# Nutritional Deficiencies in Children on Restricted Diets

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**KEYWORDS**

- Deficiencies • Restricted • Diets • Gluten
- Allergies • Vegetarian

Nutrient deficiencies in infants and children, commonly associated with poverty in developing countries, are caused by multiple factors, including maternal undernutrition; low-calorie, nutrient-poor complementary foods; and high incidence of infections. Estimates show that up to 40% of children less than 5 years of age living in poverty can be affected by protein energy malnutrition.[1] Specific micronutrient deficiencies considered major public health problems worldwide include those for iron, iodine, vitamin A, zinc, and selenium.[2] In the United States, such clinical nutrient deficiencies do not exist to the same degree, although diets may not always be optimal. The Feeding Infants and Toddlers Study, the first national study comparing nutrient intake of infants and toddlers with the new Dietary Reference Intakes (DRIs) concluded that healthy infants and toddlers in the United States had adequate intakes of most nutrients. However, there were inadequate intakes of vitamin E in 58% of toddlers from 12 to 24 months, low fat intakes for 29% of toddlers, low fiber intake, and high intake of vitamin A and zinc compared with recommended intake.[3] For children aged 2 to 11 years, the American Dietetic Association suggests potential inadequate dietary intake of vitamin E, folate, calcium, iron, magnesium, potassium, and fiber.[4] Finally, in adolescents, dietary deficiencies of vitamins A and C, calcium, iron, riboflavin, and thiamin have been noted.[5]

A review of the literature over the past 30 years demonstrates that clinical nutrient deficiencies in the United States are not absent, and particular pediatric populations may be at higher risk: children on medically prescribed diets, such as gluten-free, allergen-free, ketogenic, or tube feedings; and children on restricted diets because of developmental or behavioral disability and/or parent-selected dietary regimens. In contrast to deficiencies in developing countries, pediatric deficiencies in the United States are often not associated with poverty, but rather with caregiver nutritional

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ignorance, nutrition misinformation, fad diets, alternative nutrition therapies, and cultural preferences. This article reviews the importance of macro- and micronutrients for infants and children, and discusses the incidence and risks of nutrient deficiencies in both medically prescribed restricted diets and parent/child-selected restricted diets.

## NUTRIENTS

Nutrients can be grouped into macronutrients of carbohydrates, protein, and fat, which supply calories, and micronutrients of vitamins and minerals. The DRIs have established recommended intakes for both macro- and micronutrients.[6] These include acceptable calorie reference ranges, the acceptable macronutrient distribution range, adequate intake, and recommended dietary allowances for essential vitamins and minerals.

Nutrient deficiencies result from inadequate nutrients in relation to biologic need. This imbalance can be caused by inadequate intake, impaired nutrient absorption, or increased nutrient need. Certain nutrient deficiencies can rapidly result in impaired growth, while other deficiencies deplete body stores initially, then tissue concentrations, and ultimately impair metabolic pathways, which lead to clinical symptoms. Deficiencies of macronutrients can be classified as marasmus (a primary calorie deficit), kwashiorkor (a primary protein deficit), and marasmic kwashiorkor (both a calorie and protein deficit). Calorie deficit is a primary nutrient deficiency. However, there can also be deficiencies or imbalances of the macronutrients: carbohydrates, protein, and fat. The acceptable macronutrient distribution range for children and adolescents is:

Carbohydrates: 45% to 65% of total calories
Protein: 5% to 20% for ages 1 to 3 and 10% to 30% for ages 4 and older
Fat: 30% to 40% for ages 1 to 3 and 25% to 35% for ages 4 and older

Specific micronutrient deficiencies that may be more frequently seen in restricted diets will be discussed in more detail and include those related to iron, zinc, calcium, vitamin D, and B vitamins.

### *Iron*

Iron is a critical component of several proteins, including hemoglobin, myoglobin, cytochromes, and numerous enzymes. The largest portion of the body's iron is in the erythrocytic hemoglobin used in the transport of oxygen. The requirements are particularly elevated during periods of rapid growth. For this reason, cow's milk, which is a poor source of iron, is not recommended for use in infants under 1 year of age (under 9 months in Canada). Breast-feeding or the use of an iron-fortified formula should be continued until this time. Iron-fortified infant cereals can provide a significant amount of iron in the infant's diet once solid foods are started. During the growth spurt of preadolescence and adolescence, the need for iron can increase significantly. For females, the recommended dietary allowance for iron increases from 8 mg/d for 9- to 13-year-olds to 15 mg/d for 14- to 18-year-olds. For girls who have not started menstruating by this age, the requirement is approximately 10.5 mg/d.[7] For males, the recommended dietary allowance for iron increases from 8 mg/d for 9- to 13-year-olds to 11 mg/d for 14- to 18-year-olds.

The two forms of dietary iron are heme iron and nonheme iron. Heme iron is highly bioavailable. Sources of heme iron include beef, pork, lamb, chicken, turkey, fish, and shellfish. Nonheme iron is not as readily absorbed by the body and is found in beans,