Childhood Malnutrition: a Potential Risk of Metabolic Diseases in Adulthood

***Emokpae, M.A. and Odungide, E.E.**
Department of Medical Laboratory Science, School of Basic Medical Sciences,
College of Medical Sciences, University of Benin, Benin City, Nigeria.

***Corresponding author:**
Email: mathias.emokpae@uniben.edu;
Tel.: +234-803-451-1182.
ORCID iD:0000-0002-6266-1774

Abstract

Background: Childhood malnutrition is common in sub-Saharan countries of Africa including Nigeria. It has assumed a public health challenge to families and communities. **Objective:** To highlight the magnitude of childhood malnutrition and emphasize the need to sustain program implementations in order to halt or prevent its consequences. **Materials and Methods**: Relevant literatures were obtained and reviewed from Medline, Google Scholars and Pubmed search engines. **Results**: The trend of childhood malnutrition in Nigeria is on the increase. The need for adequate nutrition from the time of conception to the first two years of life is emphasized. Evidence indicates an association between childhood malnutrition and potential risk of developing type 2 diabetes mellitus, hypertension, cardio-vascular and neurological diseases in adulthood. **Conclusion**: Childhood malnutrition can lead to poor growth, organs development and function and adverse programming effects. Strategies that promote improvements in nutrition in pregnant women and young children would help to improve health capital and confers protection against the development of metabolic diseases in adulthood.

Keywords: Childhood malnutrition, prevention, security, metabolic diseases, Nigeria.

Introduction

Child Malnutrition has been defined or described in many ways by several authors. Child malnutrition may be defined as a pathological state resulting from inadequate nutrition. Others define malnutrition as the failure of the body to obtain the appropriate amounts of nutrients to maintain healthy tissues and organ function. One of the major health problems faced by children in developing countries today is under nutrition (1,2). Under nutrition is a major cause of diseases and death in children, especially in the low and middle income countries (3). Malnutrition causes Nigeria billions of Naira in lost revenue through lower economic productivity, absence from work due to illness and money spent on treating ailments (4). The negative impacts of malnutrition are seen in families and communities in various aspects such as economy, social and medical (5). Adequate nutrition is very important in early childhood for healthy growth, proper organ development and function, a strong immune system, neurological and cognitive development (6). The goal of this review is to highlight the magnitude of this public health issue, emphasize the provision of adequate diet especially during the first 1000 days window of opportunity in order to prevent the development of metabolic risk factors in adulthood.

Materials and Methods

Pubmed and google search engines were used to search for literatures using the following childhood malnutrition, prevention and metabolic diseases as key words. Over 3 million articles were initially obtained about 60 most relevant articles were included in the review. These articles were retrieved between November, 2019 and January 2020.

Results

The concept of the '1000 days' window of opportunity

This is an important period in a child's life and consisting of the period of conception to the second birthday after birth. Malnutrition during

this period can cause a permanent damage to the developing child's organs and tissue functions. Conversely, adequate diet in the first 1000days lays good foundation for health, development and economic well-being of the children (7).Under nutrition during pregnancy adversely affects fetal growth and has been reported to be responsible for stunting and may lead to obesity and development of metabolic diseases in adulthood (7). Interventions targeting this critical window of opportunity would have a long lasting benefit across the life cycle (8). Figure 1 shows the effects of under-nutrition throughout the life cycle of man. Malnutrition or undernutrition in pregnant mother can adversely affect the foetus leading to intra-uterine retardation (6,7). Undernutrition often begins in utero when mothers are malnourished and /or stunted and intra-uterine growth retardation occurs. It does inhibit physical growth and cognitive development and after the age of 2 years damage that occurred may be irreversible. Therefore it is crucial to prevent malnutrition during pregnancy and the first 2 years of the child, i.e. the 1000 days between conception and the child's second birthday. It has been recommended that preventive interventions should target this period of time to avoid the adverse consequences of malnutrition (9). The first 1000days is a period of very rapid growth, development and a time when developmental changes take place in the brain. There is multiplication and movement of cells especially during fetal development accompanied by sudden and rapid synaptogenesis and creation of large amount of neural connections that are required for life. However, there is gradual pruning of little used connections in order to increase neural efficiency as the child grows (10). These neurons include vision, hearing, language and higher cognitive function often referred to as the sensory pathways. During early childhood, deficiency of key nutrients such as iron, iodine, essential amino acids, essential fatty acids would lead to prolong adverse effects on learning ability, behaviour and ability to control emotion (8,10). The development of the organ systems are also affected within this period. The crown-heel length grows quickly at the 20th week of gestation (11). Linear growth may continue even up to two years of age compared to middle childhood when it slows down. Growth velocity increases again during puberty. Studies have revealed that growth potentials in the first 1000days are similar in several countries with different race and ethnicity under comparatively same or optimal health, nutrition and environmental conditions (12,13). But the variation in growth among individuals within the same population may be due to genetic differences. The pattern of growth failure among children living in poverty indicates that there is variation in the degree of growth retardation across different United Nation regions of the world. The Z-score values were negative in the early months indicating intra-uterine growth failure. This progressively negative trend continued with age until about 24 months of age (14).

Trend of malnutrition among children under five from 1990 to 2014 in Nigeria

There was a decrease in prevalence of malnutrition in the 2011 reports of the Multiple Indicator Cluster Survey (MICS) in Nigeria with 34% of children under five stunted, 31% underweight, and 16% wasted, while about 15% of children had low birth weight (<2.5kg at birth) (15). It can be inferred from the 2013 NDHS that the proportion of children who are stunted has been decreasing over the years. However, the extent of wasting has worsened, indicating a more recent nutritional deficiency among children in the country. Prevalence of stunting decreased to 37% from 42%, with a higher concentration among rural children (43%) than urban (26%). However, the proportion of children underweight increased (from 25 to 29%) and wasting from(9 to18%) (16). Similarly, the 2014 National Nutrition and Health Survey Report by the National Bureau of Statistics and UNICEF indicates that children's nutritional status marginally improved since 2013(17). However, the latest report for 2017 indicates an increasing trend in the number of children under five who are either under-weight, stunted or wasting in Nigeria (18,19).

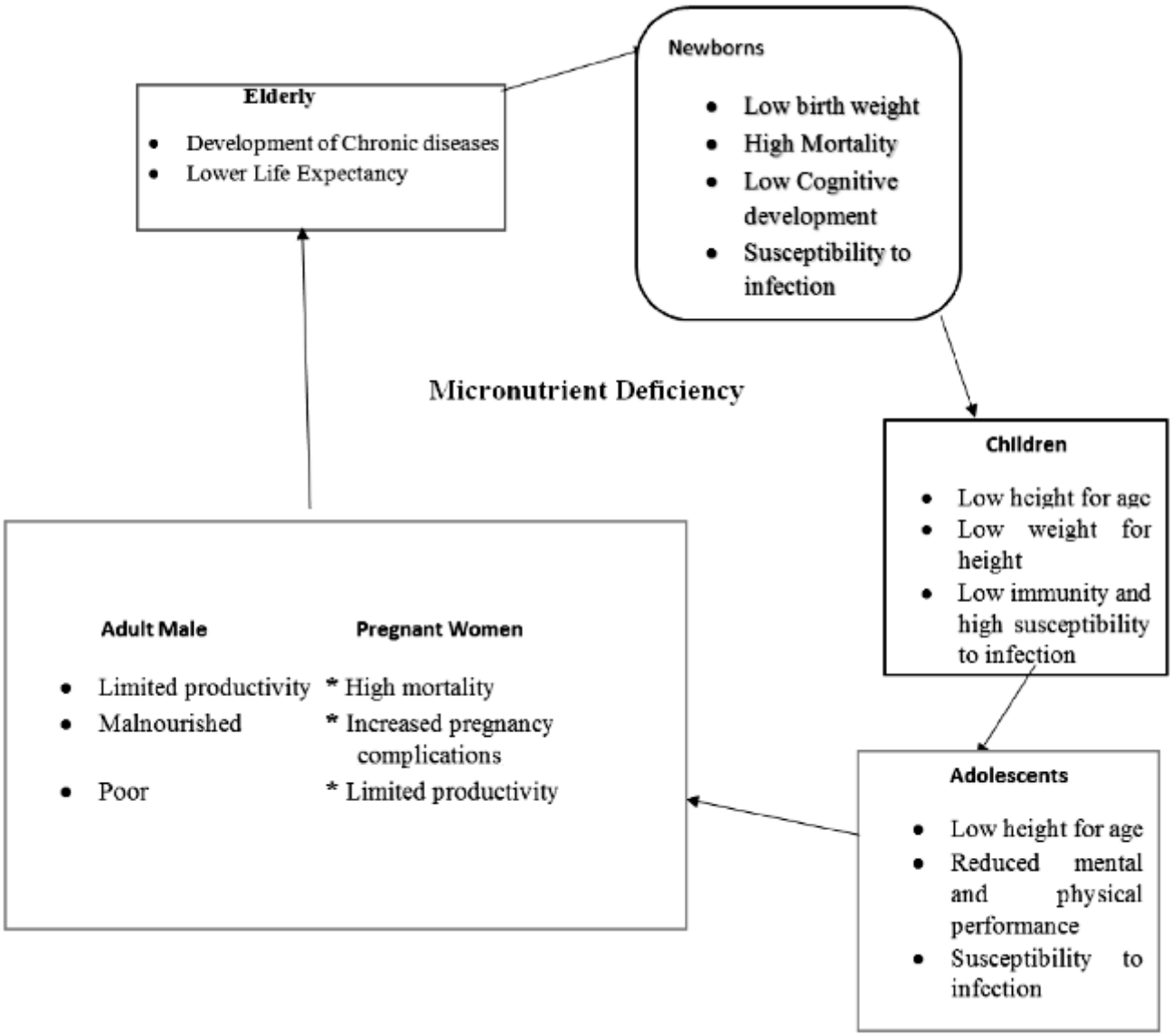


Figure 1: **Nutrition throughout the life-cycle**: (The life-cycle approach applied to micronutrient deficiency)(24).

Epidemiology

In 2013, about 17% (98 million) children under five years of age in developing countries were estimated to be underweight. The proportion of underweight children was highest (30%) in the United Nation (UN) region of south Asia, followed by West Africa 21%, Oceanic and East Africa 19% , south Eastern Asia and middle East 16% and southern Africa 12%. The prevalence was below 10% in the Eastern, central and western Asia, North Africa, Latin America and Caribbean countries (6). African children make up one-quarter of the estimated 148 million underweight children all over the world. Although under-weight prevalence has decreased slightly in Africa (from 29 percent to 26 percent over the past 17 years), the absolute number of underweight children has increased by 8 million, meaning that the rate of decline is lower than the rate of population growth (2). More than one-third of children under five in Africa are stunted—that is, having low height for their age (20).

In Nigeria, available data from the 2001–2003 Food Consumption and Nutrition Survey show that 42% of children under five were stunted,

25% underweight, and 9% wasted (21). The data suggest high levels of protein-energy malnutrition, which is usually accompanied by poor micronutrient status. Results from the 2013 Nigeria Demographic Health Survey (NDHS) is in agreement with the findings of the Nigeria Food Consumption and Nutrition Survey (NFCNS) of 2001–2003, suggesting that no improvement had occurred in the anthropometric indicators of children under five over a 10-year period (16). It was reported that more than two out of every five children were stunted, which reflects the cumulative effect of chronic malnutrition, with significantly higher proportion of stunted males (43%) than females (38%); 45 percent of children in rural areas were stunted while 31 percent in urban areas were reported to be stunted (16). The NDHS 2018(22) reports however, indicated a reduction in the proportion of children with undernutrition. It was estimated that 37% of children under five in Nigeria are stunted, 27% wasted and 22% underweight. The rate of stunting by region was lowest in south east (14-15%) and highest in North West (64-66%). The commonest predisposing factors were reported to be poverty and lack of education by mothers. Wasting (lean for height) is a sign of acute malnutrition. These conditions (stunting, wasting and underweight) among children were observed to be higher among rural children than their urban counterparts. About 68% of children under five were anaemic with more rural children (73%) more likely to be anaemic than urban children (62%). The anaemic children were more likely to come from poor homes (80%) and whose mothers had no formal education (75%). Again the prevalence rate of anaemia was highest in North West region (Zamfara state, 84%) and lowest in north central state of Kaduna (48%).

Interestingly, more than 50% of women of reproductive age were anaemia in Nigeria, a situation that is higher among rural women (62%) than urban women (54%). Anaemia was estimated to be more common among women with no formal education (64%) and those from poorest households (66%). The rate was lowest in Adamawa (34%) and highest in Sokoto with 74%.(22). The high rate of anaemia among women of reproductive age has great implication for childhood malnutrition as the women would become pregnant in under-nutrition condition. Figure 2 shows the different types of childhood malnutrition.

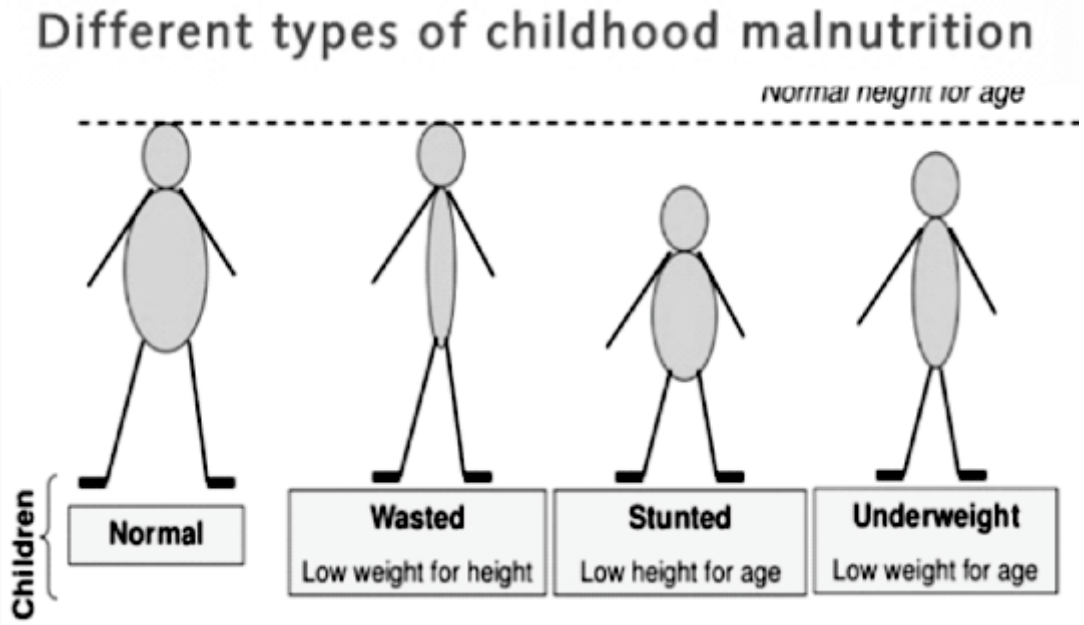


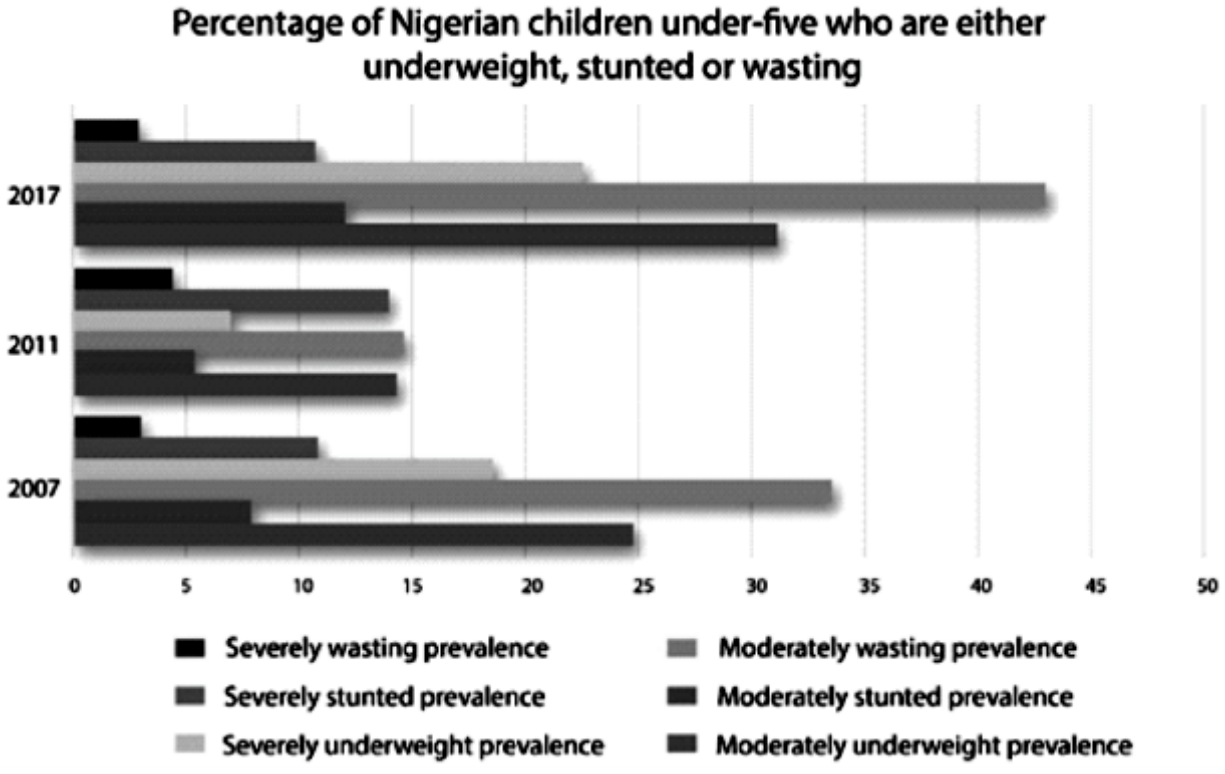
Figure 2: The different types of malnutrition (UNICEF, 2013,Epidemiology of childhood malnutrition and causes).

Macronutrient Deficiencies

Deficiencies of protein and carbohydrate may affect linear growth, but studies of energy supplementation trials among stunted children have not yielded consistent effects because growth restricting micronutrient deficiencies were also involved despite the provision of supplemental energy (23). Some protein supplementation trials had little effects on linear growth and it may be difficult to differentiate whether the benefits were strictly attributed to increased intake of protein or due to increased consumption of growth-promoting micronutrients like zinc and vitamin A which are components of protein rich foods (24). It is instructive to note that stunted linear growth is wide-spread in countries undergoing nutritional transition, where energy supply is not lacking. Therfore, it is safe to assume that micronutrient deficiencies are probably the major reason for growth failure in these settings (23).

Micronutrient Deficiencies

Micronutrients are vital components of good nutrition, and their deficiency in the human diet is responsible for many health problems. Vitamin A, iron, iodine, zinc, and folate are currently the most widely studied micronutrients. Large numbers of people all over the world are micronutrient deficient, and this deficiency remains a threat in many African countries. Both vitamin and mineral deficiency affect one-third of the population in sub-Saharan Africa, imparting minds, bodies, energies, and the economic prospects of nations (25). More than 20 percent of children under five years of age suffer from vitamin A deficiency in more than 35 countries throughout sub-Saharan Africa region (26). The prevalence of anaemia is higher than 40% in many African countries. Thirteen countries currently have been reported to be iodine deficiency and over 50 percent are among school-aged children (25). Some authors have stated that the micronutrient deficiency indicators in Nigeria reveal that 28% of children under five were suffering from iron deficiency anemia (IDA), 29.5% from vitamin A deficiency (VAD), and 29.6% from iodine deficiency (21).



Source: UNICEF,2017; National Bureau of Statistics, 2017

Etiological Factors of Childhood malnutrition

The determinants of malnutrition are multi-factorial and diverse (27). The UNICEF conceptual framework recognizes three levels of causes of malnutrition; namely the underlying cause, intermediate cause and immediate cause (UNICEF conceptual model of causes of malnutrition & mortality).

Basic Causes

The basic cause addresses systemic level challenges, reflecting structural and political processes (28). In Nigeria, this is evident in the poorly developed health care system with no adequate and functional surveillance systems (29). Mothers who are not covered by national health insurance may have increased risk of malnutrition. Nigeria is largest economy in Africa and yet an estimate of 1.1 million children is threatened by severe acute malnutrition in some regions due to poverty, insecurity and lack of access to clean drinking water (30).

Underlying Causes

This is usually observed at the community level when there is failure of an individual and household to obtain proper nutrition due to food insecurity, inequitable distribution of wealth and poor housing (31). Poverty increases the risk from and of malnutrition (32). It is very important to give adequate care, provision of food and health care to family members. Children depend totally on their parents especially mothers for food and social stimulation needs, which requires time and attention. Some authors have observed that some mothers are faced with severe time constraints because of work inside and outside the house as well as the demand to take care of several children. This situation may be compounded by lack of education on how best to take care of children (10). All these are some of the causes of growth failure among children. According to NDHS 20189 (22) reports, 97% of children in Nigeria have been breastfed with 42% of them breastfed within the first hour of life. However, about 50% of the children received complementary foods in addition to breast milk before the age of six months. The reported showed an increase in exclusive breastfeeding rate of 17% in 2013 to 29% in 2018 even though majority (72%) of the children still receive complementary food (22).This is against the UNICEF recommendation that states that new born infants should be exclusively breastfed for the first six months of life and complementary food introduced as from six months old in order to minimize the risk of malnutrition (33). Several authors have reported a decline in the use of health care facilities, as a result of obvious socio-economic inequality in Nigeria, as those in need of the facilities are located farther from it (34).

Immediate Cause

Inadequate intake or adequate intake but poor absorption due to diseases and infections has been recognized as immediate cause of malnutrition among children and growth failure. Most prevailing diseases in Nigeria include malarial, acute diarrheal disease, measles, HIV-AIDS and tuberculosis, especially if a delay in reporting to health facility or delay in seeking professional health care (3). Some authors have reported that children consuming food from polluted sources, such as drinking contaminated water from various sources such as rain water, well or pond water had higher incidence of under nutrition (35). In addition, the nutritional needs of children (amount per kg body weight) of children are high in infants than older children and adults due to rapid growth and development. It should be noted that children are particularly vulnerable to infection because of their weak immune systems (10).

Childhood malnutrition and Risk of Metabolic Diseases in Adulthood

Recently, a branch of scientific knowledge known as the Developmental Origins of Health and Disease (DOHaD) was introduced (36). The DOHaD hypothesis states that famine during early stages could change the structure and function of important tissues and organs. It is an irreversible process in foetal exposure, but may be reversible in childhood exposure (37). Childhood malnutrition has been associated with obesity and metabolic diseases in adulthood (38). Current theory suggests that obesity may be

a healthy active response to a future lack of energy caused by the sense (38). This was recognized as the possible pathway between childhood malnutrition and development of obesity in a welfare society with easy accessibility to rich calorie-dense food. Overweight and obesity are critical factors for cardiovascular disease and associated conditions such as hypercholesterolaemia, hypertension, type 2 DM, coronary heart disease and stoke (37). The first 1000days is a period of high sensitivity to programming effects from external factors like the maternal physiological environment in utero, breast milk and diet (39). At this period there is increased susceptibility to differential development changes resulting in phenotypes that may or may not be useful in adulthood. It is at this period that the thrifty genotype that can confer metabolic advantages and improve survival is developed (10,39). Other authors also introduced the "foetal origins and infant origins of adult diseases hypothesis to explain the susceptibility of individuals to several non-communicable diseases which could develop partly due to poor nutrition during early life (39). Epigenetic mechanisms responding to environmental factors that provides the molecular basis for increase susceptibility to developmental changes. The increase risk of being metabolically thrifty comes from the mismatch between ability to conserve energy in time of scarcity in early life and abundance in adulthood (10). Systematic review and meta-analysis that evaluated the association of famine exposure during early life with BMI in adulthood indicated that famine exposure contributed to increase BMI, overweight and obesity (38). The major findings from study of Survivors of Great China Famine (1959-1961) were summarized thus:

That prenatal experience of the Chinese Great Famine was associated with an increased risk of adult type 2 diabetes in a large prospective cohort study of 88,830 subjects. That coexistence of prenatal famine and abdominal obesity in adulthood was associated with a higher risk of type 2 diabetes, especially in women. That participant who had childhood exposure to famine, and had both general and abdominal obesity in adulthood, had more than four times higher risks of diabetes than the non-obese (40).The authors indicated that poor nutrition in early life has profound effects on the predisposition to type 2 DM in adulthood (41).

Several authors have reported on the high prevalence of childhood malnutrition and it's determinants in Nigeria (3,31,42-44). The causes of childhood malnutrition are attributed to poor infant feeding practices, lack of access to healthcare, water, sanitation, armed conflicts especially in the northeastern region, irregular rainfall, high unemployment and poverty.

An association between childhood malnutrition and obesity has been reported among children in low-income urban population in Brazil (45), Russia and South Africa (46). In the same vein, a correlation has been observed between childhood malnutrition and low birth weight and central fat distribution in adolescence (47). It was suggested that nutrient deficiencies in early childhood "program" the body to acquire or develops energy saving physiological mechanisms in response to nutrient constraints, such that during the period of abundant energy availability later in life, a lot of energy is conserved and obesity occurs (48). Some authors have indicated that low Birth weight is associated with high risk of developing type 2 DM in adulthood. Maternal under-nutrition may lead to permanent changes in the function and mass of pancreatic cells and sensitivity of tissues to insulin (49). Obesity has been linked to insulin resistance through increase release of free fatty acids (FFAs) and abnormal secretion of adipokines (50).

Thrifty Phenotype Hypothesis states that the thrifty gene are "genes which enable individuals to efficiently collect and process food to deposit fat during periods of food abundance in order to provide for periods of food shortage" (51). The gender differences in the development of abdominal obesity and type 2 DM which was more apparent in women than men may be due to the fact that male and female foetuses adapt differently to developmental challenges (52). The Guatemala nutrition studies supported the assertion that the first 1000days is a window of opportunity on the long run despite

disappointing results obtained in earlier reports (10,53,54). A seven years follow-up study revealed that improved nutrition did not substantially and consistently improved child development, since there was improvement in linear growth and head circumference but not weight for length (53). Another follow-up study to adolescence stage revealed that the participants were taller, had greater fat-free mass and better work capacity as well as schooling, reading and cognitive capacity of participants compared with controls. A study of the effects on chronic disease indicators revealed that the nutrition interactions did not increase risk factors rather confer small protective effects (54). Long-term follow-up to adulthood revealed that improved nutrition during the window of opportunity attenuated the development of cardiovascular disease and diabetic risk using metabolomics and cardiometabolic profiles in adulthood (10).

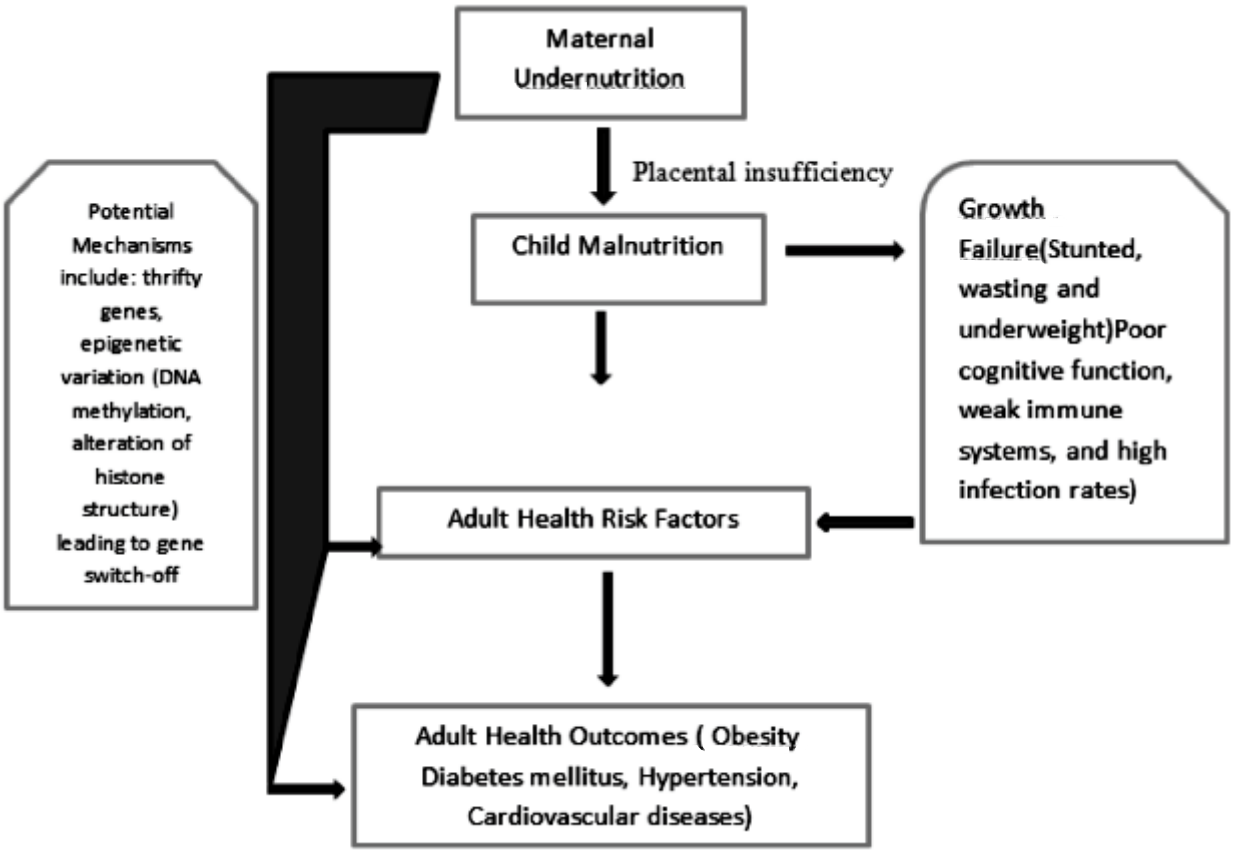


Figure 4: The Effects of Childhood Malnutrition on Adult Health and Health Outcomes

Induction of Hypothalamic-Pituitary-Adrenal Axis Secretions

It was suggested that malnutrition during early life may change neuroendocrine function and induce hypothalamic-pituitary (HPA) axis to release excessive glucocorticoids, which could increase BMI, overweight and obesity (55). Childhood malnutrition can activate the HPA axis to regulate appetite behaviour. Early life adopted this nerve pathway which can form adverse phenotypes for the future, and seeks out appetite stimulation in nerve impulse manner. In adulthood, when the energy intake is greater than the utilization, energy is accumulated in the form of adipose tissue (56).

Control of Epigenetic markers

It was suggested that childhood malnutrition may be under the control epigenetic markers that regulate histones, post translational modification and tissue remodeling into macrophages (9). Epigenetic mechanisms like DNA methylation,

alteration in histone structure and small non-coding RNA activity cause genes to switch-off and alter how cells read genes without changes in DNA sequence (9). These cells possess proinflammatory tendencies and manifest as decreased response of cytokines for sex hormones inhibitor susceptibility. In the course of life, these proinflammatory trends are exacerbated by behaviour and tended to own hormonal disorders, which was the product of exposure to early stress.

Other proposed hypotheses include post-natal accelerated "growth" or catch-up growth (57). The increased BMI experienced among females who experienced malnutrition during early life may be due to the following: women who were malnourished during early life had a higher risk of over eating than men (58), do deposit fat in the abdomen and intra-abdominal obesity due to low testosterone concentrations (59) and exhibit functional changes in the central endocrine regulatory machinery rather than fat cell abnormalities that may be responsible for the sex differences in the development of obesity in adulthood (37).

Intervention strategies to address Malnutrition

A multidisciplinary approach is required to tackle issues of child malnutrition given that its causes are diverse and multifactorial (60). The most effective battle against child malnutrition is in its prevention but when this fails and malnutrition results, prompt and effective treatment to sustain good health is paramount. An effective intervention to reduce the prevalence and adverse effects of malnutrition is essential (2). It will involve a comprehensive action that encompasses 'Focusing on the young; Education, Nutrition, Early treatment and women empowerment' (FYENEW) and it will be targeted at communities who would benefit most from it, as it would not be universal. Targeted interventions which are community based are effective for tackling cases of child malnutrition. At risk children would be identified by various strategies, such as ethnicity or regions. Emphasis on prioritizing exclusive breast feeding for the first 6 months of life is highly recommended. Appropriate complementary feeding of healthy diet and breast feeding till 2 years should be encouraged (2). Establishing framework to enable the weak and vulnerable to assess health care facilities with ease may be helpful. Evidence suggests that increasing easy accessibility to family health services improves child nutritional status (51).Adequate and balanced food intake, age specific food consumption and household food distribution would greatly prevent growth failure in Nigeria. In the quest to reduce malnutrition in Nigeria, National strategic Plan of Action for Nutrition was developed and other strategic documents such as Vision 2020 and National Strategic Health Development Plan for 2009 to 2015 were formulated (16,62). The Nigeria government has invested in several Maternal and Child Health intervention programs such as Integrated Maternal Newborn and Child Health Strategy, National Emergency Action Plan, the Expanded Program on Immunization, Integrated Community Case Management and several other programs. The UNICEF and other international organizations have also contributed to activities geared towards improving nutritional status of Nigerian women and children. Examples of such programs include Global Alliance for Improve Nutrition (GAIN), Save the Children UK, Micronutrient Initiative and Food Basket International (63). Despite the huge investments by both government and Civil Society Organizations, the desired improvement in the prevention of growth failure has not been achieved. The full implementation of the above mentioned programs on the part of government may have been impaired by dwindling financial base of the nation as a result of downward trend in the prize of crude oil, armed conflicts and banditry especially the Boko Haram group. The resources of the country have been overstretched and/or redirected to purchasing of military hardware. Other strategies recommended by CDC include: Life style changes in a suitable environment are key to keeping fit. It was suggested that environment strategies that combine one or more interventions to improve pedestrian or bicycle transportation system as well as other activities that increase physical activity should be built (64). The WHO/UNICEF

Baby-Friendly Hospital Initiative can be vigorously pursue. The ten-steps to successful breastfeeding should be taught and encouraged. It is important to create network that provide clinic-based, at-home or work-place breastfeeding support for mothers (64). Only very few organizations have such facility in place in Nigeria. The CDC guideline also enumerates nine school health guidelines that serve as foundation for developing, implementing and assessing school based healthy eating and physical activity policies and practices for pupils. For the implementation of the school based feeding program to be effective in most African societies, a lot of enlightenment is needed allay the fear of most parents. The suggested steps are healthy eating and physical activity, good quality school environments, quality school meal program, detailed physical activity program, health education among pupils and parents, general health, mental Health and social services, partner with families and community members, school employee wellness program, certified and qualified staff. When these are consciously implemented and sustained, the health indicators of populace would improve tremendously.

Laboratory Assessments

It is necessary for healthcare givers to assess nutritional status of children using laboratory methods than physical anthropometric measurements. Assessing nutritional status by laboratory methods is a more objective and precise approach than the community assessment, dietary methodology, or clinical evaluation methods. Biological fluids such as blood and urine, hair, nails could be used to measure the concentrations of nutrients in body or to assess certain biochemical functions which are dependent on an adequate supply of essential nutrients (65). However, the interpretation of laboratory result is often difficult as close connection between it and clinical or dietary findings is required. This is so because the signs and symptoms of the disease due to deficiency of nutrients may take time to develop. Overall, laboratory methods are used to establish deficiencies of such nutrient or proteins. Serum protein, particularly albumin level, the blood-forming nutrients: such as iron, folate, vitamin B6, and vitamin B12 as well as Water-soluble vitamins: thiamine, riboflavin, niacin, and vitamin C including fat-soluble vitamins: A, D, E, and K could be assayed for. Minerals such as iron, iodine, zinc and other trace elements could be determined. Complete blood count and Red blood cells indices, levels of blood lipids, glucose and various enzymes which are implicated in heart disease, diabetes, and other chronic diseases can be done (65).

It is pertinent to state that the use of laboratory tests has two primary functions: The first is to detect very little or marginal nutritional deficiencies in subjects, particularly when dietary histories are not certain or unavailable; their use is particularly important before classical clinical signs of disease appear, thus permitting the initiation of appropriate remedial steps.

The second is to supplement or enhance other studies, such as dietary or community assessment among specific population groups, in order to diagnose nutritional problems that these other modalities may have suggested or failed to reveal. It should be noted that laboratory investigation is of little or no use if it only confirms a known clinical diagnosis. Often, laboratory values will be obtained suggesting marginal or acute deficiencies when the patient appears clinically normal since clinical signs usually occur only after prolonged inadequate intake of nutrients. The likelihood then, is that the subject may be in various stages of deficiency and, if this state continues, will become ill. Most importantly, a deficiency in one nutrient can be considered an almost certain indicator of other nutritional inadequacies; these too should be rigorously investigated. The interpretation of laboratory results would always be a matter for some disagreement, since the prime objective is to detect "risk of deficiency" before clinical evidence of disease develops.

Conclusion

Childhood malnutrition is an important public health challenge in Nigeria and the proportion of under-five children affected appears to be on the increase. Evidence from this review indicates an association between childhood malnutrition and

development of type-2 diabetes mellitus, hypertension and other cardiovascular diseases in adulthood. The first 1000days is not only a window of opportunity if adequate measures are taken but can also be a window of vulnerability. Nutritional improvement within this period will greatly impact on survival, child health and adult comes. Promotion of nutritional improvements during this period will prevent the development of metabolic diseases in adulthood.

References

1. Mengistu K, Alemu K, Destaw B. Prevalence of Malnutrition and Associated Factors Among Children Aged 6-59 Months at Hidabu Abote District, North Shewa, Oromia Regional State. J Nutr Disorders Ther , 2013;T1: 001.
2. Ozoka CN. Burden of Malnutrition in Children Under 5 Years in Nigeria: Problem Definition, Ethical Justification and Recommendations. J Trop Dis, 2018;6: 268.
3. World Health Organization. Malnutrition, 2018.
4. World Bank. Costed Plan for Scaling up Nutrition: Nigeria, 2014.
5. Akombi B, Agho K, Hall J, Wali N, Renzaho AM, Meron D. (2017) Stunting, wasting and underweight in Sub-Saharan Africa: A systematic review. Intl J Environ Res Public Health, 2017; 18:863.
6. Hoseini BL, Moghadam ZE, Saeidi M, Askarieh MR, Khademi G. Child Malnutrition at Different World Regions in 1990-2013. Int J Pediatr 2015;3(5-1):921-932.
7. USAID. Nigeria Nutrition Profile, 2018. https://www.usaid.gov/nigeria/nutrition profile. Accessed 20th May 2019.
8. UNICEF. UNICEF report reveals shocking cost of malnutrition and outlines unprecedented chance to defeat it.2013.
9. DeBoer MD, Lima AAM, Oria RB, Scharf RJ, Moore SR, Luna MA, et al. Early Childhood growth Failure and the developmental origins of adult disease. Do Enteric infections and malnutrition increase risk for the metabolic syndrome? Nutr Rev 2012;70(11):642-653.
10. Mortorell R. Improved Nutrition in the first 1000 days and Adult Human Capital and Health. Am J Hum Biol. 2017;29(2):1
11. Tanner, JM. Foetus into Man. Cambridge, MS: Harvard University Press; 1978. p. 250.
12. de Onis M, Garza C, Onyango AW, Martorell R. WHO child growth standards. Acta Paediatrica. 2006; 95(450S):1–101.
13. Papageorghiou AT, Ohuma EO, Altman DG, Todros T, Ismail LC, Lambert A,et al. for the International Fetal and Newborn Growth Consortium for the 21st Century (INTERGROWTH-21st). International standards for fetal growth based on serial ultrasound measurements: The Fetal Growth Longitudinal Study of the INTERGROWTH-21st Project. Lancet. 2014; 284:869–879.
14. Victora CG, de Onis M, Hallal PC, Blössner M, Shrimpton R. Worldwide Timing of Growth Faltering: Revisiting Implications for Interventions. Pediatrics. 2010; 125(3):473–480.
15. Multiple Indicators Clusters Survey (MICS). Multiple Indicators Clusters Survey. Monitoring the Situation of Children andWomen. UNICEF/NBS/UNFPA, 2011.
16. Nigeria Demographic and Health Survey (NDHS). Nigeria Demographic and Health Survey.2013.
17. Kuku-Shittu O, Onabanjo O, Fadare O, and Oyeyemi M. Child Malnutrition in Nigeria: Evidence from Kwara State. Nigeria Strategy Support Plan. International Food Policy Research Institute. Working Paper 33, 2017.
18. UNICEF. Malnutrition (online) 2017 : https://data.unicef.org/topic/nutrition/malnutrition/ (Accessed 19 September, 2019).
19. National Bureau of Statistics. Nutrition Statistics in Nigeria. 2017, Abuja, Nigeria: National Bureau of Statistics, http://www.nigerianstat.gov.ng/social_statistics/SSD%20final.pdf .Accessed 19th September, 2019.
20. World Health Organization. Indicators for assessing infant and young child feeding practices: conclusions of a consensus meeting held 6–8 November 2007 in Washington D.C., USA. 2008.
21. Maziya-Dixon, B., Akinyele, I. O., Oguntona, E. B., Nokoe, S., Sanusi, R. A. and Harris, E.

Nigerian Food Consumption and Nutrition Survey 2001–2003, Summary. International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria, 2004.
22. National Population Commission (NPC) [Nigeria] and ICF. 2019. 2018 Nigeria DHS Key Findings. Abuja, Nigeria and Rockville, Maryland, USA: NPC and ICF.
23. Eckhardt CL. Micronutrient Malnutrition, Obesity, and Chronic Disease in Countries Undergoing the Nutrition Transition:Potential Links and Program/Policy Implications. FCND Discussion Paper 213, 2006.
24. Black, R. E., and S. Sazawal. 2001. Zinc and childhood infectious disease morbidity and mortality. British Journal of Nutrition 85 (Supplement 2): S125-S129.
25. Sadou H, Dandano IG, Alma MM, Daouda H (2014) Iodine Deficiency Disorders After Sixteen Years of Universal Dietary Salt Iodization in a Severe Iodine Deficiency Village in Niger. The Open Nutr J. 2014; 8:8-12.
26. Federal Ministry of Health (FMOH)/M.I/UNICEF. Vitamin and Mineral Deficiency Damage Assessment Report Nigeria,2004.
27. The World Bank and Nutrition. Malnutrition is one of the world's most serious but least-addressed development challenges. Its human and economic costs are enormous, falling hardest on the poor, women, and children, 2017.
28. Reinhardt, K and Franzo, J. Addressing Chronic Malnutrition through Multi-Sectoral, Sustainable Approaches: A Review of the Causes and Consequences, Front Nutr 2014;1:13.
29. Menizibeya O. The Nigerian health care system: Need for integrating adequate medical intelligence and surveillance systems. J Pharm BioAllied Scis, 2011; 3: 470-478.
30. UNICE Nigeria battles a worsening nutritional crises.2012.
31. Ndukwu CI, Egbuonu I, Ulasi, TO, Ebenebe JC. Determinants of under nutrition among primary school children residing in slum areas of a Nigerian city. Niger J Clin Pract,2013; 16: 178-183.
32. World Health Organization. Malnutrition Fact Sheet 2017, WHO Geneva, Switzerland.
33. UNICEF. 2017. The State of the World's Children 2017. Available at: https://www.unicef.org/sowc. Accessed 20 September, 2019.
34. Uthman OA. Using extended concentration and achievement indices to study socioeconomic inequality in chronic childhood malnutrition: The case of Nigeria. Int J Equity Health, 2009; 8: 1-8.
35. Tebeje NB, Bikes GA, Abebe SM, Yesuf ME. Prevalence and major contributors of child malnutrition in developing countries: Systematic review and meta-analysis. J Childhood Obesity, 2017; 2: 16.
36. Ocheke IE and Thandi P. Malnutrition in acutely ill children at the pediatric emergency unit in a tertiary hospital in Nigeria. Niger Med J, 2015; 56: 113-117.
37. Zhou J, Zhang L, Xuan P, Fan Y, Yang L, Hu C, Bo Q, Wang G, Sheng J, Wang S. The relationship between famine exposure during early life and body mass index in adulthood: A systematic review and meta-analysis. PLoS ONE, 2018; 13(2): e0192212.
38. Poulsen PH, Biering K, Winding TN, Nohr EA, Andersen JH. How does childhood socioeconomic position affect overweight and obesity in adolescence and early adulthood: a longitudinal study. BMC Obesity, 2018; 5: 34.
39. Godfrey KM, Gluckman PD, Hanson MA. Developmental origins of metabolic disease: life course and intergenerational perspectives. Trends Endocrin Met. 2010; 21(4):1999–2014.
40. Meng R,Lv J,Yu C, Guo Y, Bian Z,Yang L, Chen Y, Zhang H,et al. on behalf of the China Kadoorie Biobank Collaborative Group. Prenatal famine exposure, adulthood obesity patterns and risk of type 2 diabetes. Int J Epidemiol, 2018:399–408.
41. Wang C, Chan, JSY, Ren L, Yan JH. Obesity Reduces Cognitive and Motor Functions across the Lifespan. Neural Plasticity, 2016;2473081:1-13.
42. Amare M, Benson T, Fadare O, Oyeyemi M. Study of the Determinants of Chronic malnutrition in Northern Nigeria: Quantitative evidence from the Nigeria Demographic and Health Surveys, International Food Policy Research Institute (IFPRI) working paper 45. Food Nutr Bull 2018;39(2):296-314.
43. Senbanjo IO, Olayiwola IO, Afolabi WA, Senbanjo OC. Maternal and child under-nutrition in rural and urban communities of Lagos state, Nigeria: The relationship and risk factors. BMC Research Notes, 2013; 6: 286.

44. Maternal and Child Survival Program. 2017. "Nigeria." Available at: http://www.mcsprogram.org/where-we-work/nigeria. Accessed 20 September, 2019.
45. Sawaya, A. L., G. Dallal, G. Solymos, M. H. de Sousa, M. L. Ventura, S. B. Roberts et al. Obesity and malnutrition in a shantytown population in the city of Sao Paulo, Brazil. Obesity Research, 1995; 3 (Supplement 2): 107s-115s.
46. Popkin, B. M., M. K. Richards, and C. A. Montiero. Stunting is associated with overweight in children of four nations that are undergoing the nutrition transition. J Nutr,1996; 126 (12): 3009-3016.
47. Walker, S. P., P. S. Gaskin, C. A. Powell, and F. I. Bennett. The effects of birth weight and postnatal linear growth retardation on body mass index, fatness and fat distribution in mid and late childhood. Public Health Nutr, 2002; 5 (3): 391-396.
48. McMillen, I. C., and J. S. Robinson. Developmental origins of the metabolic syndrome: Prediction, plasticity, and programming. Physiol Rev ,2005;85(2): 571-633.
49. Nielsen JH, Haase TN, Jaksch CJ, Nalla A, Søstrup B, Nalla AA et al. Impact of fetal and neonatal environment on beta cell function and development of diabetes. Acta Obstet Gynaecol Scandinavia, 2016: 1109-1122.
50. Bosy-Westphal A, Plachta-Danielzik S, Dorhofer RP, Muller MJ. Short stature and obesity: positive association in adults but inverse association in children and adolescents. Br J Nutr. 2009, 102 (3): 453-461.
51. Hales, C.N. and Barker, D.J.P.Type 2 (Non-insulin-dependent) Diabetes Mellitus: the Thrifty Phenotype Hypothesis. Diabetologia, 1992; 35(7): 595–601.
52. Gilbert JS and Nijland MJ. Sex differences in the developmental origins of hypertension and cardiorenal disease. Am J Physiol Regul Integr Comp Physiol. 2008; 295(6): R1941–R1952.
53. Martorell R, Habicht J-P, Rivera JA. History and design of the INCAP Longitudinal Study (1969–77) and its Follow-Up (1988–89). J Nutr. 1995; 125:1027S–1041S.
54. Martorell R, Melgar P, Maluccio JA, Stein AD, Rivera JA. The development and legacy of the INCAP Oriente studies 1969–2009: The nutrition intervention improved adult human capital and economic productivity. J Nutr. 2010; 140(2):411–414.
55. Sorensen TI. Is obesity a healthy active response to an expected future lack of energy rather than a passive storage of surplus energy? Obes Facts. 2012;5(3):431–435.
56. Miller, G.E., Chen, E. and Parker, K.J. Psychological stress in childhood and susceptibility to the chronic diseases of aging: moving toward a model of behavioral and biological mechanisms. Psychol Bull, 2011; 409(8): 1603-1608.
57. Morgen CS, Mortensen LH, Rasmussen M, Andersen AM, Sorensen TI, Due P. Parental socioeconomic position and development of overweight in adolescence: longitudinal study of Danish adolescents. BMC Public Health. 2010;10:520.
58. Al-Emrani F, Stafstrom M, Ostergren PO. The influences of childhood and adult socioeconomic position on body mass index: a longitudinal Swedish cohort study. Scand J Public Health. 2013;41(5):463–469.
59. Hoegh- Poulsen P, Biering K, Andersen JH. The association between leisure time physical activity in adolescence and poor mental health in early adulthood: a prospective cohort study. BMC Public Health 2016, 16:3–015.
60. Owoaje E, Onifade O, Desmennu A. Family and socioeconomic risk factors for under-nutrition among children aged 6 to 23 months in Ibadan, Nigeria. Pan Afr Med J 2014;17: 161.
61. Essien E, Emebu P, Iseh, Haruna M. Assessment of nutritional status and knowledge of students from selected secondary schools in Sokoto metropolis, Sokoto state, Nigeria. Afr J Food Agri Nutr Dev,2014; 14: 6.
62. National Strategic Plan of Action for Nutrition (2014-2019). Health Sector Component of National Food and Nutrition Policy, 2014.
63. Ministry of Budget and National Planning. National Policy on Food and Nutrition in Nigeria, 2016.
64. Center for Disease Control and Prevention. Prevention Strategies and Guidelines (Overweight and Obesity). www.cdc.gov/obesity/resources/strategies-guidelines. Retrieved on 15th December,2019.
65. American Journal of Public Health (AJPH). Laboratory Assessment of Nutritional Status. AJPH Supplement, 1973; 63:28-32.