

A SHIFT FROM DOUBLE-BURDEN TO TRIPLE-BURDEN OF MALNUTRITION: A REVIEW

Antara Bose¹, Nitish Mondal², Jaydip Sen³

Abstract: Malnutrition is a serious emerging public health issue directly related to human health concerns of all ages starting from infancy to senescence. India, being a low-to-middle income country with a large population, is facing major challenges to combat the nutritional gap that persists mainly among nutritionally vulnerable segments of the population. Prevalence of triple burden of malnutrition encompasses both undernutrition and overnutrition with the addition of micronutrient deficiencies. The objectives of the present review paper are to evaluate the various nutritional issues related to the triple burden of malnutrition in the population. Further, the paper also focuses on the recent trends, factors, causes, and consequences that have led to a shift from "Double-Burden" to "Triple Burden" of malnutrition with special reference to Indian populations. Further, the appropriate interventions and recommendations have been discussed to face the challenges regarding the triple burden of malnutrition among nutritionally vulnerable segments of the population.

Keywords: Deficiencies, Micronutrient, Overnutrition, Public Health, Undernutrition

INTRODUCTION

In recent times the term "Double-Burden of Malnutrition" (DBM) has been replaced by the term "Triple- Burden of Malnutrition (TBM)". The existence of DBM has dealt with undernutrition and overnutrition in human populations (Doak et al. 2005; Grijalva-Eternod et al., 2012; Sharma and Mondal, 2014; Debnath et al., 2018, 2019; Biswas et al., 2019; Kumar et al., 2021), whereas TBM comprises both undernutrition and overnutrition, with the addition of micronutrient deficiencies (Meenakshi 2016; Pingali et al., 2019; Elizabeth, 2020). Globally, the burden of undernutrition (e.g., stunting) is very high, and it has been estimated that half of the children <5 years of age die due to insufficient availability of foods with essential micronutrients (Black et al., 2013; Bailey et al., 2015; UNICEF, 2019a; Bose and Sen, 2020; Kumar et al., 2021). The magnitude of undernutrition varies from protein-energy malnutrition (PEM) and chronic energy deficiency (CED) to micronutrient deficiencies among both children and adults, respectively. Micronutrient deficiencies comprise of deficiencies in vitamin A, iron, zinc, folate acid, and iodine (Faber and Wenhold, 2007; Murray et al. 2012; Debnath et al., 2019; Pingali et al., 2019; UNICEF 2019b), and this affects over two billion people globally. WHO (2007) has classified undernutrition into underweight (low weight-for-age), stunting (low height-for-age), wasting (low weight-for-height or low

1. Antara Bose, Research Fellow, Department of Anthropology, University of North Bengal, Darjeeling 734013, West Bengal, India, E-mail: abose1202@gmail.com; 2. Nitish Mondal, Associate Professor, Department of Anthropology, Sikkim University, Gangtok 737102, Sikkim, India, E-mail: nitishanth@gmail.com (Corresponding Author); 3. Jaydip Sen, Professor, Department of Anthropology, University of North Bengal, Darjeeling 734013, West Bengal, India, E-mail: jaydipsen@rediffmail.com

mid-upper arm circumference-for-age) and thinness (low BMI-for-age). Overnutrition (i.e., overweight and obesity) today remains one of the major causes in the rise of various non-communicable diseases such as coronary heart diseases, type-II diabetes, hypertension, cardiovascular diseases, and different types of cancers in adults (Astrup et al., 2008; Reilly and Kelly, 2011; Popkin et al., 2012; Ranjani et al., 2014; WHO, 2014; Praveen and Tandon, 2016; Pozza and Isidori, 2018). Recent studies have now reported that high incidence of overweight and obesity is mostly observed in the low and middle-income countries (Prentice, 2006; Popkin et al., 2012; WHO, 2014; Meenakshi, 2016; Allen et al., 2017; Mwangome and Prentice, 2019). Moreover, overnutrition or a rise in obesity is an area of major concern in the population, as it affects not only urban but also rural populations (Grijalva-Eternod et al., 2012; Meenakshi, 2016; Debnath et al., 2019). Overnutrition is observed among individuals of different ages, starting from the very pre-school children (<5 years) to adolescents and adults (Debnath et al., 2018; Bose et al. 2020). The primary reason is adhering to an inactive or sedentary lifestyle with the absence of physical activity and consumption of excess carbohydrate and fat-containing foods (Popkin et al., 2012; Eli and Li 2015; Ramachandran, 2019). However, the increase in socio-economic condition and/or incomes have led to the consumption of junk foods, aerated drinks and foods with high sugar content, drinks with high caffeine, fried items, and last but not the least the most important “sweet” like dishes resulting in diseases such as type-II diabetes, anaemia and cardio-vascular diseases (Astrup et al., 2008; Arora et al., 2014; Bailey et al., 2015; Ramachandran, 2019; Bose et al., 2020). UNICEF (2019a) has reported that out of three pre-school children of <5 years, at least one was stunted, wasted, or over-nourished where two among three children mostly belong between 6 to 24 months of age. The diagrammatic presentation of type, cause and long and short-term consequences of TBM (e.g., undernutrition, micronutrient deficiencies and overnutrition) among children are already reported by UNICEF (2019a) (Figure 1).

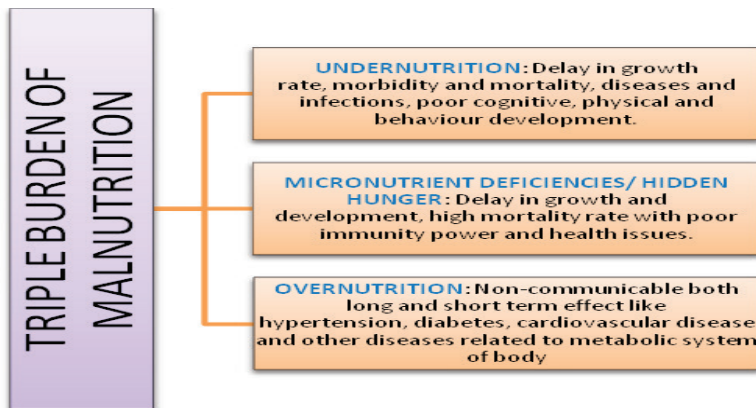


Figure 1: Triple Burden of Malnutrition (Source: UNICEF-the state of the world’s children 2019: Children, Food and Nutrition)

On one hand, undernutrition, as assessed in terms of stunting, underweight and wasting, was observed to be decreasing in Indian populations but on the other, both overweight and obesity are rising at an alarming rate whereas the overall micronutrient deficiencies are remaining at similar rates in populations (Ramachandran, 2019). This increase in the coexistence of malnutrition (e.g., TBM) is currently prevalent mostly in the low and middle-income countries (Meenakshi, 2016; Pingali et al., 2019; Elizabeth, 2020; Sunuwar et al., 2020). On a global scale, pre-school children (<5 years) of age suffer from hidden hunger, the presence of a minimal number of micronutrients in the body (UNICEF, 2019b). This study has further reported that in the year 2018, the global incidence of children with micronutrient deficiencies was 340 million, with 50 million suffered from wasting whereas 149 million children <5 years of age being stunted. Moreover, the population growth, urbanization and adoption of western lifestyles have significantly changed the lifestyles and dietary consumption patterns (Popkin et al., 2012; Eli and Li, 2015; Ramachandran, 2019), which in turn raised the demand for foodstuffs affecting health conditions, which gives rise to the TBM (Mwangome and Prentice 2019). Moreover, the increase in the prevalence of TBM has resulted in depletion of economic, agricultural, and health-related development in a population (Ingram 2018). An estimate says that about 3 billion lack of sufficient nutrients and 1 billion population consumes very fewer calories which seems insufficient for healthy living, and about 2.5 billion children, as well as adults, consume high-calorie foods (Ingram 2018). Indian Government data surveys by UNICEF and Health Ministry showed that stunting in children has decreased to 34.7% in the year 2017-2018, which was 38.4% in 2015-2016 (NFHS-4) in the country.

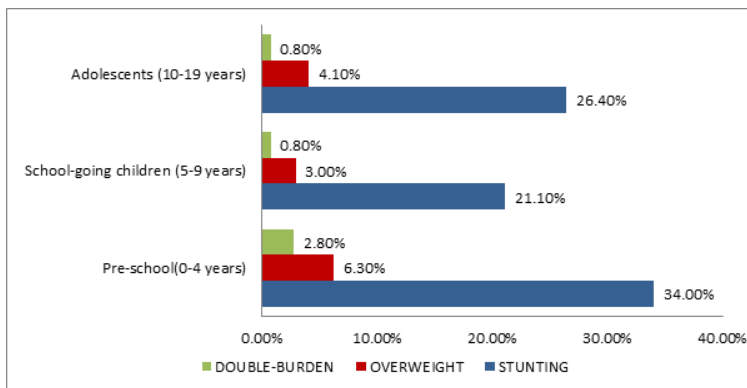


Figure 2: Double-Burden of Malnutrition among pre-schoolers (0-4 years), school-children (5-9 years) and adolescents (10-19 years) group. (Source: CNNS 2016-2018)

Malnutrition is a global phenomenon that occurs in “multiple-forms” (Webb et al., 2018). Urbanization, industrialization and westernization have made a vast

shift in the lifestyles of both children as well as among adolescents (Sharma and Mondal, 2014; Debnath et al., 2019). These changes significantly trigger shifts in socio-economic status, demographic condition, sedentary lifestyles and dietary intake which is considered as important factors for manifestations of certain non-communicable diseases (e.g., diabetes, hypertension and cardio-vascular diseases) with the change in nutritional status (e.g., obesity) in adults (Popkin et al., 2012; Sen et al., 2013; Rengma et al., 2015; Kshatriya and Acharya, 2016; Singh et al., 2017; Mondal et al., 2018; Sunuwar et al., 2020). The DBM is the result of a nutritional transition that directly is related to the health and well-being of the body. The co-existence of poverty with western lifestyles are considered to be main reasons for the existence of undernutrition, overweight, and obesity (Mondal and Sen, 2010; Capacci et al., 2013; Sharma and Mondal, 2014; Meenakshi, 2016; Debnath et al., 2019; Ramachandran, 2019; Bose and Sen, 2020). The nutritional transition has been adapted in India to such an extent that the decline of undernutrition shifted to an increase in overweight (Agarwal et al., 2013; Dandona et al., 2017). The Comprehensive National Nutrition Survey (CNNS, 2016-2018) data has confirmed the existence of DBM not only at the population level but also at the household and community levels (Figure 2) (WHO 2017a). The DBM has now been transformed to a triple one, considering micronutrient deficiencies. Recent studies have observed that micronutrient deficiencies show high prevalence among individual, household and at the community level (Meenakshi et al., 2016; Debnath et al., 2019).

OBJECTIVES OF THE PRESENT PAPER

The objectives of the present review paper are to evaluate the various nutritional issues related to the TBM in the population and also focus on the recent trends, factors, causes, and consequences that have led to a shift from DBM to TBM with special reference to Indian populations.

MATERIALS AND METHODS

Pub-Med and Google Scholar were the search engines used for the present paper. The data retrieved from PubMed and Google Scholar search terms in the combination of free text words as well as medical subject headings (MESH) terms were included for the search. The key-words used were “malnutrition, triple burden of malnutrition or TBM, overnutrition, obesity, undernutrition, nutrients, micronutrient deficiencies, pre-school, school-going, children, adolescents and India”. The database was searched for the relevant articles which were published in the English language and the articles not restricted to a particular year or decade. A total of 715 (Google Scholar) and 471 (PubMed) papers were found to be suitable and met the objectives of the present study to select and review for present study. Out of the total 1186 articles, did not meet the criteria of TBM, whereas 16 duplications of articles were found. Those papers not found suitable according to the objectives were excluded

from the present study. Hence, a total of 32 articles were finally identified in the connection of malnutrition pertaining to the emerging form of TBM showed relation either directly or indirectly, and therefore, those articles were finally included for the present study. A very recent national nutritional survey, the Comprehensive National Nutrition Survey (CNNS) (2016-2018) was also accessed. The reference list of the retrieved articles was further searched for the accumulation of data. The search was done during the period from the month of June 2020 to February 2021.

TRIPLE BURDEN OF MALNUTRITION

The very recent phrase “Triple” denotes three very challenging issues in nutritional status among individuals belonging to low and middle-income countries. The TBM is classified by Pinstrup-Anderson (2010) into three categories as energy and protein deficiency called hunger and the last is the intake of energy in excess amount leading to overweight and obesity. The burden of malnutrition in terms of TBM remains a very challenging issue among nutritionally vulnerable segments of the population, as though policies and programmes have been implemented, but improvement towards betterment is unsatisfactory thus leading to negativity (Jain and Agnihotri, 2020). The existence of DBM changes the structure of the society in various forms starting right from food systems, socio-economic developments and inequality, which makes the poor families poorer and the rich richer (Capacci et al., 2013). The prevalence of the TBM is a very recent emerging challenge, and very few studies have been done in India. The country covers a large geographic area, and there are differences in the prevalence of malnutrition for states with lower income groups (Subramanian et al., 2007; Sengupta et al., 2014; Debnath et al., 2019). These states show a higher prevalence of micronutrient deficiencies as well as stunting whereas states with higher income levels showed higher prevalence of overweight and obesity which subsequently develop as the principal causes of various diseases include musculo skeletal disorders, diabetes, types of cancer and many other related diseases (Bailey et al., 2015; Pingali et al., 2019; Debnath et al., 2019). The overall prevalence of the TBM is increasing not only at the national level but also in the community and at the household level. The recent trends suggested that prevalence of overnutrition and undernutrition are present in the form that the mother seems to be overweight, but the children remain stunted or underweight in same household level (Doaket al., 2005; Jehn and Brewis, 2009; Meenakshi, 2016; UNICEF 2019b, Kumar et al, 2021). These have associations with economic status, dietary patterns, duration of physical activity, and demographic status in the social form (Ahmed et al., 2012; Wong et al., 2015; Debnath et al., 2019; Bose and Sen, 2020). Sethi et al., (2020) using data of urban poor mothers from the Demographic Health Survey (DHS)-3 and the DHS-4 (2015-2016) reported that the prevalence of 20.6% (i.e., thin), 13.7% (i.e., overweight), 21.1% (i.e., obese), 57.4% (i.e., anaemic) and short stature (i.e., 12.8%). It is attributed to the health inequalities in terms of

socio-economic conditions play a vital role in maintaining the maternal health and nutritional requirements (e.g., Black et al., 2013; Sethi et al., 2020).

Recent trend indicates that many of the tribal population of the country are suffering from DBM as most of the populations belong to a vulnerable category. The tribal population also includes 75 “Particularly Vulnerable Tribal Groups” (PVTGs). These populations are affected by malnutrition (both undernutrition and overnutrition) which results as dual burden of communicable and non-communicable diseases in population, and also affects mental health, poor physical productivity, reproductive outcomes and leads to various types of addictions (WHO, 1995; Kumar et al., 2020). The recent population trend showed that they remain highly prone to undernutrition and obesity due to socio-economic, demographic and nutritional shifts (Subramanian et al., 2007) and are also closely associated with hypertension and cardiovascular diseases. Kshatriya and Acharya (2016) reported a high prevalence of undernutrition (51.9%, 51.3%, and 49.6%, respectively) along with hypertension (10.6%, 12.1%, and 16.5%, respectively). Further, the findings of the study showed higher prevalence and associations between overweight and hypertension was observed among five other tribes (e.g., Bhumijis, Dhodias, Kukans, Santhals) of West Bengal and Odhisa (Santhals). The prevalence of undernutrition was observed to be very high, and the incidences of overweight, obesity, and hypertension were 14.8%, 1.7%, and 9.2% among males, respectively and 10.9%, 1.5%, and 14.0% respectively among females, thus reporting a gender difference and an increase in non-communicable diseases. Kshatriya et al. (2018) later studied associations of hypertension with adiposity measures (e.g., BMI, waist-hip-ratio, waist-height-ratio, percentage body fat, visceral adiposity and skinfold thicknesses) among six major tribal groups in India. The prevalence of hypertension is attributed to body fat accumulation, which directly affecting the metabolic and physiological process. Further, several researchers have reported that trends of adopting the western lifestyles serve as an important factor for the accumulation of fat which in turn disturbs the metabolic system of the body (Rengma et al., 2015; Wong et al., 2015; Meenakshi, 2016; Mondal et al., 2018; Debnath et al., 2019; Bose et al., 2020). Further, the prevalence of undernutrition of 20%-30%, anaemia of 70%-87% as well as overnutrition accounts for 0.6% to 5-2% among Indian school children (Ramachandran and Kalaivani, 2018).

Overnutrition is increasing day by day, and in India, it is an important public health issue (Vaz et al., 2005; Ramachandran, 2014; Rengma et al., 2015; Meenakshi, 2016; Debnath et al. 2019; Bose and Sen 2020). The sex-specific prevalence of overweight and obesity was observed to be higher among women than men mostly due to socio-economic differences, sedentary lifestyle and physical inactivity (Sen et al., 2013; Kaicker et al., 2014; Rengma et al., 2015; Mondal et al., 2018). Meenakshi (2016) also reported similar trends and patterns associated with the TBM in population. Singh et al. (2017) studied 6940 urban adults from five different

cities which included Moradabad, Trivandrum, Calcutta, Nagpur, and Bombay, to report the risk of TBM prevailing due to obesity, undernutrition and disease, mainly attributed to physical inactivity or sedentary lifestyles and observed that all these co-existed due to economic development and sedentary way of living during the transition in a developing economy. The study further showed that obesity, (both central and regional adiposity) and undernutrition occurred simultaneously where a sedentary lifestyle proved to be an important factor.

One of the main reasons for malnutrition leading to the TBM is “poverty” which is the consequence of hunger. Further, it has been opined that by eradicating poverty, hunger can be reduced and, on the contrary one step to reduce malnutrition (e.g., undernutrition) is the bio-fortification of food eating crops (Meenakshi, 2016; Sharma et al., 2016; Bose and Sen, 2020). The recent national nutritional survey known as the Comprehensive National Nutrition Survey (CNNS) was conducted in 2016-2018, and it was observed that the burden of malnutrition during the very early childhood phase reduced educational capabilities.

Micronutrient deficiencies disturb the cognitive, behavioural, and physical ability of the body, causing deterioration in working ability which lastly results in mortality and morbidity (Murray et al., 2012; Bailey et al., 2015; Chauhan, 2019; Sawe et al., 2021). Their prevalence is also frequently associated with maternal and infant health (Akhtar et al., 2013; Jones et al., 2016; Sawe et al., 2021). Bailey et al. (2015) has reported that the consequence of micronutrient deficiencies has increase the mortality, and morbidity, minimum birth weight with poor development as well as risk in being affected by various diseases. Further, the micronutrient deficiency trends follow to childhood stage with inadequacy in mental development and physical growth retardation which further shifts to adolescence, the period where pubertal development slowly changes and manifested in terms of stunting, frequent infections, diseases and mental stress. The trend no doubt follows to adulthood where ‘prenatal complications’ arise with less productivity and deterioration in the social and economic status. Studies of Kapil (2014) and Kumar et al. (2014) have observed that the prevalence of micronutrient deficiencies is high in India. Iodine deficiency causes goitre, cretinism, reduces mental and physiological development thus increasing the rate of perinatal and neonatal mortality while zinc deficiency give rise to diarrhoea and respiratory diseases (Bailey et al., 2015). Vitamin A deficiency impairs the differential function of the cell, disbalances the immune system, and leads to the principal cause for night blindness or xerophthalmia (Bailey et al., 2015; Debnath et al., 2019; Bose and Sen, 2020; Sawe et al., 2021). The CNNS survey (2016-18) data has reported an overall prevalence of different micronutrient deficiencies (Table 1).

TABLE 1: OVERALL PREVALENCE OF DIFFERENT MICRONUTRIENT DEFICIENCIES (SOURCE: CNNS 2016-2018)

MICRONUTRIENT DEFICIENCIES	Pre-school children (0-4 years)	School children (5-9 years)	Adolescents (10-19 years)
Iron	31.9%	17%	21.5%
Zinc	19%	17%	32%
Vitamin A	18%	22%	16%
Vitamin B12	14%	17%	31%
Vitamin D	14%	18%	24%
Folate	23%	28%	37%
Urinary iodine	213µg/L	175µg/L	173µg/L

Micronutrient deficiencies causes due to inadequate iron intakes manifested as anaemia whose prevalence was observed among children, women and adolescent girls (Meenakshi, 2016; Debnath et al., 2019; Sharma et al., 2020; Sawe et al., 2021). Anaemia affects health in mild, moderate and severe forms that in turn, affect the mental, behavioral and psychomotor developments (Solima et al., 2014; WHO, 2017b; Bose and Sen, 2020; Kumar et al., 2021). Anaemia is caused due by insufficient intake of iron, which mainly encompasses a poor micronutrient diet and unsuitable environment, thus decreasing the potential abilities in the educational field, growth, and development deteriorate. The CNNS (2016-18) data showed that 41% of pre-school students, 24% of school children, and 28% of adolescents were anaemic. The report showed that the children and adolescents residing in urban areas were more affected by iron deficiencies (7-12%) than those from rural areas in India. The data also showed that overall prevalence of iron deficiency was 32% among pre-schoolers, 17% among school-children, and 22% among adolescents. Gender differences were also reported (girls: 31%; boys; 12%) in the survey. Micronutrients contribute their impact directly not only on individuals but to society as the deficiency in any form decreases the attention span, working capabilities further decreasing the overall performance of the total life-span (Bailey et al., 2015). The deficiency of folate in the body causes macrocytic anemia which diminishes the repair mechanism of deoxyribonucleic acid (DNA) (Bailey et al., 2015).

The TBM is the main cause of diseases such as obesity, diabetes and hypertension among children who are preterm due to its early initiation before the entry into the adult phase. These diseases are most commonly known as non-communicable diseases (NCDs) (e.g., obesity, diabetes, hypertension and cardiovascular diseases) which are mainly caused due to poor healthy diet, tobacco and alcohol consumption, socio-economic conditions and sedentary lifestyles (Labadarios, 2016; Singh et al.,

2017; Pozz and Isidori, 2018), and absence of physical inactivity (Allen et al., 2017; Ramachandran, 2019; Debnath et al., 2019; Bose et al., 2020). It is apparent that the magnitude of NCDs include cardiovascular diseases, several types of cancer, chronic respiratory diseases, hypertension and type-II diabetes has been increases couple with the burden of malnutrition in population (Ramachandran, 2006; Kapil and Sachdev, 2012; Popkin et al., 2012; Ranjani et al., 2014; Pozza and Isidori, 2018; Bose et al., 2020). Recent studies have also reported that pollution severely affects health, thus, climatic factors also contribute to non-communicable diseases in adult population (Watts et al., 2015; Myers et al., 2017; Sawe et al., 2021).

India is the second country where estimates 73 million adults to be affected by diabetes (IDF 2017). This is an emerging disease that is rising at an alarming rate among children, adolescents, and adults (Parveen and Tandon, 2016; Debnath et al., 2019; Sawe et al., 2021). An increase in diabetes strongly correlates with lifestyle patterns which gives rise to abdominal obesity (Anjana et al., 2015). Little et al. (2020) studied the prevalence of co-morbid anemia with overweight and anemia with diabetes among 753 adults residing in Tamil Nadu, South India. About 23.1% of the women and 13.1% of the men showed prevalence of anemia and overweight where as 6.2% of the women and 6.3% of the men showed occurrence of anemia with diabetes.. Hypertension is a very common NCD which are mainly seen among the adolescents group due to various unhealthy habits (Kshatriya et al., 2018). The supply of Vitamin A and iron supplements had shown a reduction in wasting (Semba et al., 2010; Bailey et al., 2015; Debnath et al., 2019), with better health and cognitive development (Adhvaryu and Nyshadham, 2016; Bose and Sen, 2020; Sewa et al., 2021).

Studies outside India, including the neighborhood countries, also showed the prevalence of TBM. Sunuwar et al. (2020) had recently studied the prevalence of DBM and TBM among 2261 mothers and their children from Nepal. The prevalence of DBM to be 6.60% and TBM to be 7.00%. The study analyzed the socio-demographic variable and observed that mothers aged age more than 35 years with at least education till secondary level and short stature were more prone to both DBM and TBM. A review based on a survey in Nepal (Wei et al., 2019) showed the prevalence of stunting among pre-school children (<5 years) to be 35.8%, wasting 9.7%, underweight 27.0% with a stable rate of anaemia and decrease in underweight whereas obese and overweight among women increased to 22.1%. A study among 2283 children aged under five years and 2467 women of 15-49 years of age showed that 41.4% of children were stunted and 51% were anaemic in Bangladesh (Rahman et al., 2019). The prevalence of anaemia among the stunted children was 56.5%, whereas women with low BMI showed high prevalence of anaemia (49.5%). Undernourished children with poor nutrition showed a direct effect in their adulthood phases in having low educational performance and productivity which is mainly caused due to poor cognitive development (Stein et al., 2008; Akresh

et al., 2011; Black et al., 2013), thus giving rise in non-communicable diseases. Guerrant et al. (2013) studied stunting among children which causes diarrhea and chronic diseases. Adolescents in Bangladesh showed “inadequate dietary diversity” (IDD) which directly associates with to TBM. A very recent study by Akter et al. (2020) showed that the prevalence of IDD in girls was 55% while it was 50.6% among boys. The study also showed that socio-economic conditions played a very important role in determining the TBM in association to IDD. A very recent study of Sawe et al. (2021) among children in Kisumu country, Kenya among 384 children showed that 23% were underweight, 30% were overweight as well as 31% consumed foods that were rich in iron.

MALNUTRITION AND NUTRITIONAL INTERVENTION PROGRAMME IN INDIA

The Indian Government had introduced many health and nutrition related schemes to achieve the Sustainable Development Goals (SDGs) in reducing the rate of mortality and morbidity, thus reducing undernutrition by the year 2030. Various programmes have been introduced by the government such as Integrated Child Development Services (ICDS) along with National Health Mission that take into account pregnant and lactating mothers and children under six years of age to eradicate micronutrient deficiencies such as vitamin A, folic acid, and iron (Chauhan 2019). Several other programmes that are in force are the Mid-day meal scheme, Janani Suraksha Abhiyan, the National Programme for Prevention and Control of Cancer, Diabetes, Cardio-vascular Diseases and Stroke (NPCDCS). The National Nutrition Mission also known as Rashtriya Poshan Abhiyan is a very recent initiative (2017-2018) taken by the Government of India under the Ministry of Health and Family Welfare which further categorizes into various health and nutrition interventions given in Figure 3.

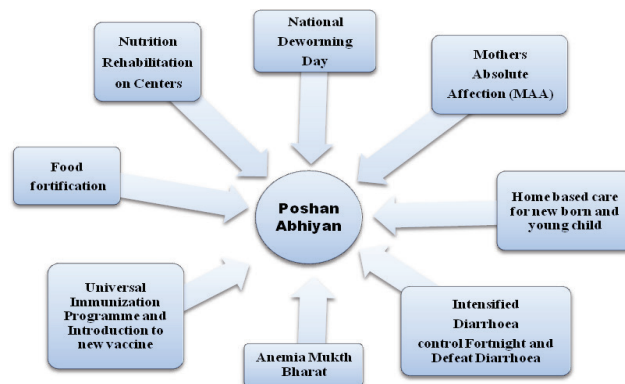


Figure 3: Poshan Abhiyan and the Key Initiatives. (Source: Ministry Of Health and Family Welfare, Government of India, 2018)

India has also targeted a Malnutrition-free Bharat Abhiyan by the year 2022. Some more interventions include the Balwadi nutrition programme, vitamin A prophylaxis, National Iodine deficiencies disorders control programme, Rajiv Gandhi schemes for Empowerment of Adolescents Girls (SABLA), Indira Gandhi Matritya Sahyog Yojna. Some schemes which are indirectly related to nutrition are Swachh Bharat Abhiyan, National Food Security Mission, Targeted Public Distribution System (TPDS), National Rural Drinking Water programme, Mahatma Gandhi National Rural Employment Guarantee Schemes (MGNREGS), Nirmal Bharat Abhiyan, Kishori Shakti Yojna, Women welfare, and many other supportive programmes. The introduction of dietary diversity with supplementations, fortifications, and home-based therapeutic foods serves as a nutritional upliftment which further determines the effective means to eradicate the emerging issues of the TBM both at the community and population level.

CONCLUSIONS

The prevalence of TBM and its emerging phenomenon mostly in the low-to-middle-income countries are unpredictable. As the TBM is the shift from the DBM, the challenges seem to be very high among nutritionally vulnerable segments of the population. Moreover, the high prevalence of malnutrition not only affects the population level, but also community, household, and individual levels which is directly related to long and short-term health consequences. The rise in TBM is closely associated with several non-communicable diseases which is a very serious issue related to public health. An increase in access to essential nutrients in the diet, leading a healthy lifestyle as well as betterment in income and healthcare facilities can serve to be the important factor for tackling growth rate in malnutrition. The future tackling of the TBM would be achieved by identification and close observation about the factors associated and thus acting accordingly through required interventions. The well-being of a country can only be determined if certain measures are taken towards better income facilities, healthy foods, hygienic conditions, sanitation, job opportunities, affordable food price, and quality are maintained.

RECOMMENDATIONS

The review paper has discussed the rapidly growing transition of malnutrition from DBM to TBM which comprises undernutrition, overnutrition, and micronutrient deficiencies. The paper further highlights the key link between health and socio-economic status and demographic conditions that mainly involves an individual's dietary habits and lifestyle in population. Recommendations are made on the following:

- The government should focus on social outcomes which are not only helpful to decrease the rate of undernutrition (e.g., stunting or underweight) but also halting the rise in overnutrition (e.g., obesity), thus providing a value

of understanding in the TBM in various parts of the country. Tracking of data using higher and good quality survey methods can assess the value of the on-going processes and efficacy of on-going intervention programmes at the community and population level.

- Mid-day meals in school should contain the required amount of nutrients with a healthy and hygienic diet. Scaling up of nutritious value should not only include healthy meal but water quality, educational availability, social factors as well sanitation should also be taken into consideration.
- Private sectors should also engage themselves with the help of the government to tackle the problem of TBM. Government and private agencies should arrange health camps with the help of medical workers which should include free medical check-ups and medicines, a counsellor should provide knowledge about faulty eating habits, essential nutritional requirements, infections, and diseases.
- Proven approaches should be implemented where unhealthy foods should be discarded with high controls and accuracy rates of labelling so that it helps children, adolescents and, adults to understand the nutritious value of each food at the community and population level.
- Education related to nutritional essentiality at the household, community, and population-level should be increased by training at the very primary level. Trained health workers should involve themselves in the discussion which directly focuses on water quality, sanitation, nutrition, hygiene, health-related to children and mother, breast feeding, infant, and young diet pattern.

AUTHORS' CONTRIBUTION: The concept and design were initiated by JS and NM. AB was involved in literature search, designing, and writing the manuscript. AB and NM prepared the draft manuscript and also prepared the revised version of the manuscript. All the authors have read and approved the final version of the manuscript before proceeding for publication.

ACKNOWLEDGEMENT: The authors acknowledge the extensive help and cooperation of the Department of Anthropology, University of North Bengal.

CONFLICT OF INTEREST: The authors report no conflict of interest. The authors alone are responsible for the writing content of the paper.

References

- Adhvaryu A., Nyshadham A. (2016). Endowments at birth and parents' investments in children. *The Economic Journal* 126:781-820.
- Agarwal R., Virnani D., Jaipal M., Gupta S., Sankar M.J., Bhatia S., Agarwal A., Devgan V., Deorari A., Paul, V.K., et al. (2013). Investigators of the LBW Micronutrient Study Group. Poor zinc status in early infancy among low and normal birth weight infants and their mothers

- in Delhi. *Neonatology* 103:54-59.
- Ahmed T., Hossain M., Sanin K.I. (2012). Global burden of maternal and child undernutrition and micronutrient deficiencies. *Annals of Nutrition and Metabolism* 61:8-17.
- Akhtar S., Ahmed A., Randhawa M.A., Atukorala S., Arlappa N., Ismail T., Ali Z. (2013). Prevalence of vitamin A deficiency in South Asia: Causes, outcomes, and possible remedies. *Journal of Health Population and Nutrition* 31:413-423.
- Akresh R., Verwimp P., Bundervoet T. (2011). Civil war, crop failure and child stunting in Rwanda. *Economic Development and Cultural Change* 59:777-810.
- Akter F., Hossain M.M., Shamim A.A., Hasan M., Hanif A.A.M., Hossain M., Ullah M.A., Sarker S.K., Rahman S.M.M., Mitra D.K., Haque M.E., Mridha M. (2020). Inadequate Dietary Diversity and its Determinants Among Adolescent Girls and Boys: Evidence from the National Nutrition Surveillance Study in Bangladesh. *Current Developments in Nutrition* 4(Suppl 2):502.
- Allen L., Williams J., Townsend N., Mikkelsen B., Roberts N., Foster C., Wickramasinghe K. (2017). Socioeconomic status and non-communicable disease behavioural risk factors in low-income and lower-middle income countries: a systematic review. *Lancet Global Health* 5:e277-e289.
- Anjana R.M., Sudha V., Nair D.H., Lakshmi Priya N., Deepa M., Pradeepa R., Mohan V. (2015). Diabetes in Asian Indians- How much is preventable? Ten-year follow-up of the Chennai Urban Rural Epidemiology Study (CURES-142). *Diabetes Research and Clinical Practice* 109:253-261.
- Arora N.K., Pillai R., Dasgupta R., Garg P.R. (2014). Whole-of-society monitoring framework for sugar, salt and fat consumption and noncommunicable diseases in India *Annals of the New York Academy of Science* 1331:157-173.
- Astrup A., Dyerberg J., Selleck M., Stender S. (2008). Nutrition transition and its relationship to the development of obesity and related chronic diseases. *Obesity Reviews* 9:S48-S52.
- Bailey R. L., West K. P., Black R.E. (2015). The Epidemiology of Global Micronutrient Deficiencies. *Annals of Nutrition and Metabolism* 66(S2): 22-33.
- Biswas T., Townsend N., Magalhaes R.J.S., Islam M.S., Hasan M.M., Mamun A. (2019). 'Current progress and future direction in the double burden of malnutrition among women in South and Southeast Asian countries. *Current Developments of Nutrition* 16: nzz026.
- Black R. E., Victora C.G., Walker S.P., Bhutta Z.A., Christian P., de Onis M., Ezzati M., Grantham-McGregor S., Katz J., Martorell R., Uauy R., Maternal and Child Nutrition Study Group. (2013). 'Maternal and child undernutrition and overweight in low-income and middle-income countries. *The Lancet* 382:427-451.
- Bose A., Sen J. (2020). Some observations on malnutrition among Indian pre-school children. *Human Biology Review* 9:219-237.
- Bose A., Sinha I., Lata Tigga P., Mondal, N., Sen J. (2020). Socio-economic and Demographic Determinants of Double Burden of Malnutrition among Rajbanshi School-going Children aged 9-14 Years from North Bengal, India. *Antrocom Journal of Anthropology* 16:141-152.
- Capacci S., Mazzocchi M., Shankar B., Trail B. (2013). The triple burden of malnutrition in Europe and Central Asia: a multivariate analysis. *FAO Regional Office for Europe and Central Asia Policy Studies on Rural Transition* 7:7-8.
- Comprehensive National Nutrition Survey (CNNS). (2019). National Report. Ministry of Health and Family Welfare (MoHFW), Government of India, UNICEF and Population Council,

New Delhi.

- Chauhan P.S. (2019). A study of policy alternatives to improve the level of micronutrient deficiency in women and children in India. *International Journal of Social Science and Economic Research* 4:80-91.
- Dandona L and Indian State-Level Disease Burden Initiative Collaborators. (2017). Nations within a nation: variations in epidemiological transition across the states of India, 1990-2016 in the Global Burden of Disease Study. *The Lancet* 390:2437-2460.
- Debnath S., Mondal N., Sen J. (2018). Socio-economic and demographic correlates of stunting and thinness among rural school-going children (aged 5-12 years) of North Bengal, Eastern India. *Journal of Life Science* 10:29-46.
- Debnath S., Mondal N., Sen J. (2019). Double burden of malnutrition among adolescents in India. *Human Biology Review* 8:155-178.
- Doak C.M., Adair L.S., Bentley M., Monteiro C., Popkin B.M. (2005). 'The dual burden household and the nutrition transition paradox. *International Journal of Obesity* (Lond) 29:129-136.
- Elizabeth K.E. (2020). Nutrition and Malnutrition. *The Encyclopaedia of Child and Adolescent Development*. Access 2020, June 30 from <https://doi.org/10.1002/9781119171492.wecado30>.
- Eli S., Li N. (2015). Caloric Requirements and Food Consumption Patterns of the Poor. *NBER Working Paper* 21697.
- Faber M., Wenghold F. (2007). Nutrition in contemporary South Africa. *Water Sa* 33:393-400.
- Grijalva-Eternod C.S., Wells J.C., Cortina-Borja M., Salse-Ubach N., Tondeur M.C., Dolan C., Meziani C., Wilkinson C., Spiegel P., Seal A.J. (2012). The double burden of obesity and malnutrition in a protracted emergency setting: a cross-sectional study of western Sahararefugees. *PLoS Medicine* 9:e1001320.
- Guerrant R.L., DeBoer M.D., Moore S.R., Scharf R.J., Lima A.A.M. (2013). The impoverished gut-a triple burden of diarrhoea, stunting and chronic disease. *Nature Review Gastroenterology & Hepatology* 10:220-229.
- Ingram J. (2018). To address the triple burden of malnutrition, focus on food systems and demand. Int Food Policy Research Institute, IFPRI Blog: Guest Post.
- International Diabetes Federation. (2017). Access on 2020, June 18 from <https://idf.org/e-library/guidelines.html>.
- Jain A., Agnihotri S.B. (2020). Assessing inequalities and regional disparities in child nutrition outcomes in India using MANUSH-a more sensitive yardstick. *Research Square*. doi.org/10.21203/rs2.23291/v3
- Jehn M., Brewis A. (2009). Paradoxical malnutrition in mother-child pairs: Untangling the phenomenon of over and under-nutrition in underdeveloped economies. *Economics and Human Biology* 7:28-35.
- Jones A.D., Hayter A.K.M., Baker C.P., Prabhakaran P., Gupta V., Kulkarni B., Smith G.D., Ben-Shlomo Y., Krishna K.V.R., Kumar P.U., Kinra S., (2016). The co-occurrence of anemia and cardiometabolic disease risk demonstrates sex-specific sociodemographic patterning in an urbanizing rural region of southern India. *European Journal of Clinical Nutrition* 70:364-372.
- Kaicker., Nidhi., Vani S.K., Gaiha R. (2014). Dietary Transition in India: An Analysis based on NSS Data. In: R.Gaiha, R. Jha and S. Vani, Kulkarni, (ed), *Diets, Malnutrition and Disease: The Indian Experience*. Chapter 3: Oxford University Press.
- Kapil U., Sachdev H.P. (2012). Urgent need to orient public health response to rapid nutrition transition. *Indian Journal of Community Medicine* 37:207-2017.

- Kapil U. (2014). Combating micronutrient deficiency disorders amongst children. *Indian Journal of Community Health* 26 (Supp 1):1
- Kshatriya G.K., Acharya S.K. (2016). Triple Burden of Obesity, Undernutrition and Cardiovascular Disease Risk among Indian Tribes. *PLoS ONE* 11: e0147934.
- Kshatriya G.K., Kumari A., Acharya S.K. (2018). Comparing the ability of anthropometric indicators in determining the prevalence of hypertension among Indian tribes. *Diabetes & Metabolic Syndrome: Clinical Research & Review* 13:696-706.
- Kumar M.M., Pathak V.K., Ruikar M. (2020). Tribal population in India: A public health challenge and road to future. *Journal of Family Medicine and Primary Care* 9:508-512.
- Kumar P., Chauhan S., Patel R., Srivastava S., Bansod D. W. (2021). Prevalence and factors associated with triple burden of malnutrition among mother-child pairs in India: a study based on National Family Health Survey 2015–16. *BMC Public Health* 21:391
- Kumar T., Taneja S., Yajnik C.S., Bhandari N., Strand T.A. (2014). Prevalence and predictors of anemia in a population of North Indian children. *Nutrition* 30:531-7.
- Labadarios D. (2016). Malnutrition in the developing world: The triple burden. *South African Journal of Clinical Nutrition* 18:119-121.
- Little M., Humphries S., Dodd W., Patel K., Dewey C. (2020). Socio-demographic patterning of the individual-level double burden of malnutrition in a rural population in South India: a cross-sectional study. *BMC Public Health* 20:675.
- Meenakshi J.V. (2016). Trends and patterns in the triple burden of malnutrition in India. *Agricultural Economics* 47:115-34.
- Ministry Of Health and Family Welfare, Government of India. (2018). Poshan Abhiyaan. Accessed on 2020 October 12 from <https://www.india.gov.in/national-nutrition-mission/#/>.
- Mondal N., Sen J. (2010) Prevalence of undernutrition among children (5-12 years) belonging to three communities residing in a similar habitat in North Bengal, India. *Annals of Human Biology* 37:198-216.
- Mondal N., Timungpi R., Sen J., Bose K. (2018). Socio-economic and demographic correlates of overweight and obesity: A study on the Karbi women of Assam, Northeast India. *Journal of Anthropology- Open Journal* 2:31-39.
- Murray C.J., Vos T., Lozano R., Naghavi M., Flaxman A.D., Michaud C., Ezzati M., Shibuya K., Salomon A., Abdalla S., et al. (2012). Disability-adjusted life years (DALYs) for 291 diseases and injuries in 21 regions, 1990-2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet* 380:2197-223.
- Mwangome M., Prentice A.M. (2019). Tackling the triple threats of childhood malnutrition. *BMC Medicine* 17:210.
- Myers S.S., Smith M.R., Guth S., Golden C.D., Vaitla B., Mueller N.D., Dangour P., Huybers P. (2017). Climatic change and global food systems: Potential impacts on food security and undernutrition. *Annual Review of Public Health* 38:259-277.
- National Family Health Survey (NHFS-4), 2015-16. International Institute of Population Sciences (IIPS) and ICF. 2017: India. Mumbai: IIPS.
- Pingali P., Aiyar A., Abraham M., Rahman A. (2019). The Nutrition Transformation: From Undernutrition to Obesity', In: *Transforming Food Systems for a Rising India*. Palgrave Studies in Agricultural Economics and Food Policy. Cham: pp 93-133. Palgrave Macmillan.

- Pinstrup-Andersen P. (2010). Food Systems and Health in Sub-Saharan Africa. Cornell University. Access on 2020 June 5 from https://images.slideplayer.com/21/6324967/slides/slide_1.jpg. Presentation.
- Popkin B.M., Adair L.S., Ng S.W. (2012). Global nutrition transition and the pandemic of obesity in developing countries. *Nutrition Reviews* 70:3-21.
- Pozza C., Isidori A.M. (2018). What's Behind the Obesity Epidemic. In: *Imaging in Bariatric Surgery*, Cham. pp. 1-8 Springer.
- Praveen P.A., Tandon N. (2016). Childhood obesity and type 2 diabetes in India. *WHO South East Asian Journal of Public Health* 5(1):17-21.
- Prentice A.M. (2006). The emerging epidemic of obesity in developing countries. *International Journal of Epidemiology* 35:93-99.
- Rahman M.S., Mushfiqee M., Masud M.S., Howladar T. (2019). Association between malnutrition and anemia in under-five children and women of reproductive age: Evidence from Bangladesh Demographic and Health Survey 2011. *PLoS ONE* 14:e0219170.
- Ramachandran P. (2006). The double burden of malnutrition in India', In: Kennedy G, Nantel G, Shetty P. (ed). *The Double Burden of Malnutrition: Case Studies from six Developing Countries*. Rome: Nutrition Planning, Assessment and Evaluation Service, Food and Agriculture Organization of the United Nations.
- Ramachandran P. (2014). Triple Burden of Malnutrition in India: Challenges and Opportunities. In IDFC Foundation Chapter 2. *India Infrastructure Report 2013/2014: The Road to Universal Health Coverage*. Orient Blackswan.
- Ramachandran P., Kalaivani K. (2018). Nutrition transition in India: Challenges in achieving global targets. *Proceedings of the Indian National Science Academy* 84:821-33.
- Ramachandran P. (2019). Combating Triple Burden of Malnutrition in Children. *Indian Pediatrics* 56:821-22.
- Ranjani H., Pradeepa R., Mehreen T.S., Anjana R.M., Anand K., Garg R., Mohan V. (2014). Determinants, consequences and prevention of childhood overweight and obesity: An Indian context. *Indian Journal of Endocrinology and Metabolism* 18(Suppl 1):S17.
- Reilly J.J., Kelly J. (2011). Long-term impact of overweight and obesity in childhood and adolescence on morbidity and premature mortality in adulthood: systematic review. *International Journal of Obesity* 35:891-898.
- Rengma M.S., Sen J., Mondal N. (2015) Socio-Economic, Demographic and Lifestyle Determinants of Overweight and Obesity among Adults of Northeast India. *Ethiopian Journal of Health Sciences* 25:199-208.
- Sawe C. J., Kogi- Makau W., Etyang G. A. K., Kimamo C. O. (2021). Tripartite of malnutrition: Co-existence of underweight, overweight and micronutrient deficiency among children in Kisumu County, Kenya. *Research Square*, Preprint.
- Semba R.D., de Pee S., Sun K., Campbell A.A., Bloem M.W., Raju V.K. (2010). Low intake of vitamin A-rich foods among children, aged 12-35 months, in India: Association with malnutrition, anemia and missed child survival interventions. *Nutrition* 26:958-962.
- Sen J., Mondal N., Dutta S. (2013). Factors affecting overweight and obesity among urban adults: A cross-sectional study. *Epidemiology Biostatistics and Public Health* 10: e8741(1-8).
- Sengupta A., Angeli F., Syamala T.S., Van Schayck C.P., Dagnelie P. (2014). State-wise dynamics of the double burden of malnutrition among 15-49-year-old women in India: How much does the scenario change considering Asian population-specific BMI cut-off values? *Ecology*

- Food and Nutrition* 53: 618-638.
- Sethi V., de Waqt A., Bhanot A., Singh K.D., Agarwal P., Murira Z., Bhatia S., Baswal D., Unisa S., Subramanian S.V. (2020). Level and Determinants of malnutrition among India's urban poor women: An analysis of Demographic Health Surveys 2006 and 2016. *Maternal & Child Nutrition* 16:e12978.
- Sharma P., Dwivedi S., Singh D. (2016). Global Poverty, Hunger, and Malnutrition: A Situational Analysis. In: Biofortification of Food Crops. *Springer Nature* 19-30.
- Sharma H., Singh S.K., Srivastava S. (2020). Socio-economic inequality and spatial heterogeneity in anaemia among children in India: Evidence from NFHS-4 (2015–16). *Clinical Epidemiology and Global Health* 1-14.
- Sharma J., Mondal N. (2014) Prevalence of Double Nutrition Burden Among Adolescent Girls of Assam, Northeast India. *Journal of Nepal Paediatric Society* 34:132-137.
- Singh R.B., Pella D., Mechirova V., Kartikey K., Deemeester F., Tomar R.S., Beegom R., Mehta A.S., Gupta S.B., De A.K., Neki D.S., Haque M., Nayse J., Singh S., Thakur A.S., Rastogi S.S., Singh K., Krishna A. (2017). Prevalence of obesity, physical inactivity and undernutrition, a triple burden of diseases during transition in a developing economy. The Five City Study Group. *Acta Cardiologica* 62:119-127.
- Soliman A.T., Sanctis V.D., Kalra S. (2014). Anemia and growth. *Indian Journal of Endocrinology and Metabolism* 18: S2-S5.
- Subramanian S.V., Kawachi I., Smith G.D. (2007). Income inequality and the double burden of under- and overnutrition in India. *Journal of Epidemiology and Community Health* 61: 802-809.
- Stein A.D., Wang M., Digirolamo A., Grajeda R., Ramkrishnan U., Ramirez M., Yount K., Martorell R. (2008). Nutritional supplementation in early childhood, schooling and intellectual functioning in adulthood. *Archives of Paediatrics & Adolescent Medicine* 162:612-618.
- Sunuwar D.R., Singh D.R., Pradhan P.M.S. (2020). Prevalence and factors associated with double and triple burden of malnutrition among mothers and children in Nepal: evidence from 2016 Nepal demographic and health survey. *BMC Public Health* 20:405.
- UNICEF. (2019a). The State of the World's Children 2019: Children, food and nutrition. Accessed on 2020, June 12 from <https://www.unicef.org/reports/state-of-worlds-children-2019>
- UNICEF. (2019b). The Changing Face of Malnutrition. Accessed on 2020, June 14 from <https://features.unicef.org/state-of-the-worlds-children-2019-nutrition/>
- Vaz M., Yusuf S., Bharathi A.V., Kurpad A.V., Swaminathan S. (2005). The Nutrition Transition in India. *South African Journal of Clinical Nutrition* 18:198-201.
- Watts N., Adger W.N., Agnolucci P., Blackstock J., Byass P., Cai W., Chaytor S., Colbourn T., Collins M., Cooper A. (2015). Health and climatic change: Policy responses to protect public health. *The Lancet* 386:1861-1914.
- Webb P., Stordalen G.A., Singh S., Wijesinha-Bettoni R., Shetty P., Lartey A. (2018). Hunger and malnutrition in the 21st century. *BMJ* 361:K2238.
- Wei J., Bhurtyal A., Dhungana R.R., Bhattarai B., Zheng J., Wang L., Sun X., Maskey M., Wang, Y. (2019). Changes in patterns of the double burden of undernutrition and overnutrition in Nepal overtime. *Obesity Review* 20: 1321-1334.
- Wong C.Y., Zalilah M.S., Chua E.Y., Norhasmah S., Chin Y.S., Siti N'A.A. (2015). Double-burden of malnutrition among the indigenous peoples (Orang Asli) of peninsular Malaysia

- global health. *BMC Public Health* 15:1-9.
- World Health Organization. (1995). *Physical Status: The Use and Interpretation of Anthropometry*. Technical Report Series No. 854. Geneva: WHO, 1-462.
- World Health Organization. (2007). *Growth Reference Data for 5-19 Years*. Accessed on 2020, July 20 from <http://www.who.int/growthref/who2007/en/index.html>.
- World Health Organization. (2014). *Global status report on non-communicable diseases 2014*. Accessed on 2020, June 23 from https://apps.who.int/iris/bitstream/handle/10665/148114/9789241564854_eng.pdf;jsessionid?sequence=1
- World Health Organization. (2017a). *Nutritional anaemia: tools for effective prevention and control*. Geneva: World Health Organization.
- World Health Organization. (2017b). *Double-duty action. Policy brief*. Geneva: World Health Organization.