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EDITORS:
MR. SANJAY KALEKAR
DR. PRIYANKA BHARDWAJ
DR. SAPNA KASLIWAL
MS. SWEETY THAKKAR

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Editors

Mr. Sanjay Kalekar

Department of English,

Daar-Ul-Rehmat Trust's A. E. Kalsekar Degree College, Kausa-Mumbra, Thane

Dr. Priyanka Bhardwaj

Rabindranath Tagore University,

Raisen,

Madhya Pradesh

Dr. Sapna S. Kasliwal

Department of Commerce,

Government College,

Rau (Indore), Madhya Pradesh

Ms. Sweety Thakkar

Faculty of Commerce & Management,

Vishwakarma University,

Pune, Maharashtra

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LIFE-SPAN NUTRITION: DIETARY REQUIREMENTS AND HEALTH CONSEQUENCES FROM INFANCY TO AGEING

Ruchi Chaudhary*[1], Trapti Pandey[1] and Shiv Pratap Singh[2]

[1]Department of Home Science,

[2]Department of Botany,

School of Sciences, IFTM University, Moradabad, 244102 India

*Corresponding author E-mail: ruchichahal1987@gmail.com

Abstract:

Life-span nutrition highlights the importance of suitable and balanced dietary intake at every stage of human development, from infancy to old age, to promote optimal growth, health, and longevity. Nutritional requirements vary across life stages due to physiological growth, hormonal changes, metabolic demands, and ageing processes. Early-life nutrition, particularly during infancy and childhood, plays a critical role in physical growth, brain development, immune maturation, and metabolic programming, influencing health outcomes in adulthood. Adolescence represents a period of increased nutritional vulnerability due to rapid growth and heightened micronutrient requirements, while adulthood nutrition focuses largely on disease prevention and maintenance of metabolic health. Pregnancy and lactation impose additional nutritional demands with intergenerational consequences for maternal and child health. Ageing is associated with physiological changes that alter nutrient needs, increasing the risk of malnutrition, sarcopenia, osteoporosis, and micronutrient deficiencies. This chapter adopts a life-course perspective to review stage-specific dietary requirements and their implications for health and disease prevention. Emphasis is placed on the role of balanced diets, micronutrient adequacy, and preventive nutrition in reducing the burden of non-communicable diseases and promoting healthy ageing. Understanding life-span nutrition is essential for nutritionists, health professionals, educators, and policymakers to design effective dietary strategies and public health interventions that support lifelong well-being.

Keywords: Life-Span Nutrition, Dietary Requirements, Human Development, Healthy Ageing, Public Health Nutrition.

1. Introduction:

Nutrition is a fundamental determinant of human growth, development, health, and longevity. It influences growth trajectories, metabolic function, immune competence, cognitive outcomes, and susceptibility to disease across the entire human life span. The concept of life-span nutrition recognises that nutritional requirements are not static; rather, they evolve dynamically from infancy through adulthood into older age in response to physiological growth, hormonal changes, metabolic demands, lifestyle factors, environmental exposures, and socio-cultural contexts.

Adequate nutrition at each life stage is therefore essential for maintaining metabolic homeostasis, supporting physical and cognitive development, and preventing both communicable and non-communicable diseases.

A growing body of scientific evidence supports the life-course approach to nutrition, which emphasises that nutritional exposures during critical periods of development beginning from fetal life and extending through infancy and childhood have profound and long-lasting effects on adult health and ageing outcomes. Poor nutrition during these sensitive windows may predispose individuals to chronic conditions such as obesity, diabetes, cardiovascular diseases, osteoporosis, and cognitive decline later in life, a concept central to the developmental origins of health and disease (DOHaD) paradigm (Barker, 2007; Kuruvilla *et al.,* 2018; Ren, Zhou, & Liu, 2025). Conversely, optimal early-life nutrition supports organogenesis, brain development, immune system maturation, and metabolic programming, thereby laying the foundation for lifelong health.

In recent years, the scientific community has increasingly adopted the concept of food as medicine, positioning dietary intake not merely as a source of energy and growth but as a strategic intervention for disease prevention and health promotion across all life stages. Contemporary nutritional frameworks emphasize life-stage–specific energy and macronutrient distribution, highlighting the nuanced roles of proteins, carbohydrates, fats, dietary fibre, and water in shaping long-term health outcomes (Heymsfield & Shapses, 2024). Evidence suggests that precise macronutrient balance enhances resilience against diet-related disorders, including obesity, type 2 diabetes, cardiovascular diseases, and certain cancers.

Midlife nutrition has emerged as a critical determinant of health in later years. Longitudinal cohort studies demonstrate that sustained adherence to healthy dietary patterns such as the Alternative Healthy Eating Index (AHEI), Mediterranean, DASH, and plant-rich diets during mid-adulthood is strongly associated with a reduced incidence of major chronic diseases and an increased likelihood of healthy ageing. Healthy ageing is defined not only by longevity but also by the preservation of physical function, cognitive capacity, and freedom from chronic disease (Tessier *et al.,* 2025). These findings underscore the modifiable nature of diet and its capacity to influence ageing trajectories even beyond early life.

Recent research further highlights the importance of dietary quality, particularly carbohydrate quality, in shaping long-term health outcomes. High consumption of whole grains, legumes, fruits, vegetables, and dietary fibre during midlife has been associated with improved physical and cognitive health in older age, demonstrating that carbohydrate quality, not merely quantity, plays a decisive role in promoting healthy ageing (Ardisson Korat *et al.,* 2025). Additionally, nutrition has been shown to influence cognitive and functional health span, with age-specific dietary patterns contributing to neural development, cognitive maintenance, and protection against age-related cognitive decline (Kim *et al.,* 2024).

Given the rapid global demographic shift toward ageing populations and the rising burden of non-communicable diseases, understanding the complexities of life-span nutrition has become increasingly important. A comprehensive life-course perspective is essential for informing public health strategies, clinical guidelines, and individualised dietary interventions aimed at promoting optimal health, functional independence, and quality of life across all stages of human development. Accordingly, this chapter provides a comprehensive review of nutritional requirements across the human life span, from infancy to old age, highlighting dietary recommendations, common nutritional challenges, and their associated health implications, with particular emphasis on preventive nutrition and healthy ageing.

2. Nutrition During Infancy (0–2 Years)

Infancy represents the most rapid and critical phase of human growth and development, characterised by exceptionally high nutrient demands relative to body size. This period is marked by rapid tissue accretion, organ maturation, immune system development, and accelerated brain growth. Adequate nutrition during infancy is therefore essential for optimal physical growth, neurocognitive development, and long-term health outcomes. Nutritional inadequacies during this sensitive window may result in growth faltering, impaired cognitive development, increased susceptibility to infections, and elevated risk of non-communicable diseases later in life (UNICEF, 2020; Haider *et al.,* 2006).

2.1 Breastfeeding and Early Nutrition: Breast milk is universally recognised as the gold standard of infant nutrition and is uniquely adapted to meet the physiological and developmental needs of infants. It provides an optimal balance of macronutrients, carbohydrates, proteins, and fats along with essential micronutrients, bioactive compounds, digestive enzymes, hormones, and immunological factors. These components collectively support gastrointestinal maturation, immune protection, metabolic regulation, and brain development (Victora *et al.,* 2016).

The WHO and UNICEF recommend exclusive breastfeeding for the first six months of life, followed by continued breastfeeding alongside appropriate complementary feeding up to two years of age or beyond (WHO, 2009). Exclusive breastfeeding has been consistently associated with reduced risks of gastrointestinal and respiratory infections, allergic disorders, and sudden infant death syndrome. In addition to these short-term benefits, breastfeeding confers long-term advantages, including improved cognitive performance and a reduced risk of childhood obesity, type 2 diabetes, and cardiovascular disease later in life (Victora *et al.,* 2016).

Recent studies further highlight the role of breastfeeding in shaping the infant gut microbiome. Human milk oligosaccharides and other bioactive components promote the growth of beneficial gut bacteria, particularly Bifidobacterium species, which are critical for immune development and metabolic programming. This early microbial colonisation is increasingly recognised as a key mediator of long-term immune tolerance and disease resistance (Granger *et al.,* 2021).

2.2 Complementary Feeding: After six months of age, breast milk alone becomes insufficient to meet the increasing energy and micronutrient requirements of infants, necessitating the introduction of complementary foods. Complementary feeding should be timely, nutritionally adequate, safe, and responsive, ensuring that foods are energy-dense and rich in essential nutrients (WHO, 2011).

Key nutrients of concern during this stage include iron, zinc, calcium, vitamin A, and essential fatty acids, which are vital for haemoglobin synthesis, immune function, skeletal development, vision, and brain growth. Evidence indicates that timely and diverse complementary feeding introduced at around six months supports optimal growth and reduces the risk of undernutrition, stunting, and micronutrient deficiencies (Black *et al.,* 2013; UNICEF, 2020).

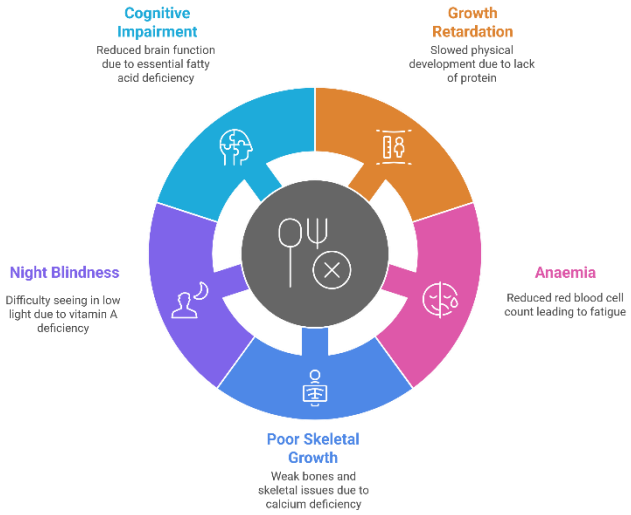

Figure 1: Nutrient deficiency outcomes

In contrast, inappropriate complementary feeding practices such as delayed introduction, low dietary diversity, inadequate nutrient density, or poor food hygiene can lead to undernutrition, iron deficiency anaemia, impaired cognitive development, and increased susceptibility to infections. Emerging research also suggests that the quality and diversity of complementary foods influence gut microbiota development, metabolic health, and immune regulation, with potential long-term implications for disease risk (Ren *et al.,* 2024). These findings emphasise the importance of evidence-based infant feeding practices during this critical stage of development.

Table 1: Key Nutritional Requirements During Infancy

Nutrient	Function	Health Implications of Deficiency
Protein	Growth and tissue development	Growth retardation
Iron	Haemoglobin synthesis	Anaemia, cognitive delay
Calcium	Bone development	Poor skeletal growth
Vitamin A	Vision, immunity	Night blindness, infections
Essential fatty acids	Brain development	Cognitive impairment

3. Nutrition in Childhood (3–12 Years)

Childhood is a vital developmental stage characterised by steady physical growth, increasing physical activity, maturation of organ systems, and rapid cognitive and psychosocial development. Nutritional adequacy during this period is essential to support linear growth, bone mineralisation, immune competence, and academic performance. Dietary habits established during childhood often persist into adolescence and adulthood, thereby influencing long-term health trajectories (WHO, 2009).

Balanced nutrition during childhood plays a critical role in preventing both undernutrition and the emerging burden of overnutrition and diet-related non-communicable diseases. Inadequate or imbalanced diets during this stage may result in growth retardation, micronutrient deficiencies, impaired learning capacity, and increased susceptibility to infections, whereas excessive intake of energy-dense, nutrient-poor foods increases the risk of obesity and metabolic disorders (UNICEF, 2020).

3.1 Macronutrient Needs: Energy requirements during childhood increase progressively with age to support growth, basal metabolism, and physical activity. Adequate energy intake is essential to prevent underweight and stunting, while excessive caloric intake can predispose children to overweight and obesity. Protein plays a crucial role in muscle development, tissue repair, enzyme synthesis, and immune function, with high-quality proteins being particularly important during periods of rapid growth (Trumbo *et al.,* 2020).

Carbohydrates serve as the primary source of energy for children and are essential for optimal brain function. Diets rich in complex carbohydrates such as whole grains, fruits, and vegetables provide sustained energy and dietary fibre, which supports gastrointestinal health. Dietary fats, particularly unsaturated fats, are essential for the absorption of fat-soluble vitamins (A, D, E, and K), cell membrane integrity, and neurological development. However, excessive intake of saturated and trans fats should be avoided due to their association with adverse cardiometabolic outcomes (FAO & WHO, 2010).

3.2 Micronutrient Importance: Micronutrient adequacy is particularly important during childhood due to its role in skeletal development, cognitive function, and immune defence. Calcium and vitamin D are critical for bone mineralisation and the attainment of optimal peak bone mass. Insufficient intake during childhood increases the risk of poor skeletal development and predisposes individuals to osteoporosis later in life (Golden *et al.,* 2014).

Iron is essential for haemoglobin synthesis and oxygen transport and plays a vital role in neurodevelopment and cognitive performance. Iron deficiency anaemia remains one of the most prevalent nutritional problems among school-aged children worldwide and is associated with impaired attention, learning difficulties, and reduced academic achievement (WHO, 2009). Iodine is another key micronutrient required for thyroid hormone synthesis, which regulates growth and brain development. Iodine deficiency during childhood can lead to intellectual impairment and reduced cognitive potential (Zimmermann & Boelaert, 2015).

3.3 Dietary Patterns and Health Risks: In recent decades, significant shifts in dietary patterns among children have been observed globally. Increased consumption of ultra-processed foods, sugar-sweetened beverages, refined carbohydrates, and foods high in saturated fats and salt has become increasingly common. These unhealthy dietary patterns contribute to childhood obesity, dental caries, dyslipidaemia, insulin resistance, and early metabolic disturbances (Popkin *et al.,* 2020; Monteiro *et al.,* 2019).

Childhood obesity is of particular concern due to its strong association with obesity, type 2 diabetes, cardiovascular diseases, and certain cancers in adulthood. Evidence suggests that early exposure to unhealthy food environments and sedentary lifestyles amplifies these risks, underscoring the importance of early dietary interventions and nutrition education (UNICEF, 2020).

Promoting balanced dietary patterns rich in fruits, vegetables, whole grains, lean proteins, and healthy fats during childhood is essential for preventing diet-related diseases and supporting optimal growth and development. School-based nutrition programs, parental involvement, and supportive food environments play a critical role in shaping healthy eating behaviours during this formative stage of life.

4. Nutrition during Adolescence

Adolescence represents a critical transitional phase between childhood and adulthood, marked by rapid physical growth, sexual maturation, hormonal changes, and significant psychological and behavioural shifts. This period is nutritionally vulnerable because approximately 20–25% of adult height and 40–50% of adult body weight is attained during adolescence, resulting in substantially increased nutrient demands (Sawyer *et al.,* 2018; WHO, 2009).

4.1 Increased Nutrient Requirements: Energy and nutrient requirements rise sharply during adolescence to support accelerated growth, pubertal development, and increased physical activity. Adequate protein intake is essential for tissue synthesis, muscle development, and enzyme production. Calcium and vitamin D are particularly crucial, as nearly 90% of peak bone mass is achieved by late adolescence, making this stage decisive for lifelong skeletal health and osteoporosis prevention (Bonjour *et al.,* 1994; Weaver *et al.,* 2016).

Additionally, iron, zinc, iodine, and folate play vital roles in oxygen transport, immune function, DNA synthesis, and neurological development. Inadequate intake of these micronutrients can impair growth, delay puberty, and reduce academic and physical performance (FAO & WHO, 2019; Parajuli & Prangthip, 2024).

4.2 Gender-Specific Nutritional Issues: Nutritional challenges during adolescence often differ by sex due to physiological and hormonal factors. Adolescent girls are particularly vulnerable to iron deficiency anaemia, primarily due to menstrual blood loss combined with increased iron requirements during growth spurts. Iron deficiency at this stage has been associated with fatigue, impaired cognition, and reduced school performance (Pasricha *et al.,* 2021; Haider *et al.,* 2006).

In contrast, adolescent boys generally have higher energy and protein needs to support increased lean muscle mass and basal metabolic rate. Inadequate dietary intake during this period may compromise physical development and athletic performance (NCD-RisC, 2020).

4.3 Behavioural Challenges and Long-Term Health Implications: Adolescence is also characterised by evolving dietary behaviours that may negatively influence nutritional status. Common challenges include skipping meals (especially breakfast), excessive consumption of fast foods and sugar-sweetened beverages, restrictive dieting, and eating disorders. These behaviours contribute to micronutrient deficiencies, overweight and obesity, insulin resistance, and disordered eating patterns that can persist into adulthood (Neufeld *et al.,* 2022; Popkin *et al.,* 2020).

Emerging evidence indicates that poor dietary habits during adolescence significantly increase the risk of non-communicable diseases (NCDs) later in life, underscoring the importance of targeted nutritional education and early preventive interventions (UNICEF, 2020).

Table 2: Nutritional Focus Areas Across Life Stages

Life Stage	**Key Nutritional Focus**
Infancy	Breastfeeding, iron, essential fats
Childhood	Balanced diet, calcium, and iron
Adolescence	Energy, protein, calcium, and iron
Adulthood	Disease prevention, balanced intake
Aging	Protein, calcium, Vitamin D, B_{12}

5. Nutrition in Adulthood

Adulthood is generally characterised by the stabilisation of physical growth; however, nutritional requirements remain dynamic due to variations in metabolic rate, physical activity, occupational demands, reproductive status, and ageing processes. During this stage, nutrition plays a pivotal role in maintaining physiological function, sustaining productivity, preserving mental health, and preventing the onset of non-communicable diseases (NCDs), which represent the leading causes of global morbidity and mortality (Feng *et al.,* 2025).

5.1 Balanced Diet and Healthy Lifestyle: A balanced and diverse diet is central to optimal health during adulthood. Dietary patterns rich in fruits, vegetables, whole grains, legumes, nuts, lean protein sources, and unsaturated fats have consistently been associated with reduced risk of cardiovascular disease, type 2 diabetes, obesity, and several cancers (Mozaffarian, 2016; Willett *et al.,* 2019).

Recent large-scale prospective cohort studies and meta-analyses have demonstrated that adherence to dietary models such as the Mediterranean diet, DASH diet, and plant-forward dietary patterns significantly lowers all-cause mortality and improves cardiometabolic health outcomes (Estruch *et al.,* 2006; Tessier *et al.,* 2025). These benefits are further enhanced when combined with regular physical activity, adequate sleep, and avoidance of tobacco and excessive alcohol consumption.

5.2 Overnutrition, Sedentary Lifestyle, and Lifestyle Diseases: In many regions, adulthood is increasingly marked by overnutrition and reduced physical activity, driven by urbanisation, sedentary occupations, and high availability of ultra-processed foods. Excessive caloric intake, particularly from refined carbohydrates, added sugars, and unhealthy fats, contributes to overweight, obesity, insulin resistance, and metabolic syndrome (Popkin *et al.,* 2020; WHO, 2011).

High dietary sodium intake is strongly associated with elevated blood pressure and increased risk of stroke and cardiovascular disease, while excessive consumption of saturated and trans fats promotes dyslipidaemia and atherosclerosis (He *et al.,* 2020; Mozaffarian *et al.,* 2021). These diet-related risk factors collectively contribute to the rising global burden of NCDs, emphasising the importance of preventive nutritional strategies in adulthood.

5.3 Role of Micronutrients in Adult Health: Although macronutrients receive significant attention, micronutrients remain essential for metabolic regulation, immune competence, cognitive function, and psychological well-being. Adequate intake of B-complex vitamins (particularly B_6, B_{12}, and folate) is critical for energy metabolism, red blood cell synthesis, and neurological health, while deficiencies have been linked to fatigue, depression, and cognitive impairment (Moravcova *et al.,* 2025).

Antioxidant micronutrients, including vitamins C and E, selenium, and zinc, help mitigate oxidative stress and inflammation, processes implicated in ageing and chronic disease development (Liguori *et al.,* 2018). Furthermore, emerging evidence suggests that optimal micronutrient status in adulthood supports healthy ageing trajectories and may reduce the risk of neurodegenerative disorders (Calder *et al.,* 2020).

6. Nutrition During Pregnancy and Lactation

Pregnancy and lactation are among the most nutritionally demanding phases of the human life span. During these periods, maternal nutrition must simultaneously support the mother's physiological adaptations, fetal growth and development, and, during lactation, optimal breast milk production to meet infant nutritional needs. Nutritional inadequacies or excesses during these critical windows can have profound short- and long-term consequences for both maternal and child health, consistent with the Developmental Origins of Health and Disease (DOHaD) hypothesis (Barker, 2007; Godfrey *et al.,* 2016).

6.1 Maternal Nutrient Requirements: Pregnancy is characterised by increased requirements for energy, protein, and several key micronutrients due to expanded maternal tissues, increased blood volume, placental development, and rapid fetal growth. Energy needs increase progressively across trimesters, while adequate protein intake is essential for fetal tissue synthesis and maternal organ expansion (Rasmussen *et al.,* 2009; Jouanne *et al.,* 2021).

Micronutrient demands rise substantially during pregnancy. Folic acid plays a critical role in DNA synthesis and cell division, and periconceptional folic acid supplementation has been

conclusively shown to reduce the risk of neural tube defects such as spina bifida and anencephaly (Haider *et al.,* 2006). Iron requirements increase markedly to support expanded maternal erythropoiesis and fetal iron stores; iron deficiency anaemia during pregnancy remains a major global public health concern and is associated with fatigue, increased infection risk, and adverse birth outcomes (WHO, 2011).

Adequate intake of calcium and vitamin D is necessary for fetal skeletal development and maternal bone health, while iodine is essential for thyroid hormone synthesis and normal fetal brain development. Iodine deficiency during pregnancy can result in impaired neurodevelopment and reduced cognitive outcomes in offspring (Zimmermann, 2012). Additionally, omega-3 fatty acids, particularly docosahexaenoic acid (DHA), are vital for fetal brain and retinal development and are increasingly emphasised in prenatal nutrition guidelines (Koletzko *et al.,* 2007).

During lactation, nutritional requirements remain elevated to support milk synthesis and secretion. Although breast milk composition is relatively resilient, maternal deficiencies—particularly of iodine, vitamin A, vitamin B_{12}, and omega-3 fatty acids—can adversely affect milk quality and infant nutrient intake (Allen & Dror, 2018).

6.2 Health Implications of Maternal Nutrition: Maternal undernutrition during pregnancy is strongly associated with adverse outcomes, including low birth weight, intrauterine growth restriction (IUGR), preterm birth, and increased infant morbidity and mortality. Evidence from epidemiological and interventional studies demonstrates that poor maternal nutrition can permanently alter fetal metabolic programming, increasing susceptibility to chronic diseases such as type 2 diabetes, cardiovascular disease, and obesity in later life (Barker, 2007; Gluckman *et al.,* 2010).

Conversely, overnutrition and excessive gestational weight gain have emerged as growing concerns, particularly in low- and middle-income countries undergoing nutritional transition. Excessive intake of energy-dense, nutrient-poor foods is associated with gestational diabetes mellitus (GDM), hypertensive disorders of pregnancy, caesarean delivery, and postpartum weight retention (Poston *et al.,* 2016; Popkin *et al.,* 2020). Importantly, offspring born to mothers with obesity or GDM have a higher risk of childhood obesity, insulin resistance, and metabolic disorders, perpetuating an intergenerational cycle of poor health.

During lactation, inadequate maternal nutrition may compromise maternal health by accelerating nutrient depletion, increasing fatigue, and reducing immune resilience. However, optimal maternal diet during breastfeeding contributes to improved infant immunity, neurodevelopment, and long-term health outcomes, reinforcing the importance of nutrition-focused maternal care beyond pregnancy (Victora *et al.,* 2016; Allen & Dror, 2018).

Overall, these findings emphasise that pregnancy and lactation represent critical windows for nutritional intervention. Ensuring adequate, balanced, and culturally appropriate maternal nutrition is essential for improving maternal well-being, promoting healthy infant development, and reducing the long-term burden of non-communicable diseases.

7. Nutrition in Ageing and Older Adults

Ageing is accompanied by multiple physiological, metabolic, and psychosocial changes that significantly impact nutritional status. Common age-related alterations include reduced appetite (anorexia of ageing), impaired gastrointestinal digestion and absorption, altered taste and smell perception, hormonal changes, and decreased muscle mass. These changes increase susceptibility to malnutrition, sarcopenia, frailty, and chronic diseases, emphasising the importance of targeted nutritional strategies for older adults (Morley *et al.,* 2014).

7.1 Protein and Muscle Health: Adequate protein intake is critical for preserving lean body mass, preventing sarcopenia, and maintaining functional independence in older adults. Evidence indicates that older adults have higher protein requirements per kilogram of body weight compared to younger adults, due to age-related anabolic resistance (Phillips *et al.,* 2016; Bauer *et al.,* 2013).

Combining resistance exercise with sufficient high-quality protein intake has been shown to improve muscle strength, physical performance, and mobility, thereby reducing the risk of falls, fractures, and disability. Leucine-rich proteins and supplementation strategies are increasingly emphasised to enhance muscle protein synthesis in ageing populations (Deutz *et al.,* 2014; Hou *et al.,* 2019).

7.2 Micronutrient Concerns: Micronutrient deficiencies are highly prevalent in older adults due to reduced intake, malabsorption, and altered metabolism. Vitamin D and calcium deficiencies contribute to decreased bone mineral density and osteoporosis, increasing fracture risk. Vitamin B12 deficiency is common due to decreased gastric acid secretion and intrinsic factor production, resulting in anaemia and cognitive decline (Green *et al.,* 2017). Antioxidants, including vitamins C and E, selenium, and zinc, play an important role in mitigating oxidative stress, reducing inflammation, and supporting immune function, which are critical for healthy ageing and prevention of chronic diseases (Gombart *et al.,* 2020; Calder *et al.,* 2020). Ensuring adequate micronutrient intake, either through diet or supplementation, is therefore vital in the elderly.

7.3 Malnutrition in Older Adults: Malnutrition in ageing populations is often underdiagnosed and undertreated, despite its association with increased morbidity, frailty, reduced quality of life, and mortality (Shlisky *et al.,* 2017; Volkert *et al.,* 2019). Common risk factors include polypharmacy, socioeconomic constraints, cognitive decline, and physical limitations affecting food access and preparation. Implementing nutrient-dense dietary plans, fortification strategies, and community-based nutrition programs can improve nutrient intake, maintain functional status, and promote healthy ageing. Early screening for malnutrition using validated tools such as the Mini Nutritional Assessment (MNA) is recommended to identify at-risk individuals and initiate timely interventions (Kaiser *et al.,* 2009; Volkert *et al.,* 2019).

8. Life-Course Nutrition and Long-Term Health Outcomes

The life-course perspective recognises that nutritional exposures at each stage of life, from preconception, infancy, childhood, adolescence, and adulthood to older age, profoundly

influence both immediate and long-term health outcomes. This framework highlights that nutrition is not only critical for growth and development but also for preventing chronic diseases and promoting healthy ageing (Barker, 2007; Godfrey *et al.,* 2016).

8.1 Developmental Origins of Health and Disease (DOHaD): Evidence from epidemiological studies and clinical research supports the DOHaD hypothesis, which posits that suboptimal nutrition during critical developmental windows such as fetal life, infancy, and early childhood can program long-term metabolic and cardiovascular health. For instance, maternal undernutrition, micronutrient deficiencies, or low birth weight are associated with an increased risk of type 2 diabetes, hypertension, obesity, and cardiovascular disease in adulthood (Barker, 2007; Gluckman *et al.,* 2010; Godfrey *et al.,* 2016).

Conversely, optimal early-life nutrition—including adequate breastfeeding, timely complementary feeding, and sufficient micronutrient intake—supports organ development, immune maturation, cognitive growth, and metabolic resilience, reducing susceptibility to non-communicable diseases (Victora *et al.,* 2016; Ren *et al.,* 2025).

8.2 Nutrition in Adolescence and Adulthood: Nutrition during adolescence and adulthood serves as a modifiable determinant of future health, capable of mitigating risks established in early life. Adherence to balanced dietary patterns, such as the Mediterranean, DASH, or plant-forward diets, has been shown to reduce cardiometabolic risk, improve cognitive function, and enhance longevity (Estruch *et al.,* 2006; Tessier *et al.,* 2025).

Regular physical activity combined with nutrient-dense diets during adulthood strengthens cardiovascular, skeletal, and immune health, and reduces the incidence of obesity, type 2 diabetes, and certain cancers (Willett *et al.,* 2019; Popkin *et al.,* 2020).

8.3 Nutrition in Older Adults and Healthy Ageing: In later life, adequate protein and micronutrient intake, along with lifestyle modifications, are key to preserving muscle mass, bone density, cognitive function, and immunity, thereby enhancing functional independence and quality of life (Morley *et al.,* 2014; Calder *et al.,* 2020). Nutritional interventions targeting older adults, such as fortified foods, community-based meal programs, and individualised dietary counselling, have been shown to reduce frailty, malnutrition, and age-related morbidity (Volkert *et al.,* 2019).

8.4 Public Health Implications: A life-course approach to nutrition emphasises that interventions should not be limited to a single life stage but should span preconception, pregnancy, infancy, childhood, adolescence, adulthood, and older age. Integrated public health strategies, including maternal supplementation, school feeding programs, workplace wellness initiatives, and community nutrition programs for older adults, can cumulatively reduce the burden of diet-related diseases and enhance population health outcomes (FAO & WHO, 2019; UNICEF, 2020).

Such an approach aligns with global health priorities to prevent malnutrition, promote healthy dietary behaviours, and ensure sustainable development goals related to health and well-being.

S. No.	Life Stage	Key Nutrients / Focus	Dietary Recommendations	Health Implications
1.	**Infancy (0–2 yrs)**	Protein, fat, DHA, iron, zinc, vitamin A, calcium	Exclusive breastfeeding for 6 months; timely complementary feeding with nutrient-dense foods	Supports rapid growth, brain development, and immune maturation; prevents micronutrient deficiencies and stunting
2.	**Childhood (3–12 yrs)**	Protein, calcium, vitamin D, iron, iodine, fibre	Balanced meals with fruits, vegetables, whole grains, lean protein; limit sugar and processed foods	Promotes skeletal growth, cognitive development, and immune function; prevents childhood obesity and early metabolic disorders
3.	**Adolescence (13–18 yrs)**	Protein, calcium, vitamin D, iron, folate, zinc	Adequate energy and nutrient intake to support puberty; gender-specific supplementation (iron for girls)	Supports growth spurts, sexual maturation, peak bone mass; prevents anaemia and nutrient deficiencies
4.	**Adulthood (19–50 yrs)**	Protein, fibre, antioxidants, B-vitamins, calcium, magnesium	Diet rich in fruits, vegetables, whole grains, lean proteins, healthy fats; maintain balanced energy intake	Maintains metabolic health, reduces risk of cardiovascular disease, diabetes, obesity, and cancer
5.	**Pregnancy & Lactation**	Protein, folic acid, iron, calcium, iodine, vitamin D, DHA	Adequate maternal intake; supplementation as needed; nutrient-dense diet to support fetal growth and milk production	Prevents neural tube defects, maternal anaemia, and low birth weight; supports infant development and maternal health
6.	**Older Adults (≥60 yrs)**	Protein, vitamin D, calcium, vitamin B12, antioxidants, omega-3	High-quality protein intake (≥1.0–1.2 g/kg/day); fortified foods; nutrient-dense diet; maintain hydration	Prevents sarcopenia, osteoporosis, cognitive decline, and immune dysfunction; promotes functional independence and healthy ageing

7.	**Life-Course Perspective**	All essential macro- and micronutrients, balanced dietary patterns	Continuous adherence to healthy dietary patterns (Mediterranean, DASH, plant-forward)	Reduces chronic disease risk, supports healthy growth and development, promotes longevity and quality of life

Key Nutrients and Dietary Recommendations Across Life Stages

Life Stage	Key Nutrients / Focus	Dietary Recommendations	Health Implications
Infancy (0–2 yrs)	Protein, Fat, DHA, Iron, Zinc, Vitamin A, Calcium	Breastfeeding & nutrient-rich complementary foods	Supports growth & brain development
Childhood (3–12 yrs)	Protein, Calcium, Vitamin D, Iron, Iodine, Fiber	Balanced meals; limit sugar & junk foods	Promotes bone health & learning
Adolescence (13–18 yrs)	Protein, Calcium, Vitamin D, Iron, Folate, Zinc	Adequate energy; iron for girls	Supports puberty & peak bone mass
Adulthood (19–50 yrs)	Protein, Fiber, Antioxidants, B-Vitamins, Calcium, Magnesium	Fruits, vegetables, whole grains, healthy fats	Reduces chronic disease risk
Pregnancy & Lactation	Protein, Folic Acid, Iron, Calcium, Iodine, DHA	Prenatal vitamins; nutrient-dense diet	Supports fetal & maternal health
Older Adults (≥60 yrs)	Protein, Vitamin D, Calcium, Vitamin B12, Omega-3	High-protein, fortified foods; hydration	Prevents frailty & cognitive decline
Life-Course Perspective	Balanced Diets (Mediterranean, DASH, Plant-Based)	Healthy eating at all stages of life	Enhances lifelong health & longevity

Conclusion:

Nutrition across the life span critically influences growth, development, and long-term health outcomes. Adequate intake during infancy, childhood, adolescence, adulthood, pregnancy, lactation, and older age supports physiological function, cognitive development, and disease prevention. Life-course nutrition underscores that early-life dietary exposures, combined with sustained healthy dietary practices, reduce chronic disease risk, promote healthy ageing, and enhance quality of life. Integrated, stage-specific nutritional interventions are essential for population health and longevity.

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About Editors

Mr. Sanjay Shriram Kalekar is an Assistant Professor in the Department of English at Daar-Ul-Rehmat Trust's A. E. Kalsekar Degree College, Kausa-Mumbra, Thane, affiliated with the University of Mumbai. He specializes in English literature and language, literary theory and criticism, Indian writing in English, and indigenous studies. He holds a Master's degree in English Literature from Savitribai Phule Pune University, qualified NET with JRF, and is pursuing a PhD at the University of Mumbai. He serves as IQAC Coordinator and member of the Board of Studies syllabus subcommittee. He authored "Communication Skills in English," contributed several book chapters, published fifty six research papers, completed refresher courses and FDPs, serves on the EDWIN editorial board, received a top ten teachers award, and convened four international conferences.

Dr. Priyanka Bhardwaj is a dedicated educationist with a strong academic background and commitment to advancing teaching and learning practices. She completed Junior Basic Training from the Jammu and Kashmir State Board of School Education and earned a Bachelor of Arts from Kurukshetra University, Kurukshetra. She obtained her B.Ed and M.Ed from Maharshi Dayanand University, Rohtak, developing expertise in pedagogy, curriculum design, and educational methodology. She also completed an M.A. in Public Administration from Maharshi Dayanand University. She earned her Ph.D. from Rabindranath Tagore University, Raisen, Madhya Pradesh. Dr. Bhardwaj has published five research papers in reputed national and international journals and emphasizes holistic learner development, academic excellence, and continuous improvement in education nationwide initiatives.

Dr. Sapna Kasliwal is presently working as an Assistant Professor in the Department of Commerce, Government College, Rau (Indore), Madhya Pradesh. She was awarded a Ph.D. for her research on mergers in the Indian banking industry. With more than twenty years of teaching experience in Commerce and Management, she has made significant contributions to higher education and academic research. She has published over forty research papers in reputed national and international journals and presented papers at several conferences. She has developed fourteen e-content lectures hosted by the Department of Higher Education, Madhya Pradesh, served on NEP 2020 e-content committees, authored two books, and edited seven books, supporting student-centric commerce education.

Ms. Sweety Thakkar is an Assistant Professor in the Faculty of Commerce and Management at Vishwakarma University, Pune, located at Kondhwa Budruk, Maharashtra. Her specialization includes Marketing and Human Resource Management, with research interests in marketing, entrepreneurship, and HR. She has ten years and six months of academic experience and one additional year of other professional experience, totaling eleven years and six months overall. She has no industry experience and does not hold any additional administrative designation. Her scholarly contributions include one research article, one book chapter, and one authored book. She is committed to strengthening management education and applied learning for undergraduate and postgraduate students through teaching excellence initiatives.

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