

SYSTEMATIC REVIEW

Effect of game-based teaching on the oral health of children: a systematic review of randomised control trials

Shankargouda Patil^{1,*}, Frank W Licari¹, Shilpa Bhandi¹, Kamran H Awan¹, Marco Di Blasio^{2,*}, Gaetano Isola³, Marco Cicciù³, Giuseppe Minervini^{4,5}

¹College of Dental Medicine, Roseman University of Health Sciences, South Jordan, UT 84095, USA

²Department of Biomedical Surgical and Dental Sciences, University of Milan, 20126 Milan, Italy

³Department of General Surgery and Surgical-Medical Specialties, School of Dentistry, University of Catania, 95124 Catania, Italy

⁴Saveetha Dental College & Hospitals, Saveetha Institute of Medical & Technical Sciences, Saveetha University, 600077 Chennai, India

⁵Multidisciplinary Department of Medical-Surgical and Dental Specialties, University of Campania "Luigi Vanvitelli", 80138 Naples, Italy

***Correspondence**

spatil@roseman.edu

(Shankargouda Patil);

marco.diblasio@studenti.unipr.it

(Marco Di Blasio)

Abstract

Poor oral health during childhood can lead to various oral diseases and have long-term implications for dental health. Innovative and engaging oral health educational approaches such as game-based teaching have emerged as a promising modality for health education. This systematic review examined the effectiveness of game-based teaching methods on the oral health of children (4–12 yrs). Scopus, Medline and Web of Science databases were searched according to specific inclusion and exclusion criteria. Inclusion criteria included randomised trials that compared traditional methods of oral health education with game-based interventions in preschoolers and school-age children. The quality of the data was determined using Cochrane risk-of-bias tool for randomized trials (ROB-2). A total of seven studies that examined 1097 children (4–12 yrs) were included in this systematic review with the association of game-based teaching of oral health. The findings indicated that the utilization of game-based methods significantly improved children's oral health outcomes when compared to traditional teaching approaches. Specifically, the game-based interventions demonstrated positive effects on various aspects of oral health, including enhanced oral health knowledge, improved oral hygiene scores, and reductions in debris and plaque scores. The game-based interventions were found to be more effective in promoting oral health when compared to conventional methods of teaching, such as verbal instructions or educational posters. Based on the limited evidence available, game-based teaching appears to be an effective approach for promoting oral health among children, consistently demonstrating positive outcomes, including improved oral health knowledge, enhanced oral hygiene scores, and reductions in debris and plaque scores. Further well-designed trials adhering to reporting guidelines and using objective measures are necessary before outlining universal guidelines for best practice.

Keywords

Children; Education; Game-based; Oral health; School-age

1. Introduction

Oral health is a vital component of overall health and well-being, particularly in children. The Global Burden of Disease Study estimates that 60–90% of children suffer from caries in primary teeth [1]. Poor oral health in children can have profound consequences, including dental caries, periodontal diseases, pain, impaired growth and development, and compromised quality of life [2–6]. Oral health problems in childhood can have long-lasting impacts on both oral health and overall health into adulthood. The early years of childhood are critical for establishing good oral hygiene habits and promoting optimal oral health that can persist into adulthood. Therefore, effective oral health education strategies are of paramount importance in promoting and maintaining oral health among children.

Traditionally, oral health education has relied on conventional methods such as lectures, demonstrations, and printed materials. While these methods have been widely used and have some efficacy, they may not always capture the attention and engagement of young learners [7]. Children have unique learning needs and preferences, and it is essential to explore innovative approaches that can effectively impart oral health knowledge while also being engaging and enjoyable [8].

In recent years, newer modalities of oral health education delivery, such as serious games and interactive games, have gained attention as promising alternatives to traditional methods [9–14]. Serious games refer to games specifically designed with educational purposes, aiming to educate players while entertaining them. Interactive games, on the other hand, involve active participation and engagement of the players through

interactive elements and features [15]. These game-based teaching approaches harness the inherent appeal of games and technology to create immersive and interactive learning experiences. In the context of oral health education, serious games can play a crucial role in enhancing children's understanding of oral health concepts, promoting positive oral hygiene behaviors, and improving overall oral health outcomes.

One of the key advantages of serious games in oral health education is their ability to integrate educational content into game mechanics, narratives and interactive challenges, serious games captivate children's attention and maintain their engagement for extended periods [16]. This sustained engagement is vital for effective learning, as it promotes active participation and allows children to explore oral health concepts and practices in a fun and stimulating manner [17]. The interactive nature of serious games enables children to learn through hands-on experiences, decision-making, and problem-solving, facilitating a deeper understanding of oral health principles and their application in real-life situations [18].

Health educators and school teachers have employed educational games in various formats ranging from board games to word games to video games to impart knowledge and enhance skills among learners [19, 20]. Board games incorporating questions from core paediatric textbooks led to positive feedback from medical students, paediatric residents and faculty [21]. A "Jeopardy!"-style game incorporating questions from contemporary paediatric journal issues, resulting in increased reading time and favorable evaluations by residents [22]. Despite the promising findings, it is important to note that the current body of research on serious games in oral health education is still limited and further investigation is warranted.

Game-based teaching capitalizes on the interactive nature of games to provide immediate feedback and reinforcement. Oral health education often requires the acquisition of practical skills and the understanding of complex concepts. Games allow for real-time feedback on performance, highlighting areas of strength and areas that need improvement [23]. Games, whether they be digital or more traditional such as board games or word games, offer the opportunity for experiential learning, enabling children to explore different scenarios, make decisions and observe the consequences of their actions within a safe and controlled environment [24]. This immediate feedback mechanism enhances learning outcomes by promoting self-assessment, error correction, and skill development [25]. Additionally, games can incorporate rewards and incentives that reinforce positive behaviors and encourage children to apply oral health knowledge in their daily lives.

By synthesizing the available evidence, we hope to inform educators, healthcare professionals and policymakers about the efficacy of innovative game-based approaches and their role in promoting oral health among children. By systematically examining the effectiveness of game-based teaching in oral health education, we hoped to valuable insights into its potential benefits, limitations and optimal implementation strategies. This systematic review aimed to evaluate the effectiveness of game-based health education interventions in improving dental health, knowledge and oral health behaviors among children.

2. Materials and methods

This review is being reported as per the PRISMA (Preferred Reporting Items of Systematic Reviews and Meta-analyses) statement following relevant guidelines from Cochrane handbook for systematic reviews of interventions [26, 27].

The review was registered in the International Prospective Register of Systematic Reviews (PROSPERO) under registration number CRD42023428660 [28].

The focused question was, "Does the use of game-based health education interventions in children improve dental health, knowledge and oral health behaviors?"

2.1 Search strategy

The inclusion criteria for selecting studies in the PICOS framework was:

Population (P): studies involving children aged 4 to 12 years were considered.

Intervention (I): studies that employed game-based teaching interventions for oral health education were included. This encompassed serious games, interactive games or other forms of digital or non-digital games used as an educational tool.

Comparison (C): inclusion: studies that examined the effectiveness of game-based teaching compared to alternative interventions, conventional teaching methods or control conditions.

Outcome (O): studies assessing oral health-related outcomes such as oral health knowledge, oral hygiene behaviors and plaque scores.

Study Design (S): randomized controlled trials.

Multiple electronic databases, including PubMed, Embase and Web of Science, were searched using a combination of keywords and Medical Subject Headings (MeSH) terms. The search strategy combined terms related to oral health, children, game-based teaching, serious games, interactive games and education. Boolean operators (AND, OR) were used to combine the search terms effectively. No filters or date restrictions were placed with only English language publications considered for inclusion.

To ensure the inclusiveness of the search, additional sources were explored, including conference proceedings, and grey literature databases. Two reviewers (SGP and FWL) independently assessed the search results to identify relevant articles. The reviewers were not blinded to the author names or affiliations. Non-relevant articles and duplicates were excluded. In the initial screening, titles and abstracts were reviewed to determine their relevance to the research question and the predefined inclusion criteria. The full texts of potentially relevant articles were then assessed in the second screening phase to determine their eligibility for final inclusion. The reference lists of relevant articles were manually searched for any additional studies that may be included. Discrepancies between reviewers were resolved by a third author (SB) through consensus. The search strategy is shown in **Supplementary Table 1**.

2.2 Data extraction

Two reviewers (KHA and MDB) independently conducted the data extraction process using a customized template, which

was subsequently verified by a third author (GI). Information from the selected studies was extracted, including study characteristics (e.g., author, publication year), study design, participant characteristics, intervention details (e.g., type of game-based teaching, duration), outcome measures and key findings.

2.3 Quality assessment

The risk of bias assessment was performed by two authors (MC and GM) independently using relevant guidelines from the Cochrane Handbook for Systematic Reviews [29]. Randomised trials were assessed using the Revised Cochrane Risk of Bias Tool (RoB-2) to evaluate their methodological quality and potential biases across five domains: randomization process, deviations from intended interventions, missing outcome data, measurement of outcomes and selection of reported results. For each domain, specific signaling questions were applied to determine the risk of bias. Based on the answers to the signaling questions, a judgment of low, high or some concerns regarding the risk of bias for each domain was assigned.

2.4 Quality of evidence for outcomes in summary of findings table

The evaluation of the evidence quality for each outcome presented in the Summary of Findings section followed the GRADE (Grading of Recommendations Assessment, Development and Evaluation) methodology. A single author (MDB) conducted the application of the GRADE system, and subsequent discussions were held with the other two authors (MC and SB) to achieve a consensus on the evidence quality for each outcome. The assessment involved considering five domains for potential downgrading of evidence quality: Risk of Bias, Inconsistency of results, Indirectness of evidence, Imprecision of results and Publication Bias. The certainty of the evidence was graded as high, moderate, low or very low.

Evidence from randomized trials was initially classified as high quality for each outcome. It was downgraded by one level for concerns related to study limitations or outcome inconsistencies, and by an additional level for concerns regarding indirectness, imprecision or publication bias.

3. Results

The initial search identified 191 records. After the removal of duplicates and screening of titles and abstracts for eligibility, the potentially relevant articles were identified. 14 full-text articles were selected for complete review. A total of seven articles published between 2015 and 2022 were selected for inclusion in this systematic review [30–36]. The PRISMA flow diagram is shown in Fig. 1.

3.1 Characteristics of the selected studies

A majority of the studies were conducted in Asia (India [30, 32, 34, 36] Jordan [31] and Iran [33]) and one study conducted in the UK [35]. The summary of the characteristics of the selected trials is shown in Table 1.

3.2 Population

The majority of the included studies focused on pre-teen children, specifically within the age range of 7 to 12 years [30, 32–36]. However, one study expanded the age range to include pre-schoolers aged 4 years and children up to 10 years old [31]. Additionally, two studies specifically targeted children between the ages of 8 and 12 years [32, 33] while three other studies included children aged 7 to 10 years, 7 to 12 years, and 12 years old, respectively [30, 34, 36]. Aljafari *et al.* [35] recruited participants within a similar age range of 6 to 8 year olds.

3.3 Intervention

The interventions used in the included studies varied in their methods including the use of board games, word games and videogames but shared a common focus on game-based teaching for improving the oral health of children.

In the studies using word games, Yogesh *et al.* [25] used a connect the dots game with a “Bright Smile” anagram, where each alphabet represented an oral hygiene instruction. The children connected the dots between the alphabets and read out the corresponding instructions, aiming to promote a happy and healthy smile. Flashcards with pictures and oral hygiene instructions were also used in this intervention. Kashyap *et al.* [36] used crosswords and puzzles with a PowerPoint presentation to educate children about oral health. The crossword consisted of 15 questions related to tooth functions, dental caries, dental plaque, *etc.*, and scores were assigned based on correct answers. Malik *et al.* [34] utilized crosswords and puzzles along with a PowerPoint presentation as their intervention method, although additional details regarding the game procedure were not provided in the article.

In the studies using board games, snake and ladder was employed by two studies. Nourian *et al.* [33] employed a snake and ladder game enhanced with question cards and a dental model to improve the practical skills of children. The training package included a game sheet, a manual, a dental model with a toothbrush, an educational brochure for parents, a CD containing educational clips, question cards with answers, game pieces and a dice. An instructive session was conducted for both children and parents, and the game was played in the waiting room under the guidance of a healthcare provider acting as a facilitator. Following completion of the game, children were encouraged to continue practicing at home with their parents [33].

Sharma *et al.* [37] incorporated a storybook method alongside the game-based approach. The game involved a snake and ladder board, where players moved their coins based on the dice roll and either climbed up ladders (representing oral hygiene do’s) or slid down snakes (representing oral hygiene don’ts). Flashcards were used to reinforce the do’s and don’ts. Additionally, dental storybooks with cartoon characters were utilized to illustrate various oral hygiene maintenance modalities [34].

Aljafari *et al.* [31] used videogames as an intervention. A video game with oral health content on a touch tablet was provided along with a DVD copy for home use. The video game focused on the importance of toothbrushing twice daily,

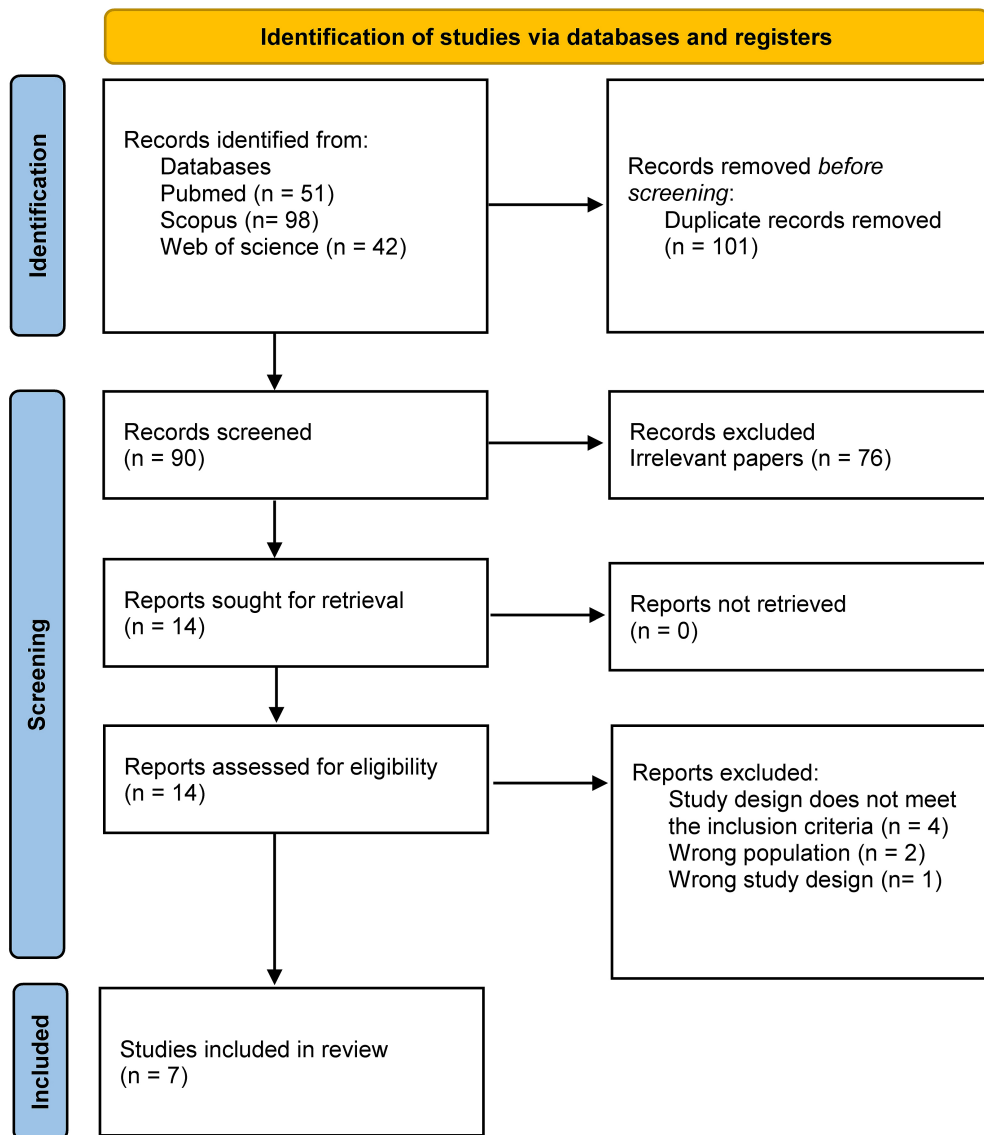


FIGURE 1. PRISMA flow chart.

reducing sugar frequency, following the “Eatwell Plate” guidelines, regular dental visits, and the application of fluoride varnish and fissure sealants for high caries risk children [35].

3.4 Duration

All the studies tested the effect of educational intervention after spacing it out from the initial teaching session, with the minimum being 1 week [30, 31, 33, 35] and maximum being 6 months [36] after the intervention. All the studies with the exception of the study by Nourian *et al.* [33] recalled the patients till 3 months interval for follow up [30–32, 34, 35] while Nourian *et al.* [33] followed up the patients till 1 month post intervention.

3.5 Standardization/calibration

Regarding standardization and calibration, Aljafari *et al.* [31, 35] appointed a dental nurse-educator for participant allocation and measurements and ensured examiner calibration through a pilot process. Malik *et al.* [34] utilized trained and calibrated

examiners, and Nourian *et al.* [33] employed blinded experts for scoring. Sharma *et al.* [37] involved undergraduate dental students supervised by investigators. Kashyap *et al.* [36] evaluated questionnaire reliability and had a trained examiner record scores.

3.6 Methodology used to assess outcome

Various assessment methodologies were employed across the included studies with the most common being the Oral Hygiene Index-Simplified (OHI-S) [33, 34, 36] and Debris Index-simplified (DI-S) [30, 33, 34, 36]. Malik *et al.* [34] utilized AlphaPlac Two Tone and the Quigley-Hein index modification for plaque index assessment, along with a close-ended questionnaire for oral health knowledge. Aljafari *et al.* [31, 35] used a range of methods including visual analog scale, Pictorial Dietary Quiz, Children’s Dietary Questionnaire, Toothbrushing & snacks selection scores, and parental questionnaires.

TABLE 1. Characteristics of the selected studies.

| Author/Year | Sample Size | Study Design | Intervention | Comparator | Outcome assessment | Results | Inference |
|--|------------------------|---|--|---|---|--|--|
| Yogesh <i>et al.</i> [25] (2015) India | 60 children (7–10 yr) | Group 1: Conventional (flash card) method (n = 30); Group 2: Both flash card and game-based (connect the dots) method (n = 30). | Connect the dots game in a “Bright Smile” anagram which would form a happy “Bright Smile” tooth upon completion along with flashcards. | Conventional flash card method of teaching. | Debris Index-Simplified and oral hygiene knowledge used close-ended questionnaire. | Both the game-based and conventional groups demonstrated a noteworthy improvement in oral hygiene scores and a reduction in debris scores compared to the baseline at 1 week and 1 month follow-up intervals. The game-based group exhibited a highly significant reduction in debris score, accompanied by a significantly better knowledge score ($p < 0.05$). | Connect the Dots game was an effective intervention aid for teaching the basic oral health concepts among school-going children. |
| Aljafari <i>et al.</i> [31] (2017) UK | 109 families (4–10 yr) | Group 1: Study group (self-directed play about oral health using video game) (n = 55); Group 2: One-to-one health educator group (verbal oral health advice) (n = 54). | Self-directed play using Video game with oral health contents in an iPad and a copy on DVD for home use. | One-on-one Verbal oral health advice by a qualified dental nurse. | 1. Visual analogue scale-child & parent satisfaction. 2. Pictorial dietary quiz score-change in dietary knowledge of child. 3. Children’s dietary questionnaire-Change in child’s diet at home. 4. Toothbrushing & snacks selection scores-engagement in toothbrushing & choice of snacks. 5. Children in the computer game group-verbally reporting of their views on the content of the game directly to the dental nurse-educator. | Both the self-directed play group and the one-to-one health educator group showed significant improvement in recognizing unhealthy foods immediately after education ($p < 0.001$). Both groups reported reduced intake of sweetened drinks ($p = 0.019$) and non-core foods ($p = 0.046$), with no significant differences between them. Children maintained their twice-daily toothbrushing routine, while snack selection remained unchanged. | Oral health education using video games can be as effective as one-to-one verbal education method. |

TABLE 1. Continued.

| Author/Year | Sample Size | Study Design | Intervention | Comparator | Outcome assessment | Results | Inference |
|--|------------------------|---|--|---|---|---|---|
| Malik <i>et al.</i> [34] (2017) India | 150 children (8–12 yr) | Group 1 (n = 75): Oral health education through PPT presentation; Group 2 (n = 75): Play method through crosswords, quiz & PowerPoint presentations. | Game-based teaching method (crosswords and quizzes) combined with PowerPoint. | Additional skill training Practice group (Group A). | Plaque score and oral health knowledge score by close-ended questionnaire. | The game-based teaching group had superior knowledge scores at 1-month (10.32) and 3-month (9.98) follow-up. Both groups showed significant improvements in oral hygiene scores and plaque reduction at 1 and 3 months, with the experimental group performing better than the control group at both time points. | Crossword game-based oral health education program is an easy and effective aid for teaching oral health instructions and preventing oral diseases in children. |
| Nourian <i>et al.</i> [33] (2021) Iran | 40 children (8–12 yr) | Control group (n = 20): Oral hygiene instructions; Intervention group (n = 20): Oral health training using modified Snake & ladder game. | Modified snake & ladder game with question cards and a dental model to improve the practical skills. | Oral hygiene instructions. | The simplified oral hygiene index (OHI-S) with two components of debris index (DI-S) and calculus index (CI-S). | The game-based learning group showed significantly lower DI-S and OHI-S scores at 1 week and 1 month after the intervention compared to the control group ($p = 0.003$ and $p = 0.001$, respectively), ($p = 0.012$ and $p = 0.007$, respectively). | Game based learning is an effective tool to promote oral health in children. |
| Sharma <i>et al.</i> [37] (2021) India | 300 children (7–12 yr) | Group 1 (n = 100): Conventional method with educative posters; Group 2 (n = 100): Play method (<i>i.e.</i> , snakes and ladders game combined with flashcards); Group 3 (n = 100): Education through self-made storybooks. | Snake & ladder board game with flash cards and self-made story books. | Oral health education through posters. | Oral Hygiene Index-Simplified Debris (DI-S) score. | The group using self-made storybooks showed maximum reduction in debris score which was highly statistically significant, followed by game based and conventional method group of oral health education. | Oral health education through story books was an effective method to teach basic health concepts to children. |

TABLE 1. Continued.

| Author/Year | Sample Size | Study Design | Intervention | Comparator | Outcome assessment | Results | Inference |
|---|-----------------------|---|---|--|--|---|--|
| Aljafari <i>et al.</i> [35] (2022) Jordan | 278 children (6–8 yr) | Intervention group: Oral health education video game; Control group: No intervention. | Video game with oral hygiene education on toothbrushing, fluoride application, sugar intake. | No intervention. | Changes in children's dietary knowledge using a Pictorial Dietary Questionnaire, plaque scores, toothbrushing diaries, diet and parent questionnaires. | The video game-based education group showed improved dietary knowledge, while both groups saw increased parental familiarity with fluoride varnish. However, there were no significant changes in children's plaque scores, toothbrushing and dietary practices, or parental familiarity with fissure sealants in either group. | Oral health education video game showing improved knowledge about diet in children. |
| Kashyap <i>et al.</i> [36] (2022) India | 160 children (12 yr) | Group 1: Oral health education through PowerPoint presentation; Group 2: Play method (crosswords and quiz with PowerPoint presentation). | 15-min lecture on oral health and ppt presentation knowledge and behavior followed by crossword puzzle. | Oral health education through PowerPoint presentation. | Debris index, simplified component of OHI-S. | The game-based group showed significant improvements in knowledge scores at post-intervention 1, 3 and 6 months, with better scores observed compared to the control group. Both groups demonstrated significant enhancements in oral hygiene scores and reductions in debris and plaque scores at all follow-up time points. | Game-based oral health education program was an easy and effective method in improving the oral health and preventing oral diseases. |

3.7 Quality assessment

In terms of the overall risk of bias, there were significant concerns regarding the risk of bias in a majority of studies. None of the studies examined were high-quality studies defined as studies with low risk of bias across all domains. Four out of seven studies showed some concerns [30, 31, 33, 35] while three studies were assessed to have a high risk of bias [32, 36, 37]. The higher ratings were due to insufficiencies occurring in multiple domains including deviation from intervention, and measurement of outcome. Poor reporting across most studies led to concerns regarding reliability and validity that are reflected in the higher ratings. A summary of the risk of bias assessment is shown in Fig. 2. The summary of findings for outcome specific ratings is shown in Table 2.

3.8 Effect of intervention

The systematic review found that game-based teaching is an effective tool for promoting oral health among children, particularly in the pre-teen and preschool age groups. The included studies consistently demonstrated positive outcomes in terms of improved oral health knowledge, oral hygiene scores, and reductions in debris and plaque scores. Game-based interventions were found to be more engaging and effective compared to conventional teaching methods, such as verbal instructions or educational posters. The use of self-made dental story books also showed promise in promoting oral health [34].

The results of Yogesh *et al.* [25], Nourian *et al.* [33], and Kashyap *et al.* [36] collectively demonstrate the positive impact of game-based teaching on oral health outcomes.

Yogesh *et al.* [25] found that both the experimental and control groups experienced a significant reduction in debris index scores after three months. However, the game-based teaching group showed a highly significant difference, indicating that game-based teaching was particularly effective in reducing debris. Moreover, the game-based teaching group exhibited significant improvement in knowledge scores compared to the control group, highlighting the educational benefits of this approach [30].

Similarly, Nourian *et al.* [33] observed statistically significant improvements in OHI-S and DI-S scores in the experimental group at one week and one-month follow-up. This suggests that game-based teaching contributed to enhanced oral hygiene and reduced debris among the participants [33].

Malik *et al.* [34] and Kashyap *et al.* [36] findings showed a trend with the game-based group showed higher knowledge scores and better oral hygiene scores, along with significant reductions in debris and plaque scores at follow-up compared to the control group. These results emphasize the sustained effectiveness of game-based teaching in improving oral health knowledge and oral health index scores over an extended period.

Aljafari *et al.* [31, 35] reported that the game-based teaching method of oral health education was comparable to the conventional method of verbal oral education instructions. Both parents and children expressed satisfaction with both methods. Immediate post-education assessments showed significant improvements in the recognition of unhealthy foods in both groups. Three months of follow-up indicated improvements

in diet, including reduced intake of sweetened drinks and non-core foods, with no significant differences between the two groups. Toothbrushing frequency remained consistent, but there were no changes in snack selection in both education methods [31, 35].

4. Discussion

Oral health is a crucial aspect of overall well-being, particularly in children, as it can affect their growth, development and quality of life. Newer modalities such as game-based teaching have gained attention due to their potential to engage and educate children effectively. Understanding the effectiveness of game-based teaching interventions can provide valuable insights into developing innovative and engaging oral health education approaches for children. By exploring the impact of game-based teaching on oral health outcomes, this review aimed to contribute to evidence-based practices and inform educational strategies for promoting oral hygiene and oral health awareness among children.

This review includes seven studies published between 2015 and 2022 that examined 1097 children (4–12 yrs) that explored the effects of game-based teaching on oral hygiene, oral health behaviors and knowledge. The findings from this study provide low-quality evidence supporting the effectiveness of game-based teaching interventions in enhancing oral health outcomes among children. Various game-based methods, including video games, snakes and ladders, crosswords, puzzles and connect the dots, demonstrated comparable efficacy in assessing children's oral health. Notably, the utilization of story books as an alternative educational approach exhibited greater advantages over the snakes and ladders game method, particularly among slightly older children who possess reading and comprehension abilities. These results suggest the potential value of incorporating story books as an engaging educational tool for promoting oral health in this specific age group [34].

Game-based learning has demonstrated positive outcomes in enhancing children's knowledge and practice of good oral health habits, such as toothbrushing twice a day and the importance of fluoride varnishes. Several studies reported that game-based interventions, combined with repeated reinforcement, resulted in improved oral hygiene among children, as evidenced by enhancements in oral hygiene index scores, debris index scores, calculus and plaque index scores [30–36]. These findings highlight the potential of game-based approaches as an educational tool for promoting oral hygiene in children [30, 32–36].

The findings of this systematic review indicate that game-based education methods have been demonstrated as effective tools for enhancing oral health outcomes among children. The interventions were not only engaging but also proved effective in improving the oral health of school-age children. Moreover, these interventions resulted in improved knowledge and awareness regarding oral health and dietary practices among both children and their parents. The game-based approach facilitated cognitive development in children and fostered confidence, moving beyond rote memorization of oral hygiene instructions. Additionally, it was observed

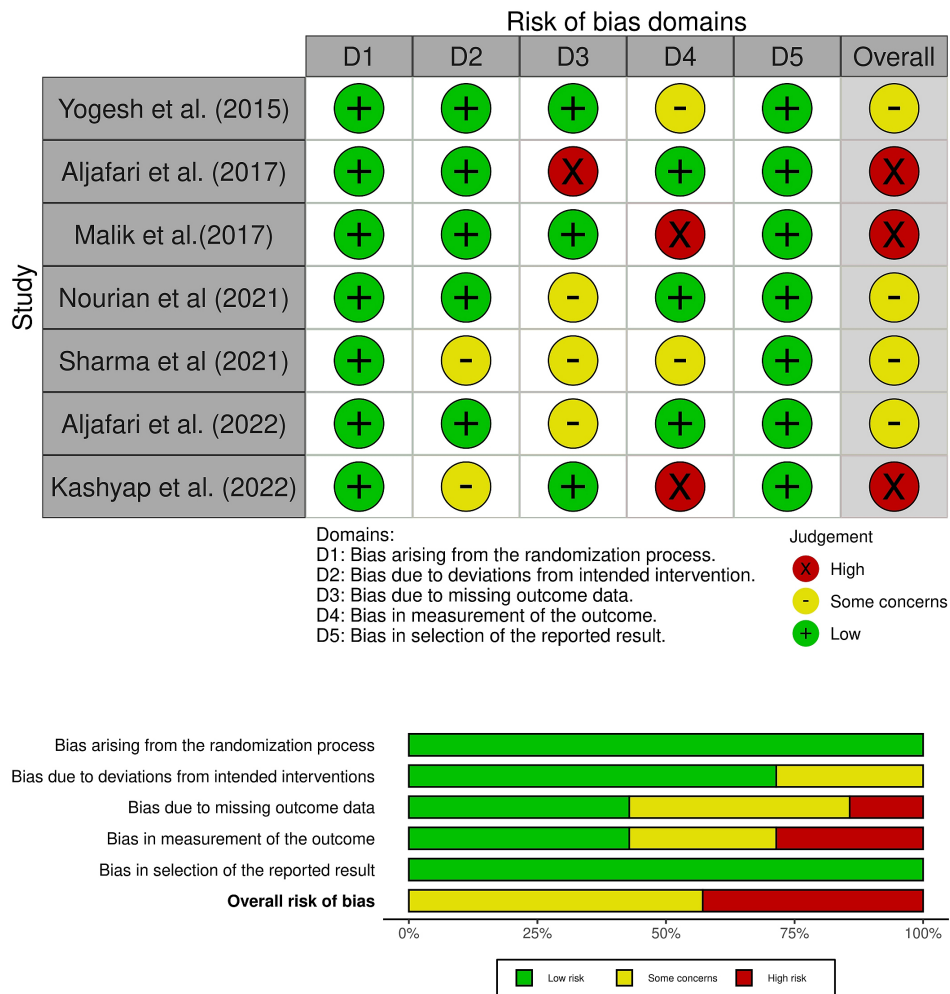


FIGURE 2. Summary of risk of bias assessment.

TABLE 2. Summary of findings table.

| | | Quality assessment | | | | Summary of findings | | |
|--|----------------------|--------------------|--------------|-------------|------------------|---|-------------------------------|-------------------------------|
| Outcome | Risk of bias | Inconsistency | Indirectness | Imprecision | Publication bias | Impact | No. of participants (Studies) | Certainty of evidence (GRADE) |
| Oral health knowledge and Oral hygiene behaviors | Serious ^a | Not Serious | Serious | Not serious | Not serious | Our confidence in the effect estimate is limited: the true effect may be substantially different from the estimate of the effect. | 797 (6) | Low ⊕⊕ |
| Plaque scores or Debris scores | Serious ^a | Not Serious | Serious | Not serious | Not serious | | 710 (5) | Low ⊕⊕ |

^athree studies showed high risk of bias; six studies were rated to have some concerns.

that utilizing diverse learning techniques, such as play-way or story book methods, yielded superior outcomes in terms of oral health promotion and knowledge acquisition in children [38]. Sharma *et al.*'s [37] unique approach using storybooks was effective fostering the creation of mental images, scenarios and memories, eliciting emotional responses in individuals. The effectiveness of these interventions can be explained by

Brain Friendly Learning Theory, which posits that learning is enhanced and more deeply ingrained in comfortable, natural conditions [39]. Emotions have been shown to impact memory formation, thereby facilitating improved learning and retention of oral health education among children. Such approaches not only alleviate classroom monotony but also effectively engage children by minimizing distractions. These findings highlight

the importance of incorporating game-based educational interventions in schools to enhance oral health knowledge and emphasize its significance to students and parents. Early awareness and education in this domain have the potential to improve not only oral health but also overall well-being of children in the long term.

This systematic review represents the first comprehensive analysis focusing on the impact of game-based learning on the oral health of school-age children. While previous studies have explored the effectiveness of similar intervention methods among visually impaired children and orphans, yielding findings that are broadly in agreement with our review [40, 41], game-based teaching methods have also demonstrated positive outcomes in other educational contexts. Notably, game-based approaches have been effective in improving learning outcomes in diverse fields among older age groups, such as system analysis courses and pharmacology instruction for Phase II medical students [42–44].

Previous studies have utilized a diverse array of interventions across varied populations. Game-based intervention for visually impaired children encompassed music and Audio Tactile Performance (ATP) technique combined with Braille [41, 45]. Other studies employed alternative intervention techniques to assess learning efficacy, such as a 3D designed game and adaptations of “PGamO” and “Who Wants to be a Millionaire” for system analysis and pharmacology instruction, respectively [42–44]. The results of these intervention techniques were consistently positive, mirroring the findings of the current review.

4.1 Overall completeness and applicability

It is important to note that the studies included in the review were conducted on a socially viable group of children with access to education, video games and schools. Therefore, the generalizability of these findings to children from diverse socioeconomic backgrounds or with limited access to educational resources should be considered with caution. It would be useful to know about the effectiveness of these interventions in other age groups and determine whether duration and permanence of change is a key issue. Some measures used relied on self-reporting, which introduces the potential for response bias.

Another limitation pertains to the relatively short follow-up period of three months in most studies. This duration may not allow for the full maturation of dental health messages and the assessment of long-term effects. Much longer follow-ups are required to demonstrate that the benefits of intervention are maintained and to assess the size of the benefit. The included trials had considerable heterogeneity related to the type of interventions. Substantial variations in the type (digital vs. non-digital games) and length of intervention were noted. Also different is the fact that some interventions were carried out with parents present, whilst in other studies independent practice was encouraged. The limited sample sizes undermine our confidence in the ability of these studies to fully address the primary objective of this review. These shortcomings may diminish the robustness of findings with small study effects.

4.2 Quality of the evidence

The body of evidence identified in this study does not allow for a robust conclusion regarding the assessment of the effectiveness of game-based teaching of oral health on school-age children. Reporting guidelines laid down in Consolidated Standards of Reporting Trials (CONSORT) or similar standards were not followed in a majority of studies. This leads to inadequate reporting on procedures that minimize selection, performance and attrition bias. Reports frequently omitted details regarding allocation concealment, randomization and lack of blinding making it challenging to fully assess the sources of bias within the studies. We accounted for this in the GRADE approach by downgrading the evidence level by two levels for serious risk of bias. The quality of evidence therefore was low, *i.e.*, we are uncertain of the estimate of the effect.

A key strength of this review is its comprehensive and rigorous search strategy, which involved multiple databases and multiple independent authors. We examined only randomized trials, considered the gold standard in research design, which enhances the validity of the review’s conclusions. However, this review is not without its limitations—specifically the small number of studies available which restricts the scope and depth of the analysis and may limit the generalizability of the findings to broader populations. We also included papers published in the English language. Despite these limitations, the review provides valuable insights into the effectiveness of game-based teaching approaches in improving oral health among children, highlighting the need for further well-designed and adequately reported studies to strengthen the evidence base in this area.

5. Conclusions

This systematic review evaluated the effectiveness of game-based teaching of oral health on children. Based on the limited evidence available, there is low-certainty evidence that game-based oral health education is effective and has the potential to engage children and make learning fun and interactive, leading to better retention of knowledge and positive behavior changes. However, the effectiveness of game-based interventions may vary depending on the design and content of the game, as well as the age of the children, societal and cultural background. Further research is needed to explore the optimal design and implementation of game-based interventions in different settings in a larger population and wider geographical locations.

AVAILABILITY OF DATA AND MATERIALS

Not applicable.

AUTHOR CONTRIBUTIONS

SP, FWL—conceptualization, formal analysis; KHA, SB—data curation; FWL, KHA—investigation, project administration, visualization; SB, SP—methodology, resources, validation; FWL, SB—software; SP, KHA—supervision; SP, SB, GM, MDB, MC, GI—roles/writing-original draft; KHA, FWL, GM, MDB, MC, GI—writing-review & editing.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Ethical approval not applicable. The review was registered in the International Prospective Register of Systematic Reviews (PROSPERO) under registration number: CRD42023428660.

ACKNOWLEDGMENT

Not applicable.

FUNDING

This research received no external funding.

CONFLICT OF INTEREST

The authors declare no conflict of interest. Giuseppe Minervini and Gaetano Isola are serving as the Editorial Board members of this journal. We declare that Giuseppe Minervini and Gaetano Isola had no involvement in the peer review of this article and have no access to information regarding its peer review. Full responsibility for the editorial process for this article was delegated to FSS.

SUPPLEMENTARY MATERIAL

Supplementary material associated with this article can be found, in the online version, at <https://oss.jocpd.com/files/article/1808331197217947648/attachment/Supplementary%20material.docx>.

REFERENCES

- [1] GHDx. Global burden of disease study 2019 (GBD 2019) reference life table. 2019. Available at: <https://ghdx.healthdata.org/record/ihme-data/global-burden-disease-study-2019-gbd-2019-reference-life-table> (Accessed: 10 April 2022).
- [2] McGrath C, Broder H, Wilson-Genderson M. Assessing the impact of oral health on the life quality of children: implications for research and practice. *Community Dentistry and Oral Epidemiology*. 2004; 32: 81–85.
- [3] Feitosa S, Colares V, Pinkham J. The psychosocial effects of severe caries in 4-year-old children in Recife, Pernambuco, Brazil. *Cad Saude Publica*. 2005; 21: 1550–1556.
- [4] Singh N, Dubey N, Rathore M, Pandey P. Impact of early childhood caries on quality of life: child and parent perspectives. *Journal of Oral Biology and Craniofacial Research*. 2020; 10: 83–86.
- [5] Filstrup SL, Briskie D, da Fonseca M, Lawrence L, Wandera A, Inglehart MR. Early childhood caries and quality of life: child and parent perspectives. *Pediatric Dentistry*. 2003; 25: 431–440.
- [6] Martins-Júnior PA, Vieira-Andrade RG, Corrêa-Faria P, Oliveira-Ferreira F, Marques LS, Ramos-Jorge ML. Impact of early childhood caries on the oral health-related quality of life of preschool children and their parents. *Caries Research*. 2013; 47: 211–218.
- [7] Stein C, Santos NML, Hilgert JB, Hugo FN. Effectiveness of oral health education on oral hygiene and dental caries in schoolchildren: systematic review and meta-analysis. *Community Dentistry and Oral Epidemiology*. 2018; 46: 30–37.
- [8] Angelopoulou MV, Kavvadia K, Taoufik K, Oulis CJ. Comparative clinical study testing the effectiveness of school based oral health education using experiential learning or traditional lecturing in 10 year-old children. *BMC Oral Health*. 2015; 15: 51.
- [9] Minervini G, Franco R, Marrapodi MM, Almeida LE, Ronsivalle V, Cicciù M. Prevalence of temporomandibular disorders (TMD) in obesity patients: a systematic review and meta-analysis. *Journal of Oral Rehabilitation*. 2023; 50: 1544–1553.
- [10] Minervini G, Franco R, Marrapodi MM, Di Blasio M, Isola G, Cicciù M. Conservative treatment of temporomandibular joint condylar fractures: a systematic review conducted according to PRISMA guidelines and the Cochrane Handbook for Systematic Reviews of Interventions. *Journal of Oral Rehabilitation*. 2023; 50: 886–893.
- [11] Minervini G, Franco R, Marrapodi MM, Di Blasio M, Ronsivalle V, Cicciù M. Children oral health and parents education status: a cross sectional study. *BMC Oral Health*. 2023; 23: 787.
- [12] Beemer LR, Ajibewa TA, DellaVecchia G, Hasson RE. A pilot intervention using gamification to enhance student participation in classroom activity breaks. *International journal of environmental research and public health*. 2019; 16: 4082.
- [13] Liu HY, Chen PH, Chen WJ, Huang SS, Chen JH, Yao CT. The effectiveness of a board game-based oral hygiene education program on oral hygiene knowledge and plaque index of adults with intellectual disability: a pilot study. *International Journal of Environmental Research and Public Health*. 2021; 18: 946.
- [14] Lin GSS, Tan WW, Tan HJ, Khoo CW, Afrashtehfar KI. Innovative pedagogical strategies in health professions education: active learning in dental materials science. *International Journal of Environmental Research and Public Health*. 2023; 20: 2041.
- [15] Haoran G, Bazakidi E, Zary N. Serious games in health professions education: review of trends and learning efficacy. *Yearbook of Medical Informatics*. 2019; 28: 240–248.
- [16] Stern SB. Creative teaching strategies. *The Journal of Continuing Education in Nursing*. 1989; 20: 95–96.
- [17] Minervini G, Franco R, Marrapodi MM, Fiorillo L, Cervino G, Cicciù M. Post-traumatic stress, prevalence of temporomandibular disorders in war veterans: systematic review with meta-analysis. *Journal of Oral Rehabilitation*. 2023; 50: 1101–1109.
- [18] Drummond D, Hadchouel A, Tesnière A. Serious games for health: three steps forwards. *Advances in Simulation*. 2017; 2: 1–8.
- [19] Hainey T, Connolly TM, Boyle EA, Wilson A, Razak A. A systematic literature review of games-based learning empirical evidence in primary education. *Computers & Education*. 2016; 102: 202–223.
- [20] Clark DB, Tanner-Smith EE, Killingsworth SS. Digital games, design, and learning: a systematic review and meta-analysis. *Review of Educational Research*. 2016; 86: 79–122.
- [21] Ogershok PR, Cottrell S. The pediatric board game. *Medical Teacher*. 2004; 26: 514–517.
- [22] D'Alessandro DM, Ellsbury DL, Kreiter CD, Starmer T. Pediatric jeopardy may increase residents' medical reading. *Ambulatory Pediatrics*. 2002; 2: 1–3.
- [23] Thatcher DC. Promoting learning through games and simulations. *Simulation & Gaming*. 1990; 21: 262–273.
- [24] Obikwelu C, Read JC. The serious game constructivist framework for children's learning. *Procedia Computer Science*. 2012; 15: 32–37.
- [25] Kumar Y, Asokan S, John B, Gopalan T. Effect of conventional and game-based teaching on oral health status of children: a randomized controlled trial. *International Journal of Clinical Pediatric Dentistry*. 2015; 8: 123–126.
- [26] Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, *et al*. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *Systematic Reviews*. 2021; 10: 89.
- [27] Minervini G, Franco R, Marrapodi MM, Fiorillo L, Cervino G, Cicciù M. The association between parent education level, oral health, and oral-related sleep disturbance. An observational cross-sectional study. *European Journal of Paediatric Dentistry*. 2023; 24: 218–223.
- [28] Schiavo JH. PROSPERO: an international register of systematic review protocols. *Medical Reference Services Quarterly*. 2019; 38: 171–180.
- [29] Higgins JP, Savović J, Page MJ, Elbers RG, Sterne JA. Assessing risk of bias in a randomized trial. *Cochrane Handbook for Systematic Reviews of Interventions*. 2019; 23: 205–228.
- [30] Akaltan KF, Önder C, Vural Ç, Orhan K, Akdoğan N, Atakan C. The effect of game-based learning on basic life support skills training for undergraduate dental students. *Journal of Dental Education*. 2023; 87: 1458–1468.

- [31] Aljafari A, Gallagher JE, Hosey MT. Can oral health education be delivered to high-caries-risk children and their parents using a computer game?—A randomised controlled trial. *International Journal of Paediatric Dentistry*. 2017; 27: 476–485.
- [32] K RSK, Deshpande AP, Ankola AV, Sankeshwari RM, Jalihal S, Hampiholi V, Khot AJP, Hebbal M, Kotha SL, S LK. Effectiveness of a visual interactive game on oral hygiene knowledge, practices, and clinical parameters among adolescents: a randomized controlled trial. *Children*. 2022; 9: 1828.
- [33] Nourian A, Motamed N, Samanipour M. Designing and development of an oral health educational game and evaluation of its effect on 8–12-year-old children’s oral health: a randomized clinical. *Journal Dental School*. 2018; 38: 104–109.
- [34] 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. *International Journal of Clinical Pediatric Dentistry*. 2017; 10: 257–260.
- [35] Aljafari A, Elkarmi R, Nasser O, Atef A, Hosey MT. A video-game-based oral health intervention in primary schools—a randomised controlled trial. *Dentistry Journal*. 2022; 10: 1–11.
- [36] Kashyap P, Reddy LvK, Sinha P, Verma I, Adwani J. Effectiveness of game-based oral health education method on oral hygiene performance of 12-year-old private school children in Lucknow City: a field trial. *Journal of Indian Association of Public Health Dentistry*. 2022; 20: 43.
- [37] Sharma A, Singh A, Dar MA, Kaur RJ, Charan J, Iskandar K, *et al*. Menace of antimicrobial resistance in LMICs: current surveillance practices and control measures to tackle hostility. *Journal of Infection and Public Health*. 2021; 15: 172–181.
- [38] Krätzig GP, Arbutnott KD. Perceptual learning style and learning proficiency: a test of the hypothesis. *Journal of Educational Psychology*. 2006; 98: 238–246.
- [39] Telner D, Bujas-Bobanovic M, Chan D, Chester B, Marlow B, Meuser J, *et al*. Game-based versus traditional case-based learning: comparing effectiveness in stroke continuing medical education. *Canadian Family Physician Medecin de Famille Canadien*. 2010; 56: e345–e351.
- [40] Hapsari NT, Suwargiani AA, Zubaedah C. Oral hygiene status of the orphan children in Ar-Rohman Foster Home Bandung after dental health education. *Padjadjaran Journal of Dentistry*. 2017; 29: 178–181.
- [41] Shariffard N, Sargeran K, Gholami M, Zayeri F. A music- and game-based oral health education for visually impaired school children; multilevel analysis of a cluster randomized controlled trial. *BMC Oral Health*. 2020; 20: 1–9.
- [42] Cheung SY, Ng KY. Application of the educational game to enhance student learning. *Frontiers in Education*. 2021; 6: 623793.
- [43] Cheng CH, Su CH. A Game-based learning system for improving student’s learning effectiveness in system analysis course. *Procedia—Social and Behavioral Sciences*. 2012; 31: 669–675.
- [44] Anupama M, Gudadappanavar, Jyoti M, Benni SBJ. Effectiveness of the game-based learning over traditional teaching–learning strategy to instruct pharmacology for Phase II medical students. *Journal of Education and Health Promotion*. 2021; 10: 91.
- [45] Gautam K, Ali Ar, Agrawal D, Choudhary A, Shekhawat A, Jain R. New vision for improving oral hygiene status of visually impaired students aged from 9 to 17 years. *Journal of Family Medicine and Primary Care*. 2020; 9: 5303.

How to cite this article: Shankargouda Patil, Frank W Licari, Shilpa Bhandi, Kamran H Awan, Marco Di Blasio, Gaetano Isola, *et al*. Effect of game-based teaching on the oral health of children: a systematic review of randomised control trials. *Journal of Clinical Pediatric Dentistry*. 2024; 48(4): 26-37. doi: 10.22514/jocpd.2024.075.