using stratified proportional sampling across three educational offices (Al-Hofuf, Al-Mubarraz, and Villages), 727 children (339 (Group A), and 328 (Group B) participated from thirteen kindergartens. Classes were randomly assigned to receive either a non-conventional program (interactive classroom sessions, online quiz games, and caregiver lectures) or a conventional PowerPoint-based lecture. Oral hygiene was assessed pre- and post-experiment using the Simplified Debris Index (DI-S) by a blinded examiner. Data were analyzed using chi-square tests, Welch's t-test, ANCOVA, Friedman and Wilcoxon signed-rank tests, and non-parametric multivariable regression (rank-transform and median regression) to account for non-normal score distributions.

Results

The experiment (Group A) and control (Group B) were well balanced on sociodemographic characteristics, with minor differences in child age and residential distribution. Both groups showed statistically significant improvement in oral hygiene scores from pre- to post-experiment ($p < 0.001$), with a very large effect in (Group A) compared to (Group B). Despite starting from a slightly worse baseline, (Group A) achieved significantly better post-experiment scores than (Group B), a difference that persisted after adjusting for baseline scores (ANCOVA: $F(1,724) = 29.43$, $p < 0.001$) and after further adjustment for sociodemographic covariates (median regression $B = -0.180$, $p < 0.001$). Improvement was also more consistent in (Group A) (Kendall's $W = 0.659$) than (Group B) ($W = 0.522$). No sociodemographic variable was an independent predictor of post-experiment oral hygiene.

Conclusion

Both conventional and game-based oral health education significantly improved preschool children's oral hygiene, but the game-based, interactive approach produced greater and more consistent improvement,

independent of sociodemographic factors. These findings support incorporating interactive, game-based methods into kindergarten oral health education programs. The study was retrospectively registered in the International Standard Randomized Controlled Trial on 23.10.2024, (registration number: ISRCTN71415867, https://www.isrctn.com/ISRCTN71415867).

Introduction

Oral health is an essential component of general health and well-being, particularly during childhood [1]. The Centers for Disease Control and Prevention (CDC) defines oral health as the health of the teeth, gums, and oral-facial system that enables individuals to eat, speak, smile, and express emotions [2]. Poor oral health negatively affects quality of life [3] and is associated with systemic health problems [4]. In children, it can lead to dental caries, and periodontal disease, pain, impaired growth and development, and reduced school performance [1].

Good oral hygiene is fundamental to preventing oral diseases by controlling dental plaque, the primary cause of dental caries and periodontal diseases [4]. The *Fédération Dentaire Internationale* (FDI) recommends brushing teeth twice daily with fluoride toothpaste as the most effective preventive measure against dental caries [5]. Developing appropriate oral hygiene practices during early childhood is essential because habits established at this stage often continue into adulthood [6]. Dental caries is the most prevalent oral disease worldwide [7] The World Health Organization (WHO) estimates that 60–90% of school-aged children experience dental caries [8]. Although highly prevalent, dental caries is largely preventable through appropriate oral hygiene and health education [9]. Furthermore, children with inadequate oral health knowledge are twice as likely to develop dental caries as those with adequate knowledge [10]. Oral health education is a key component of health promotion that aims to improve oral health knowledge, attitudes, and behaviors [3, 9]. Schools and kindergartens provide an ideal setting for oral health education because they allow access to larger numbers of children during the formative years when lifelong health behaviors are established [3, 11, 12]. Oral health education can be delivered using conventional methods, such as lectures, demonstrations, posters, and tooth models, or through interactive, non-conventional approaches [13]. Although conventional educational methods can improve knowledge, evidence suggests they have limited long-term effects on children's oral hygiene practices and oral health outcomes [3, 12, 13].

In contrast, interactive educational strategies, including games, storytelling, puppet theatre, animated videos, and other entertaining learning approaches, improve children's attention, memory, motivation, and retention of oral health information [12, 13]. Previous experiment studies have demonstrated that these approaches significantly improve oral hygiene status, oral health knowledge, attitudes, and practices among preschool and school-aged children [11, 14–17]. Reinforcement of oral health education has also been identified as a critical factor for sustaining behavioral change [3].

Despite growing international evidence supporting non-conventional oral health education, there is limited experimental research involving preschool children in Saudi Arabia. Existing Saudi studies have

primarily focused on school-aged children rather than kindergarten children [18–21].

To the best of the researcher's knowledge, no randomized controlled trial has been conducted in Al-Ahsa to compare conventional and non-conventional oral health education among kindergarten children. Therefore, this study aims to measure the oral hygiene status of preschool children at baseline stage, and to evaluate the effect of non-conventional and conventional oral health education on oral hygiene status of preschool children in Al-Ahsa, Saudi Arabia, providing evidence to support effective school-based oral health promotion programs.

Materials and Methods

Study Design: This was a prospective double-arm, single-blinded randomized controlled trial (The study was retrospectively registered in the International Standard Randomized Controlled Trial on 23.10.2024, (registration number: ISRCTN71415867, https://www.isrctn.com/ISRCTN71415867), to assess the effect of conventional versus non-conventional oral health education on a sample of preschool children enrolled in kindergartens in Al-Ahsa region.

The study area: The study focused on 148 public and private kindergartens in Al-Ahsa, Saudi Arabia, utilizing a stratified proportional sampling technique. Kindergartens were stratified by type (public or private) within the three educational offices: Al-Hofuf, Al-Mubarraz, and Villages.

The study population

This study focused on preschool children aged 5 to 6 attending kindergartens in Al-Ahsa for the academic year 2024–2025, with 13,530 children enrolled (10,930 in public and 2,600 in private kindergartens). Inclusion criteria specified children aged 5–6 who were enrolled in 2024, while exclusion criteria omitted those with dental anomalies, orthodontic appliances, or systemic diseases. Excluding children with dental issues was crucial to ensure homogeneous study samples and reliable oral hygiene assessments, particularly the Simplified Debris Index (DI-S). Despite exclusion from the study, all children received oral health education to prevent denial of learning opportunities.

The sample size: for this randomized controlled trial, we used a standard epidemiological method for cohort and experimental studies. The following equation was used for the sample size estimation $2SD^2(Z\alpha/2+ Z\square)^2/d^2$ [22]. Where SD represents the standard deviation, “Z alpha/2” corresponds to the critical value for a two-sided significance level of 95%; “Z beta” corresponds to the power of 80% and represents the expected difference between the groups. The OpenEpi statistical software (Version 3) was used to perform the calculations. The final estimated total sample size was 562 participants, with 281 participants in each group. The sample size calculated using OpenEpi and inflated by 20% to account for potential attrition and non-response. This adjustment is consistent with methodological recommendations that advise recruiting an additional 20–30% of participants beyond the minimum required to maintain statistical power in the event of loss to follow-up [23]. To account for potential loss to follow-up, the sample size increased by 20%, resulting in a final adjusted sample size of 672

participants (336 per group). This adjustment ensures that the study maintains sufficient power to detect significant differences in oral hygiene level between the experimental and control groups, aligning with the study's aim to assess the effect of non-conventional oral health education on children's oral hygiene.

Sampling Technique: This research utilized a stratified proportional sampling method involving all three educational offices. It focused on thirteen preschools, with kindergarten selection based on a comprehensive evaluation of each educational office's importance and students' enrolment. Kindergartens were selected using the Simple Random Sampling method, with each assigned a number and selected via a random number generator. The sampling fraction was 0.087, giving a selection probability of 9%. The research spanned fifteen months from March 2024 to May 2025 to allow for effective data collection amidst potential recruitment challenges.

Conceptualization of the Oral Health Education program: An age-adjusted oral health education initiative was developed following an extensive literature study and many focus group sessions with diverse stakeholders, including educators, parents, and dental professionals. The dental health material obtained from: FDI Mouth Heroes for Schools [24], A Give Kids A Smile [25], and Smile Smarts! An Oral Health Curriculum for Preschool [26].

Feasibility and appropriateness of experiment: A pilot study was executed in two kindergartens, one public and one private, involving a random selection of 10 educators and 50 child-mother. The objective of the pilot project was to evaluate the pragmatic execution of the curriculum within preschool environments and consider logistical factors, evaluate the suitability of program content, methodologies, and instructional delivery for educating kindergarteners by gathering input from kindergarten educators using an online survey. To assess moms' views on the clarity and utility of the lecture. Pragmatic logistical factors were noted, and the initiative proved to be very viable; personnel were exceptionally accommodating, and the program's activities were arranged following the morning assembly. The overall duration assessed; the instructional period was 20–25 minutes, comprising 10 minutes for teaching and 10 minutes for engagement. Teachers' feedback supported that the program's content is age-appropriate, and educational methods and delivery are suitable for kindergarten children. Mothers' feedback highlighted positive perceptions of the clarity and usefulness of education lecture. After further adjustments based on feedback, the program was feasible, appropriate, and ready for broader implementation in kindergarten settings.

Data collection: The study applied randomization and blinding to allocate participants into experiment and control groups for oral health education. Classes were randomly assigned using a lottery method, ensuring each had an equal chance of selection. Baseline examinations and caregivers' information questionnaires were completed prior to randomization to maintain fairness. Randomization at the class level was chosen to accommodate group experiments and avoid contamination. Blinding minimized bias, with the dentist conducting children's examinations unaware of (Group A) allocations, while participants remained uninformed about the educational methods used. Although teachers could not be

blinded, objective assessments of oral hygiene outcomes were upheld by the blinding of the outcome assessor. Data collection involved a team of dental and educational professionals. A dentist conducted oral examinations on children using the Debris Index (DI-S) while a recorder documented the scores. Kindergarten teachers delivered oral health education based on a structured program. A trained volunteer facilitated online quiz games to reinforce these concepts. Additionally, a dentist lectured caregivers on oral health via Zoom, coinciding with their children's education. Informed consent was obtained from caregivers to collect mothers' phone numbers, who were communicated through WhatsApp to announce sessions and share Zoom links.

Oral hygiene status was evaluated using the Simplified Debris Index (DI-S), a component of the Simplified Oral Hygiene Index (OHI-S) described by Greene and Vermillion. Although the index may have some limitations in accurately estimating debris, its major advantage is that it can be performed very rapidly, making it highly suitable for large field studies, with examination time per person is less than one minute [27].

A structured educational tool was implemented in the study groups. The non-conventional oral health education program (Group A) included interactive classroom visits, online quiz games, and a caregiver lecture, while the conventional group (Group B) received a standard oral health lecture using PowerPoint. The follow-up period was limited to three months.

Data analysis; involved a comprehensive scanning and cleaning process using Microsoft Excel followed by application in Statistical Package for Social Sciences (SPSS) Statistics version 29 [28]. Categorical variables were compared between the groups (A and B) using the chi-square tests. Continuous variables (child age, caregiver age) were compared between groups using Welch's independent-samples t-test. Welch's t-test is more robust when the two groups may have unequal variances. The distribution normality of the DI-S scores was assessed using the Shapiro–Wilk test. Corresponding non-parametric analyses, namely the Mann–Whitney U test for independent-group comparisons and the Wilcoxon signed-rank test for paired comparisons, were performed as sensitivity analyses. The conclusions were consistent between the parametric and non-parametric approaches. Because baseline DI-S scores differed significantly between the two groups, an analysis of covariance Analyses of Covariance (ANCOVA) was performed to compare post-experiment DI-S scores between groups while adjusting for baseline DI-S scores. This was to ensure that the relationship between pre-score and post-score was approximately the same in both groups. Homogeneity of regression slopes had checked before interpreting ANCOVA. Additional robust analyses were performed to account for the non-normal distribution of DI-S scores. Rank-based multivariable regression was conducted using rank-transformed outcome and continuous covariates, and median regression was used to estimate associations with the median post-experiment DI-S score. Standard errors and 95% confidence intervals for the regression estimates were obtained using 500 bootstrap resamples. All statistical tests were two-sided, and a p-value < 0.05 was considered statistically significant.

Ethical consideration: the study was retrospectively registered in the International Standard Randomized Controlled Trial Number (registration number: ISRCTN71415867). Approval was obtained from the research ethical council at Deanship of Scientific Research at King Faisal University (KFU) [KFU-REC-2024-MAR-ETHICS2027]. Formal approval letter obtained from Al-Ahsa education office to enable access to kindergartens prior to commencing data collection. Informed consent obtained from all participants 'each child caregiver', ensuring voluntary participation; the consent form also explained an overview of the general purpose of the study. Confidentiality and the right to withdraw from the study at any time. All data were stored securely and only used for research and publication purposes. All study data will be securely stored for a minimum of five years to allow for potential audits, data verification, or further analysis, while maintaining strict confidentiality and ethical standards.

Results

The demographic characteristics of 727 participants in Groups A and B, aged five to six years, with mean ages of 5.33 (Group A) and 5.26 (Group B). Most children were third or below in birth order (73.2% in (Group A), 71.6% in (Group B), and gender distribution was slightly in favor of females, predominantly residing in Al-Hofuf, Al-Mubarraz, or nearby villages. Nearly all participants were Saudi nationals (98.2% in (Group A), 99% in (Group B), and caregiver-child relationships were primarily parental (99% in (Group A), 99.7% in (Group B), 662 (91.1%) of them were mothers, and only 65 (8.9%) were fathers. Most caregivers were married (95.2% in (Group A), 96.3% in (Group B), with high educational attainment, particularly among males (66.7% (Group A), 48.1% (Group B) and female caregivers (57.5% (Group A), (53.3% (Group B). Employment rates varied, with (93.9%) of male caregivers employed in (Group A) compared to (92.6%) in (Group B), while female unemployment was higher (24.3% (Group A), 18% (Group B). Household income showed a predominance of middle-income families (58.6% (Group A), 57% (Group B). Low-income households constituted (24.8%) and (29.6%), and high-income households represented (16.5%) and (13.4%). Baseline Sociodemographic Characteristics: as depicted in table 1, Groups A and B were well balanced on nearly every sociodemographic characteristic (all $p > 0.05$). Two exceptions reached significance: children in (Group A) were older compared to (Group B) ($p = 0.033$, a negligible practical difference), and the groups differed somewhat in geographic distribution of residency ($p = 0.015$).

Table 1 compares (Group A) and (Group B) on sociodemographic characteristics of the child and caregiver.

Variable	(Group A) (n=399)	(Group B) (n=328)	Test	*p*-value
Child gender			$\chi^2(1)=0.36$	0.547
Male	187 (46.9%)	162 (49.4%)		
Female	212 (53.1%)	166 (50.6%)		
Child age, M (SD), years	5.33 (0.47)	5.26 (0.44)	t=2.14	0.033
Child's birth order, M (SD)	2.62 (1.49)	2.82 (1.55)	t=1.72	0.085
Caregiver gender				
Male	35 (8.8%)	30 (9.1%)	$\chi^2(1)=0.00$	0.964
Female	364 (91.2%)	298 (90.9%)		
Caregiver's age, M (SD), years	34.09 (5.53)	34.29 (5.45)	t=−0.48	0.630
Residency				
Hofuf	181 (45.4%)	117 (35.7%)	$\chi^2(2)=8.41$	0.015
Mubarraz	186 (46.6%)	171 (52.1%)		
Village	32 (8.0%)	40 (12.2%)		
Caregiver nationality				
Saudi	392 (98.2%)	325 (99.1%)	$\chi^2(1)=0.42$	0.517
Non-Saudi	7 (1.8%)	3 (0.9%)		
Child's nationality				
Saudi	395 (99.0%)	326 (99.4%)	$\chi^2(1)=0.03$	0.865
Non-Saudi	4 (1.0%)	2 (0.6%)		
Relationship to child				
Parent	395 (99.0%)	327 (99.7%)	$\chi^2(1)=0.47$	0.496
Other	4 (1.0%)	1 (0.3%)		
Marital status				
Married	380 (95.2%)	316 (96.3%)	$\chi^2(1)=0.30$	0.584
Other	19 (4.8%)	12 (3.7%)		
Father's education				
School	11 (33.3%)	14 (51.9%)	$\chi^2(1)=2.09$	0.191
University	22 (66.7%)	13 (48.1%)		
Mother's education				

School	154 (42.5%)	140 (46.7%)	$\chi^2(1)=1.13$	0.307
University	208 (57.5%)	160 (53.3%)		
Father's employment				
Unemployed			$\chi^2(1)=1.33$	0.249
Employed	2 (6.1%)	2 (7.4%)		
	31 (93.9%)	25 (92.6%)		
Mother's employment				
Unemployed	274 (75.7%)	246 (82%)	$\chi^2(1)=3.87$	0.057
Employed	88 (24.3%)	54 (18%)		
Household income				
Low	99 (24.8%)	97 (29.6%)	$\chi^2(2)=2.76$	0.252
Middle	234 (58.6%)	187 (57.0%)		
High	66 (16.5%)	44 (13.4%)		

Debris Index (DS)

The mean DI-S score decreased following the experiment in both groups, indicating an improvement in oral hygiene.

Between-group comparison: At baseline, the mean DI-S score was (1.448 ±S.D. 0.601) in (Group A) and (1.340 ±S.D. 0.515) in (Group B), indicating poorer oral hygiene in (Group A). Levene's test indicated unequal variances between the groups ($F = 10.52$, $p = 0.001$); therefore, Welch's independent-samples t-test was used. The baseline DI-S score was significantly higher in (Group A) than in (Group B) ($t = 2.61$, $p = 0.009$), indicating slightly poorer oral hygiene in (Group A) at the start of the experiment (Table 2).

Within-group comparison; Both groups demonstrated significant reductions in mean DI-S scores from pre- to post-experiment, indicating improved oral hygiene. Paired-samples t-tests demonstrated statistically significant reductions in DI-S scores within both (Group A) ($t = 27.03$, $df = 398$, $p < 0.001$) and (Group B) ($t = 18.37$, $df = 327$, $p < 0.001$). The mean reduction was (0.812 ±S.D. 0.600) in (Group A) and (0.564 ±S.D. 0.556) in (Group B). The corresponding effect sizes were very large for (Group A) (Cohen's $d = 1.35$) and large for (Group B) (Cohen's $d = 1.01$), indicating substantial improvements in oral hygiene in both groups (Table 2).

Table 2: presents the mean Debris Index Score (DI-S) scores for each (Group B) before and after the experiment. Comparison within and between groups, Lower Debris Index (DI-S) indicate better oral

hygiene.

Variable		**(Group A) (n = 399) M (SD)**		**(Group B) (n = 328) M (SD)**
Pre-score		1.448 (0.601)		1.340 (0.515)
Post-score		0.635 (0.453)		0.776 (0.469)
Change (Pre − Post)		0.812 (0.600)		0.564 (0.556)
Welch's t-test				
Comparison	**Test statistic**	***p-value***		**Interpretation**
Pre-score, A vs. B	Welch t = 2.61	0.009		(Group A) started slightly worse (higher DI-S) than (Group B)
Wilcoxon signed-rank tests				
Group	**t**	**df**	***p*-value**	**Cohen's d**
A	27.03	398	< 0.001	1.35
B	18.37	327	< 0.001	1.01

Because the groups differed significantly in baseline DI-S, an ANCOVA was performed to compare post-experiment DI-S scores while adjusting for baseline scores. The homogeneity-of-regression-slopes assumption for ANCOVA was met, as the Pre-score × Group interaction was not statistically significant (B = −0.047, t = −0.81, $p = 0.421$), indicating that the relationship between pre-post experiment DI-S did not significantly differ between (Group A) and (Group B) (Table 3).

The overall ANCOVA model was statistically significant, $F(2, 724) = 67.69$, $p < 0.001$), and explained 15.8% of the variance in post-experiment DI-S scores ($R^2 = 0.158$). Baseline DI-S was significantly associated with post-experiment DI-S (B = 0.303, $p < 0.001$). Importantly, after adjustment for baseline DI-S, a significant group effect remained ($F(1, 724) = 29.43$, $p < 0.001$, partial $\eta^2 = 0.039$). Group factor accounted for approximately (3.9%) of the variance in post-experiment DI-S after adjustment for the other model term. The adjusted mean post-experiment DI-S score was 0.621 for (Group A) compared with 0.794 for (Group B), with an adjusted mean difference of −0.174 (95% CI: −0.237 to −0.111). Thus, after accounting for baseline differences, (Group A) had significantly lower post-experiment DI-S scores than (Group B), indicating better oral hygiene outcomes and confirming the group difference was not attributable solely to baseline differences (Table 3).

The pre-to-post changes were further evaluated using the Friedman test as a non-parametric analysis. DI-S scores were significantly lower after the experiment in the overall sample ($\chi^2 = 432.90$, df = 1, $p <$

0.001), as well as in (Group A) ($\chi^2 = 263.10$, df = 1, $p < 0.001$) and (Group B) ($\chi^2 = 171.25$, df = 1, $p < 0.001$). The mean ranks were consistently lower for post-experiment scores than for pre-experiment scores, confirming a significant reduction in DI-S in both groups. Kendall's W indicated a substantial effect of the pre-to-post change, with a larger effect in (Group A) (W = 0.659) than in (Group B) (W = 0.522). In every case, post-scores ranked significantly lower than pre-scores, confirming a highly significant reduction in DI-S after the experiment, indicating improved oral hygiene (χ^2, all p < .001). Kendall's W (the associated effect size) was higher for (Group A) (W = 0.659) than for (Group B) (W = 0.522), indicating that children in (Group A) tended to show a more consistent improvement in DI-S than children in (Group B) (Table 3). These results align exactly with the earlier Wilcoxon signed-rank tests, with both groups improving significantly and (Group A) showing the stronger, more consistent effect (Table 2).

Table 3: ANCOVA and Friedman test comparing Pre- and Post-experiment Debris Index (DI-S).

Term	**B**	**SE**	***t***	***p*-value**
Intercept	0.370	0.045	8.31	< 0.001
Pre-score (covariate)	0.303	0.028	10.76	< 0.001
Group (A vs. B)	−0.174	0.032	−5.43	< 0.001
Group		**Adjusted mean Post-score**		
A		0.621		
B		0.794		
Difference (A − B)		−0.174 (95% CI: −0.237 to −0.111)		
Friedman test				
Sample	**n**	**χ^2 (df = 1)**	***p*-value**	**Mean rank Pre**	**Mean rank Post**	**Kendall's W**
Overall (A + B)	727	432.90	< 0.001	1.886	1.114	0.595
(Group A)	399	263.10	< 0.001	1.906	1.094	0.659
(Group B)	328	171.25	< 0.001	1.861	1.139	0.522

To assess whether the observed group difference remained after accounting for potential confounding variables, multivariable regression analyses were conducted using both rank-transform regression and median regression because of the non-normal distribution of DI-S scores. In the Conover–Iman rank-transform regression, baseline DI-S was significantly associated with post-experiment DI-S (B = 0.338, *p*

< 0.001), indicating that participants with higher baseline scores tended to have higher post-experiment scores. Group was also independently associated with the outcome (B = −79.37, $p < 0.001$), whereas child gender, child age, birth order, father's education, and mother's education were not statistically significant predictors ($p > 0.05$ for all). After adjustment for all covariates, the group effect remained statistically significant, F (1, 719) = 29.65, $p < 0.001$, partial $\eta^2 = 0.040$. The median regression analysis produced consistent findings. Baseline DI-S was significantly associated with the median post-experiment DI-S score (B = 0.274, $p < 0.001$), while (Group A) had a significantly lower median post-experiment DI-S score than (Group B) (B = −0.180, $p < 0.001$; 95% CI: −0.258 to −0.085). None of the other covariates, including child gender, child age, birth order, father's education, or mother's education, was significantly associated with post-experiment DI-S ($p > 0.05$ for all) (Table 4).

Table 4: Multi variable regression analyses

Conover-Iman rank-transform regression				
Predictor	**B (rank units)**	**SE**	**t**	***p*-value**
Rank(Pre-score)	0.338	0.035	9.58	<0 .001
Group (A vs. B)	−79.37	14.58	−5.45	< 0.001
Child gender (F vs. M)	0.35	14.39	0.02	0.981
Rank(Child age)	−0.027	0.044	−0.62	0.533
Rank(Birth order)	0.039	0.036	1.09	0.278
Rank(Father's education)	0.020	0.040	0.50	0.620
Rank(Mother's education)	−0.045	0.042	−1.07	0.286
Group effect adjusted for all covariates: F (1, 719) = 29.65, $p < 0.001$, partial $\eta^2 = 0.040$.				
Median (quantile, τ = 0.5) regression				
Predictor	**B**	**SE**	***p*-value**	**95% CI**
Pre-score	0.274	0.042	< 0.001	0.190, 0.350
Group (A vs. B)	−0.180	0.043	< 0.001	−0.258, −0.085
Child gender (F vs. M)	0.027	0.042	0.518	−0.076, 0.084
Child age	−0.020	0.046	0.659	−0.094, 0.080
Birth order	0.002	0.017	0.894	−0.023, 0.039
Father's education	−0.007	0.017	0.679	−0.030, 0.035
Mother's education	−0.014	0.019	0.469	−0.058, 0.019

Overall, the findings consistently demonstrated a significant improvement in oral hygiene following the experiment in both groups. Moreover, after adjustment for baseline DI-S and relevant sociodemographic characteristics, (Group A) demonstrated significantly lower post-experiment DI-S scores than (Group B), indicating better oral hygiene outcomes in (Group A). The consistency of this finding across ANCOVA, non-parametric analyses, rank-transform regression, and median regression supports the robustness of the observed group difference.

Discussion

The present study evaluated two approaches to oral health education in children: a nonconventional approach (Group A), consisting of a multicomponent, interactive oral health education experiment, and a conventional approach (Group B), consisting of lecture-based education. (Group A) incorporated storytelling, puzzles, memory games, simulated plaque-removal activities, practical toothbrushing training using a jaw model, and weekly online quiz games delivered via mobile phones. The quiz content covered the information presented during the educational sessions. In contrast, (Group B) received conventional PowerPoint-based lectures. The principal finding was that both approaches were associated with significant improvements in children’s oral hygiene; however, the improvement was greater in the nonconventional group. Importantly, the difference between the groups remained significant after adjustment for baseline oral hygiene and relevant sociodemographic characteristics. These findings suggest that an interactive and participatory approach may provide additional benefits over conventional lecture-based oral health education.

Effectiveness of oral health education in both groups

The significant reduction in DI-S in both groups indicates that structured oral health education can improve children's oral hygiene, regardless of whether it is delivered through a conventional or interactive format. This finding is consistent with the broader evidence supporting school-based oral health education. An umbrella review by Bhadauria et al. (2024) found that school-based oral health programs were associated with improvements in plaque status, knowledge, attitudes, and oral health behaviors, although the evidence for some longer-term clinical outcomes remained inconclusive. The authors also emphasized that the demonstrated benefits were predominantly short term and that longer follow-up is required [29]. More recently, Das et al. (2025) reviewed 27 systematic reviews of school-based oral health education and reported favorable effects on plaque, gingivitis, oral cleanliness, knowledge, attitudes, and behaviors [30]. Their findings support the value of school settings as an important platform for delivering preventive oral health education while highlighting the importance of tailoring experiments to children's needs. The improvement observed in the conventional group in the present study is therefore consistent with existing evidence. However, the greater improvement following the interactive experiment suggests that the method of delivering oral health education may influence the extent to which children engage with and apply the information provided [31].

Advantage of the nonconventional, interactive and game-based experiment

Group A showed a more favorable outcome in terms of oral hygiene, which was the main finding of the study. The experiment differed from the conventional lecture not only in the use of games but also in the extent to which children were required to participate actively in the learning process. The children were exposed to several complementary learning experiences: they listened to stories, solved puzzles, used memory-based activities, participated in simulated plaque removal, practiced toothbrushing, and completed an online quiz game using a mobile device. This combination could have amplified participation and strengthened oral health notions through repetition and interactive involvement. Rather than receiving information primarily through a lecture, children were given multiple opportunities to interact with the content and apply what they had learned. The findings are consistent with Patil et al. (2024), who systematically reviewed randomized controlled trials examining game-based oral health education in children. Their review found that game-based teaching was associated with improvements in several oral health outcomes, including oral hygiene and plaque/debris measures, compared with traditional educational approaches [1]. The present study also aligns with the more recent systematic review by Chen et al. (2025), which examined gamification in children's oral health management. The review identified positive effects of gamified experiments on oral health knowledge, behaviors, engagement, and oral hygiene-related outcomes. Importantly, the review found that digital experiments, including mobile applications and serious games, constituted a substantial proportion of the available evidence [32]. Thus, the present findings add to the emerging evidence that interactive and gamified approaches may provide advantages over conventional information-based education in pediatric oral health promotion.

Active learning and practical skill development

One potential explanation for the greater improvement in (Group A) is that the experiment addressed both knowledge and practical skills. Conventional oral health education can communicate information efficiently, but knowledge alone does not necessarily result in effective plaque control [33]. The practical brushing activity allowed children to practice the correct technique using a jaw model, while the simulated plaque-removal activity provided a simple visual representation of plaque accumulation and its removal. These activities may have helped children translate abstract oral health information into concrete actions [34].

The storytelling, puzzles, and memory games may have reinforced this learning by presenting information in different forms and requiring children to recall and apply it. The mobile quiz provided an additional opportunity for active retrieval and reinforcement. This interpretation is consistent with the findings of Peerbhay et al. (2025), who reviewed oral health promotion experiments based on behavior-change approaches in children and adolescents. Their review highlighted the importance of experiments that address behavioral processes rather than relying solely on the transmission of oral health

information [35]. The 2025 systematic review by Chen et al. provides also a useful framework for interpreting this finding. Across 41 studies, gamified pediatric oral health experiments were associated with improved engagement and oral hygiene-related behaviors. Common experiment elements included interactive activities, feedback, rewards, and mechanisms designed to encourage participation and adherence. However, the authors also noted considerable heterogeneity between experiments and a substantial risk of bias in much of the available literature [32]. Therefore, the greater improvement observed in (Group A) may reflect the integration of information, engagement, repetition, feedback, and practical skill development, rather than the presence of games alone [36].

The importance of the baseline difference

An important consideration is that (Group A) had poorer oral hygiene at baseline than (Group B). Therefore, the larger raw improvement in (Group A) cannot be interpreted independently of the initial difference. Children starting with poorer oral hygiene may have greater potential for improvement. The use of ANCOVA addressed this issue by comparing post-experiment DI-S while controlling for baseline DI-S. The adjusted analysis continued to demonstrate better oral hygiene outcomes in (Group A). This finding is important because it indicates that the observed difference was not simply a consequence of (Group A) starting with poorer oral hygiene. The multivariable analyses provided further support for this interpretation. After accounting for baseline DI-S and selected child and parental characteristics, the educational group remained significantly associated with post-experiment oral hygiene, whereas the other examined sociodemographic variables did not show significant associations. Taken together, these analyses suggest that the type of educational experiment contributed to the difference in post-experiment oral hygiene. Nevertheless, the baseline imbalance should be considered when interpreting the findings. Statistical adjustment can reduce the influence of measured baseline differences but cannot eliminate the possibility of residual or unmeasured confounding.

Consistency of the findings

Another strength of the present findings is their consistency across different analytical approaches. Both groups showed significant pre-to-post improvement using parametric and non-parametric analyses. The larger effect observed in (Group A) was also reflected in the magnitude of the pre-to-post association.

Furthermore, the between-group difference remained significant after adjustment for baseline DI-S and additional sociodemographic characteristics. The rank-transform and median regression analyses reached the same overall conclusion as the ANCOVA. This consistency is reassuring given that the DI-S scores did not follow a normal distribution. Importantly, these analyses should not be interpreted as demonstrating several independent effects. Rather, they provide complementary evidence supporting the same principal finding: both experiments improved oral hygiene, while the nonconventional experiment was associated with the more favorable outcome.

Educational and public health implications

The findings have practical implications for school-based oral health promotion. Conventional lectures remain useful for introducing fundamental concepts and can be delivered efficiently to large groups. However, incorporating interactive activities may increase children's involvement and provide opportunities to practice the behaviors being taught. A blended model may therefore be particularly appropriate. The experiment used in (Group A) illustrates one possible model. Oral health information can be introduced through storytelling and reinforced through puzzles and memory games. Practical activities can then allow children to practice appropriate brushing and understand plaque removal, while a mobile quiz can reinforce knowledge and provide an engaging form of review. Such an approach may be particularly suitable for children because it accommodates different forms of learning and maintains active involvement. The relatively simple nature of the activities used in (Group A) is also potentially advantageous from a public health perspective. Unlike technology-dependent experiments, the activities do not necessarily require tablets, smartphones, applications, or internet access. This could facilitate their implementation in schools and community settings with varying levels of resources.

The 2024 umbrella review by Bhadauria et al. supports the broader role of school oral health programs in children and adolescents, while emphasizing variation in the effectiveness of individual experiments [29]. More recent evidence similarly supports school-based education while highlighting the need for appropriately designed and targeted experiments [30].

Strengths and limitations

The study has several strengths. First, oral hygiene was assessed using a clinical DI-S measure rather than relying solely on self-reported behavior. Second, the relatively large sample provided adequate statistical power to detect differences between the educational approaches. Third, the analysis accounted for the baseline difference in DI-S and considered additional potential confounding variables. Finally, the consistency of the principal findings across several statistical approaches strengthens the credibility of the observed group difference. The baseline difference in DI-S means that the groups were not completely comparable before the experiment, although this was addressed analytically. In addition, because (Group A) received a combination of storytelling, puzzles, memory games, simulated plaque removal, and practical brushing training, the study cannot determine which component was most effective. Future research could use factorial or component-based designs to examine the individual contribution of each activity. Another limitation is the absence of long-term assessment. The current findings demonstrate improvement following the experiment, but they do not establish whether the improvement was maintained. This is an important consideration because recent research has highlighted the limited availability of long-term follow-up in pediatric gamification studies. Chen et al. (2025) specifically emphasized the need for longer-term studies to determine whether improvements in oral health behaviors are sustained [32]. Finally, the experiment should not be generalized to all forms of "game-based education." The current findings relate specifically to a structured, multicomponent,

predominantly non-digital educational program. Different games, activities, age groups, settings, or experiment durations may produce different outcomes.

Conclusion

The present study demonstrates that both conventional PowerPoint-based oral health education and a nonconventional, activity-based approach can improve children's oral hygiene. However, the nonconventional approach incorporating storytelling, puzzles, memory games, simulated plaque-removal activities, and practical toothbrushing training produced significantly better oral hygiene outcomes than the conventional lecture-based approach. The findings support the growing evidence that interactive and game-based approaches can enhance pediatric oral health education. Importantly, the results suggest that effective interactive education does not necessarily require digital technology. Simple, structured, hands-on activities may provide children with greater opportunities to engage with oral health concepts and practice the skills required for effective plaque control. Future studies should investigate the sustainability of these improvements, identify which components of the experiment contribute most to its effectiveness, and evaluate whether integrating interactive activities into routine school oral health programs can produce sustained improvements in children's oral hygiene. The study acknowledges several significant limitations. Firstly, the sampling was constrained by class organization, leading to potential biases, as the confidence intervals may be overly narrow due to shared environments. The experimental group engaged in multiple sessions, including online elements, unlike the control group, complicating the attribution of outcomes to specific factors. Absence of an untreated control group raises concerns over observed improvements potentially stemming from non-specific influences such as the Hawthorne effect. High attrition rates (30% overall) may also skew results due to differential dropout. Baseline discrepancies in factors like age and home environment, despite randomization, suggest residual confounding may affect accuracy. The outcome measure, DI-S, reflects plaque levels but does not encompass broader oral health habits, and its evaluation was influenced by circumstances around recent dental hygiene practices. Additionally, the follow-up period was limited to three months, questioning the sustainability of findings and restricting applicability due to demographic specificities in Saudi Arabia. Overall, the minimal observed difference in DI-S raises doubts about its clinical relevance.

Declarations

Acknowledgement: *the authors acknowledge caregivers' consenting in the participation in the study, and the children who participated in the clinical examination. Appreciation of the King Faisal University for the support and ethical approval for the study, gratitude goes to education authority and kindergartens personnel for the active participation and support.*

Source of Funding: *The authors declare that no funding was received for this study*

Competing interest: *the authors declare that there is no competing interests in this* study

Patient Declaration of consent: *author states that informed written consent for participation in the study and publication of the data for research and educational purposes was obtained from all participants' caregivers before the participation and after explanation of all aspects of the research and patients' rights.*

Authors' contribution: this to declare that

Hajar Ibrahim Alsuwayias the main investigator contributed to manuscript the design, conceptual , .framework, data analysis and writing of the manuscript

Elwalid F Nasir as the main supervisor, contributed to the manuscript design, conceptual framework, data analysis and writing of the manuscript.

Areej Jafar Alomran*:* contributed to data collection and writing of the manuscript.

Amany Osama Kassem, contributed to data collection and writing of the manuscript

Nada M A Suliman as the co-supervisor contributed to conceptual framework, data analysis and writing of the manuscript.

Ethical Policy and Institutional Review board statement: *The study obtained the ethical approval from the research scientific Committee at King Faisal University No. (KFU-REC-2024-MAR-ETHICS2027). The study was registered in the International Standard Randomized Controlled Trial on 23.10.2024, (registration number: ISRCTN71415867). The Consolidated Standards of Reporting Trials (CONSORT) were applied to ensure thorough design and reporting. Procedures followed were following the Helsinki Declaration of 1975, as revised in 2000.*

Data Availability Statement**:** *authors State the data set used in the current study is available upon request.*

References

1. Patil S, Licari FW, Bhandi S, Awan KH, Di Blasio M, Isola G, Cicciù M, Minervini G. Effect of game-based teaching on the oral health of children: a systematic review of randomised control trials. J Clin Pediatr Dent. 2024;48(4):26–37.
2. Oral Health [https://www.cdc.gov/oral-health/about/index.html]
3. Peteti L, Suma, Rvs K, Kumar, Gomasani S, Deepthi A, Prathyusha V, Punamalli S, Punamalli P. Impact of Oral Health Education on Children -A Review. 2021.
4. Kannan SP, Alfahaid SF, Alharbi AS, Almutairi BS, Alanazi AH, Alsaab FA, Alatallah SS, Aldhuwayhi SD. Oral Hygiene Behavior of School Children in Saudi Arabia: A Descriptive Cross-sectional Survey. Int J Clin Pediatr dentistry. 2020;13(1):66–71.
5. Oral Health A. report by FDI World Dental Federation [https://www.fdiworlddental.org/sites/default/files/2020-11/2015_wohd-whitepaper-oral_health_worldwide.pdf]

6. Sabbagh H, Alzain I. Oral health care among children in Saudi Arabia: a cross-sectional study. BMC Oral Health 2024, 24.
7. Bhattacharjee M, Mandal K. Cartoon Based Information Booklet Versus Traditional Teaching for Better Outcome in Oral Hygiene among Primary School Students. Indian J Continuing Nurs Educ 2022, 22.
8. Kale S, Kakodkar P, Shetiya S, Abdulkader R. Prevalence of dental caries among children aged 5–15 years from 9 countries in the Eastern Mediterranean Region: a meta-analysis. *Eastern Mediterranean health journal = La revue de sante de la Mediterranee orientale = al-Majallah al-sihhiyah li-sharq al-mutawassit* 2020, 26(6):726–735.
9. Mohd Z, Sinor MZ. Comparison between Conventional Health Promotion and Use of Cartoon Animation in Delivering Oral Health Education. Int J Humanit Social Sci. 2011;1:169–74.
10. Ghazali N, Jan A, Shukran AS. ASSESSMENT BETWEEN ORAL HEALTH KNOWLEDGE, ATTITUDE AND PRACTICE WITH DENTAL CARIES AMONG 6-YEARS-OLD PRIVATE PRE-SCHOOL CHILDREN. In: *2017*; 2017.
11. Thwin KM, Zaitsu T, Ueno M, Kawaguchi Y. Effects of oral health education in Myanmar preschool children and guardians. J Invest Clin Dent. 2018;9(3):e12346.
12. Sharma S, Saxena S, Naik SN, Bhandari R, Shukla AK, Gupta P. Comparison between Conventional, Game-based, and Self-made Storybook-based Oral Health Education on Children's Oral Hygiene Status: A Prospective Cohort Study. Int J Clin Pediatr dentistry. 2021;14(2):273–7.
13. Malik A, Sabharwal S, Kumar A, Singh Samant P, Singh A, Kumar Pandey V. Implementation of Game-based Oral Health Education vs Conventional Oral Health Education on Children's Oral Health-related Knowledge and Oral Hygiene Status. Int J Clin Pediatr dentistry. 2017;10(3):257–60.
14. PEREIRA WD, MATHEW MG. Impact of Different Methods of School Dental Health Education on Oral Health-Related Knowledge, Attitude and Practice Behaviour. *International Journal of Pharmaceutical Research (09752366)* 2020.
15. Aljafari A, Elkarmi R, Nasser O, Atef Aa, Hosey M. A Video-Game-Based Oral Health Intervention in Primary Schools—A Randomised Controlled Trial. Dentistry J. 2022;10:90.
16. Maheswari UN, Asokan S, Asokan S, Kumaran S. Effects of Conventional vs Game-based Oral Health Education on Children's Oral Health-related Knowledge and Oral Hygiene Status–A Prospective Study. Oral Health Prev Dent 2014, 12(4).
17. Ladera-Castañeda M, Córdova-Limaylla NE, Briceño-Vergel G, Rosas-Díaz JC, Cervantes-Ganoza LA, Cayo-Rojas CF. Impact of puppet theater on oral health knowledge and oral hygiene in preschoolers from a peruvian educational institution: A quasi-experimental study. J Int Soc Prev Community Dentistry. 2022;12(1):28–37.
18. Alhayek A, Alsulaiman M, Almuhanna H, Alsalem M, Althaqib M, Alyousef A, Alabdali J, Alqahtani S, Ansari S. The effect of conventional oral health education versus animation on the perception of Saudi males in primary school children. J Int Oral Health. 2018;10:121.

19. Halawany HS, Al Badr A, Al Sadhan S, Al Balkhi M, Al-Maflehi N, Abraham NB, Jacob V, Al Sherif G. Effectiveness of oral health education intervention among female primary school children in Riyadh, Saudi Arabia. Saudi Dent J. 2018;30(3):190–6.
20. Vundavalli S, Baig M. Effectiveness of Three Different Types of Oral Health Promotion Programs among Schoolchildren in Sakaka, Saudi Arabia: A Cluster Randomized Controlled Trial. J Datta Meghe Inst Med Sci Univ. 2022;17:568.
21. Shirzad M, Taghdisi MH, Dehdari T, Abolghasemi J. Oral health education program among pre-school children: an application of health-promoting schools approach. Health promotion Perspect. 2016;6(3):164.
22. Charan J, Biswas T. How to calculate sample size for different study designs in medical research? Indian J Psychol Med. 2013;35(2):121–6.
23. Bujang MA. A Step-by-Step Process on Sample Size Determination for Medical Research. Malaysian J Med sciences: MJMS. 2021;28(2):15–27.
24. No Health without Oral Health. How the dental community can leverage the NCD agenda to deliver on the 2030 Sustainable Development Goals. [https://www.fdiworlddental.org/sites/default/files/2020-11/fdi-wdc2017_ncd_session_proceedings.pdf]
25. Give Kids A, Smile A. [https://www.adafoundation.org/-/media/project/ada-organization/ada/ada-org/files/resources/public-programs/give-kids-a-smile/ada-gkasts-eng_dental_professionals.pdf?rev=990fc0cd385e483f9667881b2c30f894&hash=E0D1C22AF8A96D116C70E8A3130A3FE7]
26. Smile Smarts! AN ORAL HEALTH CURRICULUM FOR PRESCHOOL. [https://www.nj.gov/health/fhs/oral/documents/smilesmarts_curriculum.pdf]
27. Greene JC, Vermillion JR. THE SIMPLIFIED ORAL HYGIENE INDEX. J Am Dent Assoc (1939). 1964;68:7–13.
28. https://
29. Bhadauria US, Priya H, Purohit B, Singh A. Effectiveness of school oral health programs in children and adolescents: an umbrella review. Evid Based Dent. 2024;25(4):211.
30. Das H, Janakiram C, Karuveettil SVK. Effectiveness of school-based oral health education interventions on oral health status and oral hygiene behaviors among schoolchildren: an umbrella review. Evid Based Dent. 2025;26(2):110–1.
31. Al-Hassan S, Kazlak M, Kateeb E. Effectiveness of an Interactive School-Based Oral Health Educational Program on Periodontal Status Among Palestinian Adolescents: An Intervention Study. Child (Basel Switzerland) 2025, 12(10).
32. Chen J, Ying Y, Pang M, Chen J, Kang T, Xuan P, Chen X, Zhang W. The Application of Gamification in Children's Oral Health Management: Systematic Review. J Med Internet Res. 2025;27:e75541.
33. Nakre PD, Harikiran AG. Effectiveness of oral health education programs: A systematic review. J Int Soc Prev Community Dentistry. 2013;3(2):103–15.

34. Lin Q, Zheng Y, Chen Y, Lin Y. The Effectiveness of Hands-On Practice Combined with Multimedia Education in Oral Hygiene Instruction for Adolescent Orthodontic Patients. Oral Health Prev Dent. 2025;23:711–20.
35. Peerbhay F, Mash R, Khan S. Effectiveness of oral health promotion in children and adolescents through behaviour change interventions: A scoping review. PLoS ONE. 2025;20(1):e0316702.
36. Ahmad M, Khan R. Gamification in Education: Enhancing the Students Engagement and Learning Achievements through the Integration Use of Game based Learning. Knowl. 2024;3:23–37.

Figures

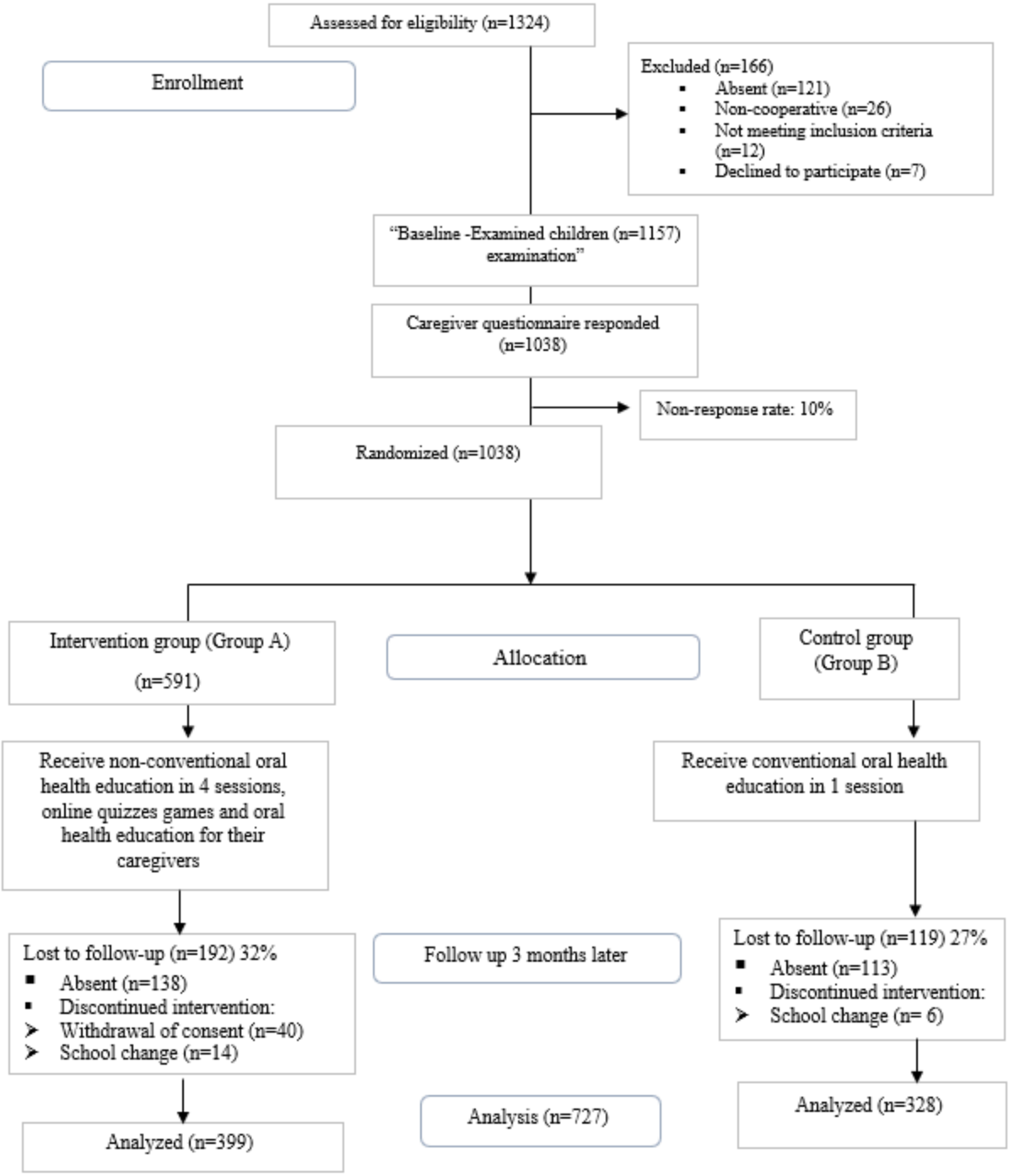


Figure 1

CONSORT flow diagram of the randomized controlled trial