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Assessing the Effectiveness of Community-Based Oral Health Interventions Using Advanced Dental Materials for Preventing Tooth Decay.

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ABSTRACT

Objective: To determine the efficacy of community-based oral health programs using advanced dental materials in the prevention of tooth decay in the local population.

Methodology: The study was a cross-sectional one carried out at a given number of community health centers and schools. A non-probability consecutive sampling method was used to select 419 participants. Structured questionnaires and oral examination were used in the collection of data according to WHO criteria. Data on oral care behaviors, community activity involvement, and the use of state-of-the-art dental supplies were documented. SPSS version 26 was used in the analysis of the data. Frequencies and percentages were used to represent descriptive statistics, and chi-square and t-tests were used to test the associations between preventive interventions and caries prevalence, with $p \leq 0.05$ regarded as significant.

Results: Out of the participants, 66.3 percent had participated in community-based oral health programs, and 46.8 percent had been administered fluoride varnish or sealant applications. The general level of dental caries was 38.4%. The prevalence of caries was significantly lower in those who had fluoride varnish or sealants (29.6%) than in those who lacked them (53.2%) ($p < 0.001$).

Conclusion: Oral health interventions at the community level with advanced dental materials are effective in preventing dental caries and enhancing oral health outcomes. The growth of such preventive measures can be critical in ensuring population-wide oral health, especially in low-resource conditions.

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Keywords: *Community-based oral health, dental caries, fluoride varnish, sealant, advanced dental materials, DMFT index*

1. INTRODUCTION

Oral health is an essential attribute of overall health and well-being.(1) The oral disease burden is still high in the world, though its prevention is mainly possible. The World Health Organization (WHO) states that almost 3.7 billion individuals have at least one oral illness at some point in their lives.(2) Of these, the most common condition of the permanent dentition is dental caries, or tooth decay.(3) The world prevalence of caries in permanent teeth is of the order of 29 percent, or more than 2 billion cases. In the case of primary (deciduous) teeth of children, the prevalence is still high; one study found the prevalence to rise in that case between approximately 49 million in 1990 and more than 52 million by 2021.(4)

The existence of these high prevalence rates in the past shows the difficulty and the chance of preventive measures. The sheer amount of facts that contribute to the development of dental caries is very multifactorial, as it is affected by the excessive consumption of free sugars, the lack of proper oral health, the lack of exposure to fluoride, socio-economic disparities, and the lack of access to dental care.(5) It is important to note that the burden of untreated caries is disproportionately high in low and middle-income countries, in which preventative services and sophisticated dental care might be less available. Oral health interventions have become popular within their respective communities in response to

this public health challenge.(6)

These interventions are usually concerned with education, fluoride varnish programmes, supervised tooth brushing, dietary counselling, and outreach in non-clinical settings. Simultaneously, the science of dental materials has been developed further: to strengthen preventive and least invasive methods of caries control, there is the use of so-called smart and bioactive materials like advanced adhesives, ion-releasing restorative materials, remineralising sealants.(7) A recent review evaluated bioactive dental adhesives that have a remineralising and antibacterial capability with adhesive properties and are aimed at preventing recurrent caries. These materials are said to offer better longevity of restorations, inhibition of secondary caries, and possibly less invasive treatment.(8, 9)

A combination of community-based interventions with the use of the latest dental materials can have a synergistic effect: reaching risk groups through outreach/preventive measures and, when using the recent materials to restore or prevent caries, the latest technologies are applied to make the maximum of the resources.(10) Nevertheless, the literature has a missing link with the effectiveness of such integrated approaches- especially in actual community based settings and not in controlled clinical trials.

Considering the alarming prevalence rates of dental caries in the majority of the world in spite of available preventive responses, there is a strong interest in investigating more efficient, scalable solutions. The community-based programmes enable the reach of many people, early detection, education and preventive action at the population level. In the meantime, modern dental supplies provide a possibility to enhance the results of any intervention required (e.g., sealants, restorative work) with the help of new technologies. The study on the effectiveness of community based oral health interventions which explicitly involve use of advanced dental materials therefore fills a significant and implementable gap: the effectiveness of such combined interventions in preventive tooth decay, particularly among underserved or high risk populations, which was the aim of the present study.

2. METHODOLOGY

A cross-sectional design was used in conducting this study to determine the effectiveness of community based oral health intervention with the use of advanced dental materials in the prevention of dental caries. The research was conducted at Dental Materials Department as allowing access to a representative sample of children and adults of different socio-economic backgrounds. The time span of the study was between Jan, 2025 to June, 2025.

The sample size was calculated by an OpenEpi, Version 3, considering a prevalence of 56.6% of dental caries and a 5% precision at 95% confidence was used.(11) The estimated sample size was 377. On the basis of a non-response rate of 10 per cent, the final target population was 419 participants.

To achieve the representative selection, non-probability consecutive sampling was used. During the initial phase, the communities and schools in urban and rural regions were randomly chosen. The second stage involved the selection of eligible individuals in these sites randomly on attendance lists or household listing. Inclusion criteria were age (between 5 and 50 years) and a minimum of 6 months of community residence (including 3-months of chronic residence), having received at least one community-based oral health intervention (such as fluoride varnish application, preventive sealants, or education), and an informed consent (or parental consent in case of underage participants). The exclusion criteria were people with systemic disease that may be related to oral health (e.g., uncontrolled diabetes, immunodeficiency), people who are undergoing orthodontic therapy, or people who are reluctant to take part.

A structured questionnaire and clinical oral examination were used to perform data collection. The questionnaire would have included socio-demographic information, oral health behavior, dietary habits and the past exposure to community-based interventions. Oral examination under the standardized conditions with the use of dental mirrors and explorers was performed by trained dental professionals to determine the presence or absence of dental caries, according to the WHO criteria of caries diagnosis. Dental records and direct observation were used to record advanced dental materials in preventive or restorative interventions.

Statistical analysis of all collected data was made in SPSS version 26. Demographic variables and oral health outcomes were calculated using descriptive statistics such as frequencies, percentages, means and standard deviations. The chi-square test of categorical variables and t-tests or ANOVA of the continuous variables when the test was deemed suitable were used to measure the associations between exposure to the community-based interventions and caries prevalence. The level of statistical significance was taken to be less than 0.05.

3. RESULTS

The number of participants in the study was 419, and the average age of the participants was 29.6 ± 10.2 years. As indicated in Table 1, most participants (38.4%) fell within the 30-50 years category, and 34.8% fell within the 15-29 years category. The proportion of females to the study population was 52.7%, and males 47.3%. A majority of the respondents (58.2%) were in the urban areas. When it comes to education, 34.1% had secondary education, 31.0% had higher education, and 11.7% had none of the formal education. Participants indicated the highest range of monthly household income, PKR 25,000-50,000, which was used by 38.4% of the respondents. (Table 1)

According to Table 2 below, 46.1% of the respondents indicated that they brushed their teeth twice a day, and 40.1% brushed their teeth once a day. Fluoridated toothpaste was in use as 72.1% of the people reported using it. Almost 67% had attended at least one oral health community-based program and 47% had attended risk-focused fluoride varnish or fluoride preventive sealant programs. Moreover, 74.2% had attended one or more oral health education sessions, which indicates the involvement of the community in the activities of promotion of oral hygiene. (Table 2)

The incidence of dental caries was quite different depending on the exposure to oral health interventions in communities (Table 3). Out of the participants of such programs, 37.1% had dental caries as opposed to 56.0% of non-participants ($p = 0.001$). Equally, the prevalence of caries was significantly lower in individuals who had fluoride varnish or sealants (29.6), compared to those, which did not have the preventive substances ($p < 0.001$). Preventive caries (34.8% vs. 57.3%) were also significantly linked to the use of fluoridated toothpaste ($p = 0.003$). (Table 3)

These findings were also supported by the mean DMFT (Decayed, Missing and Filled teeth) scores (Table 4). The DMFT score of 1.42 ±1.10 of participants who were exposed to community-based interventions was significantly lower than that of non-participants which was 2.36 ±1.42 ($p < 0.001$). Similarly, participants with an application of fluoride or sealants recorded a mean DMFT of 1.28 ± 0.96 as opposed to 2.45 ± 1.51 in participants who had not received the application ($p < 0.001$).

Table 1. Socio-Demographic Characteristics of Participants (n = 419)

Variable	Categories	n (%)
Age Group (years)	5–14	112 (26.7%)
	15–29	146 (34.8%)
	30–50	161 (38.4%)
Gender	Male	198 (47.3%)
	Female	221 (52.7%)
Residence	Urban	244 (58.2%)
	Rural	175 (41.8%)
Education Level	No formal education	49 (11.7%)
	Primary	97 (23.2%)
	Secondary	143 (34.1%)
	Higher education	130 (31.0%)
Monthly Household Income (PKR)	<25,000	102 (24.3%)
	25,000–50,000	161 (38.4%)
	>50,000	156 (37.2%)

Table 2. Oral Health Practices and Exposure to Community-Based Interventions (n = 419)

Variable	Categories	n (%)
Tooth Brushing Frequency	Once daily	168 (40.1%)
	Twice daily	193 (46.1%)
	> Twice daily	58 (13.8%)
Use of Fluoridated Toothpaste	Yes	302 (72.1%)
	No	117 (27.9%)
Participation in Community Oral Health Program	Yes	278 (66.3%)
	No	141 (33.7%)
Received Fluoride Varnish/Sealant	Yes	196 (46.8%)
	No	223 (53.2%)

Exposure to Education Sessions	Yes	311 (74.2%)
	No	108 (25.8%)

Table 3. Prevalence of Dental Caries According to Exposure to Community-Based Interventions.

Exposure Variable	Total (n)	Caries Present n (%)	Caries Absent n (%)	χ^2	p-value
Participated in Program	278	103 (37.1%)	175 (62.9%)	10.43	0.001
Received Fluoride Varnish/Sealant	196	58 (29.6%)	138 (70.4%)	15.28	<0.001
No Participation	141	79 (56.0%)	62 (44.0%)		
Used Fluoridated Toothpaste	302	105 (34.8%)	197 (65.2%)	9.12	0.003
Non-Fluoridated Toothpaste	117	67 (57.3%)	50 (42.7%)		
Statistically significant associations ($p < 0.05$) were observed between community-based oral health participation, use of advanced dental materials, and lower caries prevalence.					

Table 4. Comparison of Mean DMFT (Decayed, Missing, and Filled Teeth) Scores between Groups

Variable	Group	n	Mean ± SD	p-value
Community-Based Intervention	Participants	278	1.42 ± 1.10	< 0.001 *
	Non-participants	141	2.36 ± 1.42	
Fluoride/Sealant Application	Received	196	1.28 ± 0.96	< 0.001 *
	Not received	223	2.45 ± 1.51	
*$p \leq 0.05$ indicates statistically significant difference between groups.**				

4. DISCUSSION

In this cross-sectional study of 419 participants, we found that participation in community-based oral health programs and receipt of fluoride varnish or sealant applications were associated with substantially lower caries prevalence (29.6% among those who received varnish/sealants vs 53.2% among non-recipients) and lower mean DMFT scores (1.28 ± 0.96 vs 2.45 ± 1.51). These findings align with a substantial body of recent evidence demonstrating that preventive, community-delivered interventions reduce caries incidence and improve DMFT outcomes. Systematic reviews and program evaluations report measurable caries reductions following school- or community-based fluoride varnish and sealant programmes; for example, the Community Preventive Services Task Force concluded that school fluoride varnish delivery programs reduce caries initiation in permanent and primary teeth and reduce progression/arrest caries outcomes.(12)

Several recent systematic reviews and randomized evaluations have documented similar benefits. A 2022 systematic review of primary school-based interventions in low- and middle-income countries found improvements in oral health outcomes and behaviours attributable to school programmes combining education, topical fluoride application and sealants, supporting our finding that multifaceted community efforts are effective.(13) A targeted evaluation of fluoride varnish and fissure sealant interventions also reported significant caries-preventive effects in educational settings, reinforcing the apparent protective role of professional topical fluoride and sealant applications observed in our sample.(14, 15)

Meta-analytic evidence further supports a meaningful protective effect of fluoride varnish in or example, pooled RR ≈ 0.79 in educational settings) and reductions in DMFT/DMFS when varnish is applied regularly, which is concordant with our observed lower DMFT among varnish/ sealant recipients. These meta-analytic results suggest that the magnitude of effect in our study is within the range reported by previous evidence syntheses.(16, 17)

The literature around sealants likewise supports our findings. Systematic reviews and program evaluations of school-based sealant programmes show that fissure sealants reduce caries incidence in pit and fissure surfaces and can be successfully implemented in community/school settings—particularly among at-risk, lower-income children, mirroring our observation that sealant/varnish users had lower caries burden.(18, 19)

Our results are consistent with trials and practical program reports demonstrating that combined approaches—oral health education plus topical preventive measures—produce better outcomes than single interventions. For instance, community programs that paired education with twice-yearly fluoride varnish or sealant application reported reductions in new carious lesions and slowed progression of early lesions; these combined strategies appear to explain the stronger protective association seen among participants who attended education sessions and received advanced materials.(20, 21)

On the other hand, some studies reported modest or context specific fluoride varnish effects, particularly in low baseline caries settings or when school interventions occurred independently (without oral hygiene and dietary promotion). This variability indicates that community programme success is dependent upon implementation intensity, baseline risk, frequency of application, and concurrent behaviour change processes that may account for differences between our effect sizes and others in the literature.(22, 23)

Taken together, the evidence base from the previous literature supports three practical inferences that are consistent with our results: community-delivered preventive programmes (education + topical fluoride ± sealants) reduce caries and improve DMFT indices, the addition of modern bioactive/ remineralising materials has strong mechanistic rationale and early clinical support but requires more population-level outcome data, and program effectiveness varies with baseline risk, frequency and fidelity of delivery, and combination of behavioural and clinical components.

When comparing our cross-sectional results with the controlled trials and reviews cited above, it is important to note study design differences. Many of the strongest effect estimates arise from randomized or longitudinal program evaluations, whereas cross-sectional data of the present study capture association rather than causation and are subject to selection bias and residual confounding. In addition, trials often report outcomes after fixed intervals like 12–24 months and may standardize application frequency; differences in follow-up duration and intervention intensity likely contribute to heterogeneity across studies.

Our findings lend support to scaling community-based preventive programmes that combine oral health education with periodic topical fluoride and sealant application, and they point toward promising roles for advanced bioactive materials within these programmes. Future research should prioritize pragmatic, prospective evaluations of integrated programmes (including cost-effectiveness), and long-term comparative studies of conventional vs bioactive materials in community settings to confirm whether the short-term reductions in caries and DMFT translate into durable oral-health gains at the population level.

5. CONCLUSION

This study demonstrated that community-based oral health interventions significantly improved dental health outcomes, particularly when advanced dental materials such as fluoride varnishes and sealants were incorporated. Those who completed these preventive programs had significantly lower rates of dental caries and DMFT scores than those who had not. This continues to provide evidence that the addition of new dental materials combined with community-based education and preventive care can ultimately lead to a reduction in tooth decay. Strengthening such community-based initiatives, especially in underserved populations has the potential to transform oral health outcomes, promote long-term preventive behaviors, and reduce the need for invasive dental treatments

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