Journal of Oral Biology and Craniofacial Research 13 (2023) 506–510

Contents lists available at ScienceDirect

Journal of Oral Biology and Craniofacial Research

journal homepage: www.elsevier.com/locate/jobcr

Impact of dental caries and nutritional status on oral health related quality of life in young Indian adolescents

Sweta Singh [a], Priyanka Talmale [b,*]

[a] Department of Public Health Dentistry, K.M. Shah Dental College & Hospital, Sumandeep Vidyapeeth (Deemed to be University), Vadodara, India
[b] Department of Public Health Dentistry, SMBT Institute of Dental Science and Research, Ghoti, Dhamangaon, Igatpuri, Nashik, 422403, India

ARTICLE INFO

Keywords:
Dental
Caries
Adolescents
Oral health
Quality of life
Nutritional status

ABSTRACT

Background: A combination of poor oral health status and malnourishment ultimately affect the quality of life of the person. Hence, these tools may help in identifying individuals at risk of poor quality of life and malnutrition caused by oral problems especially in adolescents.
Objective: To test the association between dental caries, nutritional status and Oral Health Related Quality of Life (OHRQoL) in 12–15 year-old school going adolescents.
Study design: A cross sectional study was conducted on 12-15-year-old school going adolescents. A total of 1214 adolescents participated in the study. Data on quality of life was collected using OHIP-14 and clinical examination was done to assess the DMFT status and Body Mass Index (BMI) as measure of nutritional status of the subjects.
Results: DMFT was found to be positively correlated with total OHIP score, however BMI was negatively correlated with OHIP. Controlling for BMI, partial correlation analysis revealed that there is a weak association between OHIP and DMFT scores which was found to be statistically significant.
Conclusion: Both caries experience and nutrition status had significant impact on Quality of Life. All the three parameters were found to be correlated to each other.

1. Introduction

Dental caries is a complex disease affecting teeth and is one among the major public health problems, which in an individual, may cause pain and suffering and also, adversely impact the person's quality of life. It is a common chronic disease that may progress to pain and disability especially in adolescents since they are in growing stage.[1] As children enter the phase of adolescence, their dietary habits change which affects the body fat and represents effectual phase in growth and development.[2]

Adolescents are important part of any community. Any approach that evaluates quality of life can give comprehensive view of the adolescents' health. Oral health-related quality of life (OHRQoL) is recognized as an integral part of general health. It relates how day-to-day activities are affected by oral conditions with an emphasis on individual experience for the assessment of treatment needs.[3]

One of the many adverse consequences of dental caries is pain. Untreated dental caries can lead to dental pain which is known to affect daily activities, with a lasting impact on their quality of life like sleep disturbance, decreased work effectiveness, school absenteeism and avoidance of certain types of food.[4]

Recent studies have documented a "double burden of malnutrition": persistent under nutrition in rural regions and increasing overweight or obesity in urban areas.[5] Similar to dental caries, malnutrition has multifactorial etiology with diet as a common risk factor. Both are known to impact the quality of life. Untreated caries can affect ability to eat which can impair adequate intake of nutrients. Consequences of dental caries can affect quality of life which may affect growth of child.[6,7,] These tools may help in identifying individuals at risk of malnutrition caused by oral problems.[7]

Teeth are important in enabling consumption of a balanced diet and further preparing the food for digestion. Dental caries can lead to pain and also tooth loss which limits the food choices of the individual. Inability to eat coupled with discomfort, pain and anxiety leads to compromised nutritional intake. This makes dental caries and its consequences a risk factor for nutritional deficiency.

Likewise, dental pain, anxiety and tooth loss consequent to dental caries are associated with loss of enjoyment of food and unesthetic appearance, thereby leading to low self-esteem and confidence. This

* Corresponding author.
E-mail address: priyankatalmale29@gmail.com (P. Talmale).

https://doi.org/10.1016/j.jobcr.2023.05.002
Received 29 June 2021; Received in revised form 11 March 2023; Accepted 4 May 2023

establishes the detrimental effect of dental caries on quality of life. Both, dental caries and nutrition have diet as common risk factor and are likely to impact quality of life. Also, these factors are more likely to be exacerbated in under privileged groups and less developed societies where dental care is less accessible and affordable.[8] Therefore, we aimed to evaluate the association of dental caries and nutritional status with OHRQoL among 12-15-year-olds from rural area. The hypothesis for the study is increased caries experience and poor nutritional status may have negative impact on OHRQoL.

2. Materials and method

2.1. Study population

A cross-sectional study was conducted on 12-15-year-old school going adolescents enrolled in government schools of Vadodara district in Gujarat state, India. The list of registered schools was obtained from the District Education Office. The list comprised of 94 schools and the number of 12–15-year-old school going adolescents registered in these schools was approximately 35,000. The required sample size was calculated to be 1214, considering the prevalence of dental caries to be 23%.[9] A multistage cluster sampling technique was used to achieve the sample. The district was divided into four geographical zones. Two government schools were selected from each zone, making a total of eight sampled school clusters. From each of these eight schools, students were selected using proportional allocation scheme so as to achieve a total sample size of 1214.

The study protocol was reviewed and approved by the University Ethics Committee (BNPGI5/DI6096). A written informed consent from parents and assent from participants was obtained. Students absent on the day of examination or having any systemic disease, illness and acute pain were excluded from the study. The study was carried out between November 2017 and June 2018.

2.2. Instruments and measures

Data on OHRQoL was collected using Gujarati version of Oral Health Impact Profile −14 (OHIP-14) questionnaire which is rated on 5-point ordinal scale, ranging from Never (0); Hardly ever (1); Occasionally (2); Fairly often (3); Very often (4).[10] Gujarati version of OHIP-14 has been proven to be valid, and reliable instrument in previous studies.[11] The Gujarati version was checked for cross cultural adaptation by a forward and back translation approach, where a bilingual expert translated the SOC into Gujarati from English. The reconciled Gujarati version was then back-translated by an English expert, not familiar with the original questionnaire. This back-translated version was compared with the original questionnaire by another language expert. The questionnaire was evaluated by three subject experts for its face validity. A cognitive debriefing process was also followed by the cultural adaptation of the questionnaire. The Gujarati version was administered to twenty children. The Cronbach's alpha for internal consistency was 0.74. The Oral Health Impact Profile-14 (OHIP-14) has been used to assess the impact that oral health problems can have on an individual's life.[12] While several instruments have been developed to measure OHRQoL, the Oral Health Impact Profile (OHIP) has become a widely used and cross-culturally accepted standard.[12] The OHIP-14 captures seven domains of OHRQoL with two items per domain: functional limitation, physical pain, psychological discomfort, physical disability, psychological disability, social disability, and handicap. The OHIP-14 scores can range from 0 to 56 and is calculated by summing the ordinal values for the 14 items. The domain scores can range from 0 to 8. Higher OHIP-14 scores indicate worse and lower scores indicate better OHRQoL.[13]

2.3. Clinical assessment

Dental caries was assessed using WHO criteria for Decayed, Missing and Filled teeth (DMFT) Index.[14] Body Mass Index (BMI) was used as a measure to assess nutritional status. The BMI was recorded and calculated with the help of Body Composition Monitor Model HBF-375-OMRON. The BMI classification was based on WHO Growth reference for 5–19 years (2007), where those with BMI values less than 18 are considered as underweight, 19–22 are normal, 23 above are considered as overweight and obese.[15] All clinical examinations were carried out one trained and calibrated examiner.

2.4. Statistical analysis

The statistical analysis was done using IBM SPSS Statistics for Windows, version 23. Armonk, NY:IBM Corp. Pearson's correlation test has been done to check the correlation between dental caries, nutritional status and OHQoL. Chi square test was done for comparison of categorical variables. Linear regression equation to test the impact of one independent variable on the dependent variable while controlling for other variable. A logistic regression was done in addition to linear regression for categorized variables. The level of significance (p value) for all statistical tests was set at 0.05.

3. Observation and results

A total of 1214 adolescents in the age range of 12–15 years participated in the study. Majority of the adolescents were (60.2%) males. The mean weight and height of the participants was 43.21 $\pm$ 10.07 kg and 156.68 $\pm$ 12.15 cm respectively. The proportion of underweight adolescents was highest (47.6%) and lowest for overweight adolescents (12%) (Table-1). The mean BMI value (18.60 $\pm$ 4.09) for the group was only marginally above the threshold for underweight category (BMI score <18). The dental caries experience was divided into two groups as participants with caries experience (DMFT score) $\leq$3 and those with caries experience of >3. Six hundred and eight (50.1%) adolescents had DMFT score of more than three. The mean DMFT score for the sample was 3.84 and 98.76% was the prevalence of dental caries (DMFT >0).

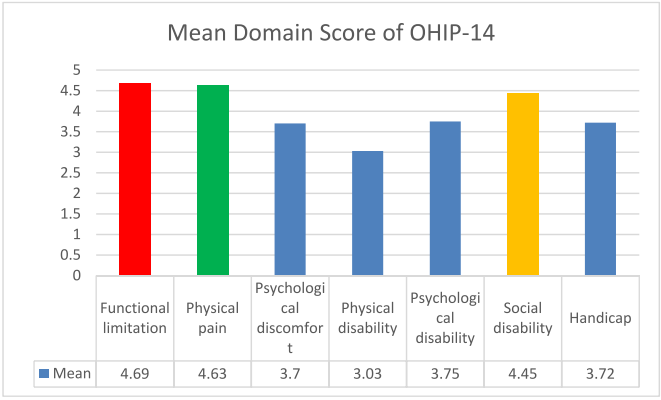
OHIP -14 assesses the impact on quality of life under seven domains. Out of the seven domains of OHIP-14, it was found that mean score for functional limitation was highest (4.69 $\pm$ 2.2) indicating that functional limitation had highest impact on quality of life of students. Mean score for physical pain (4.63 $\pm$ 1.78) and social disability (4.45 $\pm$ 1.99) were the second and third highest among the seven domains, thereby implying that domains having highest impact on quality of life were functional limitation, physical pain and social disability (Graph 1).

When distributed by the nutrition status (BMI score), it was observed that mean OHIP total score was highest for underweight group i. e underweight adolescents had poor quality of life. The overweight adolescents had lowest OHIP score implying better quality of life. This difference was found statistically significant. Number of participants with high caries experience (DMFT>3) was found to be highest in underweight group and least in overweight group and the difference was statistically significant. The results show that underweight children had

Table 1
Distribution of study population based on BMI scores.

BMI ((kg/m^2)	N (n)	Percentage (%)
Under weight	578	47.6%
Normal	490	40.4%
Over weight	146	12%
Mean BMI	18.60 $\pm$ 4.09	

The BMI classification was based on WHO Growth reference for 5–19 years (2007), where those with BMI values less than 18 are considered as underweight, 19–22 are normal, 23 above are considered as overweight and obese.[14]



Graph 1. Mean scores of the seven dimensions of OHIP-14.

higher OHIP score (poor quality of life) and high caries experience (Table 2).

When testing the relationship of dental caries (DMFT) and nutritional status (BMI) with Quality of Life, the Pearson correlation analysis showed a positive correlation between DMFT and OHIP total score and a negative correlation between BMI and OHIP scores. The results imply high caries experience was associated with poor quality of life while higher BMI (overweight and obesity) was associated with better quality of life. Both the correlations were statistically significant (p value $<$ 0.05) (Table 3) However, when compared domain wise, neither DMFT nor BMI showed significant correlation with OHIP.

Since both dental caries and nutritional status were found to be correlated to Quality of Life. a partial correlation analysis was done while controlling for BMI to test the relationship of dental caries and Quality of Life independent of nutritional status. Upon controlling for BMI, the correlation between OHIP and DMFT got weak but still remained statistically significant. Since, the correlation between DMFT and OHIP while controlling for BMI remained to be statistically significant a linear regression analysis was done. The linear regression analysis showed one unit increase in DMFT increases OHIP by 0.072 units controlling for BMI score while one unit increase in BMI decreases OHIP score by 0.73 units, controlling for DMFT (Table 4).

For the individuals with perception of high impact of oral health on Quality of Life i. e those scoring more than 50% (OHIP score $\geq$28) on OHIP-14 scale, binary logistic regression analysis was done. The OHIP score ranges from 0 to 56, half of maximum score value i. e score of 28 or above was taken as high impact. For analysis, OHIP was dichotomized to less than or more than equal to 28 and DMFT categorized to less than or more than equal to 3. Both BMI and caries experience remained to have statistically significant impact on quality of life. However, with BMI controlled; increase in one unit of DMFT score, odds of being into highly impacted group (i.e score more than 28) increased by 1.182 times while with increase in one unit of BMI, the odds of being into highly impacted group (i.e score more than 28) decreased by 0.62 times (Table 5). Both logistic and linear regression showed that higher caries experience lead to poor quality of life (increased OHIP score) and increased BMI was associated with better quality of life (lower OHIP scores).

Table-2
OHIP total score and Caries experience categorized by BMI score.

Nutritional status n = number	OHIP Total Score		Caries Experience		
	Mean ± SD	P value	≤3	>3	
Underweight (n = 578)	31.87 ± 2.71	**0.001**	194	384	**0.0001**
Normal (n = 490)	25.31 ± 3.768		290	200	
Overweight (n = 146)	18.08 ± 2.66		122	24	

Significant at p $<$ 0.05.
Figures in bold indicate statistically significant outcome.

Table-3
Correlation between DMFT, BMI and OHIP total scores.

Correlations		OHIP total score
DMFT score	Pearson Correlation coefficient	0.385**
	p-value	**0.001**
BMI score	Pearson Correlation coefficient	**−0.758****
	p-value	**0.001**

** Significant at p $<$ 0.05.
Figures in bold indicate statistically significant outcome..

Table-4
Linear regression analysis to predict OHIP score based on DMFT and BMI score.

Variables	B	SE	P value	95% CI		R^2
				Lower	Upper	
BMI score	−0.999	0.028	**0.001**	−1.055	−0.944	0.578
DMFT score	0.271	0.078	**0.001**	0.118	0.425	
(Constant)	45.159	0.708		43.77	46.547	

Dependent Variable: OHIP total score; SE: standard error; CI: confidence interval.
Significant at p $<$ 0.05.
One unit increase in DMFT increases OHIP by 0.072 units controlling for BMI score. One unit increase in BMI decreases OHIP score by 0.73 units while controlling for DMFT and these correlations are statistically significant.
Linear Regression equation: OHIP = 45.159 + (0.072 × DMFT) + (−0.727 × BMI).
P values in bold indicate statistically significant result.

Table 5
Binary logistic regression for analyzing the factors leading to high impact on quality (OHIP-14 total score of more than 28).

Model	B	S.E.	Sig.	Odds ratio	95% C·I	
					Lower	Upper
BMI	**−.463**	**.028**	**.0001**	.629	.596	.665
DMFT	.167	.058	**.004**	1.182	1.055	1.324
Constant	8.101	.618	**.000**	3298.393	–	–

Significant at p $<$ 0.05.
Figures in bold indicate statistically significant outcome.

4. Discussion

This study evaluated the relationship of dental caries and nutritional status with Oral Health Related Quality of Life in 12–15year old school going adolescents of Vadodara district, India. Adolescence is known to have changes in internal, external, intellectual and emotional areas. The index age group of 12 and 15 years are of interest as they are global monitoring ages for dental caries.[11] The prevalence of dental caries was 98.76% and mean DMFT score was 3.84. The prevalence for caries among 12 and 15 year old children in India has been reported to be 49% and 60% respectively and the mean DMFT score has been found to be 1.95 and 3.31 in 12 and 15 year old children respectively.[16] The current study group showed much higher caries prevalence and experience. This could possibly be attributed to the fact that sample was drawn from government schools which are mostly located in rural areas. Therefore it is reasonable to infer that the students came from rural and lower socioeconomic background. Also, the overall prevalence of caries in this region of the country has been reported to be higher (72%) compared to the rest of country (54.16%).[17]

The prevalence of under nutrition in the study group was 47.6%. This was considerably higher than 19% thinness prevalence in Gujarat as reported by National Family Health Surveys 3 and 4 on nutritional status of Indian adolescents (15–19 years).[18] Higher prevalence of underweight, stunting and wasting in children and adolescents in India has also been reported in other studies.[19–21] Prevalence of malnutrition

varies significantly between urban and rural areas. Increased urbanization and industrialization has been linked to increased prevalence of obesity in urban children. Prevalence of overweight and obesity was 12% in current study. Similar to the study finding, adolescents in rural, less developed areas and lower socioeconomic background have been found be at greater risk of under nutrition.[18]

The oral health related quality of life in children and adolescents from rural areas have been reported to be worse compared to urban areas. Papaioannou W et al., reported higher mean OHIP scores in population from rural areas.[22] This can be attributed to the lack of facilities, poor socio economic development, neglect of health in rural areas. The most affected domains of quality of life were functional limitation, physical pain and social disability in the present study. Viiti R et al., also reported similar findings.[23] Low BMI had higher impact on oral health related quality of life. Underweight adolescents reported to have higher OHIP scores implying poorer quality of life.

The caries experience was higher in underweight group. Low BMI has been demonstrated to be a risk factor for dental caries[24–27] It is important to note that pain and oral infection resulting from dental caries have direct and indirect effects on the nutritional status of a child, leading to underweight and malnutrition. Both dental caries and under nutrition was more pronounced in this group could be because children registered in government schools only were included in the study. These schools mostly were located in rural areas and had children from lower socio economic background enrolled with them. Under-nutrition still remains to be a public health problem among the children surveyed. Adeniyi et al. observed children in government schools had a higher prevalence of under-nutrition while those in private schools had a higher prevalence of over nutrition. This was probably due to fact that more children in public schools come from the lower socio-economic strata in society.[28]

The findings of the present shows highest mean score for functional limitation followed by physical pain and psychological discomfort among adolescents. The physical pain domain aims to show how changes in oral health conditions may cause pain or discomfort when eating, and the psychological discomfort domain refers to concerns or nervousness regarding oral health conditions; the most expressive of these parameters shows that there is an evident concern of the adolescents regarding the oral health status and its possible consequences. These results are similar to that reported by Paredes et al. who found more expression of the physical pain domain.[29] This association is due to the understanding that the dental caries can cause pain, functional limitations, disappointment or concerns regarding the oral health.[21]

Both caries experience and BMI were found be to be associated with quality of life independent of each other. The caries experience was positively correlated to OHIP score indicating poor quality of life. Therefore, it can be inferred that dental caries is associated with poor quality of life. Understandable, functional limitation and physical pain were the most common negative manifestations of impact on quality of life. The impact of dental caries on quality of life increased when analyzed for high impact group (OHIP score >28). This could be due to the impact of pain which was perceived to be most important domain of QoL and oral pain at this age is mostly a consequence of dental caries.

The nutritional status assessed as BMI correlated negatively with Quality of Life. Increase in BMI scores was associated with lower OHIP scores, implying that overweight and obese children perceived low impact of oral conditions on quality of life. Contrary to our finding, Chakravathy KP et., reported subjects with increased BMI had poor OHRQoL.[6] Freitas AR et al., found no relationship between obesity and quality of life in adolesecents.[30] Current study predominantly had adolescents from rural and lower socioeconomic background. Undernutrition in this group can be attributed to poor socioeconomic status and therefore perceive the quality of life as poor.

5. Conclusion

Dental caries was found to be associated with poor quality of life. Children with higher dental caries experience had higher OHIP scores indicating a poor Quality of Life. This relation remained significant independent of nutritional status. Nutritional status (BMI) however, showed negative correlation with OHRQoL. Children with poor nutritional status/underweight children had poorer quality of life.

The problem of malnutrition and dental caries must be addressed at early ages of life. Both the conditions have common risk factors and have significant impact on Quality of Life together and individually. Hence, health promotion in adolescents is elementary to improve their quality of life. It is recommended that promotion of good oral hygiene, healthy dietary habits and good nutrition among school going adolescents should be targeted collectively by government, health professionals, school teachers and parents towards better oral health and improved quality of life.

Presentation

None.

Ethics approval and consent to participate

Approved from Institutional Ethics Committee and Written Informed consent taken.

Funding

None.

Declaration of competing interest

None.

References

1 Boeira GF, Correa MB, Peres KG, et al. Caries is the main cause for dental pain in childhood: findings from a birth cohort. *Caries Res.* 2012;46(5):488–495.
2 Macfarlane TV, Blinkhorn AS, Davies RM, Kincey J, Worthington HV. Oro-facial pain in the community: prevalence and associated impact. *Community Dent Oral Epidemiol.* 2002;30(1):52–60.
3 Alvarez-Azaustre MP, Greco R, Llena C. Oral health-related quality of life in adolescents as measured with the child-OIDP questionnaire: a systematic review. *Int J Environ Res Publ Health.* 2021 Dec 9;18(24), 12995. https://doi.org/10.3390/ijerph182412995. PMID: 34948611; PMCID: PMC8701449.
4 Dworkin SF, Chen AC, Schubert MM, Clark DW. Cognitive modification of pain: information in combination with N2O. *Pain.* 1984;19(4):339–351.
5 Popkin BM, Corvalan C, Grummer-Strawn LM. Dynamics of the double burden of malnutrition and the changing nutrition reality. *Lancet.* 2020;395:65–74. https://doi.org/10.1016/S0140-6736(19)32497-3.
6 Chakravathy KP, Thippeswamy HM, Kumar N, Chenna D. Relationship of body mass index and dental caries with oral health related quality of life among adolescents of Udupi district, South India. *Eur Arch Paediatr Dent.* 2013 Jun;14(3):155–159. https://doi.org/10.1007/s40368-013-0040-9. Epub 2013 Apr 18. PMID: 23595623.
7 Mishu MP, Hobdell M, Khan MH, Hubbard RM, Sabbah W. Relationship between untreated dental caries and weight and height of 6- to 12-year-old primary school children in Bangladesh. *Int J Dent.* 2013;2013, 629675.
8 Alwattban RR, Alkhudhayr LS, Al-Haj Ali SN, Farah RI. Oral health-related quality-of-life according to dental caries severity, body mass index and sociodemographic indicators in children with special health care needs. *J Clin Med.* 2021 Oct 20;10(21):4811. https://doi.org/10.3390/jcm10214811. PMID: 34768328; PMCID: PMC8584947.
9 Malvania EA, Ajithkrishnan CG, Thanveer K, Hongal S. Prevalence of dental caries and treatment needs among 12-year-old school going children in Vadodara City, Gujarat, India: a cross-sectional study. *Indian Journal of Oral Sciences.* 2014;5(1):1–9.
10 Slade GD. Derivation and validation of a short-form oral health impact profile. *Community Dent Oral Epidemiol.* 1997 Aug;25(4):284–290.
11 Goje SK, Patel J, Kalyan P, Kulkarni N, Shah R, Modi B. Translation of English version of oral health impact profile-14 into Gujarati. *J Int Oral Health.* 2017;9:16–19.
12 Campos LA, Peltomäki T, Marôco J, Campos JADB. Use of oral health impact profile-14 (OHIP-14) in different contexts. What is being measured? *Int J Environ Res Publ Health.* 2021 Dec 20;18(24), 13412. https://doi.org/10.3390/ijerph182413412. PMID: 34949018; PMCID: PMC8703465.

13 Omara Maisa, Salzberger Thomas, Boecker Maren, et al. Improving the measurement of oral health-related quality of life: rasch model of the oral health impact profile-14. *J Dent*. 2021;114, 103819.
14 Who. *Oral Health Surveys- Basic Methods*. fourth ed. 1997:1–70. Geneva.
15 Kulkarni P, Nagendra, Ashok NC, Kumar DS, Siddalingappa H, Madhu B. World health organization-body mass index for age criteria as a tool for prediction of childhood and adolescent morbidity: a novel approach in southern Karnataka, India. *Int J Prev Med*. 2014 Jun;5(6):695–702.
16 Janakiram C, Antony B, Joseph J, Ramanarayanan V. Prevalence of dental caries in India among the WHO index age groups: a meta-analysis. *J Clin Diagn Res*. 2018 Aug 12;8:08–13.
17 Pandey P, Nandkeoliar T, Tikku AP, Singh D, Singh MK. Prevalence of dental caries in the Indian population: a systematic review and meta-analysis. *J Int Soc Prev Community Dent*. 2021 Jun 10;11(3):256–265. https://doi.org/10.4103/jispcd.JISPCD_42_21. PMID: 34268187; PMCID: PMC8257015.
18 Bhargava M, Bhargava A, Ghate SD, Rao RSP. Nutritional status of Indian adolescents (15-19 years) from national family health Surveys 3 and 4: revised estimates using WHO 2007 growth reference. *PLoS One*. 2020 Jun 22;15(6), e0234570. https://doi.org/10.1371/journal.pone.0234570. Erratum in: PLoS One. 2020 Sep 24;15(9):e0239923. PMID: 32569312; PMCID: PMC7307767.
19 Kotian MS, S GK, Kotian SS. Prevalence and determinants of overweight and obesity among adolescent school children of South Karnataka, India. *Indian J Community Med*. 2010 Jan;35(1):176–178. https://doi.org/10.4103/0970-0218.62587. PMID: 20606948; PMCID: PMC2888353.
20 Mukherjee R, Chaturvedi S, Bhalwar R. Determinants of nutritional status of school children. *Med J Armed Forces India*. 2008 Jul;64(3):227–231. https://doi.org/10.1016/S0377-1237(08)80099-8. Epub 2011 Jul 21. PMID: 27408152; PMCID: PMC4921655.
21 Dutta A, Pant K, Puthia R, Sah A. Prevalence of undernutrition among children in the Garhwal Himalayas. *Food Nutr Bull*. 2009 Mar;30(1):77–81. https://doi.org/10.1177/156482650903000108.PMID:19445262.
22 Papaioannou W, Oulis CJ, Yfantopoulos J. The oral health related quality of life in different groups of senior citizen as measured by the OHIP-14 questionnaire. *Oral Biol Dent*. 2015;3(1):1.
23 Vitti Rafael Pino, et al. Oral Health Impact Profile (OHIP-14) and its association with dental treatment needs of adolescents in a rural Nigerian community. *Braz J Oral Sci*. 2017;15:215–220.
24 Madhusudhan KS, Khargekar N. Nutritional status and its relationship with dental caries among 3-6-year-old AnganwadiChildren. *Int J Clin Pediatr Dent*. 2020 Jan-Feb;13(1):6–10. https://doi.org/10.5005/jp-journals-10005-1706. PMID: 32581470; PMCID: PMC7299890.
25 Kariya P, Singh S. Correlation between nutritional status and dental caries in 3–18-year-old Indian school-going children: a cross-sectional study. *World J Dent*. 2022;13(2). https://doi.org/10.5005/jp-journals-10015-2136.
26 Rego IN, Cohen-Carneiro F, Vettore MV, Herkrath FJ, Herkrath APCQ, Rebelo MAB. The association between nutritional status and dental caries in low-income children: a multilevel analysis. *Int J Paediatr Dent*. 2020 Sep;30(5):607–618. https://doi.org/10.1111/ipd.12637. Epub 2020 Mar 25. PMID: 32115793.
27 Prashanth ST, Venkatesh B, Vivek DK, Amitha HA. Comparison of association of dental caries in relation with body mass index (BMI) in government and private school children. *J Dent Sci Res*. 2011;2(2):1–5.
28 Adeniyi AA, Oyapero OA, Ekekezie OO, Braimoh MO. Dental caries and nutritional status of school children in Lagos, Nigeria –A preliminary survey. *J West Afr Coll Surg*. 2016;6(3):15–38.
29 Paredes SO, Leal Júnior OS, Paredes AO, Fernandes JMFA, Menezes VA. Oral health influence on the quality of life of school adolescents. *Rev Bras Prom Saude*. 2015 Apr-Jun;28(2):266–272.
30 Freitas AR, Aznar FD, Tinós AM, Yamashita JM, Sales-Peres A, Sales-Peres SH. Association between dental caries activity, quality of life and obesity in Brazilian adolescents. *Int Dent J*. 2014 Dec;64(6):318–323. https://doi.org/10.1111/idj.12121. Epub 2014 Aug 14. PMID: 25123152; PMCID: PMC9376397.