



Iron, Iodine and Vitamin A in the Middle East; A Systematic Review of Deficiency and Food Fortification

P Mirmiran¹, M Golzarand², L Serra-Majem³, F Azizi⁴

1. *Clinical Nutrition and Dietetics, Faculty of Nutrition Sciences and Food Technology, National Nutrition and Food Technology Research Institute, Shahid Beheshti University of Medical Sciences, Tehran, Iran*
2. *Obesity Research Center, Research Institute for Endocrine Sciences, Shahid Beheshti University of Medical Sciences, Tehran, Iran*
3. *Clinical Science, University of Las Palmas de Gran Canaria, Las Palmas de Gran Canaria, Spain*
4. *Endocrine Research Center, Research Institute for Endocrine Sciences, Shahid Beheshti University of Medical Sciences, Tehran, Iran*

(Received 17 Feb 2012; accepted 21 Jun 2012)

Abstract

Background: Micronutrient deficiency is one of the major public health problems in the Middle East affecting economic, political and social development of countries. The three commonest micronutrient deficiencies belong to iron, iodine and vitamin A.

Methods: we conducted a systematic review of published English articles in the Middle East countries using databases from PubMed, World Health Organization and Food and Agriculture Organization from 1985 onward. A total of 6050 articles were identified and after evaluation based on eligibility criteria, 81 articles included in this systematic review.

Results: Despite implementation of flour fortification other control strategies, the prevalence of iron deficiency is moderate to severe in the Middle Eastern countries, because of ineffective iron fortification program, food interaction and hemoglobin application as anemia indicators in these countries. Mild to severe iodine deficiency disorders exist in many countries of the Middle East, due to lack of effective iodine supplementation program. The prevalence of vitamin A deficiency is mild to severe and there is lack of vitamin A fortification program in many countries in this region.

Conclusion: Despite unharmonized efforts to control malnutrition of micronutrients, iron, iodine and vitamin A deficiencies are still exist in some countries of the Middle East. Effective, well controlled and harmonized programs for elimination of micronutrient deficiencies need to be initiated for governments and supported by international organizations in this region.

Keywords: Iron, Iodine, Vitamin A, Middle East, Fortification, Salt iodization

Introduction

Poverty, often defined as a low income, is a main cause of hunger and is correlated with malnutrition and a higher risk of illness and disability (1). Hunger and malnutrition directly or indirectly are responsible for half of deaths worldwide and are one of the major public health problems among the most developing countries including the Middle Eastern countries. According to the latest Food and Agriculture Organization (FAO) statis-

tics, there are 925 million hungry worldwide; 37 million of them live in the Middle East and Africa (2). Hunger not only impresses weight but also impacts high economic costs to developing countries by hindering economic, social and political development, increasing individual susceptibility to disease and decreasing learning ability and work capacity (3). In September 2000, world leaders signed the United Nations Millennium Declara-

tion to fight poverty, hunger, disease, illiteracy, environmental degradation and discrimination against women (4). Following this FAO focused on poverty and hunger reduction through improving agricultural productivity and incomes and promoting better nutritional practices at all levels and programmes that enhance direct and immediate access to food by the neediest (5). Over the past 20 years, prevalence of underweight has decreased by 50% in the Middle East, from 12.8% to 6.3%, prevalence of stunted individuals, from 28.2% to 19.7% and that of the wasted shifted from 5.6% to 4.7%; these statistics show the achievement of the Millennium Development Goals in the Middle East (6). Management of micronutrient deficiencies, also, is an important part of the efforts to combat hunger and malnutrition. Micronutrient deficiency which has adverse effect on health, learning ability, productivity, work capacity and economic development, affects all age groups, especially young children and women in both developed and developing countries. The three most

prevalent features of micronutrient malnutrition are iron, iodine and vitamin A deficiencies that not only affect many people but also lead to the burden of disease such as high susceptibility to infection, birth defects, blindness, cognitive losses and premature mortality (7).

This paper reviews the prevalence of iron, iodine and vitamin A deficiencies and the measures taken to combat these nutrient deficiencies in the Middle Eastern countries.

Methods

We conducted a systematic review of all papers published in the Middle Eastern countries between 1985 and 2011. Middle Eastern countries were defined as Islamic Republic of Iran (I.R. Iran), Jordan, Iraq, United Arab Emirates, Saudi Arabia, Bahrain, Yemen, Qatar, Turkey, Lebanon, Palestine, Kuwait, Oman, Syria and Egypt.

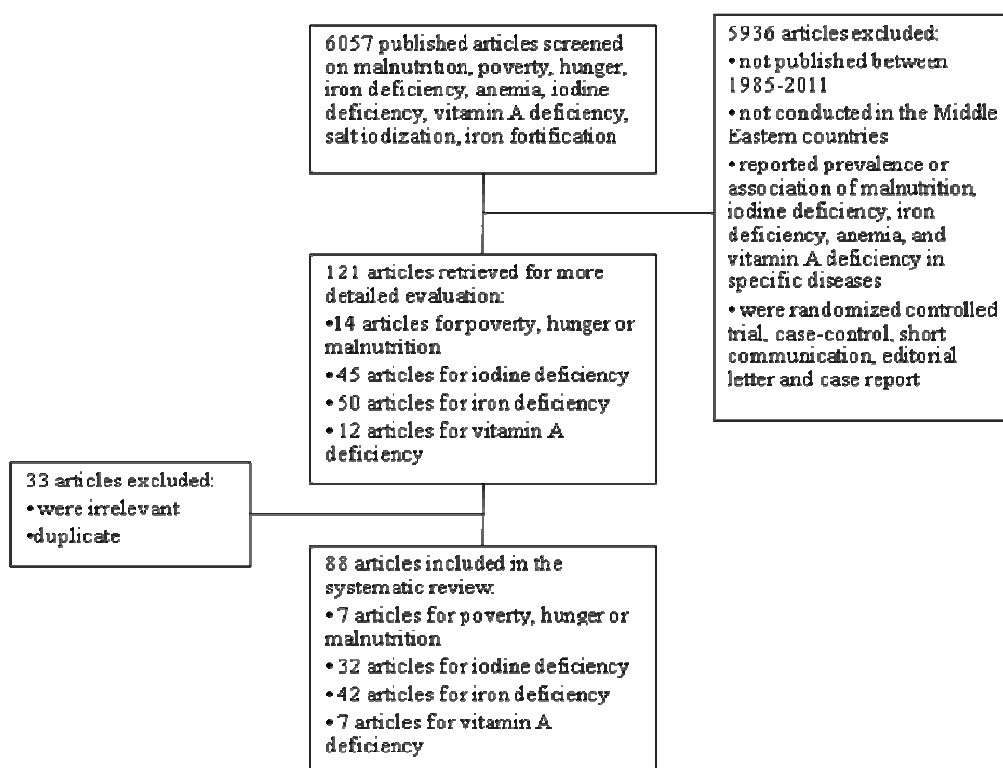


Fig. 1: Flow chart of studies reviewed. Of a total of 6057 articles, 5936 papers were excluded by examining title and abstract. Another 33 articles were excluded after reviewing the whole article and 88 papers left for systematic review. Electronic databases i.e. PubMed, World Health Organization (WHO), FAO, Flour Fortification Initiative (FFI), Micronutrient Initiative (MI), IranMedex and SID were searched using the terms “poverty”, “malnutrition”, “iodine deficiency”, “iron deficiency”, “anemia”, “vitamin A deficiency”, “salt iodization”, “iron fortification” and “hunger”, as well as Persian equivalent terms. Once the search has been completed, a total 6057 papers were screened and were retrieved and assessed for relevance based on title and abstract by one reviewer. We included any cross-sectional, longitudinal or review article in English that reported national or regional prevalence of malnutrition, iodine deficiency, iron deficiency, anemia, and vitamin A deficiency and efficacy of fortification programs.

We excluded studies that reported prevalence or association of malnutrition, iodine deficiency, iron deficiency, anemia, and vitamin A deficiency in specific diseases and all case-control, randomized controlled trial, short communication, editorial letter and case reports.

5936 articles were excluded after the title and abstract assessment. Full text of retrieved articles was evaluated by two reviewers and 33 articles that were irrelevant or duplicate were excluded. Finally, 88 were included in this systematic review (Fig.1).

Results

Iron deficiency anemia

Anemia is a public health problem in the most countries, which affects 2 billion (over 30%) worldwide (8). Anemia defines on the basis of blood hemoglobin concentrations and shows the severity of this public health problem among the population; Nutritional deficiency such as iron, folate and vitamin B12 deficiencies, hook worm, malaria, inflammatory diseases and HIV contribute to its development; however, iron deficiency is the primary cause and is responsible for more than 50% of all cases of anemia (9). According to

WHO, 47% of children under 5 years old, 30% of non-pregnant women and 42% of pregnant women suffer from anemia (10).

Iron deficiency, the most common nutritional disorder worldwide especially among children, pregnant and non-pregnant women, is one of the risk factors for the global burden of disease in 2000, which caused 841,000 deaths and 35,057,000 disability-adjusted life years (DALYs) lost (11). The main causes of iron deficiency are low intake of heme iron, high intake of non-heme iron, high consumption of phytate and phenolic compounds that inhibit iron absorption, increased requirement and heavy blood losses (7, 12).

The prevalence of iron deficiency

Iron deficiency and iron deficiency anemia (IDA) are major public health problems in the Middle Eastern countries (12-14). According to the WHO, the highest number of pre-school children, pregnant and non-pregnant women suffering from IDA live in the Eastern Mediterranean countries includes the Middle East and North Africa (8). The prevalence of IDA among preschool children was 20-67%, among school children was 12.6-50% and among pregnant women was 22.7-54% (14).

In the I.R. Iran the prevalence of iron deficiency and IDA was 31.7% and 19.7-26.2% in 12-15 month old infants, respectively, statistics which are too high (15, 16). Among children 6-60 months, 43.9% were anemic and 29.1% had IDA. The prevalence of IDA was severe in 12-24 month old children (17). 23.7% of female adolescents and 40.9% of young female adults were iron deficient and 12.2% and 3.8% have IDA, respectively (18, 19).

In Turkey, 17.2% of population have iron deficiency; 48% of infants, 21-42% of children and 14.7% of adults (20-22). The prevalence of IDA was 3.1% and 13.5% among children 6-16 years old and pregnant women, respectively (23, 24).

Surveys carried out in Saudi Arabia have reported that iron deficiency was not found among newborns and 3-4 month old infants, whereas the

prevalence of iron deficiency had increased significantly and reached to 14.5% among 12-15 month old infants (25). IDA is, also, prevalent among school students, affecting 16.1% of 7-14 year old children and 40.5% of female adolescents (16-18 years old) (26-28). The prevalence of iron deficiency and IDA were not assessed among pregnant and non-pregnant women.

Among Jordanian infants IDA is a severe public health problem (29), with one survey showing 72% of infants had IDA and 57% were iron deficient. Percentage of anemic infants born to anemic mothers was higher than to healthy mothers (81% vs. 65%) (30, 31). Anemia in pregnancy is a mild- moderate public health, but percentage of pregnant women with IDA has not been assessed (32, 33). However in one study over 50% of young and pregnant women had symptoms of IDA includes dizziness, fatigue, depression, headache and loss of memory and concentration (34). 28.4% of Jordanian children (5.5-10 years old) had iron deficiency (35).

In the United Arab Emirates, Lebanon and Egypt, iron deficiency and IDA are more prevalent among pregnant women and children (36-40). The prevalence of IDA in the Middle Eastern countries is the same as the prevalence in other developing countries (25-35%), much higher than that of industrialized countries (5-8%). However, in the Middle East data on the prevalence of IDA is limited. Most surveys have assessed anemia rather than IDA and the few surveys that have assessed IDA were provincial, not national (19).

Iron deficiency-reduction strategies

Iron deficiency contributes to maternal and child mortality, inadequate gestational weight gain, pre-term delivery, intra-uterine growth retardation,

low birth weight, impaired physical and cognitive development in children, decreased work capacity and productivity in adults and it inhibits economic and social development (8, 13, 32); improvement of iron deficiency status can increase individual productivity and national development as much as 20%. WHO has suggested several guidelines includes dietary diversification, food fortification and iron supplement tables in order to prevent and control iron deficiency and IDA worldwide (41). Iron supplementation is a useful approach for short-term when requirements are increased such as during pregnancy, but dietary diversification and food fortification are important long-term strategies (9, 15). Dietary diversification increases iron bioavailability by more consumption of food with high bioavailability iron such as meat and foods that enhance iron absorption such as citrus fruit and vegetables and low intake of foods that inhibit intestinal iron absorption such as tea, coffee, cola beverages and dairy products. However, if the prevalence of iron deficiency and IDA in children and women is high (IDA>5%), national or regional food fortification programs should be conducted to decrease the prevalence of iron deficiency.

Food fortification strategy with iron in the Middle East

The best food for fortification is cereal flour such as wheat and maize flour (10, 42). Wheat flour fortification with iron is an effective approach to combat iron deficiency, however, the iron compound used and amount of iron added is very important. Table 1 shows suggested iron levels (ppm) for fortification of wheat flour according to the iron compound and daily flour consumption.

Table 1: Recommended iron fortification levels (ppm) for wheat flour according to iron compound and daily flour consumption

Flour consumption (g/d)	Low extraction wheat flour			High extraction wheat flour
	NaFeEDTA (ppm)	Ferrous sulfate or ferrous fumarate (ppm)	Electrolytic iron power (ppm)	NaFeEDTA (ppm)
> 300	15	20	40	15
150-300	20	30	60	20

75-149	40	60	Not recommended	20
< 75	40	60	Not recommended	40

Reference: Hurrell R, Ranum P, de Pee S, Biebinger R, Hulthen L, Johnson Q, Lynch S (2010). Revised recommendations for iron fortification of wheat flour and an evaluation of the expected impact of current national wheat flour fortification programs. *Food Nutr Bull*, 31, S7-21

High levels of these flours are produce and consumed as breads, pasta, noodles and other products globally. Therefore, iron fortification of flour can improve the iron status of large parts of populations. Flour fortification with iron has played an important role in decreasing iron deficiency in countries such as Canada, U.S. and some countries of Europe; however, it has not been effective as in the most Middle Eastern countries. According to WHO, 44% of wheat flour is fortified with iron in the Eastern Mediterranean countries (43). Table 2 shows kind of food and iron levels that implemented for food fortification in the Middle Eastern countries. In Iran, pilot project of flour fortification (with 60 ppm of elemental iron and 1.5 ppm of folic acid) initiated in Bushehr province in 2001 and six years later has become national program is ongoing (44).

Table 2: Kind of food and iron levels that implemented to food fortify in the Middle Eastern countries

Countries	Selected food	Iron levels
Bahrain	Wheat flour	60 ppm
Egypt	Wheat flour	30 ppm
I.R. Iran	Wheat flour	30 ppm
Iraq	Wheat flour	30 ppm
Jordan	Wheat flour	30-40 ppm
Kuwait	Wheat flour	60 ppm
Lebanon	Wheat flour	30 ppm
Oman	Wheat flour	30 ppm
Qatar	Wheat flour	60 ppm
Saudi Arabia	Wheat flour	36.3 ppm
Syria	Wheat flour	30 ppm
Turkey	Wheat flour	40 ppm
United Arab Emirates	Wheat flour	30 ppm
Yemen	Wheat flour	30 ppm
Bahrain	-	No legislation
Egypt	Salt	30-70 ppm
I.R. Iran	Salt	20-40 ppm
Iraq	No data	No data
Jordan	Salt	40-60 ppm
Kuwait	Salt	80 ppm

Lebanon	Salt	15-30 ppm
Oman	Salt	100-135 mg
Qatar	No data	No data
Saudi Arabia	-	No legislation
Syria	Salt	18-30 ppm
Turkey	Salt	50-70 ppm
United A.Emirates	-	No legislation
Yemen	Salt	40 ppm

In other Middle Eastern countries, apart from Turkey, also, national or regional flour fortification program with iron has been conducted; however, it is effective only in five countries including Egypt, I.R. Iran, Jordan, Lebanon and Syria iron fortification program. Other countries apply non-recommended, atomized, reduced or hydrogen-reduced iron powders that have no positive effect on iron status (10). Iron fortification program hence need to be revised via changes in the iron compound use to effectively decrease the high prevalence of iron deficiency and IDA in these countries for fortification and levels of iron added. Moreover, hemoglobin is the last indicator of iron deficiency and do not affect by iron fortification in short- and mid-term, therefore other indicators of iron deficiency such as ferritin should be applied to evaluate the effect of iron fortification programs on iron status (45-47). In addition high consumption of dietary components that inhibit iron absorption such as phytate, or low consumption of iron containing foods such as meat, fortified bread and vitamin A deficiency are important factors that can decrease benefits of flour fortification with iron on iron status and anemia (48). Nevertheless, there is some doubt about the safety of flour fortification with iron that may lead to an iron overload, zinc deficiency or adverse effects in subjects with specific disease or medical conditions. Evaluation results of the flour fortification programs in Busher and Golestan, two provinces of Iran, showed neither adverse effect nor iron overload following fortification of flour with iron

(44). However, a recent study in Semnan, a province in Iran, indicated that flour fortification with iron resulted in reduction of antioxidant capacity and enhancement of oxidative stress biomarkers i.e. superoxide dismutase or glutathione peroxidase activity in non-anemic healthy men. Although in this study no symptoms of iron overload were observed but the authors did not support the safety of flour fortification with iron as a population-based strategy to combat iron deficiency and suggested that all kind of flour in the country should not be fortified (49). However, there is an agreement that every public health intervention has advantages for a majority and may have some disadvantages for a minority (44).

Conclusion

Overall, despite of FAO efforts and WHO guidelines in order to combat iron deficiency, it is a public health problem in the Middle Eastern countries due to ineffective iron fortification program, food interaction and hemoglobin application as anemia indicators in countries with successful iron fortification program. Therefore further investigations are needed to reduce the prevalence of iron deficiency and IDA in populations especially at high risk groups.

Iodine deficiency disorders

Iodine is a micronutrient that plays a role in the synthesis of thyroid hormones, which are fundamental for brain development, growth, and modulation of metabolic rate, thermogenesis and energy (50). Low dietary intake of iodine is the main cause of iodine deficiency (7). Iodine deficiency disorder (IDD), a group of iodine deficiency abnormalities, are a major public health problem worldwide and consist of a spectrum of disorders that range from simple goiter, to hypothyroidism, impaired psychosomatic performance, decreased intelligent quotient and typical cretinism; however, the main consequence of iodine deficiency is impaired development of fetal brain (51), an IDD, which data shows is the most common cause of preventable brain damage in children and which inhibits the social and economic development of

countries (52,53). Urinary iodine concentration and total goiter rate are the recommended indicators for evaluating iodine status and determining the severity of iodine deficiency in a population (7). According to WHO between 1993 to 2003 a total of 54 countries worldwide suffered from iodine deficiency and 3 billion had insufficient iodine intakes, infants, pregnant and lactating women being among those most affected (54).

Iodine deficiency-reduction strategies

Over the past years, WHO/International Council for Control of Iodine Deficiency Disorders (IC-CIDD)/UNICEF to elimination IDD worldwide used universal salt iodization (USI) which caused significant advances in IDD control (52,55). USI, defined as iodization of all salt for human, livestock and agriculture usage, is a cost-effective and enduring method that has been administrated in several countries during the last 60 years (56). However, the latest survey reported that USI trend has decreased during the past decade and 30% of households have no access to iodized salt worldwide (53). There is no legislation for mandatory iodization salt in 30 countries and iodized salt quality and population iodine status are not controlled appropriately in many countries (52). In the most countries of the Middle East iodization of salt is mandatory except for Saudi Arabia and the United Arab Emirates. I.R. Iran, Iraq, Syria, Jordan and Lebanon have the highest household iodized salt usage while Egypt and United Arab Emirates have the lowest (57).

The prevalence of Iodine deficiency and food fortification strategy with Iodine in the Middle East

Table 3 shows kind of food and iodine levels that implemented for food fortification in the Middle Eastern countries. Before implementation of salt iodization the prevalence of total goiter rate in I.R. Iran was reported to be between 10-60% and two years after mandatory iodization of all salt, in 1996, 95% of households consuming iodized salt; however, goiter was endemic (53.8%) and urinary iodine concentration (UIC) was still high in many cities of Iran because of the short duration of io-

dized salt usage. However, in 2001, after 7 years, total goiter rates significantly reduced and UIC improved (58). The last national survey was conducted in 2007 in order to monitor the IDD status and stability of salt iodization program findings showed that 98% of households consumed iodized salt and more than 95% consumed sufficient iodized salt. Total goiter rate had significantly reduced and was estimated to be 5.7% (50). National studies documented major measures had been taken to eliminate iodine deficiency in I.R. Iran which had achieved sustained control program for iodine deficiency (59,60). Studies reported that iodized salt with 40 ppm potassium iodide per kg of sodium chloride had resulted in acceptable iodine status among Iranian infants, pregnant and lactating women and in decrease in IDD prevalence after mandatory iodization of salt (60-64).

In Turkey household salt was iodized with 50-70 mg/kg potassium iodide or 25-40 mg/kg potassium iodine in 1998 to prevent consequences of iodine deficiency, especially goiter (65,66); in 2007, a national study reported 27.8% of Turkish schoolchildren had moderate and severe iodine deficiency, indicating an improvement of iodine status, in comparison to 1997 and 2002 surveys (58% and 38.9%, respectively). This study showed in two thirds of cities survey iodine deficiency has been eliminated, 73.5% of accessible salt were iodized and 56.5% contained sufficient iodine (65). However, iodine deficiency and goiter is still a public health problem in some regions of Turkey, e.g. Isparta, Kayseri and Malatya provinces (67-70). Among pregnant women, also, iodine status is controversial; approximately half the pregnant women are under the WHO/UNICEF/ICCIDD borderline level (UIC = 149.7 vs. 150 µg/L) and 24.8% had goiter; despite 95% of pregnant women using iodized salt, iodine deficiency is a critical problem in this group (71). A recent study reported iodine status as sufficient among adults, 7 years after initiation of mandatory iodization (66).

Despite salt iodization by addition of 30-70 ppm potassium iodide in Egypt, studies have indicated that goiter is endemic and UIC is low still in several regions, which may be due to inadequate iodization of salt or high consumption of goitrogens (72-74). A

recent survey in Egyptian children founded that 91.9% of schoolchildren had abnormal UIC and 25% had clinical goiter. Mild and moderate iodine deficiency was observed among 60.6% and 31.3% of children, respectively indicating iodine deficiency to be a public health problem in some areas of Egypt (75).

In 1991, IDD was recognized as a public health problem in Yemen and a salt iodization program was begun in 1995 to control IDD, a strategy which significantly decreased the prevalence and severity of IDD and total goiter rate. Four years after salt iodization initiation, a survey reported that total goiter rate decreased from 32% to 16.8% among schoolchildren, its prevalence being 31.1% and 7.4% in lowland and mountainous regions, respectively. Of schoolchildren, 4.7% and 2.6% has severe IDD in mountain and lowland regions, respectively; however, 70% had no deficiency. Girls had better iodine status than boys. However, because half of Yemeni households do not consume iodized salt may interfere by IDD elimination program (76,77).

In Kuwaiti adults, iodine intake was adequate according to WHO report, however, 23% of adults had mild and moderate iodine deficiency; UIC<100 µg/L, among pregnant women, also, 56.8% had insufficient iodine intakes (UIC<145 µg/L). In conclusion, results of these two studies suggest the need for a national survey to determine iodine status among the Kuwaiti population (78,79). Surveys carried out among schoolchildren in the other Middle Eastern countries, including Saudi Arabia, Bahrain and United Arab Emirates report that there is a mild and moderate iodine deficiency in the countries mentioned; however, it is a major public health problem only in Saudi Arabia (total goiter rate>5% and UIC<100 µg/L) (54,80,81). National surveys are needed regularly in these countries, especially Saudi Arabia and the United Arab Emirates, as there is no legislation for iodization of salt (57).

Conclusion

Overall, surveys carried out have indicated the important role of iodized salt in the prevention

IDD in the Middle Eastern countries. Iodization of salt is an useful strategy in Iran and status of IDD currently is under control without any side-effect. It is, also, an effective program to improve IDD in the rest of countries of the region and now severity of IDD is mild (except for Iraq and Saudi Arabia). However, it seems that amount of fortification is not enough to eliminate IDD, therefore further investigations are needed to reduce it.

Vitamin A deficiency

Vitamin A is an essential nutrient for growth and differentiation of cells, function of visual, immune and reproduction systems and maintenance of membranes integrity. Poor nutrition, low intake of vitamin A-rich foods and infectious diseases such as diarrhea and measles are the most common cause of vitamin A deficiency (VAD) (7). Infants, young children and pregnant women especially in low-income countries are more susceptible to VAD; it is estimated that 190 million children and 19 million pregnant women worldwide suffer from VAD which leads to night blindness, xerophthalmia, infection, iron deficiency anemia, and mortality in mentioned groups (7,82).

The prevalence of vitamin A deficiency

Vitamin A status and its severity among the population have been evaluated by prevalence of night blindness and retinol concentration in children and pregnant women determination (7). With respect to prevalence of night blindness, VAD is a mild public health problem among preschool children in the all Middle Eastern countries and is a public health problem among pregnant women in Egypt, Iraq, Saudi Arabia, Turkey and Yemen. However, according to the retinol concentration, VAD is mild-to-severe public health problem among preschool children in the most Middle Eastern countries (apart from I.R. Iran) and moderate-to-severe public health problem among pregnant women in the all countries of the Middle East, in 2005 (83). In addition, Egypt, Iraq and Yemen are among countries where vitamin A supplementation is a priority.

Vitamin A deficiency-reduction strategies

VAD is a major cause of mortality in children under five, and improving its status can enhance resistance to related diseases and decrease mortality rate by 23% (84). The main approaches to combat the VAD include vitamin A supplementation, food diversification and food fortification. The administration of high-dose vitamin A supplements is a short-term and cost-effective strategy that can reduce infection morbidity and mortality in deficient subjects especially children. In Egypt, Iraq and Yemen vitamin A supplementation programs have been implemented since 1999, with successful outcomes in Egypt (84,85). The vitamin A supplementation coverage rate (% of children aged 6-59 months) in Egypt was reported at 68% in 2008, 47% in Yemen in 2007 and 0.84 % in Iraq in 2006, by the World Bank (86-88). In contrast, food diversification and food fortification are endurable strategies to fight VAD. Food fortification of basic food items such as sugar, rice, wheat and sodium monoglutamate, have been achieved in some developing countries however it does not conduct as a national or regional program in the Middle Eastern countries (85). Hence the principle strategy for controlling vitamin A deficiency in the Middle East is education of families on vitamin A-rich food selection, coupled with vitamin A supplementation. In addition because breast milk is a good source of vitamin A, encouraging breast feeding is an important strategy to prevent VAD in infants.

Conclusion

Overall, there is mild-to-severe vitamin A deficiency in the Middle Eastern countries, and only Iraq, Egypt and Yemen are among 61 countries with prioritized vitamin A supplementation and poverty-reduction strategies, whereas and in rest of the countries food diversity, vitamin A supplementation and breast feeding are vitamin A-reduction strategies.

Ethical considerations

Ethical issues (Including plagiarism, Informed Consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc) have been completely observed by the authors.

Acknowledgements

Great thanks to the Research Institute for Endocrine Sciences, Shahid Beheshti University of Medical Sciences for the support and providing the facilities for this work. We would like to thank MS N. Shiva for language editing of the manuscript. All authors of the paper have no conflict of interest.

References

1. WHO. *Poverty*. Geneva, World Health Organization, 2011: (<http://www.who.int/topics/poverty/en/>, accessed 10 June 2011).
2. Food and Agriculture Organization of the United Nations and World Food Programme (2010). *The state of food insecurity in the world*. Rome. FAO.
3. Atinmo T, Mirmiran P, Oyewole OE, Belahsen R, Serra-Majem L (2009). Breaking the poverty/malnutrition cycle in Africa and the Middle East. *Nutr Rev*, 67: S40-6.
4. WHO. *Millennium Development Goals*. Geneva, World Health Organization, 2011 (http://www.who.int/topics/millennium_development_goals/about/en/index.html, accessed 25 June 2011).
5. FAO. *Millennium Development Goals*. Rome, Food and Agriculture Organization of the United Nations, 2011: (<http://www.fao.org/mdg/64622/en/>, accessed 26 June 2011).
6. *Global and regional trend estimates for child malnutrition*. Geneva, World Health Organization, 2011 (<http://www.who.int/nut-growthdb/estimates/en/index.html>, accessed 10 June 2011).
7. World Health Organization/ Food and Agriculture Organization (2006). *Guidelines on food fortification with micronutrients*. Geneva. WHO.
8. World Health Organization (2008). *Worldwide prevalence of anemia 1993-2005*. Geneva. WHO.
9. Hurrell R, Ranum P, de Pee S, Biebinger R, Hulthen L, Johnson Q, Lynch S (2010). Revised recommendations for iron fortification of wheat flour and an evaluation of the expected impact of current national wheat flour fortification programs. *Food Nutr Bull*, 31: S7-21.
10. World Health Organization/ United Nations Children's Fund (2004). *Focusing on Anaemia*. Geneva. WHO.
11. Stoltzfus RJ (2003). Iron deficiency: global prevalence and consequences. *Food Nutr Bull*, 24: S99-103.
12. Bagchi K (2004). Iron deficiency anaemia- an old enemy. *East Mediterr Health J*, 10: 754-60.
13. WHO. *Iron deficiency anaemia*. Geneva, World Health Organization, 2011: (http://www.emro.who.int/nutrition/micronutrients_iron.html, accessed 30 June 2011).
14. Musaiger AO (2002). Iron deficiency anaemia among children and pregnant women in the Arab Gulf countries: the need for action. *Nutr Health*, 16: 161-71.
15. Kadivar MR, Yarmohammadi H, Mirahmadizadeh AR, Vakili M, Karimi M (2003). Prevalence of iron deficiency anemia in 6 months to 5 years old children in Fars, Southern Iran. *Med Sci Monit*, 9: CR100-4.
16. Monajemzadeh SM, Zarkesh MR (2009). Iron deficiency anemia in infants aged 12-15 months in Ahwaz, Iran. *Indian J Pathol Microbiol*, 52: 182-4.
17. Keikhaei B, Zandian K, Ghasemi A, Tabibi R (2007). Iron-deficiency anemia among children in southwest Iran. *Food Nutr Bull*, 28: 406-11.
18. Akramipour R, Rezaei M, Rahimi Z (2008). Prevalence of iron deficiency anemia among adolescent schoolgirls from Kermanshah, Western Iran. *Hematology*, 13: 352-5.
19. Shams S, Asheri H, Kianmehr A, Ziaee V, Koochakzadeh L, Monajemzadeh M, Nouri M, Irani H, Gholami N (2010). The prevalence of iron deficiency anaemia in female medical students in Tehran. *Singapore Med J*, 51: 116-9.
20. Manios Y, Moschonis G, Kolotourou M, Keskin Y, Sur H, Kocaoglu B, Hayran O (2007). Iron deficiency prevalence and dietary patterns by school district in Istanbul. *J Hum Nutr Diet*, 20: 549-57.
21. Keskin Y, Moschonis G, Dimitriou M, Sur H, Kocaoglu B, Hayran O, Manios Y (2005). Prevalence of iron deficiency among school-

- children of different socio-economic status in urban Turkey. *Eur J Clin Nutr*, 59: 64-71.
22. Koçak R, Alparslan ZN, Ağrıdağ G, Başlamisli F, Aksungur PD, Koltas S (1995). The frequency of anaemia, iron deficiency, hemoglobin S and beta thalassemia in the south of Turkey. *Eur J Epidemiol*, 11: 181-4.
 23. Koç A, Kösecik M, Vural H, Erel O, Ataş A, Tatli MM (2000). The frequency and etiology of anemia among children 6-16 years of age in the southeast region of Turkey. *Turk J Pediatr*, 42: 91-5.
 24. Karaoglu L, Pehlivan E, Egri M, Deprem C, Gunes G, Genc MF, Temel I (2010). The prevalence of nutritional anemia in pregnancy in an east Anatolian province, Turkey. *BMC Public Health*, 10: 329.
 25. Babiker MA, Bahakim HM, al-Omair AO, al-Jishi N, al-Habib SA (1989). Prevalence of iron deficiency in Saudi children from birth to 15 months of age. *Ann Trop Paediatr*, 9: 111-4.
 26. Abalkhail B, Shawky S (2002). Prevalence of daily breakfast intake, iron deficiency anaemia and awareness of being anaemic among Saudi school students. *Int J Food Sci Nutr*, 53: 519-28.
 27. Al-Quaiz JM (2001). Iron deficiency anemia. A study of risk factors. *Saudi Med J*, 22: 490-6.
 28. al-Othaimen A, Osman AK, al Orf S (1990). Prevalence of nutritional anaemia among primary school girls in Riyadh City, Saudi Arabia. *Int J Food Sci Nutr*, 50: 237-43.
 29. Kilbride J, Baker TG, Parapia LA, Khoury SA, Shuqaidef SW, Jerwood D (1999). Anaemia during pregnancy as a risk factor for iron-deficiency anaemia in infancy: a case-control study in Jordan. *Int J Epidemiol*, 28: 461-8.
 30. Kilbride J, Baker TG, Parapia LA, Khoury SA (2000). Incidence of iron-deficiency anaemia in infants in a prospective study in Jordan. *Eur J Haematol*, 64: 231-6.
 31. Kilbride J, Baker TG, Parapia LA, Khoury SA (2000). Iron status, serum folate and B(12) values in pregnancy and postpartum: report from a study in Jordan. *Ann Saudi Med*, 20: 371-6.
 32. Albsoul-Younes AM, Al-Ramahi RJ, Al-Safi SA (2004). Frequency of anemia in pregnancy in Northern Jordan. *Saudi Med J*, 25: 1525-7.
 33. Jilani I, Qazaq HS, Al-Arabi ZA (1992). *A study on anemia among the pregnant at mother and childhood (MCH) centers in Jordan from the year 1990 and the first half of 1991*. Ministry of Health, Jordan.
 34. Khatib IM, Elmadfa I (2009). High prevalence rates of anemia, vitamin A deficiency and stunting imperil the health status of Bedouin schoolchildren in North Badia, Jordan. *Ann Nutr Metab*, 55: 358-67.
 35. Jarrah SS, Halabi JO, Bond AE, Abegglen J (2007). Iron deficiency anemia (IDA) perceptions and dietary iron intake among young women and pregnant women in Jordan. *J Transcult Nurs*, 18: 19-27.
 36. Hossain MM, Bakir M, Pugh RN, Sheekh-Hussen M, Bin Ishaq SA, Berg DB, Lindblad BS (1995). The prevalence and correlates of anaemia among young children and women of childbearing age in Al Ain, United Arab Emirates. *Ann Trop Paediatr*, 15(3): 227-35.
 37. Muwakkat S, Nuwayhid I, Nabulsi M, al Hajj R, Khoury R, Mikati M, Abboud MR (2008). Iron deficiency in young Lebanese children: association with elevated blood lead levels. *J Pediatr Hematol Oncol*, 30: 382-6.
 38. Alper BS, Kimber R, Reddy AK (2000). Using ferritin levels to determine iron-deficiency anemia in pregnancy. *J Fam Pract*, 49: 829-32.
 39. Barduagni P, Ahmed AS, Curtale F, Raafat M, Mansour E (2004). Anaemia among schoolchildren in Qena Governorate, Upper Egypt. *East Mediterr Health J*, 10: 916-20.
 40. Abubaker WA, Al-Assaf AF, Cleaver VL (1991). Quality assurance and iron deficiency in Egypt. *Int J Qual Health Care*, 11: 163-8.
 41. *Iron deficiency anaemia*. (<http://www.who.int/nutrition/topics/ida/en/index.html>. accessed 30 June 2011).
 42. Tripathi B, Ravi R, Prakash M, Platel K (2011). Sensory acceptability of iron-fortified millet products. *Int J Food Sci Nutr*, 62(6): 651-9.
 43. World Health Organization (2009). *Recommendations on wheat flour and maize flour fortification meeting report: interim consensus statement*. Geneva. WHO.
 44. *Flour fortification in the Islamic Republic of Iran: sustainable route to improved health*. Flour Fortification Initiative and Micronutrient Initiative. (<http://www.sph.emory.edu/wheatflour/Iran.php>, accessed 19 May 2012).
 45. Sadighi J, Sheikholeslam R, Mohammad K, Pouraram H, Abdollahi Z, Samadpour K, Kolahdooz F, Naghavi M (2008). Flour forti-

- fication with iron: a mid-term evaluation. *Public Health*, 122: 313-21.
46. Safavi SM, Aziz Zadeh A, Hosseini MR (2001). A pilot study of flour fortification with Iron Sulfate in a defined population in Isfahan, Iran. *Journal of Research in Medical Sciences*, 5(4): 306-303.
 47. Sadighi J, Mohammad K, Sheikholeslam R, Torabi P, Salehi F, Abdolahi Z, Pouraram H (2010). Flour fortification with iron and folic acid in Bushehr and Golestan provinces, Iran: Program evaluation. *Journal of School of Public Health and Institute of Public Health Researches*, 7(4): 11-24.
 48. Sadighi J, Mohammad K, Sheikholeslam R, Amirkhani MA, Torabi P, Salehi F, Abdolahi Z (2009). Anaemia control: lessons from the flour fortification programme. *Public Health*, 123: 794-9.
 49. Pouraram A, Elmadfa I, Dorosty AR, Abtahi M, Neyestani TR, Sadeghian S (2012). Long-term consequences of iron-fortified flour consumption in nonanemic men. *Ann Nutr Metab*, 60(2): 115-21.
 50. Delshad H, Mehran L, Azizi F (2010). Appropriate iodine nutrition in Iran: 20 years of success. *Acta Med Iran*, 48: 361-6.
 51. Delange F, de Benoist B, Pretell E, Dunn JT (2001). Iodine Deficiency in the World: Where Do we Stand at the Turn of the Century? *Thyroid*, 11: 437-47.
 52. De Benoist B, Delange F (2002). Iodine deficiency: current situation and future prospects. *Sante*, 12: 9-17.
 53. Padilla CD, MAHPS, Fagela-Domingo C (2008). Eliminating Iodine Deficiency: Obstacles and Their Removal. *Ann Acad Med Singapore*, 37: 45-8.
 54. Al-Hosani H, Osman H, Abdel Wareth L, Saade D, Salah M (2003). Prevalence of iodine deficiency disorders in the United Arab Emirates measured by raised TSH levels. *East Mediterr Health J*, 9: 123-30.
 55. Clar C, Wu T, Liu G, Li P (2002). Iodized salt for iodine deficiency disorders. A systematic review. *Endocrinol Metab Clin North Am*, 2002, 31: 681-98.
 56. Shawel D, Hagos S, Lachat CK, Kimanya ME, Kolsteren P (2010). Post-production losses in iodine concentration of salt hamper the control of iodine deficiency disorders: a case study in northern Ethiopia. *J Health Popul Nutr*, 28: 238-44.
 57. Azizi F, Mehran L (2004). Experiences in the prevention, control and elimination of iodine deficiency disorders: a regional perspective. *East Mediterr Health J*, 10: 761-70.
 58. Azizi F, Mehran L, Sheikholeslam R, Ordooghani A, Naghavi M, Hedayati M, Padyab M, Mirmiran P (2008). Sustainability of a well-monitored salt iodization program in Iran: marked reduction in goiter prevalence and eventual normalization of urinary iodine concentrations without alteration in iodine content of salt. *J Endocrinol Invest*, 31: 422-31.
 59. Azizi F, Sheikholeslam R, Hedayati M, Mirmiran P, Malekafzali H, Kimiagar M, Pajouhi M (2005). Sustainable control of iodine deficiency in Iran: beneficial results of the implementation of the mandatory law on salt iodization. *J Endocrinol Invest*, 25: 409-13.
 60. Hashemipour M, Nasri P, Hovsepian S, Hadian R, Heidari K, Attar HM, Amini M, Moohebat L, Sajadi A, Ajami A (2010). Urine and milk iodine concentrations in healthy and congenitally hypothyroid neonates and their mothers. *Endokrynol Pol*, 61: 371-6.
 61. Azizi F, Navai L, Fattahi F (2002). Goiter prevalence, urinary iodine excretion, thyroid function and anti-thyroid function and anti-thyroid antibodies after 12 years of salt iodization in Shahriar, Iran. *Int J Vitam Nutr Res*, 72: 291-5.
 62. Mozaffari Khosravi H, Dehghani A, Afkhami M (2004). Prevalence of endemic Goiter and urinary Iodine in 6-11 year old students in Yazd province: 10 years after salt Iodization program. *Iranian Journal of Endocrinology & Metabolism*, 5(20): 291-283.
 63. Delshad H, Shaikholeslam R, Mirmiran P, Abdolhosseini G, Hedayati M, Azizi F (2002). Goiter survey and urinary Iodine concentration in school children aged 8 to 10 year of Kerman province in 1996. *Journal of Kerman University of Medical Sciences*, 9(1): 6-1.
 64. Seyfhashemi M, Ghorbani R, Alavi MMA (2007). Prevalence of Goiter and its relationship with thyroid function test in primary school children aged 6-12 years in Semnan (2006). *Koomesh, Journal of Semnan University of Medical Sciences*, 9(1): 33-40.

65. Erdoğan MF, Ağbaht K, Altunsu T, Ozbaş S, Yücesan F, Tezel B, Sargin C, İlbeğ I, Artık N, Köse R, Erdoğan G (2009). Current iodine status in Turkey. *J Endocrinol Invest*, 32: 617-22.
66. Ertek S, Cicero A, Çağlar O, Erdogan G (2010). Relationship between serum zinc levels, thyroid hormones and thyroid volume following successful iodine supplementation. *Hormones*, 9: 263-268.
67. Bayram F, Beyazyıldız A, Gökçe C, Budak N, Erdoğan N, Kurtoğlu S, Kula M, Unlühizarci K, Keleştimur F (2009). The prevalence of iodine deficiency, serum thyroglobulin, anti-thyroglobulin and thyroid peroxidase antibody levels in the urban areas of Kayseri, Central Anatolia. *Exp Clin Endocrinol Diabetes*, 117: 64-8.
68. Egri M, Ercan C, Karaoğlu L (2009). Iodine deficiency in pregnant women in eastern Turkey (Malatya Province): 7 years after the introduction of mandatory table salt iodization. *Public Health Nutr*, 12: 849-52.
69. Cetin H, Kisioglu AN, Gursoy A, Bilaloglu E, Ayata A (2006). Iodine deficiency and goiter prevalence in Turkey after mandatory iodization. *J Endocrinol Invest*, 29: 714-8.
70. Budak N, Bayram F, Günay O, Kendirci M, Kurtoğlu S, Oz L (2007). Iodine deficiency: an important and severe public health problem in Kayseri, Central Anatolia. *J Endocrinol Invest*, 30: 920-4.
71. Kut A, Gursoy A, Senbayram S, Bayraktar N, Budakoğlu II, Akgün HS (2010). Iodine intake is still inadequate among pregnant women eight years after mandatory iodination of salt in Turkey. *J Endocrinol Invest*, 33: 461-4.
72. El-Sayed NA, Mahfouz AA, Nofal L, Ismail HM, Gad A, Abu Zeid H (1998). Iodine deficiency disorders among school children in Upper Egypt: an epidemiologic study. *J Trop Pediatr*, 44: 270-4.
73. El-Sayed NA, Ismail HM, Hussein MA and Kamel AA (1995). Assessment of the prevalence of iodine deficiency disorders among primary school children in Cairo. *East Mediterr Health J*, 1: 55-63.
74. Mohamed S, El-Tawila M, Ismail H, Gomaa NF (2010). Evaluation of the level of micronutrients in fortified foods in Alexandria, Egypt. *East Mediterr Health J*, 16: 793-800.
75. El-Mougi FA, Abd-El-Ghaffar S, Fayek NA, Mohammed MS (2004). Urinary iodine and other iodine deficiency indicators in a sample of school-age children in Egypt. *East Mediterr Health J*, 10: 863-70.
76. Zein A, Al-Haithamy S, Obadi Q, Nouredin S (2000). The epidemiology of iodine deficiency disorders (IDD) in Yemen. *Public Health Nutr*, 3: 245-52.
77. Hureibi KA, Abdulmughni YA, Al-Hureibi MA, Al-Hureibi YA, Ghafoor MA (2004). The epidemiology, pathology, and management of goitre in Yemen. *Ann Saudi Med*, 24: 119-23.
78. Al-Yatama FI, Al-Bader MD, Al-Mazidi ZM, Ali A, Al-Omair AS, Al-Jehma NA, Mohammed F (2009). Assessment of urinary iodine excretion among normal Kuwaiti adults. *Biol Trac Elem Res*, 132: 67-74.
79. Al-Yatama FI, Al-Bader MD, Al-Mazidi ZM, Ali A, Al-Omair A, Al-Ajmi NH, Mouneer M, Molla A, Mohammed F (2007). Iodine status among pregnant women in Kuwait. *J Endocrinol Invest*, 30: 914-9.
80. Moosa K, Abdul Wahab AW, Al-Sayyad J, Baig BZ (2001). National study on the prevalence of iodine deficiency disorders among school-children 8-12 years of age in Bahrain. *East Mediterr Health J*, 7: 609-16.
81. Al-Nuaim AR, Al-Mazrou Y, Kamel M, Al-Attas O, Al-Daghari N, Sulimani R (1997). Iodine deficiency in Saudi Arabia. *Ann Saudi Med*, 17: 293-7.
82. WHO. Vitamin A deficiency. Geneva, World Health Organization: (<http://www.who.int/nutrition/topics/vad/en/index.html>, accessed 2 July 2011).
83. World Health Organization (2009). *Global prevalence of vitamin A deficiency in populations at risk 1993-2005*. Geneva. WHO.
84. The United Nations Children's Fund (2007). *Vitamin A supplementation: A decade of progress*. New York. UNICEF.
85. WHO. Vitamin A deficiency. Geneva, World Health Organization: (http://www.emro.who.int/nutrition/micronutrients_via.html, accessed 2 July 2011).
86. Vitamin A supplementation coverage rate (% of children aged 6-59 months) in Egypt. (<http://www.tradingeconomics.com/egypt/vitamin-a-supplementation-coverage-rate-per->

- cent-of-children-ages-6-59-months-wb-data.html, accessed 2 July 2011).
87. Yemen, Rep. Vitamin A supplementation coverage rate. Available: (<http://www.indexmundi.com/facts/yemen/vitamin-a-supplementation-coverage-rate>, accessed 2 July 2011).
88. Iraq, Vitamin A supplementation coverage rate. (<http://www.indexmundi.com/facts/iraq/vitamin-a-supplementation-coverage-rate>, accessed 2 July 2011).