EFFECTIVE ORAL HEALTH INTERVENTIONS FOR DISADVANTAGED SCHOOLCHILDREN: A SYSTEMATIC REVIEW

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Abstract
Children from rural and low socioeconomic backgrounds face persistent inequalities in oral health, specifically dental caries, and periodontal diseases. This review aimed to identify effective interventions for promoting oral health and preventing oral diseases among primary schoolchildren from rural and low socioeconomic backgrounds. We conducted a comprehensive search using PubMed, MEDLINE and CINAHL via EBSCOhost, Cochrane Library, Web of Science, and Dentistry and Oral Sciences databases for English publications from 2000 to 2022. We included both randomised and non-randomised controlled trials that evaluated promotive and preventive oral health interventions targeting primary schoolchildren from rural and low socioeconomic backgrounds. Measured outcomes encompassed changes in dental caries status, periodontal disease status, oral hygiene status or practices, sugar consumption, or smoking behaviours. Two reviewers independently screened the articles, performed data extraction using a standardised form, and assessed the risk of bias using the Cochrane Risk of Bias 2 (RoB 2) and Risk of Bias in Non-randomized Studies - of Interventions (ROBINS-I) tools. Given the substantial heterogeneity, a narrative analysis was undertaken. Of the 35 included studies, the interventions identified as effective were health and oral health education (n=20), establishment of school or community health policies (n=5), fissure sealants (n=4), professionally applied topical fluoride (n=10), supervised toothbrushing (n=7), provision of free toothbrush and toothpaste (n=1), and fluoride mouth rinse (n=2). These interventions were found to be effective in addressing caries (n=15), periodontal disease (n=2), oral hygiene (n=2), sugar consumption (n=6) and tobacco use (n=2). However, many of the included studies have a high risk of bias. Despite the risk, these findings represent the best available evidence and serve as insights into effective interventions for disadvantaged schoolchildren. Future well-designed studies are required to provide high-quality evidence. The findings indicate that a comprehensive intervention involving both clinical prevention and oral health promotion can significantly improve the oral health of disadvantaged primary schoolchildren.

Keywords: Children, Intervention, Low Socioeconomic, Oral Health Promotion, Prevention, Rural

Introduction

The burden of oral disease is socially patterned and exhibits strong social gradients, disproportionately affecting the most disadvantaged population groups within and across societies, throughout their life course (1). In Malaysia, disadvantaged schoolchildren from low socioeconomic backgrounds, as well as those from rural areas, consistently show a higher prevalence and severity of oral diseases than the national average (2, 3). Similarly, in countries such as the United Kingdom (4) and the Netherlands (5), disadvantaged children from low-income households remain more susceptible to dental caries. In Australia, a lower parental education level has been identified as a predictor of dental caries among children (6). Poor oral health-related behaviours also reportedly follow the same social gradient; the consumption of sugar-sweetened beverages (7, 8) and cigarette smoking (9) are significantly higher among children from

underserved, rural communities. An approach to dentistry that heavily relies on advanced technology for treatment might not be practical or achievable for disadvantaged populations because even in well-resourced areas, curative dentistry fails to adequately address the needs of a significant portion of the population (10). Therefore, it is essential for public health strategies to focus on effective interventions that are promotive and preventive to improve the oral health behaviours and outcomes of this target population.

Interventions that have been implemented to tackle the disparities in oral health vary widely. At the population level, water fluoridation studies have been conducted extensively in the past, with the majority of studies published before 1975. A recent review concluded that there is insufficient information to determine whether the initiation of a water fluoridation program results in a change in disparities in caries across socioeconomic status (SES) levels (11). The use of fluoridated toothpaste, professionally applied fluoridated varnishes and gels, as well as fluoridated mouth rinses has also been studied in various populations.

Additionally, interventions such as oral health education (OHE) aim to improve oral health outcomes through the improvement of oral health behaviours. The method of imparting OHE to the target group is also crucial; OHE through the provision of motivational interviewing to caregivers has shown a greater impact in reducing caries among the lower-income group than the conventional OHE (12). Interventions that are multi-component and holistic in nature, and that create a healthier and more supportive environment such as school-based toothbrushing policies also yield favourable outcomes for schoolchildren from low socioeconomic backgrounds (13).

Several reviews have examined the effectiveness of interventions that promote oral health among children at the community, school, and individual levels. The effectiveness of community-based, population-level interventions was examined; however, this review did not provide insight into the effectiveness of interventions specifically for children of primary school age and low socioeconomic backgrounds (14). Similarly, a more recent review examined school-based interventions to improve the oral health of schoolchildren below 18 years old, but the search and findings did not address the differential effects between the different socioeconomic status groups of the study population (15). Additionally, these reviews did not include intervention studies that target risk behaviour prevention related to both oral diseases and other non-communicable diseases, such as sugar consumption and smoking, which may have the potential to be effective at improving oral health outcomes in this target population. Thus, this systematic review aims to comprehensively evaluate the effectiveness of promotive and preventive oral health interventions for improving the oral health of primary schoolchildren from rural and low socioeconomic backgrounds.

Materials and Methods

The protocol for this systematic review was developed based on the Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols (PRISMA-P) (16) and registered in PROSPERO (Registration number: CRD42022344898).

Developing a research question

The PICO (Population, Intervention, Comparator, Outcome) framework was employed to develop the research question as shown in Table 1.

Table 1: PICO framework

Framework		Concepts
P	Population	Primary schoolchildren from rural and low socioeconomic backgrounds
I	Intervention	Any form of preventive oral health interventions including: ● Toothbrushing with fluoridated toothpaste ● Topical fluoride ● Fissure sealants ● Water fluoridation Any form of promotive oral health interventions including: ● Oral health education (conventional or game-based, motivational interviewing sessions) ● Oral health promotion activities ● School healthy food policies, toothbrushing policies, sugar restriction policies, oral health promotion through a common risk factor approach
C	Comparator	Comparison group with alternative intervention or no intervention

O	Outcome	Oral health outcomes are as follows: ● Caries status ● Periodontal disease status ● Plaque status Changes in oral health behaviours; ● Toothbrushing and flossing practices Changes in oral health-related behaviours; ● High sugar diet ● Smoking

Based on this framework, the research question for this review is:

"Which promotive and preventive oral health interventions are effective in enhancing the oral health outcomes of primary schoolchildren from rural and low socioeconomic backgrounds?"

Eligibility criteria

For this review, to be included, the studies must fulfil the following criteria:

a) Type of studies

Primary studies of randomised or non-randomised controlled trials that examine the effectiveness of promotive and preventive interventions for improving the oral health of primary schoolchildren from rural and low socioeconomic backgrounds were included. The included studies must also be available in full text, written in English or Malay language (Bahasa Malaysia), and published from the year 2000 onwards.

b) Type of participants

Studies with participants comprising primary schoolchildren from rural and low socioeconomic backgrounds were included. We also included studies with participants from diverse socioeconomic backgrounds, or both rural and urban populations if the reported results were stratified by these factors. In this review, primary schoolchildren are defined as children attending primary schools in the respective population, or children aged 6 to 12 years old. Low socioeconomic background refers to a low-income household, low parental education level, or fulfilment of the income/employment deprivation index according to the respective country's measure of deprivation. Rural is defined as a place of living that is not urban, and is described in the context of poverty, geographical isolation, or deprivation of access to healthcare.

c) Type of interventions

Studies that assessed the effectiveness of one or a combination of preventive and promotive oral health interventions were considered, such as the provision of systemic or topical fluorides and school-based oral health programmes. Interventions that assessed the effectiveness of risk behaviour prevention were also included, such as school food policies to reduce the consumption of sugars, or smoking prevention programmes. The interventions were either performed directly with the children or by proxy through parents, teachers, or caregivers in any setting. These studies either compared the intervention group with a control group that involved a different intervention, or no intervention.

d) Type of outcomes

The included studies reported the baseline and post-intervention measurements, or changes or increments in oral health status, at any follow-up period, of one or more of the following outcomes:

- Caries status (i.e., changes or increment in caries incidence, prevalence and experience), including the status of incipient lesions, measured as decayed, missing, and filled deciduous teeth/surfaces (dmft/s), Decayed, Missing, and Filled permanent teeth/surfaces (DMFT/S), or the International Caries Detection and Assessment System (ICDAS).
- Periodontal disease status, including both gingivitis and periodontitis, such as changes or increments in periodontal disease incidence, prevalence, and clinical parameters (e.g., clinical attachment level, probable pocket depth, and bleeding on probing).
- Oral hygiene status, such as changes or increments in plaque scores from any clinical plaque or oral hygiene index.
- Oral health behaviours, such as changes or increments in oral hygiene practices (e.g., toothbrushing or flossing practice) and oral health-related behaviours (e.g., sugar consumption, sugar-sweetened beverage intake or smoking behaviour).

Information sources

Searches were conducted on PubMed, MEDLINE via EBSCOhost, Cumulative Index to Nursing and Allied Health Literature (CINAHL) via EBSCOhost, Cochrane Library, Web of Science and Dentistry and Oral Sciences databases for studies published from 2000

to 2022. This timeframe was selected to capture the most recent interventions, ensuring the inclusion of contemporary and relevant evidence in the review. The reference lists of existing systematic reviews relevant to the study were also searched individually to identify relevant papers.

Search strategy

Prior to the search in the electronic databases, a list of medical subheadings (MeSH) and text words were identified from the MeSH databases and relevant systematic reviews and primary papers (list provided as supplementary). Additionally, both British and American English spelling were taken into consideration. The search strategy involved only two main concepts: the type of participants and the interventions of interest, as previously defined by the eligibility criteria. This was done to ensure that all relevant studies were included. The search terms were finalised through discussion with experts in the field and an information specialist from Universiti Malaya Medical Library. Using Boolean operators, the search terms within the same concept were combined using "OR". Subsequently, both concepts were combined using "AND". The search was conducted according to the respective database interface.

Data management

For data management, search results from the databases were first imported to Endnote to facilitate the removal of duplicates. To maintain transparency and consistency in the review process, a comprehensive list of all studies was compiled in Microsoft Excel. This allowed for efficient tracking and recording of agreements between the review authors.

Study selection

The study selection was conducted independently by two reviewers. To ensure the reliability of the selection, both reviewers underwent a calibration exercise i.e., pilot testing in which both reviewers screened 100 abstracts against the pre-determined eligibility criteria. The Kappa score targeted for this exercise was 0.8 or higher. The study selection process was then conducted in two stages. In the first stage, two reviewers independently screened the titles and abstracts based on the eligibility criteria. Subsequently, the reviewers independently reviewed the full text of the eligible studies identified in the first stage. Disagreements at all stages were resolved through discussion and reaching a consensus.

Data extraction

Due to time constraints, the data from the included studies were extracted by one reviewer and checked for accuracy by another (17). This was done using a Microsoft Excel data extraction form that was first piloted on a minimum of ten primary papers. Disagreements were resolved through discussion and reaching a consensus.

Data items

The data extraction form included general information (study citation, year of publication, and country), study design, participant characteristics, intervention characteristics, control or comparator group, outcome of interest, and quality assessment. Disagreements were resolved through discussion and reaching a consensus or, if necessary, with the involvement of a third review author.

Risk of bias in individual studies

The Cochrane Collaboration's tools for assessment of the risk of bias were used. For randomised controlled trials, the Risk of Bias 2 (ROB2) tool was used. For non-randomised controlled trials, the Risk of Bias in Non-randomised Studies – of Interventions (ROBINS-I) was utilised. This assessment was done by the two reviewers independently, and disagreements were resolved through discussion and mutual agreement.

Data synthesis

In the protocol, both narrative and quantitative analyses were planned for data synthesis. However, due to substantial heterogeneity in interventions and outcomes, only narrative synthesis was conducted in this review.

Results

The results of the present review are reported and presented following the PRISMA guideline (18) and presented according to the following: study selection, study characteristics, risk of bias of included studies, and summary of outcomes.

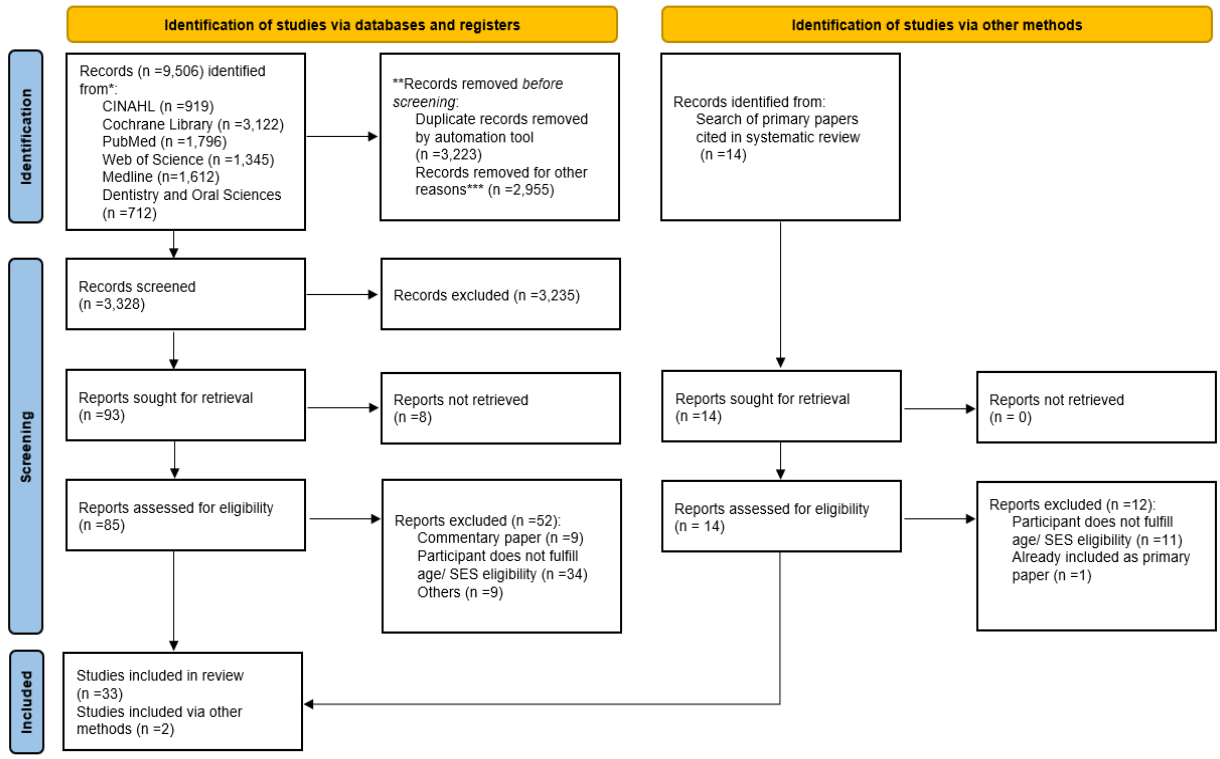

Figure 1: PRISMA flow diagram

Study selection

The overall study selection process is shown in Figure 1. A systematic search was performed on the selected databases, yielding a total of 9,506 potential studies. Subsequently, 3,223 duplicates were removed. Next, 2,955 studies were further excluded as the articles were either published before the year 2000, not in the English language, or were study protocols. During the evaluation of titles and abstracts, an additional 3,235 irrelevant articles were excluded. During the evaluation of titles and abstracts, an additional 3,289 irrelevant articles were excluded. The assessment of titles and abstracts demonstrated a high level of agreement between the two reviewers (AN and AH), with an inter-rater agreement percentage of 99.6%. Discrepancies that arose during the process were resolved through discussions between the reviewers. Eight authors were contacted via ResearchGate for the full texts of their studies that were not accessible, however, no replies were received despite multiple follow-ups. The eight studies were then excluded, leaving 85 full texts for further assessment. During the full-text assessment, another 14 potential papers were identified through the bibliographies of the retrieved articles. At the end of the full-text assessment, 64 papers were excluded, culminating in a total of 35 papers for inclusion in this review. Reasons for exclusion for these articles are provided as supplementary documents.

Study characteristics

Overall, eleven of the included studies were conducted in Asia (13, 19-28), nine in Europe (29-37), eight in North America (38-45), six in South America (46-51), and one in Africa (52). Most of the included studies were randomised controlled trials (19, 20, 22-35, 39, 41-47, 49-51), and the remaining eight were non-randomised controlled trials (13, 21, 36-38, 40, 48, 52). In terms of the setting in which the interventions were delivered, most of the studies used a school-based setting (13, 19, 20, 22, 23, 25-28, 30-41, 46, 47, 49-52). The remaining seven studies were community-based interventions (21, 24, 42-45, 48), and one study was a hospital-

based intervention (29). The interventions of the included studies were categorised into health and oral health education (n=20) (19, 20, 23, 24, 26, 28, 29, 35, 37-39, 42-45, 48-52), school and community health policies (n=5) (13, 37, 40, 41, 44), fissure sealants (n=4) (13, 21, 27, 30), professionally applied topical fluoride (n=10) (13, 19, 21, 22, 25, 28, 32, 36, 46, 47), supervised toothbrushing (n=7) (13, 25, 31, 32, 38, 47, 48), provision of free toothbrush and toothpaste (n=1) (31), and fluoride mouth rinse (n=2) (13, 34).

Caries outcomes

Among the included studies, 15 reported effective interventions for improving caries outcomes among primary schoolchildren from rural and low socioeconomic backgrounds (19-21, 24, 25, 27, 28, 30-33, 36, 46, 47, 49). Two of the interventions were OHE (20, 24), and one was a combination of OHE and motivational interviewing (49). Another three studies involved the use of dental sealants (21, 27, 30), and four involved professional topical fluoride application (19, 28, 32, 46). School-based supervised toothbrushing was found to be effective in four studies (25, 31, 33, 47) while slow-releasing fluoride device was effective in one study (36). Table 2 summarises the findings reported in the included studies.

Periodontal outcomes

Two studies reported effectiveness on periodontal outcomes (24, 48). School-based OHE delivered to schoolchildren, teachers, and caregivers through talks, videos, and pamphlets as intervention was found to be effective in one study (24), and another involved OHE in combination with dental prophylaxis and supervised toothbrushing and flossing (48). These findings are presented in Table 3.

Oral hygiene status

Table 4 outlines the findings of two studies that reported effective interventions for improving oral hygiene (48, 49). One study employed OHE in combination with dental prophylaxis and supervised toothbrushing and flossing as an intervention (48), and another used OHE in combination with motivational interviewing delivered to parents of children with high caries risk (49).

Added sugar consumption

Six studies reported effective interventions for reducing added sugar consumption as summarised in Table 5 (39-41, 45, 50, 51). Of these, four involved repeated health and nutritional education focused on reducing the intake of sugar-sweetened beverages (SSB) (39, 45, 50, 51). Another two studies employed school-based policies that create a healthy environment through the provision of healthy school meals, regulation of vending machine content as well as tailored health education (40, 41).

Tobacco consumption

Two studies reported an effective intervention against tobacco consumption, both involving school-based health and oral health education (Table 6) (24, 26).

Table 2: Summary of effective interventions on dental caries outcomes (n=15)

No	Author (Year)	Summary of intervention	Outcome measurement		Results
1	Chellappa et al. (2020)	OHE for schoolchildren in a one-off 3-day programme, delivered by teachers who were trained in OHE	DMFT, dmft	Primary & permanent dentition	Significantly lower caries increment in primary teeth of the intervention group than control group.
2	Gonzalez-Del-Castillo-McGrath et al. (2014)	OHE + motivational interviewing (MI) for parents, delivered by counsellors certified in MI	ICDAS	Primary and permanent dentition	Significantly lower caries increment in the intervention group than in the control group.
3	Ikhar et al. (2020)	OHE for schoolchildren is delivered through videos, talks, and pamphlets	DMFT/dmft	Unclear	Significantly lower caries prevalence in the intervention group than in the control group.

No	Author (Year)	Summary of intervention	Outcome measurement		Results
4	Agrawal & Pushpanjali (2011)	1.23% APF gel + OHE	Caries: DMFT, DMFS Incipient lesion: Nyvad	Permanent dentition	Significant reduction of incipient lesions in the test group to the control group.
5	Arruda et al. (2011)	5% Sodium fluoride varnish	DMFS	Permanent dentition	Significantly lower caries increment among the intervention group than the control group.
6	Wu et al. (2019)	5% Sodium fluoride varnish + OHE	ICDAS, DMFT, DMFS	Permanent dentition	Significantly lower prevalence of caries in the intervention group than control group. Significantly lower caries increment in the intervention group compared with the control group.
7	Hardman et al. (2007)	22,600-ppm fluoride varnish application + provision of toothbrush and 1,450-ppm fluoridated toothpaste	DMFS, dmfs	Primary and permanent dentition	Significantly lower caries increment in small enamel lesions of primary molars.
8	Dulgergil et al. (2005)	OHE + Glass ionomer sealants + fluoride varnish (Duraphat)	DMFT, DMFS, dmft, dmfs	Primary & permanent dentition	Significantly lower caries increment in the intervention group than control group for permanent teeth.
9	Cagetti et al. (2015)	Group 1: GIC fissure sealant Group 2: resin-based fissure sealant	dmfs	Primary dentition (second molar)	Significantly lower caries prevalence and increment of primary second molars in the GIC group than in the resin-based or non-resin-based group.
10	Tahani et al. (2020)	Resin-based fissure sealant	ICDAS	Permanent dentition (first molars)	Risk of caries incidence in non-sealed teeth was almost three times more than sealed teeth.
11	Curnow et al. (2002)	Supervised toothbrushing with 1,000-ppm fluoridated toothpaste	DFS, dfs	Primary & permanent dentition	Significantly lower caries increment in permanent molars of intervention group than control group.
12	Ferrerira et al. (2005)	Group 1: Weekly supervised toothbrushing with non-fluoridated toothpaste + 1.23% APF gel Group 2: weekly supervised toothbrushing with non-fluoridated toothpaste + placebo	DMFS	Permanent dentition (upper incisors)	Significantly higher arrested white spot lesions in both test groups than control group.
13	Jackson et al. (2004)	Supervised toothbrushing with 1,450-ppm fluoridated toothpaste	DMFS, dmfs	Primary and permanent dentition	Significantly lower caries increment of primary teeth in the intervention group than control group.

No	Author (Year)	Summary of intervention	Outcome measurement		Results
14	Ruff et al. (2021)	Grp 1: EHCP (daily toothbrushing with 1,450-ppm fluoridated toothpaste) Grp 2: EHCP + dental treatment Grp 3: EHCP + fluoride gel once a week	DMFT, DMFS	Permanent dentition	Significantly lower caries increment in Group 3 (receiving EHCP + Fluoride gel) than the control group in both DMFT and DMFS. Significantly lower caries increment in Group 2 than the control group in both DMFT and DMFS. No significant difference in caries increment between Group 1 and the control group.
15	Toumba et al. (2005)	Slow-releasing fluoride device	DMFS, dmfs	Primary and permanent dentition	Significantly lower caries increment in the intervention group than control group for primary and permanent dentitions

Table 3: Summary of effective interventions on periodontal outcomes (n=2)

No	Author (Year)	Summary of intervention	Outcome measurement	Results
1	Freitas-Fernandes et al. (2002)	OHE + prophylaxis + supervised toothbrushing and flossing	Gingival Index (GI) by Loe	Statistically significant reduction of BoP in the experimental group than the control group.
2	Ikhar et al. (2020)	OHE for schoolchildren is delivered through videos, talks, and pamphlets	Unclear	Significant reduction in periodontal disease in the intervention group than the control group.

Table 4: Summary of effective interventions on oral hygiene or plaque outcomes (n=2)

No	Author (Year)	Summary of intervention	Outcome measurement	Results
1	Freitas-Fernandes et al. (2002)	OHE + prophylaxis + supervised toothbrushing and flossing	Plaque Index (PI) by Loe	Statistically significant increase in tooth surface without visible plaque in the intervention group than control group.
2	Gonzalez-Del-Castillo-McGrath et al. (2014)	OHE + six sessions of motivational interviewing (MI) given to parents of children with high caries risk	Plaque Score Index by O'Leary	Significantly lower dental plaque score in the experimental than in the control group.

Table 5: Summary of effective interventions on added sugar consumption

No	Author (Year)	Summary of intervention	Outcome measurement	Results
1	Contento et al. (2010)	Health education taught by science teachers as obesity prevention for schoolchildren delivered through the school curriculum	EatWalk Survey (modified Food Frequency Questionnaire)	Consumption of SSB is significantly less in both frequency and size in the intervention group.

No	Author (Year)	Summary of intervention	Outcome measurement	Results
2	Cunha et al. (2013)	9 sessions of health education as obesity prevention for schoolchildren, teachers and caregivers delivered by a nutritionist.	Food Frequency Questionnaire	Statistically significant reduction in the consumption of SSB and cookies in the intervention group than the control group
3	Sichieri et al. (2008)	Health education focused on reducing SSB	24-hour dietary recall	Statistically significant decrease in the daily consumption of SSB in the intervention group to the control group.
4	Wang et al. (2019)	6-week SSB prevention education consisted of 12 group-based weekly sessions (1-h sessions twice a week) delivered by trained staff.	The survey was adapted from the Youth Risk Behavior Surveillance (YRBS) survey and a validated youth food-frequency questionnaire.	Statistically significant reductions in SSB consumption in the intervention group compared to the control group.
5	Folta et al. (2013)	School environment policy, i.e., free healthy breakfast, taste tests to encourage healthy eating, Walk-to-School campaign to encourage physical exercise, training of the school food service to provide healthy lunches, contests, and educational newsletters to parents.	68-item Family Survey Form	Statistically significant reduction of SSB in the test group compared with the control group.
6	Hawkins et al. (2018)	School environment policy includes: 1) Regulation of school food environment according to nutrition recommendations, control of fast food advertisement & vending machine contents 2) Targeted and individualised health education according to weight status to change dietary behaviour	Digital photography of food: Remote Food Photography Method (RFPM)	Added sugar consumption significantly decreased in the intervention group than the control group.

Table 6: Summary of effective interventions for tobacco consumption

No	Author (Year)	Summary of intervention	Outcome measurement	Results
1	Ikhar et al. (2020)	OHE for schoolchildren delivered through videos, talks, and pamphlets	Tobacco consumption: WHO questionnaire for addiction to tobacco	Statistically significant reduction in consumption of tobacco products in the intervention group than the control group.
2	Saraf et al. (2014)	Health education Health education on diet, exercise and smoking through three components: school, classroom and family/community	Self-administered questionnaire on tobacco (knowledge and use)	Significantly lower prevalence of current smokers in the intervention group at follow-up than control

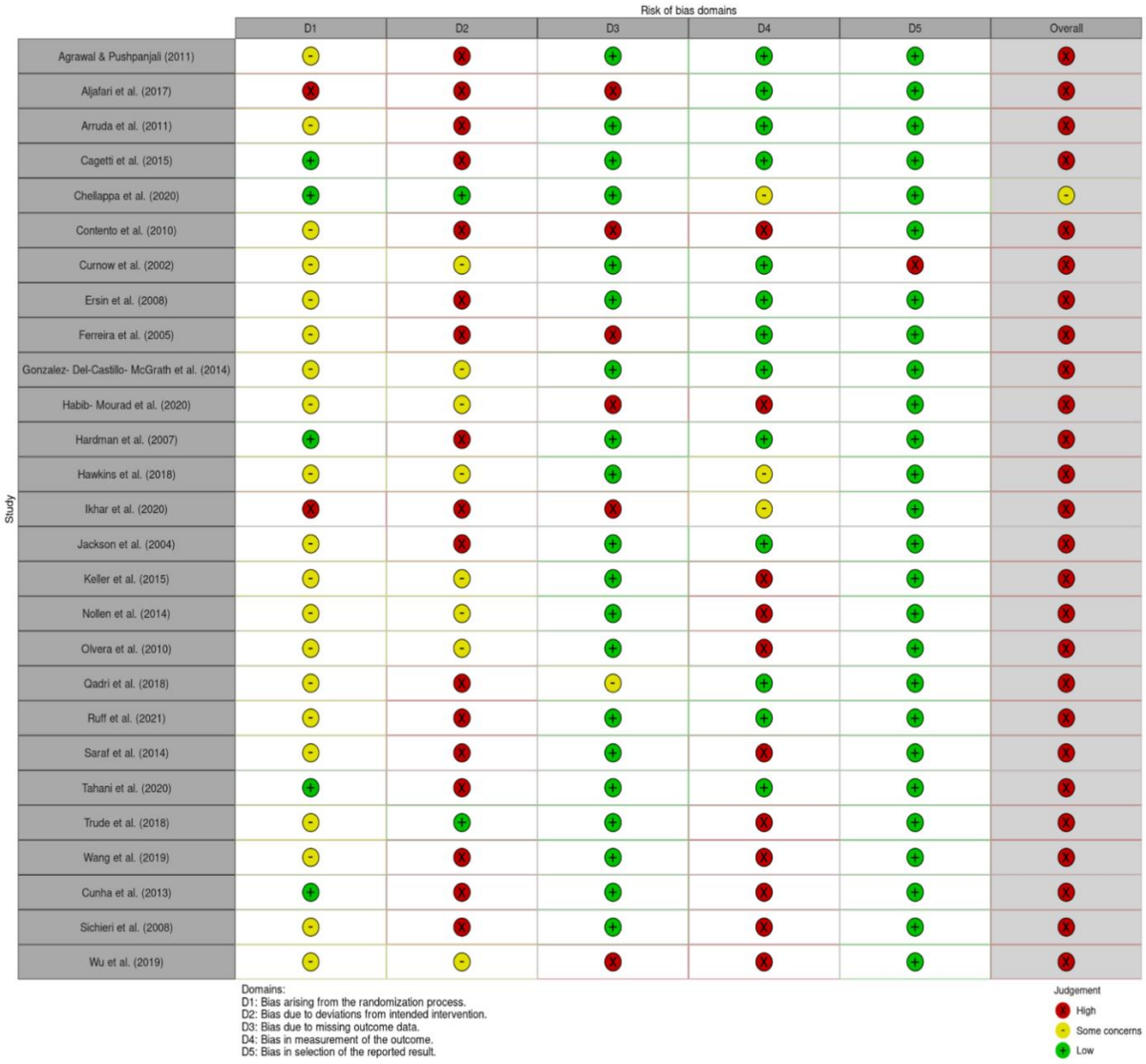

Figure 2: Risk of bias graph of included randomised controlled trials

Figure 3: Risk of bias graph of included non-randomised controlled trials

Risk of bias of included studies

Figure 2 and Figure 3 show the risk of bias in all included studies. Of the 27 RCTs, 26 were rated as having a high overall risk of bias (20, 22-27, 29-35, 39, 41-47, 49-51) mainly due to the high risk of bias in Domain 2 of the ROB 2 tool. Among the non-randomised controlled trials, three were rated as having low or moderate overall risk of bias (13, 21, 38), while the remaining five were considered to have a serious overall risk of bias (36, 37, 40, 48, 52).

Discussion

Despite the overall decline in dental caries over the past few decades, inequalities in oral health, particularly in dental caries, continue to exist (53). To address the disparities in oral health outcomes across socioeconomic status, it is crucial to implement a holistic approach to healthcare intervention that places priority on promotive and preventive measures (1, 54). Such an intervention must consist of a range of actions that comprehensively and effectively tackle the multifaceted nature of oral diseases (1, 54) and are tailored to the specific needs of the target population (55). This requires the use of the best available evidence that has been proven to be effective for this target population.

Most included studies utilised a school-based setting (13, 19, 20, 22, 23, 25-28, 30-41, 46, 47, 49-52). Given the influence that schools have on children's health outcomes (56), the prevalent use of school-based settings in the studies is expected. School-based interventions are also in line with the Health Promoting Schools concept advocated by the World Health Organization (57). This review also shows there is little evidence to suggest that the use of OHE alone is effective in improving caries among disadvantaged schoolchildren, regardless of the method of delivery. This conclusion is supported by a previous systematic review where most studies with

solely OHE as an intervention were ineffective in reducing inequalities in the oral health of schoolchildren (58). It was also revealed that topical fluoride interventions are essential to effectively address the issue of dental caries among these children (13, 19, 21, 22, 25, 28, 32, 36, 46, 47).

Oral health education, delivered repeatedly, was found to be crucial in preventing poor oral health behaviours among these disadvantaged schoolchildren, particularly in terms of added sugar consumption. In this review, exposure to health and nutritional education was found to need repetitive implementation and a long-term approach for this target population of disadvantaged schoolchildren (39, 45, 50, 51). This aligns with the findings of a study that emphasised the importance of repetition and reinforcement in sustaining the effectiveness of school-based OHE programmes, compared to the implementation of one-time OHE programmes (59). Additionally, the multiple studies from this review that employed daily supervised toothbrushing are also another example of repetitive exposure to an intervention that could potentially improve the behaviours of disadvantaged children, which resulted in a significantly lower dental caries increment (25, 31, 33, 47).

The delivery of OHE through video games or mobile applications was found not to be significantly better than the conventional OHE in improving the oral health of disadvantaged schoolchildren despite the provision of devices to the test subjects (29, 42). This contradicts evidence from similar studies that were conducted on urban children, where innovative delivery of OHE using mobile applications and video games was found to be effective (60, 61). However, this seems to be in line with studies which conclude that interventions, particularly technology-driven ones, tend to produce health inequality as they are more accessible to, adopted more frequently by, adhered to, or more effective in socioeconomically advantaged groups such as those with more resources or education (62, 63).

One study from this review found motivational interviewing to be beneficial when implemented with the conventional OHE on parents of schoolchildren with high caries risk, compared to the delivery of conventional OHE alone (49). This aligns with findings from similar studies conducted with preschool children, where the effectiveness of motivational interviewing is likely attributed to parental involvement and empowerment (12, 64).

School-based policies that create a healthy environment through the regulation of school meals were also found to be successful in reducing sugar consumption behaviour among disadvantaged children (40, 41). In this review, these school policies were established in conjunction with the provision of tailored health education to schoolchildren. This is in line with the health promotion strategies outlined by the WHO, which advocate for healthy public policies and supportive environments (65). Tackling upstream factors such as the regulation of the school environment is recommended to better support vulnerable populations to reduce inequalities in oral health, in combination with midstream and downstream factors (66, 67).

This review has several limitations. Firstly, there is a high overall risk of bias in most included studies, which is consistent with findings from another similar systematic review (14). This can lead to an underestimation or overestimation of the true intervention effect, thus requiring a cautious interpretation of findings (68). However, the findings from this review may still be useful as they represent the best currently available evidence. By identifying and synthesising effective interventions, the outcomes of this study can inform the development of targeted and impactful approaches to address oral health disparities among disadvantaged schoolchildren from rural and low socioeconomic backgrounds. Secondly, the use of narrative synthesis, although appropriate given the heterogeneity of interventions and outcomes to address the research question, could potentially introduce bias in reporting as it lacks objectivity compared to quantitative analysis, because it relies on the interpretation and judgement of the reviewer (69).

Despite the limitations of this review, it is worth noting that in addressing oral health disparities, particularly among disadvantaged schoolchildren from rural and low socioeconomic backgrounds, a multifaceted, evidence-based, and targeted approach that focuses on oral health promotion and prevention is imperative. While individual interventions offer insights, a holistic, evidence-based approach grounded in continuous research and assessment will maximise effectiveness and ensure sustainable, equitable oral health outcomes.

Conclusion

The review findings indicate that a comprehensive, school-based oral health intervention which involves both clinical prevention and oral health promotion can positively impact the oral health of disadvantaged primary schoolchildren from rural and low socioeconomic backgrounds. Future well-designed studies are required to provide high-quality evidence.

Acknowledgement

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Competing interests

The authors declare that they have no competing interests.

Ethical Clearance

Approval from the Medical Ethics Committee, Faculty of Dentistry, Universiti Malaya (Reference: DF CO2304/0027 (P)) and the Medical Research and Ethics Committee (MREC), Ministry of Health Malaysia (Reference: NMRR ID-23-00138-B7X (ISR)) were obtained.

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