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MALNUTRITION - A RISK FOR ORAL HEALTH

Dental Science

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ABSTRACT

Malnutrition prevents children from reaching their full physical growth and mental potential. Health and physical consequences of malnutrition in children are lower intellectual quotient (IQ), greater behavioural problems, delay in their physical growth, motor development and deficient social skills; susceptibility to contracting diseases. Development of dentition is integral part in maintaining and sustaining the quality of life in humans. The effect of malnutrition on developing teeth is not clear but there is evidence that dental maturity is insulated from environmental insults, such as severe malnutrition, compared to the skeleton and other body systems. Oral health conditions, dietary practices, nutritional status and general health status are all inter-related factors. This paper gives an insight on the relationship of the malnutrition and the oral health status.

KEYWORDS

Malnutrition, Protein Energy Malnutrition (PEM), Dental Caries, Enamel hypoplasia.

INTRODUCTION

Nutrition is essential for human development and is the focal point of health and well being. According to the WHO, Nutrition is the science of food and its relationship to health [1,2] and Malnutrition is the cellular imbalance between the supply of the nutrients and the energy and the body's demand for them to ensure growth, maintenance, and specific functions.[3]

Malnutrition is widespread in rural, tribal, and urban slum areas. The causes for malnourishment seen in children can be attributed to overpopulation, poverty, large family size, poor maternal health, adverse cultural practices, destruction of the environment, lack of education, gender inequality, and inaccessible medical care.[4]

The children of India are malnourished because of the above factors. Growing malnourished children exhibit behavioral changes, including irritability, apathy, decreased social responsiveness, anxiety, attention deficits, impaired growth, poor school performance and decreased intellectual achievement.[5]

Oral health conditions, dietary practices, nutritional status and general health status are all inter-related factors.[6] Nutrition promotes healthy development and maintenance of oral health. Malnutrition adversely affects the oral structures.

Studies have shown that early malnutrition affects tooth structure, delay in tooth eruption and results in increased dental caries. [7-9] It has also been found that nutritional deficit which leads to chronic malnutrition not only affects tooth exfoliation but also renders the permanent teeth susceptible to caries later in life.[9] The presence of enamel hypoplasia may be a predisposing factor in initiating and progression of dental caries and a predictor of high caries susceptibility in these children.[10]

Oral manifestation in Malnutrition

Oral cavity is influenced by the diet for development, depending on whether there is an early or late nutritional imbalance, the consequences are certainly different. A shortage of minerals and vitamins in the conception period influences the development of the dental organogenesis in the future embryo, the growth of maxilla and skull/facial development. In fact, an early nutritional imbalance influences malformations most. Moreover, the different components of the stomatognathic apparatus undergo periods of intense growth alternated with periods of relative quiescence: it is clear that a nutritional imbalance during active periods of growth will produce greater damage. Diet influences the health of the oral cavity, conditioning the onset of caries, development of the enamel, onset of dental erosion, state of periodontal health, salivary characteristics and oral mucous in general.[11]

Data on the relationship between malnutrition and oral outcomes are scarce. Few epidemiologic studies conducted over the past few decades have focused on the effect of malnutrition on the dentition, including effects on tooth eruption patterns, enamel hypoplasia, and on dental caries prevalence. Acute periodontal conditions in malnourished populations include NOMA (cancrum oris) and acute necrotizing ulcerative gingivitis. Various nutritional deficiencies, including those of calcium, vitamin D, ascorbic acid, and protein may be related to various forms of periodontal disease or manifest oral symptoms which mirror periodontal disease. These investigations have all been cross-sectional in nature, have tended to evaluate only the degree of gingivitis but not periodontitis, or have examined the effects of malnutrition on the tooth supporting structures in only the permanent dentition.[2]

An insufficient intake of proteins can lead to atrophy of the lingual papillae, connective tissue degeneration, alteration in dentinogenesis and cementogenesis, altered development of the maxilla, malocclusion and linear hypoplasia of the enamel. An insufficient supply of lipids can result in inflammatory and degenerative pathologies of salivary glands. Inadequate intake of carbohydrates can lead to altered organogenesis, caries, periodontal disease and can influence the metabolism of dental plaque.

In Mexico, children who were mild to moderately undernourished during enamel formation suffered from linear enamel hypoplasia. Linear enamel hypoplasia was nearly two folds greater than the normal children. It was seen more commonly in females and was associated with an increase in illness days and decrease in growth velocity.[12]

An Indian study assessed the effect of chronic malnutrition on saliva secretion rate and susceptibility to dental caries in children. It was found that the secretion rate of stimulated saliva is reduced in chronic malnutrition but not the unstimulated saliva. The salivary buffer capacity was continuously decreased as the secretion rate decreased with the level of malnutrition in these children. The malnourished children developed increased caries. It was concluded that chronic malnutrition in growing children enhances the cariogenic potential stemming from fermentable carbohydrates.[13]

The prevalence of developmental enamel defects and dental caries was found to be 70% in chronically malnourished and 9.3% in acutely malnourished Karen children. Enamel hypoplasia was present in 22.7% of children. At least one tooth with defective enamel was seen in 31.9% of children. Enamel defects were found in 21.2% of teeth, with hypoplasia and opacities occurring in 14.6 and 6.6% of teeth, respectively. Gender did not alter the prevalence of defects. The upper central incisors were affected more than lateral incisors. The prevalence of dental caries was 31.9% with a mean dental caries score of 1.1. The prevalence of caries associated with enamel hypoplasia was significantly greater than that associated with opacities and sound enamel.[14]

A study was conducted in China among 1344 rural children of age 3-5 years to evaluate the association between dental caries and enamel hypoplasia with malnutrition. They observed the prevalence of dental caries and enamel hypoplasia to be 82.3% and 22.3%, respectively. There was no significant difference in the caries experience between males and females. Children with low birth weight showed a slightly higher percentage of caries than those born with normal birth weight. Children with enamel hypoplasia demonstrated a significantly higher caries experience than those who did not have such defects.[9]

Three hundred and ninety boys aged 2, 4 or 6 years from Riyadh, Saudi Arabia were studied to identify factors related to malnutrition. Results revealed that, malnourished status is related to low birth-weight, low volume of water drunk, child stopped breast- and bottle-feeding before 1 year of age, and low class urban or rural area of residence. Birth-weight was itself related to area of residence, parental education and maternal illness during pregnancy. Malnutrition, low birth-weight, childhood illness, brushing of child's teeth and swallowing toothpaste were related to the prevalence of enamel hypoplasia of primary teeth.[14]

A study was conducted on oral hygiene and nutritional status of children aged 1-7 years in a rural community of Nigeria. Poor oral hygiene and malnutrition (84.3%) were common in the community. There was no statistical difference between the female and males, but a significant difference existed between the age groups.[15]

A study investigated the association between nutritional status and reduced space for dental eruption (crowding) in permanent dentition among 2060 students aged 12 to 15 years enrolled in schools in the northeast of Brazil. Nutritional status was evaluated by means of body mass index and height-for-age, using WHO reference curves. An association between low height-for-age and crowding was only observed in adolescents with prolonged history of mouth breathing. No association was observed between underweight and crowding. Malnutrition was related to crowding in permanent dentition among mouth breathing adolescents.[16]

The effect of severe malnutrition on the timing of human tooth formation was studied in a large representative sample of North Sudanese children. The sample (1102 males, 1013 females) consisted of stratified randomly selected healthy, aged 2-22 years. Nutritional status was defined by using WHO criteria of height and weight. Body mass index Z-scores and height-for-age Z-scores of $\leq$ -2(cut-off) were used to identify the malnourished group (N = 474) while the normal was defined by Z-scores of $\geq$ 0 (N = 799). Mandibular left permanent teeth were assessed using seven root and eight crown established tooth formation stages. Mean age at entry and mean age within tooth stages were calculated for each available tooth stage in each group and were compared. Results showed the mean age at entry and mean age within tooth stages were not significantly different between groups affected by severe malnutrition and normal children. This demonstrated that there is little measurable effect of sustained malnutrition on the average timing of tooth formation and supports the notion that teeth have substantial biological stability and are insulated from extreme nutritional conditions compared to other maturing body systems.[17]

A study assessed the relationship between deficiency of iron and early childhood caries among 60 children aged 2 to 6 years from Karnataka. They observed a interrelationship between the iron deficiency and early childhood caries.[18]

A study was conducted in Filipino to evaluate the relationship between malnutrition and number of permanent teeth among 1554 children of 10-13 year old. Almost 60% of children had at least one form of malnutrition. More boys were thin than girls. However no sex difference was noted in relationship to stunting. Stunted and thin children had significantly fewer permanent teeth than their non affected peers. This demonstrates a delay in the teeth eruption in thin and stunted adolescents. In 13 year old girls, all permanent teeth were erupted regardless of their nutritional status indicating a catch-up growth. Stunted and thin boys had one tooth less than normal boys at this age. It was concluded that impaired physical growth and dental development seem to have malnutrition as a common risk factor.[19]

A study from Bangladesh examined the association between untreated dental caries in primary and permanent teeth with age adjusted height and weight among 1699 of 6-12 year old children. Twenty six percent of children were underweight and 55% had untreated dental caries. Children with at least one decayed tooth were significantly underweight. The number of decayed teeth was inversely and significantly associated with the standardized age-adjusted weight. This study highlighted the association between untreated dental caries and underweight in primary school children in socially deprived countries.[20]

A study from Ghaziabad city, North India, evaluated the association between nutritional status and oral health in 280 elementary school children aged 3- 6 years. Malnutrition was observed in 58.3% children. Out of total population, 33.9% had caries affecting their primary dentition. Early 40% of caries affected children were underweight. The mean value of plaque index was highest in underweight children.[21]

In a study by Girish Babu KL, Subramaniam P, Madhusudhan KS, evaluated the association of nutritional status and dental health in 1459 anganwadi children of 3-6years old children in T-Narsipura taluk, Mysore district, South India. The prevalence of dental caries was 61.07% and was highest in 3 4 years age group. More number of females was affected with dental caries than males. The prevalence of enamel hypoplasia was 8.7%. Only 3 children reported with benign migratory glossitis at the time of examination. Association of dental health status with BMI was significant.[4]

DISCUSSION

Malnutrition is the condition that develops when the body does not get the right amount of the vitamins, minerals, and other nutrients which is needed to maintain health of the tissues and organ functions. Mild malnutrition has an acute course and it has a main deficiency in energy; moderate malnutrition is chronic in nature and it has a main deficiency in protein, while severe malnutrition is both acute and chronic, and it is composed of deficiencies in both protein and energy.[22]

Malnutrition can be classified according to its origin as primary, when the cause is a deficit in delivery (inadequate ingestion or gastrointestinal disorders), and secondary, when there is an underlying chronic disease or disorder that causes the malnutrition.[23]

Malnutrition can also be classified as acute or chronic according to the time of onset and duration of the condition. Acute malnutrition occurs when there are recent deficits of supply or the sudden onset of an extensive lesion that leads to high levels of catabolism, whereas chronic malnutrition or growth delay is due to a persistent deficit in nutrient delivery, chronic disease or acute disorders with a prolonged clinical course. Acute malnutrition mainly affects weight whereas chronic nutrition affects both weight and height in children.[23]

Acute malnutrition is the result of an acute decrease in food intake often combined with illness, anorexia, poor appetite, and sometimes medical complications, leading to rapid weight loss or failure to gain weight. Children suffering from this condition have a high mortality risk; however, the situation is reversible with treatment of medical complications and re-feeding in a short period of time.

There are two forms of acute malnutrition/wasting:
(1)Severe acute malnutrition (SAM), defined as weight-for-height below -3.0 z scores of the median World Health Organization (WHO) standards in children 6-59 months of age, and/or mid-upper arm circumference (MUAC) less than 11.5 cm, and/or the presence of bilateral pitting oedema.
(2)Moderate acute malnutrition (MAM), defined as weight-for-height -3.0 z and < -2.0 z-scores, or MUAC of 11.5 cm and < 12.5 cm and no oedema.[24]

Malnutrition and infection are the two most important factors that affect the growth of children. In most cases of childhood infections, the cause can be traced to insufficient food intake or absorption, which renders the human system vulnerable to infections. The magnitude of the problem of malnutrition among children under five years of age is high throughout India.[25]

Malnutrition denotes impairment of health arising either from deficiency or excess or imbalance of nutrients in the body.[26] More than 26,000 children under the age of 5 die around the world each day, nearly all of them live in developing countries. Malnutrition increases susceptibility to infections while an infection aggravates malnutrition by decreasing appetite, inducing catabolism and increasing demand for nutrients. The increased susceptibility to infections may be caused

by the impairment of immune function due to malnutrition.[27] Malnutrition and infections are the two most important factors that affect the growth of children.

The magnitude of the problem of malnutrition among children under five years of age is high throughout India. About 2.3 crore children in India, upto 6 years of age, are suffering from malnourishment and are underweight. Forty eight percent of Indian children under-5 years of age are stunted due to chronic undernutrition and 20% of children suffer from wasting due to acute undernurition. In Karnataka, the prevalence of underweight, stunting and wasting was estimated to be 43.9%, 36.6% and 20%, respectively (NFHS-3).[28]

Government of India has implemented Integrated Child Development Services (ICDS) programme to curb malnutrition. This programme provides six services viz, anganwadi-supplementary nutrition, preschool education, immunization, health checkup, referral services, nutrition and health education. The majority of deaths associated with children are marginally malnourished.. Their nutritional status is a sensitive indicator of their health.

Malnutrition appears to have multiple effects on the oral tissues and subsequent development of oral disease. It results in altered tissue homeostasis, reduced resistance to microbial biofilms and tissue repair capacity. Malnutrition is associated with enamel hypoplasia, dental caries and salivary gland changes. Change in the salivary characteristics reduces the defence mechanism of saliva and its ability to buffer the plaque acids.

Status of malnutrition in children is widely estimated using anthropometric methods like WHO, IAP standards, BMI, MUAC, weight for age and height for age. Assessment of nutritional status provides information on growth and body composition. Obtaining such data is important for evaluating underweight, stunting, wasting or overweight associated with increased risk for adverse health outcomes.[27]

Malnourished children have compromised general health as well as oral health. They suffer from high incidence of enamel hypoplasia, dental caries, alterations in salivary characteristics, delay in eruption of teeth and crowding.[7-9] Several studies in Guatemala have suggested a positive relationship between malnutrition induced enamel hypoplasia and dental caries.[29-32] Three cross sectional studies showed increased primary dentition caries levels in stunted children.[7,9,33] Increase in primary dentition caries was also associated with wasting and stunted children.

Chronic malnutrition in growing children increases the incidence of dental caries. Shakya et al, also reported a high prevalence of dental caries (70%) in malnourished children.[34] Other studies have reported 30-34% of dental caries in underweight children. A systematic review by Hooley et al, highlighted the inverse relationship between dental caries and BMI from studies done in developing countries.[35] It has been suggested that early malnutrition may produce defects in teeth during the period of development so that they are more susceptible to subsequent dental caries after eruption. Adding to this, the high prevalence of dental caries could be due to low literacy rates, especially among mothers, non-access to dental care, non-fluoride exposure, lack of balanced diet and low calorie diet and above all lack of awareness about proper oral hygiene measures.

Malnutrition in early childhood is associated with enamel hypoplasia of the primary dentition. Enamel hypoplasia is the pathway between malnutrition and dental caries. In literature on malnutrition associated dental caries, enamel hypoplasia is described as the lesion characterized as hypoplastic grooves and/or pits in the enamel, often horizontal or linear in appperance. The WHO has modified this definition to include enamel opacities.

Enamel hypoplasia appears to be the result of an interference with normal ameloblastic activity during the appositional phase of enamel development, which in turn results in an area of arrested matrix formation.[1] Variety of ameloblastic dysfunctions may occur which could result in a spectrum of defects including microscopic, hypocalcified and grossly hypoplastic defects.

Infection in the first 35 days of life can lead to enamel hypoplasia of primary teeth. The infection may have direct effect on enamel hypoplasia through febrile responses, or an indirect effect, i.e. infections being markers for malnutrition rather than an etiological risk. Enamel hypoplasia has been associated with caries development as it may provide a mechanical nidus for bacteria and food and higher soulibilty of enamel in an acidic environment due to hypomineralization.[36]

Reports on the prevalence of enamel hypoplasia range from 18 to 24%.[36,37,38] Linear enamel hypoplasia of the deciduous incisor teeth is commonly seen in children living in malnourished communities throughout the world. In many countries the prevalence is reported to be greater among children of lower social class.[36,39,40] Estimates of its prevalence have ranged from 14 to 85 per cent in the developing countries.[1,36] Clinically, the lesion is characterized by a horizontal groove most frequently found on the labial surface of the deciduous maxillary incisors. It is located on the portion of those teeth that are formed in the neonatal period: the middle third of the maxillary central incisor crown and the incisal third of the lateral incisor crown.[41]

There are no studies on structural or chemical properties due to malnutrition-associated hypoplasia/hypomineralization. In fact little is known of the microscopic structure of teeth with developmental defects.[42] Future investigations should be conducted to study the structural and chemical changes of hypoplastic teeth caused due to malnutrition.

Nutritional deficiencies also affect the health of oral mucosa. The oral lesions commonly seen are fissured tongue, geographic tongue, aphthous ulcers, depapillated tonque and angular cheilitis. The prevalence of benign migratory glossitis was found to be 0.5% among children of Tehran, Iran.[43]

Malnutrition is a serious health concern. For a developing country like India, poverty, lack of awareness and illiteracy contribute toward the widespread malnutrition. The addition of war and natural disasters to the list also exacerbates the prevalent situation. Malnutrition in turn leads to disease morbidity and mortality especially in the pediatric group and places additional burden on the already limited resources of the country. In the bigger picture, it also leads to poor work performance and thus hindrance in the country's development and progress. Although there has been a general increase in awareness and concern regarding nutrition in India, still no major improvements have been seen over the past few decades.

The major public health problems related to nutrition are low birth weight, protein energy malnutrition (PEM), nutritional anemia, iodine deficiency disorders (IDD), endemic fluorosis, lathyrism etc. Nutritional problems affected a substantial proportion of the population, particularly women and children. In this context, the Government of India (GOI) took pioneering steps to formulate national programs to combat macro and micronutrient under nutrition. These programs have evolved on the basis of research studies in the country, taking into account, the magnitude of the nutritional problems, ecological factors responsible, and feasible interventions that could be implemented within the existing infrastructure. Over the past 15 years India's economic growth rate has been unprecedented from 6% in the 1990s to 8% in real gross domestic product (GDP) in 2000-2010 according to International Monetary Fund (IMF). However, the economic growth has not been associated with corresponding reductions in the rates of childhood under nutrition. The National Family Health Survey (NFHS) showed that 43% of children under 5-years-old were underweight for age in 1998-1999; by 2005-2006 the percentage had only dropped to 40%. There is a wide gap in food production and consumption. The achievement of macro food grain security at the national level did not reach the household and the level of food insecurity in India is still high.[44]

The Government of India has several national programs like Integrated Child Development Services (ICDS), National Iodine Deficiency Disorder Control Program (NIDDCP), National Iron + initiative etc., The activities under each program have been listed and its impact as assessed by various evaluation programs has also been mentioned. The determinants of under nutrition are a result of a complex interaction between various factors articulated by UNICEF as immediate, underlying, and fundamental determinants. The fact remains that inspite of all the programs, household food security is determined by a more complex array of factors. Concerted effort and a convergence by all the programs are required with particular emphasis on gender equity. More attention is required in rural areas, backward class,

scheduled caste and tribe people, very young children between 0-2 years, and the girl child.

RECOMMENDATIONS[45]

1. Mothers should be advised to initiate breastfeeding within one hour of delivery.
2. Importance of exclusive breastfeeding for the first six months of baby's life and proper weaning thereafter should be properly explained to mother.
3. Nutritional education has to be imparted to the people regarding consumption of cost-effective nutritious diet.
4. Special efforts have to be made to improve acceptance of family planning methods for limiting the family and to give adequate spacing between children.
5. Environmental sanitation has to be promoted in reducing infection and breaking the vicious cycle of infection leading to under nutrition.
6. Socioeconomic development among the rural masses needs to be ensured, which is the important factor to tackle malnutrition, mainly under nutrition.
7. Government should allocate more money in health sector for integrated health packages and should ensure proper functioning of health programs.

To reduce the high caries burden, prevention and intervention should be initiated at the earliest. Regular oral hygiene aids along with remineralizing agents should be provided free of cost or at subsidized prices so that hypoplastic teeth do not progress to dental caries.

It is evident from the present review that malnourished children are prone to compromised oral health. Community based oral preventive measures should be taken to reduce the oral health problems in these children. Oral health education should be given to the mothers on feeding and dietary practices. Both parents and children should be made aware of oral hygiene measures and continues reinforcement should be carried out at regular intervals. Motivation of anganwadi workers is necessary to explain the oral health related problems through non-conventional ways like short plays, videos and games. Establishment of dental home is atmost important in these children so that their unmeet dental caries needs can be treated.

CONCLUSION

Various studies have shown that malnutrition and protein energy malnutrition effects on the tooth eruption patterns, enamel hypoplasia, dental caries prevalence and periodontal ligament. They also have other effects on the oral cavity, like inflammation of the lining of the oral cavity and the tongue and oral ulcers.

Malnutrition is a risk to oral health with unfavorable socio demographic factors, which calls for a need to improve the living conditions and adequate utilization of available health and nutritional supplementary services through intersectoral approach.

REFERENCES

1. Psoter WJ, Reid BC, Katz RV. Malnutrition and dental caries: a review of the literature. Caries Res. 2005 Nov-Dec;39(6):441-7.
2. Russell SL, Psoter WJ, Jean-Charles G, Prophte S and Gebrain B. Protein-energy malnutrition during early childhood and periodontal disease in the permanent dentition of Haitian adolescents aged 12 - 19 years: a retrospective cohort study. Int J Paediatr Dent. 2010 May; 20(3): 222-229.
3. Ehizele AO, Ojehanon PI, Akhionbare O. Nutrition and oral health. J of Post graduate Medicine. 2009;11(1):76-82.
4. Girish Babu KL, Subramaniam P, Madhusudan KS. Association of nutritional status and dental health among 3 - 6 -year-old children of a South Indian population. Saudi J Oral Sci 2019;6:31-6.
5. National Commission for Protection of Child Rights. Raichur, Karnataka visit Report. Malnutrition, Death and other Child Rights Violations: New Delhi, India: NCPCR 2012.
6. Lessard GM. Nutritional aspects of oral health- new perspectives. Am J Clin Nutr. 1995;2:446.
7. AlvarezJO et al. Chronic malnutrition, dental caries, and tooth exfoliation in Peruvian children aged 3-9 years. Am J Clin Nutr. 1988 Aug;48(2):368-72.
8. AlvarezJO, Navia JM. Nutritional status, tooth eruption, and dental caries: a review. Am J Clin Nutr. 1989 Mar;49(3):417-26.
9. Li Y, Navia JM, Bian JY. Caries experience in deciduous dentition of rural Chinese children 3-5 years old in relation to the presence or absence of enamel hypoplasia. CariesRes. 1996;30(1):8-15.
10. Ramos-Martinez K, Gonzalez-Martinez F, Luna-Ricardo L. Oral and nutritional health status in children attending a school in Cartagena, 2009. Rev Salud Publica (Bogota) 2010;12(6):950-60.
11. Scardina GA and Messina P. Good Oral Health and Diet. J Biomed Biotechnol. 2012; 2012: 720692.
12. Goodman AH, Martinez C, Chavez A. Nutritional supplementation and the development of linear enamel hypoplasias in children from Tezonteopan,Mexico. Am J Clin Nutr. 1991 Mar;53(3):773-81.
13. Johansson I, Saellström AK, Rajan BP, Parameswaran A. Salivary flow and dental caries in Indian children suffering from chronic malnutrition. Caries Res. 1992;26(1):38-43.
14. Rugg-Gunn AJ, Al-Mohammadi SM, Butler TJ. Malnutrition and developmental defects of enamel in 2- to 6-year-old Saudi boys. Caries Res. 1998;32(3):181-92.
15. Okolo SN et al. Oral Hygiene and Nutritional Status of Children Aged 1 7 Years in a Rural Community. Ghana Med J. 2006 March; 40(1): 22-25.
16. Thomaz EBAF, Cangussu MCT, da Silva AAM and Assis AMO. Is Malnutrition Associated with Crowding in Permanent Dentition?. Int J Environ Res Public Health. 2010 Sep; 7(9): 3531-3544.
17. Elamin F, Liversidge HM. Malnutrition Has No Effect on the Timing of Human Tooth Formation. PLoS One. 2013; 8(8).
18. Koppal PI, Sakri MR, Akkareddy B, Hinduja DM, Gangolli RA, and Patil BC. Iron Deficiency in Young Children: A Risk Marker for Early Childhood Caries. Int J Clin Pediatr Dent. 2013 Jan-Apr; 6(1): 1-6.
19. Heinrich-Weltzien R, Zorn C, Monse B, Kromeyer-Hauschild K. Relationship between Malnutrition and the Number of Permanent Teeth in Filipino 10- to 13-Year-Olds. Biomed Res Int. 2013; 2013: 205950.
20. Mishu MP, Hobdell M, Khan MH, Hubbard RM, and 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.
21. Sood S, Ahuja V, Chowdhry S. Reconnoitring the association of nutritional status with oral health in elementary school-goingchildren of Ghaziabad City, North India. J Indian Soc Pedod Prev Dent. 2014 Jul-Sep;32(3):197-201.
22. Sheetal A, Hiremath VK, Patil AG, Sajjansetty S, Kumar SR. Malnutrition and its oral outcome - a review. J Clin Diagn Res. 2013 Jan;7(1):178-80.
23. Prieto MB, Cid JL. Malnutrition in the critically ill child: the importance of enteral nutrition. Int J Environ Res Public Health. 2011 Nov;8(11):4353-66.
24. Kouam CE et al. Perspectives for integration into the local health system of community-based management of acute malnutrition in children under 5 years: a qualitative study in Bangladesh. Nutr J. 2014 Mar 20;13:22.
25. R A et al. Nutritional status of children aged 3-6 years in a rural area of Tamilnadu. J Clin Diagn Res. 2014 Oct;8(10):JC01-4.
26. Dasgupta A, Butt A, Saha TK, Bsau G, Chattopadhyay, Mukherjee A. Assessment of malnutrition among young adolescents: can BMI be replaced by MUAC. Indian J of Com Med 2010. Apr;35(2):276-279.
27. Rytter MJ, Kolte L, Briend A, Friis H, Christensen VB. The immune system in children with malnutrition--a systematic review. PLoS One. 2014 Aug 25;9(8):e105017.
28. National Family Health survey(NFHS-3). Mumbai: International Institute for Population Sciences.2005-06. Available at http://www.rchiips.org/nfhs/NFHS-3%20Data/Karnataka_report.pdf (accessed on 25 Feb 2015).
29. Infante PF, Gillespie GM. Dental caries experience in the deciduous dentition of rural Guatemalan children ages 6 months to 7 years. J Dent Res. 1976;55:951-957.
30. Infante PF, Gillespie GM. Enamel hypoplasia in relation to caries in Guatemalan children. J Dent Res. 1977;56:493-498.
31. Sweeney EA, Guzman M. Oral conditions in children from three highland villages in Guatemala. Arch Oral Biol. 1966;11:687-698.
32. Sweeney EA, Saffir AJ, De LR. Linear hypoplasia of deciduous incisor teeth in malnourished children. Am J Clin Nutr. 1971;24:29-31.
33. Cleaton-Jones P et al. Nutritional status and dental caries in a large sample of 4- and 5-year-old South African children. S Afr Med J 2000;90:631-635.
34. Shakya A, Shenoy R, Rao A. Correlation between malnutrition and dental caries in children. J Nepal Paediatr Soc. 2013;33(2):99-102.
35. Hooley M, Skouteris H, Boganin C, Jr JS and Kilpatrick N. Body mass index and dental caries in children and adolescents: a systematic review of literature published 2004 to 2011. Syst Rev. 2012; 1: 57.
36. Enwonwu CO. Influence of socio-economic conditions on dental development in Nigerian children. Arch Oral Biol. 1973;18:95-107.
37. Jelliffe DB and Jelliffe EFP. Linear enamel hypoplasia of deciduous incisor teeth in malnourished children. Am J Clin Nutr. 1971;24: 893.
38. Sweeney EA, Saffir AJ and de Leon R. Linear hypoplasia of deciduous incisor teeth in malnourished children. Am J Clin Nutr. 1971;24,:29-31.
39. Jelliffe DB., Jelliffe EFP. Garcia I and de Barrios G. The children of the San Blas Indians of Panama. J Pediat. 1961;59: 271-285.
40. MacGregor AB. The role of physical properties of food in dental caries. Bibl Nutr Dieta. 1964; 5:119-142.
41. Mayer J and Baume LJ. Pathologie de la melanodontie infantile. de I odontoclasie et de la carie circulaire. Rev Suisse Odont. 1966;76:48-92.
42. Fearne J, Anderson P, Davis GR. 3D X-ray microscopic study of the extent of variations in enamel density in first permanent molars with idiopathic enamel hypomineralization. Br Dent J. 2004;196:634-638.
43. Jahanbani J1, Morse DE, Alinejad H. Prevalence of oral lesions and normal variants of the oral mucosa in 12 to 15-year-old students in Tehran, Iran. Arch Iran Med. 2012 Mar;15(3):142-5.
44. Sreedevi A. An overview of the development and status of national nutritional programs in India. J Med Nutr Nutraceut 2015;4:5-13.
45. Mathad V, Shivprasad S. Malnutrition: A Daunting Problem for India's Spectacular Growth. Indian J Clin Practice.2013;23(11):760-764