Asia Pac J Clin Nutr 2008;17 (S1):346-348

Review Article

Coexistence of micronutrient malnutrition: implication for nutrition policy and programs in Asia

Pattanee Winichagoon PhD

Institute of Nutrition, Mahidol University, Thailand

Micronutrients (MN) share common metabolic pathways, or work in complementarity. Missing or having too much of one micronutrient may tip the balance, resulting in manifested deficiencies of one or more micronutrients. Coexistence of micronutrient deficiencies have been reported from developing countries. This raises the concern of the commonly implemented single micronutrient supplementation. Efficacy of high dose of multiple micronutrient supplementation has been tested but results are mixed. This may be dependent on which outcomes were measured. It is possible that interaction is more likely with high dose of MN supplementation. Shifting from single to multiple micronutrient supplementation will still encounter the same challenges to program effectiveness. Food-based strategy is a promising public nutrition measure. However, it requires a holistic environment to be effective. More evidence on efficacy and/or effectiveness of food-based interventions is urgently needed, to establish policy and program options to deal with coexistence of multiple micronutrient deficiencies. Interactions among micronutrients are recognized, and should be taken into account for designing appropriate intervention program.

Key Words: dietary assessment, micronutrients, Asian diets

INTRODUCTION

Micronutrients share common metabolic pathways, or work in complementarity. Missing or having too much of one micronutrient (MN) may tip the balance, resulting in manifested deficiencies of one or more micronutrients. Dietary intakes of several countries showed that intakes of several micronutrients tend to be much lower than the recommended dietary allowances. Better understanding on interactions among micronutrients is needed for designing appropriate intervention program. This raises the concern of the commonly implemented single micronutrient intervention. This paper examines the evidence of coexisting of MN deficiencies and its implication for policy and program in Asian region.

COEXISTENCE OF MICRONUTRIENT MALNUTRITION IN ASIA

Deficiencies of micronutrients have been reported from national or large scale surveys in several countries in Asia.[1,2] Most surveys reported prevalence of individual micronutrient deficiencies. Interventions which address micronutrient deficiencies tend to be single, vertical programs, and focus on vulnerable groups for the specified micronutrients. Recent studies reported high prevalence of coexistence of two or more MN deficiencies. Dhijkhuizen, et al found high prevalence and concurrent deficiencies of iron, vitamin A and zinc deficiencies among lactating mothers and their infants.[3] Low plasma retinol (<0.7 μmol/L) increased risk of anemia, iron and zinc deficiencies. Jiang, et al reported 11 MN deficiencies among rural pregnant Nepali women during their first trimester.[4] Only 4% of women had no deficiency, 14.3% had a single MN deficiency, the rest had at least two MN deficiencies, and almost one-fifth (17.7%) had 5 MN deficiencies. Anemia and zinc deficiency was found to be high (33 and 61%, respectively). Folate deficiency was only 12%, despite the high prevalence of deficiencies of B-vitamins. The prevalence also varied by season. Thurlow et al reported concurrent MN deficiencies among school children in rural NE Thailand.[5] 60% of children were at risk of two or more coexisting MN deficiencies, most commonly was suboptimal iodine and zinc. In summary, multiple MN deficiencies are common among Asian countries. The co-occurrence and severity of these MN deficiencies vary depending on age group, physiological state, and seasonality.

MICRONUTRIENT INTERACTIONS

Interaction among MN in the biochemical and physiological pathways have been reported, although exact mechanisms are not all elucidated. The improvement in hemoglobin concentration and reduction of anemia prevalence was shown by vitamin A or multiple micronutrient supplementation.[6] It has been hypothesized that vitamin A may be involved in the synthesis of iron-transporter protein. Hence, iron mobilization from the storage for erythropoesis increases.

Concurrent deficiencies of vitamin A and iodine were reported among Moroccan school children. Increasing

Corresponding Author: Pattanee Winichagoon, Institute of Nutrition, Mahidol University, Salaya, Nakhon Pathom, Thailand
Tel: 66-2-889-2168; Fax: 66-2-441-9344
Email: nupwn@mahidol.ac.th
Manuscript received 9 September 2007. Accepted 3 December 2007.

sever ity of VAD predicted greater thyroid volume and TSH concentration.[7] In the subsequent trial in South Africa, vitamin A supplementation was shown to improve the response to iodized salt among goitrous children. This effect was independent of iodine supplementation.

The interaction between iron and iodine was also shown among school children in Côte d'Ivoire.[8] A large dose of iodine was given to goitrous children with or without anemia for 6 mo. Reduction of thyroid size and TSH, and increased thyroxine and a sharp decline in goiter prevalence was observed among non-anemic children, Iron supplementation given to anemic children decreased the prevalence of goiter.

MULTIPLE MICRONUTRIENT INTERVENTIONS

Given the coexistence of micronutrient malnutrition, the question is whether providing multiple micronutrient interventions will concurrently improve the situation. The other important consideration is what the outcomes of interest are. The main outcomes measured included micronutrient status, anemia, growth, morbidity and cognition, and pregnancy outcomes in case of pregnant women. Key interventions include supplementation, fortification and dietary diversification.

Several efficacy of multiple MN supplementation (at least 2 nutrients) has been tested in small children and pregnant women in developing countries. MN supplements may be in the form of syrup, foodlet, sprinkles.[9-11] In a double-blind randomized study, Thu et al compared effects of daily and weekly multiple MN supplementation on micronutrient status and growth of Vietnamese 6-24 mo infants.[9] At baseline, 45.6% of infants were anemic, 36.3 and 45.6% had low zinc (<10.7 μmol/L) and vitamin A deficiency (serum retinol < 0.7 μmol/L), respectively. Weekly and daily supplementation was comparable in improving MN status. However, only growth of stunted infants increased significantly in both supplemented groups. Iron and zinc supplementation was conducted in four locations in SE Asia (2 sites in Indonesia, Vietnam and Thailand).[10] The combined supplement significantly reduced prevalence of anemia and zinc deficiency, but was less efficacious than when individual nutrients were supplemented. Zinc supplementation appeared to negatively affect iron status, but not vice versa. A meta-analysis of randomized trials examining impacts of multiple micronutrient supplementation against single nutrient, namely, iron and vitamin A, on growth and anemia. Multi-micronutrient interventions improved linear growth, but neither vitamin A nor iron alone did. Iron intervention, however, resulted in reduced anemia prevalence.[11]

Multiple fortification of MN have been developed and tested. Food vehicles commonly used in Asia are staple food, condiments and complementary food.[12,13] MN in the form of a premix or microcapsule can be added to food vehicles. Various technology has been developed to improve bioavailability of MN. Efficacy of some of these fortified foods have also been reported.[12-14]

Despite being a more demanding strategy, dietary diversification remains to be the most sustainable strategy. However, bioavailability of vitamins and minerals in plant-based diets is commonly an issue of concern. Hotz and Gibson used different methods to enhance bioavailability of MN in population consuming plant-based diets.[15] Various methods of food processing were attempted to improve bioavailability of zinc. Combination of thermal and mechanical processing, soaking, fermentation and germination have been successfully used in Malawi. However, for these strategies to be effective, nutrition education and skill training must be integrated. Including small amount of animal source foods have been shown to improve micronutrient intakes.

POLICY AND PROGRAMMATIC CHALLENGES

Despite the coexistence of multiple MN deficiencies, it does not follow automatically that multiple MN interventions would be the strategy of choice. Assessing multiple micronutrient status is further complicated when the clinical deficiencies of micronutrients subside. It is inevitable that biochemical parameters will be needed to identify the problems of multiple MN deficiencies. Evidence showed that the presence of inadequacy of one micronutrient reduces response to intervention of another nutrient. On the other hand, high dose multiple MN supplementation resulted in less impact on certain outcomes (e.g., anemia) than single nutrient.

The interaction between or among micronutrients pose technological challenge in the formulation of the multiple MN, both for supplements or fortified foods. Multiple fortification of common staples or condiments have been developed, and have been studied in recent years. Various delivery forms instead of medicinal tablet include innovations such as sprinkles, foodlet and microcapsule are promising to provide several MN simultaneously. Shifting from single to multiple micronutrient supplementation will still encounter the same challenges to program effectiveness.

Improvement of traditional diets was shown to be feasible, but it lacks proven effectiveness and is context-specific. Nevertheless, lessons from this approach (specifically, traditional/local wisdom, community mobilization and participation, and women's roles) are important. Effectiveness of these strategies is still needed to strengthen the policy advocacy and implementation of program. Integrating several intervention strategies will be more promising and sustainable using food-based approach as a core strategy, to address multiple micronutrient deficiencies in developing countries.

AUTHOR DISCLOSURES

Pattanee Winichagoon, no conflicts of interest.

REFERENCES

1 Barba CVC and Feliciano E. Micronutrient deficiency and its alleviation: The Philippines experience. Asia Pac J Clin Nutr. 2002;11(Suppl):S371-S376.
2 Ministry of Public Health. National nutrition surveys in Thailand, 2003.
3 Dijkhuizen MA, Wieringa FT, West CE, Muherdiyantiningsih and Muhilal. Concurrent micronutrient deficiencies in lactating mothers and their infants in Indonesia. Am J Clin Nutr. 2001;73:786-791.
4 Jiang T, Christian P, Khatry SK, Wu L and West,jr. KP. Micronutrient defiiciencies in early pregnancy are common, concurrent, and vary by season among rural Nepali pregnant women. J Nutr. 2005;136:1106-1112.

5 Thurlow RA, Winichagoon P, Pongcharoen T, Gowachirapant S, Boonpraderm A, Manger MS, Bailey KB, Wasantwisut E and Gibson RS. Risk of zinc, iodine and other micronutrient deficiencies among school children in North East Thailand. Eur J Clin Nutr. 2006;60:623-632.
6 Mejıa LA, Chew F. Hematological effect of supplementing anemic children with vitamin A alone and in combination with iron. Am J Clin Nutr. 1988;48,595-600.
7 Zimmermann MB**,** Rita Wegmüller, Christophe Zeder, Nourredine Chaouki and Toni Torresani. The Effects of Vitamin A Deficiency and Vitamin A Supplementation on Thyroid Function in Goitrous Children. J Clin Endocrinol Metab. 2004;89:5441-5447.
8 Zimmermann MB, Adou P, Torresani T, Zeder C and Hurrell RF. Iron supplementation in goitrous, iron deficient children improves their response to oral iodized oil. Eur J Endocrinol. 2000;142:217-223.
9 Thu BD, Schultink W, Dillon D, Gross R, Leswara ND and Khoi HH. Effect of daily and weekly micronutrient supplementation on micronutrient deficiencies and growth in young Vietnamese children. Am J Clin Nutr. 1999;69:80-86.
10 Wieringa FT, Berger J, Dijkhuizen J, Hidayat A, Ninh NX, Utomo B, Wasantwisut E and Winichagoon P. Combined iron and zinc supplementation in infants improved iron and zinc status, but interactions reduced efficacy in a multicountry trial in southeast Asia J Nutr. 2007;137:466-471.
11 Ramakrishanan U, Nancy A, McCAbe G and Martorell R. Multimicronutrient interventions but inot vitamin A or iron interventions alone improvechild growth: Results of 3 meta-analyses. J Nutr. 2004;134:2592-2602.
12 Zimmermann MB, Wegmuller R, Zeder C, Chaouki N, Biebinger R, Hurrell R and Windhab E. Triple fortification of salt with microcapsules of iodine, iron and vitamin A. Am J Clin Nutr. 2004;80:1283-1290.
13 Chitpan M, Chavasit V, Kongkachuichai R. Development of fortified dried broken rice as a complementary food. Fd Nutr Bull. 2005;26:376-384.
14 Winichagoon P, McKenzie J, Chavasit V, Pongcharoen T, Gorwachirapan S, Boonpraderm A, Manger MS, Bailey KB, Wasantwisut E and Gibson RS. Amulti-micronutrient-fortified seasoning powder enhances the hemoglobin, zinc and iodine status of primary school children in North East Thailand: A randomized controlled trial of efficacy. J Nutr. 2006;136:1617-1623.
15 Hotz C and Gibson RS. Traditional food-processing and preparation practices to enhance the bioavailability of micronutrients in plant-based diets. J Nutr. 2007;137:1097-1100.