Chapter 11

Nutrition in Middle Childhood and Adolescence

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INTRODUCTION

Adolescence is the period between childhood and adulthood. Patton and others (2016) further delineate this period as early adolescence (ages 10–14 years), late adolescence (ages 15–19 years), youth (ages 15–24 years), and young adulthood (ages 20–24 years). Definitions of age groupings and age-specific terminology used in this volume can be found in chapter 1 (Bundy and others 2017). Worldwide, there are nearly 1.8 billion people ages 10–24 years, constituting one-quarter of the total population; 89 percent of young people (ages 10–24 years) live in low- and middle-income countries (LMICs).

Figure 11.1 shows some of the interactions of nutrition and development during the life course. Adolescent development is complex, with puberty, neurocognitive maturity, and social role transitions interacting in complex ways, all with important consequences for nutrition.

Physical Growth and Mental Development

Growth failure and micronutrient inadequacy during childhood and adolescence can delay growth and create high risk of chronic diseases in adulthood. Puberty is accompanied by a growth spurt that increases the requirements for both macronutrients and micronutrients. These higher requirements are balanced by a more efficient use of protein for development rather than energy. For females, pubertal timing is affected by childhood body mass index (BMI) and percentage of body fat; data for males are inconclusive.

Pubertal timing depends on nutrition during childhood. It also reflects earlier maternal nutrition because appetite control, energy homeostasis, and the pubertal axis are being developed in natal and early postnatal life (Soliman, De Sanctis, and Elalaily 2014). In childhood, stunting (low height for age) and wasting (low weight for height) delay both overall growth and the onset of puberty. In addition, girls born small for gestational age are at risk for insulin resistance, premature pubarche, early menarche, and an attenuated growth spurt. Although increased adiposity is a normal physiologic process that precedes puberty, early weight gains are linked to taller stature in childhood, with a probable increase in growth hormone, insulin-like growth factor, and future obesity, as well as a possible increase in hyperinsulinemia (Viner, Allen, and Patton 2017, chapter 9 in this volume).

Importance of Nutrition in Adolescence

Adolescence is a time of transition when habits are formed that persist into adult life. Good habits, such as exercise and a healthy diet, are likely to bring many benefits, including improved performance in school (Doku and others 2013). Nutritional habits are important, with high intake of processed, energy-dense foods, high BMI, and iron deficiency among the top 20 risk factors of disability-adjusted life years (DALYs) worldwide (WHO 2009).

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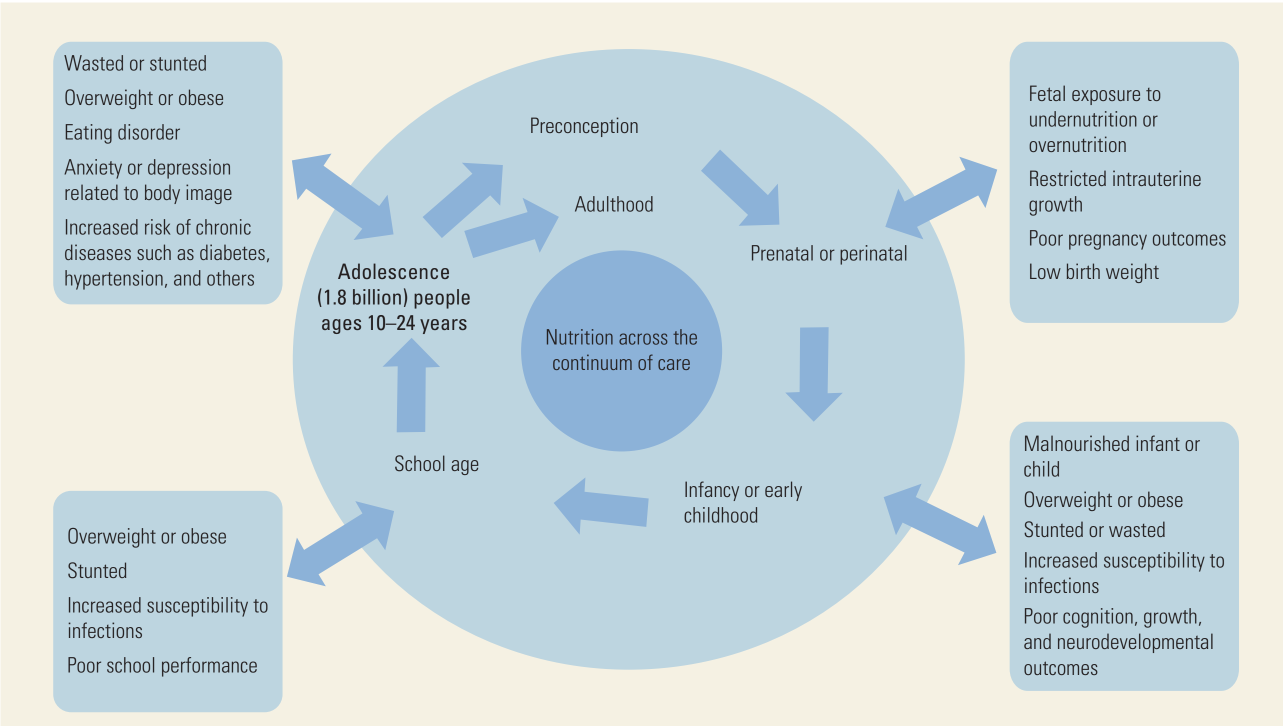
Figure 11.1 Nutrition and Related Risk Factors across the Continuum of Care



Such factors pose risks for later-life noncommunicable diseases, which are responsible for two of every three deaths globally (Sawyer and others 2012).

Most studies and guidelines on eating behavior are from high-income countries (HICs). The 2010 U.S. dietary guidelines for adolescents (ages 9–18 years), for example, suggest that girls require 1,400–2,400 calories per day and boys require 1,600–3,200 because of their typically larger frames and muscle mass. However, any teenager involved in athletic physical activity can require up to 5,000 calories per day (Caprio and others 1994).

The available studies suggest that adolescents are becoming more independent in their food choices, more likely to be influenced by their peers, and less likely to pick healthy foods (Seymour, Hoerr, and Huang 1997). Other factors that affect their overall nutrition include the kinds of foods available at home, amount of time available to make food (Venter and Winterbach 2010), knowledge of food content (Li and others 2008), and ability to purchase snacks (Ahmed and others 2006). Sociodemographic, behavioral, and environmental factors are also linked to different patterns of adolescent nutrition. Sociodemographic factors include socioeconomic status, age, sex, location, and degree of urbanization. Behavioral factors include patterns of beverage intake, portion sizes, dieting, family dinners, eating in front of and viewing television, and skipping meals (especially breakfast). Environmental factors include eating or buying food prepared outside the home, maternal education and employment, and parental diet (Moreno and others 2014).

Gender norms are often more harmful than beneficial with regard to nutrition and physical activity. Girls are exposed to a culture of overdieting and unhealthy weight loss more often than boys, and many believe that exercise is unfeminine and that athletic women are masculine. Qualities encouraged in sports, such as strength, dominance, and competition, are also considered unfeminine. Spencer, Rehman, and Kirk (2015) found that girls prioritize body image over health. Dror and Allen (2014) reviewed consumption of dairy products in developed countries and found that girls consume less dairy than recommended because they think it causes weight gain, and because their parents either do not consume dairy or do not urge their children to do so, among other reasons. Although the media, parents, and peers can foster negative images, they can also help introduce healthier approaches to weight control and nutrition (Spencer, Rehman, and Kirk 2015).

This chapter discusses the evidence on nutrition for children ages six to nine years and for adolescents, including undernutrition, overweight and obesity, micronutrient deficiencies, nutrition for pregnant adolescents, and eating disorders. Each section discusses the issue and then presents evidence on the effectiveness of interventions to address it. Chapter 3 of this volume (Galloway 2017) discusses global nutrition outcomes at ages 5 to 19.

UNDERNUTRITION

Statistics on undernutrition—including wasting, stunting, anemia, and vitamin A deficiency—in children younger than age five years are well known, but data on undernutrition specifically in adolescents are rare. In the least developed countries, the prevalence of adolescent underweight is 22 percent (UNICEF 2014) and is associated with various health risks. Undernutrition is linked to lower gut immunity, decreased protective secretions, and low innate and acquired immunity (Seidenfeld, Sosin, and Rickert 2004).

Undernourished adolescents have commonly experienced stunted growth in childhood. Undernutrition in early life can result in fewer pancreatic cells that produce insulin. Although this deficit is compensated for in adolescence, with stunted adolescents having more peripheral insulin receptors, this compensation contributes to increased accumulation of fat (Rytter and others 2014). Stunted children, adolescents, and adults have higher rates of later arterial hypertension. Undernutrition in childhood and adolescence also results in constant physiologic and psychologic stress, increasing the production of stress hormones that weaken the body and decreasing the production of thyroid hormones and insulin-like growth factor that regulate growth.

Marshall, Burrows, and Collins (2014) have suggested that dietary intake is generally inadequate for children and adolescents in LMICs (table 11.1), and adolescents do not fulfill their daily nutritional requirements. Furthermore, disparity is high among adolescents from lower socioeconomic profiles as compared with their wealthier counterparts.

Prevalence of Undernutrition

Data on undernutrition in adolescents are underrepresented in global databases, although some smaller studies report regional data. Among adolescents ages 10–14 years, protein energy malnutrition affects 12 girls per 100,000 in Africa and 3 girls per 100,000 in the Eastern Mediterranean (WHO 2014). Matsuzaki and others (2015) studied 722 adolescents and young adults in India from 2003 to 2005 and found mean BMI of 16.8 kilograms/square meter in adolescents and 19.3 kilograms/square meter in young adults. Thomas, Srinivasan, and Sudarshan (2013) studied 409 students in rural India and found that 39 percent were thin (BMI below the 5th percentile for age) and 59 percent were stunted. Lopes and others (2013) studied 523 adolescents (ages 12–18 years) in urban Brazil and found that 9 percent were stunted and 24 percent were overweight, with 36 percent of families having mild and 24 percent having moderate to severe food insecurity. Stunting was associated with low intake of calcium and iron, whereas food insecurity was associated with low intake of protein and calcium. In a study of 23,496 students (ages 11–17 years) conducted in seven African countries (Benin, Djibouti, the Arab Republic of Egypt, Ghana, Malawi,

Table 11.1 Dietary Intake of Children and Adolescents

Study	Findings
Marshall, Burrows, and Collins 2014	Most school-age children in LMICs eat plant-based foods, fewer than 50 percent consume dairy, breakfast is the most often skipped meal, and consumption of processed foods is increasing.
Doku and others 2013; Ochola and Masibo 2014	In Ghana, 31 percent of those ages 12–18 years ate breakfast fewer than four days a week, 56 percent rarely ate fruits, 48 percent rarely ate vegetables, and boys were more physically active than girls.
Barugahara, Kikafunda, and Gakenia 2013	In Uganda, girls ages 11–14 years achieved the World Health Organization daily requirements in the following proportions: 30 percent for folate, 36 percent for energy, 54 percent for iron and riboflavin, 59 percent for protein, 61 percent for vitamin A, 89 percent for vitamin C, and 92 percent for fiber.
Kawade 2012	In India, school-going girls (ages 10–16 years) were deficient in zinc, with 50 percent having cognitive impairments.
Nago and others 2010	In Benin, adolescents (ages 13–19 years) received 40 percent of their daily diet from food prepared outside the home, accounting for 75 percent of their daily energy intake.
Alam and others 2010	In Bangladesh, consumption of nonstaple good-quality food items within the last week were less frequent and correlated positively with the household asset quintile.

Note: LMICs = low- and middle-income countries.

Table 11.2 Summary Estimates of Effectiveness of Interventions for Undernutrition in Adolescence

Study	Intervention	Outcome
Creed-Kanashiro and others 2000	Nine-month intervention consisting of participatory training with community kitchen leaders, educational materials, increased access to heme iron (chicken liver and blood) in first five months	Anemia: RR, 0.32; 95% CI, 0.15 to 0.69 Iron deficiency: RR, 0.78; 95% CI, 0.37 to 1.63
Mann, Kaur, and Bains 2002	Iron (60 milligrams per day) as well as energy supplementation (in the form of pinnies to energy deficient group for three months) Pinnies were prepared from whole wheat flour, semolina, whole soy flour, refined oil, sugar, whole milk powder, and crushed groundnut kernels in the rations. A 60 gram pinni provided 325 kilocalories. The subjects were supplemented with 1.5–3 pinnies according to their energy deficiency.	Hemoglobin: mean difference, −0.10; 95% CI, −0.46 to 0.26

Note: CI = confidence interval; RR = relative risk.

Mauritania, and Morocco), Manyanga and others (2014) found that almost 16 percent of girls and 25 percent of boys were underweight. The highest prevalence of underweight was found in males in Ghana (34 percent), and the lowest was found in females in Egypt (10 percent).

Interventions for Undernutrition

Numerous interventions involving food supplementation have been found to be effective in different age groups, particularly in pregnant women to increase birth weight. However, limited evidence is available for children older than age five years and adolescents. In a study on adolescents (ages 17–19 years) in Peru, Creed-Kanashiro and others (2000) found that a nine-month intervention including participatory training, educational materials, and increased access to heme iron in the first five months reduced anemia. Mann, Kaur, and Bains (2002) supplemented the diet of anemic girls ages 16–20 years in India for three months and found no difference in hemoglobin levels between those consuming adequate and those consuming inadequate calories (table 11.2).

OVERWEIGHT AND OBESITY

Obesity and overweight are consequences of excess food intake, often combined with genetic factors. Childhood obesity and overweight have been linked to severe obesity in adulthood, with a stronger effect on men. Being overweight as an adolescent is strongly associated with obesity as an adult (Ferraro, Thorpe, and Wilkinson 2003). Guo and others (1994) found that white adolescents (age 18 years) with a BMI above the 60th percentile had a 34 percent (male) and 37 percent (female) chance of being overweight at age 35 years. In Sub-Saharan Africa, being overweight as a child has been linked to significant morbidity and mortality as an adult, with higher BMI associated with type 2 diabetes, hypertension, coronary heart disease (although this effect is not independent of the effect of high adult BMI), asthma, polycystic ovary syndrome, and premature mortality (Park and others 2012; Reilly and Kelly 2011). Furthermore, being above or below a healthy weight has been linked to genetic and environmental factors such as maternal height, age, education, household size, and socioeconomic status (Keino and others 2014).

While undernutrition—especially stunting—continues to be a severe problem, particularly in LMICs, the increasing global trend in child overweight and obesity is alarming because countries have to programmatically deal with the double burden of disease. In rapidly developing and urbanizing societies, diets are becoming more energy dense and processed, yet lacking in fiber and multivitamins, while lifestyles are becoming more sedentary (Popkin 1994). In LMICs, the concern is really the exposure to the nutrient mismatch: starting out with poor fetal nutrition or low birth weight and being overweight in early adulthood, in parallel with the nutrition transition (Adair and Cole 2003; Borja 2013). The role of fetal and early childhood development in establishing risk for noncommunicable disease is discussed in detail in *Disease Control Priorities*, third edition (*DCP3*), volume 5, chapter 6 (Afshin and others 2017), while the policies for addressing unhealthy diet and obesity as risk factors for disease are discussed in Mozaffarian and others (2011), as well as in *DCP3* volume 5, chapter 5 (Bull and others 2017) and chapter 7 (Malik and Hu 2017).

Declining physical activity may also be a factor in increasing childhood overweight and obesity. In 85 countries, no more than 50 percent of boys or girls participated in 60 minutes or more of physical activity per day, with the Middle East and North Africa having the lowest ratios for girls (Patton and others 2012). These changes are accompanied by growth that favors urban over rural areas, with the result that overweight and stunted populations reside in the same country (Popkin 1994; Tzioumis and Adair 2014; Usfar and others 2010). This duality can also be found within the same household or even the same person: when energy-dense food is being consumed in a household, an adult could gain weight but be deficient in micronutrients, while a child could lack adequate calories and nutrients and fail to grow appropriately (Tzioumis and Adair 2014).

Prevalence of Overweight and Obesity

Worldwide, from 1980 to 2013, the prevalence of overweight and obesity combined has risen by 27 percent for adults and 47 percent for children (ages 2–19 years) to 37 percent and 13 percent, respectively (Ng and others 2014). Overweight and obesity increased in both LMICs and HICs during this period, increasing to 23 percent from 16 percent for girls and to 24 percent from 17 percent for boys in HICs, and to 13 percent from 8 percent for girls and boys in LMICs. In LMICs, the highest obesity rates are in the Middle East and North Africa, certain Pacific Islands, Caribbean nations, Chile, Costa Rica, Mexico, and Uruguay (Ng and others 2014).

In Latin America and the Caribbean, between 16.5 million and 21.1 million adolescents (ages 12–19 years) were overweight or obese from 2008 to 2013 (Rivera and others 2014). In China, from 2004 to 2009, the prevalence of overweight in boys ages 12–18 years rose from 7.5 percent to almost 13 percent, sedentary activity increased from 2.2 hours to 3.1 hours per day, and energy intake decreased 19 percent (Seo and Niu 2014). Manyanga and others (2014) studied overweight and obesity in students ages 11–18 years in seven African countries and found that 23 percent of girls were overweight and 4.5 percent were obese, compared with 18 percent and 3 percent, respectively, of boys. The highest rates of overweight in females were in Mauritania (36 percent) and Djibouti (9 percent); the lowest rates of overweight in males were in Ghana (7 percent) and Benin (0.3 percent). In Indonesia, 6 percent of children ages 6–14 years and 19 percent of those ages 15 years and older were overweight or obese (Usfar and others 2010). Ogden and others (2006) found equally high rates in HICs.

Interventions for Overweight and Obesity

Interventions to prevent obesity (lifestyle modification) have been found to yield positive results such as lower blood pressure (Cai and others 2014). However, most of the studies are from HICs. Waters and others (2011) found that interventions focusing on nutritional awareness, increased physical activity, and better-quality diets significantly lowered BMI in children ages 6–12 years. The strongest impact was found for interventions focusing on diet and physical activity that were conducted in community and school settings (Bleich and others 2013). Lobelo and others (2013) reviewed technology-based interventions, such as web-based programs, e-learning, and active video games, for healthy weight management and obesity prevention and found positive effects on diet, physical activity, and psychosocial functioning (table 11.3).

Interventions to manage obesity include methods that seek to impart awareness about healthy nutrition and physical activity, behavioral therapy, and use of

Table 11.3 Summary Estimates of Effectiveness of Interventions for Obesity in High-Income Countries

Study	Intervention	Outcome
Obesity prevention: Bhutta and Lassi 2016	Health promotion and education or counseling on diet, physical activity, lifestyle support, and dietary advice	BMI: SMD, –0.05 (–0.11, –0.01); 16 studies, *N* = 14,912
Obesity management: Bhutta and Lassi 2016	Counseling on diet, physical activity, lifestyle support, and dietary advice	BMI at 6 months follow-up: SMD, –3.02 (–5.08, –0.22); 4 studies, *N* = 362
Obesity management: Bazzano and others 2014	Randomized, parallel-group trial with a low-fat or low-carbohydrate diet, with dietary counseling	Participants with a low-carbohydrate diet had a –3.5 kg (95% CI, –5.6 to –1.4 kg) decrease in weight compared with a –1.5% (95% CI, –2.6% to –0.4%) decrease among participants with a low-fat diet at 12 months

Note: BMI = body mass index; CI = confidence interval; kg = kilogram; SMD = standardized mean difference.

medicine (orlistat, sibutramine, and metformin) or surgery. Such interventions have been found to decrease overweight in children and adolescents. Behavioral interventions lasting 12 months had the most effect on decreasing BMI, followed by behavioral interventions combined with medicine (Whitlock and others 2010). When combined with healthy lifestyle counseling, nutritional interventions were found to improve school performance, with increased physical activity linked to improved function, memory, and mathematics achievement (but not to reading, vocabulary, and language achievement); attention; inhibitory control; or simultaneous processing (Martin and others 2014). For severe obesity, behavioral and surgical interventions were found to lower BMI and improve functioning in adolescents, but surgery outperformed behavioral therapy for at least two years of follow-up (Ells and others 2015).

MICRONUTRIENT DEFICIENCIES

Adolescents need more nutrients than adults because they gain at least 40 percent of their adult weight and 15 percent of their adult height during this period. Inadequate intake can lead to delayed sexual development and slower linear growth (Jacob and Nair 2012).

Cognitive growth also depends on micronutrients; B complex vitamins are important in neural communication, and their absence leads to depression (Black 2008). Vitamin B12, folate, and thiamine are important for neural pathways, and deficiency has been linked to impaired episodic memory and language issues (Black 2008). Iron is required for oligodendrocyte growth and neurotransmitter production, and deficiency affects cognition, memory, and social and motor development (Fretham, Carlson, and Georgeiff 2011). Iodine is involved in structural development, and its absence causes mental retardation (Kapil 2007). Zinc is found in the forebrain and hippocampus, and its deficiency is linked to impaired attention, learning, and memory, as well as to possible development of neuropsychological diseases (Nyaradi and others 2013).

Studies have found inconsistent impact of micronutrient supplementation on children ages 5–15 years in LMICs (Khor and Misra 2012). Iron has been shown to affect weight and mid-arm circumference in children older than age six years (Vucic and others 2013). Vitamin D has been linked to a healthy lipid profile, with higher levels associated with low triglycerides and low total cholesterol, including good ratios of low- to high-density cholesterol (Kelishadi, Farajzadegan, and Bahreynian 2014).

Prevalence of Micronutrient Deficiencies

Iron deficiency anemia is one of the top five causes of years lost to disability (YLDs) and accounts for nearly 50 percent of total YLDs for adolescents (ages 10–19 years). It is the top cause of YLDs in boys and girls ages 10–14 years in South-East Asia and in boys in the Americas (WHO 2009). For 13,113 young people in the Islamic Republic of Iran, older adolescents (ages 14–17 years) had lower than recommended intake of vitamin A, calcium, and phosphorus; younger adolescents (ages 11–16 years) had lower than recommended intake of zinc, calcium, phosphorus, magnesium, and folate; and young adults (ages 18–28 years) had lower than recommended intake of folate, iron, and calcium (Akbari and Azadbakht 2014). In China, children younger than age 18 years were found to be deficient in vitamins A, B12, and K, as well as in iodine, iron, selenium, zinc, and calcium (Akbari and Azadbakht 2014). Children and women, including adolescent girls in resource-poor conditions, are especially vulnerable. Wong and others (2014) found lower than recommended intake of vitamins C and A and riboflavin in Asia, vitamin B6 in Africa, and folic acid in all regions studied. However, in Latin America and the Caribbean, the intake of vitamins A, C, B6, and riboflavin was higher than recommended.

Interventions for Micronutrient Deficiencies

Many children and adolescents have a micronutrient-deficient diet, and appropriate nutrient supplements are needed. Nutrients can be provided via tablets, powders sprinkled on food or mixed in water, and fortified spreads or snacks. Such foods need to have adequate amounts of energy and micronutrients, taste good, be clean and hygienic, and have a long shelf life (Nestel and others 2003). There is some indication that supplementation is helpful for healthy children. Multiple-micronutrient supplementation has been associated with a marginal increase in fluid intelligence and improved academic performance; however, more research is needed (Eilander and others 2010).

Given the persistence of iron-deficiency anemia, vitamin A deficiency, and iodine deficiency, food fortification (iron and iodine in salt), diet modification, and public health and disease control measures (deworming and malaria nets) may be needed (Ahluwalia 2002). In older populations, studies have not supported the use of antioxidant vitamins or mineral supplements (Dangour, Sibson, and Fletcher 2004). However, in children, adolescents, and women, iron supplementation has been found to increase attention, concentration, and intelligence (Falkingham and others 2010). In children younger than

Table 11.4 Summary Estimates of the Effectiveness of Micronutrient Interventions

Study	Intervention	Outcome
Bhutta and Lassi 2016 (adolescents)	Daily iron supplementation	Anemia: RR, 0.60 (0.42, 0.86); 1 study, N = 238
	Weekly iron and folic acid supplementation	Anemia: RR, 0.46 (0.23, 0.94); 4 studies, N = 852
	Vitamin A supplementation	Anemia: RR, 0.73 (0.56, 0.93); 1 study, N = 138
	Calcium supplementation	BMD change: MD, 1.09 (–0.15, 2.33); 1 study, N = 53
		BMD change of hip after one-year supplementation: MD, 1.09 (–0.15, 2.33); 1 study, N = 53
		BMD change of hip after one-year supplementation: MD, 1.17 (–0.45, 2.79); 1 study, N = 53
		Mean birth weight: SMD, 0.47 [–0.17, 1.10]; 2 studies, N = 307
	Vitamin D	Serum 25 hydroxy vitamin D (OH)D levels at three years: MD, 8.8 (–2.68, 20.28); 2 studies, N = 588
	Zinc supplementation	Hemoglobin: SMD, 4.81 (0.47, 8.66); 2 studies, N = 494
		Serum zinc: SMD, 4.28 (2.49, 6.06); 3 studies, N = 805
	Iodine supplementation	Thyroid-stimulating hormone: MD, 0.30 (–0.06, 0.66); 1 study, N = 47
	Multiple micronutrients	Anemia: RR, 0.95 (0.76, 1.18); 1 study, N = 113

Note: BMD = bone mineral density; MD = mean difference; RR = relative risk; SMD = standardized mean difference.

age 18 years, calcium supplementation had a small positive effect on total body and upper-limb bone mineral density (Winzenberg and others 2006), but it did not lower the risk of fracture (Falkingham and others 2010). In pubertal girls, calcium supplementation was associated with increased bone mass during 18 months of intervention (Teegarden and Weaver 1994). Iodine supplementation via salt was found to decrease the risk of goiter, cretinism, low intelligence, and low urinary iodine excretion (Aburto and others 2014). More evidence is needed on supplementation for adolescents (table 11.4).

NUTRITION FOR PREGNANT ADOLESCENTS

Nutrition for adolescents is important given that risk of preterm birth, low birth weight, asphyxia, stillbirth, and neonatal death are higher in adolescents than in young adults (ages 20–24 years) (WHO 2016a). Fall and others (2015) analyzed five longitudinal studies from Brazil, Guatemala, India, the Philippines, and South Africa and reported links between maternal and child undernutrition. They also reported adverse health outcomes in adults, including shorter height; less schooling; lower income or assets; lower–birth weight offspring; higher BMI; and harmful glucose concentrations, lipid profiles, and blood pressure. Undernutrition and low birth weight are further linked with some cancers and mental illnesses. Overall, stunting is a strong indicator of lower human capital (WHO 2016b).

Adolescent girls are vulnerable to malnutrition secondary to the potential for pregnancy and socioeconomic adversity. Approximately 16 million girls ages 15–19 years give birth each year, accounting for 11 percent of total births and 23 percent of DALYs attributable to pregnancy and childbirth worldwide (WHO 2016a). Half of all births in this age group occur in seven countries: Bangladesh, Brazil, the Democratic Republic of Congo, Ethiopia, India, Nigeria, and the United States. Early pregnancies have significant health, social, and economic repercussions; 10 percent of all maternal deaths occur in adolescents, and 20 countries with the most adolescent maternal deaths account for 82 percent of all maternal deaths (Verguet and others 2017, chapter 28 in this volume; WHO 2016a). The risk of maternal mortality is higher in adolescents than in young adults ages 20–24 years, and 14 percent of all unsafe abortions occur in adolescents (Nove and others 2014). Pregnant adolescents are more likely to leave school; poorer and less educated adolescents are more likely to become pregnant (Nove and others 2014), which can result in transgenerational socioeconomic disadvantage (WHO 2007). Maternal malnutrition; micronutrient deficiency; obesity; gestational diabetes mellitus; and use of alcohol, tobacco, and psychotropic drugs affect mothers and their babies.

Impaired fetal growth, more common in adolescent pregnancies, has been linked to adult diabetes (Sawyer and others 2012).

Interventions during Pregnancy

Interventions for gestational diabetes mellitus in pregnant women have mixed results. Lassi and Bhutta (2015) found that healthy diet, increased physical activity, and strict glycemic control reduced the risk of gestational diabetes, decreased adiposity, and improved pregnancy outcomes in adolescents and women. However, Yin and others (2014) found no significant impact of physical activity on the risk of gestational diabetes. Mohd Yusof and others (2014) found no significant change in the risk of gestational diabetes with similar interventions, but they did find an association between earlier initiation of intervention and underweight babies. Behavioral therapy added to standard antenatal care can lead to lower gestational weight gain—a risk factor for gestational diabetes—in obese women without comorbid conditions (Mohd Yusof and others 2014). These studies do not provide evidence specifically for adolescent mothers.

Many studies have found that micronutrient supplementation during pregnancy is beneficial. Daily iron supplementation increases mean birth weight and decreases the risk of low-birth weight babies, and preventive iron supplementation decreases the risk of maternal anemia and iron deficiency at term (Pena-Rosas and others 2012). An intermittent regimen of iron and folic acid supplementation has been found to be as efficacious as a daily regimen, but with fewer side effects (Fernandez-Gaxiola and De-Regil 2011). No studies have specifically studied supplementation in pregnant adolescents.

Folic acid supplementation during pregnancy helps prevent neural tube defects (De-Regil and others 2010). It has also been found to decrease the incidence of megaloblastic anemia and increase mean birth weight (Lassi and others 2013). The evidence for vitamin A is mixed. Vitamin A decreases the risk of anemia, improves hemoglobin levels during pregnancy, and improves birth weight for women with human immunodeficiency virus, but it has no effect on other outcomes in pregnant women or infants (Thorne-Lyman and Fawzi 2012). Zinc fortification increases zinc serum levels and may improve growth (Das and others 2013). Vitamin D supplementation increases serum levels (Ota and others 2015). Calcium supplementation in both high- and low-dose regimens reduces hypertensive disorders during pregnancy and preterm births and increases birth weight (Hofmeyr, Belizan, and von Dadelszen 2014). The WHO recommends iodine intake of 250 micrograms per day for pregnant women in iodine-deficient-endemic areas (Zimmermann 2009).

Protein energy supplementation has been found to affect pregnant women in general, especially if they are undernourished. This intervention increases mean birth weight and decreases the risk of low birth weight, small-for-gestational-age births, and stillbirths (Imdad and Bhutta 2012). Again, no studies have been conducted specifically on adolescent mothers. For the majority of micronutrients, evidence could not be found on adolescent populations; therefore, this is an area of research for countries where adolescent pregnancy is still common.

EATING DISORDERS

The American Psychiatric Association (2013) defines an eating disorder as a continuous disturbance of food consumption that leads to either a different pattern of eating or different absorption of food and can cause significant physical or psychological complications. Disorders such as anorexia nervosa, bulimia nervosa, and binge-eating disorder cause nutritional problems including decreased growth, impaired weight gain, and poor oral health (Gonçalves and others 2013). Eating disorders at younger ages (11–17 years) have been linked to eating disorders, overweight, and depression at later ages (17–23 years) (Gonçalves and others 2013).

Anorexia is defined as low self-esteem and a fear of gaining weight; anorexic individuals are frequently severely underweight and amenorrheic (Seidenfeld, Sosin, and Rickert 2004). Anorexia can severely impair bone health, reduce physical and sexual growth, cause hormonal dysfunction, affect cognitive development, and predict future psychological disease (Donaldson and Gordon 2015; Seidenfeld, Sosin, and Rickert 2004). Mortality from anorexia is 12 times higher than mortality from any other cause for American women ages 15–24 years (Herpertz-Dahlmann, Bühren, and Seitz 2011). Bulimia is defined by episodes of binge eating followed by purging through forced vomiting or abuse of diet pills or laxatives and by compensating through excessive exercise (Seidenfeld, Sosin, and Rickert 2004). Adolescents with bulimia have higher suicidal ideation (53 percent of sample) than those with no psychopathology (4 percent) (Sullivan 1995).

Although the majority of the evidence is from HICs, similar patterns have been reported in upper-middle-income countries. Girls are exposed to risk factors beginning in early adolescence. Peer pressure to be thin, thinness as the ideal body image, and dissatisfaction with current body type can increase the chances that adolescents will develop eating disorders (Crow and others 2014). Adolescent girls who binge eat have high functional impairment and comorbid mental health problems. This behavior, along with weight concerns and other behaviors to control weight, were found to be associated with higher BMI two years later in teen girls in the United States (Rohde, Stice, and Marti 2015). Perhaps partly as a result of peer pressure in early adolescence, eating disorders develop most commonly in middle and late adolescence (Portela and others 2012).

Prevalence of Eating Disorders

In 2010, 193.9 million DALYs were attributable to substance abuse and mental disorders (7.4 percent of all DALYs). Eating disorders accounted for 1.2 percent of DALYs attributable to mental and substance abuse. The highest amount of DALYs were reported in persons ages 10–28 years. In the United States, up to 30 million people suffer from eating disorders, with 86 percent of sufferers reporting onset before age 20 years and 43 percent at ages 16–20 years (Whiteford and others 2013). Multiple studies from the United States found that eating disorders were prevalent in 3.6 percent of adolescents and that 63 percent of these individuals had comorbid psychiatric disorders as well (Stice, Marti, and Rohde 2013); lifetime prevalence was 13 percent (Smink and others 2014). For a Dutch cohort of adolescents ages 11–19 years, Smink, van Hoeken, and Hoek (2012) found that lifetime prevalence was 1.7 percent for anorexia, 0.8 percent for bulimia, and 2.3 percent for binge-eating disorder in women; these disorders were rare for men. In the Islamic Republic of Iran, the prevalence of diagnosed eating disorders was 0.25 percent. Boys and girls scored much lower on the eating disorder examination questionnaire when compared with previous studies from Western countries (Nakai and others 2015). Although the occurrence of bulimia nervosa has decreased in recent decades, the overall incidence rate of anorexia nervosa has remained stable (Smink, van Hoeken, and Hoek 2012).

Interventions for Eating Disorders

Interventions that focus on prevention include media literacy and advocacy, psychological education, and self-esteem building (Nakai and others 2015). Interventions that focus on treatment include family therapy, individual therapy, cognitive behavioral therapy, interpersonal psychotherapy, cognitive training, dialectical behavior therapy, and enhanced cognitive behavioral therapy. Only family treatment behavioral therapy has been well established for anorexia. Newer or not well-established therapies include family treatment behavior and supportive individual therapy for bulimia and Internet-delivered cognitive behavioral therapy for binge-eating disorder (Dobbins and others 2013). It is impossible to compare effectiveness because studies use different methods to measure outcomes.

CONCLUSIONS

Malnutrition in adolescence has been a neglected area of research and programming globally. The evidence for effective interventions to address nutritional problems in LMICs is particularly weak. In particular, proven effective responses for stunting, overweight and obesity, and micronutrient deficiencies are not yet available. From HICs, there is some evidence on interventions for eating disorders and obesity, although much further work is needed in these settings as well.

Yet there is an emerging double nutritional threat to child and adolescent health in LMICs. To reduce deficiency-related malnutrition while preventing overweight and obesity, integrated adolescent health programs are needed that prevent infection, improve diet quality, and encourage physical activity. Although the double burden of nutrient deficiency, coupled with overweight and obesity, is increasing in LMICs, policies in most countries focus almost exclusively on undernutrition in multiple forms; only a few countries have implemented national policies to prevent obesity. In view of the rapidly growing number of adolescents who are overweight or obese, the detrimental effects of obesity on health, and the costs to health care systems, programs to monitor and prevent unhealthy weight gain in children and adolescents are urgently needed (Lassi and others 2015).

NOTE

World Bank Income Classifications as of July 2014 are as follows, based on estimates of gross national income (GNI) per capita for 2013:

- Low-income countries (LICs) = US$1,045 or less
- Middle-income countries (MICs) are subdivided:
  a) lower-middle-income = US$1,046 to US$4,125
  b) upper-middle-income (UMICs) = US$4,126 to US$12,745
- High-income countries (HICs) = US$12,746 or more.

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