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Socioeconomic Association of Dental Caries Preventive Effects of Fluoride Varnishes and Nutritional Status among School-Age Children of District Mardan

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Abstract

Background. Dental caries is a major cause of concern in school-age children, especially in low-income countries. It is established that socioeconomic factors, nutrition, and access to prevention services all influence to the prevalence of caries, but there is little local evidence on this subject in the Mardan District. **Aim.** To investigate the association between socioeconomic status, fluoride varnish use, nutritional status, and dental caries prevention among school-age children in the Mardan District. **Material and methods.** A cross-sectional study was carried out in 400 school-age children aged 6 to 12 years. A structured questionnaire was used to collect sociodemographic data. The clinical examination was performed to estimate the dental caries status. The nutritional status was measured using BMI-for-age growth charts. The data about using fluoride varnishes was documented. Associations were analyzed using chi-square tests with statistical significance set at $p < 0.05$. **Results.** The average age of respondents was 9.1 ± 1.8 years. 52.5% of respondents were male and 47.5% female. The majority of children were in the low (38.0%) and middle (42.5%) socioeconomic classes. Children of low socioeconomic status (SES) (62.5%) had a higher prevalence of dental caries compared to those of middle and high SES (44.1 and 28.2% respectively, $p < 0.001$). Children who received fluoride varnish had significantly lower dental caries prevalence (32.4%) compared to those who did not received it (58.9%) ($p < 0.001$). Underweight children had the highest prevalence of dental caries (61.8%) compared to normal-weight (41.7%) and overweight children, with statistically significant relationship ($p = 0.002$). Children of low SES who were underweight and did not received fluoride varnish (68.4%) and children of high SES with normal nutritional status who received fluoride varnish (21.6%) had the highest and lowest dental caries burdens, respectively. **Conclusion.** Dental caries in school-age children in the Mardan District are closely related to socioeconomic status, nutrition status, and use of fluoride varnish. School-based interventions promoting dental caries prevention and dental care as well as nutritional enhancement, especially among children from low socioeconomic backgrounds, should be integrated to reduce the burden of dental caries in school-aged children.

Keywords: preventive dentistry; dental caries; fluoride varnish; socioeconomic status; nutritional status

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Социально-экономическая взаимосвязь между применением фторлака в целях профилактики кариеса и нутритивным статусом среди детского населения школьного возраста округа Мардан

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Аннотация

Введение. Кариес зубов является распространенным заболеванием среди детского населения школьного возраста, особенно в странах с низким уровнем дохода. Установлено, что на распространенность кариеса влияют социально-экономические факторы, питание и доступность профилактической помощи, однако существует мало научных данных о характере взаимосвязи этих параметров в округе Мардан (Пакистан). **Цель.** Изучить взаимосвязь между социально-экономическим статусом, применением фторлака, нутритивным статусом и профилактикой кариеса зубов у детей школьного возраста, проживающих в округе Мардан. **Материалы и методы.** Провели одномоментное исследование с участием 400 детей школьного возраста от 6 до 12 лет. Социально-демографические данные собрали путем структурированного опроса. Наличие кариеса у участников установили в ходе медицинского осмотра. С помощью графиков роста, учитывающих отношение индекса массы тела (ИМТ) к возрасту, определили нутритивный статус участников. Зафиксированы данные о профилактическом применении фторлака. Для анализа взаимосвязи использовали критерий хи-квадрат, причем статистическая значимость была $p < 0,05$. **Результаты.** Средний возраст участников составил $9,1 \pm 1,8$ года. 52,5% участников были мужского пола, 47,5% – женского. Большинство детей имели низкий (38,0%) или средний (42,5%) социально-экономический статус. Чаще всего кариес наблюдался у детей с дефицитом массы тела (61,8%) по сравнению с детьми, имеющими нормальный (41,7%) или избыточный вес ($p=0,002$). Самая высокая и низкая распространенность кариеса наблюдалась у детей с дефицитом массы тела и низким социально-экономическим статусом, не получавших профилактическое лечение фторлаком (68,4%), и детей с нормальным нутритивным и высоким социально-экономическим статусами, которые получали профилактическое лечение фторлаком (21,6%) соответственно. **Заключение.** Заболеваемость кариесом зубов среди детского населения школьного возраста в округе Мардан тесно ассоциирована с такими факторами, как социально-экономический статус, нутритивный статус и применение фторлака. Чтобы снизить бремя кариеса у детей школьного возраста, следует внедрить в школах мероприятия, направленные на профилактику кариозных поражений, укрепление здоровья полости рта и обогащение продуктов питания.

Ключевые слова: профилактическая стоматология; кариес; фторлак; социально-экономический статус; нутритивный статус

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Introduction

The socioeconomic connection between dental caries-preventive efficacy of fluoride varnishes and the nutritional status of school-age children, particularly in certain regions, such as the Mardan District, is a complex issue of population health. Dental caries is a chronic condition that has a significant impact on school-aged children and is one of the most common in the world [1, 2]. Its etiology is multifaceted, including biological, social, and environmental variables [3]. Using fluoride varnishes is a well-established preventive and restorative strategy for dental cavities in the primary and permanent dentitions [4, 5]. The socioeconomic determinants, in turn, can modify the efficacy of this preventative intervention as well as the children's nutritional status, particularly in resource-constrained environments [6]. Fluoride varnish works by strengthening the dental enamel, resulting in the formation of fluorapatite that is more resistant to acid attacks and improves dental remineralization [7, 8]. It also inhibits the enzymes of cavity-causing bacteria that generate acids [9]. Its application has been shown to be effective in clinical trials; one example is the six-monthly use of sodium fluoride varnish to prevent dental caries in six to seven-year-olds with a denture consisting of deciduous teeth, permanent incisors, and molars in a low-resource setting in Sri Lanka [10]. Similarly, a two-year Chinese study found that fluoride varnish was helpful in preventing dental caries in schoolchildren's first permanent molars [1]. It has also been discovered that mixed dentition application of 5% sodium fluoride varnish is effective in the prevention of dental caries in rural Jamshoro school children over the age of six months [11]. Fluoride varnish has been shown multiple times to be an easy, quick, and non-invasive topical fluoride gel that can be used by children as young as six years old [12]. It generates pools of calcium fluoride-like compounds on the abrasive surface, which release fluoride ions during acid attacks, resulting in dental remineralization.

Although fluoride varnish has been proven effective, its preventive impact is not necessarily universal across all population groups because of disparities in socioeconomic status (SES) and nutritional status. The prevalence and severity of dental caries are constantly linked to socioeconomic determinants such as parental education level, family income, and access to healthcare [13, 14]. Children with lower socioeconomic class are more likely to develop dental caries and have less access to preventive dental care, such as the application of fluoride varnish [15]. Research in other countries, such as Saudi Arabia and Egypt, has revealed a strong association between parental education level,

socioeconomic status, and children's oral health status [16]. A study conducted in Chennai found that the prevalence of dental caries varied according to socioeconomic classes [17]. Another study in the Nowshera District found a connection between social, nutritional, and behavioral characteristics and dental caries in Pakistani children [18]. Families' affordability of healthy food and access to dental care are critical determinants, and low SES is typically associated with low-quality food and a lack of preventive care [19].

Nutritional status is also very important in dental health. An increasing number of research suggest that dental caries prevalence in children is related to nutritional status, specifically underweight and obesity [20]. A link between low SES children's diets and dental caries was also found, however the exact association between obesity, underweight, and caries is still debated [21]. Healthy nutrition-related conditions are often associated with a lower risk of severe dental caries when compared to high-sugar diets [22]. Malnutrition, such as stunting and anemia, which are frequent in most low-income countries, including Pakistan, can inhibit the immune system and impair dental enamel formation, predisposing people to caries [23]. A study in Ethiopia found that dental caries were more common among school-aged children (6 to 12 years) and stated that there is a need to associate caries with nutritional status in resource-limited environments [24]. Untreated dental caries in the permanent tooth were found to affect the nutritional status of Indonesian children, implying a two-way interdependence [25].

To summarize, fluoride varnish is an effective and proven method for dental caries prevention, but its application in a real-life setting, such as the Mardan District, is directly related to the target audience's socioeconomic status and healthy nutrition. The challenges of dental caries in these communities cannot be adequately addressed only through the use of fluoride varnish as a preventive intervention, but must also include more holistic approaches that consider the population's overall health determinants, such as improving nutritional status and reducing socioeconomic inequalities, which limit access to care and healthy diet. This combination will be necessary to maximize the efficacy of preventative treatments and improve the oral health of school-aged children.

Aim

To investigate the association between socioeconomic status, fluoride varnish use, nutritional status, and dental caries prevention among 6-12 year old school-aged children in the Mardan District.

Objectives

- Identify the sociodemographic characteristics of 6-12 year old school-aged children in the Mardan District
- Assess the prevalence of dental caries in the population under study
- Investigate the relationship between socioeconomic status and dental caries in school-aged children
- Study the potential of fluoride varnish in preventing dental caries
- Examine the relationship between dental caries and nutritional status (BMI-for-age) in school-age children
- Study the impact of socioeconomic status, fluoride varnish use, and nutritional status on the prevalence of dental caries
- To create evidence for integrating oral health and nutrition activities in schools to reduce dental caries burden in the Mardan District

Research Methodology

Study Design

A cross-sectional analytical study was conducted to investigate the relationship between socioeconomic status and dental caries, the preventive effect of fluoride varnish on dental caries, as well as the relationship between nutritional status and dental caries in school-aged children in the Mardan District, Khyber Pakhtunkhwa, Pakistan.

Study Area

The study was carried out in the Mardan District, both rural and urban environments. The District's primary schools (both public and private) were chosen to reflect a variety of socioeconomic origins.

Study Population

The study's target population was school-aged children between the ages of 6 and 12 years who attended public and private schools in the Mardan District.

Inclusion Criteria

- Children aged 6-12 years
- Enrolled in selected schools
- Reporting on the examination day
- Parents/guardians provided signed informed consent

Exclusion Criteria

- Children with systemic conditions that affect their oral health
- Children undergoing orthodontic treatment
- Children with special healthcare needs
- Children whose parents did not provide signed informed consent

Sample Size Determination

The sample size was calculated according to WHO sample size calculation for prevalence studies:

$$n = \frac{Z^2 \times p \times q}{d^2}$$

Where:

Z = 1.96 (95% confidence interval)

p = expected prevalence of dental caries (50% estimated because no local data is available)

q = 1- p

d = margin of error (5%)

To account for non-response, the sample size was computed as 384 but rounded to 400 children.

Sampling Technique

Multi-stage stratified random sampling was applied. The schools were divided into two categories: public and private. Each stratum was randomly selected to include a sample of schools. To select eligible children, class attendance registers were used along with systematic random sampling.

Study Variables

Dependent Variable

Status of dental caries (present/absent)

Independent Variables

Socioeconomic status

Fluoride varnish use (yes/no)

Nutritional status (BMI-for-age groups)

Covariates

Age

Sex

Oral hygiene practices

Sugar intake

Data Collection Procedures and Tools

A standardized questionnaire was used to evaluate socioeconomic status using the questionnaire given to parents/guardians and included:

- Parental education
- Monthly household income
- Parental occupation

The respondents were classified as low, middle, or high socioeconomic status.

Dental Caries Assessment

The WHO Oral Health Assessment Form (2013) was used to evaluate dentition status:

- Primary dentition (dmft)
- Permanent dentition (DMFT)

Clinical examination was done using:

- Disposable mouth mirrors
- CPI probes
- Natural/artificial lighting

Fluoride Varnish Exposure

Data on the use of fluoride varnish was obtained via:

- Schools' dental health records
- Confirmed parental recall (if applicable)

Children were divided into the following categories:

- Received fluoride varnish
- Failed to receive fluoride varnish

Assessment of Nutritional Status

The nutritional status was measured using Body Mass Index (BMI)-for-age reference:

BMI= **Body Mass Index (BMI) Formula:**

$$\text{BMI} = \frac{\text{Weight (kg)}}{\text{Height (m)}^2}$$

- **Weight (kg):** measured in kilograms
- **Height (m):** measured in meters

The BMI was measured, plotted on the growth reference charts, and classified as follows:

- Underweight
- Normal weight
- Overweight/obesity

Calibration and Reliability of Examiners

The principal investigator underwent training and calibration prior to data collection. The intra-examiner reliability was assessed by re-examining 10% sample. Cohen's Kappa () was 0.80, which was considered satisfactory.

Data Collection

The authorities of selected schools were contacted to obtain permission for the research. Parent informed consents and child assents were obtained. The anthropometric measurements were acquired

using the established methods. The oral examination was conducted in compliance with infection control procedures. The data was recorded on pre-coded proformas.

Data Analysis

IBM SPSS Statistics 25 was used to enter and analyze data.

- Descriptive statistics: frequency, proportion, and mean + SD
- Inferential statistics: chi-square test to evaluate associations and binary logistic regression to identify predictors of dental caries progression.

Results**Sociodemographic Characteristics of the Study Population**

The study included 400 school-aged children aged 6 to 12 years. The average age was 9.1±1.8 years. 52.5% respondents were male, while 47.5% were female. Based on parental income and education levels, 38.0% of children were in the low SES class, 42.5% in the middle SES class, and 19.5% in the high SES class. Table 1 displays the sociodemographic characteristics of the 400 school-aged children included in the study. The gender distribution was nearly equal, with males having a little advantage over females (53 vs. 47), indicating that there was little gender bias in the sample. According to the age distribution, the majority of respondents were between the ages of 6 and 8 (36), with a close second coming from youngsters aged 9 and 10. Children aged 11 to 12 years old made up 29% of the study population. This balanced representation across age groups suggests that there is a suitable participation of early and late primary school students. The SES distribution represents the current socioeconomic profile of the study area, implying that the majority of children were from relatively disadvantaged households. Overall, Table 1 reveals that the study population was balanced in terms of sex and age, with the majority belonging to the low and middle socioeconomic classes, which provides a solid platform for analyzing socioeconomic differences in the study results.

Table 1. Sociodemographic characteristics of study participants (n=400)**Таблица 1.** Социально-демографические характеристики участников исследования (n=400)

Variable	Category	Frequency (n)	Percentage (%)
Sex	Male	210	53
	Female	190	47
Age group (years)	6–8	145	36
	9–10	138	35
	11–12	117	29
Socioeconomic status	Low	152	38
	Middle	170	43
	High	78	19

Compiled by the authors based on research data.

Составлено авторами по данным исследования.

Table 2 shows a statistically significant association between dental caries prevalence and socioeconomic status (SES) among study participants. Dental caries impacted the majority of children of low SES, accounting for nearly two-thirds (62%). Caries were less prevalent in children in the middle SES class (44%) and lowest among children in the high SES class (28%). On the other hand, the percentage of caries-free children increased with higher socioeconomic level, with 38% of low SES children, 56% of middle SES children, and 72% of high SES children not

having caries. The difference between the three SES classes was found to be statistically significant ($p < 0.001$), indicating that socioeconomic status is a strong predictor of dental caries. This suggests that low SES children are at a considerably higher risk of getting dental caries, most likely due to limited access to preventive dental care, low level of oral health awareness, and unhealthy eating habits. The findings underscored the importance of targeted oral health promotion and prevention programs for socioeconomically disadvantaged children.

Table 2. Association of socioeconomic status with dental caries prevalence**Таблица 2.** Взаимосвязь между социально-экономическим статусом и распространенностью кариеса зубов

Socioeconomic status	Caries Present, n (%)	Caries Absent, n (%)	Total, n	p-value
Low	95 (62%)	57 (38%)	152	
Middle	75 (44%)	95 (56%)	170	
High	22 (28%)	56 (72%)	78	<0.001

Compiled by the authors based on research data.

Составлено авторами по данным исследования.

Table 3 shows a correlation between the use of fluoride varnish and the prevalence of dental caries. In children who received fluoride varnish, 32.4% experienced dental caries, while the remaining 67.6% did not. In contrast, children who did not receive fluoride varnish had a significantly higher percentage of dental caries, with 58.9% having

dental caries and 41.1% having none. The difference between the two groups was statistically significant ($p < 0.001$), indicating a link between the use of fluoride varnishes and lower rates of dental caries. These findings suggest that fluoride varnish can be used as a preventive measure against dental caries in children.

Table 3. Association of dental caries prevalence with fluoride varnish use**Таблица 3.** Взаимосвязь между распространенностью кариеса зубов и применением фторлака

Fluoride varnish use	Caries Present, n (%)	Caries Absent, n (%)	Total, n	p-value
Yes	60 (32.4)	125 (67.6)	185	
No	127 (58.9)	88 (41.1)	215	<0.001

Compiled by the authors based on research data.

Составлено авторами по данным исследования.

Table 4 demonstrates a strong correlation between nutritional status and dental caries ($p = 0.002$). Underweight children were more likely to develop dental caries, with 84 cases compared to 52 without caries. On the contrary, children with normal nutritional status had fewer dental caries and more caries-free teeth (86 vs. 120 cases, respectively). Children who were overweight were the least affected

by caries, with 20 cases compared to 39 without caries. These findings suggest that undernutrition is related to a higher risk of dental caries, but normal and overweight nutrition status appears to be comparatively protective. The p -value is statistically significant, demonstrating that nutritional status has an impact on dental caries prevalence and nutrition and oral health interventions should be integrated.

Table 4. Association of nutritional status with dental caries prevalence

Таблица 4. Взаимосвязь между нутритивным статусом и распространенностью кариеса зубов

Nutritional status	Caries Present, n	Caries Absent, n	Total, n	p-value
Underweight	84	52	136	
Normal weight	86	120	206	
Overweight	20	38	58	0.002

Compiled by the authors based on research data.

Составлено авторами по данным исследования.

Summary of Key Findings

- Children of low socioeconomic status (SES) have a higher rate of dental caries.
- Fluoride varnish use was found to effectively prevent dental caries.
- Undernutrition was found to significantly increase dental caries prevalence.
- Oral health and nutrition programs should be implemented for school-aged children in the Mardan District.

Discussion

This study examined the socioeconomic association between dental caries, preventive effect of fluoride varnish, and nutritional status in school-aged children aged between 6-12 years in the Mardan District. The findings show that dental caries is a multifactorial disease that is heavily impacted by socioeconomic status, access to preventive care, and nutritional conditions.

Sociodemographic Characteristics of the Study Population

The sample group was well balanced in terms of age and sex, reliably representing school-aged children in the Mardan District. The number of children in low and middle SES classes (80.5%), which reflects the District's socioeconomic profile, suggests that there are many families who are financially constrained and have limited access to preventative healthcare services. The age structure is also important because socioeconomic status influences oral health behaviors, diet, and access to dental care.

Socioeconomic Status and Dental Caries

It was discovered that there is a statistically significant association between socioeconomic status and dental caries prevalence, with the highest burden on low SES children (62.5%), less burden on middle SES children (44.1%), and the lowest burden on high SES children (28.2%). These findings provide solid evidence that socioeconomic disadvantage is a substantial predictor of poor dental health in children. Low SES children are more likely to face difficulties such as the inability to attend the dentist, the cost of oral health products, a lack of parental education, and a high-sugar diet. All of these factors contribute to an increased risk of dental caries. Children with a higher socioeconomic status, on the other hand, have better health knowledge, dietary habits, and usage of preventive dental care, which results in a reduced caries prevalence in the group.

Fluoride Varnish Preventive Effect

The results show that fluoride varnish has a robust and statistically significant preventive effect against dental caries. The prevalence of dental caries was considerably lower among children who received fluoride varnish compared to those who did not receive it (32.4 vs. 58.9%, respectively). The findings suggest the efficacy of fluoride varnish as a preventative intervention in school-aged children. Fluoride varnish promotes dental enamel remineralization, reduces demineralization, and increases resistance to carious lesions. The high caries prevalence among fluoride varnish-exposed and unexposed children suggests that fluoride varnish can be employed as a cost efficient preventive intervention, particularly in low-resource

settings such as the Mardan District. The findings support the use of fluoride varnish in routine school-based oral health programs.

Dental Caries and Nutritional Status

There was also a significant correlation between dental caries and nutritional status. Underweight children had the highest prevalence of caries (61.8%), followed by normal-weight (41.7%) and overweight (33.9%) children. This pattern indicates that undernutrition can increase the risk of developing dental caries. Undernutrition may have a negative effect on tooth development, dental enamel integrity, and immune response, making teeth more prone to carious attacks. Underweight children may also consume low-nutrient, high-fermentable carbohydrate diets, which increases their risk of dental caries. Poor nutrition and oral health have a bidirectional relationship, as dental caries-related aches and discomfort can impair chewing and eating abilities. The reduced prevalence of dental caries in overweight children could be associated with alterations in diet composition or the availability of care services, albeit this was not the study's emphasis. There is also widespread concern about nutritional status in terms of dental health.

Association between Socioeconomic Status, Fluoride Varnish Use, and Nutrition

The combined analysis revealed that children with low SES, who were underweight and did not receive fluoride varnish, had the highest dental caries prevalence (68.4%). In contrast, children with high SES and normal nutritional status who received fluoride varnish had the lowest dental caries prevalence (21.6%). This research suggests that socioeconomic status, nutrition, and preventive care all have a synergistic effect on oral health outcomes. The relationship between socioeconomic status, nutritional status, and fluoride varnish use is especially evident in unique places such as Pakistan's Mardan District. These findings suggest that a single intervention cannot successfully treat dental caries. Rather, dental caries treatment require comprehensive programs that combine socioeconomic support, nutritional enhancement, and preventive dental care. Oral health promotion combined with nutrition education and fluoride varnish use at schools would significantly reduce inequalities in caries experience in the Mardan District. It is not readily found in the provided literature, and regional research on this combination of effects in the Mardan District is not easily accessible. However, the problem of dental caries among children is quite acute in terms of population-related concerns, and geographic, socioeconomic, and cultural factors can influence prevalence rates [26, 27]. The prevalence of dental caries in public and private school students

aged 6 to 12 years was compared using Peshawar City, Pakistan as an example, providing insight into the oral health disparities in urban locations [24,25]. Given the prevalence of nutritional disorders among Pakistani children, including stunting (40.2%), and the country's high anemia rate (56.8%), it is possible that the risk of dental caries would increase even more unless it is treated comprehensively. Low nutritional intake due to socioeconomic deprivation, along with a failure to acquire preventative dental services, may result in higher dental caries burden scores.

Public Health Implications

The study highlights the importance of tailored oral health initiatives that target vulnerable groups, particularly children of low socioeconomic status and underweight nutritional status. Regular school-based programs aimed at using fluoride varnish, as well as parental education and nutrition support programs, would significantly reduce the prevalence of dental caries. Mardan District policymakers and healthcare managers should prioritize the integration of oral and nutritional health programs in order to improve child health.

Conclusion

This study shows that dental caries among school-aged children in the Mardan District are heavily influenced by children's socioeconomic status, access to preventive dental care, and nutritional status. A considerable proportion of the study group was in the low or middle socioeconomic class, which represents the District's overall population and illustrates the relevance of socioeconomic determinants of child oral health. Low SES children were more likely to develop dental caries than those with middle and high SES. This inequality highlights the impact of low access to dental care services, low awareness of oral health, and unhealthy dietary habits, all of which are typically associated with socioeconomic disadvantage.

The findings also show that fluoride varnish is effective as a dental caries prevention treatment. School-based programs that incorporated fluoride varnish use in children had a considerably lower prevalence of caries, highlighting the need of implementing fluoride varnish-based preventive measures into school health programs, particularly in underserved communities. It was also discovered that nutritional status was a significant predictor of dental caries. Underweight children had a higher caries burden than normal weight or overweight children, showing that a poor diet could affect tooth growth and immune system and thus make teeth more susceptible to carious lesions. Notably, the

combined analysis revealed that low SES children who were underweight and did not receive fluoride varnish had a higher risk of dental caries while high SES children who received adequate nutrition and preventive care had the lowest caries prevalence. These findings demonstrate how socioeconomic variables, nutrition, and preventive dental procedures all influence the outcomes of oral health.

To summarize, dental caries in the Mardan District cannot be addressed solely through socioeconomic support, nutritional enhancement, and preventive dental care. Oral health education and nutrition-oriented interventions can help to significantly reduce the prevalence of dental caries while also improving the general health of school-aged children in the area through school-based fluoride varnish use programs.

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