Journal of Multidisciplinary Dental Research

REVIEW ARTICLE

Nutritional Imbalances and their Oral Manifestations: A Review

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ARTICLE INFO

Article history:
Received 06.01.2025
Accepted 15.05.2025
Published 23.07.2025

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https://doi.org/10.38138/JMDR/v11i1.25.2

ABSTRACT

Systemic sickness frequently manifests itself in the oral cavity, which serves as the body's window. The presentation of disease states involves the involvement of multiple tissues, such as the tongue, lips, gingiva, mucosal surfaces, teeth, and bone. Malnutrition has an impact on dental health, and poor dental health can cause malnutrition. Due to their interdependent relationship, healthy eating promotes healthy teeth, and vice versa. Malnutrition may lower resistance to the microbial biofilm, change homeostasis, and impair tissue healing ability, all of which can contribute to the advancement of oral cavity disease. Even the mouth cavity's development may be impacted. This article throws a light on the oral manifestations of nutritional deficiencies.

Keywords: Malnutrition; Oral Manifestations; Vitamins; Diet

1 INTRODUCTION

The oral cavity frequently exhibits clinical signs of dietary deficits and systemic sickness initially. Oral cavity is often one of the first locations to exhibit clinical indications., hence a thorough examination of the oral cavity aids in the early identification of nutritional deficiency and systemic illness. Additionally, nutritional deficiencies may be caused by discomfort, agony, and masticatory trouble. Individuals with damaged dentition consume less calcium, iron, protein, fat, carbs, fiber, vitamin B5, and vitamins C and E orally [(1)]. The first indication of an undiagnosed acute or chronic systemic disease can be manifested in the oral cavity. Mucosal alterations, bleeding and inflammation of the periodontal tissue, and the overall health of the teeth should all be assessed during the examination [(2–4)].

1.1 Vitamin A Deficiency

Vitamin A is essential for immunological defenses, bone growth, healthy cell development, preservation of oral cavity linings, preventing the keratinization of mucus-forming cells, proper tooth spacing, cell differentiation, and osteoclast stimulation. Xerostomia, gingivitis, periodontitis, reduced odontoblast differentiation, hyperkeratotic white patches, epithelial proliferation and maturation problems, tooth morphogenesis defects, and enamel hypoplasia are all signs of a vitamin A deficiency.

1.2 Vitamin B Deficiencies

The eight molecules that make up the vitamin B complex (B1, B2, B3, B5, B6, B7, B9, and B12) are essential for regular cell functioning and metabolic processes.

Vitamin B1 (Thiamine): The primary oral manifestations associated with thiamine deficiency include:

1. Glossitis

- Inflammation of the tongue, often referred to as "beefy red tongue." The tongue may become red, swollen, and sores and the symptoms may cause discomfort during eating and speaking.

2. Cheilosis (Angular Cheilitis)

- Cracks, sores, or fissures at the corners of the mouth. This condition is often painful and can lead to difficulty

in opening the mouth or speaking.

3. Oral Burning Sensation

- Patients may report a sensation of burning or discomfort on the tongue and other oral mucosal surfaces due to nerve involvement caused by thiamine deficiency.

4. Stomatitis (Inflammation of the Oral Mucosa)

- The mucous membranes inside the mouth may become inflamed, affecting both the cheeks and the lips.

5. Dry Mouth (Xerostomia)

- Thiamine deficiency can also lead to decreased salivary production, contributing to dry mouth, which can increase the risk of oral infections, dental caries, and difficulty swallowing.

Vitamin B2 (riboflavin): Numerous oral symptoms, including angular cheilitis, recurrent aphthous stomatitis, and pharyngeal and oral mucous membrane edema, can be brought on by a riboflavin deficit. The term "magenta tint" is commonly used to indicate atrophic, riboflavin-deficient glossitis.

Vitamin B3 (Niacin): Essential part of the oxidation-reduction process. Niacin deficiency causes pellagra, a condition characterized by inflammation of the intestinal mucous membranes, dermatitis, and dementia. Oral Manifestation includes burning mouth syndrome and excruciating pain, angular cheilitis, gingival redness are all linked to vitamin B3 hypovitaminosis [4].

Vitamin B12 (Cobalamine): Tongue burning, irritation and inflammation is one of the oral symptoms. Fissuring and likely the loss of circumcillate papillae result in decreased taste.

1.3 Vitamin C Deficiency

Ascorbic acid, another name for vitamin C, is necessary for the upkeep of collagen, which makes up about one-third of all proteins in the body. A lack of vitamin C can cause scurvy, which typically shows up as bleeding gums and increased tooth mobility because the collagen that makes up the periodontal ligament is weakened. The periodontium heals because of the antioxidant properties of vitamin C and its role in collagen production, which facilitate wound healing. Additionally, vitamin C can aid in iron absorption [5].

Antioxidant vitamin C can help counteract cell change and prevent the start of carcinogenesis. It is thought that vitamin C plays a protective function in patients with oral cancer. According to a study including patients with oral cancers, salivary levels of vitamin C were lower than those of the control group [6].

1.4 Vitamin D Deficiency

Pregnant women who use high-dose vitamin D supplements had a lower chance of having infants with enamel abnormalities. Vitamin D deficiency leads to amelogenesis imperfecta, dentogenesis imperfecta, and ectodermal dysplasia during tooth development. It can also trigger decreased bone mineral density, leading to jawbone resorption. Recent research suggests that vitamin D supplementation can prevent the onset and progression of dental caries, recommending its use in children at risk of severe early-childhood caries [7].

1.5 Vitamin E Deficiency

Both anti-inflammatory and antioxidant qualities are possessed by vitamin E. Oral mucositis can be effectively managed with vitamin E.

1.6 Vitamin K Deficiency

Due to its restricted capacity to get across the placental barrier, vitamin K levels are low in newborns. A lack of vitamin K can lead to newborn hemorrhagic illness since it is essential for the production of blood clotting proteins. Spontaneous and potentially catastrophic bleeding in the brain, skin, and digestive tract are the hallmarks of this illness, which may have serious or even fatal neurological consequences [7].

1.7 Iron Deficiency Anemia

Iron is one of the trace elements present in the enamel's hydroxyapatite, which has been shown in earlier research to reduce the risk of dental caries [3]. Globally, the most prevalent cause of anemia is nutritional iron deficiency. There are various factors which contribute to iron deficiency anemia which include Age, gender, and socioeconomic status blood loss, reduced absorption, or inadequate iron intake. Low-income nations have the greatest prevalence rates of iron deficiency and anemia because of a poor plant-based diet and persistent illnesses that restrict iron absorption [3]. Oral symptoms are widely recognized and easy to identify. These include-

- angular cheilitis,
- recurrent erythematous mucositis,
- oral mucosal pallor,
- glossitis, glossodynia,
- oral ulcers,
- oral candidiasis,
- glossitis.

1. **Iron deficiency in dental caries and periodontal diseases**

A different Canadian study that sought to ascertain if severe early childhood caries and iron status were related

discovered that children with severe early childhood caries had notably low levels of iron, ferritin, and hemoglobin. Compared to children without dental caries, children with severe early childhood caries had nearly double the adjusted chances of having low ferritin levels [3].

1.8 *Zinc Deficiency*

Saliva, dental plaque, and the hydroxyapatite of dental enamel all contain zinc. It contributes to healthy teeth formation and is used in mouth rinses and toothpaste due to its important role in the prevention of plaque and dental calculus formation. Zinc improves the mechanical characteristics of composite restorative materials and dramatically inhibits the growth of *Streptococcus mutans*.

While zinc deficiency has been linked to poor oral and periodontal health, zinc supplements are beneficial against a variety of oral illnesses, including gingivitis, periodontitis, halitosis, and others [8]. The dental cement zinc oxide eugenol is mostly utilized as a temporary filling material works better around dental implants than resin cement and also it does not cause peri-implant mucositis in individuals with a history of periodontitis [9]. According to a study conducted on rats, rats which were fed on zinc containing diet had a better oral health than Zinc deficient diet rats in terms of gingival index [10].

1.9 *Magnesium and Calcium Deficiency*

Magnesium plays a critical function in the remineralization process of teeth by aiding in the development and expansion of hydroxyapatite crystals. Studies have demonstrated that magnesium helped prevent decay because the mean concentration of magnesium in healthy enamel was statistically significantly higher than in mesiodens enamel, despite the previous belief that calcium promoted good mineralization [11].

Calcium deficiency without magnesium would weaken enamel, making it vulnerable to decay-causing acids. The metabolism of calcium and magnesium is primarily responsible for the alveolar bone, which supports teeth. Together, calcium and magnesium regulate electrical impulses in cells. Cellular dysfunction may result from a shift in the calcium-magnesium ratio. Additionally, adequate magnesium intake is necessary for healthy nerve function. About 50–60% of the body's total magnesium content is stored in the teeth. Even a little insufficiency can cause substantial bone loss.

1.10 *Deficiency of Protein*

Collagen is a protein that plays a crucial role in the development of the maxilla, mandible, gingiva, periodontal ligaments, cementum, dentin, and oral mucosa. The preservation and repair of oral tissues, as well as the production of antibodies that are essential for infection resistance, depend on amino acids, which are the building blocks of protein. Degeneration of the tissues supporting the dentition, poor resistance to oral infections, delayed wound healing, and poor structural integrity of the dentition are all consequences of protein shortage [12].

1.11 *Deficiency of Copper*

A sustained dietary deficiency in copper, particularly during periods of active growth, causes anemia and impaired keratinization in the mouth cavity. Patients with oral potentially malignant disorders such oral leukoplakia and oral submucous fibrosis, as well as malignant tumors like squamous cell carcinoma, had considerably higher serum copper levels [13]. The role of copper in development of caries is controversial. Copper has been found to be caries promoting agent whereas study conducted by Brudevold et al on human enamel says that the presence of copper is not associated with the development of enamel hypoplasia, dental caries, pigmentation and increased solubility [14]. The anemic impact is ascribed to decreased iron oxidation and ceruloplasmin ferroxidase activity. Lower immunity can lead to a number of oral cavity infections because of associated neutropenia.

2 DISCUSSION

The chemical molecules known as vitamins are necessary for regular metabolic processes. Some vitamins are created by the gut microbiota, whereas the majority must be received through diet because humans are unable to manufacture them [7]. Vitamins can be classified as either water-soluble or fat-soluble (Figure 1).

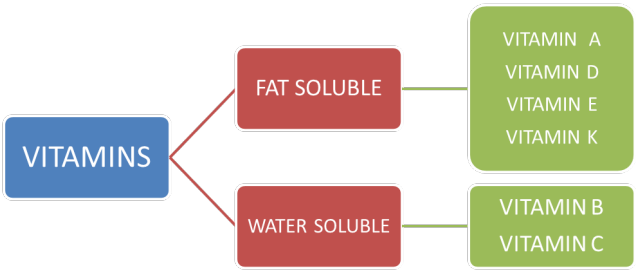

Fig. 1: Water-soluble and Fat-soluble Vitamins

The B complex vitamins, which include B2 (riboflavin), B3 (niacin), B6 (pyridoxine), B9 (folic acid), and B12 (cobalamin), are the water-soluble vitamins that are most crucial for dental health. Vitamins K (phylloquinone), D (calciferol), E (tocopherol), and A (retinol) are fat-soluble vitamins that significantly impact the oral mucosa [15]. Malnutrition seems to affect oral tissues in a number of ways,

Table 1: Oral manifestations of various nutritional deficiencies [1–6,8–14]

Nutrient Deficiency	Oral Manifestations	Description/Clinical Signs
Vitamin A Deficiency	- Xerostomia (dry mouth)	Reduced saliva production due to altered mucous membranes.
	- Oral mucosal changes (keratinization)	Dry, thickened, or roughened mucosa due to impaired epithelial growth.
	- Increased susceptibility to oral infections	Higher risk of gingivitis, periodontal disease, and fungal infections.
Vitamin B1 (Thiamine) Deficiency	- Glossitis (inflammation of the tongue)	The tongue appears inflamed, red, and sore, often with papillary atrophy.
	- Oral burning sensation	Burning discomfort, especially in the tongue.
	- Cheilosis (cracks at the corners of the mouth)	Painful fissures or sores at the angles of the mouth, often seen in severe cases.
Vitamin B2 (Riboflavin) Deficiency	- Glossitis (beefy red tongue)	Tongue becomes swollen, inflamed, and bright red with smooth edges.
	- Angular cheilitis	Cracked, sore lesions at the corners of the mouth.
	- Sore throat and difficulty swallowing	Due to inflammation of the mucous membranes.
Vitamin B3 (Niacin) Deficiency	- Glossitis	Red, inflamed tongue.
	- Angular cheilitis	Cracking and soreness at the corners of the mouth.
	- Stomatitis (inflammation of the mouth)	Painful lesions, redness, and ulcers in the oral mucosa.
Vitamin B6 (Pyridoxine) Deficiency	- Glossitis (smooth, sore tongue)	The tongue becomes smooth, red, and sore due to atrophy of the papillae.
	- Angular cheilitis	Cracked corners of the mouth with soreness and irritation.
	- Stomatitis (inflammation of the oral mucosa)	Painful lesions and inflammation on the lips, gums, and mucosal surfaces.
Vitamin B12 Deficiency	- Glossitis (beefy red, smooth tongue)	The tongue appears smooth, shiny, and red due to loss of filiform papillae.
	- Angular cheilitis	Cracking and soreness at the corners of the mouth.
	- Recurrent oral ulcers	Painful sores, often on the tongue or inside the cheeks.
Folate (Vitamin B9) Deficiency	- Glossitis (inflamed, red, and swollen tongue)	Similar to B12 deficiency, the tongue becomes red, smooth, and sore.
	- Recurrent aphthous ulcers	Frequent occurrence of painful, round ulcers in the mouth, especially on the tongue.
Vitamin C Deficiency	- Gingivitis (swollen, bleeding gums)	Red, swollen, and bleeding gums due to impaired collagen synthesis.
	- Periodontal disease	Increased susceptibility to gum disease and loss of gum tissue.
	- Tooth mobility and loss	Due to weakened periodontal ligaments and alveolar bone.
	- Petechiae (small, pinpoint hemorrhages)	Small purple or red spots on the mucous membranes, often associated with bleeding gums.

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Table 1 continued

Iron Deficiency	- Glossitis (smooth, pale tongue)	Tongue appears smooth and pale due to the loss of papillae.
	- Angular cheilitis	Cracks at the corners of the mouth due to skin and mucosal weakening.
	- Pale mucosa (pale oral tissues)	The mucous membranes of the mouth and tongue may appear unusually pale due to anemia.
Zinc Deficiency	- Oral ulcers (recurrent)	Frequent, painful ulcers in the mouth, including the tongue and cheeks.
	- Glossitis (smooth, inflamed tongue)	Inflammation and smoothness of the tongue due to papillary atrophy.
	- Delayed wound healing	Slow healing of oral mucosal injuries or dental extractions.
Calcium Deficiency	- Tooth enamel hypoplasia	Enamel defects, such as pitting, discoloration, and increased risk of tooth decay.
	- Gingival bleeding	Due to the weakened bone structure, gum tissues may bleed easily.
Magnesium Deficiency	- Burning sensation in the tongue and mouth	A feeling of burning in the tongue or soft palate.
	- Oral ulcers	Painful, recurrent oral ulcers may occur, especially on the tongue or lips.
Protein Deficiency	- Muscle wasting around the face	Can lead to atrophy of the muscles of mastication and facial appearance.
	- Cheilitis (inflammation of the lips)	Swelling and inflammation of the lips.
	- Poor wound healing	Delayed healing of oral tissues following dental procedures or injury.
Copper Deficiency	- Pale mucous membranes	Pale oral mucosa due to impaired red blood cell production.
	- Gingival bleeding	Increased bleeding of the gums due to weakened blood vessels.
	- Oral ulcers	Recurrent ulcers may develop in the oral mucosa due to poor tissue repair.

Table 2: Recommended Daily Allowance [16]

Fat-Soluble Vitamins

Vitamin	Age Group 1-3 years	Age Group 4-8 years	Age Group 9-13 years	Adolescents 14-18 years	Key Sources
Vitamin A	300 mcg	400 mcg	600 mcg	900 mcg (M) / 700 mcg (F)	Carrots, sweet potatoes, spinach
Vitamin D	15 mcg (600 IU)	15 mcg (600 IU)	15 mcg (600 IU)	15 mcg (600 IU)	Sunlight, fortified milk, fatty fish
Vitamin E	6 mg	7 mg	11 mg	15 mg	Nuts, seeds, vegetable oils
Vitamin K	30 mcg	55 mcg	60 mcg	75 mcg	Leafy greens, broccoli, soybeans

Water-Soluble Vitamins

Vitamin	Age Group 1-3 years	Age Group 4-8 years	Age Group 9-13 years	Adolescents 14-18 years	Key Sources
Vitamin C	15 mg	25 mg	45 mg	75 mg (M) / 65 mg (F)	Citrus fruits, bell peppers, strawberries
Thiamine (B1)	0.5 mg	0.6 mg	0.9 mg	1.2 mg (M) / 1.0 mg (F)	Whole grains, pork, legumes
Riboflavin (B2)	0.5 mg	0.6 mg	0.9 mg	1.3 mg (M) / 1.0 mg (F)	Dairy, eggs, green leafy vegetables
Niacin (B3)	6 mg	8 mg	12 mg	16 mg (M) / 14 mg (F)	Meat, fish, whole grains
Pantothenic Acid	2 mg	3 mg	4 mg	5 mg	Avocado, eggs, chicken
Vitamin B6	0.5 mg	0.6 mg	1.0 mg	1.3 mg (M) / 1.2 mg (F)	Fish, bananas, chickpeas
Biotin (B7)	8 mcg	12 mcg	20 mcg	25 mcg	Eggs, nuts, seeds
Folate (B9)	150 mcg	200 mcg	300 mcg	400 mcg	Leafy greens, legumes, fortified cereals
Vitamin B12	0.9 mcg	1.2 mcg	1.8 mcg	2.4 mcg	Meat, fish, dairy

Micronutrients

Micronutrient	Age Group 1-3 years	Age Group 4-8 years	Age Group 9-13 years	Adolescents 14-18 years	Key Sources
Calcium	700 mg	1,000 mg	1,300 mg	1,300 mg	Dairy, leafy greens, fortified drinks
Iron	7 mg	10 mg	8 mg	11 mg (M) / 15 mg (F)	Red meat, beans, fortified cereals
Magnesium	80 mg	130 mg	240 mg	410 mg (M) / 360 mg (F)	Nuts, seeds, whole grains
Phosphorus	460 mg	500 mg	1,250 mg	1,250 mg	Meat, fish, dairy
Zinc	3 mg	5 mg	8 mg	11 mg (M) / 9 mg (F)	Meat, shellfish, whole grains
Copper	340 mcg	440 mcg	700 mcg	890 mcg	Shellfish, nuts, seeds

(Ref: Dietary Reference Intakes (DRIs): Recommended Dietary Allowances and Adequate Intakes, ElementsFood and Nutrition Board, National Academies)

which can lead to the development of oral diseases. It impacts the growth of the oral cavity and the advancement of oral illnesses by altering tissue homeostasis, decreasing resistance to microbial biofilms, and decreasing the ability to repair damaged tissue [17].

Inadequate dietary intake, poor nutrient absorption, altered requirements are some of the causes of nutritional deficiencies. Raising awareness, guidance towards screening and proper diet and multi-vitamin supplementation can close nutritional gaps and raise a population's intake of under consumed nutrients [18]. Both Under intake and Over intake of the nutrients can affect the overall wellbeing and hence it has to be consumed within in the recommended amount. The recommended dietary allowance (RDA) is the average daily dietary intake level that suffices to meet the nutrient requirements of nearly all healthy persons of a specific sex, age, life stage, or physiological condition (Table 1).

3 CONCLUSION

Proper awareness, periodic screening and early diagnosis are important to reduce the severity of nutritional deficiencies, as well as its over intake. As dental practitioners, we should be able to detect the early signs and symptoms of each condition and provide definitive treatment on time. Following a conclusive diagnosis, a customized treatment plan is created, which may involve medication, dental hygiene guidelines, nutritional counselling, or a referral to a specialist for thorough administration. In addition to preventive measures and posttreatment care, patient education is essential in elucidating the nature of the insufficiency, its ramifications, and the suggested course of treatment. In order to track therapy progress and guarantee successful deficit resolution, follow-up meetings are planned. As health care providers, we should have sufficient knowledge in assessing the severity of deficiency, which aids in understanding its potential impact on oral health and overall well-being.

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