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Review Article

Programs targeting micronutrient deficiencies in Egypt: Achievements and challenges

Sahar Zaghloul, M.B.B.Ch., M.Sc., Ph.D.

National Nutrition Institute, Cairo, Egypt

Abstract

Micronutrient deficiencies are serious nutritional problems with cognitive, developmental and economic consequences. Supplementation, fortification, biofortification are best cost effective specific interventions dealing directly with the nutrition problems. Egypt has been suffering from many public health significant micronutrient deficiencies for long time. Many programs have been developed and implemented to deal with these problems. The current review presents description of the most common supplementation and fortification programs targeting iron, iodine and vitamin A, tracking its performance, effectiveness and challenges.

Introduction

Micronutrient deficiencies affect more than 2 billion individuals globally ***(FAO, 2013).*** This translates as one in three people could be mentally impaired, has poor health, low work capacity, low poor school performance and at high risk of early death. Even mild to moderate deficiencies can have physical and cognitive consequences affecting country socioeconomic development. Vitamin A and zinc deficiencies weaken the immune system and adversely affect child health and survival.Zinc deficiency affect normal growth leading to stunting in children. Iodine and iron deficiencieshinder children from reaching their physical and intellectual potential ***(Black, 2003).***Vitamin A deficiency often results in night blindness, and it may affect eye health and child survival ***(Sommer, 1995).*** Vitamin D and calcium deficiencies cause rickets and growth retardation in children as well as osteoporosis and osteopenia (weak bones) in adults ***(WHO & FAO, 2004).*** Micronutrient deficiencies contribute to one third of child death per year (1.1 million of the 3.1 million child deaths) ***(Black et al. 2013; Black et al. 2008).***

Causes of micronutrient deficiencies

The best description of malnutrition in children was presented by Martorell when he defined malnutrition as a “syndrome of developmental impairment” caused by a complex of multifactorial dynamics ***(Martorell, 1999)***. To understand the complexity of malnutrition, the United Nations Children’s Fund(UNICEF) developed a three tiers conceptual model for malnutrition ***(UNICEF, 2015).*** These levels were compiles at individual, household/community and national. Individual level represents immediate factors of imbalance between dietary intake of energy and nutrients not meeting requirements for growth and development causing illness or ability to combat infection. The household/ community level factors or underlying factors represent imbalance in food supply and demand such as household food insecurity, inadequate health care for women and children and unhealthy environment including poor sanitation and hygiene. Basic causes of poor nutrition operate at national and international level and include poverty, inequity and civil unrest. Therefore social, economic, and food polices and regulations have a long-term influence on maternal and childhood undernutrition.

Inadequate vitamin and mineral intake can result from increased micronutrient needs during pregnancy, lactation and growth .Women and children have greater needs for micronutrients ***(Darnton-Hill et al., 2005).*** Micronutrient deficiencies during pregnancy have long-term effects on fetal growth and development. Nearly 19 million babies are born each year are at risk of brain damage and mental retardation due to iodine deficiency ***(UNICEF, GAIN, 2018).*** 50,000 women die during childbirth each year because of severe anemia and 40 percent of women inthe developing world have low work capacity***(UNSCN 2005; Micronutrient Initiative 2014).*** Poor dietary patterns associated with low socioeconomic status, barriers to ready access of healthy food, insufficient nutrition knowledge regarding food shopping, preparation and storage are other factors contributing to low vitamin and mineral intakes***(Huskisson et al., 2007).***

Evaluating the public health significance of micronutrient malnutrition

Micronutrient deficiencies are common but only when they have public health implication, large scale interventions are recommended. Determining public health significance has been determined based on cutoffs either prevalence or biological indicator of micronutrient. The cutoffs for almost each deficiency have been determined by World Health Organization (WHO). For anemia a cutoff point of <5% is considered no public health problem; 5-19.9%-mild public health problem; 20-39.9%-moderate public health problem; >40%-severe public health problem ***(WHO, 2011 a).***

Vitamin A deficiency is considered a public health problem among children between 6-71 month if prevalence of low serum retinol <0.7 µmol/L, is 2-9% mild, 10-19% moderate and 20% and above is severe ***(WHO, 2011b).*** Zinc indicator is low height-for-age or stunting among under-5 children and public health significance is classified as low ≤20 %, moderate >20–40% or high ≥40***%)(WHO, 2006a).***The same cutoff can be applied to indicate when there may be a substantial risk of zinc deficiency. Plasma or serum zinc < 70 µg/dl is considered zinc deficient. The same cutoff can be applied to indicate when there may be a substantial risk of zinc deficiency,

Criteria for assessing the public health severity of iodine deficiency are mild if median urinary iodine is between 50-99 µg/l and total goitre prevalence 5.0-< 19.9(%), moderate if median urinary iodine is 20–49 µg/l and total goiter prevalence is 20–29.9 %, severe if median urinary iodine is <20 µg/l and total goiter prevalence is >30% ***(WHO/UNICEF/ICCIDD, 2007).*** Insufficient data on folate and vitamin D made it difficult to develop criteria for public health significance ***(WHO, 2006a).***

Interventions to address micronutrient deficiencies

There are three main types of interventions to prevent and combat vitamin and mineral deficiencies, which can be deployed individually or in combination. Supplementation is short-term; food fortification is medium-term and dietary diversificationis a long-term intervention focus on balanced nutrition. These approaches complement each other rather than being mutually exclusive ***(Trentmann et al., 2012).*** Supplementation and fortification do provide the quick improvement of micronutrient status for individuals or targeted populations but do not address the primary causes of poor micronutrient status (***Berti et al, 2014.)*** Underlying and systematic causes of malnutrition need to be addressed through nutrition-sensitive activities and interventions such as breastfeeding promotion, agriculture approach, increase income, safe water supply and sanitary environment, women empowerment and infection prevention and treatment ***(USAID, 2018).***These underlying factors indirectly increase food availability,accessibility and consumption of diverse food. Nutrition –sensitive approaches will not be covered in this paper.

At Copenhagen consensus in 2008 ***(CC08, 2008),*** panelists examined the cost effectiveness of micronutrient supplementation (Vitamin A and zinc), micronutrient fortification (iron and salt iodization), biofortification (agricultural improvements through research and development), de-worming (which also improves education), and nutritional education campaigns. Micronutrient supplements were the top-ranked and fortification was the third ranked solution, with tremendously high benefits compared to costs. Therefore, with the low cost of supplementation and fortification and the unmatched benefit-cost ratio of micronutrient programming, supplementation and fortification initiatives should be integrated into ongoing health services and existing food production methods ***(Global Report, 2009).***

Fortification programs or addition of micronutrients to processed foods can focus on widely consumed staple foods within a country, while dietary supplementation can provide micronutrients in effective doses and delivery forms targeted to specific population groups e.g. Vitamin A supplied through supplements, for example, can prevent child blindness and reduce mortality in children aged 6 months to 5 years old by 23 percent ***(Mayo-Wilson, et al., 2011).*** In another word, supplementation is quick fix of nutrient deficiency while food-based-strategies (fortification, biofortification and diversity) have more sustainable impacts. Therefore fortification of oil, margarine and milk with vitamin A was used as complementary medium term interventions. Food fortification is a cost effective solution mandated by government authorities and implemented by food industry ***(Trentmann et al., 2012)*** and is one of the best approaches to alleviating mineral deficiency and impact overall health of the general population ***(Sultan et al., 2014; Ahmed et al., 2014).***

WHO in its guide to program manager ***(WHO, 2007)*** provided an action plan to implement intervention program formed of the following steps: formation of coalition or advocacy, political support/commitment, development of supportive legislation and regulations, development of protocols, creation of demand for fortified food through social marketing campaigns to increase public awareness, capacity building of producers and laboratory for quality control and quality assurance to monitor programs. With program in place, continuous monitoring and evaluation is needed at national biological indicators, industry and public awareness. Also evidence of program effectiveness obtained by assessing changes in nutritional status, targeted nutrients and other outcomes are needed to allow up or back scaling of the program. However, it is difficult to know whether improvements in nutritional status of a population are due to intervention or to other changes ***(WHO, 2006 a).***

The current review will present Egypt's efforts to deal with micronutrient deficiencies of iodine, iron and vitamin A. Evaluation of the programs and faced challenges will be discussed.

Current micronutrient deficiency status in Egypt

In Egypt micronutrient deficiencies are significant, extensive and challenging. Around quarter (27%) of the children aged 6-59 months have moderate or mild anemia (10% moderately anemic and the rest are mildly anemic) and are mostly residing in rural areas (29%), and frontier governorates ***(Ministry of Health and Population, EL Zanaty and Associates and ICF International., 2015)***. Children between 9 and 12 months of age had the highest prevalence of anemia at 49.2% while children between 48 months and 59 months had the lowest prevalence at 16.1%. Girls aged 5-19 years were more anemic (21%) compared to boys (18%). The highest prevalence of iron deficiency anemia was among girls between 12-14 years of age (25%) and boys between 15-19 years (22%) ***(Rezk et al., 2015).*** According to the 2014 EDHS report, 25% of women, 15– 45 years were mildly anemic. The rate of anemia was highest among women living in rural Upper Egypt and lowest among women from the three Frontier Governorates at (31% vs. 20%, respectively).

Folate deficiency (<10 nmol/L) was 14.7% among mothers (n=579) ***(Tawfik et al, 2014)***. Serum retinol level (<20 µg/dL) was 6% among preschool children and 3.7% among their mothers. However it is worth noting that the survey was conducted eight years after implementation of vitamin A supplementation program in Egypt ***(Tawfik et al., 2010).***

Vitamin A deficiency (VAD) in Egypt was 11.9% among 6-71 months children and 10.9% among their mothers. VAD was the highest among the age group 12-24 months and in Upper Egypt ***(Moussa et al., 1995 &1997).***

Vitamin D insufficiency (serum 25(OH)D<50 nmol/L) and inadequacy (serum 25(OH)D 50-80 nmol/L) are also alarming. 40% of pregnant women at ≥37 weeks' gestation (immediately before delivery) were Vitamin D insufficient and

28.9% were vitamin D inadequate ***(El Rifai et al., 2014).*** In children 9-11 years vitamin D insufficiency was 11.5% and inadequacy 15% (Abu Shady et al., 2016). 72% of women with mean age of 31.5 years were vitamin D insufficient ***(Botros et al., 2015).*** However it is important to note that none of the studies were nationally representative.

Unlike other micronutrients and 20 years after implementation of Universal Salt Iodization program in Egypt, adequate iodine intake was reported among school children 6-10 years (median urinary iodine concentration was 170 µg /l). However inadequate intake of iodine among pregnant women was prevalent (median urinary iodine is 130 µg /l. ***(MOHP, UNICEF, GAIN 2015).*** This does not necessarily mean that there are no pockets of IDD at the governorate or district levels in Egypt. In addition households using adequately iodized salt was 79% shy from meeting the 90% goal for program success.

Economic costs of malnutrition in Egypt

The annual loss in gross domestic products (GDP) associated with inadequate nutrition was estimated at 12% in poor countries (Horton and Steckel, 2011). Malnutrition undermines Egypt economic progress. The cost of stunting was estimated to be 20 billion Egyptian pounds (1.9% of GDP) in direct costs of mortality and morbidity (5.4 billion EP because of mortality, 665 million EP estimated health care cost) and indirect costs of impaired cognition that results in poor school performance (271 million EP) and reduced economic productivity and earnings of adults (10.7 billion EP) ***(WFP, 2013)***. Long term consequences also include future risk for overweight and subsequently NCDs such as hypertension and cardiovascular disease. Suboptimal nutrient status in adults is associated with the risk of several chronic diseases, including CVD, osteoporosis, and cancer, suggesting that monitoring, assessment, and intervention are important across all socioeconomic groups ***(Fairfield and Fletcher, 2002; Fletcher and Fairfield, 2002).***
Abegunde et al. (2007) estimate that Egypt lost a cumulative US$1.26 billion to chronic diseases between 2005 and 2015; most of the loss is due to cardiovascular diseases and diabetes.In addition, the economic cost of anemia alone is associated with a 7 percent of DGP in Egypt ***(Horton and Ross, 2003).***

Nutrition Governance

Many bodies are responsible for the formulation of policies which could be considered the nutrition governance in Egypt. Inter-ministerial Committee on Nutrition under Prime Minister was formed by Prime Minister decree No. 1278 in 1993 and is considered high decision making committee formed from senior staff and researchers from Ministries of Agriculture, Health, Planning, Education, Information and Supply, specialized institutes such as Nutrition Institute and National Institute of Planning and university professors. The same decree included establishment of nutrition unit at Ministry of Agriculture to work in cooperation with the Nutrition Institute. The committee is responsible for planning and implementing of nutrition policies. However very little is known about the current status of this committee and its leadership is not noticeable. The regulations and criteria for selecting its members, the duration of service on the committee and whether it is supposed to function from top down or bottom up is not clear. Among the recommendations reported in the nutrition agenda for action, a policy paper on scaling up nutrition interventions in Egypt, is to reactive the inter-ministerial committee on nutrition and to establish a National Nutrition Multi-Sectoral Coordinating Committee (NNMSCC) as a mean to strengthen leadership and coordination in nutrition ***(MOHP and UNICEF, 2017).***

The Food Security Committee hosted by Ministry of Agriculture is mainly responsible for issues related to food production and availability.

The Health Committee at the People's (National) Assembly is a powerful legislative body responsible for overseeing the functioning and accountability of the MOHP, especially concerned with social protection issues, must approve any new health sector legislation, bylaws, or decrees, or the modification of existing ones. It must also approve the endorsement or amendment of cooperative agreements with bilateral or international organizations in the health sector ***(WHO, 2006).***

Recently, the Egyptian Parliament established the National Food Safety Authority (the "NFSA") by virtue of the new law 1/2017 (the "NFSA Law"). The NFSA Law puts an obligation on the Prime Minister to issue the Executive Regulation of the NFSA Law within six months starting from the date of entry into force ***(11 January 2017).*** It is not clear yet how the National Food Safety Authority will formulate its relationship with existing committees.

In summary, harmony and synergism between current nutrition governance in Egypt is missing. Use of national research data generated is suboptimal. These are among key issues hindering Egypt from making nutrition changes. As pointed out by ***Gillespie et al. (2017),*** nutrition changes are driven by commitment, coherence, accountability, scientific data evidence, capacity, leadership and finance.

The coming section aims to map out the main policies, strategies and plans which relate to improving vitamins and minerals nutrition in Egypt.

Formulation of National Nutrition Policy and Strategy

Before 1992, ad hoc programs addressed the problem of malnutrition.Egypt started to formulate national strategies and national plan of action since 1994 following the 1992 international conference on nutrition (ICN) declaration ***(FAO, WHO, 1992)***. The Inter-ministerial committee prepared Egypt plan of action for improvement of nutrition situation in September 1994 highlighting the continuous cooperation between ministries to ensure food safety by strengthening inspection capacity and enforcement of the law. In addition subsidy for bread and enrichment of flour with the needed micronutrients was recommended. Nutrition education and consumers awareness was endorsed(WHO, Global database on the Implementation of Nutrition Action (GINA).The main policy areas included:

- incorporating nutrition objectives, considerations and components into development policies and programs;
- improving household food security;
- protecting consumers through improved food quality and safety;
- preventing and managing infectious diseases;
- promoting breastfeeding;
- caring for the socio-economically deprived and nutritionally vulnerable;
- preventing and controlling specific micronutrient deficiencies;
- promoting appropriate diets and healthy lifestyles;
- assessing, analyzing and monitoring nutrition situations (***Egypt National Plan of Action for Nutrition, 1994)***.

The Food and Nutrition Policy and Strategy 2007-2017 was focused on twelve policy areas ***(National Nutrition Institute, 2007)*** and was developed to be part of the National Development Policy, the National Health Policy and at the same time fits into the context of food and nutrition security. The overall goal was to guarantee universal availability and accessibility to adequate high quality, safe food and promote healthy dietary practices for prevention and control of nutritional disorders**.**

Most recently MOHP in collaboration with UNICEF ***(UNICEF, 2017)*** has been leading the work to update the National Nutrition policy and strategy of Egypt (2017-2025) to scale up nutrition interventions and adapting the World Health Assembly nutrition targets to achieve by 2025 including

1. Reduction of chronic undernutrition in children under 5 years by 40%
2. Reduction of anemia in women of child-bearing age by 50%
3. Reduction of Low Birth Weights by 30%
4. No increase of overweight in children under 5 years of age
5. Increase in exclusive breast-feeding during the first six months by 50%
6. Reduce and maintain childhood wasting to less than 5% ***(MOHP, NNI, UNICEF, 2017)***.

Nutrition specific interventions

Supplementation and fortification interventions towards micronutrient deficiencies in Egypt

Universal Salt Iodization Program (USI)

The universal salt iodization program is the classic example of a successful, large-scale public health fortification program ***(Andersson, Vallikannu, & Zimmermann, 2012).*** In Egypt most of the indicators for sustainability of the program have been achieved. These include the following:

Political commitment

Securing political commitment and advocacy was demonstrated with the formation of multisectoral national committee for Iodine deficiency disorder prevention in 1992 headed by the undersecretary of health and composed of key decision makers from ministries of health, industry, information, El Nasr Saline Company, experts from universities, WHO and UNICEF. The committee was established to monitor the situation, to reinforce the regulations, monitor the impact of salt iodization in addition to establishing nutrition education and awareness campaigns. The committee managed to amalgamate iodized salt production in one company (El Nasr Saline company) to ensure production of iodized salt nationally and by end of 1995 ***(El Sayed, 2009).***

Legislative actions to support the program

The universal salt iodization program began in Egypt in 1996 and was supported with strong legislative actions where Minister of Industry and Minerals (MOI) produced decree 163/1997 to change the Egyptian Organization for Standardization and Quality Control (EOS) No 2732/1996 to produce iodized salt and EOS No. 179/1996 to replace the fortificant iodine with potassium iodate 30-70 ppm. Also ministerial decree41/2003 established the use of iodized salt for human consumption and baladi bread. EOS 2732/2005 were issued included characteristics, specifications of salt for human use ensuring the use of refined salt about 97 percent sodium chloride and iodine content (30 – 70 ppm) of table salt. In addition, it addressed packing and labelling requirements, requirements for salt transport, storage, sizes of salt packs and information requirements for salt labels.

EOS 2732/2015 (Table salt fortified with iodine) was developed as an update of EOS 2732/2005. Under this update repackers are responsible for iodine contents of salt at retail and market levels instead of salt producers. Term “added” potassium iodate was adapted to discriminate between commercial fraud and harmful for human use.

Coalition partnership and coordination

The strength of the program lies in the formation of a strong support from a coalition of international and national stakeholders including WHO, UNICEF, Iodine Global Network (IGN), WFP, and the Global Alliance for Improved Nutrition (GAIN) together with the Iodine deficiency disorder Scientific Secretariat of Egypt/ National Nutrition Institute (IDDSSE/ NNI) in collaboration with governmental bodies including Ministry of Health and Population (MOHP), MOI, experts from academia and salt producers. The program has been effective in sustaining adequate iodine nutrition in school-age children for over a decade. UNICEF secured fund for procurement of fortificant (estimated at 30 tons/year at cost of L.E.3 million EP) from 1996 to 2000 when MOHP incorporated the costs into its central budget.

Monitoring and Evaluation

Once the National Salt Iodization program was established in Egypt, it was essential to provide a continuous monitoring and evaluation program ***(WHO/UNICEF/ICCIDD, 2007).*** Guidelines state that an efficient salt iodization monitoring system includes ongoing and routine collection of relevant data, measuring salt iodine quality, household use of iodized salt, population iodine and thyroid function assessment.

The program also succeeded in incorporating indicators for sustainability which included capacity building of staff, laboratories, salt producers quality assurance and quality control, monitoring of indicators (EDHS and repeated national surveys) and incorporating nutrition information in curricula for in-service training of physicians, nurses and health workers.

The criteria for monitoring progress toward sustainable elimination of IDD were established by WHO/UNICEF/ICCIDD in 2001 and included:

1. Proportion of households using adequately iodized salt > 15 ppm>90%;
2. Proportion of population with median urinary iodine below100 µg/L <50%;
3. Proportion of population with median urinary iodine below50 µg/L <20%.

Baseline surveys to assess median urinary iodine in children 8-10 years of age were conducted between 1992-1996 at governorate level and was conducted by High Institute of Public Health in Alexandria (HIPH) using standardized protocol for study design, sampling and data collection (Table 1). The studies adapted two-stage cluster sampling. The first stage included probability proportional to the size of the population and a constant number of subjects per cluster. The second stage included randomly selected school children between 8-10 years of age. Schools included in the surveys were government, private and Azhar schools from six governorates: New Valley, Aswan, Minia, Kafr El Sheikh, Assuit and Sohag (Table 1). Goiter prevalence and the median urinary iodine (UIC) reported in New Valley (1993) were 82.3%, 89 µg/L; Aswan (1995), 17.5%, 108 µg/L; Kafr El Sheikh (1996), 27.1%, 151µg/L; Minia (1996) 36.9%, 142 µg/L; Assiut (1996) 36.8%, 112 µg/L; Sohag (1996) 30.1%, 128 µg/L. Overall, prevalence of IDD in Upper Egypt was 34.6%. In general, females experienced higher incidence of goiter than males, except in New Valley where, school children recruited were younger than their counterparts in other states (6-11 years) ***(El-Sayed et al., 1997, El-Sayed et al., 1998, El-Sayed, 1998).***

Table 1:
Percent of Children with Iodine Deficiency Disorder by median urinay iodine and Biochemical Indicators (< 100 µg/L) in Six Governorates in Egypt

Governorate/Field work year	Age in years	N	< 100 µg/L (%)	Median (µg/L)
New Valley /1993	6-11	576	58.3	89
Aswan/1995	8-10	232	45.7	108
Kafr El-Sheikh/1996	8-10	465	28.0	151
Minia /1996	8-10	442	38.9	142
Assiut/1996	8-10	452	41.8	112
Sohag/1996	8-10	453	29.8	128

Social Marketing campaign to increase awareness

To promote iodized salt coverage, social marketing campaigns were conducted in 1998, 2001, 2007, 2008, 2010 and 2013-2014. Social marketing is about changing consumer behavior to adopt healthier habits by applying commercial technologies ***(Andreasen, 1995).*** Explicitly social marketing offers and promotes a beneficial product, behavior, or concept, in an acceptable way to the target population. Encouraging food preparers (women) to use iodized salt, a fortified food product requires formulating and testing products, program strategies and activities, and specific messages and materials ***(Favin and Griffith, 1992).***

Barriers to the limited use of iodized salt included lack of availability of iodized salt in the market, especially remote areas; the high price of packed salt; availability of the low priced unpacked noniodized salt or repacking of iodized salt; lack of legislative forms that ban the use of non -iodized salt; lack of iodized salt logo to assist the public to recognize the "iodized salt" packages; lack of consumers' awareness of the importance of iodized salt and harmful impact of non-iodized salt and poor handling and storage of iodized salt. Clear consumer misconceptions and beliefs was expressed and included that unpacked salt bought from vendors has strong taste and give better quality for food preservation than packed salt bought from shops; sayahat salts do naturally exist "not manmade product", and that "salt is self -protected" since it is used for preservation and people have been using sayahat salt and nothing has happened".

Effectiveness evaluations

To track progress of the Universal salt iodization program, two national iodine assessment surveys were conducted in 2006-2007 and 2013-2014 (Table 2). Results show median urinary iodine within normal range in both surveys 183.7 µg/L and 170.0 µg/L respectively. However median urinary iodine was estimated at 135 µg /l in 2014 indicating low iodine intake among pregnant women (optimal goal 150-249 µg/l). Percent of households using adequate iodized salt was 69.1% in 2006-2007 survey and 74.7% in 2013-2014 survey a little bit short from the 90% coverage recommended. Egypt Demographic and Health Survey (EDHS) also assessed iodized salt availability (Table 3). Data showed marked increase in iodized salt coverage from 27.5% in 2000, 56% in 2003, 78% in 2005, 79% in 2008 and 90.5% in 2014.

Table2:
Percent of Households Using Iodized Salt and Population Median Urinary Iodine from National Urinary Iodine Assessment Surveys (2007, 2014)

Study Author	Fieldwork Dates	Target population	Household Sample Size	Sampling	Median UrinaryIodine (u/L)	% Households Using Adequately Iodized Salt*
MOHP/UNICEF 2007	2006-2007	children 8-10 years of age	3600 primary school children	Cluster sampling proportionate to population size Metropolitan, Lower Egypt, Upper Egypt Frontiers region.	183.7 µg/L	69.1% (> 15 ppm) 14.8% (5-14.9 ppm) 16.1% (0 ppm)
MOHP/UNICEF/ GAIN, 2017	2014-2016	Children 6-12 years Pregnant women	3248 Primary school children (PSC) 1500 pregnant women (PW) 2916 salt samples	Cross sectional multi-stage stratified cluster survey Metropolitan, urban Lower Egypt, rural Lower Egypt, urban Upper Egypt and rural Upper Egypt	170.0 µg/L PSC 135.0 µg/L PW	74.7% (>15 ppm) 17.8% (5-14.9 ppm) 7.5% (0 ppm)

- Titration method

Challenges

Challenges facing the program include the large number of salt producers and repackagers mainly unlicensed unregulated business could threaten USI. In addition, lack of implementation of the QA/QC procedures by small- and intermediate-size salt producers, which lead to inadequate iodine levels in salt. Lack of awareness of USI program among the population (70%) and inadequately iodized salt at home, 7.5% households have 0 ppm threatens the sustainability of the program. Nutrition education is warranted of the existence of the USI program and the importance of adequate iodine nutrition. Monitoring the progress through national surveys every five years still not secured as it relies on fund from international agencies. Research needs to be a line in existing institutional budget or central budget from MOHP.

Table3:
Percent of Households Using Iodized Salt (Demographic Health Survey between 2000 and 2014)

Survey Year	Fieldwork Dates	Household Sample Size	% Households Using Adequately Iodized Salt*	% Households Using Non-iodized Salt (ppm =0)	
				Urban	Rural
2014	4/14-6/14	9099	90.9	-	-
2008	3/08-6/08	18968	79	0.6	3.7
2005	4/05-6/05	21972	78	5.1	23.9
2003	5/03-6/03	10089	56	7.9	33.9
2000	2/00-4/00	16957	27.5	34.6	53.6

*Adequately iodized salt was defined as > 25 ppm in 2000 and 2003 DHS surveys and >15 ppm in 2005 and 2008 DHS surveys 2014 did not use the term adequately iodized salt, just iodized salt. In 2014 adequately iodized salt was detected using a semi-quantitative method.

Flour Fortification with Iron

Egypt flour fortification program started in 2008 after obtaining approval of the Prime Minister and Health Committee of the People's Assembly. The program was research based. NNI in a series of research established that iron deficiency anemia is a national pervasive public health problem and iron supplement interventions were not successful on long term. In addition a study investigating the feasibility and acceptance of fortified baladi bread was feasible and revealed high acceptance of the fortified 82% extraction wheat flour. Baladi bread was selected as vehicle because it is staple food for Egyptian and the existence of a distribution system at national level. The wheat flour is fortified at 30 parts per million (ppm) of iron in the form of ferrous sulphate and 1.5 ppm folic acid. The program includes 143 mills fortify their flour: 50% Government-owned and 50% Private. Every day, approximately 17, 000 MT of flour are distributed to 18,000 bakeries throughout Egypt.

The program was managed by World Food Program (WFP) and Ministry of Supply and Internal Trade and a Flour Fortification Alliance was formed later in 2006 from partners from MOHP, NNI, MOA, MOE, the National Academy of Scientific Research, the National Research Centre, Ministry of Finance, Faculty of Medicine, Faculty of Agriculture, and private and public sector partners including Egyptian nutrition researchers and the Food Industry Holding Company. The National Fortification Alliance set the national flour fortification action plan, policy guidelines, and budget. The program included training, advocacy, communication campaigns, social marketing and a monitoring and evaluation system ***(WFP, 2010, 2015)***.

WFP and GAIN provided initial set-up costs to launch the program. With the seed money secured, Government agreed to contribute sufficient funds (US$23 million) to run the program for 5 years. To formalize a long-term commitment, Government, GAIN and WFP signed a tripartite Memorandum of Understanding defining the roles and responsibilities of each party and committing to the common goal of providing fortified wheat flour to the population of Egypt.

Effectiveness evaluations

Evaluation of the program was planned by national pre and post assessment surveys. The pre-assessment survey was conducted in 2009/2010 ***(NNI, WFP, 2010).*** Data was obtained from 4526 households account for 18338 individuals representing four target groups: women of reproductive age 20-49.9 years; preschool children <5 years; schoolchildren

5-<12 years; and adolescents 12-18 years. The prevalence of anemia as indicated by hemoglobin level was found among 47.2% of women, 39.6% of preschool children, 35.0% of school children and 35.7% for adolescents. School children (55.7%) and women (53.0%) in Lower Egypt had the highest prevalence of iron deficiency anemia followed by preschool children from Cairo (54.1%) and adolescents (52%).

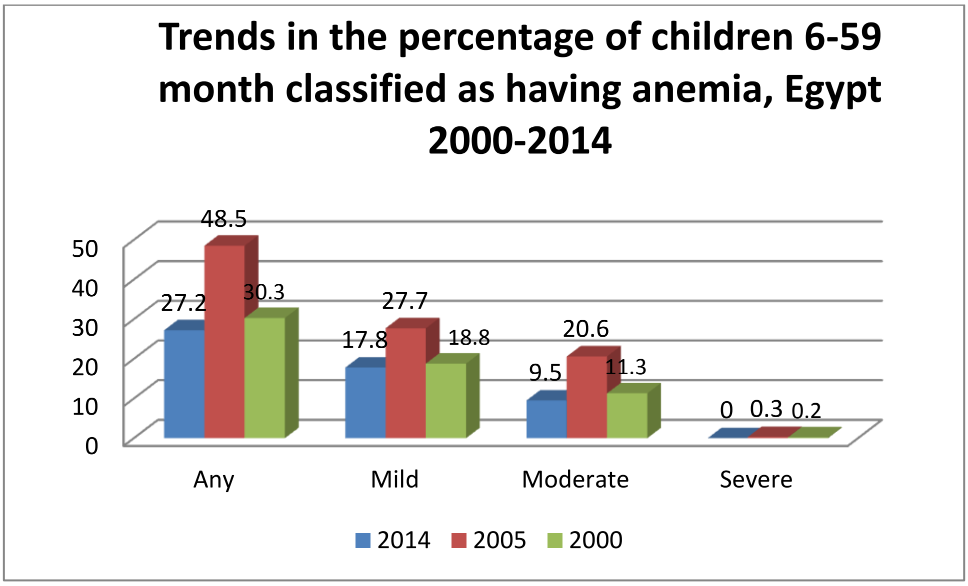
Effectiveness of the Program

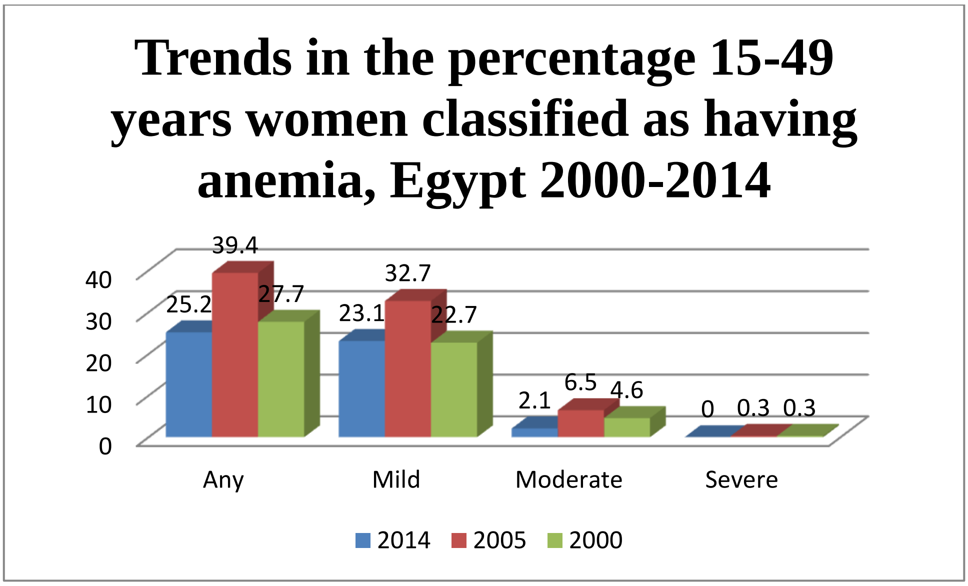
Post assessment survey was not conducted because of political unrest. For the current review, EDHS data between 2000 and 2014 have been used to assess the effect of flour fortification program (Figures 1 and2). The 2014 survey revealed reduction of iron deficiency anemia from 48.5% in 2008 to 21.3% in 2014 (21.3% reduction) among children aged 6-59 months (Ministry of Health and Population, ***EL Zanaty and Associates and ICF International., 2015).*** Also in women 15– 45 years anemia was reduced from 39.4% in 2008 to 25.2% in 2014 (17.8% reduction). Reduction in iron deficiency anemia was achieved 5 years from onset of the flour fortification program which makes us speculate that the flour fortification program may have contributed to the reduction of iron deficiency anemia and stunting.

Challenges

Challenges to the program included financial constraints and the large turnover of senior staff in almost all ministries after the Arab Spring 2011 which led to stop the flour fortification program in 2013 ***(WHO, 2015).*** Also political unrest prohibited the post intervention assessment survey needed to evaluate the effectiveness of the program ***(WFP, 2015).***

Appropriate use of financial resources and fund raising skills should be a crucial component of any program and requires capacity building among program administrators. Involvement of private sector is crucial to support the program in reward for tax exemptions. Although UN agencies financial support should be used as seed fund to develop and test the program but transfer to governmental budget not only show political commitment but is important factor for sustainability of any program. Flour fortification program need to resume as it is has the potential to reduce iron deficiency anemia in Egypt to achieve the World Health Assembly nutrition targets by 2025.





Vitamin A Supplementation and Fortification

Vitamin A deficiency (VAD) is associated with high susceptibility to infection, birth defects, blindness, cognitive losses and premature mortality ***(Mirmiran et al., 2016).*** The main strategies to combat the VAD include vitamin A supplementation, food diversification and food fortification. Vitamin A supplementation in children 6–59 months of age living in developing countries is associated with a reduced risk of all-cause mortality and a reduced incidence of diarrhoea ***(WHO, 2011).***

WHO also developed guidelines for classification of the severity of Vitamin A deficiency ***(WHO, 2011).*** VA prevalence of 2%–9% is considered a mild public health problem, 10%–19% a moderate public health problem, and ≥20% a severe public health problem. In addition, UNICEF used a coverage rate of ≥70% as a threshold to identify countries with relatively high VAS coverage that could initiate downscaling of the program ***(UNICEF, 2007).***

In Egypt, a package of services "The Basic Benefit Package was offered "at primary health care facilities since 1999 as part of the Health Sector Reform Program launched by the Ministry of Health and Population ***(WHO, 2006).*** Services are offered to the general population with a special emphasis on the poorest and the low-incomes categories. Among the package, is the multiple supplementation programs for new mothers and children which is comprised of: 1) Vitamin A supplementation for all infants at 9 and 18 months of age (100,000 IU and 200,000 IU); 2) A single dose of Vitamin A supplementation for women after delivery (200,000 IU); 3) Iron and folic acid tablets supplementation for all pregnant women 4) Weekly dose of iron supplementation for infants 6 month to 30 months 5) Zinc supplementation for infants as part of diarrheal diseases treatment. Programs are offered free of charge**.**

Targeting food diversity, MOHP provides nutrition education materials to health care facilities to be used by healthcare providers. Egypt Nutrition Landscape survey conducted in 2012 revealed insufficient availability of nutrition education materials in all the facilities. Materials to support and promote breastfeeding, proper infant and children nutrition and child growth monitoring were more available (50%) at facilities visited than educational materials targeting micronutrient deficiencies, obesity and stunting (20%) ***(UNICEF, 2012).*** In addition, in 2010, Egypt has launched a major national project to produce vitamin-enriched vegetable oil ***(WFP, 2010).*** The project is in partnership with the United Nations World Food Programme (WFP) and the Global Alliance for Improved Nutrition (GAIN) and targeted 60 million Egyptian subsidy recipients.No data is available on oil fortification, implementation and effectiveness.

Effectiveness of the Program

In Egypt, vitamin A supplementation programs have been implemented since 1999. Vitamin A deficiency dropped from 11.9% to 6% among 6-71 months children and from 10.9% to 3.7% among mothers eight years after implementation of the program (Tawfik et al., 2010).No updated data are available on vitamin A status among children. Onthe other hand, the EDHS since has been monitoring vitamin A supplementation coverage rate (% of children aged 6-59 months receiving vitamin A supplementation). Results from EDHS show drop of coverage level from 68% in 2008 to 17% in 2014 among children < 5 years of age and from 57% to 31.2% among mothers (Ministry of Health and Population, EL Zanaty and Associates and ICF International., 2008, Ministry of Health and Population, ***EL Zanaty and Associates and ICF International., 2015).*** The drop in vitamin A supplementation coverage between 2008 and 2014 urges the need for national assessment survey to determine the impact of the reduction in coverage on the magnitude of the problem.

Challenges

In short, there is outdated data on vitamin A status in Egypt, vitamin A supplementation services are suboptimal as demonstrated with the low coverage rate and no information is available on vitamin A fortification. The no data status prevent planners and decision makers from proper evaluation of these programs which could affect their abilities to focus or redirect the resources to more health problems and to target the most vulnerable areas in the country. Scaling down the supplementation program in unneeded areas and governorates could improve coverage in most needed regions where vitamin A deficiency is more prevalent under the current budgetary constraints. In addition, multiple interventions in this case supplementation and fortification have the potential for excessive intake which is a growing concern. The fine tuning of these programs are important to target the most vulnerable individuals. Moreover, lack of awareness of the supplementation program among health care providers contributes to lack of targeting the vulnerable ***(UNICEF, 2012).***
Another challenge to the accuracy of VA status surveys data is the need to estimate C-reactive protein and alpha 1-acid glycoprotein, positive acute phase proteins, and adjust for the presence of inflammation sinceretinol (ROH) and retinol binding protein (RBP)concentrations are depressed in the presence of inflammation. These inflammation markers will assist in interpreting low ROH values ***[Tanumihardjo, 2015].*** Various adjustment approaches exist (***Thurnham et al., 2015;Trentmannet al., 2012)***, and there is a growing consensus that VAD should only be estimated once ROH or RBP are adjusted using both C-reactive protein and alpha 1-acid glycoprotein.However, our review suggests that country-level data on VAD are sorely needed specially with implementation of multiple VA interventions without a current understanding of national VAD prevalence.

Conclusion and Recommendation

The current review presented three nutrition programs targeting iodine, iron and vitamin A deficiencies in Egypt. USI was the most successful large scale intervention program with well-established sustainability indicators. Lack of monitoring data for flour fortification and vitamin A supplementation programs make it difficult to properly evaluate the effectiveness of the interventions. Inconsistency and lack of availability of monitoring data of these programs is obvious. This gap in knowledge is partly due to the absence of the nutrition governance responsible for planning, implementing and tracking of nutrition policies. We recommend that international agencies that fund supplementation and fortification programs support national stakeholders to fill the data gap, to provide opportunities for capacity building of laboratories, personnel and management to strengthen the skills, abilities, processes and resources of governmental institutions to produce country level data suitable for evidence-based . This important role requires clear nutrition research plan, coordination among stakeholders and more powerful monitoring and evaluation role. Governmental institutions need to conduct National Health Nutrition Survey regularly to generate data to cover the gap of knowledge about current nutrition health status (prevalence and incidence of malnutrition), severity of deficiencies, identify target populations and evaluation of existing nutrition programs to assess challenges and barriers to program implementation in addition to determine the need to scale up or back of programs or to make programs more targeted. Data regarding safety of use of fortification is needed. Fortification policies are guided by accurate assessment of intake of fortified food, estimate of the problem to demonstrate need, impact on intake for each age and gender groups to avoid unintended consequences due to excessive intakes for other groups of the population. Databases from research have to be generated and updated regularly with clear outcome measures to reflect the rapidly evolving market place, consumption and nutrition status of the population. This subsequently would require a comprehensive food composition table updated regularly. Current food composition table has limited nutrient contents. Dietary data are important to explain deficiencies in certain pockets across the country as well as predict for coming nutrition health problems. At the national level, program planners should make evidence-based decisions, based on biochemical data before changes to programs are made.

Only through strong committed Nutrition governance with coherence among collaborators and accountability operative coordination among different stakeholders, high quality data will be generated and sound decision will be made.

References

Abu Shady, M.M.; Youssef, M.M.; Salah El-Din, E.M.; Abdel Samie, O.M.; Megahed, H.S.; Salem, S.M.; Mohsen, M.A.; Abdel Aziz, A.; El-Toukhy, S.(2016).
Predictors of serum 25-hydroxyvitamin D concentrations among a sample of Egyptian schoolchildren. ScientificWorldJournal, 8175768.

Ahmed, A.; Ahmad, A.; Khalid, N.; David, A.; Sandhu, M.A.; Randhawa, M.A.; Suleria, H.A. (2014).
A question mark on iron deficiency in 185 million people of Pakistan: its outcomes and prevention. Crit Rev Food Sci Nutr,*54*, 1617-1635.

Andreasan AR (1995).
Marketing social change. San Francisco CA: Jossey-Bass.Allen, L. H. (2001). Biological Mechanisms that Might Underlie Iron's Effects on Fetal Growth and Preterm Birth. The Journal of Nutrition 131: S581–S589.

Andersson, M., Vallikkannu, K., & Zimmermann, M.B. (2012).
Global iodine status in 2011 and trends over the past decade. The *Journal of Nutrition*, 142(4): 744–750. doi: 10.3945/jn.111.149393.

Berti, C.; Faber, M.; Smuts, C.M. (2014). Prevention and control of micronutrient deficiencies in developing countries: current perspectives. *Nutrition and Dietary Supplements 6*, 41-57.

Black, M. M. (2003).
Micronutrient Deficiencies and Cognitive Functioning'. *The Journal of Nutrition*, *133*(11 Suppl 2), 3927S–3931S.

Black, R. E., L. H. Allen, Z. A. Bhutta, L. E. Caulfield, M. de Onis, M. Ezzati, C. Mathers, and J. Rivera.(2008).
Maternal and Child Undernutrition: Global and Regional Exposures and Health Consequences." The Lancet 371 (9608): 243–260.

Black, R. E., C. G. Victora, S. P. Walker, Z. A. Bhutta, P. Christian, M. de Onis, M. Ezzati, S. Grantham-McGregor, J. Katz, R. Martorell, and R. Uauy.(2013).
"Maternal and Child Undernutrition and Overweight in Low-Income and Middle-Income Countries." The Lancet 832 (9890): 427–451.

Botros, R.M.; Sabry, I.M.; Abdelbaky, R.S.; Eid, Y.M.; Nasr, M.S.; Hendawy, L.M. (2015).
Vitamin D deficiency among healthy Egyptian females. *Endocrinol Nutr*, *62*, 314-321.

CC08 (2008).
Copenhagen Consensus 2008 – Results.
https://www.copenhagenconsensus.com/sites/default/files/cc08_results_final_0.pdf

Darnton-Hill, I., P. Webb, P. Harvey, J. M. Hunt, N. Dalmiya, M. Chopra, M. J. Ball, M. W. Bloem, and B. de Benoist. (2005).
"Micronutrient Deficiencies and Gender: Social and Economic Costs." American Journal of Clinical Nutrition 81 (5): 11,985–12,055.

Deweyer JT, Wiemer KL, Dary O, Keen CL, King JC, Miller KB, Philbert MA, Tarasuk V, Taylor CL, Gaine PC, Janis Ab, Bailey RL (2015).
Fortification and Health: Challenges and opportunities. AdvNutr; 6:124-131, 2015; doi: 103945/an. 114.007443).

Egypt National Plan of Action for Nutrition (1994).
Follow Up ICN
https://extranet.who.int/nutrition/gina/sites/default/files/EGY%201994%20Egypt%20National%20Plan%20of%20Action%20for%20Nutrition.PDF

Egyptian National Nutrition Institute (2007).
National Food and Nutrition Strategy Egypt 2007-2017, (Cairo, 2007).

El Rifai, N.M.; Abdel Moety, G.A.; Gaafar, H.M.; Hamed, D.A. (2014). Vitamin D deficiency in Egyptian mothers and their neonates and possible related factors. *J Matern Fetal Neonatal Med*, *27*, 1064-1068.

El-Sayed N, Ismail HM, Hussein MA, Kamel AA (1995).
Assessment of the prevalence of iodine deficiency disorders among primary school children in Cairo. Eastern Mediterranean Health Journal, 1(1):55-63.

El-Sayed NA, Gad ZM, Nofal LH, Ismail HM, ElSahn FF, Gad A. (1997).
Iodine deficiency disorders among primary school children in Kafr El Sheikh, Egypt. EMHJ 3(1): 29-37.

El-Sayed N, Mahfouz A, Nofal L, Ismail HM, Gad A, AbuZeid H. (1998).
Iodine deficiency disorders among school children in Upper Egypt: an epidemiologic study. Journal of Tropical Pediatrics, 44: 270-274.

El-Sayed NA, AbouZeid HM, Nofal LH, Ismail HM, Mahfouz AR, Abdel Halim Z (1999).
Monitoring the current status of IDD and the quality of iodized salt in New Valley governorate. Bull. HIPH, 29: 2, 269-80.

El-Sayed N (2009):
Desk review of IDD program of Egypt. UNICEF (unpublished).

El-Zanaty, F.; Ann Way. Egypt Demographic and Health Survey 2000.
Calverton, Maryland [USA]: Ministry of Health and Population [Egypt], National Population Council and ORC Macro. Available online http://dhsprogram.com/pubs/pdf/FR117/00FrontMatter.pdf

El Zanaty and Way A (2005).
Egypt Demographic and Health Survey. Cairo, Al Zanaty Inc.

El Zanaty and Way A (2008):
Egypt Demographic and Health Survey. Cairo Al Zanaty Inc.

Fairfield, K.M.; Fletcher, R.H. (2002).
Vitamins for chronic disease prevention in adults: scientific review. *JAMA*, *287*, 3116-3126

Favin, M and Griffiths M (1992).
Social Marketing of Micronutrients in Developing Countries. Paper prepared for the World Bank. The Man off Group: Washington, D.C.

Fletcher, R.H.; Fairfield, K.M.(2002).
Vitamins for chronic disease prevention in adults: clinical applications. *JAMA* **2002**, *287*, 3127-3129.

Food and Agriculture Organization of the United Nations.(2008).
An Introduction to the Basic Concepts of Food Security.

Food and Agriculture Organization of the United Nations(2013).
The State of Food and Agriculture. Rome. http://bit.ly/KAn84P.

Food and Agriculture Organization of the United Nations, World Health Organization. (1992).
International Conference on Nutrition. Nutrition and development – a global assessment. Geneva: World Health Organization. (ICN/92/INF/5).

Gillespie S, van den Bold M, Stories of Change Study Team (2017).
Stories of change in nutrition. Glob Food Secur2017;13:1-11.doi:10.1016/j.gfs.2017.02.004.

Global Alliance for Vitamin A (GAVA) (2012).
Technical Consultation on Guidance to Vitamin A Supplementation Programs for Children 6–59 Months of Age; GAVA: Ottawa, ON, Canada.

Global report (2009).
Investing in the future. A united call to action on vitamin and mineral deficiencies. Global Report 2009. Available online: http://www.unitedcalltoaction.org/documents/Investing_in_the_future.pdf

Global iodine nutrition scorecard (2015).
http://ign.org/cm_data/Scorecard_2015_August_26.pdf.

Horton S, Ross J. (2003).
The economics of iron deficiency. *Food Pol.* 2003; 28: 51– 75.

Horton, S.; Steckel, R.H. (2011).
Malnutrition. Global economic losses attributable to malnutrition 1900-2000 and projections to 2050. Assessment Paper Copenhagen Consensus on Human Challenges. http://www.copenhagenconsensus.com/sites/default/files/malnutrition.pdf

Huskisson, E.; Maggini, S.; Ruf, M. (2007).
The role of vitamins and minerals in energy metabolism and well-being. *J Int Med Res*, *35*, 277-289.

Hwalla, N., Al Dhaheri, A. S., Radwan, H., Alfawaz, H. A., Fouda, M. A., Al-Daghri, N. M.,Zaghloul S, Blumberg, J. B. (2017).
The Prevalence of Micronutrient Deficiencies and Inadequacies in the Middle East and Approaches to Interventions. *Nutrients*, *9*(3), 229. http://doi.org/10.3390/nu9030229

Martorell R (1999).
The nature of child malnutrition and its long-term implications. *Food and Nutr Bull***,** 20 (3), 288-293.

Mayo-Wilson, E., Imdad, A., Herzer, K., Yakoob, M. Y., &Bhutta, Z. A. (2011).
Vitamin A supplements for preventing mortality, illness, and blindness in children aged under 5: systematic review and meta-analysis. BMJ, 343:d5094.

Micronutrient Initiative. (2009).
Investing in the Future: A United Call to Action on Vitamin and Mineral Deficiencies. www.unitedcalltoaction.org/documents/Investing_in_the_future.pdf.

Micronutrient Initiative (2014).
About Hidden Hunger. www.micronutrient.org/English/View.asp?x=573

Micronutrient Initiative and UNICEF.(2004).
Vitamin and Mineral Deficiency: A Global Damage Assessment Report..http://bit.ly/1pGNSk1.

Ministry of Health and Population, El-Zanaty and Associates & ICF International. (2015)
Egypt Demographic and Health Survey 2014. Ministry of Health and Population, Cairo, Egypt, and ICF International, Rockville, MD, USA.

Ministry of Health and Population, United Nation UNICEF (2017).
Nutrition agenda for action a policy paper on scaling up nutrition interventions in Egypt Cairo, 2017. https://www.unicef.org/egypt/sites/unicef.org.egypt/files/2017-12/EGY_Nutrition_Agenda.pdf

MirmiranP , M Golzarand , L Serra-Majem , F Azizi. (2012).
Iron, Iodine and Vitamin A in the Middle East; A Systematic Review of Deficiency and Food Fortification IranianJPubl Health, Vol. 41, No.8, , pp. 8-19

Moussa, W.A., El – Nehry, F. and Abdel Galil, A. (1995):
National Survey for assessment of vitamin A status in Egypt Final report, Nutrition Institute / UNICEF.

Moussa, W.A., Shaheen, F.M., El – Nehry, F. and Abdel Galil, A. (1997):
Vitamin A status in Egypt. In Proceedings of the XVIII IVACG meeting, Cairo

National Nutrition Institute (NNI) and United Nations Children's Fund (UNICEF) (2007).
Evaluation of the effect of social marketing campaign in improving iodized salt knowledge and increasing consumption. NNI, Cairo Egypt.

National Nutrition Institute (NNI) and WFP.(2010).
Baseline Survey Data on Iron Deficiency Anemia in Egypt.
National

Nutrition Institute (NNI), Ministry of Health (MOH), United Nations Children's Fund (UNICEF) (2011). Consumer and market survey for iodized salt in Egypt. NNI, Cairo Egypt.

Raiten, D.J.; Ashour, F.A.S.; Ross, A.C.; Meydani, S.N.; Dawson, H.D.; Stephensen, C.B.; Brabin, B.J.; Suchdev, P.S.; van Ommen, B.; Grp, I.C. (2015). Inflammation and Nutritional Science for Programs/Policies and Interpretation of Research Evidence (INSPIRE). J. Nutr. 145, 1039s–1108s

Sommer, A. (1995) Conjunctival impression cytology for assessment of vitamin A status. Vitamin A Deficiency and Its Consequences. A Field Guide to Detection and Control.3rd ed World Health Organization. Geneva, Switzerland

Sultan, S.; Anjum, F.M.; Butt, M.S.; Huma, N.; Suleria, H.A. (2014). Concept of double salt fortification; a tool to curtail micronutrient deficiencies and improve human health status. J Sci Food Agric94, 2830-2838.

Tanumihardjo, S.A.(2015). Vitamin A fortification efforts require accurate monitoring of population vitamin A status to prevent excessive intakes. Procedia Chem., 14, 398–407

Tawfik, A.A.; Gohar, A.S.; Abdel Halim, S.; Abdel Rahman, M.K. (2010). Current vitamin A status in Egypt. Bulletin of the National Nutrition Institute of the Arab Republic of Egypt, 4-12.

Tawfik, A.A.; Hanna, E.T.; Freig, S.A.(2014) Folate status in Egypt. IOSR Journal of Nursing and Health Science 3, 32-36.

Thurnham, D.I.; Northrop-Clewes, C.A.; Knowles, J. (2015) The Use of Adjustment Factors to Address the Impact of Inflammation on Vitamin A and Iron Status in Humans. J. Nutr., 145, 1137s–1143s.

Trentmann C, Reinhard I and Vierc L (2012). Supplementation, Food Fortification and Dietary Diversification A three-pronged approach to reducing hidden hunger https://www.bmz.de/en/zentrales_downloadarchiv/themen_und_schwerpunkte/ernaehrung/food_fortification.pdf.

United Nations Children's Fund (2007). Vitamin A Supplementation: A Decade of Progresshttp://www.unicef.org/publications/files/Vitamin_A_Supplementation.pdf

United Nations Children's Fund. (2010) MRC South Africa, WHO and Egyptian Ministry of Health and Population, Egypt Nutrition. Landscape Analysis Report, (Cairo, Egypt).

United Nations Children's Fund (2015). UNICEF's approach to scaling up nutrition for mothers and their children. Discussion paper. Programme Division, UNICEF, New York..https://www.unicef.org/nutrition/files/Unicef_Nutrition_Strategy.pdf

United Nations Children's Fund. (2017).
Nutrition agenda for action a policy paper on scaling up nutrition interventions in Egypt. (https://www.unicef.org/egypt/egy_Nutrition_Agenda_2017.pdf)

United Nations Children's Fund. (UNICEF) and the Ministry of Health and Population Egypt, Report on the National Iodine Nutrition Survey 2006–2007, UNICEF and the Ministry of Health Egypt, Cairo, 2007

UNICEF, GAIN. Brighter Futures: Protecting early brain development through salt iodization – The UNICEF-GAIN partnership project. New York: UNICEF; 2018.
https://www.unicef.org/nutrition/files/brighter-future_Protecting-early-brain-development-through-salt-iodization-web-final.pdf

UNSCN (United Nations Standing Committee on Nutrition). 2005.
"The Critical Role of Nutrition for Reaching the Millennium Development Goals and Success of the Millennium Development Project." Background Briefing Note. SCN meeting in ECOSOC (UN Economic & Social Council) June 7. www.un.org/en/ecosoc/meetings/2005/docs/nut.issue.paper.pdf.

United States Agency for International Development (2018).
Micronutrients-brief. Multi-sectoral nutrition strategy 2014–2025 Technical Guidance Brief. Interventions for Addressing Vitamin and Mineral Inadequacies.

Wirth JP, Petry N, Tanumihardjo SA, Rogers LM, McLean E, Greig A, et al. (2017).
Vitamin a supplementation programs and country-level evidence of vitamin a deficiency. Nutrients. 9(3):190.

World Food Programme (2011)
ODC, Secondary analysis of the food and security situation in Egypt, May 2011.

World Food Programme (2010).
Economic Benefits of Flour Fortification in Egypt: Applying Global Evidence to the National Environment (Cairo, 2010).

World Food Programme (2010).
Egypt Launches Ground-breaking Oil Project to Boost Nutrition.https://www.wfp.org/news/news-release/egypt-launches-ground-breaking-oil-project-boost-nutrition.

World Food Programme (2013).
The Status of Poverty and Food Security in Egypt: Analysis and Policy Recommendations—Preliminary Summary Report. Cairo, Egypt: World Food Programme. https://documents.wfp.org/stellent/groups/public/documents/ena/wfp257467.pdf

World Food Programme (2013).
Cost of hunger in Egypt: implications of child undernutrition on the social and economic development in Egypt. In: The social and economic impact of child undernutrition in Egypt. Cairo, Egypt: Egyptian Cabinet Information Decision Support Center; 2013.

World Food Programme (WFP) (2015).
How WFP and the Government of Egypt Provide Micronutrients to over 60 Million Citizens. A Case Study on Fortification Programming in a Middle Income Country.

World Health Organization (2006).
Guidelines on Food Fortification with Micronutrients. Geneva, World Health Organization.

WHO (2011 a).
Haemoglobin concentrations for the diagnosis of anaemia and assessment of severity. Vitamin and Mineral Nutrition Information System. Geneva, World Health Organization, 2011 (WHO/NMH/NHD/MNM/11.1)

WHO. Guideline (2011b):
Vitamin A supplementation in infants and children 6–59 months of age. Geneva, World Health Organization.

WHO (2011).
Serum retinol concentrations for determining the prevalence of vitamin A deficiency in populations. Vitamin and Mineral Nutrition Information System. Geneva, World Health Organization. (WHO/NMH/NHD/MNM/11.3) (http://www.who.int/vmnis/indicators/retinol.pdf

WHO/EMRO. (2006).
Health system profile Egypt. Cairo: WHO/EMRO.
http://apps.who.int/medicinedocs/documents/s17293e/s17293e.pdf

WHO and FAO. (2004).
Vitamin and mineral requirements in human nutrition. Geneva, Switzerland: WHO and Rome, Italy: FAO.
http://whqlibdoc.who.int/publications/2004/9241546123.pdf.

WHO/UNICEF/ICCIDD (1994).
Indicators for assessing iodine deficiency disorders and their control through salt iodization. WHO/Nut. 1994/6.

WHO/ UNICEF/ ICCIDD (2001).
Assessment of iodine deficiency disorders and monitoring their elimination: A guide for programme managers. WHO/NHD/01.1.

WHO/UNICEF/ICCIDD (2007).
Assessment of iodine deficiency disorders and monitoring their elimination. A guide for programme managers, 3rd ed. Geneva: World Health Organization.
http://whqlibdoc.who.int/publications/2007/9789241595827_eng.pdf.