

ANALYSIS OF ECONOMIC BURDEN AND COST BENEFIT OF FOOD FORTIFICATION IN RELATION TO MALNUTRITION IN PAKISTAN

Muhammad Usman Zafar¹, Qing Ping¹, Asmat Matloob² and Tahir Zahoor^{2,*}

¹College of Economics and Management, Huazhong Agriculture University, Wuhan, China; ²National Institute of Food Science and Technology, University of Agriculture, Faisalabad, Pakistan.

*Corresponding author's e-mail: zahoor_t@yahoo.com

The consequences of vitamins and minerals deficient diet has presented considerable health issues that is extensively prevalent in developing countries including Pakistan. Consumer's dependence on plant based foods and lower availability of meat appears to be the considerable reason to increase the prevalence of nutritional scarcity. However, infants and child bearing women are the most susceptible individuals victimized due to malnutrition. Mainly the micronutrients which are deficient in malnutrition include iron, iodine and vitamin A which leads to anemia, goiter and many other disorders. Health and wellbeing of people can be improved by decreasing the micronutrient deficiencies. Among various strategies to combat these deficiencies, food fortification in recent era looks to be most favorable way to handle the situation of malnutrition without altering the existing dietary habits. Food fortification efficiently enhances nutrient bioavailability by imparting positive effects on consumer's health with a significant economical impact. The effectiveness of fortification either bio-fortification or food fortification programs is determined by effective implementation, monitoring, quality control, compliance and correction of identified issues in addition to efficacy of the fortified food. Accordingly, in this paper, the current situation of micronutrient deficiencies has been reviewed along with status of wheat flour fortification to facilitate further research activities.

Keywords: Malnutrition, fortification, human health, pregnant mothers, mineral deficiency, imbalanced diet, low-cost strategy

INTRODUCTION

Malnutrition is diverse form of deprived nutrition moving towards both overweight and underweight situations originated by a multifaceted collection of problems involving nutritional insufficiency, diseases and traditional dietary factors. Malnutrition due to micronutrient deprivation can direct to stunting and muscle wasting, diabetes, hypertension and other related illnesses. In developing nations, malnutrition is common among pregnant and lactating women due to insufficient food intake in spite of increased nutritional requirements that enhances the potential complication for both mother and child enhancing the infant and maternal mortality rates (Bloomfield, 2011) and long-lasting malnutrition effects (Victora *et al.*, 2008). Pregnant mother's malnutrition results in complications such as anemia, hypertensive disorders including preeclampsia and also elevates the chances of serious hemorrhages (Wu *et al.*, 2012). Hypertension and hemorrhages during pregnancy are the major reasons of maternal death all around the world (Firoz *et al.*, 2014). Fetal under nutrition causes low birth weight and maternal malnutrition leads to early delivery due to intrauterine growth restriction and several birth defects that include neural tube defects (Wu *et al.*, 2012). Infant malnutrition promotes poor cognitive abilities, academic and professional abilities (de Onis *et al.*, 2012; Martorell and Zongrone, 2012). Additionally, poor nutritional status of

mother affects the succeeding generations (Gigante *et al.*, 2015). First 100 days (starts from conception) are thought to be serious to prevent from stunting (Victora *et al.*, 2010).

Micronutrients are essential for better birth outcomes through various ways including sustained and improved nutritional status and an immunological improvement that reduces the maternal death rate (Papathakis *et al.*, 2016). In developing countries, pregnant mothers generally consume diet that is deficient in vitamin A, zinc and iron (one of the major deficiencies) due to minimum consumption of animal based food products. Available foods are not enough to meet the increased nutritional requirement of mothers (Ramakrishnan *et al.*, 2012).

The situation of malnutrition in the developing countries need to be tackled through various programs either for increasing awareness through educational institutes, media, seminars and community nutrition programs involving social infrastructure. The most important and impactful implementation of government policies, although initiated, through effective compliance which is still lacking in the developing nations.

NEED FOR FORTIFICATION

Pakistan is the sixth largest country in the world with population of greater than 200 million, most often the residents of this country are prone to natural disasters (HDR,

2010). UNICEF (United Nations International Children's Emergency Fund) nutrition survey has exposed the upsetting level of malnutrition. Forty-four percent children undergoes from stunting signifying chronic malnutrition, among them 58% children are living in FATA and 15% children undergo muscle wasting signifying the acute malnutrition. It surpasses the threshold level of international emergency condition. Every 5th child bearing women and 62% children under 5 years are anemic and severe vitamin A deficient. Mothers, a major susceptible malnourished population of underdeveloped countries, have poor knowledge of Infant and young feeding practices. The rate of breast feeding just after delivery is only 18%, depicting lowest rate in South Asia. Only 38% children complete breast feeding up to six months. Pakistani children are facing long term nutritional scarcity due to food insecurity, low socioeconomic status, susceptibility towards disease, poor hygienic practices and lack of knowledge of feeding young ones. Every third child under the age of five year dies because of malnutrition (UNICEF, 2015).

Pakistan had various nutrition assessment programs in past but still there is big need to address the major reason and effects of imbalanced nutrition. To make successful nutrition program it is essential that a component of community level intervention aimed various fundamental determinants of imbalanced nutrition must be intervened. The programs should be tightly bounded with the philosophy of justice, community contribution and possession along with scientific legitimacy. Nutrition surveys of Pakistan distressing findings suggest that there is critical requirement for execution of various programs for the health of children and mother, also re-evaluate the residing programs such as micronutrient fortification policies, Vitamin A supplements and food insecurity (NNS, 2011), although in this regard WFP has launched various scaling up nutrition strategies.

South Asian countries (developing region) are facing a serious but overlooked problem of under-nourished masses. According to report published by WHO, iron (Fe) deficiency is prevalent in approximately 4 billion people, zinc (Zn) deficiency in 2.7 billion and more than one type of vitamin is lacking in millions of people globally. The population with low income (which is one of the multidimensional problem of the under develop region) is predominantly suffering from suboptimal nutrition. The burden on the health system adds to the economic costs in the developing world. Renowned international economists have ranked controlling micronutrient malnutrition as a top development priority (Leung *et al.*, 2012). Eventually, reduction in poverty through economic growth will help to reduce the problem. An immediate and short-term solution that involves targeted micronutrient interventions include food supplementation and fortification at industry level (Fe fortification struggles after a successful example of iodine fortification in salt) and education programs that creates awareness about nutrition

should be initiated keeping in view the economic status of the country.

Malnutrition (micronutrients deficiency) directly influenced 155 million children under five years of age in developing countries (WHO, 2016) which is a severe health issue worldwide, extensively prevalent and alarming. Dependence of people on plant based foods and lower meat consumption is one of the main reasons to increase the prevalence of micro nutritional scarcity. The negative consequences of a diet deficient in vitamins and minerals are considerable health issues. This "hidden hunger" is more prevalent in susceptible population particularly in infants, child bearing mothers and lactating mothers. Every four out of 10 Pakistani lives in poverty indicating the non-affordability rate as higher in rural areas as compared to urban areas. Nearly two third (66.7%) of Pakistani people are not capable to afford the healthy food. The province wise data for non-affordability rate as reported by WFP (2016) indicates as Baluchistan 83.4%, Sindh 70.8%, Khyber Pakhtunkhwa 67.4%, Punjab 65.6% and in Islamabad 31.5%. The problems regarding micronutrient deficiencies may be specifically highlighted independently. The common micro-nutrient deficiencies, a global issue among susceptible population, are particularly iron, zinc, vitamin A, vitamin D presently need a high consideration of the stakeholders (WFP, 2016).

Health and well-being of people can be considerably improved by decreasing the micronutrients scarcities. It is a severe worldwide health issue and extensively prevalent in developing areas increasing the affected population. The demonstration of micronutrients scarcities are anemia, goiter and vitamin A deficiency. Furthermore, these are the most vital risk factors of disease and death by affecting two billion individuals (Akhter *et al.*, 2011). All of the above facts demand the formulation of viable nutrients fortification strategy at Government level; NGO's and private sector can also play their role to alleviate the problem of nutrients deficiencies through fortification programs. The status of individual deficiency as reported earlier is briefly discussed below:

Iron deficiency: Approximately, 1.6 billion people globally suffer from anemia. It annually contributes 20% maternal deaths, 17% reduction in efficiency of labor and 2.5% loss of income due to impaired cognitive skills. Annually 300,000 children are born with birth defects due to mother's folate deficiency. About 40-60% children (6-24 months age) have threats of low cognitive development due to iron deficiency. Iron salts are generally utilized to fortify food products. Effective fortification with iron would reduce anemia by 14%. Furthermore, folic acid fortified salt and flour has reduced neural tube defects (NTDs) by 40-50% (State of the World Report, 2015).

Zinc deficiency: It is the most widespread deficiency after iron deficiency due to lower intake of animal based food resulting in several unfavorable effects including poor weight

gain, hair loss, some digestive problems (diarrhea and loss of hunger), poor immunity make more vulnerable to infections and postponed sexual maturation (Badii *et al.*, 2012). No improvement in zinc deficiency is identified over the past decade, but further increasing slightly from 41% in 2001 to 42% in 2011 in non-pregnant women and 37 to 39% in young children (MQSUN, 2014).

Vitamin D deficiency: Its deficiency interferes with the calcium absorption leading towards bone problems like osteoporosis (condition of fragile bone with an increased susceptibility to fracture) and rickets (defective mineralization or calcification of bones). Nearly 70% pregnant women are vitamin-D deficient in Pakistan with about one-quarter being severely deficient, higher in urban areas as compared to rural areas due to insufficient sun exposure in homes. About 40% young children in Pakistan were vitamin D deficient in 2011, including about 9% with severe deficient (MQSUN, 2014).

Iodine deficiency: Iodine deficiency mostly exists in Northern areas of Pakistan. Iodine is an essential mineral in the production of thyroid hormone and its inadequate intake causes goiter (abnormal growth of thyroid). Its deficiency causes impaired intellectual capability and affected 35 million infants that born mentally impaired further intellectual losses of infants range from 7.4 to 15 IQ points (Leung *et al.*, 2012). Overall higher mortality rate has been connected with development of infectious diseases and poor immunity (Rayman, 2012). Efficient way to ensure adequate intake of iodine is salt fortification with potassium iodide. Iodized salt has been used since last many decades that reduced goiter by 40% in Pakistan. Salt iodization is greatly dependent on diverse environmental condition that's why other iodized foods such as biscuits, rice and breads are also recommended (Leung *et al.*, 2012)

Selenium deficiency: Selenium is a trace element obtained from staple foods such as grains and cereals. It plays a major role in regulating thyroid hormone. It is also crucial for brain functioning, deficiency may cause irreversible brain damage enhanced the risk of Parkinson's and Alzheimer's disease. Selenium supplementation further reduces the mortality rate. Low selenium intake results in impaired immunity, skin discoloration, hair loss, stress and reproductive issues (Rayman, 2012). Its fortification is not widely used except in infant formulas. Additionally, deficiency of selenium along with iodine deficiency also imposes a significant impact on the people suffering from thyroid-related disorders. It may also cause negative effect on neonatal growth and its survival. In Pakistan, occurrence of thyroid-related complications is very common and data related to the relationship of iodine deficiency in diet and its effects have been published frequently. However, data on selenium deficiency and its status in Pakistan has not been surveyed and established so far (Akhter and Rahman, 2009).

Vitamin A deficiency: The data has shown that every year approx. 250,000 to 500,000 children suffer childhood blindness due to inadequate intake of vitamin A. Approximately 250 million young children undergo vitamin A deficiency is moving towards compromised immune system (State of the World Report 2015). Vitamin A deficiency (VAD) is extensively spread in low socioeconomic countries and is one of the severe threats of micronutrient deficiency. Poorly developed areas are more susceptible to vitamin A deficiency in contrast of developed world and half of the VAD cases present in Africa and South Asia. Child bearing women are more vulnerable to this deficiency (Akhter *et al.*, 2011).

Food deficiencies with reference to imbalanced micronutrient intake has directly or indirectly due to disease burden, has shown huge impact on the economy of a country during the current scenario and in future it is expected to continue if not properly taken care. The accumulated economic consequences (Lost workforce, lost future productivity, lost current productivity, current healthcare costs) value spread over 10-year period is in the range of \$ 12.252 billion. The detail of which is presented in the Table 1.

Table 1. Economic loss of the current and future year's expectancy due to micronutrient deficiency (WFP, 2016).

Year	Economic loss (\$ billions)
2015	1.152
2016	1.168
2017	1.184
2018	1.200
2019	1.216
2020	1.232
2021	1.249
2022	1.266
2023	1.283
2024	1.301
Total	12.252

The essential four approaches to deal micronutrient malnutrition includes supplementation, fortification, food diversification and public health improvement steps involving good feeding practices and controlling infectious diseases are the priorities to be a main part for the policy makers that may reduce the expectancy of economic losses in coming years. These strategies would require information of nutrients suppliers and their convenience to humans through effective interventions. Food diversification approach includes the utilization of diversified food including nutrients covering malnutrition due to improved micro and macronutrients levels in body. People living in poor areas rely on traditional foods which is usually deficient in one or the other minor component. Although availability of food in general is sufficient in the country from food security point of view but

the unjustified distribution and lacking to certain parts of the country like Sindh (Thar, Mithi etc.) needs government effective strategy to be covered with respect to upscaling nutrition program for the individual's victim of malnutrition (Wahlqvist, 2008).

Under these circumstances, it depicts the need to put in further food constituents to get balance in consumption of nutrients through food diversification for nutrition programs in emergencies. In contrast of food diversification, success of supplementation strategies relies on level of exposure and fulfillment. Supplementation of iron in syrups and pills form has not been flourished in poor areas. Zinc supplementation is helpful in reducing the rates of deaths and illness caused by infections.

Contrary, food fortification is much cost effective, supple and satisfactorily accepted to get better nutrition in various developed areas, includes fortification of cereals, margarine and milk has significantly reduced the chances of nutritional deficiencies (Wahlqvist, 2008). Fortification of vegetable ghee and fats are the good vehicle for providing balanced nutrients with respect to vitamin A and D. Earlier practices depicted that this technique is economically and technically efficient to enhance the intake levels of micronutrients in people. To create a successful fortification plan, it is significant to consider physical and chemical variations going in the resultant product and outcomes of fortification is to be cautiously examined.

Food fortification is secure and economically efficient way to reduce micronutrient deficiencies and extensively applied at mass/universal and targeted levels. Mass fortification is regulated by industries to produce fortified products that are largely utilized by general population involving wheat flour fortification with folate and iron and salt iodization with reference to Pakistan. Targeted fortification is crucial for nutritionally deficient population and people in emergency.

In Pakistan, wheat is one of the major crop nearly 80% cultivars harvest it. During 2016-17 wheat production was nearly 25.3 million tons, high production than last years. It is the staple food and diversified breads are often prepared on

conventional clay oven (tandoor). Wheat flour recently supplied 72% of total calorie intake per day per capita. The highest wheat consumption per capita makes it ideal vehicle for iron fortification (MQSUN, 2014). Wheat flour fortification is a low-cost strategy comparatively to other nutritional interventions as manufacturing and supply system is previously in place to target large number of population and no behavioral modifications are required. It also tackles Hidden Hunger efficiently on a large scale. It is a powerful tool that enables school going children to achieve their academic potential, preparing mothers for healthy pregnancies and fighting against diseases. Micronutrient fortification to staple foods (wheat flour, salt and oil/ghee) can be implemented effectively. Extra cost on fortification may differ in each product but is generally less than a part of 1% greater than the non-fortified food. This extra cost is then diluted across whole market that further reduces individual cost (GAIN, 2015).

Wheat flour fortification cost: There are three aspects of costs which are covered premix cost, industrial cost and Government cost. Table 2 and 3 presents cost of fortification and detail workings of premix cost, industrial cost and government costs along with related assumptions.

Pakistan experiences 39% underweight young children. 1/3rd children under 5 years age are anemic. Micronutrient scarcities in pregnant women depicted 47.6% zinc, 68.9% vitamin D, 46% vitamin A deficiency and in young women it was 41.3% zinc, 66.8% vitamin D, 42.1% vitamin A deficiency (NNS, 2011). Nearly 2 billion people suffer from micronutrient malnutrition. Economically, it causes annual 2-5% GDP loss with cost estimation between US\$ 20-30 billion (State of the World Report 2015). Cost of protein energy malnutrition decreased 12% GDP (GAIN, 2015).

During current years, a huge number of technological efforts have been highlighted to defeat mineral malnutrition in developing countries, as the elevated deficiency of zinc, iron and iodine besides vitamin A shortage. Deficiency in the body is due to lower hemoglobin level, cause anemia, decreased RBCs leads to decreased growth and development in children,

Table 2. Various aspects of cost consideration of wheat flour fortification (WFP, 2016).

Year	Premix Cost (\$ millions)	Industrial Cost (\$ millions)	Government cost (\$ millions)	Total (\$ millions)	Total (\$ billions)
2015	16,665,047	6,453,277	1,194,000	24,312,324	0.024
2016	35,020,846	2,502,369	644,000	38,167,215	0.038
2017	36,797,366	2,537,899	744,000	40,079,266	0.040
2018	38,664,005	2,575,232	644,000	41,883,237	0.042
2019	40,625,333	2,614,459	744,000	43,983,792	0.044
2020	42,686,155	2,655,675	744,000	46,085,830	0.046
2021	44,851,517	2,698,982	744,000	48,294,499	0.048
2022	47,126,722	2,744,486	644,000	50,515,208	0.051
2023	49,517,343	2,792,299	744,000	53,053,641	0.053
2024	52,029,234	2,842,537	644,000	55,515,770	0.056

poor working abilities in adults and also cause various disorders during pregnancy (Gharibzahedi and Jafari, 2017). Technological efforts have been highlighted to defeat malnutrition. Studies have shown that daily intake of vitamin A fortified bun enhanced the vitamin A status in individuals with less serum retinol level. Similar effects were observed by the consumption of vitamin A fortified cookies (Jinabhai *et al.*, 2001). Zinc fortification can improve the available zinc in body as resulted by small scale trials (Brown *et al.*, 2007) also reduced the prevalence of infectious diseases including malaria, diarrhea and pneumonia that are general cause of mortality in children. High food prices further deteriorate the situation. In 2008, 72 million people (51%) were food insecure and daily caloric intake was less than 2100Kcal. Number of severely food insecure people (less than 1700 Kcal/day intake) has increased from 9.6 to 45.3 million, two third of them from rural areas. During 2010, two Pakistani staples, rice and wheat, have increased 30-50% times more cost due to global food crisis (GAIN, 2015).

Table 3. Current and estimated cost-benefit ratio of wheat fortification program (WFP, 2016).

Year	Cost (\$ billions)	Benefit (\$ billions)	Benefit Cost Ratio
2015	0.024	0.103	4.22
2016	0.038	0.213	5.59
2017	0.040	0.222	5.53
2018	0.042	0.231	5.51
2019	0.044	0.240	5.45
2020	0.046	0.249	5.41
2021	0.048	0.259	5.37
2022	0.051	0.270	5.34
2023	0.053	0.281	5.29
2024	0.056	0.292	5.26
Total	0.442	2.359	5.34

Consumer choices are transferred from whole grains to extracted flour, especially western styled bread. Pakistani cultivars preserve 60% wheat for seed and household consumption. 23-30% wheat purchased by the government and remaining 15% procured privately, due to this, food security is of vital concern in Pakistan (GAIN, 2015). Conclusively, the whole grain not only wheat but other cereals may be bio-fortified with subsequent fortification of various foods during processing is a dire need for the uplift of nutrition status of the country. Importantly, the cost will be benefitted through the reduction in disease burden. The Government should take initiatives and well-defined policy making in this regard.

Conclusions: Considering the increased number of malnourished population due to the intake of vitamin and mineral deficient diet, strong government policies are required in developing countries including Pakistan. Iron

deficiency through wheat flour fortification, as regulated recently in Punjab Pure Food Rule (PPFR) edition 2017, needs to be implemented particularly for pregnant and lactating women for iron compensation and for the security of infant's health. Vitamin A deficiency through fats and oils products should be followed for the industrial development. Food products diversification and dietary habits for Zinc, Iodine and Selenium compensation in foods necessitate the policy maker's deliberations. Keeping in view the economic burden of the country and subsequently calculating the cost benefits of Food Fortification, particularly in wheat, based on review should be implemented with respect to regulation involving the social and economic experts for effective scaling up nutrition in Pakistan.

Acknowledgments: The acknowledgments are particularly for the WFP, WHO, UNICEF and all authors who provided data for the idea to be generated for future recommendations

REFERENCES

- Akhter, P. and M.K. Rahman. 2009. Assessment of selenium intake levels through typical Pakistani diet. *Nutr. Food Sci.* 39:268-276.
- Akhtar, S., F.M. Anjum and M.A. Anjum. 2011. Micronutrient fortification of wheat flour: Recent development and strategies. *Food Res. Int.* 44:652-659.
- Badii, A., N. Nekouei, M. Fazilati, M. Shahedi and S. Badii. 2012. Effect of consuming zinc-fortified bread on serum zinc and iron status of zinc-deficient women: A double blind, randomized clinical trial. *Int. J. Prev. Med.* 5:124-130.
- Bloomfield, F.H. 2011. How is maternal nutrition related to preterm birth? *Ann. Rev. Nutr.* 31:235-261.
- Brown, K.H., K.R. Wessells and S.Y. Hess. 2007. Zinc bioavailability from zinc-fortified foods. *Int. J. Vit. and Nut. Res.* 77:174-181.
- de Onis, M., M. Blossner and E. Borghi. 2012. Prevalence and trends of stunting among pre-school children, 1990-2020. *Public Health Nutr.* 15:142-148.
- Firoz, T., H. Sanghvi, M. Merialdi and P. von Dadelszen. 2014. Pre-eclampsia in low and middle-income countries. *Best Pract. Res. Clin. Obs. Gynaecol.* 25:537-548.
- Gharibzahedi, S.M.T. and S.M. Jafari. 2017. The importance of minerals in human nutrition: Bioavailability, food fortification, processing effects and nanoencapsulation. *Trend Food Sci. Tech.* 62:119-132.
- Gigante, D.P., B.L. Horta, A. Matijasevich, C.L. de Mola, A.J. Barros, I.S. Santos, F.C. Barros and C.G. Victora. 2015. Gestational age and newborn size according to parental social mobility: an intergenerational cohort study. *J. Epidemiol. Comm. Health.* 69:944-949.

- GAIN. 2015. Global Alliance for Improved Nutrition. Analysis of Economic losses due to iron and folic acid deficiencies in Pakistan-Food Fortification, a cost-effective strategy to reduce losses: Pakistan. Global Alliance for Improved Nutrition, Pakistan.
- Human Development Report. 2010. The Real Wealth of Nations: Pathways to Human Development. United Nations Development Program, New York, USA.
- Jinabhai, C.C., M. Taylor, A. Coutsoadis, H.M. Coovadia, A.M. Tomkins and R. Sullivan. 2001. A randomized controlled trial of the effect of anti-helminthic treatment and micronutrient fortification on health status and school performance of rural primary school children. *Ann. Tropic. Paediatr.* 21:319-333.
- Leung, A.M., L.E. Braverman and E.N. Pearce. 2012. History of U.S. iodine fortification and supplementation. *Nutr.* 4:1740-1746.
- Martorell, R. and A. Zongrone, 2012. Intergenerational influences on child growth and undernutrition. *Paediatr. Perinat. Epidemiol.* 26:302-314.
- MQSUN. 2014. Maximizing the Quality of Scaling up Nutrition Programmes. Pakistan Food Fortification Scoping Study: Pakistan, PATH, UK; pp.1-58.
- NNS. 2011. National Nutrition Survey. Government of Pakistan Planning Commission Planning and Development Division Government of Pakistan Conducted by Aga Khan University, Pakistan Supported by UNICEF, Pakistan.
- Papathakis, P.C., L.N. Singh and M.J. Manary. 2016. How maternal malnutrition affects linear growth and development in the offspring. *Mol. Cell. Endocrinol.* 435:40-47.
- Ramakrishnan, U., F.K. Grant, T. Goldenberg, V. Bui, A. Imdad and Z.A. Bhutta. 2012. Effect of multiple micronutrient supplementation on pregnancy and infant outcomes: A systematic review. *Paediatr. Perinat. Epidemiol.* 26:153-167.
- Rayman, M.P. 2012. Selenium and human health. *The Lan.* 379:1256-1268.
- State of the World Report. 2015. Food Fortification. Micronutrient Forum, 180 Elgin Street, Suite 1000 Ottawa, Ontario, Canada.
- United Nations International Children's Emergency Fund. 2015. Pakistan Annual Report, UNICEF. Available online at <https://www.unicef.org/>
- Victora, C.G., L. Adair, C. Fall, P.C. Hallal, R. Martorell, L. Richter and H.S. Sachdev. 2008. Maternal and child undernutrition: consequences for adult health and human capital. *Lan.* 371:340-357.
- Victora, C.G., M. de Onis, P.C. Hallal, M. Blossner, and R. Shrimpton. 2010. Worldwide timing of growth faltering: revisiting implications for interventions. *Pediatrics* 125:473-480.
- Wahlqvist, M.L. 2008. National food fortification: A dialogue with reference to Asia: Policy in evolution. *Asia Pacific J. Clin. Nutr.* 17:24-29.
- WFP. 2016. World Food Programme. Zero Hunger: The Heart of the 2030 Agenda. Rome, Italy.
- WHO. 2016. World Health Organization. Diet, nutrition and the prevention of chronic diseases-report. Geneva: World Health Organization.
- Wu, G., B. Imhoff-Kunsch and A.W. Girard. 2012. Biological mechanisms for nutritional regulation of maternal health and fetal development. *Paediatr. Perinat. Epidemiol.* 26:4-26.