

## Effects of Chicken Eggs Consumption in Combating Undernutrition and Malnutrition in Developing Countries: A Review

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### Abstract

Human undernutrition remains a major public health concern globally, contributing to over three million preventable maternal and child deaths each year. Undernutrition in some selected African countries indicated that, it has debilitating impacts not only on the physical and cognitive capacity of the people but it also affects significantly the national economies by reducing Gross Domestic Product (GDP) by as much as 16%. The most affected social strata are the growing children, women under reproductive and lactating ages. The people in Africa and Asia are the ones who are most affected by these challenges. Therefore, this review study was made to explore the severity of undernutrition and its impact on these segments of the globe and identify potential food items to ameliorate these problems. The methodology used was desk review of the national and international related secondary data to gather with personal observations. The compiled data was analyzed using simple descriptive statistics. As it is well known, the major staple diets of the rural farmers in developing countries are cereals, which are deficient in most nutrients including micronutrients. Animal Source Foods (ASF) on the other hand are rich in their nutritional content and quality and produced by rural farmers mainly for sell to their urban counter parts. As a result of this and knowledge gaps, the rural farmers are the ones who are suffering most by undernutrition. The analysis of Demographic and Health Survey (DHS) data shows that people living in rural areas are between 1.3 and 3.3 times more likely to be stunted than their urban peers due to nutrition deficiency. Among ASFs, chicken eggs are considered the best choice due to their affordability, limited taboos, accessibility and limited requirements for refrigerators. Therefore, depending on their age category, one to two eggs per day per person supplementation has substantial physical and mental contributions for healthy life to rural children, lactating and pregnant women, respectively. On top of introducing this nutritionally dense diet to the target groups in developing countries, regular awareness creation, cooking demonstration, nutrition messaging, monitoring and evaluation is required to evaluate the impact of eggs intervention for further scaling up.

**Keywords:** Animal Source Foods; Eggs; Malnutrition, Undernutrition; Stunting; Wasting

### Definitions

**Adequate Intake (AI):** is the recommended average daily intake level based on observed or experimentally determined approximations or estimates of nutrient intake by a group of apparently healthy people that are assumed to be adequate [1].

**Food Security:** exists when all people at all times have physical and economic access to sufficient, safe, and nutritious food that meets

their dietary needs and food preferences for an active and healthy life [2].

**Nutrition Security:** is used to capture the quality aspects of food supply [2].

**Recommended Dietary Allowance (RDA):** is the levels of intake of essential nutrients that, on the basis of scientific knowledge, are judged by the Food and Nutrition Board to be adequate to meet the

known nutrient needs of practically all healthy persons [3].

**Malnutrition:** encompasses all forms of nutrient imbalances including undernutrition and overnutrition which leads to overweight or obese [4].

**Undernutrition:** is the physical outcome of insufficient dietary intake and/or infectious disease [4].

**Stunting:** low height compared to age, which is growth retardation due to poverty, low socio-economic level and chronic disease [4].

**Wasting:** low weight compared to height due to hunger and insufficient food intake [4].

**Underweight:** low weight for age due to food shortage [4].

**Overweight (obesity):** is an abnormal or excessive fat accumulation that presents a risk to health [4].

### Global Undernutrition and Its Impact

Food security remains one of the most significant issues facing the world today, with the most recent estimates revealing 842 million people (one in eight people) to be affected by chronic undernutrition [2]. The burden of malnutrition across the world remains unacceptably high, and progress unacceptably slow [5]. Malnutrition in childhood, pregnancy and lactating women has many adverse consequences on child survival and long-term well-beings [2,5]. It has also far reaching consequences for human capital, economic productivity, and national development overall. Malnutrition is responsible for more ill health than any other causes [2]. In general, as most literature indicated, malnutrition is expressed itself in different forms including growth retardation, fatigue, visual impairment, learning disabilities, impaired brain functions, decrease IQ, decreased psychomotor skills, as well as an

increased likelihood of illness and death. Children under five years of age face multiple burdens: 150.8 million are stunted, 50.5 million are wasted and 38.3 million are overweight [2]. Meanwhile 20 million babies are born of low birth weight each year. Overweight and obesity among adults are at record levels with 38.9% of adults overweight or obese, stretching from Africa to North America, and increasing among adolescents [2,6], which puts them at risk on non-communicable diseases, such as cancers, cardiovascular disease and diabetes. Human undernutrition remains a major public health challenge globally, contributing to over 3 million preventable maternal and child deaths each year [7,8]. In addition to these, globally about a billion of the world population regularly goes to bed hungry and up to two billion intermittently experience food insecurity; about two billion suffer from hidden hunger, surviving on diets that fail to meet all their nutritional needs [9]. Undernutrition is the outcome of insufficient food intake and recurrent infectious diseases [10]. A number of recent researches increasingly indicated that malnutrition not only has deleterious effects on physical growth, resistance to infection, and work capacity but also on cognitive development, school performance and physical activity in adults and children [11,12]. Adults who were malnourished during childhood are likely to earn 20% less than their well-nourished counterparts [8].

The impact of malnutrition and undernutrition are mostly prevailing in developing countries where there is a shortage of food supply and limited nutritional diversity. These are mostly observed in Africa, Asia and limited extent in Latin America and the Caribbean (Figure 1). Poor people survive on diets based on starchy foods from cereals that fail to meet all their nutritional requirements. The reality indicated that, as the people earn more, the higher would be their nutrient-rich animal source food. Although poverty, food, and nutrition security are intrinsically linked, these problems are not confined to poor countries; today 14% of U.S. citizens are classified as food insecure [13].

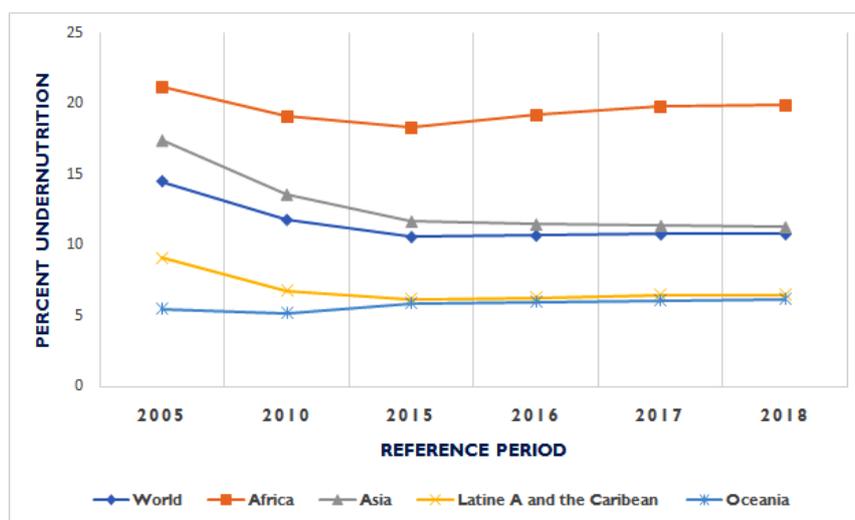
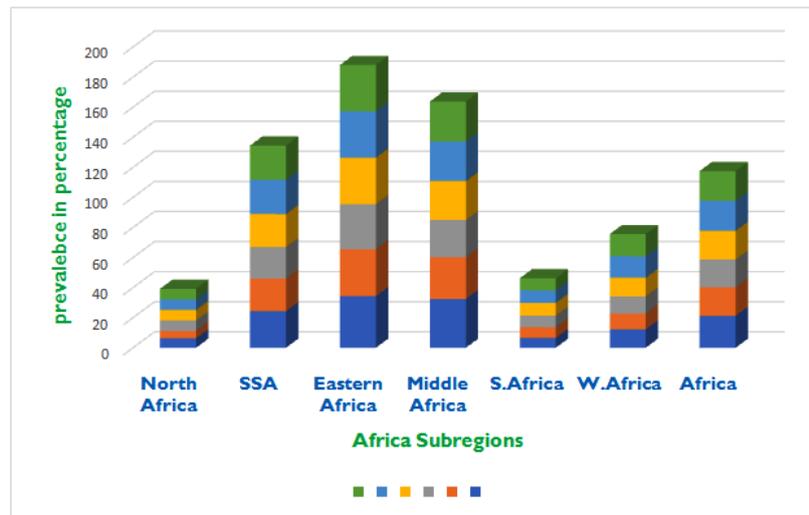


Figure 1: Global Undernutrition Trends [14]

### Regional Malnutrition and Undernutrition Status

Global malnutrition challenges is not affecting evenly different corners of the world at the same time. A large proportion of children and adults who are malnourished and living in developing countries are rural farmers whose living depends on smallholder farming. An analysis of Demographic and Health Survey (DHS) data shows that people living in rural areas are between 1.3 and 3.3 times more likely to be stunted than their urban counter parts [8].

The problem of malnutrition and undernutrition is more prevalent in African countries in general but most rampant in the East African corridor as it is indicated in Figure 2. In Sub-Saharan Africa, the prevalence of undernourishment appears to have risen from 20.8 to 22.7 percent between 2015 and 2016, and the number of people undernourished rose from 200 to 224 million accounting for 25 percent of the 815 million people undernourished in the world in 2016 [15].

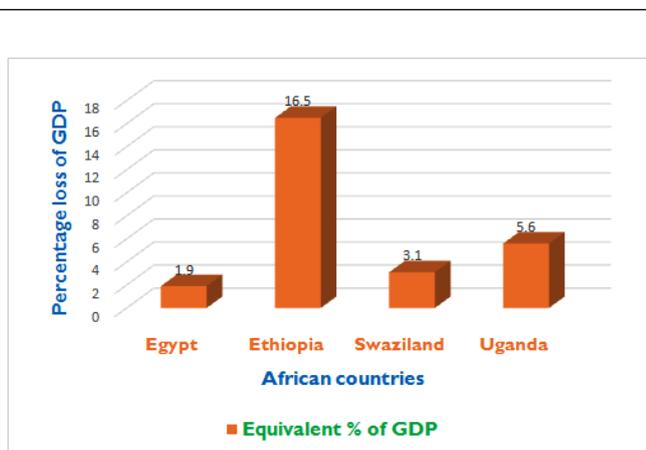


**Figure 2:** Under Nourishment Trends in Different African Sub-regions [14]

Undernutrition in some selected African countries indicated that, it has a debilitating impact not only on the physical and cognitive capacity of the people but it also affects significantly the national economies by reducing Gross Domestic Product (GDP) by as much as 16.5% like Ethiopia as indicated in Figure 3[8]. As the graph indicated significant proportion of the Ethiopian GDP is allocated to minimize undernutrition which otherwise could have been used to complement other development efforts of the nation.

### Animal Sources Foods Contribution to Ameliorate Undernutrition

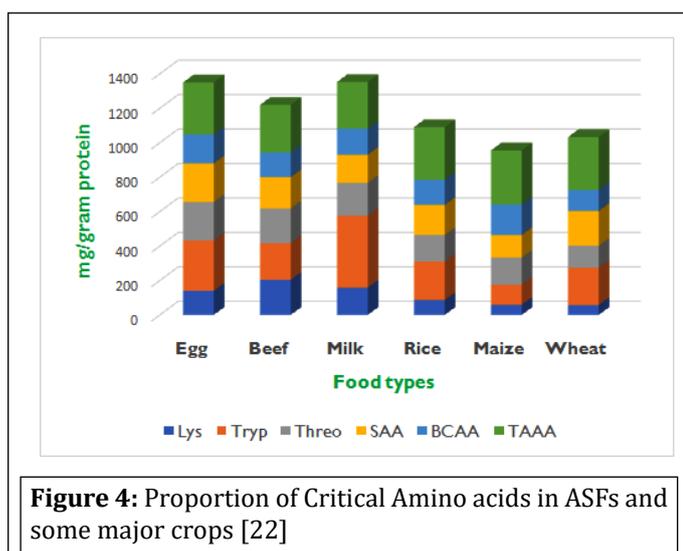
The effects of in adequate intake of nutrients are most pronounced during period of rapid physiological changes and during stages of accelerated growth, e.g. infancy and early childhood, and adolescence [16]. During pregnancy and lactation, nutrients needed for fetus growth and milk production increase a woman’s total nutrient requirement [16]. Overcoming deficiencies in diet quantity and quality are major nutritional challenges globally, particularly in developing countries. Animal Source foods (ASF) are therefore, foods rich in energy and excellent sources of high quality and readily digestible protein with high biological value and efficient source of micronutrients that are needed by the people to support normal development, physiological functioning and overall good health [9,16]. In contrast, plant-based diets tend to be deficient in one or more essential amino acids, especially lysine, methionine, and threonine. Micronutrients (including iron, Zinc, Vitamin A, and Calcium) also tend to be more bioavailable in ASFs, and some, such as vitamin B12 are found naturally only in ASFs [9]. Milk, meat, and eggs currently provide around 13% of the energy and 28% of the protein consumed globally but in developed countries; these rise to 20 and 48% for energy and protein, respectively [17].



**Figure 3:** Effect of undernutrition on GDP of some selected African Countries [8]

Consumption of ASF has been strongly associated with better growth, cognitive function, activity, pregnancy outcome and morbidity in three longitudinal studies in Egypt, Kenya and Mexico [18]. Animal Source Foods, including poultry meat and eggs can provide high-quality protein and micronutrients in bioavailable forms, which even in small quantities substantially increase the nutrient adequacy of traditional diets based on staple crops [7]. Many of the staple cereal-based foods consumed in developing countries not only deficient in nutrients but recognized to contain anti-nutritional factors, which limit the availability of micronutrients [7,17]. Diets based on cereals contain high levels of phytic acid, which dramatically reduces the uptake of iron and zinc by forming poorly absorbed complexes in the acidic environment of the stomach and small intestine [7]. Therefore, inclusion of small amounts of ASF, which contain iron in the bioavailable heme form and protein, is known to enhance the uptake of less readily absorbed non-heme iron found in cereals and green leafy vegetables.

However, smallholder farmers in the rural areas of developing countries can't afford other ASFs other than eggs because they are relatively costly and they need refrigerator for storage of extra volumes. In the case of eggs, no any taboos in consumption of chicken eggs and the nutrients in egg are in their balanced form, which usually help to evaluate other livestock products as standards. Therefore, eggs are better options to ameliorate the nutrition challenges in rural area in developing countries as compared to other ASFs. However, most poor farmers in rural areas in developing countries, they tend to sell ASFs rather than consuming to cover their expenses [19]. As to the egg storage experiences, under homestead chicken farming situation, eggs can be stored up to 5-7 days in shady places [20] where as in United States commercial poultry farming system, eggs can be stored up to 30 days with refrigeration [21]. Other research outputs indicated that, boiling of eggs can also help to increase their shelf lives. The distribution of the critical amino acids are in balanced form in eggs as compared to other ASFs and some major crops as indicated in Figure 4.



**Figure 4:** Proportion of Critical Amino acids in ASFs and some major crops [22]

**Note:** Lys = Lysine; Tryp = Tryptophan; Threo= Threonine; SAA= Sulphur Amino Acids; BCAA = Branched-Chain Amino Acids; TAAA = Total Aromatic Amino Acids

### Nutritional Quality and Importance of Eggs to Alleviate Undernutrition

Since the ancient times, humans have used chicken eggs as food. Compared to eggs, no other single animal-based food is eaten by so many people all over the world, and none is served in a wide variety of ways [18]. The popularity of eggs is justified not only because of the ease of production and numerous uses in cookery, but also because of their balanced nutritive values [23]. Eggs have been considered as a powerhouse of nutrition due to their excellence profile as a nutrient-dense food containing a balanced source of essential amino and fatty acids, some minerals and vitamins as well as the number of functional defensive factors to protect against bacterial and viral infections, with 97% protein digestibility and 94% biological score (a measure of the efficiency of converting dietary protein to body tissue) [7, 24-27]. One egg has on the average, 75 calories, 7 grams of high-quality protein, 5 grams of fat, and 1.6 grams of saturated fat, along with vitamins, minerals, and carotenoids and it has also high in disease fighting dietary bio-active compounds such as lutein and zeaxanthin which may reduce the risk of age-related macular degeneration the leading cause of blindness [28]. For a number of key nutrients, eggs provide a large proportion of the Recommended Dietary Allowance (RDA) or Adequate Intake (AI) for young children as well as pregnant and lactating women [28]. For a healthy infant between 7 to 12 months of age, one 50 g egg provides 59% of the RDA for protein, 88% and 98% of the AI for Vitamin B12 and Choline, respectively [28]. Egg protein is of high biological value because it contains all the essential amino acids needed by human body in ideal balance form for both men and women [18]. About one billion people, mainly in developing countries, suffer from iodine deficiency especially in India, Africa and China, often with serious consequences of slow brain development in the fetus, mental retardation in the infant, and goiter in adults [19]. On the other hand, a hen's egg normally contains about 53 micro gram iodine/100 g edible portion of an egg, which is about 33 percent of the Recommended Dietary Intake [19]. Therefore, eggs can also contribute to alleviate the deficiency of Iodine in developing countries.

Eggs are not detrimental to human health especially for those who are below poverty line and are very important for their good health and well-being [26]. Daily consumption of one to two eggs have no significant effect on human health [26]. The Australian, Canadian and Irish Heart Foundations and the British Nutrition Foundation have raised their guideline with recent findings that there is no conclusive evidence from egg consumption with an increasing risk of heart disease [26].

In addition to the above research findings, a randomized

controlled trial was conducted in Ecuador (Lulun Project) in 2015 using 6-9 months age children for six months by supplementing one egg per day per child. The control groups were fed their traditional diets for six months. The result after six months indicated that in supplemented groups stunting was reduced by 47% and underweight improved by 74% [29]. This controlled experiment indicated that, egg has an enormous potential in alleviating nutrition deficiency and reducing stunting in rural areas where these challenges are dominantly prevailing in developing countries.

Maternal consumption of eggs during lactation may also enhance the breast milk composition of certain nutrients, thus contributing to the nutrition and potentially also to the development of breastfed children [28]. Eggs provide > 50% of the Adequate Intakes for critical nutrients in breastfeeding infants and may offer immune protection and they are more affordable than other ASFs, and relatively simple to store and prepare [29]. In the world there are a large regional difference exist in egg consumption; the prevalence of egg consumption among African children is less than half that of most other world regions and threefold less than in Latin America and the Caribbean [28,30].

The study conducted on the benefits of eggs for child nutrition and women during pregnancy and birth outcomes by [19] in USA indicated that, feeding one large egg (50g) per day for healthy breastfed infant aged 7-12 months and two large eggs for pregnant and lactating women individually resulted in a very good proportion of AI and RDA for each respective age groups. The percentage proportion of AI/RDA for healthy infant 7-12 months, pregnant and lactating women by providing one to two large eggs per day per person is summarized and presented in Figure 5.

The study made by the American scientists [30] indicated that, the contribution of eggs to infant diets in its 100 grams contents was compared with human milk and the result indicated that nutrient values of an egg is superior as compared to human milk as indicated in Figure 6. For several decades, the high cholesterol content in egg yolk was a concern in public health because of the links to increasing risk of coronary heart disease, cancer and stroke. However, recent reviews of the evidence and newer studies have sufficiently refuted this belief [30].

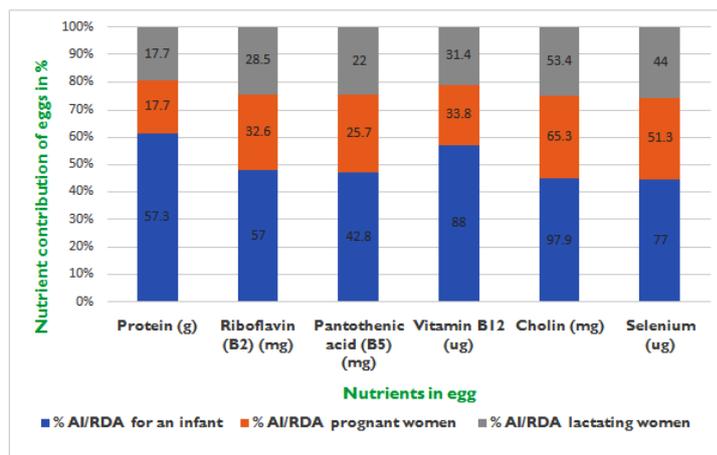


Figure 5: Nutrient supply of eggs to infant, pregnant and lactating women. [19]

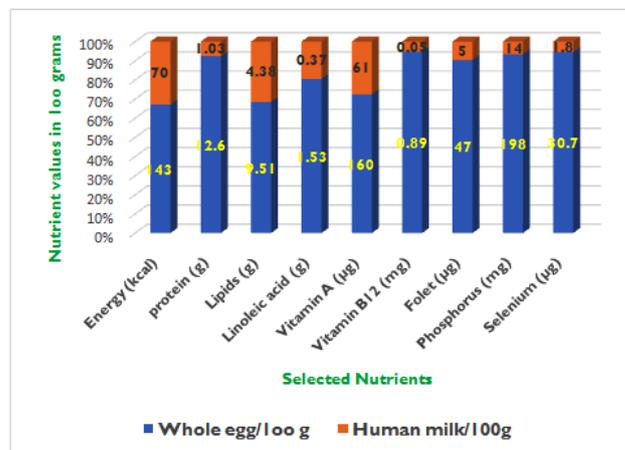


Figure 6: Comparative evaluation of eggs and human milk in 100 grams of their content for infants at the age of 7-12 months [30]

## Conclusions

Malnutrition and Undernutrition, which are the major causes of stunting, wasting and obesity are the global problems, which mainly affect growing children, lactating and pregnant women. However, the challenges are more deleterious in developing countries especially at rural family. The most affected geographic regions are the African and Asian continents. The rural people in these regions are dependent on cereal-based diets, which are nutritionally deficient to respond to their body requirements. The animal source foods, which are produced by the rural farmers in these regions, are sold to urban counter parts in order to cover other household burning expenses. The animal source foods are naturally rich in their nutritional contents but rural farmers due to affordability, access, knowledge gap, storage facilities and other cultural barriers underutilize ASFs. Among ASFs, eggs are likely to be used by the rural farmers because of very limited associated taboos, affordability, it's consumable size without the requirements of cold storage and access by rural farmers.

Eggs can be purchased relatively cheaply and in small numbers. One egg is almost a meal in itself and when hard-boiled will last for several weeks. Children with their lunch can take it to school safely. Poultry meat and eggs are widely available, relatively inexpensive and can be central importance in helping to meet shortfalls in essential nutrients, particularly of impoverished people. The incidence of several common metabolic diseases associated with deficiencies of critical dietary minerals, vitamins, and amino acids can be minimized by the contribution of chicken eggs, which is rich in all essential nutrients. Consumption of one egg per day per child will have no effect on blood cholesterol and recent research also suggests that two eggs per day per adult will also have no effect on most of the population. In general, eggs are not detrimental to human health and that for those in low income countries, eggs are very important for good health and well-being, and their consumption should be encouraged.

Eggs provide an exceptional protein source as well as fatty acids and a large range of vitamins, minerals and bioactive compounds that could potentially improve birth outcomes, child nutrition, and brain development. Egg consumption is low among women of reproductive age and young children with the lowest intakes in the African Region, India, and among children 6 to 8 months of age in all regions. Feeding one egg per day for six months for 6-9 months old children in Ecuador revealed that, an increase in linear growth, reduced stunting by 47%, and improve underweight by 74% and increase in biomarkers associated with cognitive development. Eggs provide the most concentrated source of choline, which is essential for a myriad of processes critical for brain development. The unique egg matrix that includes macronutrients, micronutrients, and the hormone and immune factors may act in concert to not only promote growth but also child development.

## Recommendation

- Capacity building and awareness creation and behavioral changes of the rural farmers to consume ASF mainly eggs using local media and during agricultural events.
- Cooking demonstration and promotion of egg consumption to rural women to share new and locally acceptable recipes.
- Encourage nutrition diversification in rural areas including eggs.
- Establish strong agricultural and health extension services on egg production and consumption.
- Institutional linkage among the major actors to incorporate nutrition to their plan.
- Projects should target the rural women and children during nutrition interventions.
- Prepare and disseminate educational materials on nutrition sensitive messages.
- Implement school feeding program using one egg per day per child for introduction of better nutrition, to bring impacts on consumption patterns of entire communities and help the development of local eggs production through back and forth linkages.

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