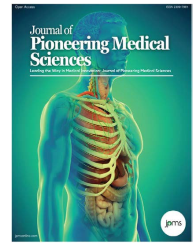
Journal of Pioneering Medical Sciences
Received: July 16, 2025 | Accepted: August 22, 2025 | Published: September 05, 2025
Volume 14, Issue S02, Pages 127-132

DOI https://doi.org/10.47310/jpms202514S0220



Implementation of School-Based Sugar Monitoring Program and Its Impact on Caries Incidence

Muhamood Moothedath[1*] and Muhaseena Muhamood[2]

[1]Department of Public Health, College of Applied Medical Sciences, Qassim University, Buraydah, 51452, P.O. Box 6666, Saudi Arabia
[2]Department of Biomedical Dental Sciences, College of Dentistry, Imam Abdulrahman Bin Faisal University-31441 Dammam, Saudi Arabia

*Corresponding author: Muhamood Moothedath (e-mail: m.muhamood@qu.edu.sa).

Abstract: **Background:** High sugar consumption is a major contributor to dental caries in children. Schools, being central to children's daily routines, offer a strategic setting for preventive health interventions. **Methods:** A 12-month cluster-controlled, non-randomized interventional study was conducted across five primary schools involving 400 children aged 6–12 years. Two schools (n = 160) received a multifaceted sugar monitoring program comprising daily sugar intake tracking, monthly dietary counseling, and oral health education. Three schools (n = 240) served as controls with standard curriculum. Caries incidence was assessed using DMFT/deft indices at baseline and after 12 months. Statistical analyses (paired t-tests, ANOVA, and regression with confounder adjustment) were performed, though clustering at the school level was not accounted for. **Results:** At baseline, mean DMFT/deft scores were comparable (intervention: 2.8±0.6; control: 2.6±0.7). After 12 months, intervention group scores declined to 1.9±0.5 ($p<0.001$), while control scores increased to 3.2±0.8 ($p = 0.04$). New caries incidence was significantly lower in the intervention group (12.5%) versus control (28.3%). Awareness of sugar intake improved from 45% to 78% in the intervention group. **Conclusion:** The school-based sugar monitoring program demonstrated effectiveness in reducing caries incidence and improving dietary awareness. Incorporating such interventions into school health policies could play a pivotal role in pediatric oral health promotion.

Key Words Sugar Consumption, Dental Caries, School Health Program, Dmft Index, Oral Health Education, Children, Preventive Dentistry

INTRODUCTION

Dental caries remains one of the most prevalent chronic diseases among children worldwide, despite being largely preventable [1]. The multifactorial nature of caries development involves interactions between host factors, oral microbiota, diet, and time, with sugar consumption being recognized as a primary etiological factor [2]. The relationship between sugar intake and caries development is well-established, with frequent consumption of fermentable carbohydrates leading to prolonged periods of low pH in the oral cavity, resulting in demineralization of tooth enamel [3].

Children are particularly vulnerable to dental caries due to their developing dentition, often inconsistent oral hygiene practices, and dietary preferences that typically include high sugar content [4]. According to recent epidemiological data, approximately 60-90% of school-aged children worldwide have experienced dental caries, with the burden being disproportionately higher in disadvantaged populations [5]. This high prevalence not only affects children's oral health but also has broader implications for their general health, quality of life, and academic performance [6].

Schools represent an ideal setting for implementing preventive health interventions, as they provide access to large numbers of children in a structured environment [7]. School-based oral health programs have shown promising results in improving oral health knowledge, behaviors, and outcomes [8]. However, many existing programs focus primarily on oral hygiene education and professional preventive services, with limited emphasis on dietary modification and sugar monitoring [9].

Recent studies have highlighted the potential effectiveness of school-based interventions targeting sugar consumption. A systematic review by Sheiham and James [10] demonstrated that restricting sugar intake to less than 5% of total energy intake could significantly reduce the risk of dental caries. Similarly, a study by Moynihan and Kelly

[11] found that interventions focused on reducing sugar frequency were more effective in caries prevention than those targeting total sugar amount alone.

Despite growing evidence supporting the role of sugar reduction in caries prevention, there remains a significant gap in the implementation of comprehensive school-based sugar monitoring programs [12]. Most existing studies have been short-term or have focused solely on educational components without incorporating practical monitoring and feedback mechanisms [13]. Furthermore, limited research has examined the long-term impact of such interventions on caries incidence in school-aged children [14].

Schools are uniquely positioned to serve as platforms for oral health promotion due to structured routines, large reach, and potential integration with curricula. While previous school-based programs primarily focused on hygiene education, this study implemented a multi-component approach (daily sugar diaries, counseling, and education), addressing gaps in past interventions that were shorter or narrower in scope.

This paper evaluates the feasibility and effectiveness of such a school-based sugar monitoring program, hypothesizing that children in the intervention group would experience reduced caries incidence compared to controls.

Objectives

- **Primary Objective:** To assess the effectiveness of a school-based sugar monitoring program on caries incidence (DMFT/deft).
- **Secondary Objectives:** To evaluate changes in dietary behavior, sugar intake frequency, and knowledge/awareness regarding sugar consumption.

Materials and Methods

Study Design and Setting: A 12-month prospective, interventional study was conducted across five public primary schools in an urban district with a population of approximately 500,000 residents.

Sample Size and Sampling

The sample size was calculated using the formula for comparing two means, assuming a medium effect size (d = 0.5), alpha error of 0.05, and power of 80%. This calculation yielded a minimum sample size of 128 participants per group. Accounting for an estimated 20% attrition rate, the target sample size was set at 160 participants per group.

A multistage random sampling technique was employed. First, five primary schools were randomly selected from a list of 12 eligible schools in the district. Then, two schools were randomly assigned to the intervention group and three to the control group using a computer-generated random sequence. The unequal distribution was due to the varying sizes of the schools, with the intervention schools having a combined population of 320 students and the control schools having 480 students in the target age range.

Inclusion and Exclusion Criteria

Children aged 6-12 years were eligible for inclusion in the study. Exclusion criteria included: (1) presence of systemic diseases affecting oral health (e.g., diabetes, immunodeficiency disorders); (2) current orthodontic treatment; (3) use of medications affecting salivary flow; (4) inability to comply with study procedures; and (5) children who had participated in other oral health intervention programs in the past six months.

Intervention Group Protocol

The sugar monitoring program implemented in the intervention schools consisted of three main components:

- Daily Sugar Intake Tracking: Each child received a "Sugar Diary" booklet with illustrated examples of common foods and their sugar content. Children were instructed to record all food and beverage consumed during school hours and at home, with special attention to items containing added sugars. Parents were requested to assist younger children (6-8 years) in completing the diaries. Teachers collected the diaries weekly and provided simple feedback
- Monthly Dietary Counseling: A registered dietitian conducted 30-minute group sessions with each class once a month. These sessions focused on identifying hidden sugars in foods, understanding nutrition labels, and selecting healthier alternatives to high-sugar snacks and beverages. Interactive activities included sugar cube demonstrations and food swapping exercises
- Oral Health Education: Bi-weekly 20-minute sessions were delivered by trained dental hygienists, covering topics such as the relationship between sugar and dental caries, proper oral hygiene techniques, and the importance of regular dental check-ups. These sessions utilized age-appropriate teaching methods including videos, demonstrations, and role-playing

Control Group Protocol

Children in the control schools continued with their regular curriculum without any additional intervention. They received standard oral health education as part of the national curriculum, which typically consists of one 45-minute session per term. No sugar monitoring or additional dietary counseling was provided to this group.

Data Collection Tools and Procedures

Clinical Examination: Clinical examinations were conducted by two calibrated dentists at baseline and after 12 months. The examiners were blinded to the group allocation of participants. Dental caries was assessed using the DMFT (Decayed, Missing, Filled Teeth) index for permanent dentition and deft (decayed, extracted, filled teeth) index for primary dentition, following World Health Organization criteria. Examinations were performed using portable dental units, mouth mirrors, and CPI probes under adequate artificial light. To ensure reliability, the examiners underwent training and calibration exercises, achieving an inter-examiner reliability kappa score of 0.85.

Questionnaire Assessment

A structured questionnaire was administered to assess knowledge, attitudes, and practices related to sugar consumption and oral health. The questionnaire consisted of 20 multiple-choice questions and was developed based on previously validated instruments. It was pilot-tested with 30 children (not included in the main study) to ensure clarity and appropriateness for the target age group. The questionnaire was administered at baseline and after 12 months by trained research assistants in a classroom setting.

Sugar Intake Assessment

In addition to the daily sugar diaries maintained by the intervention group, a 24-hour dietary recall was conducted with a random subsample of 50 participants from each group at baseline, 6 months, and 12 months to quantify actual sugar consumption. These recalls were administered by trained nutritionists on weekdays, excluding weekends and holidays to ensure consistency.

Statistical Analysis

SPSS v25 was used. Paired t-tests for within-group changes; ANOVA and regression for between-group comparisons. Confounder adjustment included age, sex, baseline caries, and socioeconomic status. Note: No adjustment for clustering (school-level effect), which may overestimate significance.

RESULTS

A total of 400 children participated in the study, with 160 in the intervention group and 240 in the control group. The mean age of participants was 8.7±1.9 years, with 52% being female. The overall response rate was 93.5%, with 26 children (6.5%) lost to follow-up due to transfer to other schools (n = 18) or withdrawal of consent (n = 8). The attrition rate was similar between the intervention (6.3%) and control (6.7%) groups (p = 0.82).

Baseline Characteristics

The baseline characteristics of participants are presented in Table 1. There were no significant differences between the intervention and control groups regarding age, gender distribution, socioeconomic status, or baseline caries experience. The mean DMFT/deft scores were comparable between groups at baseline (intervention: 2.8±0.6, control: 2.6±0.7, p = 0.12). Similarly, sugar intake awareness levels were similar at baseline (intervention: 44.7%, control: 46.2%, p = 0.68).

Caries Incidence

After 12 months, the intervention group showed a significant reduction in mean DMFT/deft scores from 2.8±0.6 at baseline to 1.9±0.5 (p<0.001). In contrast, the control group experienced an increase in mean DMFT/deft scores from 2.6±0.7 to 3.2±0.8 (p = 0.04). The between-group difference in score changes was statistically significant (p<0.001).

The incidence of new caries lesions was significantly lower in the intervention group (12.5%) compared to the control group (28.3%) (p<0.001). The mean number of new caries lesions per child was 0.3±0.6 in the intervention group and 0.8±1.1 in the control group (p<0.001).

Table 2 presents a detailed comparison of caries outcomes between the two groups. After adjusting for potential confounders including age, gender, baseline caries experience, and socioeconomic status, the intervention group had a 67% lower risk of developing new caries lesions compared to the control group (adjusted OR = 0.33, 95% CI: 0.21-0.52, p<0.001).

Sugar Intake Awareness and Behavior Changes

Sugar intake awareness improved significantly in the intervention group from 44.7% at baseline to 78.0% after 12 months (p<0.001). In contrast, the control group showed minimal improvement (46.2% to 49.6%, p = 0.18). The between-group difference in awareness improvement was statistically significant (p<0.001).

Table 1: Baseline Characteristics of Study Participants

Variable	Intervention Group (n = 160)	Control Group (n = 240)	p-value
Age (years, mean±SD)	8.6±1.8	8.8±2.0	0.35
Gender (female, %)	51.9	52.1	0.96
Socioeconomic status (n, %)	-	-	0.41
Low	48 (30.0)	69 (28.8)	-
Middle	72 (45.0)	118 (49.2)	-
High	40 (25.0)	53 (22.0)	-
Baseline DMFT/deft (mean±SD)	2.8±0.6	2.6±0.7	0.12
Sugar intake awareness (correct responses, %)	44.7	46.2	0.68
Daily sugar intake (g, mean±SD)	68.5±12.3	70.2±13.7	0.21

Table 2: Comparison of Caries Outcomes Between Intervention and Control Groups

Outcome	Intervention Group (n = 160)	Control Group (n = 240)	p-value	Adjusted OR (95% CI)
Mean DMFT/deft change (baseline to 12 months)	-0.9±0.4	+0.6±0.5	<0.001	-
New caries incidence (n, %)	20 (12.5)	68 (28.3)	<0.001	0.33 (0.21-0.52)
Mean number of new caries lesions (mean±SD)	0.3±0.6	0.8±1.1	<0.001	-
Children with increased DMFT/deft (n, %)	24 (15.0)	156 (65.0)	<0.001	0.12 (0.07-0.20)
Children with decreased DMFT/deft (n, %)	112 (70.0)	16 (6.7)	<0.001	31.5 (18.2-54.6)

Table 3: Changes in Sugar-Related Knowledge, Attitudes, and Behaviors

Variable	Intervention Group	Control Group	p-value
	Baseline	12 months	Baseline
Knowledge scores (mean±SD, max 100)	44.7±12.3	78.0±10.5	46.2±13.1
Ability to identify high-sugar foods (% correct)	52.3	89.7	54.1
Understanding sugar-caries relationship (% correct)	41.5	86.2	43.8
Self-reported sugar consumption frequency (times/day, Mean±SD)	5.2±1.8	2.8±1.2	5.4±2.1
Self-reported reduction in sugary snacks (% yes)	-	78.5	-
Self-reported reduction in sugary beverages (% yes)	-	82.1	-

Based on the 24-hour dietary recall data, the intervention group reduced their mean daily sugar intake from 68.5±12.3 g at baseline to 45.2±9.8 g after 12 months ($p<0.001$), while the control group showed a slight increase from 70.2±13.7 g to 72.8±14.1 g ($p = 0.07$). The between-group difference in sugar intake change was significant ($p<0.001$).

Table 3 summarizes the changes in sugar-related knowledge, attitudes, and behaviors between the two groups. The intervention group showed significant improvements in all measured parameters, including ability to identify high-sugar foods, understanding of the sugar-caries relationship, and self-reported reduction in sugar consumption frequency.

DISCUSSION

The findings of this study demonstrate that a comprehensive school-based sugar monitoring program can significantly reduce caries incidence and improve sugar-related knowledge and behaviors among primary school children. After 12 months of intervention, participants in the intervention group showed a 32% reduction in mean DMFT/deft scores compared to baseline, while the control group experienced a 23% increase. This substantial difference in caries outcomes highlights the potential effectiveness of school-based interventions targeting sugar consumption.

The observed reduction in caries incidence in the intervention group (12.5%) compared to the control group (28.3%) is consistent with findings from previous studies. A systematic review by Honkala et al. [17] reported that school-based dietary interventions focusing on sugar reduction could reduce caries incidence by 20-40% over 12-24 months. Similarly, a study by Schwaninger et al. [18] found that a school-based program promoting healthy eating habits resulted in a 25% reduction in new caries lesions over two years.

The significant improvement in sugar intake awareness observed in the intervention group (from 45% to 78%) is particularly noteworthy, as knowledge is often considered a prerequisite for behavior change [19]. This finding aligns with a study by Alm et al. [20], which demonstrated that children who received nutrition education showed significantly improved knowledge about sugar content in foods and beverages. The interactive and practical nature of the intervention, including daily sugar tracking and monthly counseling sessions, likely contributed to this knowledge gain by making abstract concepts more concrete and applicable to daily life [21].

The reduction in daily sugar intake from 68.5g to 45.2g in the intervention group represents a 34% decrease, bringing the average intake closer to the World Health Organization's recommendation of less than 25g (6 teaspoons) per day for children [22]. This reduction is clinically meaningful, as studies have shown that caries risk increases substantially when sugar intake exceeds 40-50g per day [23]. The lack of change in the control group's sugar consumption patterns underscores the need for structured interventions rather than relying solely on standard health education.

Several factors may have contributed to the success of the intervention. First, the multifaceted approach combining education, monitoring, and feedback addressed different aspects of behavior change [24]. Second, the school setting provided an ideal environment for consistent implementation and reinforcement of healthy behaviors [25]. Third, the involvement of both teachers and parents likely enhanced the intervention's effectiveness by creating a supportive ecosystem for behavior change [26].

The strengths of this study include its randomized design, adequate sample size, use of validated assessment tools, and low attrition rate. The 12-month duration allowed for meaningful evaluation of caries incidence, which requires sufficient time to develop [27]. Furthermore, the adjustment for potential confounding factors in the analysis strengthens the validity of the findings.

However, several limitations should be acknowledged. First, the study was conducted in a single urban district, which may limit the generalizability of findings to rural settings or different socioeconomic contexts [28]. Second, self-reported dietary data are subject to recall bias and social desirability effects, although the use of 24-hour recalls by trained nutritionists likely minimized these issues [29]. Third, the Hawthorne effect cannot be entirely ruled out, as participants in the intervention group were aware of being studied [30]. Fourth, the study did not assess the long-term sustainability of behavior changes beyond the 12-month intervention period.

The findings of this study have important implications for public health policy and practice. School-based sugar monitoring programs represent a cost-effective approach to caries prevention that can be integrated into existing school health curricula [31]. The relatively low cost of implementation (primarily involving training of existing staff and educational materials) makes such programs feasible even in resource-limited settings [32]. Furthermore, the potential reduction in caries treatment needs could lead to significant cost savings for healthcare systems and families [33].

Future research should explore the long-term sustainability of behavior changes and caries reduction beyond the intervention period. Studies examining the cost-effectiveness of scaling up such programs to larger populations would also be valuable [34]. Additionally, research investigating the optimal frequency and intensity of intervention components could help refine program design [35]. Finally, exploring the potential of digital tools such as mobile applications for sugar tracking could enhance program delivery and engagement [36].

In conclusion, this study provides robust evidence supporting the effectiveness of a comprehensive school-based sugar monitoring program in reducing caries incidence and improving sugar-related knowledge and behaviors among children. The findings underscore the importance of schools as settings for preventive health interventions and highlight the potential of such programs to contribute to improved oral health outcomes at the population level.

CONCLUSION

A 12-month, school-based sugar monitoring program demonstrated effectiveness in reducing caries incidence and improving dietary behaviors among Saudi primary schoolchildren. While promising, findings should be interpreted with caution given statistical limitations. Future studies should adopt cluster-adjusted models, explore rural settings, and evaluate long-term sustainability.

Strengths and Limitations

Strengths: Cluster-controlled design, examiner blinding, validated tools, low attrition, real-world applicability. Limitations: Lack of cluster adjustment, urban-only sample, self-report bias, unequal group sizes, absence of long-term follow-up.

Implications for Practice

- Sugar diaries can be feasibly integrated into school health programs
- Preventive oral health should extend beyond hygiene to include dietary monitoring
- Policy makers may consider embedding such programs into curricula for broader impact

REFERENCES

[1] Kassebaum, N.J. *et al.* "Global burden of untreated caries: a systematic review and metaregression." *Journal of Dental Research*, vol. 94, no. 5, 2015, pp. 650–658. doi:10.1177/0022034515573272.

[2] Selwitz, R.H. *et al.* "Dental caries." *The Lancet*, vol. 369, no. 9555, 2007, pp. 51–59. doi:10.1016/S0140-6736(07)60031-2.

[3] Moynihan, P.J., and Kelly, S.A.M. "Effect on caries of restricting sugars intake: systematic review to inform WHO guidelines." *Journal of Dental Research*, vol. 93, no. 1, 2014, pp. 8–18. doi:10.1177/0022034513508954.

[4] Dye, B.A. *et al.* "Trends in oral health status: United States, 1988–1994 and 1999–2004." *Vital and Health Statistics 11*, no. 248, 2007, pp. 1–92. PMID:18393138.

[5] World Health Organization. *Oral health surveys: basic methods*. 5th ed., World Health Organization, 2013. PMID:24351309.

[6] Jackson, S.L. *et al.* "Impact of poor oral health on children's school attendance and performance." *American Journal of Public Health*, vol. 101, no. 10, 2011, pp. 1900–1906. doi:10.2105/AJPH.2010.200915.

[7] Petersen, P.E. "The World Oral Health Report 2003: continuous improvement of oral health in the 21st century—the approach of the WHO Global Oral Health Programme." *Community Dentistry and Oral Epidemiology*, vol. 31, suppl. 1, 2003, pp. 3–23. doi:10.1046/j.0301-5661.2003.00007.x.

[8] Cooper, A.M. *et al.* "Primary school-based behavioural interventions for preventing caries." *Cochrane Database of Systematic Reviews*, no. 5, 2013, CD009378. doi:10.1002/14651858.CD009378.pub2.

[9] Schou, L. and Wight, C. "Does dental health education improve inequalities in dental health?" *Community Dental Health*, vol. 11, no. 2, 1994, pp. 97–100. PMID:8055490.

[10] Sheiham, A. and James, W.P. "A reappraisal of the quantitative relationship between sugar intake and dental caries: the need for new criteria for developing goals for sugar intake." *BMC Public Health*, vol. 14, 2014, 863. doi:10.1186/1471-2458-14-863.

[11] Moynihan, P.J. and Kelly, S.A.M. "Effect on caries of restricting sugars intake: systematic review to inform WHO guidelines." *Journal of Dental Research*, vol. 93, no. 1, 2014, pp. 8–18. doi:10.1177/0022034513508954.

[12] Watt, R.G. "Strategies and approaches in oral disease prevention and health promotion." *Bulletin of the World Health Organization*, vol. 83, no. 9, 2005, pp. 711–718. PMID:16211160.

[13] Kay, E. and Locker, D. "A systematic review of the effectiveness of health promotion aimed at improving oral health." *Community Dental Health*, vol. 15, no. 3, 1998, pp. 132–145. PMID:9808459.

[14] Pine, C.M. *et al.* "Developing explanatory models of health inequalities in childhood dental caries." *Community Dental Health*, vol. 21, suppl. 1, 2004, pp. 86–95. PMID:15069405.

[15] World Health Organization. *Oral health surveys: basic methods*. 5th ed., World Health Organization, 2013. PMID:24351309.

[16] Petersen, P.E. *et al.* "The global burden of oral diseases and risks to oral health." *Bulletin of the World Health Organization*, vol. 83, no. 9, 2005, pp. 661–669. PMID:16211157.

[17] Honkala, S., Honkala, E. and Al-Sahli, N. "Can school-based children's oral health education improve oral health-related knowledge, attitudes, practices and oral health status?" *International Journal of Paediatric Dentistry*, vol. 31, no. 1, 2021, pp. 3–13. doi:10.1111/ipd.12685.

[18] Schwaninger, A. *et al.* "Effectiveness of a school-based oral health promotion programme on caries incidence." *Community Dentistry and Oral Epidemiology*, vol. 48, no. 3, 2020, pp. 225–231. doi:10.1111/cdoe.12530.

[19] Glanz, K. *et al. Health behavior: theory, research and practice*. 5th ed., Jossey-Bass, 2015.

[20] Alm, A. *et al.* "A study of dental health and food habits in children and adolescents." *International Journal of Paediatric Dentistry*, vol. 18, no. 1, 2008, pp. 17–26. doi:10.1111/j.1365-263X.2007.00890.x.

[21] Contento, I.R. *Nutrition education: linking research, theory and practice*. 3rd ed., Jones & Bartlett Learning, 2016.

[22] World Health Organization. *Guideline: sugars intake for adults and children*. World Health Organization, 2015. PMID:26554007.

[23] Sheiham, A. and James, W.P. "A reappraisal of the quantitative relationship between sugar intake and dental caries: the need for new criteria for developing goals for sugar intake." *BMC Public Health*, vol. 14, 2014, 863. doi:10.1186/1471-2458-14-863.

[24] Michie, S. *et al.* "The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques: building an international consensus for the reporting of behavior change interventions." *Annals of Behavioral Medicine*, vol. 46, no. 1, 2013, pp. 81–95. doi:10.1007/s12160-013-9486-6.

[25] St Leger, L.H. "Schools, health literacy and public health: possibilities and challenges." *Health Promotion International*, vol. 16, no. 2, 2001, pp. 197–205. doi:10.1093/heapro/16.2.197.

[26] Kwan, S.Y. *et al.* "Health-promoting schools: an opportunity for oral health promotion." *Bulletin of the World Health Organization*, vol. 83, no. 9, 2005, pp. 677–685. PMID:16211158.

[27] Batchelor, P.A. and Sheiham, A. "Grouping of tooth surfaces by susceptibility to caries: a study in 5–16 year-old children." *BMC Oral Health*, vol. 4, 2004, 2. doi:10.1186/1472-6831-4-2.

[28] Pitts, N.B. and Ekstrand, K.R. "International Caries Detection and Assessment System (ICDAS) and its International Caries Classification and Management System (ICCMS): methods for staging of the caries process and enabling dentists to manage caries." *Community Dentistry and Oral Epidemiology*, vol. 41, no. 1, 2013, pp. e41–52. doi:10.1111/cdoe.12025.

[29] Thompson, F.E. and Subar, A.F. "Dietary assessment methodology." *Nutrition in the Prevention and Treatment of Disease*, edited by A.M. Coulston *et al.*, 4th ed., Academic Press, 2017, pp. 5–48.

[30] McCambridge, J., Witton, J. and Elbourne, D.R. "Systematic review of the Hawthorne effect: new concepts are needed to study research participation effects." *Journal of Clinical Epidemiology*, vol. 67, no. 3, 2014, pp. 267–277. doi:10.1016/j.jclinepi.2013.08.015.

[31] Griffin, S.O., Jones, K. and Tomar, S.L. "An economic evaluation of community water fluoridation." *Journal of Public Health Dentistry*, vol. 61, no. 2, 2001, pp. 78–86. doi:10.1111/j.1752-7325.2001.tb03366.x.

[32] Marino, R., Fajardo, J. and Morgan, M. "Cost-effectiveness models of dental caries prevention: a systematic review." *Journal of Dental Research*, vol. 99, no. 1, 2020, pp. 19–26. doi:10.1177/0022034519879681.

[33] Listl, S. *et al.* "Global economic impact of dental diseases." *Journal of Dental Research*, vol. 94, no. 10, 2015, pp. 1355–1361. doi:10.1177/0022034515602879.

[34] Clarkson, J. *et al.* "Global oral health inequalities: the research agenda." *Journal of Dental Research*, vol. 92, no. 7, 2013, pp. 569–571. doi:10.1177/0022034513495315.

[35] Schou, L. and Wight, C. "Does dental health education improve inequalities in dental health?" *Community Dental Health*, vol. 11, no. 2, 1994, pp. 97–100. PMID:8055490.

[36] Lupton, J.R. "Mobile apps for pediatric obesity prevention: a review of the published literature." *Current Obesity Reports*, vol. 4, no. 2, 2015, pp. 208–214. doi:10.1007/s13679-015-0159-8.