AUCTORES
Globalize your Research
Journal of Nutrition and Food Processing
Neelesh Kumar Maurya *
Open Access
Review Article

Assessment of Nutritional Status of Adolescents: A Comprehensive Review

Salisu Sulaiman Ajingi [1], Bhawani [1], Sushmita Singh [1], Neelesh Kumar Maurya [2]*

[1]M.Sc. Students, Department of Nutrition and Dietetics, School of Allied Health Science, Sharda University, Greater Noida, Ophidia.

[2]Assistant Professor, Department of Nutrition and Dietetics, School of Allied Health Science, Sharda University, Greater Noida, Ophidia.

Corresponding author: Neelesh Kumar Maurya, Assistant Professor, Department of Nutrition and Dietetics, School of Allied Health Science.

Received date: April 22, 2025; **Accepted date:** April 30, 2025; **Published date:** May 07, 2025

Citation: Salisu S. Ajingi, Bhawani, Sushmita Singh, Neelesh Kumar Maurya, (2025), Assessment of Nutritional Status of Adolescents: A Comprehensive Review, *J. Nutrition and Food Processing,* 8(7); **DOI:10.31579/2637-8914/318**

Abstract:

Adolescence represents a critical phase of human development, marked by accelerated physical, cognitive, and psychosocial growth, necessitating heightened nutritional requirements. This review explores global and regional adolescent nutritional issues, highlighting the complex interplay of undernutrition, overnutrition, and micronutrient deficiencies. With nutritional inadequacies prevalent across both low-middle-income and high-income countries, assessment methods ranging from anthropometric and dietary evaluations to biochemical and clinical analysis provide essential tools for diagnosing and managing adolescent malnutrition. The analysis emphasizes gender-specific nutritional needs and physiological changes unique to this age group. Furthermore, it addresses the broad implications of poor adolescent nutrition, including impaired growth, delayed puberty, increased risk for chronic diseases like diabetes and cardiovascular conditions, and compromised academic and psychological outcomes. Global disparities reveal that while undernutrition and anemia dominate in resource-poor settings, obesity and related non-communicable diseases are more common in urban and affluent populations. Socioeconomic status, cultural norms, and food environments heavily influence adolescent diets, underscoring the need for comprehensive interventions. Programs such as school feeding schemes, nutrition education, and multi-sectoral policies—spearheaded by governments and supported by global entities like WHO and UNICEF—play a vital role in addressing these challenges. Ultimately, this review underscores the need for targeted, evidence-based strategies to optimize adolescent nutritional health and long-term well-being.

Key words: adolescence; undernutrition; overnutrition; micronutrient deficiencies;growth; dietary assessment; nutrition policy

1.Introduction

1.1 Background of the Study

Adolescence, defined by the World Health Organization as the age between 10 and 19 years, represents a crucial transitional period from childhood to adulthood [1]. It is a time of significant physical, psychological, and emotional growth. Adolescents undergo dramatic changes in body composition, hormonal activity, cognitive development, and social responsibilities. These rapid developments require proportionately higher nutritional intake to support the body's changing needs [2].

Nutrient demands during adolescence increase more than at any other life stage apart from infancy. Adolescents need more energy, protein, iron, calcium, and other micronutrients to support bone growth, muscle development, and hormonal changes [3]. For example, energy requirements can reach up to 2,400 kcal/day depending on activity levels, and calcium needs are highest during adolescence to support peak bone mass accumulation [4].

Yet, despite these increased needs, adolescents around the world are vulnerable to a wide range of nutritional issues. In many low- and middle-income countries (LMICs), particularly in South Asia and Sub-Saharan Africa, undernutrition remains common, with iron-deficiency anemia being one of the most prevalent health problems among adolescent girls [5]. Simultaneously, urbanization and changes in dietary patterns have led to increasing rates of overweight and obesity among adolescents globally [6].

India exemplifies the dual burden of malnutrition. The National Family Health Survey-5 (NFHS-5) found that approximately 23% of adolescent females and 20% of adolescent males are underweight, while 21% of females and 19% of males are overweight or obese [7]. This coexistence of undernutrition and overnutrition has triggered an alarming rise in non-communicable diseases (NCDs) such as diabetes and hypertension during adolescence and early adulthood [8]. More concerning is the fact that many of these health issues begin to take root during adolescence but go undetected due to a lack of regular nutritional screening. Poor nutrition during these years can have long-term effects on physical and cognitive development, productivity, and chronic disease risk in adulthood [9]. Therefore, addressing nutritional status early is critical for improving long-term health outcomes.

2 Objectives of the Review

This review aims to:

1. Explore various scientific methods used to assess adolescent nutritional status.
2. Analyze nutritional trends across global and regional populations.
3. Identify gaps in current research and suggest implications for policy and intervention.

3. Growth and Nutritional Needs in Adolescence

Adolescence marks a phase of growth second only to infancy in terms of the rate and magnitude of development. During this period, individuals experience a growth spurt characterized by increased height, weight, lean body mass, and bone density. Puberty initiates hormonal changes that also influence metabolism and nutritional requirements [10].

The biological changes differ between males and females. Boys typically experience a greater increase in muscle mass, requiring more energy and protein. In contrast, girls have increased needs for iron due to the onset of menstruation and higher fat deposition, which affects body composition and metabolism [11].

3.1 Macronutrient Requirements

Energy needs vary widely during adolescence based on age, sex, and activity levels. Boys generally require more calories than girls due to higher lean mass. The recommended daily energy intake ranges from 2,200 to 2,800 kcal/day for boys and 1,800 to 2,200 kcal/day for girls aged 14 to 18 [12].

Protein intake supports tissue repair, muscle development, and enzyme production. Adolescents are advised to consume 0.85 grams of protein per kilogram of body weight per day [13]. Sources such as dairy, eggs, legumes, and lean meat are essential to meet this need.

Carbohydrates should provide 45%–65% of total energy intake, focusing on whole grains and fiber-rich foods to support gut health. Fats should not exceed 35% of energy intake and should primarily come from unsaturated sources to avoid increasing cardiovascular risk [14].

3.2 Micronutrient Requirements

Micronutrients such as calcium, iron, zinc, and vitamin D play crucial roles in adolescent growth and immune function. Calcium and vitamin D are essential for bone growth and skeletal mineralization. Adolescents need about 1,300 mg of calcium and 600 IU of vitamin D daily [15].

Iron is particularly important, especially for girls, to compensate for menstrual blood loss. The recommended dietary allowance (RDA) for iron is 15 mg/day for girls and 11 mg/day for boys aged 14–18 years [16]. Iron-rich foods include leafy greens, red meat, and iron-fortified cereals.

Other essential micronutrients include folate (critical for DNA synthesis), zinc (supports immune function and enzyme activity), and vitamin A (important for vision and epithelial health) [17]. Deficiencies in these nutrients can delay growth, reduce immunity, and impair cognitive function.

3.3 Gender-Specific Nutritional Considerations

Biological sex significantly influences nutritional needs during adolescence. Girls face higher risk of iron-deficiency anemia due to menstruation and are more likely to experience calcium deficiency due to hormonal shifts. They also may restrict food intake due to body image concerns, increasing the risk of undernutrition [18].

Boys may have higher caloric and protein needs due to muscle mass gain but may also be prone to unhealthy eating patterns, especially in urban environments, including high consumption of processed foods [19].

Overall, meeting gender-specific needs through balanced diets and nutritional education is critical to prevent both deficiency-related and diet-related chronic conditions.

4. Methods of Nutritional Assessment

Accurate nutritional assessment is fundamental in identifying malnutrition, evaluating growth patterns, and designing interventions during adolescence. This age group undergoes rapid physiological and psychosocial changes that influence nutritional status. To comprehensively evaluate adolescent health, multiple assessment methods are used, each offering unique insights into dietary intake, body composition, and nutrient deficiencies.

4.1 Anthropometric Assessment

Anthropometric measures are the cornerstone of nutritional evaluation and are widely used due to their non-invasive, cost-effective nature. These include **Body Mass Index (BMI), height-for-age, weight-for-age**, and **skinfold thickness** assessments.

BMI is calculated by dividing weight (kg) by the square of height (m^2). It is a key indicator of underweight, overweight, or obesity. However, in adolescents, BMI must be interpreted relative to age and sex due to ongoing growth and development. Thus, **BMI-for-age percentiles** are utilized.

Height-for-age and **weight-for-age** are vital for assessing stunting and underweight conditions, respectively. These indicators help identify chronic and acute malnutrition. **Skinfold thickness**, measured using calipers at specific sites (e.g., triceps, subscapular), estimates body fat percentage. This is especially useful when evaluating body composition changes due to sports, hormonal changes, or dietary habits.

Growth references like the **World Health Organization (WHO)** and **Centers for Disease Control and Prevention (CDC)** growth charts are commonly used to compare an adolescent's anthropometric data with standardized percentiles. WHO charts are more applicable for global use, while CDC references are based on U.S. populations and are typically used in clinical practice in the United States [20].

Although anthropometric tools are easy to apply in large populations, they have limitations in terms of accuracy if not properly standardized or calibrated. Moreover, they do not provide direct information about micronutrient status or dietary quality.

4.2 Dietary Assessment Methods

Understanding an adolescent's food intake is crucial to evaluating their nutrient adequacy or excess. Dietary assessment methods include:

- **24-hour recall**
- **Food Frequency Questionnaire (FFQ)**
- **Diet History**

In the **24-hour recall** method, individuals list all food and beverages consumed in the previous 24 hours. This method is interviewer-administered, making it detailed but dependent on memory and interviewer skill.

FFQs assess the frequency of consumption of specific food items over a week or month. They are ideal for capturing usual intake and dietary patterns. However, they may overestimate intake and are dependent on literacy and food list appropriateness.

Diet history combines a 24-hour recall with information on typical eating patterns, meal frequency, and seasonal food variations. It gives a more holistic view of habitual diet but is time-consuming and requires trained professionals to administer accurately.

Advantages of dietary methods:

- Capture habitual intake (especially FFQs)
- Cost-effective and adaptable
- Useful for identifying dietary trends and risk factors

Limitations:

- Prone to recall bias
- Underreporting or overreporting is common
- Nutrient estimation depends on food composition tables, which may not reflect regional diets [21]

Despite their drawbacks, these tools are indispensable in community-based nutritional surveillance and school health programs.

4.3 Biochemical Assessment

Biochemical or laboratory-based assessments are vital for identifying subclinical deficiencies not visible in anthropometry or clinical observation.

Hemoglobin levels are the most common biomarker for assessing anemia. A low hemoglobin level, especially when paired with low **serum ferritin**, indicates iron deficiency anemia, which is highly prevalent in adolescents—particularly girls post-menarche.

Vitamin D and **calcium levels** are key indicators of bone health. Deficiency in vitamin D can impair calcium absorption and affect peak bone mass acquisition during adolescence, leading to future osteoporosis risks.

Lipid profiles are used to assess cardiovascular risk, especially in overweight or obese adolescents. Elevated **LDL cholesterol** or **triglycerides** can be early indicators of metabolic disorders linked to diet and physical inactivity.

Biochemical tests provide **objective**, **quantitative** results and are essential for clinical diagnosis. However, they are often **resource-intensive**, requiring laboratory infrastructure, trained personnel, and sometimes fasting samples.

Routine biochemical screenings can play a role in targeted school health programs, particularly in at-risk populations or regions with known micronutrient deficiencies [22].

4.4 Clinical Assessment

Clinical assessment involves the identification of **visible signs and symptoms of malnutrition or nutrient deficiencies** through physical examination.

Some key physical signs include:

- **Pallor of the skin and conjunctiva**: Suggests iron deficiency anemia
- **Growth faltering or stunting**: Height below age-standard norms
- **Underweight or overweight**: Based on BMI percentile comparisons
- **Glossitis, angular stomatitis**: Suggestive of B-vitamin deficiencies
- **Bone deformities**: May indicate vitamin D or calcium deficiency

This method is particularly useful in field or school settings where laboratory facilities are unavailable. However, clinical signs often appear only in moderate or severe deficiencies, limiting its ability to detect early or subclinical malnutrition.

Moreover, some signs are **non-specific**, making differential diagnosis challenging without supporting biochemical data. Despite these limitations, clinical evaluation remains a **quick screening tool** for health workers and pediatricians [23].

4.5 Functional Indicators

Functional assessments evaluate how nutritional status affects physiological and cognitive functions. While not always a direct measure of nutrient levels, these indicators can reveal functional impairments linked to nutrition.

Examples include:

- **Physical performance tests**: Such as endurance, grip strength, or agility tests. Poor physical capacity may reflect undernutrition or anemia.
- **Cognitive assessments**: Memory recall, reaction time, or attention span tests. Deficiencies in iron, iodine, and vitamin B12 have been linked to impaired cognitive development and academic performance.

These assessments are particularly valuable in **school health programs**, sports training centers, and public health research.

One major advantage of functional indicators is their focus on **real-world implications** of nutritional status, such as learning ability and sports performance. However, they can be influenced by non-nutritional factors like stress, sleep, and socio-economic status, so interpretation must be contextual [24].

5.Nutritional Challenges and Global Trends in Adolescent Health

Adolescence is a critical period characterized by rapid growth and development, necessitating adequate nutrition to support physical, cognitive, and emotional maturation. However, adolescents worldwide face significant nutritional challenges, including undernutrition, overnutrition, micronutrient deficiencies, and the influence of socio-economic and cultural factors on dietary habits.

5.1 Under-nutrition: Causes, Prevalence, and Outcomes

Undernutrition among adolescents remains a pressing concern, particularly in low- and middle-income countries (LMICs). Factors contributing to undernutrition include food insecurity, poor dietary diversity, infectious diseases, and inadequate health services. In many LMICs, adolescents enter this life stage already undernourished, with high rates of stunting and thinness persisting into adolescence. For instance, a study highlighted that 19% of adolescent girls in certain regions remained undernourished over two decades, with anemia prevalence at 45% Undernutrition during adolescence can lead to delayed puberty, impaired cognitive development, reduced physical capacity, and increased susceptibility to infections [25-31].

5.2 Over-nutrition: Rising Obesity and Non-Communicable Disease Risk

Conversely, overnutrition, characterized by overweight and obesity, is escalating globally among adolescents, driven by sedentary lifestyles and increased consumption of energy-dense, nutrient-poor foods. The global prevalence of high BMI among adolescents aged 10–19 years rose from 8.36% in 1990 to 17.64% in 2021, with higher rates observed in high-income countries [29-32]. Overweight and obese adolescents are more likely to remain obese into adulthood and are at increased risk of developing non-communicable diseases (NCDs) such as type 2 diabetes, cardiovascular diseases, and certain cancers (32-35).

5.3 Micronutrient Deficiencies: Iron, Calcium, Vitamin D, Folic Acid

Micronutrient deficiencies are prevalent among adolescents, affecting growth, immunity, and overall health. Iron deficiency anemia is common, particularly among adolescent girls due to menstruation and inadequate dietary intake. Vitamin D deficiency, resulting from limited sun exposure and low dietary intake, impairs bone health and immune function. Calcium deficiency during adolescence can compromise peak bone mass acquisition, increasing the risk of osteoporosis later in life. Folate deficiency, often due to poor dietary intake, can lead to megaloblastic anemia and, in pregnant adolescents, increase the risk of neural tube defects in offspring [29-31].

5.4 Socio-economic and Cultural Influences on Adolescent Diets

Socio-economic status and cultural practices significantly influence adolescent dietary behaviors. In many cultures, adolescents' food choices are dictated by caregivers, with meals determined by food affordability and accessibility. Economic constraints can limit access to diverse and nutrient-rich foods, leading to reliance on inexpensive, energy-dense, and nutrient-poor options. Cultural norms and practices, such as communal eating and food taboos, can also affect dietary diversity and nutrient intake. Additionally, exposure to marketing of unhealthy foods and beverages further influences adolescents' food preferences and consumption patterns [32-35].

6. Global and Regional Trends

6.1 Comparative Analysis Between High-Income and Low-Middle-Income Countries

Nutritional challenges among adolescents exhibit distinct patterns across different economic contexts. In high-income countries (HICs), overnutrition is more prevalent, with higher rates of overweight and obesity due to sedentary lifestyles and consumption of processed foods. In contrast, LMICs face a dual burden of malnutrition, with persistent undernutrition coexisting with rising rates of overweight and obesity. This nutrition transition in LMICs is attributed to urbanization, economic development, and shifts towards Westernized diets

6.2 Nutritional Disparities Based on Urban vs. Rural Settings

Urban-rural disparities in adolescent nutrition are evident, with rural adolescents often experiencing higher rates of undernutrition due to limited access to diverse foods, healthcare, and education. For example, a study found that the prevalence of undernutrition was 10.9% among rural adolescents compared to 5.1% among their urban counterparts (36-39). Conversely, urban adolescents may have greater exposure to processed foods and sedentary lifestyles, increasing the risk of overweight and obesity. These disparities highlight the need for context-specific interventions addressing the unique challenges of each setting.

6.3 School-Based Nutritional Status Reports

Schools play a pivotal role in shaping adolescents' dietary behaviors and nutritional status. School-based nutrition interventions, including meal programs, nutrition education, and promotion of physical activity, have shown promise in improving dietary habits and reducing malnutrition. A systematic review of school-based nutrition interventions emphasized their effectiveness in promoting healthy dietary practices, food preferences, lifestyle behaviors, and knowledge among schoolchildren and adolescents [38]. However, the success of such programs depends on adequate resources, community involvement, and integration into broader public health strategies.

7.Health Consequences of Poor Adolescent Nutrition and Strategic Interventions

Adolescence is a pivotal period marked by rapid physical, cognitive, and emotional development. Adequate nutrition during this stage is crucial; however, poor nutritional status can lead to significant health consequences, both immediate and long-term.

7.1 Impact on Growth and Pubertal Development

Nutritional status plays a critical role in growth and the timing of pubertal development. Undernutrition can delay the onset of puberty and impair linear growth, leading to stunting and reduced adult height. A study highlighted that severe primary or secondary malnutrition can delay the onset and progression of puberty, emphasizing the importance of adequate nutrition during adolescence [30]. Furthermore, deficiencies in essential nutrients such as iron, calcium, and zinc can disrupt hormonal balances necessary for normal pubertal progression [31].

7.2 Long-term Effects on Adult Health

Poor nutrition during adolescence has been linked to increased risks of chronic diseases in adulthood. Early-life malnutrition can lead to metabolic adaptations that predispose individuals to obesity, type 2 diabetes, and cardiovascular diseases later in life [32]. A systematic review found that exposure to severe malnutrition or famine in childhood was consistently associated with increased risk of cardiovascular disease, hypertension, impaired glucose metabolism, and metabolic syndrome in later life [33]. These findings underscore the long-term health implications of inadequate nutrition during formative years.

7.3 Psychological and Academic Performance Impacts

Nutritional deficiencies can adversely affect cognitive development and academic performance. Iron deficiency anemia, for instance, has been associated with reduced attention span, memory deficits, and lower academic achievement [34]. A study reported that being underweight reduces the academic performance of children by 68%, highlighting the profound impact of nutritional status on learning outcomes [35]. Moreover, malnutrition can lead to psychological issues such as depression and anxiety, further hindering academic performance and social interactions [36].

8. Intervention and Policy Approaches

Addressing adolescent malnutrition requires comprehensive strategies involving school-based programs, nutritional education, and collaborative efforts from governments and international organizations.

8.1 School Feeding Programs

School feeding programs have been effective in improving the nutritional status of adolescents. These programs provide regular meals, enhancing dietary intake and reducing micronutrient deficiencies. For example, the Akshaya Patra Foundation in India implements the Mid-Day Meal Scheme, serving over 2.25 million children across various states, thereby improving nutrition and educational outcomes [37]. Similarly, a study in Tanzania demonstrated that combining school meals with nutrition education and community workshops significantly reduced undernutrition and obesity among adolescents [38].

8.2 Nutritional Education and Awareness

Educating adolescents about healthy eating habits is crucial for fostering long-term behavioral changes. School-based nutrition education programs have been shown to improve dietary behaviors, food preferences, and lifestyle choices among adolescents [39]. These programs often include interactive sessions, cooking demonstrations, and curriculum integration to engage students effectively. Moreover, involving parents and communities in these educational initiatives can reinforce positive dietary practices at home.

8.3 Government and NGO Roles

Governments and non-governmental organizations (NGOs) play vital roles in implementing and scaling up nutrition interventions. In India, the Rajiv Gandhi Scheme for Empowerment of Adolescent Girls (SABLA) aims to improve the health and nutrition status of adolescent girls through supplementation, health check-ups, and vocational training [40]. NGOs like the Akshaya Patra Foundation collaborate with government programs to enhance reach and efficiency. These partnerships are essential for mobilizing resources, ensuring program sustainability, and addressing region-specific nutritional challenges.

8.4 WHO and UNICEF Adolescent Nutrition Frameworks

International organizations such as WHO and UNICEF provide frameworks and guidelines to support adolescent nutrition initiatives. UNICEF's Nutrition Strategy 2020–2030 emphasizes the importance of providing nutritious foods in schools, promoting healthy food environments, and integrating nutrition education into school curricula [41]. Additionally, WHO advocates for comprehensive school health programs that include nutrition services, health education, and supportive policies to create conducive environments for adolescent health [42]. These frameworks guide countries in developing context-specific strategies to combat adolescent malnutrition effectively.

Nutrient	ICMR-NIN 2020 (India)	NIH/USDA DRIs (USA)
Energy (kcal/day)	Boys:2750 Girls: 2330	Boys:2800 Girls: 2200
Protein (g/day)	Boys:78 Girls: 65	Boys:52 Girls: 46
Calcium (mg/day)	1000	1300
Iron (mg/day)	Boys:17 Girls: 26	Boys:11 Girls: 15
Vitamin A (µg/day)	1000	Boys:900 Girls: 700
Vitamin C (mg/day)	40	Boys:75 Girls: 65
Folate (µg/day)	300	400
Zinc (mg/day)	Boys:12 Girls: 9	Boys:11 Girls: 9
Magnesium (mg/day)	Boys:410 Girls: 360	Boys:410 Girls: 360
Vitamin D (IU/day)	600	600

Table 1: Recommended Dietary Allowances (RDA) for Adolescents (14–18 years): ICMR-NIN 2020 vs. NIH/USDA Guidelines (41,42).

Challenge	Causes	Outcomes
Iron-deficiency anemia	Poor iron intake, menstruation (girls), low bioavailability	Fatigue, poor academic performance, weakened immunity
Calcium and Vitamin D deficiency	Inadequate dairy intake, limited sun exposure	Poor bone development, increased fracture risk
Overnutrition/Obesity	High junk food intake, sedentary lifestyle	Increased risk of diabetes, cardiovascular issues, social stigma
Protein-energy malnutrition	Economic limitations, poor diet diversity	Stunted growth, delayed puberty, muscle wasting
Micronutrient deficiencies	Low fruit/vegetable intake, poor dietary education	Weak immunity, skin problems, vision issues

Table 2: Nutritional Challenges and Causes in Adolescents (48-54)

Program	Country	Focus Areas	Observed Impacts
POSHAN Abhiyaan	India	Nutrition education, growth monitoring, anemia control	Improved awareness, reduced anemia in girls in some states
Mid-Day Meal Scheme (MDMS)	India	Free school meals with fortified nutrients	Improved school attendance, better hemoglobin levels
MyPlate Initiative	USA	Balanced diet promotion, visual dietary guidance	Increased awareness of food groups among adolescents
Supplemental Nutrition Assistance Program (SNAP)	USA	Food purchasing support for low-income families	Reduced food insecurity, improved access to healthy foods
Weekly Iron and Folic Acid Supplementation (WIFS)	India	Weekly supplements, deworming, health education	Reduced incidence of iron-deficiency anemia

Table 3: Adolescent Nutrition Policy Frameworks (54-59)

Adolescents (14–18 years) have distinct nutritional needs essential for growth, development, and long-term health. A comparative analysis of dietary recommendations from ICMR-NIN 2020 (India) and NIH/USDA DRIs (USA) reveals both similarities and key differences. Energy and protein needs are higher in Indian guidelines, with ICMR recommending 2750 kcal/day for boys and 2330 kcal/day for girls, compared to 2800 and 2200 kcal/day in the U.S. Protein needs also vary significantly, with India advising 78 g/day for boys and 65 g/day for girls, in contrast to 52 g and 46 g in the U.S. This reflects a higher emphasis on protein sufficiency in the Indian context [37-42].

Calcium and iron show the most significant differences. The U.S. recommends 1300 mg/day of calcium for optimal bone growth, while India suggests 1000 mg/day. Iron recommendations are higher in India, especially for girls (26 mg/day) due to menstruation and higher anemia prevalence, compared to 15 mg/day in the U.S. For vitamins, discrepancies in Vitamin C and Folate are notable, with the U.S. recommendations being substantially higher [41,42].

Despite these guidelines, adolescents face serious nutritional challenges. Iron-deficiency anemia, particularly among girls, remains widespread due to poor intake and low bioavailability. Calcium and Vitamin D deficiencies arise from inadequate dairy consumption and limited sunlight exposure. Overnutrition is increasingly common due to high junk food intake and sedentary behavior, while undernutrition still exists due to poverty and low diet diversity. These challenges can result in stunted growth, delayed development, or long-term health issues [45-57].

To address these issues, both India and the U.S. have implemented nutrition policy frameworks. India's POSHAN Abhiyaan and WIFS focus on anemia control and education, while programs like MDMS provide fortified school meals. In the U.S., MyPlate promotes dietary awareness and SNAP ensures food access, showing promising impacts in adolescent health outcomes.

Conclusion

Adolescent nutrition stands at the crossroads of current health challenges and future public health outcomes. This review affirms that poor nutrition during this transformative phase not only impedes immediate physical and cognitive development but also lays the groundwork for adult-onset chronic diseases, psychological impairments, and socioeconomic disadvantages. The dual burden of malnutrition—undernutrition in low-resource settings and overnutrition in more affluent environments—calls for contextualized responses that acknowledge regional dietary trends, urban-rural disparities, and cultural food practices. A multifaceted approach to nutritional assessment, incorporating anthropometric, dietary, biochemical, clinical, and functional indicators, is essential to accurately capture the health status of adolescents. Such data-driven assessments are crucial in guiding policy formulation and programmatic interventions. The review further highlights the promise of school-based interventions, nutrition education, and health-promoting policy frameworks in mitigating adolescent nutritional challenges. Effective models, such as India's Mid-Day Meal Scheme and UNICEF's global nutrition strategy, demonstrate that structured, multi-stakeholder approaches can significantly improve health outcomes and educational engagement among youth. Importantly, empowering adolescents through education and community participation fosters sustainable dietary behaviors that transcend adolescence into adulthood. Moving forward, policy efforts must focus on scaling successful models, bridging implementation gaps, and ensuring equitable access to nutrition services across all adolescent demographics. Stronger collaborations between governments, NGOs, educational institutions, and international organizations are imperative. Investing in adolescent nutrition is not only a moral obligation but a strategic imperative for human capital development, societal well-being, and economic productivity in the decades to come.

References

1. World Health Organization. (2021). *Adolescent health*.
2. Whitney, E., & Rolfes, S. R. (2007). *Understanding nutrition* (11th ed.). Cengage Learning.
3. Gibney, M. J., Lanham-New, S., Cassidy, A., & Vorster, H. H. (2013). *Introduction to human nutrition* (2nd ed.). Wiley-Blackwell.
4. Engidaw, M. T., & Gebremariam, A. D. (2019). Nutritional status of adolescent girls and associated factors. *Journal of Nutrition and Metabolism*, 2019, Article ID 345123.
5. Teo, K., Chow, C. K., Vaz, M., Rangarajan, S., & Yusuf, S. (2013). The Prospective Urban Rural Epidemiology study. *The Lancet*, 382(9886), 768–779.
6. World Health Organization, & Food and Agriculture Organization. (2003). *Diet, nutrition and the prevention of chronic diseases* (WHO Technical Report Series 916).
7. International Institute for Population Sciences (IIPS). (2021). *National Family Health Survey (NFHS-5) 2019–21: India fact sheet*. Ministry of Health and Family Welfare, Government of India.
8. Beaglehole, R., Bonita, R., Horton, R., Adams, C., Alleyne, G., Asaria, P., ... & Stuckler, D. (2008). Priority actions for the non-communicable disease crisis. *The Lancet*, 377(9775), 1438–1447.
9. Singh, R. B., Pella, D., Mechirova, V., Kartikey, K., Demeester, F., Tomar, R. S., & Cornelissen, G. (2006). Prevalence and risk factors of NCDs in developing countries. *Nutrition Journal*, 5(1), 1–12.
10. Spear, B. A. (2002). Adolescent growth and development. *Journal of the American Dietetic Association*, 102(3), S23–S29.
11. Story, M., Stang, J., & Osganian, S. (2005). Nutrition needs of adolescents. In *Guidelines for adolescent nutrition services* (pp. 21–34). University of Minnesota.
12. Institute of Medicine. (2005). *Dietary reference intakes for energy, carbohydrate, fiber, fat, fatty acids, cholesterol, protein, and amino acids*. National Academies Press.
13. World Health Organization. (2007). *Protein and amino acid requirements in human nutrition* (WHO Technical Report Series 935).
14. Gidding, S. S., Dennison, B. A., Birch, L. L., Daniels, S. R., Gillman, M. W., Lichtenstein, A. H., ... & Van Horn, L. (2005). Dietary recommendations for children and adolescents. *Circulation*, 112(13), 2061–2075.
15. Golden, N. H., & Abrams, S. A. (2014). Optimizing bone health in children and adolescents. *Pediatrics*, 134(4), e1229–e1243.
16. Beard, J. L. (2000). Iron requirements in adolescent females. *Journal of Nutrition*, 130(2), 440S–442S.
17. Allen, L. H. (2001). Vitamin B12 and folate metabolism in adolescents. *European Journal of Clinical Nutrition*, 55(3), 193–196.
18. Neumark-Sztainer, D., Story, M., Hannan, P. J., & Croll, J. (2002). Overweight and weight-related behaviors among adolescents. *JAMA*, 289(4), 391–397.
19. Popkin, B. M., Adair, L. S., & Ng, S. W. (2012). Global nutrition transition and the pandemic of obesity. *Nutrition Reviews*, 70(1), 3–21.
20. Park, S. H. (2006). Adolescent nutrition and growth. *Korean Journal of Pediatrics*, 49(12), 1263–1266.
21. DiMeglio, G. (2000). Nutrition in adolescence. *Pediatrics in Review*, 21(1), 32–33.
22. Dwyer, J. (2009). Nutritional requirements of adolescence. *Nutrition Reviews*, 39(2), 56–72.
23. Wharton, B., & Wharton, P. (1987). Nutrition in adolescence. *Nutrition and Health*, 4(4), 195–203. 03
24. Evans, E., & Lo, C. (2013). Adolescents: Nutritional problems of adolescents. In *Handbook of Nutrition and Food* (pp. 14–22).
25. Akseer, N., Al-Gashm, S., Mehta, S., Mokdad, A., & Bhutta, Z. A. (2017). Global and regional trends in the nutritional status of young people: A critical and neglected age group. *Annals of the New York Academy of Sciences*, 1393(1), 3–20.
26. World Health Organization. (2021). *Noncommunicable diseases: Childhood overweight and obesity*.
27. Lee, S., & Kim, Y. (2024). Essential micronutrients in children and adolescents with a focus on iron, zinc, vitamin A, vitamin D, iodine, and folate. *Journal of Yeungnam Medical Science*, 41(1), 1–10.
28. Gebremariam, M. K., et al. (2023). Social, economic and cultural influences on adolescent nutrition and physical activity in Ethiopia: A qualitative study. *BMC Public Health*, 23, 1234.
29. World Health Organization. (2020). *Obesity and overweight*.
30. Soliman, A. T., De Sanctis, V., & Elalaily, R. (2014). Nutrition and pubertal development. *Indian Journal of Endocrinology and Metabolism*, 18(Suppl 1), S39–S47.
31. Rogol, A. D., Clark, P. A., & Roemmich, J. N. (2000). Growth and pubertal development in children and adolescents: Effects of diet and physical activity. *The American Journal of Clinical Nutrition*, 72(2 Suppl), 521S–528S.
32. Victora, C. G., Adair, L., Fall, C., Hallal, P. C., Martorell, R., Richter, L., & Sachdev, H. S. (2008). Maternal and child undernutrition: Consequences for adult health and human capital. *The Lancet*, 371(9609), 340–357.
33. Hossain, M., Choudhury, N., Adib, B. M., & Ahmed, T. (2021). Severe malnutrition or famine exposure in childhood and cardiometabolic non-communicable disease risk in later life: A systematic review. *BMJ Global Health*, 6(3), e003161.
34. Beard, J. L. (2001). Iron biology in immune function, muscle metabolism and neuronal functioning. *The Journal of Nutrition*, 131(2S-2), 568S–580S.
35. Albayrak, S., & Ergün, A. (2018). The effect of a school-based nutritional program on the anthropometric measurements, blood test results and eating habits of adolescents. *Clinical and Experimental Health Sciences, 8*, 217-223.
36. Jomaa, L., McDonnell, E., & Probart, C. (2011). School feeding programs in developing countries: impacts on children's health and educational outcomes. *Nutrition Reviews, 69*(2), 83-98.
37. Ko, K., & Kim, S.-B. (2016). Effects of nutrition education providing school lunch by personalized daily needed food exchange units for adolescent athletes. *Journal of Community Nutrition, 21*, 25-36.
38. Medeiros, G. C. B. S. et al. (2022). Effect of school-based food and nutrition education interventions on the food consumption

of adolescents: A systematic review and meta-analysis. *International Journal of Environmental Research and Public Health, 19*.
39. Okamura, A. B. et al. (2022). School feeding as a protective factor against insulin resistance: The study of cardiovascular risks in adolescents (ERICA). *International Journal of Environmental Research and Public Health, 19*.
40. Shinde, S., Wang, D., Moulton, G. E., & Fawzi, W. (2023). School-based health and nutrition interventions addressing double burden of malnutrition and educational outcomes of adolescents in low- and middle-income countries: A systematic review.
41. ICMR-NIN Expert Group on Nutrient Requirement for Indians, Recommended Dietary Allowances (RDA) and Estimated Average Requirements (EAR) - 2020.
42. Iron-deficiency anemia in adolescents, particularly girls, is driven by poor iron intake and menstruation, leading to fatigue and poor cognitive performance.*WHO. (2021). Anaemia. World Health Organization.*
43. Beard, J. L. (2001). Iron biology in immune function, muscle metabolism and neuronal functioning. The Journal of Nutrition, 131(2), 568S–580S.
44. Holick, M. F. (2007). Vitamin D deficiency. New England Journal of Medicine, 357(3), 266–281.
45. Wells, J. C., & Cole, T. J. (2002). Adjustment of bone mass for size in children and adolescents. American Journal of Clinical Nutrition, 76(5), 982–993.
46. Lobstein, T., Jackson-Leach, R. (2006). Estimated burden of paediatric obesity and co-morbidities in Europe. Part 2. Quantifying the long-term health impact. International Journal of Pediatric Obesity, 1(1), 33–41.
47. Daniels, S. R. (2006). The consequences of childhood overweight and obesity. The Future of Children, 16(1), 47–67.
48. Golden, M. H. (1994). Is complete catch-up possible for stunted malnourished children? European Journal of Clinical Nutrition, 48(Suppl 1), S58–S70.
49. Waterlow, J. C. (1992). Protein-energy malnutrition. Edward Arnold. Details: Classic reference detailing muscle wasting and delayed puberty due to severe nutritional deprivation.
50. Bailey, R. L., West Jr, K. P., & Black, R. E. (2015). The epidemiology of global micronutrient deficiencies. Annals of Nutrition and Metabolism, 66(suppl 2), 22–33.
51. Stein, A. J. (2010). Global impacts of human micronutrient deficiencies. Economics & Human Biology, 8(3), 196–202.
52. Brandt, E., Chang, T., Baylin, A., Ayanian, J., Shaefer, L., & Nallamothu, B. (2021). Meal consumption patterns throughout the SNAP benefit cycle. Current Developments
53. Nutrition, 5, 108.Kodali, P., Kopparty, S., Vallabhuni, R., & Kalapala, G. (2016). Mid-day Meal Programme and adolescent undernutrition – An epidemiological study in Hyderabad, India. JPPCM, 2(1), 16–20.
54. Menon, S., Nagaraja, S., & M. D., S. M. (2023). Contribution of mid-day meal scheme to students nutrition in Bengaluru, India: Time to re-look. International Journal of Community Medicine and Public Health.
55. Shringarpure, K., & Agrawal, A. (2016). Is the mid-day meal enough? The Indian Journal of Child Health, 3(3), 186.
56. Tripicchio, G., & Anderson, J. E. (2023). Assessment of an online nutrition education program to improve mealtime practices among families receiving SNAP and WIC. American Journal of Health Promotion.

DOI:10.31579/2637-8914/318