Food for Thought: The Relationship Between Oral Health and Nutrition

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Conflict of Interest Disclosure Statement

- The author reports no conflicts of interest associated with this course.

Short Description

Food for Thought: The Relationship Between Oral Health and Nutrition is a free dental continuing education course that covers a wide range of topics relevant to the oral healthcare professional community.

Course Contents

Overview

This course is designed to elevate your understanding of the powerful connection between optimal nutrition and oral health. As dental professionals, we occupy a unique and critical role on the front lines of healthcare. The oral cavity, often called the "window to overall health" can reveal early signs of systemic conditions, placing us in a prime position to identify and address broader health concerns.

Through our regular interactions with patients, we have a valuable opportunity to offer evidence based nutritional guidance. By doing so, we can empower individuals to make informed dietary choices that support not only their oral health but their overall well-being.

Learning Objectives

Upon completion of this course, the dental professional should be able to:

- Describe the basic principles of nutrition and their relevance to oral and systemic health.
- Identify the roles of macronutrients and micronutrients in maintaining oral health.
- Compare evidence-based dietary patterns such as Mediterranean, Keto, Paleo, Carnivore, and MIND diets.
- Describe the protective roles of phytonutrients in oral and systemic health.
- Explain dysbiosis and role of oral microbiome.
- Evaluate the use of prebiotics and probiotics in oral health management.
- Identify nutritional factors contributing to dental caries and periodontal disease.
- Recognized oral manifestations of eating and feeding disorders (FED).
- Describe the links between diabetes and oral health.
- Develop precision nutritional counseling strategies tailored to individual needs.
- Collaborate effectively with dietitians and other health professionals.
- Identify the impact of food insecurity on oral health disparities and propose strategies to address them.

Glossary

anticariogenic – A food that contributes favorably to dental health by discouraging acid production.

antioxidant – Compounds that inhibit oxidation and prevent cell damage caused by free radicals.

beriberi – A vitamin B1 (thiamine) deficiency which causes loss of appetite, muscle weakness, enlarged heart, and burning tongue.

cariogenic – A fermentable carbohydrate that will cause a reduction of salivary and biofilm pH to less than 5.5, promoting tooth decalcification.

cariostatic – Caries-inhibiting.

celiac disease - An autoimmune reaction to eating gluten, causing intestinal inflammation.

cheilitis – Unilateral or bilateral presence of cracks in the corners of the mouth.

collagen – Connective tissue that helps support body structures such as skin, bones, teeth and tendons.

complex carbohydrate – Sugars containing more than 12 carbon atoms. Found in foods such as whole grains, vegetables, and beans.

cruciferous vegetables - A family of plants whose leaf structure resembles a cross. Examples include cabbage, cauliflower, Brussel sprouts, broccoli and bok choy.

demineralization – The removal or loss of calcium, phosphate, and other minerals from tooth enamel.

diet history – A detailed dietary record which may include a 24 hour or 3, 5, and 7-day recall.

dysphagia – Difficulty swallowing.

dysbiosis - Imbalance of gut microbiota.

fermentable carbohydrate – Carbohydrates that can be metabolized by bacteria in plaque to decrease the pH to a level where demineralization occurs.

glossitis – Inflammation of the tongue.

glycemic index - A number value assigned to ingested food which measures the rate at which it causes the level of glucose in the blood to rise.

homeostasis – To maintain a relatively stable state of equilibrium maintained by physiological processes.

insulin – A hormone needed for cell utilization of carbohydrates.

interprofessional collaboration - health professionals from two or more different disciplines work together to achieve shared goals in patient care.

macronutrients – Carbohydrates, protein, and fats, needed for energy.

micronutrients – Vitamins and minerals needed in small quantities.

microbiota – collection of microorganisms residing in the gut.

nutrient-dense – Containing a high percentage of nutrients in relation to the number of calories it provides.

nutrigenomics - Personalized nutrition that studies how genes respond to food.

osteomalacia - Calcium deficiency during growth years where bone mineralization is reduced.

osteopenia – A decrease in density, calcification, or insufficient synthesis of bone which may put an individual at risk for osteoporosis.

prebiotics - non-digestible food ingredients that support gastrointestinal health.

postbiotics - Bioactive compounds produced by prebiotics that support host health.

Phytonutrients – Chemical compounds found in a variety of fruits, vegetables, and seeds that reduce inflammation in the body and promote positive health effects.

refined carbohydrate – Processed carbohydrates from which the fiber and bran have been removed, leaving only starch.

salivary gland hypofunction - Decreased volume of saliva leading to xerostomia.

scurvy – a nutritional deficiency disease caused by a lack of vitamin C.

ultra-processed food – Packaged foods that undergo industrial processing.

vegan – A person who eats only a plant-based diet and consumes no foods of animal origin.[7]

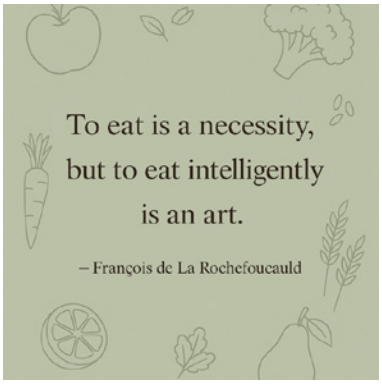
villous - Finger shaped mucous membrane in the small intestine to assist with nutrient absorption.

xylitol – A sugar alcohol which can reduce *S. mutans* in the oral cavity.

Introduction

Oral health is a critical component of overall systemic health and significantly influences an individual's quality of life. Yet, poor oral health affects over four billion people globally.[1] Research has established strong connections between chronic oral conditions and systemic diseases such as cardiovascular disease, diabetes, and neurodegenerative disorders—driven by inflammation linked to imbalances in the oral microbiome.[1]

Dental patients often struggle to interpret nutritional information and make informed dietary choices. Conditions such as early childhood caries, oral lesions, and periodontal disease can lead to tooth loss, which may further impair mastication and hinder the proper digestion of nutrient-dense foods-compounding nutritional challenges and impacting overall health.



Foundations of Nutrition and Oral Health

Diet and nutrition are significant influencers of oral health. Oral pathology is one of the first observations leading to prevalent systemic disease including metabolic disorders. Nutritional imbalances, including vitamins D and C, as well as minerals such as calcium, zinc, and magnesium, are associated with chronic oral diseases, such as gingivitis, periodontal disease, and dental caries.[2]

The Bidirectional Relationship between Systemic and Oral Health

The oral microbiota is vital to the human microbiome.[2] The delicate balance between bacteria symbiosis and host resistance ensures the oral tissue integrity. However, many factors may interfere with that balance, nutritional status is one of them. The introduction of high glycemic, ultra processed foods and beverages have caused a decline in oral health, and an increase in several other diseases, such as cardiovascular, autoimmune, gastrointestinal, cancer, and obesity.[3] The relationship between diet, oral and systemic health is therefore, bidirectional.[4]

Overview of Macronutrients and Micronutrients

- Carbohydrates: Why Quality Counts
- Protein: Animal vs Plant : A Balanced Perspective
- Fats: Choosing the Best
- Vitamins: Micronutrients with Macro Impact
- Minerals: Essential for Calcified Structures
- Phytonutrients: Nature's Defense System

Carbohydrates: Why Quality Counts

The type of carbohydrates you choose plays a crucial role in your overall health. Complex carbohydrates are a smarter, more nutritious choice than highly refined ones. The best include whole grains, quinoa, fruits, vegetables, and legumes. These foods are rich in vitamins, minerals, fiber, phytonutrients, and help maintain stable blood sugar levels.[30]

In contrast, refined carbohydrates like white bread, pastries, sugary drinks and processed snacks are quickly digested, often leading to blood sugar spikes, weight gain, dysbiosis of the microflora, and increased risk of metabolic disorders.[30]

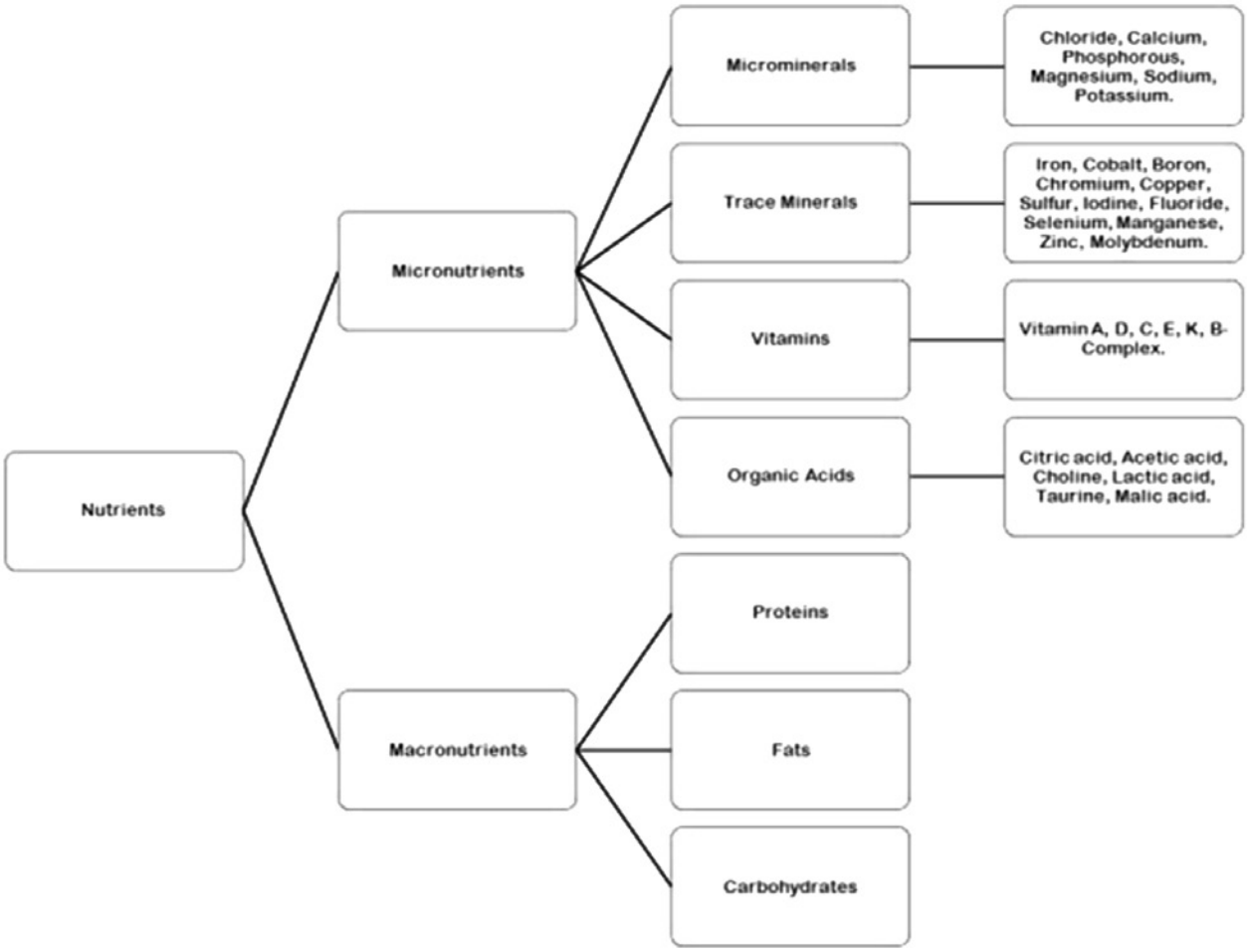


Figure 1. Classification of Nutrients[32]

Tips for Choosing Healthy Carbohydrates:

- Look for "whole" as the first ingredient on the food label.
- Choose foods with a low glycemic Index (GI).
- Eat moderate portions of carbohydrates at each meal.
- Choose whole fruit over fruit juices for fiber.

The glycemic index (GI) is a numeric ranking system for carbohydrates based on their immediate effect on blood glucose levels. Foods that break down quickly have a high GI, such as white bread and sugary snacks, and cause a sharp spike in blood sugars. By contrast, low GI foods, such as lentils and beans, are digested more slowly, resulting in a gradual rise in blood sugar and lower demand for insulin. This distinction is especially important for individuals with diabetes, as low GI foods support better glycemic control and help maintain blood glucose homeostasis. Aim for lower glycemic index foods, which require less demand for insulin and promote blood glucose homeostasis.[30]

The table above categories foods by their glycemic load. During nutritional counseling, it's important to highlight the difference between types of carbohydrates. For patients diagnosed with insulin resistance, or diabetes, ask about their most recent A1C level and whether they wear a continuous glucose monitor (CGM). Glucose control is highly individualized, and CGM's give patients real time readings and personalized results.

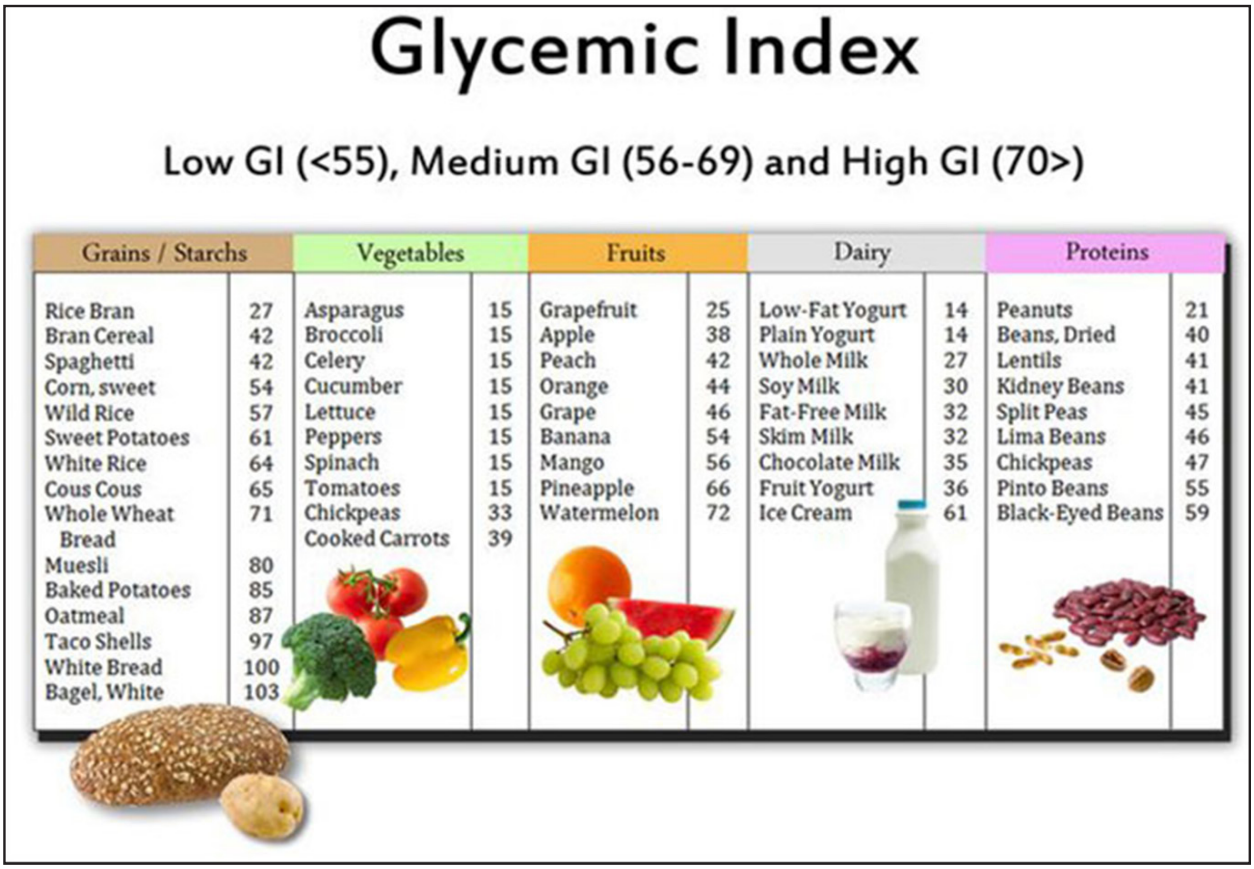


Figure 2. Glycemic Index.[30]

Some individuals must restrict carbohydrates due to food intolerances. Celiac disease is an autoimmune reaction to gluten, which is a combination of two proteins found in grains like wheat, barley, and rye. When consumed, these carbohydrates trigger inflammation in the duodenum of the small intestine causing villous atrophy, which in turn prevents the absorption of nutrients and symptoms of abdominal bloating, cramping, diarrhea, and vomiting.[11]

Carbohydrate deficiency symptoms include hypoglycemia, ketosis, cognitive impairment, and digestive issues due to low fiber intake. Low-carb diets may also reduce the intake of B vitamins and minerals, commonly found in whole grains and fruits.[11]

Protein: Animal vs Plant : A Balanced Perspective

Proteins are found in muscle, bone, skin, hair, and all body tissues and are responsible for growth, maintenance, and repair. Protein is built from building blocks called amino acids, which is considered a complete protein. Since our bodies cannot synthesize complete proteins, they must be obtained by the foods we eat.[31]

Animal proteins are considered complete proteins because they contain all nine essential amino acids in optimal ratio for human health. They are also highly bioavailable, being easier for the body to digest and absorb- and are rich in key nutrients like vitamin B12, heme iron, zinc, and omega-3 fatty acids (especially from fatty fish). However, red, and processed meats contain higher levels of saturated fat and cholesterol, which are linked to heart disease and certain cancers. Additionally, animal-based foods have a greater environmental impact compared to plant-based alternatives.[31]

Plant proteins, on the other hand, are often incomplete. mostly lacking one or more

essential amino acids, with the exception of quinoa, soy, and buckwheat, which provide complete profiles. Despite this, plant protein offers significant health benefits, supporting gut health, reducing inflammation, and are associated with a lower the risk of chronic diseases. Foods like vegetables, legumes, nuts and seeds and whole grains also provide fiber and antioxidants, which are absent in animal products.[31]

A balanced approach that includes both plant and animal protein, especially lean sources like fish and poultry, can offer the best of both worlds. This strategy ensures a complete amino acid profile while also incorporating fiber, phytonutrients and a wide range of essential vitamins and minerals.

Protein Deficiency

Protein is essential for the synthesis of all body tissues; therefore, a deficiency can compromise the structural integrity, including that of the maxilla, mandible, and oral mucosa.[4] Individuals living in poverty or developing countries, particularly children and the elderly pose the greatest risk of protein deficiency.[4]

Fats: Choosing the Best

Fats are one of the three macronutrients, alongside carbohydrates and protein. They play a vital role in the body by providing energy, supporting hormone production, maintaining cell integrity, and enabling the absorption of fat-soluble vitamins, A, D, E, and K. Fats also help promote satiety by slowing digestions, which can aid in appetite control. However, not

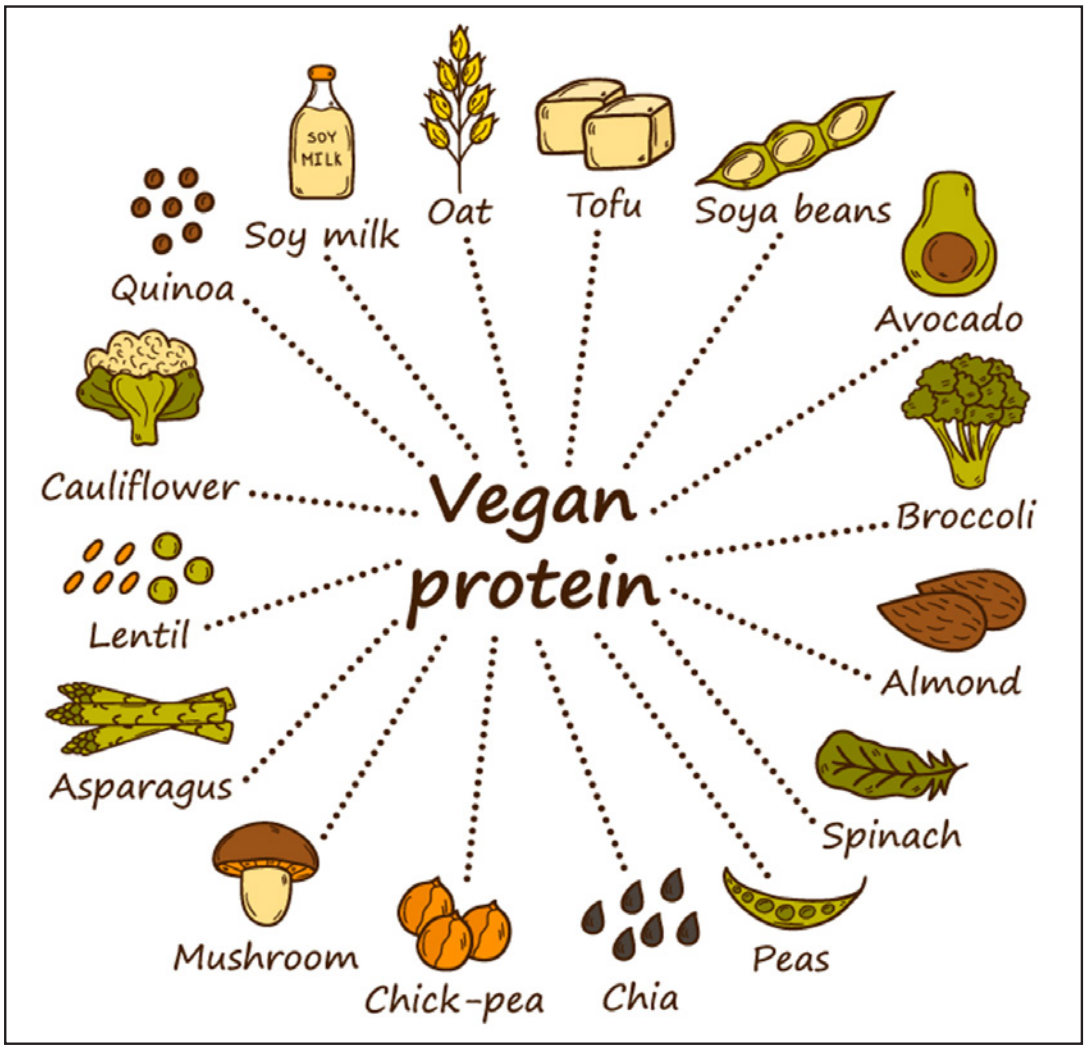


Figure 3. Vegan Protein.[29]

all fats are created equal. Unsaturated fats, from olive oil, nuts, seeds, and fish are considered heart healthy. They can reduce inflammation, support brain function, and promote a healthy cholesterol matrix. Also, research suggests they may lower the risk of cardiovascular disease and improve insulin sensitivity. Trans fats, found in processed and fried foods, are harmful and have been banned in many countries due to their strong link to heart disease and inflammation. Saturated fats, present in red meat, butter, cheese, and seed oils have mixed research findings. While some studies suggest they may not be as harmful as once thought, most health organizations still recommend consuming them in moderation. Balance is the key when it comes to consuming fats. They are calorie dense, so excessive intake can lead to weight gain. Favor unsaturated fats from olive oil, avocado, nuts, seeds, and fatty fish. Limit saturated fats by choosing lean meats and low-fat dairy, while avoiding trans fats altogether.[4]

Vitamins: Micronutrients with Macro Impact

Vitamins are calorie free, organic, and play a crucial role in overall health. They function as antioxidants, helping to prevent cellular damage and they also reduce inflammation throughout the body. In addition to their systemic benefits, vitamins are closely linked to the health of oral tissues.[31]

Key vitamins such as C, D, E, and B-complex groups play important roles in maintaining oral health. Vitamin C is essential for collagen synthesis and helps preserve the integrity of oral tissues. A 2024 meta-analysis found that higher vitamin C intake was significantly associated with reduced risk of periodontal disease.[31] Vitamin D supports calcium absorption and is critical for tooth mineralization. It also shows promise in protecting against periodontal disease.[31]

Vitamins are categorized into two main groups: water soluble and fat soluble. Tables 1 and 2 provide an overview of each vitamin type, biological function, dietary sources, and symptoms associated with deficiencies.[31]

Minerals: Essential for Calcified Structures

All food groups contain foods rich in essential minerals. However, the mineral content in our diet can vary significantly based on the quality of foods we eat as well as the soil and water conditions in which plants have grown. The most common mineral deficiencies include calcium, zinc, iron, magnesium, and iodide.[31]

Top minerals associated with oral health include calcium, phosphorus, and fluoride. Calcium, the primary component of tooth enamel, is essential for enamel remineralization. Calcium forms hydroxyapatite, along with phosphorus, and is crucial for resisting acid erosion and repair of early enamel lesions.[5] Fluoride plays an important role in strengthening and preventing demineralization by integrating fluorapatite into the enamel.[4] A balanced intake of these minerals support not only teeth but oral microbiome balance.[5]

Tables 3 and 4 provide an overview of these key minerals, including their roles in maintaining health, primary dietary sources, and potential health effects of deficiencies.[31]

Phytonutrients: Nature's Defense System

Phytonutrients are bioactive compounds naturally present in colorful fruits, vegetables, legumes, whole grains, and herbs. These compounds have shown promising potential in reducing the risk of both cancer and chronic inflammation. Research indicates that a diverse diet, rich in phytonutrients are associated with a 30-40% lower risk of developing chronic disease.[6] Some of the most extensively studied phytonutrients include carotenoids, resveratrol, anthocyanins, quercetin, flavonoids, and polyphenols, all commonly found in plant-based diets. The table below outlines the health benefits of various phytonutrients.[6]

Phytonutrients play a significant role in promoting and maintaining oral health through several mechanisms. Flavonoids, carotenoids, and polyphenols act as powerful antioxidants. This can reduce the risk of inflammatory conditions, such as periodontal disease.[6] Phytonutrients, like quercetin, resveratrol, and curcumin have shown to module inflammatory pathways, potential reducing gingival inflammation and improving periodontal outcomes.[6] Green tea and cranberries can inhibit the growth of Streptococcus mutans and

Table 1. Water-soluble Vitamins: C, B's.[31]

Vitamin	Source	Deficiency	Oral Deficiency
C-Ascorbic acid ✓ Assists with formation of collagen fibers ✓ Strengthens the immune system ✓ Helps with protein metabolism ✓ Aids with calcium and iron absorption ✓ Antioxidant	✓ Peppers ✓ Citrus fruits ✓ Kiwi ✓ Strawberries ✓ Cruciferous vegetables ✓ Tomatoes ✓ Leafy greens	✓ Scurvy	✓ Gingival inflammation ✓ Petechiae ✓ Poor healing
B1-Thiamin or thiamine ✓ Coenzyme for energy production	✓ Pork, trout, black beans	✓ Beriberi ✓ Wernicke-Korsakoff Syndrome	✓ None
B2-Riboflavin ✓ Coenzyme for energy production	✓ Milk, meat, enriched breads and cereals	✓ Ariboflavinosis	✓ Angular cheilitis ✓ Glossitis
B3-Niacin ✓ Coenzyme and partner with B2 ✓ Assists with blood cell formation	✓ Meat, fish, beans, nuts, coffee, enriched breads and cereals	✓ Pellagra (dermatitis, diarrhea, dementia)	✓ None
B6-Pyridoxine ✓ Coenzyme	✓ Chickpeas, beef, liver, tuna, salmon, chicken, bananas	✓ Microcytic anemia; ✓ Depressed immunity, irritability, glossitis	✓ Glossitis ✓ Angular cheilitis
B12-Cobalamine ✓ Needs intrinsic factor from stomach for absorption ✓ Works with folate to make RBCs	✓ Animal products exclusively. Need supplementation if you follow a vegan diet	✓ Pernicious anemia	✓ Glossitis ✓ Angular cheilitis ✓ Tissue inflammation
B9-Folate/folic acid ✓ Coenzyme in the synthesis of nucleic acid DNA, RNA	✓ Beef, liver, green leafy vegetables, fruits	✓ Megaloblastic anemia ✓ Neural tube defects ✓ Low birth weight	✓ Ulcerated tongue ✓ Mucosal lesions
Biotin-H ✓ Regulates blood sugar levels ✓ Synthesis of RNA, DNA	✓ Liver, cauliflower, salmon, carrots, bananas, nuts	✓ High blood sugar ✓ Skin conditions	✓ Inflammation of mucosal membranes
B5-Pantothenic acid ✓ Coenzyme ✓ Synthesis of fatty acids, cholesterol, and hormones	✓ Yeast, chicken, beef, potatoes, oats, whole grains.	✓ Loss of muscle coordination	✓ None

Table 2. Fat-Soluble Vitamins: A, D, E, K.[11]

Vitamin	Source	Deficiency	Oral Deficiency
Vitamin A-Beta-carotene/ Retinol ✓ Immune function ✓ Assist with formation of tissue of eye and cornea ✓ Important antioxidant	✓ Sweet potatoes, pumpkin, spinach, carrots, liver ✓ Cantaloupe, mangos, red pepper	✓ Macular degeneration ✓ Night blindness ✓ Exophthalmia (total blindness)	✓ Xerostomia ✓ Oral leukoplakia ✓ Hyperkeratosis
Vitamin D-Calciferol ✓ Promotes calcium absorption ✓ Assist with bone formation, remodeling, and growth ✓ Aids in cell growth, nerve and muscle formation, the immune system, and reduction of inflammation	✓ UV light ✓ Fatty fish; tuna, salmon ✓ Fortified milk products, and orange juice	✓ Adults-osteomalacia ✓ Kids-rickets ✓ Delayed dentition, enamel hypocalcification	✓ Failure of bone wounds to heal ✓ Enamel hypocalcification ✓ Loss of alveolar bone
Vitamin E-Tocopherol ✓ Antioxidant ✓ Immune function ✓ Inhibits blood clotting	✓ Vegetable oils ✓ Nuts and seeds; sunflower, almonds, hazelnuts	✓ Nerve pain, immune system disorders	✓ None
Vitamin K-Phylloquinone ✓ Cofactor for prothrombin formation necessary for clotting ✓ Bone metabolism	✓ Intestinal bacteria ✓ Dark leafy greens; spinach, kale, collards ✓ Broccoli, soybeans, edamame	✓ Hemolytic anemia ✓ Failure of wounds to stop bleeding	✓ Failure of clotting

Table 3. Minerals for Bones and Teeth.[31]

Mineral	Source	Deficiency
Calcium: (Ca) ✓ Most abundant mineral in the body ✓ Stored in teeth and bones ✓ Muscle contraction ✓ Hormone production	✓ Dairy ✓ Fortified orange juice and soy milk	Hypocalcemia ✓ Osteomalacia ✓ Osteopenia ✓ Rickets
Phosphorus: (P) ✓ Formation of bone and teeth ✓ Protein synthesis ✓ Muscle contraction	✓ Dairy ✓ Meat ✓ Fish ✓ Nuts and legumes	Hypophosphatemia ✓ Muscle weakness ✓ Bone pain and fracture ✓ Loss of appetite
Fluorine: (F) ✓ Increase retention of calcium in teeth and bones	✓ Ground water ✓ Tea ✓ Gelatin	✓ Dental caries ✓ Bone fractures in elderly
Magnesium: (Mg) ✓ Mineralization of bone and teeth ✓ Neural transmitter ✓ Muscle contraction	✓ Green leafy vegetables ✓ Nuts ✓ Whole grains ✓ Chocolate	Hypomagnesium ✓ Diarrhea and vomiting ✓ Muscle tremors

Table 4. Trace Minerals: Needed in smaller amounts but play a powerful role in health.[31]

Trace Minerals	Source	Deficiency
Iron:(Fe) ✓ Component of hemoglobin ✓ Transportation of oxygen ✓ Absorption aided by Vitamin C and hampered by phytochemicals	✓ Heme iron: meat, fish, poultry ✓ Non-heme iron: legumes, leafy greens and chocolate	✓ Food insecure households ✓ Impaired immunity ✓ Angular cheilitis
Zinc: (Zn) ✓ Coenzyme in over 100 functions ✓ Immunity ✓ Wound healing	✓ Red meat ✓ Poultry ✓ Shellfish	✓ Loss of appetite, taste and smell ✓ Slow tissue repair ✓ Eye and skin lesions
Copper (Cu) ✓ Aids in the absorption of iron ✓ Antioxidant	✓ Shellfish ✓ Nuts ✓ Organ meats ✓ Legumes	✓ Osteoporosis, ✓ Anemia ✓ Muscle weakness
Manganese (Mn) ✓ Antioxidant ✓ Wound healing ✓ Co-enzyme	✓ Raisin bran cereal ✓ Brown rice ✓ Pineapple ✓ Green tea	✓ Growth reduction ✓ Glucose intolerance
Iodide (I) ✓ Part of thyroid hormone ✓ Immune system	✓ Iodized salt ✓ Cod ✓ Yogurt ✓ Milk	Hypothyroidism ✓ Goiter ✓ Weight gain ✓ Intolerance to cold

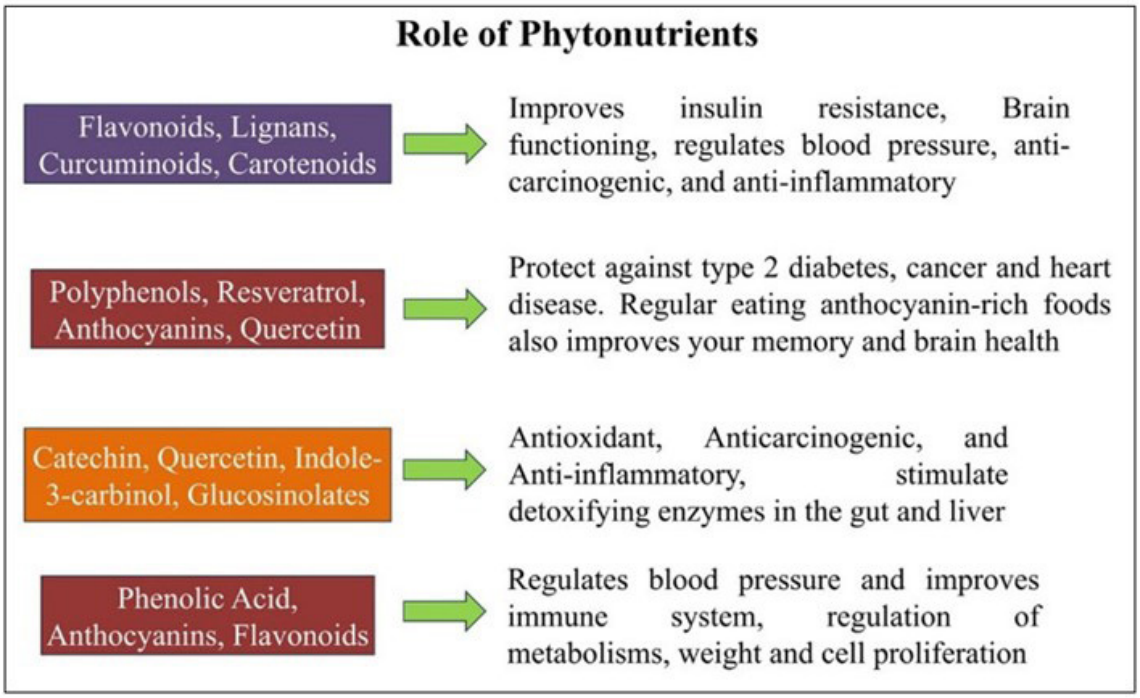


Figure 4. Recommended Cholesterol Guidelines for Adults.[24]

Porphyromonas gingivitis bacteria, associated with dental caries and periodontal disease.[7] By reducing oxidative stress and inflammation, phytonutrients may help maintain the health balance or the oral microbiome, essential for disease prevention and overall oral health.[7]

Oral Microbiome and Prebiotics & Probiotics

Over the past decade research has revealed a strong connection between gut microbiome and both physical and mental health. Diets high in added sugars and ultra-processed foods can disrupt the balance of gut bacteria, leading to inflammation and gut dysbiosis. This imbalance has been linked to a range of issues, including autoimmune diseases, food intolerances, fatigue, sleep disturbances, gastrointestinal symptoms, anxiety, and depression.[8] To support a healthy gut microbiome, include both prebiotics and probiotic rich foods that contain beneficial bacteria like lactobacillus and bifidobacterium, which help maintain gut integrity and support immune function. A diversified, fiber rich diet including fermented foods supports beneficial bacteria in both the mouth and gut.[9] Below are good sources of symbiotic foods to support gut health.[9]

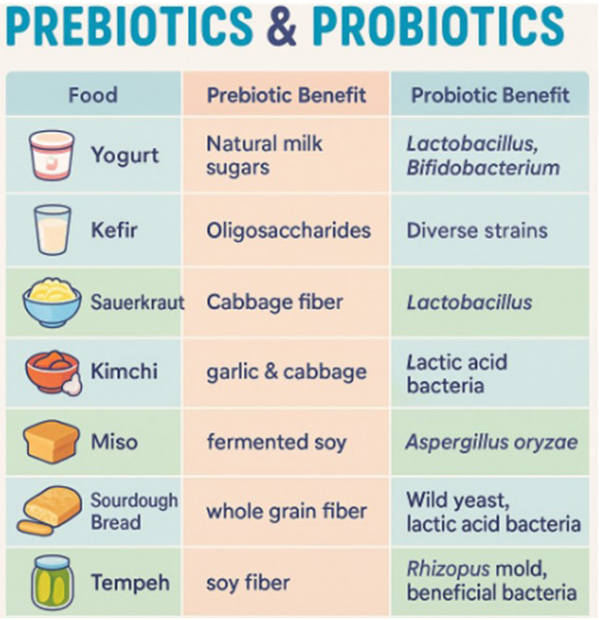


Figure 5. Benefits of Prebiotics and Probiotics
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Oral and gut microbiomes are closely interconnected through the oral-gut axis. Microbial translation occurs when microbes from the mouth travel and colonize in the gut, via salvia and swallowed food. In cases of dysbiosis, a microbial imbalance, oral

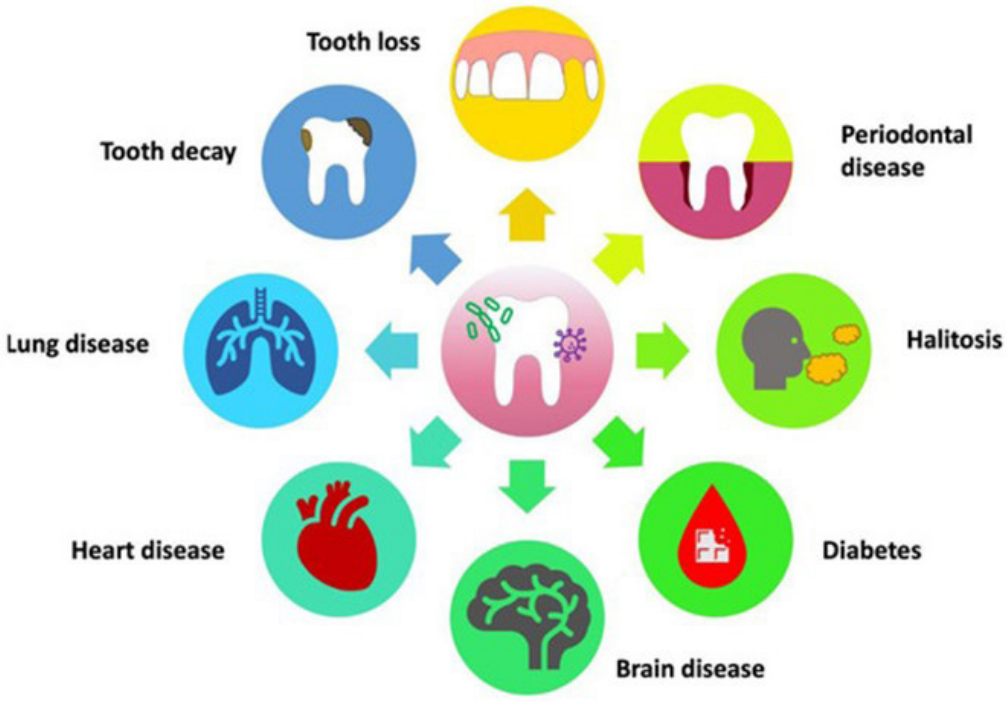

Figure 6. Effects of imbalanced oral microbiota on systemic health.[8]

pathogens can disrupt gut microbiome and contribute to inflammation and disease. This is also a bidirectional communication, where gut and oral microbiome communication and gut dysbiosis can affect oral tissues.[8] Both microbiomes play a role in immune regulation, metabolism, and inflammation.

Disruption in one can potentially contribute to conditions like inflammatory bowel disease, cardiovascular disease, neurological disorders, and certain cancers. Diet, oral hygiene, medications and stress can influence both microbiomes. The figure below shows the effects of the imbalance of the oral microbiota on systemic health.[8]

Prebiotic and probiotics may positively influence oral health by balancing the oral microbiome, restoring balance, and reducing pathogenic species. Certain strains, such as Lactobacillus rhamnosus and Streptococcus salivarius have been shown to reduce levels of Streptococcus mutans and are major contributors of dental decay.[8] While Streptococcus salvarius K12, typically introduced into the body by probiotic supplements, may reduce volatile sulfur compounds (VSC's) which are responsible for halitosis.[8]

Nutrition Trends

Mediterranean + DASH = MIND Diet

The Mediterranean diet, which is mostly plant-based, along with the DASH diet (Dietary Approaches to Stop Hypertension) focusing on low sodium intake are two evidence based, flexible, and effective eating strategies to reduce the incidence of chronic diseases. The MIND diet, short for Mediterranean-DASH Intervention for Neurodegenerative Delay-is a hybrid of both diets, designed to support brain health and reduce the risk of Alzheimer's disease and age-related cognitive decline.[10]

The MIND diet encourages a daily intake of dark greens such as kale and spinach, along with other non-starchy vegetables, nuts, olive oil, whole grains such as oats, quinoa, and legumes. Berries, fish, and poultry are suggested twice per week. Quality matters, choosing locally grown, organic, and wild harvested when possible.[10]

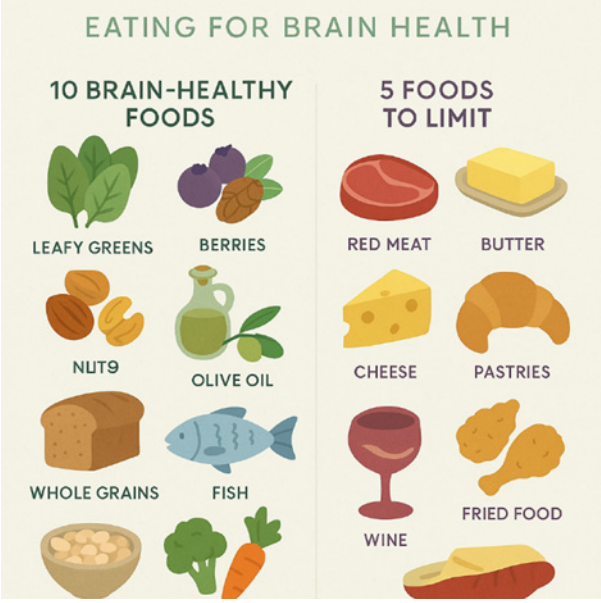

Figure 7. Eating for Brain Health
Image Source: Generated by AI

Nutrigenomics & Personalized Nutrition

Nutrigenomics, the study of how food affects a person's genes and their response to specific foods, has grown in popularity, especially with advancements in AI technology.[11] The goal is personalized dietary recommendations to enhance health and prevent disease. This approach is transforming functional foods into tools for precision health, targeting inflammation and nutrient absorption. Functional foods are foods which contain probiotics, vitamins, antioxidants, omega-3's and adaptogens, such as ashwagandha and reishi mushrooms, believed to help regulate stress, balance hormones, and provide health benefits beyond basic nutrition.[11]

Personalized diets show promise in enhancing the efficacy of medical treatments related to obesity, cancer, and cardiovascular disease, by focusing on the interconnection between predisposition genotype, nutrition, and disease, to deliver exact nutrition based on individual biomarkers.[11] The diagram below refers to the complex relationship between individual genome and how nutrients are absorbed, metabolized, and utilized affecting growth, development, health, and disease susceptibility.

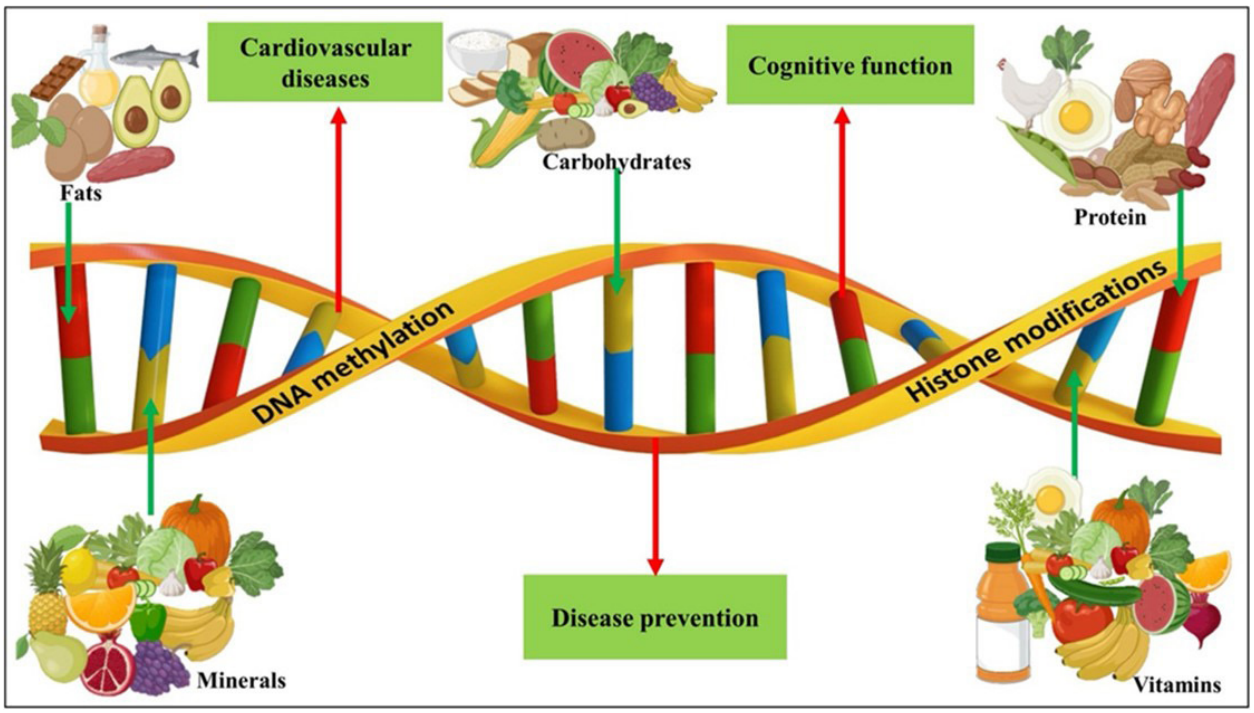

Figure 8. Relationship Interconnection between genotype, nutrition and disease.[11]

Nutrigenomics offers promising applications in oral health. It can help identify genetic predisposition to conditions such as gingivitis and periodontal disease, enabling dental professionals to recommend personalized dietary strategies that reduce inflammation and support tissue regeneration.[12]

Diet also plays a key role in shaping the oral microbiome. Incorporating foods like fermented products can promote the growth of beneficial bacteria and suppress harmful ones, potentially reducing dysbiosis associated with dental disease.[12]

Specific nutrients, such as omega-3 fatty acids, polyphenols, and vitamins C and E have been shown to enhance antioxidant defenses and modulate gene expression by downregulating inflammatory pathways.[12] Ultimately, the goal of personalized nutrition in dentistry is to recognize that everyone has unique genetic and nutritional needs to support systemic and oral health.

Anti-Inflammatory Diets

Anti inflammatory diets, rich in fruits, vegetables, legumes, nuts, and fatty fish have the potential to reduce inflammation and support cognitive and heart health.[13] Chronic inflammation is a key contributor to cardiovascular disease, causing atherosclerosis in the arteries. Similarly, neuroinflammation can impair neuroplasticity, implicated in Alzheimer's disease and dementias.[14]

The Mediterranean diet consistently reduces inflammatory markers like C-reactive protein (CPR) and interleukin-6 (IL).[13] The relationship between chronic inflammation and diet is becoming increasingly evident, with minimally processed, whole foods containing fiber, and antioxidants are associated with lower CPR and IL concentrations. In contrast, proinflammatory, Western diets, consisting of animal-based, processed food rich in saturated fats, added sugars, sodium, and refined grains, lacking in nutrient dense foods, increase proinflammatory markers.[13]

In oral health, elevated CRP levels are often found in individuals with periodontal disease, gingivitis, and dental caries, reflecting the oral contribution to systemic inflammation. Because of the bidirectional relationship, heightened inflammatory states elsewhere in the body can make oral conditions worse.[15]

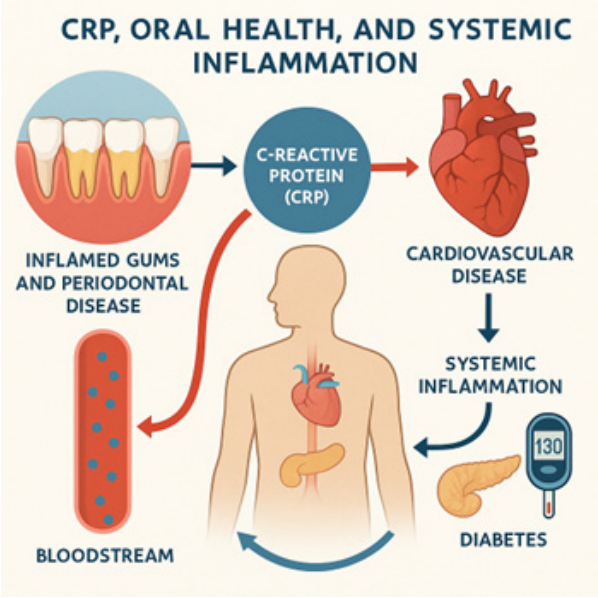

Figure 9. CRP, Oral Health and Systemic Inflammation
Image Source: Generated by AI

Ketogenic, Paleolithic, and Carnivore Diets

The Ketogenic diet, characterized by 70 to 75% fat, 20 to 25% protein intake, and 5-10 % carbohydrate was originally developed in the 1920's at the Mayo clinic as a treatment for childhood epilepsy.[16] In recent decades, it has gained popularity as a weight loss strategy. While it can improve blood sugar control and insulin sensitivity, the diet can be challenging to maintain long term and lacks essential nutrients such as fiber and certain minerals.[16]

The modern Paleolithic diet is considered the most balanced and sustainable compared to the three, thanks to the inclusion of fruits, vegetables, and lean meats. It emphasizes whole, unprocessed foods that are naturally low in added sugars, which supports metabolic health and reduces inflammation. However, because it excludes grains, legumes, and dairy, it can make it restrictive and potentially more difficult to follow.[16]

The Carnivore diet, consisting exclusively of animal products such as meat, eggs, and some dairy, is the most restrictive of the three diets. Studies and anecdotal reports suggest it may reduce autoimmune symptoms and promote rapid weight loss. However, it typically lacks fiber, vitamin C, and other essential micronutrients and its long-term health effects remain unstudied.[16]

Food trends are taking a collective shift toward healthier, more sustainable, and technology driven food systems. Key highlights include the growing adaptation to personalized nutrition tailored to individual health needs of our patients. The hope, as healthcare providers, is to encourage our patients to eat real food, read food labels, and incorporate a mindful eating approach that is both healthy and environmentally sustainable.

Nutritional Factors in the Dental Caries Process

The etiology of dental caries is a dynamic process that involves a susceptible tooth, cariogenic bacteria in dental biofilm (*Streptococcus mutans and lactobacillus*), and the detrimental effects of cariogenic carbohydrates. Modifying factors also include the absence of fluoride, xerostomia, and inadequate oral hygiene. The demineralization process during an acid attack and subsequent remineralization by saliva and fluoride happens continuously throughout the day. Studies demonstrate it can take approximately 19 to 22 months for the cavitation process to progress to the dentin, making the caries process complex and continuous.[17]

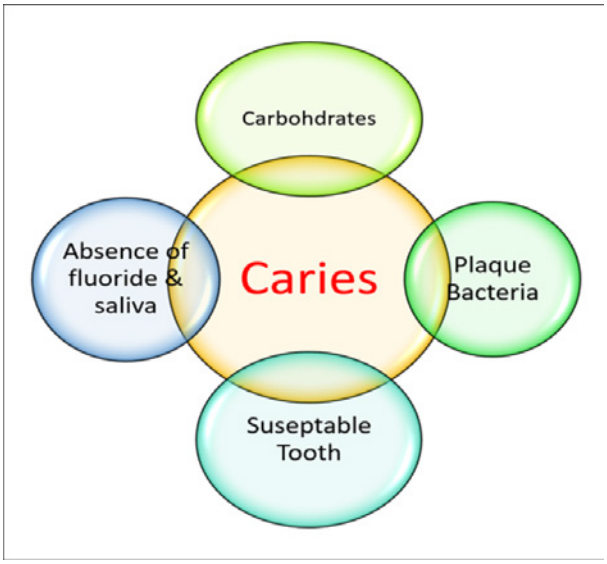

Figure 10. Etiology of caries process

Every time food or beverage is consumed, it creates an opportunity for oral bacteria to produce an acid, initiating the caries process. One of the most significant risk factors is the frequency of sugar intake. Each exposure to fermentable carbohydrates provides bacteria with a fresh chance to metabolize sugars and release acid.[17]

Within just three minutes of consuming cariogenic food and drink, the pH level in dental biofilm can drop before 5.5. triggering enamel demineralization. The key to preventing the caries process is to minimize the time the oral environment remains acidic.[17]

Poor diet quality and nutrient deficiencies in contemporary diets are major contributors to increased caries risk. The rise of synthetic and ultra-processed food has long term effects on oral health. Both emotional and behavioral factors significantly shape diet choices that can also lead to a rise in dental caries.[17]

Cariostatic food, those that do not contribute to enamel breakdown, help maintain the healthy pH balance of 6.8 to 7.0. Foods rich in protein, fats, phosphorus, and calcium, such as meat, milk, cheese, and nuts can help with this process.[17] Providing patients with nutritional guidance, such as reducing the intake of fermentation carbohydrates, encouraging hydration with fluoridated water and avoiding frequent sipping on sugar drinks is an essential part of comprehensive dental care.[17]

- For sugar intake
- For cariostatic foods
- For hydration
- For meal timing

The harmful effects of soda, juice and popular energy drinks are the leading contributor to early childhood caries and tooth decay among children and adolescents, particularly in underserved communities. A single 12-ounce soda contains ten teaspoons of sugar, along with acids that erode enamel. Even sugar free options often contain citric and phosphoric acid, which can directly demineralize tooth enamel.[17]

Our role as oral health educators is to analyze dietary habits and causative factors to determine a patient's risk for dental caries. The education strategies below demonstrate the importance of interprofessional collaboration and nutrition engagement that surrounds a patient's dental journey.[17]

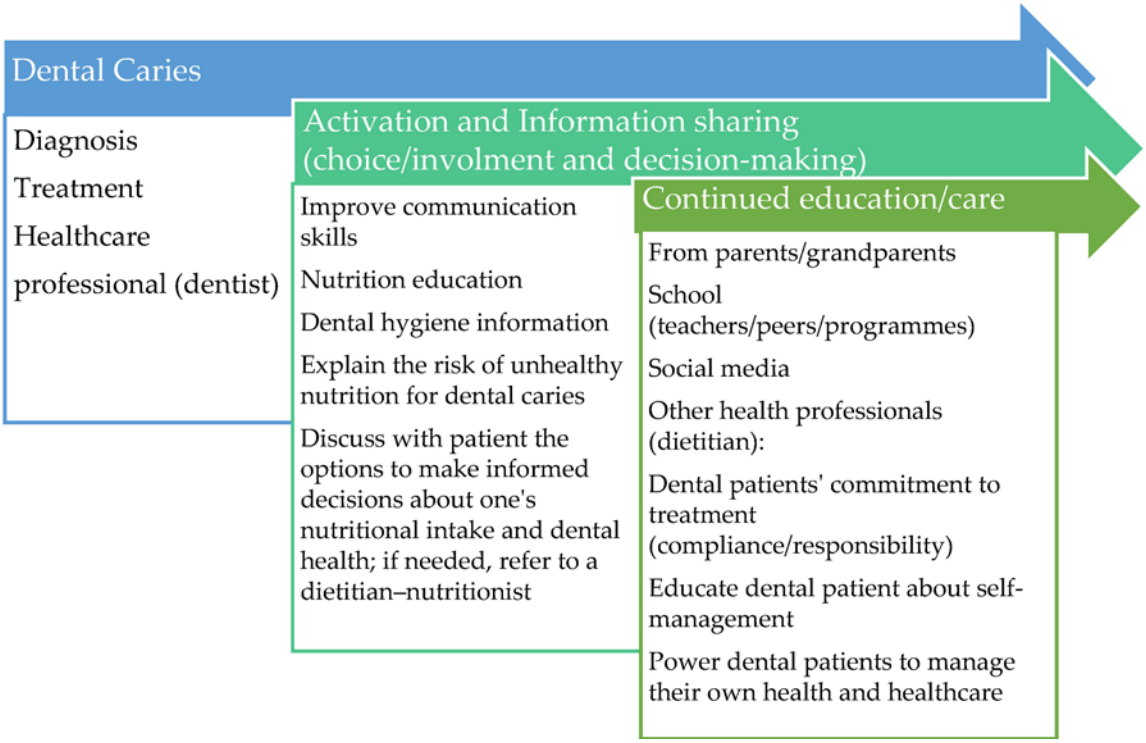

Figure 12. Education Strategies[17]

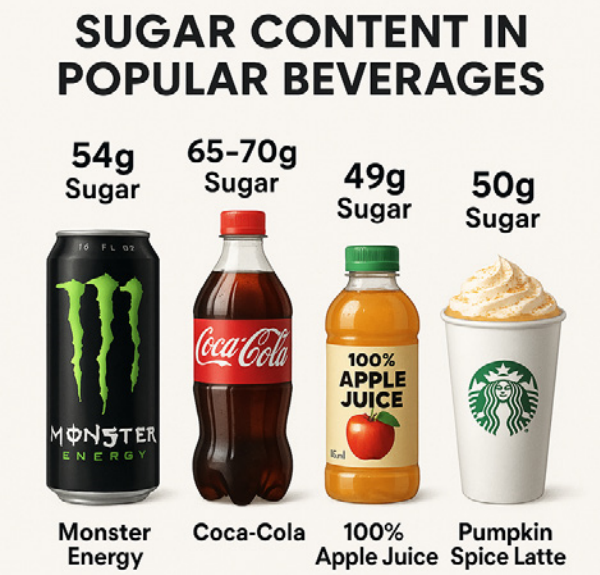

Figure 11. Etiology of caries process
Image Source: Generated by AI

Dietary Patterns and Periodontal Disease

Periodontal disease is a multifactorial, chronic, inflammatory disease, driven by microorganisms in biofilm and the host's immune response. The typical proinflammatory diet, high in processed foods, sugars, and saturated fats significantly increase the risk of periodontitis.[18]

Nutrition, and the intake of phytonutrients, antioxidants and macro and micronutrients play a significant role in the body's ability to manage periodontal health. A balanced diet can support the immune response and promote healing and slow progression. Studies show the Mediterranean, plant-based diet is associated with a reduced risk.18 Vitamin C, and omega-3 fatty acids are particularly beneficial in reducing inflammation and promoting healing.[18]

The table below highlights key nutrients for optimal periodontal health.

Special Populations and Oral Health

Oral health is a vital component to overall well-being, especially in vulnerable populations, such as children, older adults, individuals with eating disorders, and patients with systemic diseases. These groups are especially at risk in underserved areas with limited access to dental care and nutritious foods.

Table 5. Nutrients Important for a Healthy Periodontium.[18]

Vitamin D ✓ Calcium, phosphorus, and magnesium absorption ✓ Deficiency linked to periodontal disease ✓ Bone metabolism	**Vitamin A** ✓ Builds and maintains epithelium ✓ Enhances immune system ✓ Salivary gland function
B-Complex Vitamins ✓ Formation of new cells ✓ Cofactor for nutrients ✓ Periodontal wound healing ✓ Collagen synthesis (biotin)	**Protein** ✓ Promotes growth maintenance and repair of all tissues
Vitamin C ✓ Aids in collagen formation ✓ Deficiency causes ascorbic acid gingivitis ✓ Enhances immune response	**Iron, Zinc** ✓ Aids in collagen formation ✓ Wound healing ✓ Regulates inflammation
Calcium ✓ Builds and maintains alveolar process	**Lipids** ✓ Omega-3 fatty acids have anti-inflammatory properties ✓ Obesity is a risk factor for periodontal disease
Fiber ✓ Controls serum glucose and inflammatory response ✓ Deficiency linked to periodontal inflammation	**Probiotics** ✓ Strengthens immune system ✓ Inhibits colonization of harmful microorganisms ✓ May reduce lactobacillus

Pediatric Nutrition and Tooth Development

Oral health is a vital component of a child's overall health, significantly influencing both their overall physical and psychological development. Nutritional imbalances, whether from undernutrition or overfeeding can increase risk of dental decay, delayed or impaired tooth development, underdeveloped mandible, and reduced salivary flow.[19] Children are particularly susceptible to the effects of diet and food quality, due to rapid growth and physiological demands.

Nutritional status of the body influences the pre-eruptive phases of tooth development. Deficiencies in vitamin D, C, B, A, and protein have been associated with enamel hypoplasia, making teeth more susceptible to a cariogenic environment.[19]

While vegetables and fruits offer nutrient dense calories that support healthy development, processed food high in preservatives and sugar significantly alter the oral microbiome. These dietary choices can overwhelm the buffering capacity of saliva and disturb the mouth's natural pH balance.[19]

This underscores not only the importance of food quantity and quality, but also the need for education, targeted at patients, parents, and caregivers, and strong interprofessional collaboration between dentists and pediatricians to promote optional oral and overall health in children.

Geriatric Nutrition and Oral Function

Malnutrition in older adults is both a cause and consequence of poor oral health. Conditions like periodontal disease, tooth loss, xerostomia and impaired chewing and swallowing, can significantly reduce nutrient intake. These challenges are especially pronounced among older adults in disadvantaged communities, where access to dental care and nutritious food may be limited.[20]

Older adults are particularly vulnerable to inadequate nutrition and poor dietary habits, which can further comprise their oral health. Maintaining good oral hygiene and functional dentition is essential for ensuring sufficient nutritional intake and reducing the risk of malnutrition.[20]

Nutritional counseling for older adults should emphasize increasing the intake of healthy fats and high-quality protein, particularly from sources like fish and nuts, as well as phytonutrients from a variety of fruits and vegetables. These dietary components support both general health and oral health, helping to maintain strong teeth and periodontal structure.[20]

A recent study found over 25% of older patients screened for nutritional deficiencies in dental clinics were malnourished or at risk.[20] Oral health providers should routinely perform dietary assessments for older adults to ensure adequate nutrition and reinforce the importance of a functioning dentition.

Feeding and Eating Disorders (FED) and Oral Manifestations

Feeding and eating disorders (FED) encompass a spectrum of psychiatric conditions that typically emerge from childhood through early adulthood. These include anorexia nervous (AN), bulimia nervous (BN), binge eating disorder (BED) and other specified feeding or eating disorder (OSFED), avoidance restrictive food intake disorder (ARFID), and pica.[21]

Epidemiological data show that;[21]

- 9% of the US populations will experience an eating disorder in their lifetime.
- 22% of children and adolescents will display disorder eating behaviors globally.
- Anorexia nervosa (AN) is among the highest mortality of any psychiatric disorder.

At the core of all FED's is a disturbance of compensatory eating behaviors, often motivated by body image concerns and accompanied by co-occurring mood and anxiety disorders. Individuals with BN or BED are frequently overweight or obese and may suffer from serious metabolic complications.[21]

The COVID-19 pandemic significantly exacerbated the prevalence and severity of FED's. Studies report a marked increase in new diagnosis, particular among adolescents and young adults with a higher rate of psychiatric comorbidity and hospitalizations.[21]

Dental professionals are in a unique position to identify early signs of FED during routine examinations. Common oral manifestations include;[21]

- Xerostomia
- Enamel erosion
- Tooth sensitivity
- Increased caries rate
- Mucosal irritation

A personalization and precision medical approach, one that considers biological, psychological, and social dimensions of FED's can improve treatment outcome. Interprofessional collaboration, particularly with mental health providers offering cognitive behavioral therapy (CBT) is considered the gold standard of managing these complex conditions.

Diabetes and Oral Health Links

The oral cavity serves as a critical indicator of overall health, with its pathology exerting an impact on systemic conditions. Neglecting oral health can exacerbate systemic conditions, and vice versa, due to the bidirectional relationship between oral and overall health.[22]

Diabetes mellitus (DM) encompasses a broad spectrum of metabolic disorders, characterized by insufficient insulin production to insulin resistance, or a combination of both, resulting in impaired glucose levels. Chronic hyperglycemia associated with DM significantly elevates the risk of various oral health issues including periodontal disease, head and neck cancers, salivary gland dysfunction, dental caries, and delayed wound healing. Glycemic control plays a critical role in the success rates of dental implant in patients, as poor regulation can hinder bone health and increases the likelihood of complications.[22] Additionally, DM influences vascular changes in the gingival, alters the immune response, elevates inflammatory markers and disrupts the microbiome balance within the periodontal pockets.[22]

Special population groups are at greater risk of complications from the bidirectional conditions of oral health and systemic health risks. The interdisciplinary approach and collaboration between dental and medical professionals are essential to improve patient outcomes. Preventive oral care and early intervention are emphasized as key strategies in managing and potentially mitigating chronic disease progression.[22]

Figure 13. Erosion caused by chronic vomiting in bulimia.[31]

Image source: ©2003 Lippincott Williams & Wilkins.

Clinical Integration and Counseling

Clinical integration and dietary counseling are essential components of comprehensive patient care, especially in managing and preventing chronic disease. By improving communication between oral health care providers and physicians, dietitians, and other specialists, we can approach patient centered care, streamline pathways, better manage disease, and enhance patient satisfaction and support.[23]

Nutritional Screening

Nutritional screening tools are recognized as vital for identifying patients at risk for diet related oral and systemic health issues. Subjective and objective approaches can begin with questions about diet, chewing ability and oral health status, while evaluation of soft tissue health and healing capacity may detect signs of nutritional deficiencies such as oral lesions, glossitis and angular cheilitis.[23]

The Mini Nutritional Assessment (MNA) tool is ideal for older adults and assesses dietary intake, weight loss, mobility, and psychological stress. The Malnutrition Universal Screening

Tool (MUST) focuses on BMI, weight loss and acute disease impact. While the Nutrition Screening Initiative (NSI) includes questions about eating habits, health conditions and functional status. The AAP oral health risk assessment is useful in pediatric settings and includes nutritional and hygiene counseling prompts, and a self management goal sheet for caregivers.[24] To choose the best nutritional screen tool, it's important to match the tool to your patient population, clinical setting and depth of information needed.

Oral health specific tools can be used to assess caries risk based on carbohydrate intake and frequency. Caries Management by Risk Assessment (CAMBRA) is an evidence-based approach for patient-specific caries management at its earliest stages. The first step involves categorizing caries risk based on the clinician's overall assessment of patient's disease indicators, caries protective factors, and caries predisposing factors. The treatment guideline below assesses caries risk as low, moderate, high, or extreme risk categories.[25]

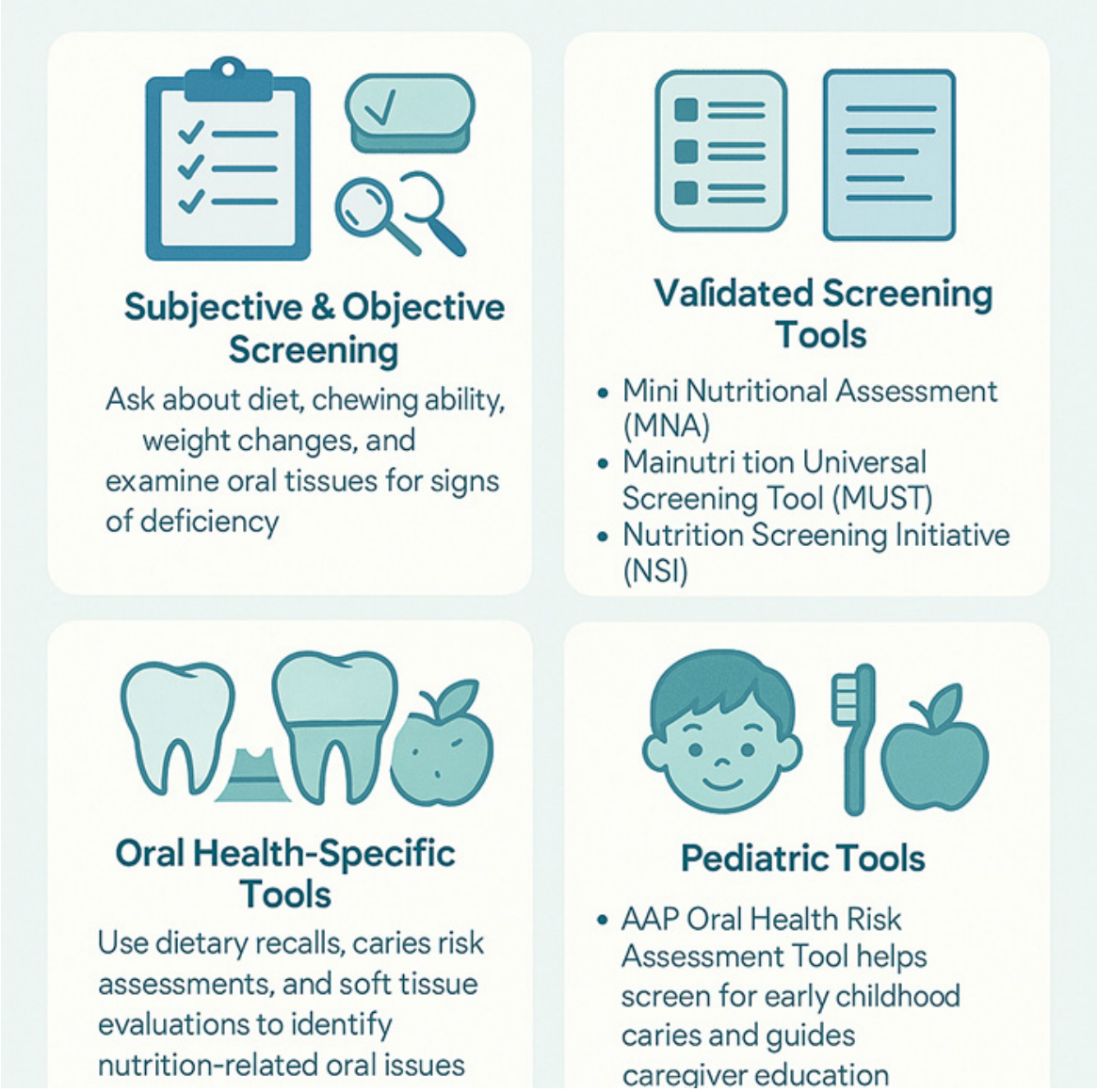

Figure 14. Nutritional Screening Tools
Image Source: Generated by AI

Low Risk:	Routine care and fluoride toothpaste are sufficient.
Moderate Risk:	Add fluoride varnish and dietary counseling.
High Risk:	Requires fluoride + antibacterial therapy (e.g., chlorhexidine), xylitol, and sealants.
Extreme Risk:	All of the above plus salivary substitutes and more aggressive management.[25]

Precision Nutritional Counseling

Precision nutrition counseling (PNC) is tailored dietary advice based on an individual's genetic profile, lifestyle and behaviors, medical and dental history, nutritional biomarkers, and microbiome composition.[26] This approach moves beyond generic dietary recommendations to offer targeted interventions that can help prevent or manage oral diseases like caries, periodontal diseases, and oral mucosal conditions. Benefits using PNC include preventive care and patient education, improvement in patient outcomes, strengthens interprofessional collaboration with dietitians, and empowers patients with actionable, personalized strategies.[26]

Applications in Oral Healthcare:

Caries Prevention

- Identify sugar intake patterns and recommend healthier alternatives.
- Support remineralization with calcium, phosphate, and vitamin D.

Periodontal Disease Management

- *Promote anti-inflammatory diets rich in*:
  - Omega-3 fatty acids
  - Antioxidants
  - Dietary fiber
- Reduce refined carbohydrates and saturated fats.

Oral Microbiome Modulation

- Use probiotic and prebiotic strategies to support healthy oral flora.
- Create personalized dietary plans to reduce pathogenic bacteria.

Systemic Health Integration

- Diabetes
- Cardiovascular disease
- Obesity
- Nutritional interventions to support whole-body health.

Special Populations

- Pediatric
- Geriatric
- Patients with FED's

Interprofessional Collaboration with Dietitians

Dentistry's evolving role reflects a bidirectional focus on the connection between oral health and conditions, such as cardiovascular disease and diabetes. This shift marks a transition from solely treating oral disease to actively promoting overall health and wellness.[27] As research continues to support the value of early detection, preventive care, and personalized treatment strategies, oral health care providers are increasingly integrated into the wider healthcare system.

Technology advances, including teledentistry and AI driven tools, can enhance the efficiency, accessibility, and data information nature of dental care.[27] However, several challenges hinder the integration of nutrition care into dental practices, these include:

- Limited training in nutrition for dental professionals.
- Time constraints during dental visits.
- Lack of reimbursement models.
- Absence of onsite registered dietitians.

To address these gaps, recommendations include:

- Embedding nutrition education into dental school curriculum and continuing education programs.
- Establishing an interprofessional care model that includes dietitians as part of dental teams.
- Utilizing routine oral health visits as opportunities for nutritional screening and counseling, particularly for high-risk populations.

Food Insecurity and Oral Health Disparities

An estimated 23.7 million adults, approximately 9.2% of the US population experience food insecurity.[28] Research shows a strong association between food insecurity and poor oral health outcomes.[28] Adults who rate their oral health as fair or poor are significantly more likely to experience food insecurity. These disparities are especially pronounced among Black, Hispanic, and younger adults (18-44) who report higher rates of food insecurity and are more likely to experience one or more oral health symptoms.[28]

Figure 15. Relationship between food insecurity and oral health symptoms.[28]

Oral health care providers can play a vital role in addressing food insecurity by screening at-risk patients during dental visits. Through interdisciplinary collaboration with social workers, nutritionists, and community-based organizations, providers can help connect patients to resources that improve food access and overall well-being.[28]

Conclusion

Nutrition plays a foundational role in both systemic and oral health, with a complex, bidirectional relationship that underscores the importance of dietary choices in clinical dental practice.[4] Understanding the composition and function of macronutrients; carbohydrates, proteins, and fats, as well as micronutrients like vitamins, minerals and phytonutrients, are essential for promoting optimal oral health. The quality of carbohydrates, the balance between animal and plant proteins, and the types of fats consumed all influence inflammation, oral microbiome balance, and disease risk.

Emerging research on the oral microbiome, including the roles of prebiotics, probiotics, fiber, and fermentation, highlights the intricate connections between diet and microbial health. Nutrition trends such as the Mediterranean, DASH, and MIND diets, along with a personalized approach such as nutrigenomics and anti-inflammatory protocols offer promising strategies for disease prevention and management. While popular diets like keto, paleo, and carnivore have gained attention, their long-term impact on oral and systemic health requires careful consideration.

Nutritional factors are deeply embedded in the dental caries process and periodontal disease progression. Special populations including pediatric, geriatric, and individuals with feeding and eating disorders (FED) or diabetes mellitus (DM) require tailored nutrition guidance to support oral development, function, and disease prevention. Integrating nutritional screening and precision counseling into dental care, alongside interprofessional collaboration with a dietitian and community resources, empower providers to address border determinants of health.

Finally, recognizing and responding to food insecurity is critical in reducing oral health disparities. By identifying at-risk patients and fostering interdisciplinary partnership, oral health professionals can contribute meaningfully to improving both nutritional status and oral health outcomes across diverse populations.

Course Test Preview

To receive Continuing Education credit for this course, you must complete the online test. Please go to: *https://www.dentalcare.com/en-us/ce-courses/ce583/test*

1. The relationship between diet, oral health and systemic health is best described as;
A. Unidirectional
B. Irrelevant
C. Bidirectional
D. Linear

2. Which of the following dietary patterns is most likely to disrupt the balance of oral microbiota?
A. High fiber diet.
B. Mediterranean diet.
C. Plant based diet.
D. High glycemic diet.

3. Which of the following are NOT considered macronutrients?
A. Vitamins.
B. Protein.
C. Fats.
D. Carbohydrates.

4. Why are animal proteins considered complete proteins?
A. They are high in saturated fat and cholesterol.
B. They contain all nine essential amino acids.
C. They are rich in fiber and antioxidants.
D. They are more environmentally sustainable.

5. What does the glycemic index (GI) measure?
A. The number of calories from carbohydrates.
B. The amount of trans fats in a food.
C. The effect of carbohydrates on blood glucose.
D. The essential amino acid quality of protein.

6. What is the primary role of vitamin D in oral health?
A. Enhances connective tissue regeneration.
B. Supports calcium absorption and tooth mineralization.
C. Prevents dental decay by balancing the pH of the microbiome.
D. Aids in the stimulation of saliva.

7. Which of the following is NOT a benefit of phytonutrients?
A. Serves as an essential nutrient.
B. Functions as an antioxidant to reduce inflammation.
C. Maintains the balance of the oral microbiome.
D. Reduces the risks of chronic diseases.

8. What term is used to describe microbial imbalances in the body?
A. Symbiosis.
B. Dysbiosis.
C. Probiotics.
D. Fermentation.

9. What is the role of Streptococcus salivarius K12 in oral health?

A. Increases salivary production.
B. Increases C-reactive proteins.
C. Promotes biofilm formation.
D. Reduces volatile sulfur compounds.

10. What is the goal of nutrigenomics in healthcare?

A. To promote universal dietary guidelines.
B. To provide personalized dietary recommendations.
C. To measure calorie intake for safe weight loss.
D. To promote fasting as a health strategy.

11. Elevated C-reactive protein (CRP) levels in the oral cavity are often associated with which conditions?

A. Periodontal disease and gingivitis.
B. Oral cancer and leukoplakia.
C. Tooth sensitive and enamel erosion.
D. Bruxism and TMJ disorders.

12. Why is an interdisciplinary approach important in managing diabetes and oral health?

A. It reduces the need for medications.
B. It eliminates the need for dental visits.
C. It improves patient outcomes through collaboration.
D. It focuses on systemic health.

13. Which dietary components are emphasized in managing periodontal disease through precision nutrition counseling?

A. Avoiding dairy products.
B. Incorporating high glycemic carbohydrates.
C. Combining low-fiber foods.
D. Including omega-3 fatty acids.

14. What is the primary purpose of the MIND diet?

A. To promote safe weight loss.
B. To reduce neurodegenerative disease.
C. To increase muscle mass.
D. To treat digestive disorders.

15. Which of the following are modifying factors that contribute to the development of dental caries?

A. Xerostomia.
B. Presence of streptococcus mutans.
C. Tooth morphology.
D. Cariogenic carbohydrates.

16. Which of the following is a probiotic benefit associated of sauerkraut?

A. A variety of microbial strains.
B. Presences of lactic acid bacteria.
C. Contains Lactobacillus species.
D. Contains Aspergillus oryzae.

17. What is considered the "gold standard" for managing feeding and eating disorders (FED)?

A. Nutritional supplements.
B. Antibiotic therapy.
C. The DASH diet.
D. Cognitive behavioral therapy (CBT).

18. What makes the modern Paleolithic diet more balanced compared to the Ketogenic and Carnivore diets?

A. It includes high fat dairy.
B. It allows for legumes.
C. It includes fruits and vegetables.
D. It allows for whole grains.

19. Which of the following minerals is the most abundant in the body while also playing a key role in the formation of hydroxyapatite?

A. Calcium.
B. Fluoride.
C. Phosphorus.
D. Magnesium.

20. Which water-soluble vitamin plays a key role in collagen formation in the oral cavity and can be found in citrus fruits, cruciferous vegetables, and greens?

A. Vitamin D.
B. Vitamin C.
C. Vitamin B.
D. Vitamin A.

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Additional Resources

- No Additional Resources Available

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