

Chapter 2

Pregnancy, Child Nutrition, and Oral Health

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Keypoints

- Adequate nutritional status prior to and during pregnancy supports the development of oral health in infants and children
- Recommended infant feeding practices, introduction of foods, and healthful dietary choices promote optimum growth and development and decreased risk of early childhood caries
- Caries in children is associated with multiple dietary factors including frequent fermentable carbohydrate consumption
- Poor oral health in children with childhood disorders and diseases is associated with possible increased risk for malnutrition and growth impairment

Keywords Prenatal nutrition • Perinatal nutrition • Tooth development • Maternal oral health • Maternal protein energy malnutrition • Vitamin nutrition • Mineral nutrition • Oral health • Infant feeding practices • Early childhood feeding practices

Introduction

Adequate nutrition is imperative during pregnancy as nutrition is an important factor in the health, growth, and development of the mother and the fetus [1–3]. Appropriate prenatal weight gain is associated with a lower risk of complications during the pregnancy and the birth process [1, 4–6].

Growth and development of the fetus begins during pregnancy and continues as the child grows into early adulthood. Physical growth is defined as increases in cell size caused by processes of cell multiplication involving hyperplasia, hypertrophy, and accretion occurring in set patterns. However,

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this can occur at different rates and ages. The effects of nutrition are expressed throughout this process of growth and development and demonstrated throughout the tissues and structures of the developing body [7].

Since the consequences of poor oral health can impact lifelong health, pregnancy and childhood are key periods to access oral healthcare [8]. According to the Surgeon General's Report on Oral Health, oral health is defined as having healthy teeth as well as "being free of chronic oral-facial pain conditions, oral and pharyngeal (throat) cancers, oral soft tissue lesions, birth defects such as cleft lip and palate, and scores of other diseases and disorders that affect the oral, dental, and craniofacial tissues, collectively known as the *craniofacial complex*" [9]. Nutrition is the intake of food, considered in relation to the body's dietary needs [10]. Diet refers to what we eat and drink and has a local effect on the oral cavity. Depending on the diet's composition, it can impact risk of dental caries and enamel erosion. Nutritional status impacts an individual's tooth and soft tissue development and resistance to infections, particularly periodontal disease and caries. A nutritious diet is essential for the development and maintenance of healthy teeth and soft tissue which in turn are needed to consume a varied and healthy diet throughout life [11]. Nutrient deficits can impact tooth development, including the integrity of the tooth and enamel, as well as the soft tissue and composition of saliva. Protein-calorie malnutrition and deficiencies of vitamins C, A, D, and iodine have been documented in human studies to have an impact on tooth development and maintenance [12–15].

This chapter explores relationships between oral health and nutritional status and dietary intake from conception through adolescence according to the developmental stages of pregnancy, infancy, early childhood, and school-aged children. Oral health and nutritional disorders among individuals with special needs are reviewed.

Prenatal and Perinatal Nutrition and Tooth Development

Adequate nutrition prior to and during pregnancy can impact the dentition of the infant. During fetal development, the primary teeth begin forming at about 6 weeks post conception with cells in the oral cavity of the fetus differentiating to form the dental lamina, the site of tooth bud formation. Tooth mineralization begins in the late bell stage of tooth development or about 4 months gestation with the formation of dentin, the foundation for the deposition of enamel [14, 16] and continues throughout adolescence [9]. Nutrition directly impacts the development of enamel and dentin of the primary and permanent teeth during fetal growth. In addition, preconception nutritional status of the mother as well as access to adequate nutrition during pregnancy has an impact on the general health and outcomes of the infant and may impact the infant's future health as an adult [17]. Nutrient deficiencies or insults from teratogens during pregnancy can impact the development of the primary and permanent teeth [17]. Upon birth, all primary and many unerupted permanent teeth are in various stages of development [9]. Early childhood caries (ECC) and hypoplasia found in infants and children in developing countries are associated with malnutrition or undernutrition during the perinatal period [18]. Individual nutrients are related to critical periods of calcification and poorly calcified teeth resulting in reduced caries resistance [19].

Maternal Oral Health Concerns in Pregnancy

During pregnancy the diet provides sufficient calories and other nutrients to meet the requirements of the mother as well as support the needs of the growing fetus. This allows the mother to establish nutrient stores required for ongoing fetal development and for future lactation needs [1]. Despite

available prenatal care for mothers and their fetuses, approximately 5% of infants born in the USA are diagnosed with intrauterine growth retardation (IUGR) [20]. Epidemiological studies have linked IUGR with the etiology of many chronic diseases in adults [20]. Energy and nutrient intake during pregnancy, along with prenatal weight gain, affect overall and oral fetal development and the child's gestational age and birth weight [21].

Routine oral healthcare is important to a pregnant woman's overall health status and to the future oral health of her child [22]. Both periodontal disease and dental caries are preventable through evidence-based interventions [23]. Educational interventions prior to and during pregnancy can promote disease prevention and positive, oral health behaviors and nutrition habits. The presence of periodontal disease and/or dental caries during the preconception period and during pregnancy will influence the mother's oral health conditions, may affect the outcome of the pregnancy, and the child's future risk of developing early and severe dental caries [24]. Periodontal disease in the mother has been associated with adverse pregnancy outcomes including premature birth [11, 25, 26], preeclampsia [27, 28], gestational diabetes [29], fetal loss [30], and small for gestational age infants [26]. Several investigators have demonstrated a relationship between treatment of periodontal disease during pregnancy and a reduction in risk of preterm birth [7, 32, 33].

During pregnancy the mother experiences changes in hormonal activity, in gastrointestinal anatomy and physiology [33], and alterations in blood flow, blood pressure, and respiratory function [34]. Some of these symptoms include nausea, vomiting, gastroesophageal reflux, changes in taste and food cravings, as well as fatigue; all of which may vary in presentation by trimester. Pregnancy-related gastric acid reflux, experienced during nausea and vomiting, can lead to dental enamel erosion. Morning sickness, which may be experienced early in pregnancy and acid reflux, common in latter stages of pregnancy, can also contribute to dental erosion [35]. Physiologic changes in the oral cavity due to shifts in estrogen levels can result in tooth mobility and maternal gingivitis [35–38]. Estrogen metabolism by gingival tissue and the synthesis of prostaglandins contribute to increased incidence of gingivitis during pregnancy [39]. An increase in estrogen levels results in a decreased production of collagen and keratinization of the gingival epithelium reducing the ability to repair and maintain gingival tissue [40]. In pregnancy higher levels of progesterone results in increased vascular permeability of gingival tissues [40]. Studies have demonstrated an association between periodontal infection and adverse outcomes of pregnancy including preterm birth and low birth weight of the infant [41, 42].

Dental caries during pregnancy is of unique concern because of the maternal-child linkage. Caries occurs when cariogenic bacteria in dental plaque metabolize fermentable carbohydrates and produce acid that can be transferred between mother and child through direct salivary transmission. Mothers who have extensive tooth decay are more likely to have high titers of *mutants streptococci*, a known oral bacteria, resulting in a higher risk of ECC in their children [23]. Levels of cariogenic bacteria in maternal saliva and transmission of bacteria from mother to child is facilitated by kissing, sharing of eating utensils, and cleaning pacifiers with mother's saliva [23]. The age of the child on exposure to cariogenic bacteria, the composition of the child's diet, and the child's salivary flow rate and composition can also impact transmission of cariogenic bacteria [23].

Oral pregnancy tumors may occur in up to 5% of women during pregnancy [43]. They are caused by combined effects of increased levels of progesterone and oral bacteria, are primarily located on the gingiva and have a smooth and erythematous appearance. The tumors can present after the first trimester with associated bleeding and may interfere with eating, but usually recede after delivery [43].

Table 2.1 Daily recommendations for increased energy and protein by trimester for women with a preconception BMI of 18.5–24.9 [45]

Trimester	Energy (K cal)	Protein (g)
First	No increase	25
Second	340	25
Third	452	25

Note Adjustments of these recommendations are needed for women with a BMI ≤ 18 or ≥ 25

Maternal Protein Energy Malnutrition

In order to optimize the health of the pregnant woman and to reduce risk of complications, women should enter pregnancy in good nutritional status and maintain optimal nutritional status throughout the pregnancy. Weight gain during pregnancy provides for the fetus, placenta, and amniotic fluid as well as tissue accretion in the mother [44]. Maternal protein energy malnutrition (PEM) can have significant effects on both the mother and the fetus. Ideal weight gain during pregnancy enhances pregnancy outcomes. Weight gain recommendations are individualized in relation to prepregnancy body mass index (BMI). Recommended weight gain during pregnancy for a woman at a normal BMI of 18.5–24.9 is between 25 to 35 pounds [45]. A woman with a BMI of less than 18.5 has a desirable weight gain of 28–40 pounds, an overweight woman (BMI 25–29.9) a desirable weight gain of 15–25 pounds, and an obese women (BMI ≥ 30.0) should gain between 11–20 pounds [45]. Table 2.1 [45] lists recommended increases in energy and protein needs by trimester for a woman with a normal BMI preconception. Energy intakes will differ by trimester and should be adjusted based on a woman’s preconception BMI.

The 2002 Daily Recommended Intake (DRI) for protein necessary to provide adequate needs for the developing fetus and the pregnant women is 1.1 g/kg/day of body weight for a woman aged 20–39 years or an additional 25 g/day. (See DRI in the Appendices.) When evaluating the protein intake of a pregnant woman consider total protein needs and quality, as well as total energy intake. Low birth weight or preterm birth is associated with inadequate weight gain during pregnancy [45]. PEM of the mother is associated with a child’s delayed tooth eruption [46], with tooth size and with possible decreased enamel solubility, as well as salivary gland dysfunction, all of which influences a child’s caries risk [47]. Low birth weight and preterm delivery are associated with enamel hypoplasia of the child’s primary and permanent teeth [47].

Maternal Vitamin and Mineral Nutrition

Maternal nutrition status impacts tooth development of the fetus pre-eruptively; whereas post-eruptively the impact is due to the local effects of diet [48]. See Table 2.2 for a list of effects of nutrient deficiencies on infant/child tooth development [49] and Table 2.3 for a list of vitamins and minerals recommended during pregnancy. Deficiencies of vitamins A and D along with PEM are related to a child’s risk for enamel hypoplasia and salivary gland atrophy leading to reduced ability to buffer plaque acids and increased susceptibility to dental caries [50]. Maternal intake of vitamins A, C, and D and the minerals calcium, phosphorus, fluoride iron, and iodine impact developing dentition [9] of the fetus. Frank vitamin A deficiency is rare in developed countries, but typically occurs along with PEM in developing countries [51]. Sources of vitamin A, such as fortified milk and dark yellow/orange and dark green fruits and vegetables, when limited in the maternal diet, increase risk of vitamin A deficiency. A vitamin A deficiency during pregnancy can influence an

Table 2.2 Effects of prenatal nutrient deficiencies on tooth development [49]

Nutrient	Effect on tissue	Effect on caries	Human data
Protein–calorie malnutrition	Tooth eruption delayed	Yes	Yes
	Tooth size		
	Enamel solubility decreased		
	Salivary gland dysfunction		
Vitamin A	Decreased epithelial tissue development	Yes	Yes
	Tooth morphogenesis dysfunction		
	Decreased odontoblast differentiation		
	Increased enamel hypoplasia		
Vitamin D/calcium/phosphorus	Lowered plasma calcium	Yes	Yes
	Hypomineralization (hypoplastic defects)		
	Tooth integrity compromised		
	Delayed eruption patterns		
Ascorbic acid	Dental pulpal alterations	No	No
	Odontoblastic degeneration		
	Aberrant dentin		
	Stability of enamel crystal (enamel formation)		
Fluoride	Inhibition of demineralization	Yes	Yes
	Stimulation of remineralization		
	Mottled enamel (excess)		
	Inhibition of bacterial growth		
Iodine	Delayed tooth eruption	No	Yes
	Altered growth patterns		
	Malocclusion		
	Slow growth		
Iron	Tooth integrity	Yes	No
	Salivary gland dysfunction		

infant's risk of impaired development of epithelial tissues, affect odontoblast differentiation, result in defective tooth enamel and dentin [52], and may reduce the extent of tooth mineralization [53]. Vitamin A deficiency in pregnancy is associated with preterm birth, IUGR, and low birth weight [54] as well as antepartum hemorrhage secondary to abruption placentae [55].

Vitamin D, calcium, and phosphorus deficiencies in pregnancy will have a substantial impact on a child's tooth development and integrity, particularly related to enamel hypoplasia and hypomineralization and eruption of teeth. These deficiencies impact both primary and permanent teeth [12, 52]. Vitamin D deficiency occurs when dietary consumption of this nutrient is inadequate or when the pregnant woman is not exposed to adequate sunlight [56]. Hypomineralization of primary teeth related to inadequate intake of Vitamin D, calcium, and phosphorus can increase susceptibility to ECC in the infant [12, 16].

Ascorbic acid (Vitamin C) deficiency in pregnancy is associated with defective dentinal tissue development [13]. Ascorbic acid is involved in maintaining the integrity of the osteoblasts, fibroblasts, chondroblasts, and odontoblasts [13, 57] and is needed for collagen synthesis. Collagen supports the organic matrix for the deposition of calcium phosphate crystals that form during bone mineralization [13, 58]. Ascorbic acid deficiency in rats resulted in a reduction in dentin formation in laboratory studies [58]. Requirement for ascorbic acid increases during pregnancy and can be met through ingestion of fresh fruits and vegetables. Scurvy, the chronic deficiency disease of ascorbic

Table 2.3 Daily vitamin and mineral recommendations for pregnant women

Vitamin	Recommended intake ^a	Quantity in standard prenatal supplement	Some recommended food sources	Supplementation recommended?
A	770 RE		Fish oils, dark green leafy vegetables, and deeply colored fruits	No
B ₁	1.4 mg		Green leafy vegetables, lean pork, soy milk, enriched whole grain breads and cereals	No
B ₂	1.4 mg		Green vegetables, eggs, milk, meats	No
B ₆	1.9 mg	2 mg	Wheat germ, pork, cereals, legumes	No
B ₁₂	2.6 µg		Meats, poultry, fish, shellfish, milk, eggs, cheese	No
C	85 mg	50 mg	Dark green vegetables, citrus fruits	No
D	5 µg	5 µg	Fortified milk, egg yolks, fatty fish	No
E	15 mg		Polyunsaturated plant oils, wheat germ, tofu, avocado, sweet potatoes	No
K	90 mg		Leafy green vegetables, cabbage, cheese	No
Folate	600 µg	400–600 µg	Dark-green leafy vegetables, beans, peas, lentils	Yes
Niacin	18 mg NE		Peanut butter, lean ground beef, chicken, tuna, shrimp	No
Mineral				
Iron	27 mg	30 mg	Red meats, spinach, broccoli, tofu, shrimp, iron-fortified cereals	Yes
Calcium	1000–1300 mg	250 mg	Dairy products including milk, yogurt and cheese; leafy vegetables; almonds; calcium-fortified foods	No ^b
Phosphorus	700–1250 mg		All animal foods (meats, fish, poultry, eggs, milk)	No
Zinc	11–12 mg	15 mg	Lentils, shrimp, crab, turkey, pork, lean ground beef, eggs, tofu	No ^c

^a Source Institute of Medicine [12, 15, 63]

^b Supplementation is recommended if food high in calcium are not consumed

^c Both iron and copper compete with zinc at absorption sites; therefore, zinc supplementation is recommended when elemental iron supplementation exceeds 60 mg/d

RE Retinol equivalents; NE Niacin equivalents

acid, is characterized by swollen, bleeding gingiva and tooth loss. Vitamin A and ascorbic acid, through the effects of calbindin and collagen, promote mineralization and development of teeth [13].

Fluoride promotes mineralization of teeth and assists in resistance of teeth to caries by inhibiting demineralization and stimulating the remineralization of enamel of teeth [52]. Fluoride supplementation during pregnancy does not appear to be of benefit to the developing fetus [59]. The uptake of fluoride into teeth is most prominent during infancy and thereafter decreases with age [12, 52].

The fluoride content of breast milk is relatively low [9]. The primary sources for fluoride include community water supplies, some foods and beverages, and dental products [9]. A key role of fluoride is to maintain the stability of the tooth enamel [9]. Fluoride is most effective when ingested during infancy, beginning at 6 months of age, through ingestion of fluoridated community drinking water [60, 61]. In the absence of a fluoridated water supply, the child's physician may prescribe fluoride-containing vitamin supplements (Table 2.4).

Dental fluorosis characterized by white opaque flecks or white or brown staining and in extreme cases, pitting of the enamel is caused by excessive fluoride ingestion. Multiple sources of fluoride especially from supplementation and toothpaste can contribute to fluorosis in the young child.

Table 2.4 Recommended dietary fluoride (F) supplementation for infants and children based on levels in fluoridated water [60, 61]

Age	Fluoride content of water supply		
	<0.3 ppm F	0.3–0.6 ppm F	>0.6 ppm F
Birth–6 months	0	0	0
6 month–3 years	0.25 mg	0	0
3–6 years	0.50 mg	0.25 mg	0
6 year up to at least 16 years	1.00 mg	0.50 mg	0

Note: ppm = part per million

Excess systemic fluoride effects on tooth structure are limited to between the ages of infancy to 14 years of age as the permanent teeth are formed within this time period [60, 61].

Intake of the minerals iron and iodine play a role in tooth development. Iodine deficiency can result in delayed tooth eruption and malocclusion and iron deficiency can impact the integrity of the tooth structure [15]. In addition to effects on dentition, both minerals are fundamental for growth and development of the fetus. A demand for increased iron during pregnancy is due to maternal blood volume expansion and the fetal iron requirements for normal development. Ingestion of adequate iron from food sources during pregnancy may be difficult for some women; therefore, iron supplementation of 30–60 mg/day is suggested [62]. Adequate iodine intake is readily achieved through use of iodized salt in the diet.

Infant and Early Childhood Feeding Practices and Oral Health

To ensure the growth, health, and development of children, adequate nutrition during infancy and early childhood is essential to avoid risk of illness, and malnutrition leading to childhood obesity, an increasing public health concern worldwide [64]. The first 2 years of life offer a critical window of opportunity for ensuring that children experience adequate and appropriate growth and development through optimal feeding practices. During the first 6 months of life, exclusive breastfeeding meets the energy and nutrient needs for most infants [65]. However, only approximately 34.8% of infants are exclusively breastfed during this period of time [66].

Breastfeeding provides short-term and long-term advantages for both child and mother [67], including protection against a range of acute and chronic diseases. See Table 2.5 [67–74]. The potential long-term advantages of breastfeeding are increasingly acknowledged as imperative [68, 69].

Obesity in later childhood and adolescence is less common among breastfed children than formula-fed children; a longer duration of breastfeeding is associated with a lower risk of obesity [75, 76]. However, breastfeeding duration of greater than 1 year is associated with decreased iron stores [77].

Children fed with commercial formulas have an increased risk of chronic diseases with an immunological basis. These include asthma and other atopic disorders [70, 71], type 1 diabetes [72], celiac disease [73], ulcerative colitis, and Crohn’s disease [74]. Published evidence links formula feeding with risks to cardiovascular health, such as changes in blood pressure [78], blood cholesterol levels [79], and resulting atherosclerosis in later adulthood [80].

After the age of 6 months, the requirements for energy and other nutrients begins to exceed what is provided by breast milk [81] and additional or complementary foods are required to meet dietary needs [82] and to promote development of masticatory efficiency and gastrointestinal tract function.

Table 2.5 Advantages of breastfeeding for infants and mothers [67–74]

	Advantages of breastfeeding to infant	Advantages of breastfeeding to mother
Short-term advantages	Lower morbidity of diarrheal, respiratory, and allergic diseases, lower risk of otitis media and ear infections, and development of type 1 diabetes	Reduced post-partum bleeding
Long-term advantages (adulthood)	Associated with lower mean serum cholesterol, systolic and diastolic blood pressure, overweight and obesity risk, type 2 diabetes	Lower risk of ovarian and breast cancer and development of rheumatoid arthritis

Table 2.6 Guidelines for introducing solid or complementary foods into an infant’s diet [84]

Child should be able to sit upright with good head control
Child should reach for food and seem eager to be fed
Child should be able to move the food from a spoon to his/her throat
Generally infants need to have doubled their birth weight or weigh about 13 pounds to be ready for solid foods
Introduction of foods has typically been by tradition with single grain cereals introduced first, followed by vegetables then fruits although no evidence exists that demonstrates an advantage of one food over another when introducing
Provide one new food at a time and wait 2–3 days before introducing another new food to allow assessment of allergy symptoms
Within a few months of introducing foods to the child’s diet, the diet should contain breast milk or infant formula, cereals, vegetables, fruits, meats, eggs, and fish

Once complementary foods have been introduced, breastfeeding continues to be a major source of nutrients for the infant, providing about 50% of energy needs up to the age of 1 year [83].

Complementary foods include several categories of foods and assist in transition from a liquid-based diet (breast milk, or infant formula) to a diet including foods offering a wide range of tastes and textures. It is recommended the complementary foods in an infant’s diet be limited in the amount of salt, saturated fats and sugar, and adequate in proteins, carbohydrates, fiber, vitamins, and minerals are included [66].

In order to meet the nutritional needs of young children, complementary foods need to be nutritionally adequate, safe from food-borne pathogens or toxins, and fed in a manner that is appropriate to meet the child’s energy and nutrient needs. Potential concerns with complementary feeding include offering calorie dense and nutrient-poor foods, offering foods too frequently or not often enough, and replacing breast milk with beverages of inferior quality [60].

Guidelines from the American Academy of Pediatrics regarding the introduction of solid or complementary foods are addressed in Table 2.6 [84].

Health Consequences of Early Childhood Caries

The combined presence of cariogenic microorganisms, fermentable carbohydrate, and a susceptible tooth and host initiate the infectious and transmissible disease known as dental caries. Although preventable and reversible, ECC is the most common chronic infectious disease of childhood. When left untreated it results in pain, bacteremia, high treatment cost, reduced growth and development, speech disorders, and premature tooth loss. Consequently, ability to bite and chew can be compromised and children may exhibit loss of self-esteem, and harm to permanent dentition [85, 86]. ECC may reduce a child’s ability to consume a varied diet.

Table 2.7 Recommended dietary guidelines and practices for oral health promotion of infants and young children [92–94]

<i>Birth to 6 months</i>
<ul style="list-style-type: none">• Whether breast- or bottle-feeding is the method of choice, infant feeding schedules should encourage routine consumption of milk rather than on-demand feeding• Discourage bedtime bottles and nocturnal feeding after eruption of first tooth• Diminish transmission of bacteria from caregiver to infant by wiping the gums after feedings and implementing oral hygiene when the first tooth erupts• Promote introduction of water in bottles as appropriate but not until routine feeding is well established• Instruct mothers to avoid introduction of food until the infant doubles the birth weight or weighs at least 13 lbs or reaches 6 months of age
<i>6–12 months</i>
<ul style="list-style-type: none">• Promote weaning from the bottle in combination with the introduction of a cup and spoon• Promote introduction of food to encourage self-feeding
<i>1–3 year</i>
<ul style="list-style-type: none">• Stress the value of mealtime and snacks and the importance of variety and moderation. Offer no more than 1 cup/d of fruit juices and only at meals and avoid all carbonated beverages during the first 30 months of life

Dietary data from the Healthy Eating Index for 2- to 5-year-old children found those with the best dietary practices were 44% less likely to display severe ECC compared with children with less desirable eating habits [87]. Increased consumption of readily available sugar-sweetened beverages, candies, chips, and cookies adds excessive calories to the diet and increases the risk of caries. Inadequate intake of fruits and vegetables deprives the child of nutrients essential to growth and development [88, 89].

Extensive ECC may be associated with low weight for age; Acs et al. [90] found a significant difference in baseline weights between preschool children with ECC and those who were caries free. In addition, those with ECC met failure to thrive weight criteria at baseline measurement. Children treated for ECC experienced significant increases in their age-adjusted percentile weights ($p < 0.01$) [90]. Since ECC is associated with underlying nutritional deficiencies in the perinatal period [91], it seems probable that as the disease progresses, developmental eating behaviors and nutritional status are vulnerable.

Recommended Infant and Early Childhood Feeding Practices to Promote Oral Health

Breast milk or formula is supplemented and partially replaced with complementary foods as the infant is developmentally ready (refer to Table 2.6). The introduction of pureed and solid foods is recommended to coincide with developmental, cognitive, and physiological needs. Feeding guidelines promote adequate nutritional intake to support continued growth and development as well as oral health for infants and young children (Table 2.7) [92–94].

School-Age Children and Oral Health

Oral health is critically important for the overall health and development of children of all ages. Approximately 42% of children (2–11 years) have had dental caries in their primary teeth and 21% of children (6–11 years) have had dental caries in their permanent teeth [95]. Caries remains one of

the most common infectious diseases in children, occurring five times more than asthma [96]. Disparities exist for children from low- and moderate-income households and children of color are more likely to have caries compared to white children [95]. Children with special healthcare needs are at increased risk of caries, particularly those with cognitive disabilities, developmental or neuromuscular disorders, chronic illnesses, immune compromising diseases, certain cardiac, kidney, or liver diseases, and those who are homeless or living among migrant populations [97]. Untreated dental caries can result in serious consequences that impact self-esteem and social functioning, ability to chew and consume a varied diet, failure to gain weight, and causes for pain and discomfort. All of these circumstances can disrupt the child's ability to function successfully in school and in society [85].

Diet and caries are closely related. Cariogenicity of a food or a constituent of a food is relative to and interdependent with multiple dietary factors, including diet composition, frequency of eating, food components of the meal, and sequencing of foods at a meal, and duration of exposure [98]. A variety of nutrient-dense foods including grains, dairy, fruits, vegetables, and protein foods should comprise the base of a child's diet. Fermentable carbohydrates including those found in simple sugars, naturally in foods, and as part of processed foods can contribute to incidence of dental caries [98]. Energy-dense, low-nutrient food examples of such carbohydrates include candies, cookies, and chips which in small quantities can be included within an individual child's diet and within their desired energy requirement allowance. In contrast, there are nutrient-dense fermentable carbohydrates, including fresh fruits, which also have an important role in the diet. The frequency and consistency of meals and snacks are as important in the caries process as is the food composition. Oral bacteria continue to metabolize fermentable carbohydrates for 20–40 minutes following each eating episode. Demineralization occurs until acid production ceases. The more frequently fermentable carbohydrate containing foods are consumed, the more sustained is the production of acids leading to demineralization and allowing less time for remineralization to occur. Saliva production provides protection against dental decay through its buffering capacity thus providing the opportunity for remineralization of the tooth enamel to occur. Conditions which result in decreased saliva production or xerostomia can result in increased dental caries risk [99].

Children and Youth with Special Health Care Needs, Nutrition and Oral Health

Approximately 13.9% of children in the United States have special healthcare needs [100, 101] and are at increased risk for oral diseases. A variety of medical conditions are associated with risk of poor oral health (Table 2.8) [102, 103]. Chronic childhood disorders may require dietary modifications that impact oral health. The need for frequent feedings, parental overindulgence with cariogenic foods and beverages, long-term use of cariogenic medications, and xerostomia are common issues that contribute to dental caries risk in this population [102]. Children with special healthcare needs may have higher levels of dental plaque, increased occurrence of gingivitis, and higher calculus index [103, 104] than their counterparts. Poor oral health status among children with special needs has been attributed to inadequate dental hygiene behaviors and diets high in fermentable carbohydrates [103–105]. Lui et al. [106] reported that risk factors associated with decay in the population were the frequency of intake of sweets, plaque scores, and the ability of the child to brush their teeth.

Common medical issues that affect children with special healthcare needs including gastroesophageal reflux disease (GERD), motility disorders of the oral, pharyngeal, and esophageal structures, sialorrhea, sensory processing disorders, failure to thrive, use of enteral feedings and medications, and feeding problems [107]. These conditions may affect oral health and impact tooth

Table 2.8 Medical conditions in children associated with increased risk for poor oral health [100, 101]

Asthma
Autism spectrum disorders
Cancers
Cerebral palsy
Congenital heart disease
Critical illness
Cystic fibrosis
Down syndrome
Gastroesophageal reflux disease
Gastrostomy feeding
Hemophilia or other clotting disease
Immune dysfunction
Type 1 diabetes mellitus
Juvenile idiopathic arthritis
Renal/liver failure
Seizure disorder
Sickle cell anemia
Special needs children

development as well as affect risk of dental caries, periodontal disease, and fungal infections [107]. GERD, commonly observed in infants and children, has been associated with higher levels of salivary *mutants streptococci* [108]. A higher rate of erosion is seen in these children with GERD due to the combination acid reflux, higher levels of salivary *mutants streptococci*, and possible conditions of bruxism and/or hyperactive bite [109].

Motor disorders among children with special health care needs attributed to a variety of neurological disorders, mental retardation, traumatic brain injury, cerebral palsy, cleft lip/palate, and even disruption of the extra-oral integrity due to cancer therapies can impact feeding ability and oral health [110]. Loss of muscle tone of the cheeks, lips, and tongue contributes to sialorrhea, and prolonged exposure of food in the mouth resulting in increased caries risk [111]. Sialorrhea frequently seen in children with cerebral palsy, those being fed via gastrostomy tube, those prescribed multiple medications, and those with GERD can result in dehydration, bad breath, chapped skin and lips, and fungal infections. Excessive salivation results in difficulty forming a cohesive bolus, impairing the swallowing process, increasing risk of aspiration, and prolonging oral clearance time [112]. Oral hypersensitivity can result in facial or oral defensiveness presenting as biting, lip pursing, grimacing, gagging, emotional outbursts such as crying, or defensive techniques including turning of the head or pushing at food or utensils as they come close to the mouth. Dental hygiene, such as brushing and flossing as well as interventional dental care, may be difficult to achieve [113].

Many children with special healthcare needs require a wide range of medications typically provided in liquid form and containing significant amounts of sucrose [114]. Children who require sucrose-containing medications over an extended period of time are at increased risk for dental caries. Other side effects of medications such as xerostomia or sialorrhea may further increase the risk of decay [115]. Hospitalized children potentially develop poor oral hygiene secondary to lethargy or malaise. Medications, medical treatments, and intubation make these children vulnerable to poor oral health outcomes [116].

Children with the diagnosis of failure to thrive may require a higher calorie diet to meet needs for catch up growth [117]. Added calories in the forms of fats, oils, and proteins as well as high-calorie liquid nutrition supplements and sources of fermentable carbohydrates are commonly recommended. Parents who add snacks and juices high in carbohydrates or added sugars may increase calories but may also increase caries risk [102]. Enteral nutrition provided via gastrostomy feeding tubes is the

most common approach to the care of the child who cannot meet their nutritional needs orally [102]. Although evidence is limited, children with gastrostomy feeding tubes have a tendency to have increased levels of plaque and calculus buildup compared to gender- and age-matched special needs children who do not require a feeding tube and thus may require vigilant oral hygiene intervention [118].

Children with Diabetes

Diabetes, including Types 1 and 2, is associated with increased risk of oral infectious diseases and is further addressed in [Chapter 11](#). Despite the increased incidence of Type 2 diabetes in children, much of the oral health research in the area of diabetes and pediatrics has focused on type 1 diabetes mellitus (T1DM) [119–125]. Children with T1DM are more prone to calculus accumulation and gingivitis even with comparable oral hygiene habits practiced by children who do not have a diagnosis of diabetes [124].

Children with Eating Disorders

Oral healthcare professionals (OHCPs) may be among the first healthcare professionals to recognize signs and symptoms of an eating disorder (e.g., anorexia nervosa, bulimia) in a child or adolescent. Hence, they are in an ideal position to screen for eating disorders during routine office visits [128]. Perimolysis, swelling of the parotid gland, salivary amylase concentrations, tooth erosion, and dental caries may occur in children with eating disorders [128]. Enamel erosion and parotid gland swelling are the most common oral manifestations associated with chronic vomiting, occurring predominantly along the lingual surfaces of the anterior teeth and buccal and occlusal surfaces of the posterior teeth [129–133]. The incidence of dental caries in this population is variable with conflicting results [129, 131–134]. Individuals with eating disorders are at risk for osteopenia and hence should be referred to a physician for evaluation of bone health [128]. When an eating disorder is suspected, further probing questions should be explored with the child and parent depending on the age of the child. A referral to the child's primary care provider for further evaluation and a registered dietitian (RD) for evaluation is warranted. Nutrient deficiencies may occur in children with eating disorders and may be evidenced in the condition of the oral mucosa, indicating that an oral exam could lead to early diagnosis of an eating disorder [128].

Children with Cystic Fibrosis and Other Chronic Respiratory Disorders

Management of the child with cystic fibrosis includes medications, a high-calorie high-fat diet, and other therapies. Foods high in fermentable carbohydrates, in particular added sugars, are often included in the diet to assist in maintaining the increased caloric demands. In such instances, frequent brushing is needed to reduce risk for caries. Narang et al. [137] reported a lower prevalence of caries in individuals with cystic fibrosis; however, a universally higher prevalence of dental defects and calculus accumulation compared to normal children. Pancreatic enzyme replacement and long-term antibiotics, common interventions in children, with cystic fibrosis have been associated with caries reduction [137].

Children with Inborn Errors of Metabolism

“Inborn errors of metabolism” is an inclusive term for a variety of disorders which result from hereditary deficiency of a specific enzyme necessary for a specific metabolic pathway [138]. Included in this group are disorders of protein, carbohydrate and lipid metabolism and defects in organelle function. Treatment and management of some of these disorders requires complex medical nutrition therapy with adherence to specialized diets, many of which are highly cariogenic. Some diseases, such as glycogen storage diseases may require frequent feedings of high carbohydrate snacks or beverages and in some cases nighttime feedings high in carbohydrate must be provided during sleep. Although this type of dietary pattern is indicative of a high caries risk, the prevalent oral pathology is unknown in this cohort of children. A challenge to achieve optimal dental health in these children is confounded by their dietary needs and requirements. Treatment of dental and oral disorders may also be compromised due to metabolic derangements. An interprofessional team approach is needed to address appropriate care for these individuals with any of these complex disorders [139].

Children with Cancer

The oral health needs of the differing types of childhood cancer differ according to cancer type and treatment [140]. Children under the age of 3.5 years who are treated with chemotherapy are at risk for microdont teeth in the adult dentition when compared to older children receiving chemotherapy [140]. Complication of cancer treatments can lead to mucositis and xerostomia; caries risk may be higher if children are consuming greater quantities of fermentable carbohydrates more frequently without oral hygiene interventions [102].

Children with HIV

Oral lesions that affect children with HIV include fungal lesions caused by *Candida* strains, herpes simplex, linear gingival erythema, parotid enlargement, and oral ulcerations [141]. Children with HIV may experience reduced appetite and decreased food intake, impaired absorption and higher nutrient requirements requiring an energy dense diet, high in calories and protein. Frequent snacks and meals and nutritional supplements are provided to meet the nutrient requirements exacerbated by needs to support growth and development. The prevalence of caries is higher in children with HIV especially in advanced disease [102]. Chapter 14 on HIV provides more detail on oral health problems of children with HIV.

Children with Asthma

Asthma, a leading cause of hospitalization in children, places them at risk for oral infections of *candida albicans* due to use of corticosteroid inhalers. In addition, the use of inhaled steroids has been associated with increased risk of gingivitis and tooth decay [102, 142]. These children should be identified as needing preventive oral care and encouraged to consume a diet that reduces caries risk.

Children with Congenital Heart Disorders

Malnutrition and growth impairment are typical in children with congenital heart disorders secondary to poor appetite, early satiety, malabsorption, fluid restriction associated with increased calorie needs, and hypoxemia-induced fatigue [102]. These children have been shown to have an increased level of dental decay, enamel hypoplasia, and periodontal disease [143–145]. The higher prevalence of decay and untreated decay compared to healthy children [143–145] is of concern in this group of children because of their susceptibility to infective endocarditis as a result of oral bacteremia. In order to meet increased energy demands, dietary recommendations for individuals with congenital heart disorders include small frequent meals secondary to hypoxemia-induced fatigue and frequent vomiting [146].

Children with Craniofacial Anomalies

Of all craniofacial anomalies, cleft lip with or without cleft palate and cleft palate are the most common resulting from failure of the first branchial arches to fuse [9]. Structural anomalies may require multiple surgeries and alterations in both speech and dental development may occur. Caries risk may increase due to difficulties removing plaque and these children may experience oral aversions making dental hygiene efforts difficult [147].

Children with special healthcare needs require special attention to oral hygiene to help reduce risk of dental caries and other oral health diseases that occur in this population. Table 2.8 lists medical conditions in children, including those discussed in this chapter, associated with increased risk for poor oral health. Cleaning the gingiva and mouth with moist gauze prior to tooth eruption and use of appropriate-sized toothbrushes with assistance in brushing can enhance oral hygiene behaviors. An electric toothbrush may be needed for plaque removal since manual dexterity may be limited.

Summary

Throughout pregnancy, infancy, and childhood, nutrition and diet play a significant role in oral health status. Assuring adequate nutrition of the mother and fetus throughout pregnancy and into childhood will increase the likelihood of establishing health behaviors that will promote positive health outcome. Malnutrition can contribute to adverse pregnancy outcomes to include preterm delivery, failure to thrive, obesity, and altered growth patterns, all of which are associated with increased risk for oral diseases. OHCPs should address diet, nutrition, and oral health concerns specific to the stage of growth and development and promote positive parenting behaviors that promote health and development. Pregnant women and children who have experienced unintentional weight change, or who have problems meeting their nutritional needs via their regular diet or those for whom a nutrient deficit is suspected should be referred to a Registered Dietitian (RD).

References

1. American Dietetic Association. Nutrition and lifestyle for a healthy pregnancy outcome. *J Am Diet Assoc.* 2008;108(3):553–61.
2. Brenseke B, Prater MR, Bahamonde J, Gutierrez JC. Current thoughts on maternal nutrition and fetal programming of the metabolic syndrome. *J Pregnancy.* 2013;2013:1–13.

3. Blumfield ML, Hure AJ, Macdonald-Wicks L, Smith R, Collins CE. Micronutrient intakes during pregnancy in developed countries: systematic review and meta-analysis. *Nutr Rev*. 2012;71(2):118–32.
4. Institute of Medicine (U.S.). Committee to reexamine IOM pregnancy weight guidelines. In: Rasmussen KK, Yaktine AL, editors. *Weight gain during pregnancy: reexamining the guidelines*. Washington DC: National Academies Press; 2009.
5. National Institute for Health and Clinical Excellence. <http://www.iom.edu/Reports/2009/Weight-Gain-During-Pregnancy-Reexamining-the-Guidelines.aspx> (2009). Accessed 17 June 2013 (Published May 2009).
6. Dietary interventions and physical activity interventions for weight management before, during and after pregnancy. 2010. <http://www.nice.org.uk/nicemedia/live/13056/49926/49926.pdf>. Accessed 31 May 2013. (Published July 2010).
7. Marshall TA. Diet and nutrition in pediatric dentistry. *Dent Clin North Am*. 2003;47:279–303.
8. Boggess KA. Maternal oral health in pregnancy. *Obstet Gynecol*. 2008;111(4):976–86.
9. US Department of Health and Human Services. Oral health in America: a special report of the surgeon general. Rockville: US Department of Health and Human Services, National Institute of Dental and Craniofacial Research. National Institutes of Health. <http://www.nidcr.nih.gov/DataStatistics/SurgeonGeneral/sgr/chap1.htm> (2000). Accessed 21 July 2013.
10. WHO. Definition of Nutrition. <http://www.who.int/topics/nutrition/en/>. Accessed 17 June 2013.
11. Allston AA. *Improving women's health and perinatal outcomes: the impact of oral diseases*. Baltimore: Women's and Children's Health Policy Center; 2001.
12. Institute of Medicine. *Dietary reference intakes for calcium, phosphorus, magnesium, vitamin D, and fluoride*. Washington DC: National Academy Press; 1997.
13. Fontana M. Vitamin C (ascorbic acid): clinical implications for oral health—a literature review. *Compend Contin Educ Dent*. 1994;15(7):916–29.
14. Ligh RQ, Fridgen J, Saxton C. The effect of nutrition and diet on dental structure integrity. *J Calif Dent Assoc*. 2001;39(4):243–9.
15. Institute of Medicine. *Dietary reference intakes: dietary reference intakes for vitamin a, vitamin k, arsenic, boron, chromium, copper, iodine, iron, manganese, molybdenum, nickel, silicon, vanadium, and zinc*. Washington DC: National Academy Press; 2001.
16. Jontell M, Linde A. Nutritional aspects of tooth formation. *World Rev Nutr Diet*. 1986;48:114–36.
17. Gardiner PM, Nelson L, Shellhaas CS, Dunlop AL, Long R, Andrist S, Jack BW. The clinical content of preconception care: nutrition and dietary supplements. *Am J Obst Gyn*. 2008;199(6 Suppl 2):S345–56.
18. Davis GN. Early childhood caries: a synopsis. *Community Dent Oral Epidemiol*. 1988;26:106–16.
19. DePaola DP, Kuftinec MM. Nutrition in growth and development of oral tissues. *Dent Clin North Am*. 1976;20:441–59.
20. Marsal K. Intrauterine growth restriction. *Curr Opin Obstet Gynecol*. 2002;14:127–35.
21. Barker DJP, Clark PM. Fetal undernutrition and disease in later life. *Rev Reprod*. 1997;2:105–22.
22. California Dental Association Foundation. Oral health during pregnancy and early childhood: evidenced based guidelines for health professionals. http://www.cdafoundation.org/portals/0/pdfs/poh_guidelines.pdf (2012). Accessed 5 March 2013.
23. Boggess KA, Edelstein BL. Oral health in women during preconception and pregnancy: implications for birth outcomes and infant oral health. *Matern Child Health J*. 2006;10:S169–74.
24. Berkowitz RJ. Acquisition and transmission of mutants streptococci. *J Calif Dent Assoc*. 2003;31:15–138.
25. Hejoel PP, Bollen AM, Noonan CJ, del Aguila MA. Antepartum dental radiography and infant low birth weight. *JAMA*. 2004;291(16):1987–93.
26. Offenbacher S, Jared HL, Mauriello SM, Mendoza LC, Couper DJ, Stewart DD, Murtha AP, Cochran DL, Dudley DJ, Reddy MS, Geurs NC, Hauth JC. Effects of periodontal therapy on rate of preterm delivery. *Obstet Gynecol*. 2009;113:551–9.
27. Li X, Kollveit KM, Tronstad L, Olsen I. Systemic diseases caused by oral infection. *Clin Microbiol Rev*. 2000;13(4):547–58.
28. Boggess KA, Leiff S, Murtha AP, Mosss K, Beck J, Offenbacher S. Maternal periodontal disease is associated with an increased risk for preeclampsia. *Obstet Gynecol*. 2003;101:227–31.
29. American Academy of Periodontology. Statement regarding periodontal management of the pregnant patient. *J Periodontol*. 2004;75(3):495.
30. Moore S, Ide M, Coward PY, Randhawa M, Borkowska E, Baylis R, et al. A prospective study to investigate the relationship between periodontal disease and adverse pregnancy outcome. *Br Dent J*. 2004;197:251–8.
31. Michalowicz BS, Hodges JS, DiAngelis AJ, et al. Treatment of periodontal disease and the risk of preterm birth. *N Engl J Med*. 2006;355(18):1885–94.
32. Clothier B, Stringer M, Jeffcoat MK. Periodontal disease and pregnancy outcomes: exposure, risk, and intervention. *Best Pract Res Clin Obstet Gynecol*. 2007;21(3):451–66.

33. Longo SA, Moore RC, Canzoneri BJ, Robichaus A. Gastrointestinal conditions in pregnancy. *Clin Colon Rectal Surg.* 2010;22(2):80–9.
34. Ritter AV, Sutherland JH. Pregnancy and oral health: talking with patients. *J Esthetic Restorative Dent.* 2007;19(6):373–4.
35. Silk H, Douglass AB, Douglass JM, Silk L. Oral health during pregnancy. *Am Fam Physician.* 2008;77(8):1139–44.
36. American Dental Association. Pregnancy and oral health. <http://www.mouthhealthy.org/en/pregnancy/concerns/>. Accessed 2 May 2013.
37. Ferris GM. Alteration in female sex hormones. Their effect on oral tissues and dental treatment. *Compend Contin Educ Dent.* 1993;14(12):1558–1571.
38. Amar S, Chung KM. Influence of hormonal variation on the periodontium in women. *Periodontol.* 2000;1994(6):79–87.
39. Lee A, McWilliams M, Janchar T. Care of the pregnant patients in the dental office. *Dent Clin North Am.* 1999;4(3):485–94.
40. Markou E, Eleana B, Lazaros T, Antonios K. The influence of sex steroid hormones on gingiva of women. *Open Dent J.* 2009;5(3):114–9.
41. Offenbacher S, Katz V, Fertick G, Collins J, Boyd D, Maynor G, et al. Periodontal infection as a possible risk factor for preterm low birth weight. *J Periodontol.* 1996;67:1103–13.
42. Scannapieco FA, Bush RB, Paju S. Periodontal disease as a risk factor for adverse pregnancy outcomes. A systematic review. *Ann Periodontol.* 2003;8(1):70–8.
43. Sills ES, Zegarelli DJ, Hoschander MM, Strider W. Clinical diagnosis and management of hormonally responsive oral pregnancy tumor (pyogenic granuloma). *J Reprod Med.* 1996;41(7):467–70.
44. Butte NF, King JC. Energy requirements during pregnancy and lactation. *Public Health Nutr.* 2005;8:1010–27.
45. Institute of Medicine. Weight gain during pregnancy: reexamining the guidelines. Washington DC: National Academy Press; 2009.
46. Alvarez JO. Nutrition, tooth development, and dental caries. *Am J Clin Nutr.* 1995;61:410S–416S.
47. Psoter WJ, Reid BC, Katz RV. Malnutrition and dental caries: a review of the literature. *Caries Res.* 2005;39(6):441–7.
48. Rugg-Gunn AJ. Dental caries—the pre-eruptive effects of diet. In: Rugg-Gunn A, Hackett AF, editors. *Nutrition and dental health.* Oxford: Oxford Medical Publications; 1993. p. 15–35.
49. Touger-Decker R, Rigassio-Radler D, Depaola. Nutrition and dental medicine. In: Ross AC, Caballero B, Cousins RJ, Tucker KL, Ziegler TR, editors. *Modern nutrition in health and disease.* 11th Ed. Baltimore: Lippincott Williams & Wilkins; 2014:1016–1040.
50. Moynihan PJ. The role of diet and nutrition in the etiology and prevention of oral diseases. *Bull World Health Organ.* 2005;83:694–9.
51. Ladipo OA. Nutrition in pregnancy: mineral and vitamin supplement. *Am J Clin Nutr.* 2000;72:280S–90S.
52. Avery JK. Agents affecting tooth and bone development. In: Avery JK, Steele PF, Avery N, editors. *Oral development and histology.* 3rd ed. New York: Thieme Medical Publishers; 2001.
53. Harris SS, Navia JM. In vivo and in vitro study of the effects of vitamin A deficiency on rat third molar development. *J Dent Res.* 1986;65(12):1445–8.
54. Ramakrishnam U, Manjrekar R, Rivera J, Gonzalez-Cossio T, Martorell R. Micronutrients and pregnancy outcome: a review of the literature. *Nutr Res.* 1999;19:103–59.
55. Sharma SC, Bonnar J, Dostalova L. Comparison of blood levels of vitamin A, β -carotene, and vitamin E in abruptio placentae with normal pregnancy. *Int J Vitam Nutr Res.* 1986;56:3–9.
56. Bawden JW. Calcium transport during mineralization. *Anat Rec.* 1989;224(2):226–33.
57. Dixon SJ, Wilson JX. Adaptive regulation of ascorbate transport in osteoblastic cells. *J Bone Miner Res.* 1992;17(6):675–81.
58. Ogawara M, Aoki K, Okiji T, Suda H. Effect of ascorbic acid deficiency on primary and reparative dentinogenesis in non-ascorbate-synthesizing ODS rats. *Arch Oral Biol.* 1997;42(10):695–704.
59. Leverett DH, Adair SM, Vaughan BW, Proskin HM, Moss ME. Randomized clinical trial of the effect of prenatal fluoride supplements in preventing dental caries. *Caries Res.* 1997;31(3):174–9.
60. CDC Centers for Disease Control and Prevention. Community water fluoridation. http://www.cdc.gov/fluoridation/safety/dental_fluorosis.htm. Accessed 31 May 2013.
61. American Academy of Pediatric Dentistry. Guideline on Fluoride therapy american academy of pediatric dentistry. 2012. http://www.aapd.org/media/Policies_Guidelines/6_fluoridetherapy.pdf. Accessed January 2, 2014.
62. Institute of Medicine. Iron deficiency anemia: recommended guidelines for the prevention, detection, and management among U.S. children and women of childbearing age. Washington DC: National Academies Press; 1993.

63. Institute of Medicine. Dietary reference intakes: thiamine, riboflavin, niacin, vitamin B-6, folate, vitamin B-12, pantothenic acid, biotin, and choline. Washington DC: National Academy Press; 1998.
64. WHO. Infant and young child feeding: model chapter for textbooks for medical students and allied health professionals. Geneva: World Health Organization; 2009.
65. Butte N, Lopez-Alarcon MG, Garza C. Nutrient adequacy of exclusive breastfeeding for the term infant during the first six months of life. Geneva: World Health Organization; 2002.
66. WHO. Guiding principles for feeding non-breastfed children 6–24 months of age. Geneva: World Health Organization; 2005.
67. Leon-Cava N, Lutter C, Ross J, Martin L. Quantifying the benefits of breastfeeding: a summary of the evidence. Washington DC: Pan American Health Organization; 2002.
68. Fewtrell MS. The long-term benefits of having been breastfed. *Current Paediatrics*. 2004;14:97–103.
69. WHO. Evidence on the long-term effects of breast-feeding: systematic reviews and meta-analyses. Geneva: World Health Organization; 2007.
70. Gdalevich M, Mimouni D, Mimouni M. Breastfeeding and the risk of bronchial asthma in childhood: a systematic review with meta-analysis of prospective studies. *J Pediatr*. 2001;139:261–6.
71. Oddy WH, Sherriff JL, de Klerk NH, Kendall GE, Sly PD, Beilin LJ, Blake KB, Landau LI, Stanley FJ. The relation of breastfeeding and body mass index to asthma and atopy in children: a prospective cohort study to age 6 years. *Am J Public Health*. 2004;94:1531–7.
72. Sadauskaite-Kuehne V, Ludvigsson J, Padaiga Z, et al. Longer breastfeeding is an independent predictive factor against development of type 1 diabetes in childhood. *Diabetes/Metab Res Rev*. 2004;20:150–7.
73. Akobeng AK, Ramanan AV, Buchan I, Heller RF. Effect of breastfeeding on risk of coeliac disease: a systematic review and meta-analysis of observational studies. *Arch Dis Child*. 2006;91:39–43.
74. Klement E, Cohen RV, Boxman J, Joseph A, Reif S. Breastfeeding and risk of inflammatory bowel disease: a systematic review with meta-analysis. *Am J Clin Nutr*. 2004;80:1342–52.
75. Harder T, Bergmann R, Kallischnigg G, Plagemann A. Duration of breastfeeding and risk of overweight: a meta-analysis. *Am J Epidemiol*. 2005;162:397–403.
76. Burke V, Beilin LJ, Simmer K, Oddy WH, Blake KV. Breastfeeding and overweight: longitudinal analysis in an Australian birth cohort. *J Pediatr*. 2005;147:56–61.
77. Maguire JL, Salehi L, Birken CS, Carsley S, Mamdani M, Thorpe KE, Lebovic G, Khovratovich M, Parker PC. Association between total duration of breastfeeding and iron deficiency. *Pediatrics*. <http://pediatrics.aappublications.org/content/early/2013/04/10/peds.2012-2465.abstract>. Accessed 6 May 2013.
78. Martin RM, Gunnell D, Davey Smith G. Breastfeeding in infancy and blood pressure in later life: systemic review and meta-analysis. *Am J Epidemiol*. 2005;161:15–26.
79. Owen CG, Whindup PH, Odoki K, Gilg JA, Cook DG. Infant feeding and blood cholesterol: a study in adolescents and a systematic review. *Pediatrics*. 2002;110:597–608.
80. Martin RM, Ebrahim S, Griffin M, Davey Smith G, Nicolaides AN, Georgiou N, Watson S, Frankel S, Holly JM, Gunnell D. Breastfeeding and atherosclerosis: intima media thickness and plaques at 65-year follow-up of the Boyd Orr Cohort. *Arterioscler Thromb Vasc Biol*. 2005;25:1482–1488.
81. Dewey KG, Cohen RJ, Brown KH. Effects of exclusive breastfeeding for 4 versus 6 months on maternal nutritional status and infant motor development: results of two randomized trials in Honduras. *J Nutr*. 2001;131:262–7.
82. Dewey K, Brown K. Update on technical issues concerning complementary feeding of young children in developing countries and implications for intervention programs. *Food Nutr Bull*. 2003;24:5–28.
83. PAHO/WHO. Guiding principles for complementary feeding of the breastfed child. Washington DC: Pan American Health Organization/World Health Organization; 2002.
84. American Academy of Pediatrics. Starting solid foods. <http://patiented.aap.org/categoryBrowse.aspx?catID=5005>. Accessed 6 June 2013.
85. Kagihara LE, Niederhauser P, Stark M. Assessment, management, and prevention of early childhood caries. *J Am Acad Nurse Practitioners*. 2009;21:1–10.
86. Moynihan P, Peterson PE. Diet, nutrition and the prevention of dental diseases. *Public Health Nutr*. 2004;7(1a):201–26.
87. Nunn ME, Braunstein NS, Krall KEA, et al. Healthy eating index is a predictor of early childhood caries. *J Dent Res*. 2009;88:361–6.
88. Ballew C, Kuester S, Gillespie C. Beverage choices affect adequacy of children's nutrient intakes. *Arch Pediatr Adolesc Med*. 2000;154:1148–52.
89. Kant AK. Reported consumption of low-nutrient-density foods by American children and adolescents. *Arch Pediatr Adolesc Med*. 2003;157:789–96.
90. Acs G, Shulman R, Ng NW, Chussid S. The effect of dental rehabilitation on the body weight of children with failure to thrive: case reports. *Compend Contin Educ Dent*. 1998;19(2):164–168, 170–171.
91. Davis GN. Early childhood caries: a synopsis. *Community Dent Oral Epidemiol*. 1988;26:106–16.

92. American Academy of Pediatric Dentistry. Policy on dietary recommendations for infants, children, and adolescents. American Academy of Pediatric Dentistry. http://www.aapd.org/media/Policies_Guidelines/P_DietaryRec.pdf (2012). Accessed 17 June 2013.
93. American Academy of Pediatric Dentistry. Guideline on infant oral health care. American Academy of Pediatric Dentistry. http://www.aapd.org/media/Policies_Guidelines/G_infantOralHealthCare.pdf (2011). Accessed 17 June 2013.
94. American Academy of Pediatrics. Policy statement: oral health risk assessment timing and establishment of the dental home. *Pediatrics*. 2003;111(5):1113–6.
95. Dye BA, Yan S, Smith V, et al. Trends in oral health status: United States. 1988–1994 and 1999–2004. *Vital Health Stat*. 2007;11:1–92.
96. National Institute of Dental and Craniofacial Research. Oral health in America. A Report of the surgeon general. Rockville: US Department of Health and Human Services; 2000. (NIH Publication 00-4713).
97. American Academy of Pediatric Dentistry Council on Clinical Affairs. Guideline on management of dental patients with special health care needs. *Pediatr Dent*. 2008–2009;30(7 Suppl):107–11.
98. Mobley C, Marshall TA, Milgrom P, et al. The contribution of dietary factors to dental caries and disparities in caries. *Acad Pediatr*. 2009;9:410–4.
99. Castellano CR, Rizzolo D. Maximizing oral health in children: a review for physician assistants. *J Am Acad Physician Assist*. 2012;25(7):28–33.
100. Mayer ML, Skinner AC, Slifkin RT. Unmet need for routine and specialty care: data from the national survey of children with special health care needs. *Pediatrics*. 2004;113(2):e109–15.
101. U.S. Department of Health and Human Services, Health Resources and Services Administration, Maternal and Child Health Bureau. The national survey of children with special health care needs chartbook 2005–2006. Rockville: U.S. Department of Health and Human Services; 2007.
102. Moursi AM, Fernandez JB, Daronch M, Zee L, Jones CL. Nutrition and oral health considerations in children with special health care needs: implications for oral health care providers. *Pediatr Dent*. 2010;32(4):333–42.
103. Lewis CW. Dental care and children with special health care needs: a population-based perspective. *Acad Pediatr*. 2009;9:410–26.
104. Chen HS, Huang ST. Evaluation of oral health and its related factors of children and adolescents in Taiwan. Report No. DOH94-HP-1310/DOH95-HP-1317. Taichung: Bureau of Health Promotion, Department of Health; 2007.
105. Lui HY, Huang ST, Hsiao SY, Chen CC, Hu WC, Yen YY. Dental caries associated with dietary and tooth brushing habits of 6–12 year old mentally retarded children in Taiwan. *J Dent Sci*. 2009;4:61–74.
106. Lui HY, Chen CC, Hu WC, Tang RC, Chen CC, Tsai CC, Huang ST. The impact of dietary and tooth-brushing habits to dental caries of special school children with disability. *Res Dev Disord*. 2010;31:1160–9.
107. Sullivan PB, Lambert B, Rose M, Ford-Adams M, Johnson A, Griffiths P. Prevalence and severity of feeding and nutritional problems in children with neurological impairment: Oxford feeding study. *Dev Med Child Neurol*. 2002;42(10):674–80.
108. Ersin NK, Oncag O, Tumgor G, Aydogdu S, Hilmioglu S. Oral and dental manifestations of gastroesophageal reflux disease in children: a preliminary study. *Pediatr Dent*. 2006;28(3):279–84.
109. Linnett V, Seow WK. Dental erosion in children: a literature review. *Pediatr Dent*. 2001;23(1):37–43.
110. Jones ML, Boyd LD. Interface with a community feeding team to address oral health of special needs children: a pilot project. *J Dent Hyg*. 2011;85(2):132–142.
111. Biasco P. Prevalence and predictors of drooling. *Dev Med Child Neurology*. 2012;54(11):970.
112. Ahluwalia M, Brailsford SR, Tarelli E, et al. Dental caries, oral hygiene, and oral clearance in children with craniofacial dysfunctions. *Caries Res*. 2004;38(2):175–362.
113. Dodrill P, McMahon S, Ward E, Weir K, Donovan T, Riddle B. Long-term oral sensitivity and feeding skills of low-risk pre-term infants. *Early Hum Dev*. 2004;76(1):23–37.
114. McGhee B, Katyal N. Avoid unnecessary drug-related carbohydrates for patients consuming the ketogenic diet. *J Am Diet Assoc*. 2001;101(1):87–101.
115. Maguire A, Rugg-Gunn AJ, Butler TJ. Dental health of children taking antimicrobial and non-antimicrobial liquid oral medication long-term. *Caries Res*. 1996;30(1):6–21.
116. Blevins JY. Oral health care for hospitalized children. *Ped Nurs*. 2011;37(5):229–235.
117. Cooke RJ. Catch-up growth: implications for the preterm and term infant. *Eur J Clin Nutr*. 2010;64:S8–10.
118. Jawadi AH, Casamassimo PS, Griffen A, Enrile B, Marcone M. Comparison of oral findings in special needs children with and without gastrostomy. *Pediatr Dent*. 2004;26(3):283–8.
119. Lamster IB, Lalla E, Borgnakke WS, Taylor GW. The relationship between oral health and diabetes mellitus. *J Am Dent Assoc*. 2008;139(Suppl 5):19S–24S.
120. Karjalainen KM, Knuuttila ML. The onset of diabetes and poor metabolic control increases gingival bleeding in children and adolescents with insulin-dependent diabetes mellitus. *J Clin Periodontol*. 1996;23(12):1060–7.

121. Alves C, Brandao M, Ansion J, Menezes R. Oral health knowledge and habits in children with type 1 diabetes mellitus. *Braz Dent J.* 2009;20(1):70–73.
122. Orbak R, Simsek S, Orbak Z, Kavrut F, Colak M. The influence of type 1 diabetes mellitus on dentition and oral health in children and adolescents. *Yonsei Med J.* 2008;49(1):357–65.
123. Lalla E, Cheng B, Lai S, Tucker S, Greenbery E, Goland R, Lamster IR. Periodontal changes in children and adolescents with diabetes. *Diab Care.* 2006;29(2):295–9.
124. Siudikiene J, Machiulskiene V, Nyvad B, Tenovuo J, Nedzelskiene I. Dental caries increments and related factors in children with type 1 diabetes mellitus. *Caries Res.* 2008;42:354–62.
125. Siudikiene J, Machiulskiene V, Nyvad B, Tenovuo J, Nedzelskiene I. Dental caries and salivary status in children with type 1 diabetes mellitus, related to the metabolic control of the disease. *Eur J Oral Sci.* 2006;114:8–14.
126. Siudikiene J, Maciulskiene V, Dobrovolskiene R, Nedzelskiene I. Oral hygiene in children with type 1 diabetes mellitus. *Stomatologii.* 2005;7(1):24–7.
127. Hague AL. Eating disorders: screening in the dental office. *J Am Dent Assoc.* 2010;141(6):675–8.
128. Frydrych AM, Davies GR, McDermott BM. Eating disorders and oral health: a review of the literature. *Aust Dent J.* 2005;50(1):6–15.
129. Steinberg B. Women's oral health issues. *J Calif Dent Assoc.* 2000;28:663–7.
130. Ruff J, Koch M, Perkins S. Bulimia: dentomedical complications. *Gen Dent.* 1992;40:22–5.
131. Ohrn R, Enzell K, Angmar-Mansson B. Oral status of 81 subjects with eating disorders. *Eur J Oral Sci.* 1999;107:157–63.
132. Robb N, Smith B, Geidrys-Leeper E. The distribution of erosion in the dentitions of patients with eating disorders. *Br Dent J.* 1995;178:171–5.
133. Philipp E, Willershausen-Zonnchen B, Hamm G, Pirke K. Oral and dental considerations in bulimic and anorectic patients. *Int J Eat Disord.* 1991;4:423–31.
134. Brownridge E. Eating disorders and oral health. How the dentist can help. *Ont Dent.* 1994;71(15–18):34.
135. Brown S, Bonifazi DZ. An overview of anorexia and bulimia nervosa, and the impact of eating disorders on the oral cavity. *Compendium.* 1993;140:1594–608.
136. Zachariassen R. Oral manifestations of bulimia nervosa. *Women Health.* 1995;22:67–76.
137. Narang A, Maguire A, Nunn JH, Bush A. Oral health and related factors in cystic fibrosis and other chronic respiratory disorders. *Arch Dis Chil.* 2003;88:702–7.
138. Burton BK. Inborn errors of metabolism in infancy: a guide to diagnosis. *Pediatrics.* 1998;102(6):E69.
139. Cleary MA, Francis DEM, Kilpatrick NM. Oral health implications in children with inborn errors of metabolism. *Int J Ped Dent.* 1997;7:133–41.
140. Hutton A, Bradwell M, English M, Chapple I. The oral health needs of children after treatment for a solid tumor or lymphoma. *Int J Paed Dent.* 2010;20:15–23.
141. Hodgson TA, Naidoo S, Chidzonga M, Ramos-Gomez F, Shiboski C. Identification of oral health care needs in children and adult, management of oral diseases. *Adv Dent Res.* 2006;19:106–17.
142. Bimstein E, Wilson J, Guelmann M, Primaosch RE. The relationship between oral and demographic characteristics of children with asthma. *J Clin Ped Dent.* 2006;3(2):86–9.
143. Balmer R, Bu'Lock F. The experiences with oral health and dental prevention of children with congenital heart disease. *Cardiol Young.* 2003;13:439–43.
144. Busuttill NA, Mooney G, El-Bahannasawy E, Vincent C, Wadhwa E, Robinson D, Fung DE. The dental health and preventive habits of cardiac patients attending the Royal Hospital for Sick Children Glasgow. *Eur Arch Paed Dent.* 2006;7:23–30.
145. Stecksén-Blicks C, Rydberg A, Nyman L, Asplund S, Svanberg C. Dental caries experience with congenital heart disease: a case control study. *Int J Paed Dent.* 2004;14:94–100.
146. Moynihan P. Diet therapy in chronically sick children: dental health considerations. *Quintessence Int.* 2006;37(444–448):35.
147. Norwood KW, Slayton RL. Oral health care for children with developmental disabilities. *Pediatrics.* 2013;131:614–9.

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