CHAPTER 2

Diet-related nutrition and health issues in Indian population

A. Jyothi Lakshmi[1] and Jamuna Prakash[2]
[1]Protein Chemistry and Technology Department, CSIR-Central Food Technological Research Institute, Mysuru, India
[2]Ambassador for India, Global Harmonisation Initiative, Vienna, Austria

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2.1 Introduction

Food is the "basic right of every human being," at the same time, "we are what we eat," that is, the food we eat reflects our nutritional status and in turn our health and well-being. Innovation, being the key to research and development, has conquered every field of life for which food and nutrition are not an exception. Economic inequalities, technological intervention and selective outreach, and globalization associated with diminishing health and nutritional awareness have impelled toward the adoption of faulty or imbalanced dietary practices. Lifestyle changes associated with reduced physical activity due to less labor-intensive activities, mechanization, and stress to cope with the changing work cultures in all strata have impacted on compromised nutrition. These uninterrupted changes in lifestyle accompanied by faulty feeding practices are increasing the occurrence of overnutrition and obesity leading to the increasing prevalence of noncommunicable diseases at one end and persisting occurrence of

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undernutrition (though with a notable reduction in severe forms) due to inadequate food intake at the other end. This dual burden of malnutrition faced by our country poses the challenges to the health and nutrition professionals as “food and nutrition” is the root cause for it, although it is backed by various other factors. The extent of dietary influences on the magnitude of various health and nutrition issues prevalent in India will be discussed in the subsequent sections.

2.2 Historical overview

The dietary surveys conducted by National Nutrition Monitoring Bureau (NNMB) periodically, that is, from 1975 onwards have shown a decade wise gradual decrease in consumption of energy-based foods, that is, cereals, sugar, and jaggery have slid down, whereas protein and micronutrient-based foods (iron and vitamin A, and some B-complex vitamins) such as pulses, vegetable, and fruits that were below adequacy levels, have remained the same over the four decades. Energy and protein consumption patterns of households declined by 20% with a shift from the adequacy to inadequacy zone (NNMB, 2012). These observations also confirm that the diets were cereal-based and lacked protective nutrients from the past four decades (Table 2.1).

The partial improvement in nutritional status could be attributed to various factors such as attaining self-sufficiency in food production through the green revolution, providing food grains to poor families at subsidized rates through the public distribution system and through the inception of direct national nutrition programs to children, pregnant women, and school children. The major national nutrition intervention programs that were incepted from 1960 onwards are compiled in Table 2.2.

Table 2.1 An overview of nutritional status of preschool children from 1970s to 2012 (NNMB, 2012).

Nutritional indicator		Prevalence from 1975 to 2012
Children	• Severe protein-energy malnutrition	Kwashiorkor and marasmus have become rare
	• Underweight	Reduced from 75.5% to 41%
	• Stunting	Reduced from 82% to 45.7%
	• Wasting	Reduced from 27% to 16.0%
Adults	• Chronic energy deficiency	Reduced by 26% in female and 20% in male
	• Obesity/overweight	Increased by fivefold in adults
Vitamin A deficiency		Bitot’s spots have become negligible
Vitamin B-complex deficiency		Angular stomatitis is significantly declined
Prevalence of diabetes, hypertension, and cancer		Has increased and still increasing

Table 2.2 National nutrition programs and the target groups.

National nutrition program	Beneficiaries
Applied nutrition program	Promoting the production and consumption of protective foods for pregnant and lactating mothers and children
Integrated Child Development Services Scheme	Provides supplementary nutrition to preschoolers (500 kcal of energy and 12–15 g protein/day), extra nutrition for severely malnourished children, nonformal education for preschoolers, health checkups, immunization, referral services, and nutrition and health education for both children and pregnant women (600 kcal and 18–20 g protein/day)
Nutrition program for adolescent girls	Girls <35 kg and pregnant women <45 kg will be provided with 6.0 kg take-home ration/month for three consecutive months in a year
National nutritional anemia prophylaxis program	Provision of iron supplements Children, 1–5 years—20 mg elemental iron + 0.1 mg folate/day Children, 6–10 years—30 mg iron + 0.25 mg folate Adolescents, 12–18 years—100 mg iron + 0.5 mg folate/day Pregnant women—60 mg iron + 0.5 mg folate/day for 100 days
Weekly iron and folic acid supplementation program for nonschool going adolescents	Iron folic acid tablets on a weekly basis for 12–18-year girls for 52 weeks Biannual deworming tablets
National prophylaxis program for prevention of vitamin A deficiency	For all children 6–11 months, 100,000 IU; 1–5 years old—200,000 IU of vitamin A on a 6-monthly basis. On diagnosis of vitamin A deficiency—a megadose of 200,000 IU of vitamin A immediately and the next dose 1–4 weeks later
National iodine deficiency disorder control program	Universal salt iodization in the country—30 ppm at the manufacturing level and 15 ppm at the consumption level
Mid-day meal program	Provide one full meal to school children providing one-third of the calorie and half of the protein requirement per day
Nutrition program for adolescent girls (*Kishori shakti yojna*)	Targeted for adolescent girls of 11–18 years, it covers awareness on watch over menarche, half-yearly general health check-up, training on minor ailments, deworming, prophylactic measures against anemia, goiter, vitamin deficiencies, and supplementary nutrition

The national nutritional studies conducted from past 4 to 5 decades at global, national, societal, and individual levels have clearly shown that the qualitative and quantitative dietary adequacy is the major determinant of the health and nutritional status of our populace. Dietary adequacy is dependent on socioeconomic, agroclimatic, environmental, and physiological factors. The lead national health and nutrition surveys—NNMB and National Family Health Survey (NFHS) surveys that report the health and nutritional status from pregnancy have reported that the effect of faulty feeding practices originates "in utero" and percolates through the life cycle in varied forms depending on the prevailing factors.

Consumption of a balanced diet leads to normal health and nutritional status, but the dietary patterns vary widely across the nation due to diversity in domicile, food availability, accessibility, affordability, and other priorities. Lack of nutritional nutritional awareness to judge the veracity of dietary suggestions from social media and peer pressure can result in a wide spectrum of nutritional imbalances ranging from undernutrition to overnutrition and obesity leading to the developmental impairments of organs and finally the onset of chronic degenerative diseases. The effect of dietary imbalances including micronutrient deficiencies in different population groups, namely pregnant women, children, and adults are summarized in the following sections with epidemiological data and associated observations.

2.3 Dietary intake and nutritional and health status of pregnant women

Pregnancy requires additional nutrients for meeting the growth and developmental needs of the fetus, for meeting the mother's own requirements, and to establish good nutrient stores for postpartum requirements of lactation. Dietary surveys have shown that diets of a sizeable proportion of pregnant women meet around 50% of recommended dietary allowances (RDAs) of protein and calories (Fig. 2.1) (NNMB, 2012). Micronutrient inadequacies including iron and folic acid were reported in more than 75% of the mothers. The iron–folic acid supplements provided by the government was consumed completely by only 30% of the mothers. This is well reflected in the prevalence of anemia by 58.7% of pregnant women (NFHS-4, 2015–16).

Specific nutrient deficiencies during pregnancy apart from affecting the growth of the fetus are also known to cause genetic alterations resulting in adverse health impairments in later life (Table 2.3).

Poor maternal nutritional intake during pregnancy negatively impacts fetal genetic trajectory and restricts fetal growth. It affects the vascularity of the placenta that effectively transports nutrients to the offspring and results in low birth weight that has profound adversities in later life (Table 2.4).

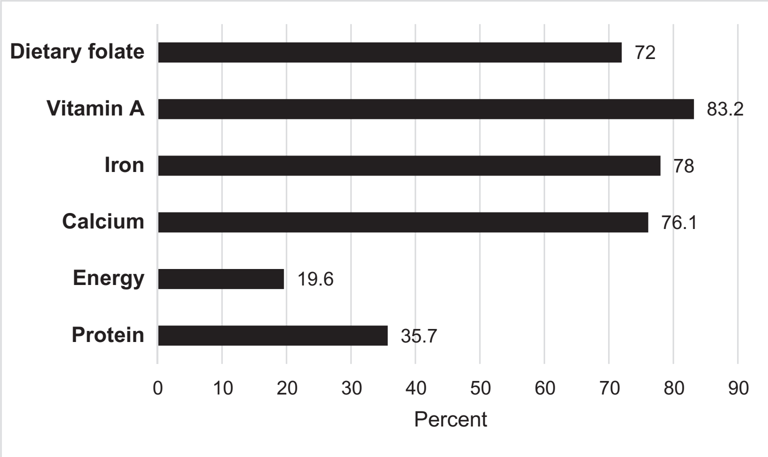


Figure 2.1 Percent of pregnant women obtaining <50% of the recommended dietary allowance of major nutrients through diet (NNMB, 2012).

2.4 Dietary adequacy of under five children and adults

Dietary imbalances have been attributed to be the direct cause for the prevalence of malnutrition in India. These are in common frank inadequacies of the critical nutrients leading to undernutrition and deriving disproportionate calories from the macronutrients leading to overweight and obesity associated with micronutrient deficiencies.

Children below 5 years who have a high growth rate associated with higher calorie requirements per unit body weight were reported to have a dietary inadequacy of energy (23%–41%) and micronutrients (Table 2.5). Calorie inadequacy was reported along with protein inadequacy or in isolation in 40%–50% of the children both in longitudinal and cross-sectional studies (NNMB, 2012; Kulsum et al., 2008). Energy inadequacy was reported among preschoolers even in families where the nutrient adequacy levels were better among adults and older children. Micronutrient inadequacy was reported in a much higher proportion of the children. Inadequate intake of iron, vitamin A, and folic acid was of a higher level among the preschool children. Among adults too, a similar trend of inadequacy was evident, around 30% of them showed different proportions of calorie and protein inadequacy. The quantitative inadequacy of iron ranged from 33% to 45% and vitamin A around 80%. Most diet surveys have clearly shown that cereals and pulses are the major sources of all nutrients, and diets lack in sufficient quantities of protective foods such as fat, milk, vegetables, and fruits. The qualitative inadequacy (amino acid content) and poor digestibility also contribute for compromised nutrition that is reflected in deficiencies and functional impairments (Bamji & Nair, 2016; Lakshmi et al., 2005; Kulsum et al., 2009).

Table 2.3 Impact of specific nutrient deficiencies in mother on infant's later life: few observations.

Implications of macronutrient deficiencies
• Protein inadequacy leads to the deficiency of amino acids and impairment of one-carbon metabolism and DNA methylation • Protein deficiency leads to cardiometabolic disorders in later life of the infant, including higher blood pressure • Maternal undernutrition produces infants with thin lean mass and higher adipose percentage with insulin • Deficiency of protein and micronutrients along with excess fat affected kidney development in infants (Wood-Bradley et al., 2015)
Implications of micronutrient deficiencies
• Iron deficiency anemia is associated with adverse birth outcomes such as preterm delivery, low birth weight, and growth restriction (Allen, 2000). It is associated with the cardiovascular risk of the offspring during pregnancy • Inadequate intake of folic acid during the first trimester of pregnancy was reported to cause neural tube defects (Wasserman et al., 1998). Deficiency of folic acid and vitamin B_{12} is associated with raised homocysteine levels that restrict fetal growth • Higher folate and lower vitamin B_{12} are associated with offspring adiposity and insulin resistance • Raised level of serum homocysteine due to dietary deficiencies of folic acid, vitamins B_{12} and B_6 (perhaps B_2), involved in its metabolism, seems to be an important etiological factor for cardiovascular and other chronic diseases (Raman, 2016) • Imbalance or deficiency of B vitamins is known to have shown increased homocysteine levels that are indicative of cardiovascular disease in adult life (Yajnik et al., 2008; Krishnaveni et al., 2014; Yajnik et al., 2014) • Vitamins A and D influence gene expression by interacting with nuclear receptors, folic acid, and vitamin B_{12} through epigenetic mechanisms. Deficiencies of these nutrients distract both the mechanisms altering the cellular processes in critical times during fetal development and influence the structure and function of organs and systems and contribute to long-term effects on disease susceptibility termed as programing • Synapse formation and myelination during the critical periods of brain development and nutrient deprivation during this period cause irreversible brain dysfunction (Georgieff, 2007) • Zinc deficiency is known to affect the regulation of the autonomic nervous system as well and hippocampal and cerebellar development (Vazir and Boindala, 2016). PEM and zinc deficiency are reported to cause stunting, affecting learning and poor cognitive development (Özaltin et al., 2010)

2.5 Undernutrition

The nutritional status of the population for whom the dietary inadequacies are reported confirms the presence of undernutrition determined based on anthropometric indices that are alarmingly high in children below 5 years and also in adults.

Acute and chronic forms of undernutrition, which originate during early infancy, increase by fivefold by the end of 11 months (Table 2.6) and continue at the same

Table 2.4 Consequences of imbalanced nutrition during pregnancy.

The implications of low birth weight/intrauterine growth retardation
• The secondary factor for 40%–80% neonatal deaths • Risk factor for perinatal morbidities • Increased risks of disorders/disruptions of child growth development—neurologic disorders, learning disabilities, childhood psychiatric disorders, and mental retardation • Increased morbidities in the long run (Goldenberg and Culhane, 2007) • Long-term disability imposes a high economic burden on households depriving them of proper nutrition (Abu-Saad and Fraser, 2010) • Increases the risk of type 2 diabetes during adulthood (Whincup et al., 2008). Low metabolic capacity coupled with high metabolic load posed due to faulty dietary habits is reported to lead to high levels of body fat and glycemic load increases the risk for diabetes (Unnikrishnan et al., 2016) • Subjects showed higher insulin resistance and higher glucose at 4 years of age. A follow-up at 8 years showed that those who had the highest current weight also had higher insulin resistance and worst cardiovascular profile (Bavdekar et al., 1999)
Low birth weight with higher adiposity
• Cord blood contained higher levels of leptin, insulin, and lower adiponectin that strongly suggests a higher risk of diabetes in their adulthood (West et al., 2014; Yajnik et al., 2002)
Implications of maternal overnutrition
• Excess energy intake leads to a birth weight >4 kg in infants due to fetal hyperinsulinemia • Fetal overnutrition due to hyperinsulinemia programs the offspring for type 2 diabetes • The infants are born larger and develop obesity, insulin resistance, impaired glucose tolerance, and diabetes at a younger age
Implications of gestational diabetes
• Infants born with a larger size at birth and with higher subcutaneous adiposity showed higher insulin and glucose levels and had glucose resistance at nine years. • In addition, mothers with vitamin B_{12} deficiency had a higher risk of being diabetic 5 years postpartum in comparison to those without vitamin B_{12} deficiency (Krishnaveni et al., 2010)

Table 2.5 Percent adequacy of dietary intake of nutrients in children (under five) and adults.

Subjects	Protein	Energy	Calcium	Iron	Vitamin A	Dietary folate
Adults	80–100	80–88	55–62	55–77	20–22	53–61
Children <5 years	>100	69–77	33–41	52–55	15–19	60–72

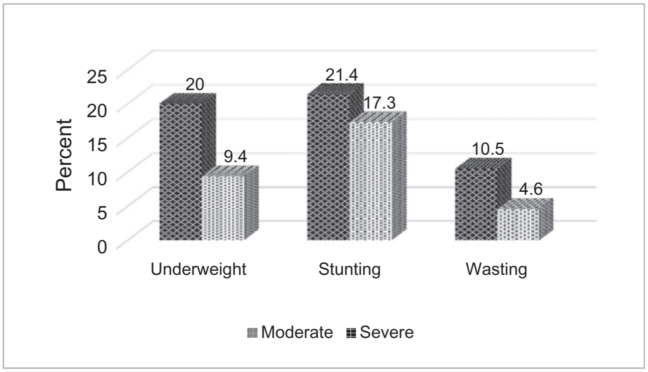
pace up to 5 years old. Children between 6 and 23 months receiving an adequate diet were only 9.6%, which is the period of onset of malnutrition (NFHS-4, 2015–16). With this higher prevalence rate, India contributes to about 40% of stunted and 50% of wasted children in the world (UNICEF, 2013). Around 4.6% of children were

Table 2.6 Prevalence of under nutrition in India in different age groups (%).

Age group	Underweight	Stunted	Wasted	Reference
Infancy (0–11 months)	7–32	6–35.2	25	NNMB (2012)
Children (<5 years)	35.8	38.4	21.1	NFHS-4 (2015–16)
	41.1	45.7	15.5	NNMB (2012)

Undernutrition among adults

Chronic energy deficiency	Women	Men	Reference
	35.5	34.2	NFHS-4 (2015–16)
	33	32	NNMB (2012)



Moderate: < Mean – 2 SD to < Mean- 3 SD; Severe: < Mean – 3 SD

Figure 2.2 Prevalence (%) of undernutrition—0–59 months (RSOC, 2013–14).

reported to be subjected to severe acute malnutrition with very low weight for height (Fig. 2.2). Around one-third of the adult population was found to be chronic energy deficient (CED) as per both the surveys. Overnutrition leading to obesity was also observed in 15.8% of adult population (NFHS-4, 2015–16).

2.6 Micronutrient deficiencies

Different from macronutrient deficiencies, micronutrient deficiencies cannot be visualized unless they are clinically manifested, by then the unfavorable consequences in impaired growth, immunity, learning and cognitive ability, and work performance, in general, would have witnessed the adversities. The economic losses due to micronutrient deficiencies in India indexed as DALYs are estimated to range from 0.8% to 2.5% of GDP. Micronutrient deficiencies are estimated to cost India around $2.5 billion per year (PHFI, 2015). Therefore these deficiencies are termed as "hidden hunger" (Bamji and Nair, 2016). Among the micronutrient deficiencies, iron deficiency anemia, vitamin A deficiency, and zinc deficiencies are the major ones. Ocular manifestations of vitamin A deficiency such as Bitot's spots and night blindness are observed among children at <1% among preschool children and 1%–2% among older children and pregnant women (NNMB, 2012). However, a higher percentage of our population showed low serum retinol levels indicative of a higher degree of vitamin A deficiency going asymptomatic. Iron deficiency anemia based on hemoglobin levels was found to be high with 69.5% among children, 55.3% in women, and 58.5% in pregnant women (PHFI, 2015; NFHS-4, 2015–16). One of the well-proven and researched etiologies for iron deficiency anemia is poor bioavailability from plant-based diets in addition to low intake of iron. Research has shown that the bioavailability of iron from the habitual Indian diets containing different staple cereals ranged between 3% and 8% in different age groups (Nair et al., 2013). Intake of other nutrients such as ascorbic acid, zinc, vitamin A, and folic acid is also inadequate in the dietaries of this population.

Iodine deficiency disorders were among the micronutrient deficiencies prevalent among the local population and are still prevalent in India, with <5% in six states and >0.5% in Maharashtra and West Bengal among the states covered by NNMB surveys. ICMR survey has indicated that no state or union tertiary in India is free from iodine deficiency (Pandav et al., 2013). Human brain development is completed before 3 years old and iodine deficiency during pregnancy or early childhood would lead to irreversible brain damage. The salt iodization program came to existence in 1992, and since then the deficiency has reduced drastically.

2.7 Undernutrition and cognition

Cognitive functions depend on the combined activity of several neurons, several biochemical pathways, and enzymes that require proper nourishment. Improving the nutritional status of stunted infants before 2 years of life could improve the cognitive function of children (Crookston et al., 2013) although correcting the nutritional status at later stages of life was not found to be beneficial (Carba et al., 2009). Multiple micronutrient supplementation during pregnancy showed a better impact on child nutrition than individual nutrient supplementation. Trials with fish oil supplementation showed that α-linoleic acid, docosahexaenoic acid, and eicosapentaenoic acid were important components of myelination and synaptogenesis (Vazir and Boindala, 2016).

2.8 Overnutrition and allied health ailments

Owing to the improvement in the economic status over the last four decades, there has been a reduction in CED by 20%–27% with an associated fivefold increase in overweight and obesity (Vijayaraghavan, 2016). The shift observed in the type of malnutrition has led to a different spectrum of health issues. The economic liberalization of India has brought in false-positive lifestyle changes such as increased ownership of vehicles, sedentary occupation cultures for long hours, less exposure to sunlight, and absence of proper compensated recreational physical activity (Anjana et al., 2014). An increase in the availability of processed foods in both organized and unorganized sectors was reflected in the compound annual growth rate of 8.4% from 2005–06 to 2009–10 (Rais et al., 2013). Increased marketing of food has increased the availability of packaged and processed foods containing more salt, sugar, and preservatives. The transitional dietary changes have led to increase in the occurrence of chronic degenerative diseases. The prevalence of diabetes and obesity is on a rise and is becoming an epidemic in human history, and India is considered to be the third-largest country in this context (Zimmet, 2017).

2.9 Influence of diet and nutrition on the increasing occurrence of disease

Increased food availability and accessibility in India lead to an unhealthy nutrition transition that is reported to accelerate the noncommunicable diseases. Data from major dietary surveys have revealed the components of transition diets and the impact is depicted in Table 2.7.

Obesity is characterized by excess adipose tissue accumulation resulting from an imbalance in energy intake and expenditure. High body mass index (BMI) is an important risk factor contributing to diabetes in India and has doubled from 1990 to 2016, during which diabetes has increased almost in every state. Improvement in food security and increased disposable income has led to dietary transitions of the population from traditional millet and coarse cereal-based foodstuffs to highly refined cereal-based foods that are energy-intense, nutrient-poor, and high-carbohydrate diets leading to increased BMI among our population (ICMR, 2018; Popkin, 2001; Mohan et al., 2011). Nearly 20% of the local population are obese as per the latest survey (Table 2.8).

2.9.1 Diabetes mellitus

The burden of diabetes has steadily increased over the last decades at the global and national levels for which India has contributed a major part. Diabetes is identified as one of the four priority noncommunicable diseases targeted for action due to its growing disease burden (ADA, 2015). It has become one of the major threats in the industrialized world not only among adults but also among adolescents and children (Rao et al., 2014). Surveys including that conducted by ICMR have revealed the prevalence of 5.5%–7.7% between 1990 and 2016, whereas the NFHS survey has shown still

Table 2.7 Transition in the dietary pattern and health consequences.

Observation	Imbalance of dietary nutrients	Consequences	Reference
Increased consumption of refined grains—polished rice and refined wheat flour replacing whole grains	Increased refined carbohydrates, reduced dietary fiber and micronutrients	Increased glucose and insulin concentrations Increased digestibility of carbohydrates, increased risk for diabetes	NSSO (2010); NNMB (2012); Kapil and Sachdev (2012)
Reduced consumption of protective foods such as pulses, milk, vegetables, and fruits	Low amounts of proteins, fiber, and micronutrients	Contributes to increased GI	NNMB (2012)
Increased consumption of visible fats and oils Processed, baked, and fried foods have increased	FAO data suggest that energy from fat has increased from 14% to 19% and vegetable oils from 6% to 10% Trans fat consumption above the safety level of 1.1% of energy	Contributes to obesity, altered lipid profile, and cardiovascular diseases	FAO (2004) Misra et al. (2009)
Sugar-sweetened beverages and energy drinks have increased Consumption of processed foods has increased	Per capita sugar consumption from sweets and beverages has increased to 25 kg/capita/annum. This increases the consumption of sugar, salt, and preservatives.	Increases risk of obesity and other chronic diseases	Gulati and Misra (2014)
Changed lifestyle with reduced exposure to sunlight	Increase in vitamin D deficiency	Negative impact on the glycemic index	Adams and Hewison (2010)

higher prevalence. Prediabetes and diabetes in India are as high as 13% in some Indian regions (Anjana et al., 2017). Diabetes contributes to 3.1% of all deaths in India. Asian Indians were found to have the peak prevalence of diabetes 10 years earlier compared to their other Asian counterparts, and the take-off point for the increased prevalence of diabetes among Asian Indian individuals was 25–34 years as per the ICMR study (ICMR, 2018). There is sufficient evidence of an "Asian phenotype" in diabetes, and the progression from prediabetes to diabetes appears to occur faster in this population. The clinical and biochemical features that dispose Asians to a higher risk are higher

Table 2.8 Prevalence of overweight and obesity (%).

Age group	Obesity (BMI >25)	Diabetes (Blood glucose 140 to >160)	Hypertension	Reference
Women	20.6	8.6	8.8	NFHS-4 (2015–16)
Men	18.9	11.9	13.6	
Adults	–	69.2 million	–	IDF (2015)
All	–	–	One-fifth of Indian population	Bhansali et al. (2015)

waist circumference, higher waist-to-hip ratio, more subcutaneous and visceral fat, and higher insulin resistance than individuals of US origin (Bajaj et al., 2014). Almost an equal or higher proportion of the population is also subjected to hypertension in the same population.

Diet has shown a strong correlation on the onset, progression, severity, and secondary complications of diabetes. There is vast literature on the association of dietary constituents and the occurrence of diabetes with traditional and current transitional diets. The association between single dietary ingredients and/or constituents and diabetes has been extensively studied, and a few studies are cited in Table 2.9.

The main features observed in the transition dietaries in urban areas have shown a higher proportion of refined cereals and junk foods and sweetened beverages. The predictive risk of developing metabolic syndrome was found to be 7.9% with elevated fasting blood glucose levels accelerating diabetes (Radhika et al., 2009; Unnikrishnan et al., 2016).

2.9.2 Cardiovascular disease

Cardiovascular diseases have become the leading cause of disease burden and deaths globally for which India is not an exception. These diseases contributed to 28.1% of the total deaths and 14.1% of the disability-adjusted life years (DALYs) in India (India State-Level Disease Burden Initiative CVD Collaborators, 2018). Increased consumption of saturated fatty acids such as palmitic and myristic acids, lauric acid, trans fatty acids, high sodium intake, and unfiltered boiled coffee have all shown to increase the risk of cardiovascular disease (Ding et al., 2014). High intake of fruits and vegetables conferred 48% protection against cardiovascular disease and 30% of risk reduction from myocardial infarction. Consumption of green leafy vegetables was associated with a lower risk of ischemic disease. Replacing saturated fatty acids with carbohydrates is known to reduce the risk of cardiovascular disease (Siri-Tarino et al., 2010).

Meta analyses to assess the comparative effect of different types of dietssuch as Dietary Approaches to Stop Hypertension (DASH) diet, Mediterranean diet, Low sodium and Vegetarian diet were assessed. All diets were effective in reducing blood

Table 2.9 Association of major dietary constituents and the onset of diabetes.

Dietary constituent	Biochemical change
The quality and quantity of carbohydrates	Higher glycemic index and glycemic load diets along with low dietary fiber content are known to increase insulin demand and further lead to pancreatic β-cell exhaustion (Radhika et al., 2009) One to two servings of sugar-sweetened beverages per day is known to cause insulin resistance, impair β cell function, increase inflammation, and increase the risk of diabetes by 26% (Malik et al., 2010) Substituting brown rice over white rice significantly lowered blood glucose and insulin levels (Mohan et al., 2011)
Quality and type of fats	Fatty acids influence glucose metabolism by altering cell membrane function, enzyme activity, insulin signaling, and gene expression Replacing saturated fats and trans fatty acids with unsaturated fats has beneficial effects on insulin sensitivity and is likely to reduce the risk of type 2 diabetes Linoleic acid from the n-6 series improves insulin sensitivity, while saturated fats are known to impair insulin activity. The effect of the ratio of ω-6 and ω-3 fatty acids on the insulin sensitivity and metabolic abnormalities are controversial (Bradley, 2018)
Protein quality and quantity	Proteins are believed to induce insulin secretion both by the direct stimulation of pancreatic β-cells by amino acids and via incretin hormones expressed in response to meal composition • Coingestion of a protein and amino acid mixture with carbohydrates in type 2 diabetes subjects can increase the plasma insulin response 2−3-fold (Loon et al., 2003) • The ratio of animal and plant protein in a meal can affect insulin secretions • Among amino acids, branched-chain amino acids (BCAA) and phenylalanine are known to affect insulin secretion, and the effect was higher with BCAA alone • The glucose-lowering and insulinotropic effect of amino acids were more effective when ingested with glucose. BCAAs, arginine, and glutamic acid, when ingested with glucose, were found to function as secretagogues • Among dietary proteins, legumes, soya, and whey proteins were more effective in regulating glucose levels • Whey protein was found to be superior in the regulation of glucose homeostasis by—increasing satiety, preventing postprandial glucose spikes, and increased postprandial insulin response. Whey proteins lead to the subsequent synthesis and secretion of the incretin hormones, glucose-dependent insulinotropic polypeptide (GIP), and glucagon-like peptide-1 (GLP-1) in healthy subjects. (Pal et al., 2014; Gunnerud et al., 2013; Ricci-Cabello et al., 2014)

pressure and lipid levels at varying levels. DASH diet have shown more promising evidences in reducing hypertension, LDL and total cholesterol but no effect was seen in triglycerides (Eckel, Jakicic, Ard, de Jesus, Miller, & Hubbard, et al., 2014).

DASH diet comprises of whole grains, higher fresh fruits and vegetables, low fat dairy products and lesser quantity of sodium, fat and meat products.

Mediterranean diet comprises of higher proportion of whole grains, legumes, fresh fruits and vegetables, moderate quantity of fish, olive oil, low fat dairy products, small quantities of red wine, while red meats are avoided (Shai et al., 2008). In this type of dietary intervention, recurrent cardiovascular diseases (CVD) was reduced by 70%. Indian migration study carried out in four cities of India to assess the impact of vegetarian diets showed lower levels of total cholesterol, blood glucose, and blood pressure (Shridhar et al., 2014).

2.9.3 Diet and hypertension

Excess dietary salt intake account for 17%–30% risk for hypertension, which in turn is associated with stroke, direct vascular damage, obesity, stomach cancer, osteoporosis, kidney stones, and thirst (WHO, 2013). According to a nationwide India diabetes study, one-fifth of the Indian population is hypertensive and consumes dietary salt higher than the recommended 6 g/person/day (Bhansali et al., 2015). Radhika et al. (2009) observed that salt intake significantly correlates with the prevalence of hypertension in the Chennai urban population. NNMB report (2012) indicate that 20% of hypertensives in rural area consume more than 5 g of salt/person/day. Adults with type 2 diabetes or at least 3 CVD risk factors on Mediterranean diets showed a reduction of blood pressure by 6–7/2–3 mm Hg (Eckel et al., 2014). DASH diet is used as an effective dietary measure to manage hypertension (Sacks and Campos, 2010).

2.9.4 Diet and cancer

Around 0.55 million deaths occur annually in India, the most commonly prevalent fatal forms of cancer in India are oral, pharynx and lung in men, and cervix, breast, and stomach cancer in women (Dikshit et al., 2012). Overweight and obesity as an outcome of imbalanced nutrition are reported to be one of the contributing factors for cancer. Association of dietary factors and the occurrence of cancer from cross-sectional epidemiological studies are indicated in Table 2.10.

Consequences of noncommunicable diseases such as diabetes, cardiovascular disease, cancer, and mental health between 2012 and 2030 in India is estimated to be US $4.58 trillion (Bloom et al., 2011). The losses are a sum of reduced savings, medical expenses at both household and national level, loss of productivity due to sick workers, increase in DALYs in younger age groups and, on the whole, the cost of the

Table 2.10 Association of dietary imbalances and the occurrence of different types of cancer.

Type of cancer	Dietary associations
Reduced risk for oral, esophageal, breast, endometrial, and cervical cancers in Indian migrants in Singapore	High intake of vegetables, fruits, fish, eggs, and diets high in carotenoids and nutrients such as vitamins C and E (Sinha et al., 2003)
Increased prevalence of upper aerodigestive cancer	Reduced intake of vegetables/fruits, pulses, fish, and low intakes of vitamin A, C, and B complex and selenium (Krishnaswamy et al., 2016)
Increased risk of breast cancer and ovarian cancer	• Increased energy, saturated fat, and reduced physical activity and vice versa • Protective association of green tea and reduction of risk of ovarian cancer • Dried fish, high temperature foods, chilies, and spicy foods • (Crane et al., 2015)

diseases is known to cause 5%—10% loss of GDP. A reduction of 0.5% loss of economy is known to increase mortality by 10% (Patel et al., 2011).

2.10 Future outlook

Diet is the sole source of all nutrients that further determines the nutritional status and health status of the individual from "in utero" to elderly both in health and sickness and this fact is proven through epidemiological, clinical, long-term, cross-sectional, and community-based studies. Well-controlled nutrition intervention studies have further confirmed that certain impairments due to specific nutrient deficiencies can be reversed through the replenishment of the nutrients through dietary interventions that have better compliance and sustainability. Clinical trials have also shown better management of disease conditions with dietary modifications. The social network is playing a prominent role in creating health and nutrition awareness, although there is no regulation to validate the claims. There is no scarcity of knowledge or the professionals; however, appropriate outreach of research outcomes to the beneficiaries is a limiting factor. To overcome the persistent ill effects of malnutrition in our country, the integration between the nutritionists, medical professionals, food scientists, policymakers, and food manufacturers has to be strengthened. The beneficiaries who are the stakeholders need to be sensitized about ill-effects of malnutrition percolating through generations and modification of genetic substance through the widely reachable and acceptable social media.

References

Abu-Saad, K., Fraser, D., 2010. Maternal nutrition and birth outcomes. Epidemiol. Rev. 32, 5−25.

ADA (American Diabetes Association), 2015. Classification and diagnosis of diabetes. Diabetes Care 38, S8−S16.

Adams, J.S., Hewison, M., 2010. Update in vitamin D. J. Clin. Endocrinol. Metab. 95, 471−478.

Allen, L.H., 2000. Anemia and iron deficiency: effects on pregnancy outcome. Am. J. Clin. Nutr. 71 (5 Suppl.), 1280S−1284S.

Anjana, R.M., Pradeepa, R., Das, A.K., Deepa, M., Bhansali, A., Joshi, S.R., et al., 2014. Physical activity and inactivity patterns in India − results from the ICMR INDIAB study (Phase-1) [ICMR-INDIAB-5]. Int. J. Behav. Nutr. Phys. Act. 11, 26−32.

Anjana, R.M., Deepa, M., Pradeepa, R., Mahanta, J., Narain, K., Das, H.K., et al., 2017. Prevalence of diabetes and prediabetes in 15 states of India: results from the ICMR-INDIAB population-based cross-sectional study. Lancet Diabetes Endocrinol. 5, 585−596.

Bajaj, H.S., Pereira, M.A., Anjana, R.M., Deepa, R., Mohan, V., Mueller, et al., 2014. Comparison of relative waist circumference between Asian Indian and US adults. J. Obes. 2014, 1−10. Available from: https://doi.org/10.1155/2014/461956. Article ID461956.

Bamji, M.S., Nair, M., 2016. Food-based approach to combat micronutrient deficiencies. Proc. Indian Natl. Sci. Acad. 82, 1529−1540.

Bavdekar, A., Yajnik, C.S., Fall, C.H., Bapat, S., Pandit, A.N., Deshpande, V., et al., 1999. Insulin resistance syndrome in 8-year-old Indian children: small at birth, big at 8 years, or both? Diabetes 48, 2422−2429.

Bhansali, A., Dhandania, V.K., Deepa, M., Anjana, R.M., Joshi, S.R., Joshi, P.P., et al., 2015. Prevalence of and risk factors for hypertension in urban and rural India: the ICMR−INDIAB study. J. Hum. Hypertens. 29, 204−209.

Bloom, D.E., Cafiero, E., Llopis, E.J., Gessel, S.A., Bloom, L.R., Fathima, S., et al., 2011. The Global Economic Burden of Non-Communicable Diseases. World Economic Forum and Harvard School of Public Health, Geneva.

Bradley, B.H.R., 2018. Dietary fat and risk for type 2 diabetes: a review of recent research. Current Nutr. Rep. 7, 214−226.

Carba, D.B., Tan, V.L., Adair, L.S., 2009. Early childhood length-for-age is associated with the work status of Filipino young adults. Econ. Hum. Biol. 7, 7−17.

Crane, T.E., Khulpateea, B.R., Alberts, D.D., Basen-Engquist, K., Thompson, C.A., 2015. Dietary intake and ovarian cancer risk: a systematic review. Cancer Epidemiol. Biomark. Prev. 23, 255−273.

Crookston, B.T., Schott, W., Cueto, S., Dearden, K.A., Engle, P., Georgiadis, A., et al., 2013. Post-infancy growth, schooling, and cognitive achievement: young lives. Am. J. Clin. Nutr. 98, 1555−1563.

Dikshit, R., Gupta, P.C., Ramasundarahettige, C., Gajalakshmi, V., Aleksandrowicz, L., Badwe, R., 2012. Cancer mortality in India: a nationally representative survey. Lancet 379, 1807−1816.

Ding, M., Bhupathiraju, S.N., Satija, A., van Dam, Hu, F.B., 2014. Long-term coffee consumption and risk of cardiovascular disease: a systematic review and a dose-response meta-analysis of prospective cohort studies. Circulation 129, 643−659.

Eckel, R.H., Jakicic, J.M., Ard, J.D., de Jesus, J.M., Miller, H.N., Hubbard, V.S., et al., 2014. 2013 AHA/ACC guideline on lifestyle management to reduce cardiovascular risk: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. J. Am. Coll. Cardiol. 63 (25-PA), 2960−2984.

FAO (Food and Agriculture Organization), 2004. The State of Agricultural Commodity Markets. Source: www.fao.org/3/a-y5419e.

Georgieff, M.K., 2007. Nutrition and the developing brain: nutrient priorities and measurement. Am. J. Clin. Nutr. 85, 614S−620S.

Goldenberg, R.L., Culhane, J.F., 2007. Low birth weight in the United States. Am. J. Clin. Nutr. 85 (2), 584S−590S.

Gulati, S., Misra, A., 2014. Sugar intake, obesity, and diabetes in India. Nutrients 6, 5955−5974.

Gunnerud, U.J., Ostman, E.M., Bjorck, I.M.E., 2013. Effects of whey proteins on glycaemia and insulinaemia to an oral glucose load in healthy adults; a dose−response study. Eur. J. Clin. Nutr. 67, 749−753.

ICMR (Indian Council of Medical Research), 2018. Public Health Foundation of India, Institute for Health Metrics and Evaluation. GBD India Compare Data Visualization. <http://vizhub.healthdata.org/gbd-compare/india> (accessed 18.03.18.).

IDF (International Diabetes Federation), 2015. Diabetes Atlas, seventh ed. Belgium.

India State-Level Disease Burden Initiative CVD Collaborators, 2018. The changing patterns of cardiovascular diseases and their risk factors in the states of India: the Global Burden of Disease Study 1990−2016. Lancet Glob. Health 6, e1339−e1351.

Kapil, U., Sachdev, H.P.S., 2012. Urgent need to orient public health response to rapid nutrition transition. Indian J. Commun. Med. 37, 207−212.

Krishnaswamy, K., Vaidya, R., Rajgopal, G., Vasudevan, S., 2016. Diet and nutrition in the prevention of non-communicable diseases. Proc. Indian Natl. Sci. Acad. 82, 1477−1494.

Krishnaveni, G.V., Veena, S.R., Hill, J.C., Kehoe, S., Karat, S.C., Fall, C.H., 2010. Intra-uterine exposure to maternal diabetes is associated with higher adiposity and insulin resistance and clustering of cardiovascular risk in Indian children. Diabetes Care 33, 402−404.

Krishnaveni, G.V., Veena, S.R., Karat, S.C., Yajnik, C.S., Fall, C.H., 2014. Association between maternal folate concentrations during pregnancy and insulin resistance in Indian children. Diabetologia 57, 110−121.

Kulsum, A., Lakshmi, J.A., Prakash, J., 2008. Food intake and energy protein adequacy of children from an urban slum in Mysore, India − a qualitative analysis. Malays. J. Nutr. 14, 163−172.

Kulsum, A., Lakshmi, J.A., Prakash, J., 2009. Dietary adequacy of Indian children residing in an urban slum − analysis of proximal and distal determinants. Ecol. Food Nutr. 48 (3), 161−177.

Lakshmi, J.A., Begum, K., Saraswathi, G., Prakash, J., 2005. Dietary adequacy of Indian rural pre-school children: influencing factors. J. Trop. Pediatr. 51, 39−44.

Loon, L.J., Kruijshoop, M., Menheere, P.P., Wagenmakers, A.J., Saris, W.H., Keizer, et al., 2003. Amino acid ingestion strongly enhances insulin secretion in patients with long-term type 2 diabetes. Diabetes Care 26, 625−630.

Malik, V.S., Popkin, B.M., Bray, G.A., Després, J.P., Willett, W.C., Hu, F.B., 2010. Sugar-sweetened beverages and risk of metabolic syndrome and type 2 diabetes: a meta-analysis. Diabetes Care 33, 2477−2483.

Misra, A., Chowbey, P., Makkar, B.M., Vikram, N.K., Wasir, J.S., Chadha, D., et al., 2009. Consensus statement for diagnosis of obesity, abdominal obesity and the metabolic syndrome for Asian Indians and recommendations for physical activity, medical and surgical management. J. Assoc. Physicians India 57, 163−170.

Mohan, V., Joshi, S.R., Seshiah, V., Sahay, B.K., Banerjee, S., Wangoo, S.K., et al., 2011. Current status of management, control, complications and psychosocial aspects of patients with diabetes in India: results from the DiabCare India 2011 Study. Indian J. Endocrinol. Med. 18, 370−378.

Nair, K.M., Brahmam, G.N.V., Radhika, M.S., Dripta, R.C., Ravinder, P., Balakrishna, N., et al., 2013. Inclusion of guava enhances non-heme iron bioavailability but not fractional zinc absorption from a rice-based meal in adolescents. J. Nutr. 143, 852−858.

NFHS-4 (National Family Health Survey), 2015−16. [Internet]. Mumbai: International Institute for Population Sciences (IIPS) and Macro International; 2009. Available from: <http://www.rchiips.org/nfhs/nfhs4.shtml>.

NNMB (National Nutrition Monitoring Bureau), 2012. Diet and Nutritional Status of Rural Population, Prevalence of Hypertension and Diabetes Among Adults and Infant and Young Child Feeding Practices − Third Repeat Survey, NNMB Technical No. 26, National Institute of Nutrition.

NSSO (National Sample Survey Organization), 2010: Migration in India, Report No. 533, Ministry of Statistics and Program Implementation, Government of India, New Delhi.

Özaltin, E., Hill, K., Subramanian, V., 2010. Association of maternal stature with offspring mortality, underweight, and stunting in low- to middle-income countries. J. Am. Med. Assoc. 303, 1507−1516.

Pal, S., Radavelli-Bagatini, S., Hagger, M., Ellis, V., 2014. Comparative effects of whey and casein proteins on satiety in overweight and obese individuals: a randomized controlled trial. Eur. J Clin. Nutr. 68, 980−986.

Pandav, C.S., Yadav, K., Srivastava, R., Pandav, R., Karmarkar, M.G., 2013. Iodine deficiency disorders (IDD) control in India. Indian J. Med. Res. 138, 418−433.

Patel, V.S., Chatterji, D., Chisholm, S., Ebrahim, G., Gopalakrishna, C., Mathers, V., et al., 2011. Chronic diseases and injuries in India. Lancet 377, 413−428.

PHFI, 2015. India Health Report-Nutrition, 2015. Public Health Foundation of India, New Delhi.

Popkin, B.M., 2001. The nutrition transition and obesity in the developing world. J. Nutr. 13, 871S−873SS.

Radhika, G., Van Dam, R.M., Sudha, V., Ganesan, A., Mohan, V., 2009. Refined grain consumption and the metabolic syndrome in urban Asian Indians (Chennai Urban Rural Epidemiology Study 57). Metabolism 58, 675−681.

Rais, M., Acharya, S., Sharma, N., 2013. Food processing industry in India: S&T capability, skills and employment opportunities. J. Food Process. Technol. 4, 260. Available from: https://doi.org/10.4172/2157-7110.100026.

Raman, R., 2016. Nutritional modulation of gene function in disease susceptibility: homocysteine-folate metabolism pathway. Proc. Indian Natl. Sci. Acad. 82, 1413−1424.

Rao, K.R., Lal, N., Giridharan, N.V., 2014. Genetic & epigenetic approach to human obesity. Indian J. Med. Res. 140, 589−603.

Ricci - Cabello, I., Ruiz-Pérez, I., Rojas-García, A., Pastor, G., Rodríguez-Barranco, M., Goncalves, C., 2014. Characteristics and effectiveness of diabetes self-management educational programs targeted to racial/ethnic minority groups: a systematic review, meta-analysis and meta-regression. BMC Endocr. Disord. 14, 60−65.

RSOC, 2013−14. Government of India (2015). Rapid Survey on Children 2013−2014 − India Fact sheet, Ministry of Ministry of Human Development. <http://wcd.nic.in/issnip/National_Factsheet_RSOC_02-07-2015.pdf>.

Sacks, F.M., Campos, H., 2010. Diet therapy in hypertension. N. Engl. J. Med. 362, 2102−2112.

Sinha, R., Anderson, D.E., McDonald, S.S., Greenwald, P., 2003. Cancer risk and diet in India. J. Post Grad. Med. 49, 229−235.

Siri-Tarino, P.W., Sun, Q., Hu, F.B., Krauss, R.M., 2010. Saturated fat, carbohydrate, and cardiovascular disease. Am. J. Clin. Nutr. 91, 502−509.

Shai, I.R.D., Schwarzfuchs, D., Henkin, Y., Shahar, D.R., Witkow, S., Greenberg, I., et al., 2008. Loss with a low-carbohydrate, Mediterranean, or low-fat diet. N. Engl. J. Med. 359, 229−241.

Shridhar, K., Dhillon, P.K., Bowen, L., Kinra, S., Bharathi, A.V., Prabhakaran, D., et al., 2014. The association between a vegetarian diet and cardiovascular disease (CVD) risk factors in India: The Indian Migration Study. PLoS ONE 9, 1−8.

UNICEF, 2013. Improving Child Nutrition, The Achievable Imperative for Global Progress UNICEF. New York.

Unnikrishnan, R., Anjana, R.M., Mohan, V., 2016. Diabetes mellitus and its complications in India. Natl. Rev. Endocrinol. 12, 357−370.

Vazir, S., Boindala, S., 2016. Nutrition, brain development and cognition in infants, young children and elderly. Proc. Indian Natl. Sci. Acad. 82, 1495−1506.

Vijayaraghavan, K., 2016. The persistent problem of malnutrition. Proc. Indian Natl. Sci. Acad. 82, 1341−1350.

Wasserman, C.R., Shaw, G.M., Selvin, S., Gould, J.B., Syme, S.L., 1998. Socioeconomic status, neighbourhood social conditions, and neural tube defects. Am. J. Public Health 88, 1674−1680.

West, J., Wright, J., Fairley, L., Sattar, N., Whincup, P., Lawlor, D.A., 2014. Do ethnic differences in cord blood leptin levels differ by birthweight category? Findings from the born in Bradford cohort study. Int. J. Epidemiol. 43, 249−254.

Whincup, P.H., Kaye, S.J., Owen, C.G., Huxley, R., Cook, D.G., Anazawa, S., et al., 2008. Birthweight and risk of type 2 diabetes: a quantitative systematic review of published evidence. J. Am. Med. Assoc. 300, 2885−2897.

WHO, 2013. Global Action Plan for the Prevention and Control of Noncommunicable Diseases: 2013–2020. 2013. <http://apps.who.int/iris/bitstream/10665/94384/1/9789241506236_eng.pdf> (accessed 08.03.18.).
Wood-Bradley, R., Barrand, S., Giot, A., Armitage, J., 2015. Understanding the role of maternal diet on kidney development; an opportunity to improve cardiovascular and renal health for future generations. Nutrients 7, 1881–1905.
Yajnik, C.S., Lubree, H.G., Rege, S.S., Naik, S.S., Deshpande, J.A., Deshpande, S.S., et al., 2002. Adiposity and hyperinsulinemia in Indians are present at birth. J. Clin. Endocrinol. Metabol. 87, 5575–5580.
Yajnik, C.S., Deshpande, S.S., Jackson, A.A., Refsum, H., Rao, S., Fisher, D.J., et al., 2008. Vitamin B_{12} and folate concentrations during pregnancy and insulin resistance in the offspring: The Pune Maternal Nutrition Study. Diabetologia 51, 29–38.
Yajnik, C.S., Chandak, G.R., Joglekar, C., Katre, P., Bhat, D.S., Singh, S.N., et al., 2014. Maternal homocysteine in pregnancy and offspring birthweight: epidemiological associations and Mendelian randomization analysis. Int. J. Epidemiol. 5, 1487–1497.
Zimmet, P.Z., 2017. Diabetes and its drivers: the largest epidemic in human history? Clin. Diabetes Endocrinol. 3, 1–8.