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ORIGINAL ARTICLE

Prevalence of dental caries and its association with nutritional status among school-going children from remote, rural communities of Pakistan

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ABSTRACT

Objective: To assess the prevalence of dental caries and its association with nutritional status among school-going children in a remote rural community of district Swat, Pakistan.

Methods: This cross-sectional study was conducted in Swat from July to August 2023 among 482 children aged 10–16 years, selected through multistage sampling from public and private schools. Data were collected using a structured questionnaire adapted from WHO oral health surveys, anthropometric measurements, and clinical oral examination using Decayed, Missing, and Filled Teeth index. Nutritional status was assessed using BMI-for-age Z-scores (BAZ) based on WHO growth standards. Data were analyzed using SPSS version-29.

Results: Out of 482 elementary-level students assessed, 154 (32%) were females, with mean age of 12.9±2.73 years. Prevalence of dental caries was 250 (51.7%). Regarding nutritional status, 99 (20.5%) children were wasted, 46 (9.5%) were at risk of being overweight, and 12 (2.5%) were overweight/obese. A statistically significant difference was observed in BAZ scores between children with and without caries ($p<0.001$). Multivariable analysis showed that higher BAZ scores were associated with a lower likelihood of dental caries. Additionally, oral healthcare-seeking behavior and self-reported feelings of frustration, depression, or irritation were significantly associated with dental caries ($p<0.001$ and $p=0.018$, respectively).

Conclusion: Dental caries is highly prevalent among school-going children in this rural setting and is significantly associated with poor nutritional status. Lower BAZ score is linked with increased caries risk. Integrated interventions addressing both oral health and nutrition are essential to improve child health outcomes in low- and middle-income countries.

Keywords: Body Mass Index (MeSH); BMI-for-Age (MeSH); Malnutrition (MeSH); Nutritional Status (MeSH); Oral Health (MeSH); Vulnerable (MeSH); Child (MeSH); Adolescent (MeSH); Pakistan (MeSH); Dental Caries (MeSH); Quality of Life (MeSH).

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INTRODUCTION

The World Health Organization (WHO) defines oral health as a state of being free of mouth and facial pain, oral infection and sores, periodontal (gum) disease, tooth decay, tooth loss, and other diseases and disorders that limit an individual's capacity for biting / chewing, smiling and speaking, and psychosocial wellbeing. Good oral health serves as an important indicator of overall health. Unfortunately, despite tremendous efforts to raise awareness regarding the importance of oral health and hygiene, oral problems remain one of the commonest illnesses worldwide. For example, in 2023, the WHO's global oral health status report (GOHSR), which provides the most comprehensive information on oral health and disease status globally, stated that oral disease affects 3.5 billion people across the globe which is equivalent to almost half of the world's population.[1] Dental caries was the commonest oral health problem affecting 2.5 billion people across the world. School children are at high risk of developing caries with an estimated prevalence of 60-90% especially in developing countries.[2] As a result, children in this age bracket are the primary target of most oral health improvement initiatives. The WHO also recommends oral health screening for all children at 5, 12 and 15 years of age.[3]

Untreated dental caries has several detrimental impacts on health such as pain, disability, decreased well-being and consequential negative impacts on their quality of life.[4] If the carious lesion is left untreated, the resultant tooth ache and discomfort can impair growth, cognitive development and even academic performance.[5] The impact of dental caries on growth and development also has negative consequences on nutritional status of the children. Mounting research evidence suggests poor nutritional status as an important risk factor for caries development in children.[6,7] As a result, dental caries prevalence is still on the rise in developing countries where malnutrition is common.[8]

Pakistan has one of the world's highest levels malnourished children. Up to 40% of the children under five years of age have stunted growth, as revealed in 2018 national nutrition survey of Pakistan.[9] Micronutrients deficiencies are also common (e.g., anemia >50%; vitamin A deficiency >50%) in this group. Since dietary intake and nutritional status is an important risk factor for poor oral health conditions,

including caries, research studies have attempted to elucidate the relation between body mass index (BMI) and prevalence of dental caries.[10] However, it is crucial to note that BMI is an indirect measure of nutritional status and is influenced by several factors such as dietary intake, distribution of body fat and even psychological, ethnic and environmental factors. In children, the most accurate measure of nutritional status is underweight (low weight-for-age), stunting (low height-for-age) or wasting (low weight-for-height), as these parameters effectively capture the underlying biological processes.[11]

Despite this, there is limited evidence from Pakistan, particularly from resource-constrained and rural settings, examining the relationship between dental caries and comprehensive nutritional indicators beyond BMI. Therefore, this study was designed to assess the prevalence of dental caries and its association with nutritional status, including underweight, stunting, wasting, and overweight, among school-aged children in a resource-poor community of Swat district, Pakistan.

METHODS

This cross-sectional study was carried out in the Swat district of Pakistan, from July-Aug 2023. Swat is located 151 km north of Peshawar, the capital of Khyber Pakhtunkhwa province of Pakistan. Because of its geographic location in Hindukush–Himalayan region, majority of the land is occupied by mountains and thick forests with agriculture, livestock, fisheries, forest resources and tourism are the main sources of income for majority of the population.[12] Tehsil Matta, the second most populated tehsil of district Swat was chosen as the study site because of its remote location, sharing longest border with adjacent districts and predominantly agro-pastoral communities.

Ethical approval for the study was granted by Research Ethics Committee of Khyber Medical University Institute of Health Sciences, Swat Campus, Pakistan (Reference #: Dir/RC/KMU-IHS-EC/003, dated: June 28, 2023). The required sample size for this study was calculated using the single population proportion formula: $n=Z^2P(1-P)/d^2$, where n represents the minimum sample size, Z is the standard normal deviation at a 95% confidence level (1.96), P is the expected prevalence of dental caries, and d is the margin of error (5%). A conservative prevalence estimate of 50% was assumed due to the unavailability of reported caries prevalence for our remote and rural area to obtain the maximum sample size. Based on this calculation, the minimum required sample size was 384 participants. To improve statistical power and compensate for possible non-response or incomplete records, the sample size was increased, and a total of 482 children were included in the final analysis.

A multistage sampling strategy was developed for the selection of schools and research participants. In the first stage, a list of all registered government and private schools was obtained from the District Education Officer (DEO) office, this list was used as the sampling frame. The schools were stratified on the sectoral basis (public and private) and 04 public, and 04 private schools were selected using simple random sampling from the list. In the next stage, children eligible based on the inclusion criteria (elementary level students, physically and mentally normal, not on any nutritional supplements) were chosen through systematic random sampling from the schools' official enrollment lists. Before data collection commenced, the research team visited the schools, briefed the principal/head of the school about the purpose of the study and steps involved, and invited participation in the study. Once agreement to proceed had been granted, the school principals were provided with a consent and information sheet to deliver to parents/guardians of the study participants. Considering the age and education level of the participant and their parents/legal guardians, the research team developed an information sheet and consent form, both in Urdu (national language of Pakistan) and Pashto (local language). The information sheet described the study purpose and methods using simple and easy to understand language. Participation in the study was completely voluntary and either parent/legal guardian was free to decline participation of their child in the study.

To assess the perceived oral health of each study participant, a paper based, interviewer administered structured questionnaire was used. The questionnaire was adapted from WHO methodology and oral health surveys in Pakistan[13] with slight modification to make it suitable for use in the local settings. Before implementation, the questionnaire was pilot tested on 20 volunteers who were not part of the actual survey. The final survey questionnaire consisted of 25 open- and closed-ended questions on demographics (section A), socioeconomic status (section B), oral health and hygiene practices (section C) and self-reported oral health and impact (section D) and was designed to take approximately 10 minutes to complete. On the day of the survey, the data collection team met students in their class in the presence of the school principal. The survey and data collection process were outlined and explained to all the study participants in their local language (Pushto). Any queries or questions raised by the participants were clarified by the research team. All the children meeting eligibility criteria of the study were invited to participate in the study. The school authorities assisted in taking verbal (assent) and written consent from the children before data collection started. Data was collected by trained data collectors, before anthropometric assessment and clinical oral examination, to maximize response.

For anthropometric assessment (height and weight), the data collectors were first trained in-house on measurement techniques by an expert working in UNICEF- and WHO-supported nutrition projects in the area. Shorr boards and electronic scale (Seca, UK) were used to measure height and weight during the training and field study. After training, a standardization test was used to assess the ability of the data collectors (n=6) to measure the height and weight of 10 children with accuracy and precision. The standardization exercise was necessary to flag any issues in measurement technique that might require additional

training. To record height, the children were asked to stand barefoot on the Sharr board in the Frankfurt horizontal plane position. Height was recorded to the nearest 0.1 cm (mean of three independent readings). To record weight, the participants were first instructed to remove shoes, watches and jewelry before standing on a calibrated, digital weight scale. Weight was recorded to the nearest 0.1 kg (mean of three independent measurements).

Undernutrition was defined using anthropometrical measurements of weights and heights of children plotted against specific age and gender reference values from the WHO growth charts. Z-scores were calculated, that is, the difference between a child's weight or height and the median value at that age and gender in the reference population, divided by the standard deviation (SD) of the reference population, different forms of undernutrition was derived as follows:

Stunting: A child whose height-for-age is less than -2 SD.

Wasting: One whose weight-for-height is less than -2 SD.

Underweight: A child whose weight-for-age is less than -2 SD.

Oral examination was performed by two independent examiners (ZK & TA) who received training on caries detection and assessment using Decayed, Missing and Filled Teeth (DMFT) scores.[14] The training was followed by a calibration session to assess inter and intra-examiner reliability. The Kappa score was >0.71 indicating substantial agreement. Oral examination was performed in artificial light using a single set of disposable dental mirror, probe and cotton wool rolls to avoid the risk of cross infection. All clinical examinations were carried out by the same examiners who documented the presence of dental caries (enamel or dentine) and missing or filled teeth with the aid of a data collector who recorded the findings on data collection sheet. All the data, including survey questionnaires and clinical exam-inations, were entered into a Microsoft Excel spreadsheet and around 10% of the data was randomly checked for any errors in data entry. The final data were analyzed using the Statistical Package for Social Science version 29 (IBM Statistics, Chicago, IL, USA). The Kolmogorov-Smirnov and the Shapiro-Wilk tests were used to assess the normality of the data. Depending on the type of data and variables, descriptive statistics (independent sample t-test Chi-square test) were performed to compare differences between the groups. Nutritional status was assessed using BMI-for-age, WHO growth standards. The difference between BMI-for-age z score (BAZ) between those with carries and those without carries was assessed through QQ plot (using comparison of empirical quartiles of the two groups) and violin plots. Logistic regression was used to investigate association between carries status and BMI-for-age adjusted for age, gender, maternal education and family income. A p-value <0.05 was considered significant.

RESULTS

This descriptive cross-sectional study included a total of 482 elementary level students aged 10-16 years. Mean age of the children was 12.9±2.73 years and 154 (32%) were females. The study group included 232 (48.1%) children who were enrolled in government/public sector schools while 250 (51.9%) were from private schools.

Table I: Distribution of dental caries with respect to sociodemographic characteristics of participants

Variable	Categories	Overall	Dental caries		p-value
		N=482	Absent (N=232)	Present (N=250)	
Age (years)		12.9 (1.2)	12.9 (1.2)	12.8 (1.2)	0.99
Gender	Male	328 (68.0%)	156 (47.6%)	172 (52.4%)	0.714
	Female	154 (32.0%)	76 (49.4%)	78 (50.6%)	
Type of School	Govt.*/Public	226 (46.9%)	101 (44.7%)	125 (55.3%)	0.155
	Private	256 (53.1%)	131 (51.2%)	125 (48.8%)	
Family Size	1-4 members	29 (6.0%)	10 (4.3%)	19 (7.6%)	0.23
	5-9 members	362 (75.1%)	174 (75.0%)	188 (75.2%)	
	≥10 members	91 (18.9%)	48 (20.7%)	43 (17.2%)	
Mother's education	No formal education	267 (56.2%)	130 (48.7%)	137 (51.3%)	0.814
	Primary level	42 (8.8%)	22 (52.3%)	20 (47.7%)	
	High school	53 (11.2%)	24 (54.5%)	29 (45.5%)	
	College or University	55 (11.6%)	30 (54.5%)	25 (45.5%)	
Household income (min, max) in PKR x10^3		60 (30, 100)	65 (30, 100)	60 (30, 100)	0.895
Source of drinking water	Covered well	117 (24.3%)	60 (25.9%)	57 (22.8%)	0.789
	Hand pump	22 (4.6%)	10 (4.3%)	12 (4.8%)	
	Tubewell / Borehole / Suction pump	144 (29.9%)	68 (29.3%)	76 (30.4%)	
	Municipal / Piped water	40 (8.3%)	21 (9.1%)	19 (7.6%)	
	Spring water	152 (31.5%)	68 (29.3%)	84 (33.6%)	
	Others	4 (0.8%)	3 (1.3%)	1 (0.4%)	

*: Government

Table I presents sociodemographic characteristics of the study participants described by caries status (present or absent). Overall, 250 (51.7%) children had dental caries with male students being slightly more affected than

Table II: Distribution of dental caries based on oral hygiene habits of children

Characteristics	Category	Status of Dental Caries		p-value
		Present	No Caries	
How many times do you clean/brush your teeth every day?	No or rarely	35 (13.9%)	33 (14.2%)	0.749
	One time only	152 (60.6%)	141 (60.5%)	
	Two times	63 (25.1%)	56 (24%)	
	Three times or more	1 (0.4%)	3 (1.3%)	
What time do you clean / brush your teeth?	In the morning only	145 (65.9%)	128 (63.4%)	0.562
	In the afternoon	6 (2.7%)	10 (5%)	
	evening before going to bed	13 (5.9%)	9 (4.5%)	
	Morning and evening	46 (20.9%)	41 (20.3%)	
	other	10 (4.5%)	14 (6.9%)	
What do you use for cleaning your teeth?	Toothbrush and toothpaste	191 (87.2%)	177 (88.1%)	0.555
	Miswak	27 (12.3%)	23 (11.4%)	
	Dental floss	1 (0.5%)	0	
	Other	0	1 (0.5%)	
How often do you visit dentist?	Regularly after every 6-8 months	2 (0.8%)	3 (1.3%)	<0.001
	Occasionally	11 (4.4%)	20 (8.6%)	
	Whenever I have an oral health issue	115 (45.8%)	58 (24.9%)	
	I never visited dentist	123 (49%)	152 (65.2%)	
Currently or in the past 12 months, have you experienced any of the following?	Tooth ache	23 (9.3%)	22 (9.6%)	0.070
	Sensitivity to hot and cold	22 (8.9%)	29 (12.7%)	
	Gum bleeding when eating or cleaning teeth	14 (5.6%)	9 (3.9%)	
	Persistent Bad breath	5 (2%)	7 (3.1%)	
	Shaky teeth	10 (4%)	9 (3.9%)	
	More than one of the above problems	130 (52.4%)	91 (39.7%)	
	I never experienced any dental problem	44 (17.7%)	62 (27.1%)	
Have you had any difficulty eating, chewing or drinking (hot and cold) because of your mouth, teeth or gums?	Yes	118 (47.4%0	95 (40.9%)	0.155
	No	131 (52.6%)	137 (59.1%)	
Have you ever felt irritated, frustrated or depressed because of your mouth, teeth or gums?	Yes	99 (39.4%)	68 (29.2%)	0.018
	No	152 (60.6%)	165 (70.8)	
Have you ever avoided smiling or laughing when around with other children or other children asked you questions about your teeth, gum or mouth?	Yes	51 (20.2%)	45 (19.3%)	0.798
	No	201 (79.8%)	188 (80.7%)	
Are you satisfied with the appearance of your teeth?	Yes	216 (85.7%)	203 (87.1%)	0.651
	No	36 (14.3%)	30 (12.9%)	

females (52.4 cf. 50.6%). Similarly, students enrolled in government/public sector schools exhibited a higher frequency of dental caries (55.3%) than those in the private schools (48.8%). However, no statistically significant difference was observed for age, gender, school type, family size, mother education, monthly household income and source of drinking water between the two groups.

Table II shows that most oral hygiene practices, including frequency and timing of tooth brushing and methods used for cleaning teeth, were not significantly associated with dental caries. However, dental healthcare-seeking behavior and self-reported feelings of irritation, frustration, or depression were significantly associated with caries status. Children with caries were more likely to report multiple oral health problems and infrequent dental visits.

Figure 1 presents the overall nutritional status of the study-group children based on WHO growth standards. Based on BMI-for-age-z score (BAZ), the participants were categorized as wasted (BAZ<-2.0), risk of being overweight (BAZ>1.0), overweight/obese (BAZ>2.0. The mean z-score of all the children was -0.79±1.29, indicating a lower growth trend than the standard growth mean z-score. Overall, undernutrition/wasting was the most common problem affecting 20.5% of the study participants. Prevalence of overnutrition was less common with 9.5% of the children were at risk of being overweight and only 2.5% were overweight/obese.

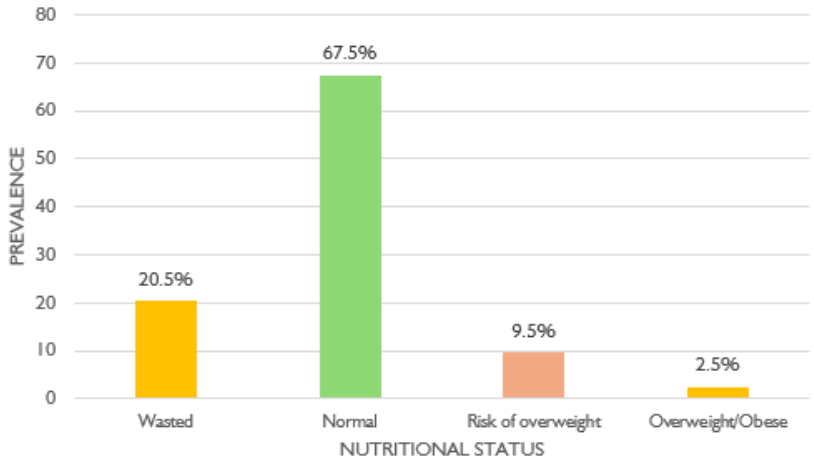

Figure 1: Overall prevalence of nutritional status of the study participants based on BAZ score

Figure 2 shows the BAZ scores of the two groups based on dental caries status. Figure 2A shows quantiles for BAZ score for adolescents with no caries on x-axis and those with caries on y-axis. The separation between two lines shows that the BMI-for-age is not similar in the two groups. The plotted lines are below the reference line, which shows that the BAZ score of caries free adolescents is higher than those with caries. Figure 2B reflects the median BAZ score with quartiles of the two groups and shows that the median ABZ score of caries-free adolescents was significantly higher (p-value: 001) than those subjects with caries. Multivariable adjusted logistic regression analysis showed that the likelihood of caries is lower in participants with higher BMI/BAZ score

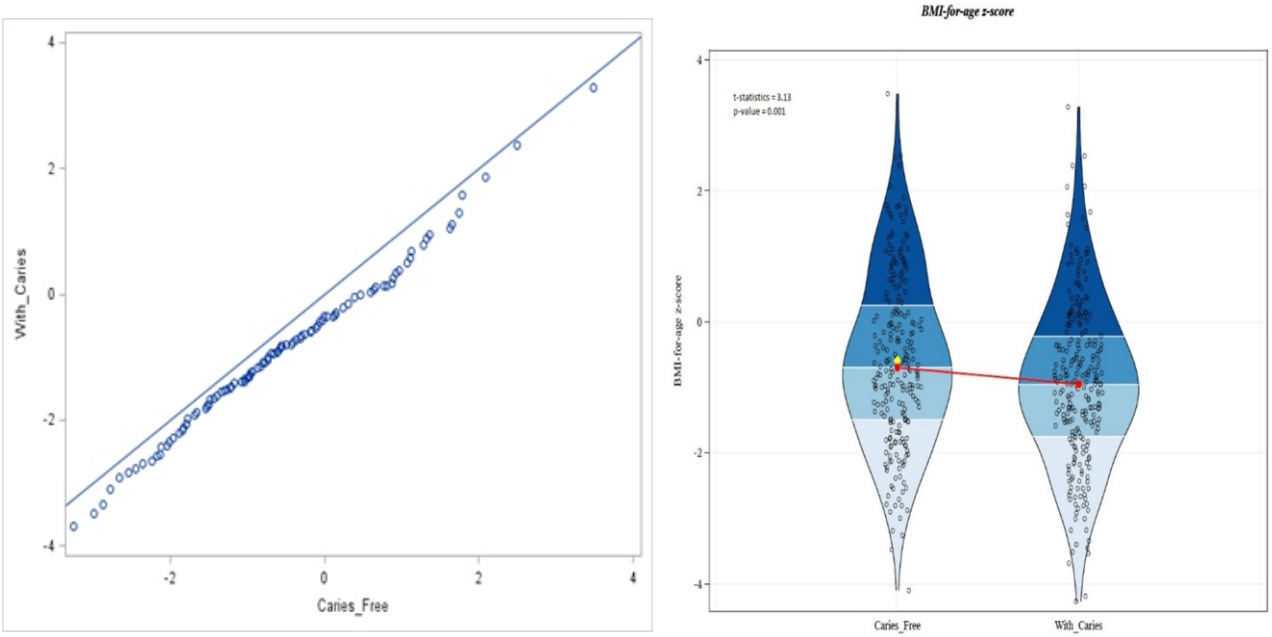

Figure 2: BAZ distribution by caries category. **(A)** QQ plot of children with and without caries. **(B)** Violin plot for the comparison of empirical quartiles between carious and non-carious children

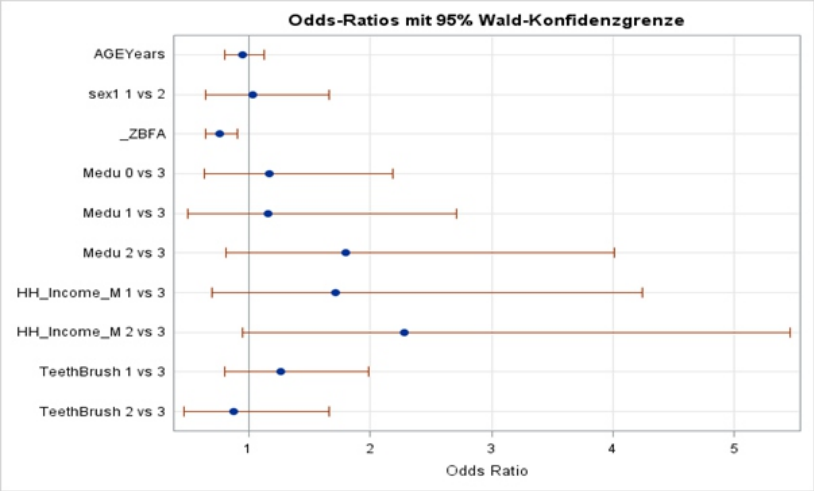

Figure 3: Adjusted odds ratio of potential risk factors with carries

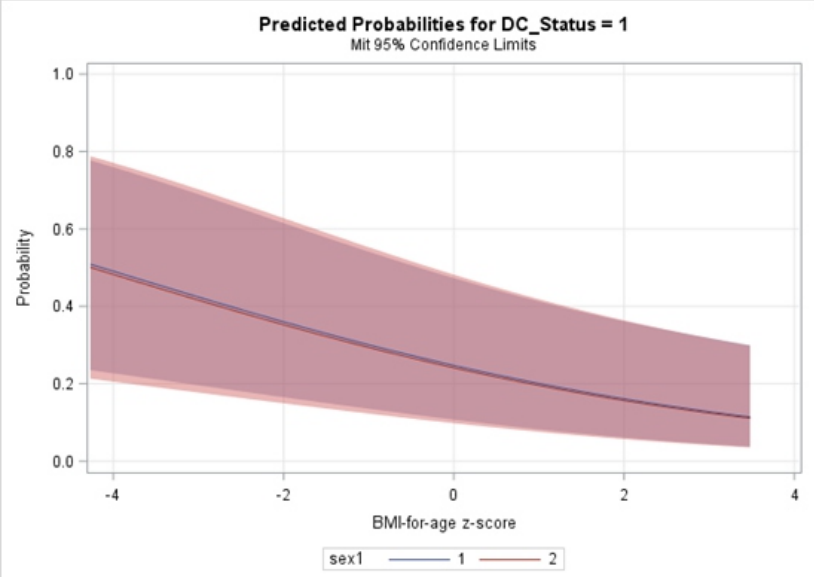

Figure 4: Predicted probabilities for having caries with different BMI-for-age Z-score

(0.76, CI:0.64-0.91) after adjusting for other variables like age, gender, maternal education, household income, teeth brushing practices and sources of drinking water than those with higher BMI (Figure 3). Probability calculation using logistic regression (Figure 4) indicates that adolescents with a higher BAZ score are less likely to have caries compared to those with lower BAZ scores. This relationship suggests that as BMI increases, the probability of dental caries decreases. Even after adjusting for factors such as age, gender, maternal education, household income, teeth brushing practices, and sources of drinking water, the association remains evident. This finding points toward a protective effect associated with higher BMI in relation to caries risk among adolescents.

DISCUSSION

This study assessed the prevalence of dental caries and its association with nutritional status among school-going children in a rural setting of district Swat, Pakistan. The findings demonstrate a high burden of dental caries, with more than half of the participants affected. Importantly, an inverse association was observed between BAZ and dental caries, indicating that children with poorer nutritional status are at greater risk of developing caries. These results highlight the interplay between nutrition and oral health in resource-constrained settings.

Dietary intake and nutritional status are among the most important determinants of health in children and adolescents. Poor nutrition / malnutritionnot only affects the growth and development in children, but it can also have detrimental impact on oral health and quality of life.[15] The problem is more severe in low-and-middle-income countries like Pakistan where malnutrition is endemic[9] and the healthcare standards are well below those of the developed world. As a result, malnourished children are among the population group who are at high risk of developing malnutrition related oral problems and related consequences. In this descriptive cross-sectional study, we have reported prevalence of dental caries and associated factors in school going children residing in resource poor, rural communities of Pakistan.

The study participants were high school students aged 10-16 years. Child cognition in this age bracket is sound enough to respond to the questions of the interviewers. More than half of the study population (51.8%) had at least one carious tooth present in their mouth. The prevalence was slightly lower than the national level prevalence of dental caries in Pakistan (56.6%) as reported in a recent systematic review and meta-analysis.[16] However, these differences might be due to the age differences, locality and socioeconomic status of the study participants. Although, our study reports high caries prevalence in the govt/public school's student (55.3%) than those in the private schools (48.8%), the differences were not significant. These findings are in concordance with a recently published study by Khan ZA, et al.,[17] who found no significant difference in caries prevalence in school-going children attending public and private schools in Peshawar, the capital of the province where Swat is located. In dental surveys, the type of school (private or public) a student attends are an indirect indicator of socioeconomic

status. Public sector schools in Pakistan are state funded schools offering free or low-cost education and therefore mainly attended by children belonging to low-income families. Therefore, the high prevalence of caries in these children is not uncommon and reported in other countries too.[18] Children with carious teeth also reported high prevalence of oral health problems during the last 12 months which negatively affects their quality of life as suggested by the finding that 39.4% of caries sufferers feel depressed due the oral health problems. The impact of carious teeth on quality of life were higher in our subject group than in a Benin (Nigeria) based study where 27% reported emotional disturbance.[4] Other sociodemographic variables such as household monthly income, family size and drinking water source were not significantly different between the two groups.

Our study also reports a high double burden of malnutrition (both under and over-nutrition) in adolescents. Assessment of the nutritional status showed that every one in five adolescents (20.5%) were wasted and every one in ten adolescents (9.5%) were at risk of being overweight. The prevalence of wasting is slightly higher than both the national (17.7%) and provincial (Khyber Pakhtunkhwa) level prevalence (15%) of wasting in Pakistan as reported in the National Nutrition survey of Pakistan in 2018.[9] The reason for the higher prevalence of wasting in our study participants could be because rural communities in Pakistan and elsewhere in the world are always at high risk of malnutrition due to poor socioeconomic status, diet quality and limited access to the healthcare facilities.[19] We found a significant association between the occurrence of dental caries and growth indices based on BAZ scores of children, indicating a clear inverse relationship among the two variables. Although, several studies reported a two-way relationship between caries and malnutrition, we don't know whether caries cause malnutrition in children or vice versa. The current study along with other suggests that the presence of carious teeth in children is a risk factor for malnutrition.[20-22] Research evidence from randomized trials also reported improvements in growth indices after dental treatment of severe, untreated caries.[23] This coherency of results between the current study and several other studies reported in different regions of the globe is evidence of a strong association between growth and oral health in children. Mechanistically, the direct relationship between BMI and dental caries is plausible since both conditions share common risk factors, such as excessive intake of beverages, snacks and sugary or junk food.[24] Although, the study is the first of its kinds reporting prevalence of dental caries and its association with nutritional status from resource poor, rural communities of Pakistan, it has several limitations. First, the cross-sectional design of this study does not allow for establishing a cause-and-effect relationship. Second, we did not collect dietary intake data which is crucial for nutritional status assessment and caries development. Third, the use of the dmft/DMFT index as a dental caries assessment tool identifies caries at its early stage but does not measure caries severity. This limitation may affect the accurate detection of associated functional limitations in children. In future, prospective cohort studies are recommended to investigate the long-term association of caries with weight, height, BMI and overall growth indices based on z-scores in children with a range of dentition.

CONCLUSION

This study demonstrates a high prevalence of dental caries (51.7%) among children aged 10-16 years in remote rural community of district Swat-Pakistan, with a significant inverse association between dental caries and BMI-for-age score. These findings highlight the close relationship between oral health and nutritional status. In low- and middle-income settings such as Pakistan, integrated strategies focusing on oral hygiene promotion, timely dental care, and nutritional improvement are essential to enhance child health and quality of life.

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AUTHORS' CONTRIBUTION

The following authors have made substantial contributions to the manuscript as under:

MS & AS: Conception and study design, drafting the manuscript, critical review, approval of the final version to be published

ZK & TA: Acquisition of data, drafting the manuscript, approval of the final version to be published

KI: Analysis and interpretation of data, critical review, approval of the final version to be published

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

CONFLICT OF INTEREST

Authors declared no conflict of interest, whether financial or otherwise, that could influence the integrity, objectivity, or validity of their research work.

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DATA SHARING STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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