



THE ROLE OF PROTEIN, FAT, CARBOHYDRATES AND VITAMINS IN THE CHILDREN'S BODY, SIGNS OF DEFICIENCY AND MEASURES TO MAINTAIN BALANCE

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Abstract. *Childhood nutrition requires a careful balance of macronutrients and micronutrients to support growth, development and long-term health. Proteins, fats and carbohydrates provide energy and building blocks for tissue synthesis, while vitamins regulate metabolism and physiological functions. Deficiencies or excesses of these nutrients can lead to clinical problems such as growth failure, immune dysfunction, and metabolic disorders. International organizations (WHO, UNICEF) provide guidelines on adequate nutrient intakes and dietary practices. This review systematically examines the physiological roles of proteins, fats and carbohydrates in children; the importance of vitamins; signs of deficiency; recommended daily intakes; practical diet recommendations; and considerations for special situations (food allergies, malabsorption, vegetarian diets). Attention is given to WHO/UNICEF feeding recommendations and scientific evidence for nutrient requirements. The goal is to present a comprehensive, scholarly translation of the original Uzbek article into academic English, with appropriate references to current guidelines and literature.*

Keywords: *Child nutrition, Proteins, Fats, Carbohydrates, Vitamins, Micronutrient deficiencies, Dietary guidelines, WHO/UNICEF recommendations*

Introduction. Proper nutrition is fundamental to children's growth, development and lifelong health. During infancy and childhood, energy and nutrient

requirements are higher per unit body weight than in adults to support rapid growth of tissues, bone and the brain. Yet globally, many children do not receive diets of sufficient quality and diversity. For example, UNICEF reports that only 28% of 6–23 month-old children worldwide receive a minimally diverse diet. In fact, 72% of children aged 6–23 months lack even the minimum dietary diversity needed for healthy growth. Nearly half of young children consume no fruits or vegetables daily, and 60% are not given any animal-source foods such as eggs, meat or fish, despite recommendations that these nutrient-rich foods be offered every day. These patterns contribute to both undernutrition (such as stunting or micronutrient deficiency) and emerging problems of overweight and obesity. According to UNICEF, overweight now exceeds underweight for the first time among school-age children globally.

WHO and UNICEF emphasize that the first 2 years of life are critical: infants should be exclusively breastfed for the first 6 months, then gradually introduced to nutrient-dense complementary foods while continuing breastfeeding until at least age two. After 6 months, children need frequent meals and snacks from a variety of food groups to meet high nutrient needs. However, even older children often lack dietary diversity. To promote balanced nutrition, UNICEF/WHO recommend that young children consume foods from at least five of eight key food groups daily (including grains, dairy, fruits & vegetables, vitamin-A-rich produce, pulses, eggs, and animal proteins). This breadth of diet ensures adequate intake of protein, essential fats, vitamins and minerals.

This review will discuss the physiological functions of proteins, fats and carbohydrates in the child's body, describe the roles of vitamins, and outline the clinical signs of deficiency. We summarize current recommended intakes (WHO/FAO, IOM) and practical dietary guidelines for children, integrating the latest WHO/UNICEF recommendations on feeding practices. We also consider special cases such as food allergies, malabsorption syndromes and vegetarian diets, which require tailored nutrition planning. Throughout, evidence and guidelines from

WHO, UNICEF and peer-reviewed sources are cited to ensure scientific accuracy and up-to-date information.

Physiology of Macronutrients. Proteins. Proteins are organic macromolecules composed of amino acids and serve as the main structural and functional components of all living cells. They are essential for building new tissues (muscle, bone, skin, blood cells) and for repairing damaged cells[10][1]. In children, protein needs are relatively high due to rapid growth; growing infants and adolescents require more protein per kg of body weight than adults. Dietary proteins are hydrolyzed to amino acids in the gastrointestinal tract and absorbed into the bloodstream. These amino acids are used to synthesize body proteins, including enzymes, hormones, antibodies and structural proteins like collagen. Eight amino acids are considered “essential” because the body cannot synthesize them; they must be supplied by the diet.

Animal-source foods (meat, fish, eggs, dairy) provide high-quality proteins containing all essential amino acids in the proportions needed by humans. Plant proteins (grains, legumes, vegetables) are often incomplete on their own, but can complement each other when consumed in combination (for example, beans with rice) to supply a full amino acid profile. Proteins are also a source of energy (4 kcal per gram) when carbohydrate intake is low, but it is physiologically preferable to spare protein for growth and function.

According to authoritative dietary reference guides, the protein intake must be sufficient to prevent deficiency and allow normal growth. The Recommended Dietary Allowance (RDA) for protein in children is often expressed per body weight. For example, current guidelines indicate that children ages 4–13 years require about 0.95 grams per kg per day of good-quality protein, while older adolescents (14–18 years) require about 0.85 g/kg/day. These values represent the minimum needed to maintain nitrogen balance and support growth. In practical terms, typical RDAs (from IOM/FAO sources) for protein range from about 13 g/day for ages 1–3, to 19 g/day for ages 4–8, up to 34 g/day for ages 9–13, and about 52 g/day for boys 14–

18. (Actual requirements depend on body size and activity; very active or ill children may need more protein.)

Signs of protein deficiency in children include impaired growth and muscle wasting. Severe protein-energy malnutrition can manifest as marasmus (generalized wasting) or kwashiorkor (characterized by edema and fatty liver). In kwashiorkor, low plasma protein levels cause fluid to accumulate in tissues, leading to a distended abdomen, swollen legs and edema. A child with kwashiorkor may appear puffy yet muscle-wasted, with dry brittle hair and dermatitis. Marasmus, by contrast, is due to overall calorie deficiency, resulting in severe weight loss and wasting of both fat and muscle. Fortunately, these severe conditions are now relatively rare in most countries, but mild protein deficiency can still stunt growth and weaken immunity.

Fats. Dietary fats (lipids) are important sources of concentrated energy (9 kcal per gram) and provide essential fatty acids that the body cannot synthesize. They also facilitate absorption of fat-soluble vitamins (A, D, E, K) and are structural components of cell membranes and the myelin sheath of nerves. In infants and young children, fat is particularly important for brain development and insulation. For example, long-chain polyunsaturated fatty acids (like DHA) from fish oils are critical for neural and retinal development.

Not all fats are the same, however. Saturated fats (from butter, lard, coconut oil) and trans fats (industrial hydrogenated oils) should be limited because they raise LDL cholesterol and increase cardiovascular risk. Unsaturated fats (monounsaturated and polyunsaturated, from vegetable oils, nuts, seeds, fish) are healthier. The WHO advises that both adults and children limit total fat to 30% or less of total energy, and minimize saturated ($\leq 10\%$ energy) and trans fats ($\leq 1\%$ energy). This means that in a healthy child's diet, the majority of fats should come from sources like vegetable oils, nuts, avocado and fatty fish, rather than from fried foods or fatty cuts of meat.

Physiologically, fats serve as energy reserves, cushioning internal organs and maintaining body temperature. Essential fats also modulate inflammation and immune function. Inadequate fat intake can lead to deficiency of fat-soluble vitamins and essential fatty acids; for instance, infants fed fat-free formulas are at risk of vitamin E deficiency. Conversely, excessive fat intake, especially saturated fat, can contribute to unhealthy weight gain. WHO guidelines emphasize replacing saturated and trans fats with unsaturated fats[9]. Practical advice includes using vegetable oils for cooking and avoiding excessive fried foods.

Carbohydrates. Carbohydrates are the body's preferred energy source, especially for the brain, red blood cells, and exercising muscles. In children, carbohydrates should make up a substantial portion of calories – often 45–65% of energy according to dietary guidelines – though quality matters more than quantity. Complex carbohydrates and starches (from whole grains, cereals, legumes, vegetables and fruits) provide sustained energy and dietary fiber. Fiber in fruits and vegetables also supports healthy digestion, glycemic control and gut health. In fact, WHO recommends specific daily fiber intakes for children: about 15 g for ages 2–5, 21 g for ages 6–9, and 25 g for ages 10 and older.

Simple sugars (sucrose, fructose, glucose) found in sweets, sugary drinks and processed foods can provide quick energy but little nutrition. Excessive intake of free sugars is discouraged. The latest WHO guideline explicitly recommends limiting free sugar intake to less than 10% of total energy for both adults and children, with a conditional recommendation to further reduce it below 5%. High sugar consumption in children is linked to obesity, dental caries, and nutrient displacement (empty calories replacing nutritious foods). Therefore, children's diets should favor whole carbohydrate sources: whole grain breads, brown rice, oats, legumes and whole fruits, which also supply vitamins and fiber, rather than candy and sodas. WHO's recent advice stresses carbohydrate quality: prioritize foods rich

in dietary fiber and nutrients (whole grains, vegetables, fruits, pulses) and minimize added sugars.

Carbohydrates also spare protein from being used as fuel. If carbohydrate intake is very low, the body may catabolize protein (muscle tissue) and fat to meet energy needs. However, true carbohydrate deficiency is rare when a reasonable diet is consumed, because the body can synthesize glucose (through gluconeogenesis) to some extent. The key practical message is to ensure adequate intake of nutrient-rich carb sources and limited intake of sweets.

Role of Vitamins. Vitamins are micronutrients required in small amounts but vital for metabolic processes, growth and development. Unlike macronutrients, vitamins cannot be synthesized by the body (except vitamin D from sunlight) and must be obtained through diet or supplements. In children, vitamins support organ development, brain function, immunity and bone health. Major vitamins include the fat-soluble vitamins A, D, E, K and the water-soluble B-complex and vitamin C. Deficiency of any essential vitamin can impair health and development.

Vitamin A. Vitamin A (retinol and related compounds) is crucial for healthy vision, immune function, and epithelial integrity. In children, vitamin A is needed for normal eye development and resistance to infection. WHO stresses that vitamin A is “vital to child health and immune function”, and that supplementation in deficient areas dramatically reduces morbidity and mortality. Sources include dairy products, liver, eggs and provitamin A carotenoids in colorful fruits and vegetables.

Vitamin D. Vitamin D regulates calcium–phosphate metabolism and bone mineralization. It is produced in the skin by sunlight and also found in some foods (fatty fish, fortified milk, egg yolks). Adequate vitamin D prevents rickets in children (soft, misshapen bones) and supports general growth. Breastfed infants in many regions are at risk of vitamin D deficiency because breast milk alone provides insufficient vitamin D. WHO notes that newborn infants worldwide are at risk of deficiency and that vitamin D supplementation of 400 IU (10 µg) daily for infants is

widely recommended to prevent rickets. (In fact, many health agencies advise a daily supplement of about 400 IU for all young infants.) Vitamin D also modulates the immune system and muscle function.

Vitamin C. Vitamin C (ascorbic acid) is important for collagen synthesis, wound healing, antioxidant defense and immune response. Good sources are citrus fruits, berries, tomatoes, peppers and green leafy vegetables. Deficiency leads to scurvy, characterized by gum bleeding, easy bruising, anemia, and poor wound healing. Even mild vitamin C deficiency can impair iron absorption and immunity. Thus fruits and vegetables rich in vitamin C should be included daily.

B Vitamins. The B-complex vitamins (thiamine (B1), riboflavin (B2), niacin (B3), pyridoxine (B6), folate (B9), cobalamin (B12), and others) play central roles in energy metabolism, red blood cell production and neural function. For example, vitamin B12 (found in animal foods) and folate are essential for DNA synthesis and preventing anemia. Vitamin B1 is necessary for carbohydrate metabolism and nervous system function. Deficiency of B vitamins can cause anemia, neurologic symptoms or growth failure. Children on restricted diets (e.g. vegans) or with malabsorption may require supplements of B12 or folate.

Other Vitamins. Vitamin E acts as an antioxidant in cell membranes, protecting cells from oxidative damage. Vitamin K is needed for blood clotting (coagulation) and bone health. K is produced partly by gut bacteria and obtained from leafy greens; deficiency leads to bleeding and bruising.

WHO and UNICEF emphasize that vitamin deficiencies are a major concern in child health. For instance, in areas where diets lack animal products and fat, vitamin A deficiency is common, increasing risks of blindness and infection. To address this, WHO recommends periodic high-dose vitamin A supplementation for all children 6–59 months living in deficient regions (100,000 IU for 6–11 months old, 200,000 IU for 12–59 months). Likewise, routine pediatric care often includes vitamin D and iron supplementation for at-risk infants. The use of fortified foods or

multiple micronutrient powders is another WHO/UNICEF strategy to ensure children receive adequate vitamins when diets alone are insufficient.

Deficiency Symptoms. Insufficient intake or absorption of key nutrients can produce characteristic clinical signs and developmental problems. Children are especially vulnerable, as deficiencies can stunt growth and weaken immunity. Important deficiency syndromes include:

Protein–Energy Malnutrition: Chronic lack of calories and protein leads to failure to thrive. In mild cases, children grow poorly and gain little weight. Severe deficiency manifests as marasmus (wasted appearance from overall energy deficiency) or kwashiorkor (a form of protein malnutrition). Kwashiorkor is distinguished by low blood albumin and edema: affected children often have a swollen (“distended”) belly, puffy face and legs, and fatty liver. Other features include thinning hair, skin rash, irritability and delayed development. Without treatment, severe protein malnutrition can be fatal.

Essential Fatty Acid Deficiency: While rare, inadequate intake of essential fats (omega-3 and omega-6 fatty acids) can cause dry, scaly skin, poor wound healing and growth delays. Infants on fat-free diets may develop deficiency signs (dermatitis, alopecia). More commonly in developed settings, essential fatty acid status can be low if diets contain too little plant oils or fish; this may subtly affect immune function and cognition.

Vitamin A Deficiency: Early signs include night blindness and eye issues (xerophthalmia). Advanced deficiency leads to Bitot’s spots on the conjunctiva and potentially irreversible blindness. Vitamin A deficiency also impairs immune function: children lacking vitamin A have higher rates of measles and diarrheal complications. UNICEF notes that vitamin A deficiency “weakens children’s immunity, increases the risk of blindness and can lead to death from common childhood diseases”.

Vitamin D Deficiency: Insufficient vitamin D causes rickets in children: bones become soft and bowed under body weight. Symptoms include bone pain, delayed motor development, and in advanced cases, seizures (from low calcium). Even without overt rickets, low vitamin D can reduce calcium absorption and weaken bones.

Vitamin C Deficiency (Scurvy): Signs emerge after a few months of inadequate intake and include irritability, fatigue, swollen or bleeding gums, bruising easily (petechiae), and poor wound healing. Joint pain and skeletal changes (especially at growth plates) may also occur. Though rare in modern times, mild vitamin C deficiency can still occur in picky eaters, causing lethargy and anemia.

Vitamin B Deficiencies: For example, thiamine (B1) deficiency causes beriberi – in infants, this may present as high-output heart failure (wet beriberi) or neurologic irritability (dry beriberi). Niacin (B3) deficiency causes pellagra (dermatitis, diarrhea, dementia). Folate (B9) deficiency leads to megaloblastic anemia, and B12 deficiency (especially in strict vegetarians) causes anemia and neurologic symptoms. Vitamin K deficiency leads to easy bruising and bleeding (poor blood clotting).

Mineral Deficiencies: Though not vitamins, deficiencies of minerals like iron, iodine and zinc are common in children. Iron deficiency (often dietary or from blood loss) causes anemia, fatigue and cognitive impairment. Iodine deficiency can lead to goiter and developmental delay. These are covered extensively by WHO programs (e.g. iron supplementation, iodized salt).

In summary, the lack of any macronutrient or vitamin in a child's diet can undermine growth and health. Clinicians recognize specific patterns (e.g. stunting, edema, skin lesions, neurological signs) associated with various nutrient deficits. Public health strategies often focus on the most critical ones – vitamin A, iron, iodine and protein-energy – through supplementation and food fortification.

Recommended Daily Allowances. Nutrient recommendations for children are provided by WHO/FAO, UNICEF and nutrition authorities (IOM/EFSA, etc.), and vary by age, sex and physiological state. Key recommendations include:

Protein: As noted, about 0.95 g/kg/day for ages 4–13 and 0.85 g/kg/day for ages 14–18 is recommended[14]. In practice, this translates to roughly 13–34 g/day for children and up to ~50 g/day for teen boys. Because quality matters, these amounts assume good-quality animal or combined plant proteins.

Fat: WHO recommends that total fat provide no more than 30% of total calories, with saturated fat <10% and trans fat <1%. This implies that for a 1500 kcal/day diet, total fat would be ≤50 g (30% of 1500 kcal) and saturated fat <17 g. Essential fatty acids (omega-6, -3) should be ensured (e.g. 5% of energy from linoleic acid).

Carbohydrates: There is no fixed “RDA” for total carbohydrates, but guidelines often suggest 45–65% of energy. Importantly, free sugars should be limited to <10% of energy (WHO recommendation). For example, in a 1400 kcal diet, this is <35 g of free sugars per day. WHO further recommends diets high in complex carbs and fiber-rich foods[18].

Fibre: WHO recommends at least 25 g/day of fiber for adults; for children, age-appropriate intakes are 15 g (age 2–5), 21 g (6–9), and 25 g (10+ years). High-fiber childhood diets (within reason) support healthy digestion and satiety.

Vitamin A: A common reference intake is about 400–600 µg retinol activity equivalents (RAE) per day for young children, higher for teenagers (700–900 µg). WHO/UNICEF focus more on supplementation (100,000–200,000 IU twice yearly for under-5s in deficient areas).

Vitamin D: About 10 µg (400 IU) per day is generally recommended for infants and children to prevent deficiency. WHO eLENA notes that many organizations recommend 5–10 µg daily for infants. In sunlight-poor regions, supplementation is advised.

Other Vitamins: Typical RDAs (Institute of Medicine) include: vitamin C ~15–45 mg/day depending on age; thiamine ~0.5–1.2 mg; riboflavin ~0.4–1.3 mg; niacin ~6–12 mg; B6 ~0.5–1.3 mg; folate ~150–300 µg; B12 ~0.9–2.4 µg; and vitamin K ~30–60 µg. (Exact values vary by country and age group). A balanced diet containing fruits, vegetables, grains and proteins generally meets these targets if varied.

Sugars & Salt: WHO advises limiting free sugars to <10% of energy. Sodium intake should also be kept low (e.g. <2 g/day salt or <800 mg sodium for older children) to prevent hypertension later in life (though children with very low salt also need iodized salt to prevent deficiency).

In practice, many countries use food-based recommendations. For example, UNICEF and WHO suggest that 6–23 month-old children should receive daily foods from at least five of eight food groups (including sources of protein, fat, vitamins and minerals), rather than focusing on numerical nutrient targets. This food-group approach helps ensure a mix of macronutrients and micronutrients.

Practical Dietary Guidelines. Parents and caregivers can implement several practical measures to maintain nutrient balance in a child's diet:

Breastfeeding and Complementary Feeding: For infants (0–6 months), exclusive breastfeeding is recommended. After 6 months, continue breastfeeding while introducing complementary foods. Give small frequent meals (3–5 times/day plus snacks) of nutrient-dense foods from multiple groups. Use fortified cereals, pureed meats, legumes, yogurt and pureed vegetables to provide protein, fat and micronutrients.

Food Variety (Dietary Diversity): Aim for at least five of eight nutritious food groups each day. These groups include: grains (rice, wheat, maize), dairy (milk, cheese, yogurt), other fruits/vegetables, vitamin-A rich fruits/vegetables (carrots, mango, sweet potato), protein-rich foods (meats, fish, eggs), legumes/nuts and tubers. A highly diverse diet ensures supply of essential amino acids, vitamins and

minerals. For example, combining grains with legumes supplies a complete protein profile. Including leafy greens and brightly colored fruits covers many micronutrients. Caregivers are encouraged to prepare child-appropriate dishes that mix food types rather than single-item meals.

Fruit & Vegetable Intake: Encourage plenty of fruits and vegetables (fresh, cooked or pureed) in the diet every day. WHO guidelines suggest a minimum intake for children: about 250 g/day for ages 2–5, 350 g for ages 6–9, and 400 g for ages 10+. These foods provide vitamins A, C, folate, fiber and phytochemicals. Discourage sugary snacks by offering fruits or chopped veggies as snacks instead.

Protein & Iron Sources: Include animal proteins (lean meat, fish, poultry, eggs) or plant proteins (beans, lentils, tofu) daily. These supply high-quality protein, iron and B vitamins. For vegetarian children, ensure combining legumes with grains and using fortified soy products to meet protein and micronutrient needs. If dairy is excluded (milk allergy or vegan diet), use fortified alternatives (soy or rice milk with added calcium and vitamin D).

Healthy Fats: Provide some dietary fat at every meal for energy and vitamin absorption. Good sources include milk, cheese, avocado, nut butters, and vegetable oils (olive, canola). Eggs and fish (salmon, tuna) are valuable sources of omega-3 fats. Limit fried and processed foods with trans fats.

Carbohydrates and Fiber: Base meals on whole grains and starchy vegetables (whole wheat bread, brown rice, oats, potatoes) which are energy-dense and fiber-rich. These should make up roughly half of each meal (e.g. grains plus tubers). Limit refined carbs and sweets; when sweets are given (cookies, candy), do so occasionally and in small portions. The goal is to favor complex carbs and natural sugars (fruit) over added sugars, aligning with WHO advice to keep free sugar intake very low.

Dairy or Calcium: Include dairy (milk, yogurt, cheese) if tolerated, or fortified plant milks, to ensure sufficient calcium and vitamin D. These support bone growth. If a child is allergic to cow's milk, use soy/rice formulas or other fortified products.

Meal Patterns: Serve regular balanced meals and snacks rather than letting the child graze freely. Children have small stomachs and need energy-dense foods in modest amounts. Frequent snacks (e.g. fruit slices, yogurt, peanut butter on whole-wheat toast) can help meet calorie and nutrient needs.

Food Safety and Hygiene: Prepare foods hygienically (wash hands, cook thoroughly) to prevent infections that can aggravate malnutrition. Introduce age-appropriate textures gradually (purees to soft lumps to finger foods) to support motor development. Encourage responsive feeding: watch child's hunger cues, feed patiently, and avoid force-feeding. These practices improve intake and growth.

Limiting Unhealthy Elements: Minimize salt and added sugars in a child's diet. Avoid giving sugary beverages or excessive juice (fruit juice is allowed in very small amounts, diluted if needed). Instead, teach children to drink water or plain milk between meals. Check that processed foods (e.g. snacks, cereals) are not excessively high in sugar or salt; use the guidance in [55†L270-L276] and [18†L250-L259] to make healthier substitutions.

The image above shows a young child receiving nutritional supplements at a UNICEF-supported health clinic. Community nutrition programs like this help deliver essential micronutrients (e.g. high-dose vitamin A, iron) to at-risk children in developing regions. Such interventions are aligned with WHO recommendations for preventing vitamin A deficiency and other micronutrient shortages in young children.

Supplementation and Fortification: In settings where dietary intake may be inadequate, WHO/UNICEF recommend additional measures. For example, vitamin A supplementation (100k–200k IU every 4–6 months) is provided to all children 6–59 months in high-risk areas. Iron supplementation or fortified foods (flour, cereal) are used where anemia is common. UNICEF specifically supports distributing vitamin A, deworming tablets and iron supplements to under-5s in areas of poor nutrition. Similarly, multiple micronutrient powders (“sprinkles”) may be added to

home-prepared foods to boost vitamin and mineral content. These public health strategies complement a healthy diet to ensure children meet their nutritional requirements.

Special Cases (Allergies, Malabsorption, Vegetarianism). Some children have dietary restrictions or conditions that require special planning to maintain nutrient balance:

Food Allergies: If a child is allergic to common foods (cow's milk, eggs, peanuts, wheat, soy, fish, etc.), elimination of these foods can risk deficiencies. For example, milk allergy may limit calcium and vitamin D intake; egg allergy affects protein and certain vitamins (A, D). In such cases, parents should substitute safe alternatives. For milk allergy, use calcium-fortified alternatives (soy or rice milk) and ensure enough calcium from other sources (leafy greens, fortified juices). For egg allergy, provide protein from meat, fish or legumes. A dietitian can help identify suitable replacements and supplements. Care must be taken that elimination diets do not unbalance macronutrients or micronutrients. (For instance, many childhood allergy diets are high in carbohydrates; clinicians watch for weight or nutrient gaps). Ensuring a variety of allowed foods and, if needed, using fortified products or supplements helps prevent malnutrition in allergic children.

Malabsorption Syndromes (e.g. Celiac Disease): Children with gastrointestinal disorders that impair absorption (such as celiac disease) must follow strict dietary adjustments. Celiac disease requires a lifelong gluten-free diet (no wheat, barley, rye). Gluten-free products often have less fiber, iron, folate and B vitamins than their gluten-containing counterparts. According to recent reviews, even after intestinal healing, a gluten-free diet can lead to insufficient intake of fiber, calcium, iron, folate and other vitamins. This risk arises because many gluten-free flours and processed gluten-free foods are not fortified. Therefore, children on gluten-free diets should be monitored: encourage naturally gluten-free whole foods (rice, corn, potatoes, vegetables) and select fortified gluten-free products. Healthcare

providers often recommend supplements (iron, calcium, vitamin D, B vitamins) if dietary intake is inadequate. Regular follow-up with a dietitian can identify any nutrient gaps and ensure the child's growth remains on track.

Vegetarian and Vegan Diets: Children raised on vegetarian diets (lacto-ovo-vegetarian or vegan) can thrive if carefully planned, but risks of deficiency exist. Lacto-ovo-vegetarian children typically meet protein and calcium needs through dairy and eggs, but strict vegans (no animal products at all) must be vigilant about certain nutrients. The main concerns for vegan children are vitamin B12, vitamin D, calcium and omega-3 fatty acids. Plant foods contain no B12, so vegan families should use B12-fortified foods or give a daily supplement (about 5–10 µg/day) to children. Vegan breastfed infants in particular require B12 supplementation because breastmilk may be low in B12. Vitamin D is also predominantly in animal foods or fortified products; supplementation (at least 10 µg or 400 IU for infants, 15 µg for older children) is recommended for strictly vegan children and for all breastfed infants. Calcium can be obtained from fortified plant milks, tofu processed with calcium, and low-oxalate greens (kale, bok choy). The American Academy of Pediatrics notes that vegan children may consume high fiber, which can be filling and reduce calorie intake; thus families should plan energy-dense meals (adding healthy oils or nut butters) and monitor growth. In summary, well-planned vegetarian diets can meet children's needs, but require attention to supplements and fortified foods, especially for B12 and D.

Conclusion. Optimal nutrition in childhood is multidimensional, involving the right quantities of proteins, fats, carbohydrates and a spectrum of vitamins and minerals. Each nutrient plays specific roles: proteins and amino acids build tissues; essential fatty acids support brain and immune development; carbohydrates provide energy for daily activities and growth. Vitamins act as cofactors for metabolic pathways and protect against disease. WHO and UNICEF emphasize that malnutrition in any form (undernutrition, micronutrient deficiency or excess weight)

can have lifelong consequences. They therefore advocate for diverse, nutrient-rich diets from infancy, exclusive breastfeeding, and strategic use of supplementation and food fortification where needed.

Practically, caregivers should follow balanced meal patterns that include grains, fruits, vegetables, proteins (meat, eggs, beans, dairy), and healthy fats, while minimizing added sugars, salt and unhealthy fats. WHO guidelines (e.g. fat <30% energy, sugar <10% energy) and UNICEF recommendations (diverse foods from 5 of 8 food groups daily) provide concrete targets. Vulnerable groups — such as children with allergies, malabsorption conditions or strict vegetarian diets — require tailored dietary planning or supplements to ensure no essential nutrient is missed.

In sum, maintaining macronutrient and micronutrient balance is critical for healthy growth and preventing disease. Academic and public health sources (WHO, UNICEF, IOM) concur that combination of varied whole foods, appropriate fortified products, and supplementation (especially for vitamin A and D) best achieves this balance in children. Ongoing monitoring of children's growth and dietary intake can identify problems early. By following up-to-date scientific guidelines and feeding practices, health professionals and parents can safeguard children's development and long-term well-being.

References

World Health Organization (2023). WHO updates guidelines on fats and carbohydrates. (Provides recommendations on fat intake, fat type, and fruits/vegetable and fiber targets).

World Health Organization (2018). Vitamin A supplementation in infants and children 6–59 months. (Guideline: high-dose vitamin A for children in deficient areas).

World Health Organization (2017). Vitamin D supplementation for infants. (Recommendations on 5–10 µg vitamin D for infants, consistency of global recommendations).

World Health Organization (2023). Reducing free sugars intake in children to reduce NCDs. (Recommends free sugars <10% of energy for children).

UNICEF (2020). Global Nutrition Strategy 2020–2030. (Data on child dietary diversity and malnutrition; recommends diverse diets).

UNICEF (n.d.). Early childhood nutrition. (Breastfeeding and complementary feeding guidelines; importance of dietary diversity and supplementation).

MDPI – Proteomes (2021). Dietary Protein Requirements in Children: Methods for Consideration (Peer-reviewed article on protein needs; RDA per kg; defining minimum intake).

Cleveland Clinic (2023). Kwashiorkor. (Overview of protein–energy malnutrition: edema, distended abdomen in children with protein deficiency).

Cleveland Clinic (2023). Vitamin Deficiency. (Summary of vitamin deficiency symptoms including vitamin D–rickets, vitamin C–scurvy, vitamin K–bleeding).

MDPI – Journal of Nutrition (2015). Vegetarian diets in children and adolescents (Review: nutritional considerations in vegan diets; risks of B12, vitamin D and calcium deficiencies).

BMC Gastroenterology (2024). Nutritional consequences of celiac disease and gluten-free diet (Review: Gluten-free diets often lead to low intake of fiber, Ca, Fe, folate, vitamins).