Short Communication

Micronutrient deficiencies and anemia among preschool children in rural Vietnam

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The prevalence of trace elements deficiencies, vitamin A deficiency, anemia, and their relationships were investigated in a cross sectional study involving 243 children aged from 12 to 72 months in rural Vietnam. Serum levels of copper, zinc, selenium and magnesium were determined by inductively coupled plasma mass spectrometer and that of retinol by high performance liquid chromatography. Hemoglobin concentration in whole blood was measured by the cyanmethemoglobin method. The prevalence of deficiencies in zinc, selenium, magnesium, and copper was 86.9%, 62.3%, 51.9%, and 1.7%, respectively. On the other hand, 55.6% were anemic and 11.3% had vitamin A deficiency. Deficiency in two or more micronutrient was found in 79.4% of the children. Parameters associated significantly with anemia were selenium deficiency (OR 2.80 95% CI 1.63-4.80, $p = 0.0002$) and serum retinol <1.05 μmol/L (OR 1.83, 95% CI 1.10-3.05, $p = 0.021$). Magnesium deficiency (OR 3.09 95% CI 1.36-7.03) was found to be a risk factor for zinc deficiency and vice versa. The results indicate that micronutrient deficiencies are prevalent among preschool children in Vietnam. In addition, the results also demonstrate a strong relationship between selenium deficiency and anemia. Clearly, sustainable strategies are urgently required to overcome the problems in the country.

Key Words: hemoglobin, trace element, vitamin A, zinc, selenium, magnesium

INTRODUCTION
Micronutrient deficiencies are important nutritional problems and are widespread in many developing countries, including Vietnam.[1,2] Anemia and iron deficiency remain to be major problems among preschool children in developing countries, and their consequences include retarded psychomotor development, impaired cognitive function, and growth retardation.[3,4,5] Vitamin A deficiency is a leading cause of growth failure, depressed immune responses, higher risk of xerophthalmia and blindness, and increased morbidity and mortality.[3] Further more, vitamin A deficiency may contribute to the development of anemia through effects on iron metabolism, hematopoiesis, and increased susceptibility to infection.[3]

   Trace elements are essential nutrients with regulatory, immunologic, and antioxidant functions resulting from their action as essential components or cofactors of enzymes in metabolism.[6,7] More than 25% of enzymes in the human body need to be activated by metal ions to carry out their metabolic functions.[8,9] Zinc is required for the

structure and activity of more than 300 enzymes from various organs in the human body. The importance of zinc is reflected by the numerous functions and activities over which it exerts a regulatory role.[10] Zinc is also needed for nucleic acid metabolism and protein synthesis, cellular differentiation and replication, as well as glucose metabolism and insulin secretion.[10,11] Copper is also a necessary micronutrient and has many important functional roles in the immune system and its response.[12] Evaluating serum copper levels is of great importance in acute and chronic infections.[11] Selenium is a vital trace

element for efficient and effective operation of many functions of the human immune system. It also plays a large role in cell metabolism and cancer prevention. Furthermore, selenium is a component of glutathione peroxidase and can be used as an antioxidant.[13,14] Magnesium is required in a wide variety of fundamental cellular activities that support diverse physiologic systems. Magnesium is involved in more than 300 enzymatic reactions in which food is metabolized and new products are formed.[15] Magnesium also has a cofactor function for the parathyroid hormone and its deficiency may impair the production of the hormone.[16]

The etiology of multiple micronutrient deficiencies is multifactorial; including inadequate intakes, genetic, and infectious diseases may all play a role.[17,18] In developing countries, poor dietary quality is often a major determinant of inadequate micronutrient intakes. Diets of poor quality are primarily plant based, and often contain very small amounts of animal sourced foods. Inadequate intakes of trace elements may also be caused by environmental factors, because their concentrations in plant foods are dependent on soil trace element levels. In Vietnam, micronutrient deficiencies are highly prevalent.[19,20] However, few studies have been conducted to examine the relationships among anemia, vitamin A deficiency, and the status of one or two micronutrients in children in the country.[21-23] In addition, to our knowledge, there is still a dearth of data on these subjects in Vietnam. Therefore, the aim of this study was to investigate the importance of multiple micronutrient deficiencies among preschool children in the northern mountainous regions of Vietnam by examining the prevalence of: zinc, copper, selenium, magnesium and vitamin A deficiencies, as well as anemia, and their interrelationships in children.

MATERIALS AND METHODS
A cross-sectional study was conducted in October 2003 in three rural, poor, and mountainous communes of the Dinh Hoa district, Thai Nguyen Province, located in the northern region of Vietnam and 150 km north of Hanoi. The district has a population of approximately 90,000 with 6,125 children less than 5 years of age (Dec, 2006). A total of 243 boys and girls aged 12 to 72 months were randomly selected from the area by systematic random sampling.[24] Health status of the subjects were examined by physicians. Only those who were free from chronic and acute illness, and congenital abnormalities were included in the study. The study protocol was approved by the Institutional Review Board of the National Institute of Nutrition in Hanoi, Vietnam. Written informed consent was obtained from the parents or guardians of each child in the study. Children with hemoglobin concentration lower than 80 g/L were referred to the local district health centre for treatment following the guidelines from the Vietnamese Ministry of Health.

Body weight was recorded to the nearest 0.1 kg, while children were minimally clothed, with a pediatric scale for children (SECA beam balance, Hamburg, Germany). Length of children <24 months of age and height of children >24 months were measured to the nearest 0.1 cm. *Z*-scores were calculated for the indicators: weight-for-age, height-for-age, and weight-for-height with EPI-INFO

Version 3.3.2 (Centers for Disease Control and Prevention, Atlanta) by using the National Center for Health Statistics data as a reference.[25] Underweight, stunting, and wasting were defined as weight-for-age Z-scores <-2, height-for-age Z-scores <-2, and weight-for-height Z-scores <-2, respectively.

Fasting blood samples were collected between 7am and 11am at the Commune Health Centers. Three mL of venous blood were drawn into sterile none-contaminated polypropylene tubes (Becton Dickinson, Franklin Lakes, NJ, USA); 20 µL of whole blood were immediately mixed in 5mL of Drabkin's solution for assessment of hemoglobin concentration. All tubes were kept in dark cool boxes (0-4°C) and transported to the local Health District Center. Sera were separated from cells by centrifugation at 4000 g for 10 min at 4°C, within 4 hours. Aliquots of sera were stored at –70°C until analysis. For the determination of trace elements, sera were kept on dry ice and brought to the University of Tokushima, Japan.

The hemoglobin concentration was measured within 12h of sampling, via the cyanmethemoglobin method using Sigma diagnostic kits (Sigma). Serum ferritin was analyzed with an enzyme immunoassay using commercial kits (Spectro Ferritin, Ramco Laboratories Inc, Houston, TX). Serum retinol was analyzed by using High Performance Liquid Chromatography (HPLC model LC 10ADvp, Shimadzu, Japan,) according to the method of the International Vitamin A Consultative Group in a darkened room at the National Institute of Nutrition in Hanoi, Vietnam.[26]

Concentrations of trace elements in serum were determined at the University of Tokushima, Japan by using an inductively coupled plasma mass spectrometer (ICP-MS) model 8500, Shimadzu, Tokyo, Japan; according to the method suggested by Hasegawa.[27] Basically, 200µL of serum sample was aliquoted into a teflon tube and covered with a teflon ball. After adding 1.5 mL of concentrated HNO_3 (Wako Pure Chemicals, Japan), the tube was heated on an aluminum-heating block (IWAKI, Asahi Techno Glass, Japan) at 120°C for 5 hours. The sample was further heated until almost all the moisture has evaporated at 200°C, after removing the teflon ball. Finally, the residue was dissolved with 2 mL of 0.1 M HNO_3, which contained 10 ng/mL internal standard elements (Indium, Rhenium, and Thallium). The diluted serum solution was used for analysis in the ICP-MS. The multi standard solutions for the standardization of calibration curves were prepared from the single element standard solutions (1000 µg/mL), purchased from Wako Pure Chemicals (Osaka, Japan). The results were calculated from three runs.

Statistical analyses were carried out using the SPSS software for Windows, version 11.0 (SPSS, Inc, Chicago, Illinois, USA). Data were checked for normality by using a one-sample Kolmogorov-Smirnov test. When data were not normally distributed, statistical analysis was carried out after log transformation. Continuous response variables (anthropometry, hemoglobin concentration, serum ferritin, serum retinol, copper, zinc, selenium, and magnesium), and results were presented as mean ± SD or as geometric means for log-transformed data. Anemia was defined as hemoglobin concentration <110 g/L for children aged 12-60 months, and <115 g/L for children aged

Table 1. Anthropometric and hematological indices of preschool children in the northern mountainous regions of Vietnam

Variable	Boys (n=137)	Girls (n=106)	Total (n=243)
Anthropometry			
Weight-for-age Z-scores[†]	-1.94 ± 0.72	-2.04 ± 0.68	-1.98 ± 0.70
Height-for-age Z-scores	-1.66 ± 1.13	-1.73 ± 1.20	-1.69 ± 1.16
Weight-for-height Z-scores	-1.22 ± 0.79	-1.29 ± 0.77	-1.25 ± 0.78
Underweight, n (%)	65 (47.4)	57 (53.8)	122 (50.2)
Stunting, n (%)	45 (32.8)	43 (40.6)	88 (36.2)
Wasting, n (%)	17 (12.4)	18 (17.0)	35 (14.4)
Blood analysis			
Hemoglobin[†](g/L)	108 ± 10.7	107 ± 11.6	108 ± 11.1
Anemia, n (%)	74 (54.0)	61 (57.5)	135 (55.6)
Serum ferritin[‡,§](µg/L)	45.4 (39.0; 52.9)	53.1 (44.4; 63.4)	48.7 (43.4; 54.6)
Iron deficiency, n (%)	13/131 (9.9)	10/104 (9.6)	23/235 (9.8)
Serum retinol[‡] (µmol/L)	1.02 (0.97; 1.07)	1.02 (0.95; 1.08)	1.02 (0.98; 1.06)
Vitamin A deficiency[¶], n (%)	13 (9.5)	13 (12.3)	26 (10.7)
Serum retinol<1.05 µmol/L	71 (51.8)	55 (51.9)	126 (51.9)
Zinc[‡](µg/L)	514 (495; 533)	515 (494; 537)	514.3 (501; 528.4)
Zinc deficiency[*], n (%)	116[*] (87.2)	90 (86.5)	206 (86.9)
Copper (µg/L)	1073 (1038; 1110)	1059 (1022; 1097)	1067(1041; 1093)
Copper deficiency[**], n (%)	3 (2.2)	1 (1.0)	4 (1.7)
Selenium[†](µg/L)	66.4 ± 18.6	63.9 ± 18.2	65.3 ± 18.4
Selenium deficiency[**], n (%)	83 (61.9)	66 (62.9)	149 (62.3)
Magnesium (mg/L)	18.0 ± 1.8	18.1 ± 1.5	18.0 ± 1.7
Magnesium deficiency[**], n (%)	72 (53.7)	52 (49.5)	124 (51.9)

[†]Mean ± SD; [‡]Geometric mean (95% CI); [§]Iron deficiency: serum ferritin <12 µg/L for children <60 m, <15 µg/L for children ≥60 months; [¶]Vitamin A deficiency: serum retinol < 0.70 µmol/L; [*]Cutoff according to Hotz and Brown (2004); [**]Cutoffs according to Sauberlich (1999)

60-72 months.[28] Severe anemia was defined as hemoglobin concentration <70 g/L. Iron deficiency was defined as serum ferritin concentration below 12 µg/L for children aged 12-60 months, and 15 µg/L for children aged 60-72 months.[28] Vitamin A deficiency was defined as serum retinol level below 0.70 µmol/L.[26] Deficiencies with regard to copper, selenium, magnesium, and zinc were defined when their serum levels were below 750 µg/L,[29] 70 µg/L,[29] 18.0 mg/L,[29] and 650 µg/L,[30] respectively. The following criteria were used to define multiple micronutrient deficiencies: serum copper <750 µg/L;[29] serum selenium <70 µg/L;[29] serum magnesium <18.0 mg/L;[29] serum zinc <650 µg/L;[30] hemoglobin concentration <110 g/L for children aged 12-60 months, and <115 g/L for children aged 60-72 months;[28] and serum retinol <0.70 µmol/L.[26] Logistic regression analyses were used to examine the relationship between anemia, low concentration of serum retinol (<1.05 µmol/L), and trace element deficiencies. Regression coefficients were converted to odds ratios (OR), and the confidence intervals (CI) for the odds ratios were derived from the standard error estimates of the regression coefficients. Differences in variables between groups were examined by using independent-samples t-test. Statistically significant differences were indicated by $p < 0.05$.

RESULTS

A total of 243 preschool children aged from 12 to 72 months, were included in the study. Of these children, 235 children had serum ferritin, and 239 had trace element concentrations measured. The mean age of the 243 children was 41.6 ± 17.9 months, and there were 137 boys and 106 girls. The mean weight-for-age Z-score, height-for-age Z-score, and weight-for-height Z-score were -1.98 ± 0.70, -1.69 ± 1.16, and -1.25 ± 0.78, respectively. The prevalence of children with underweight, stunting, and wasting was 50.2% (122/243), 36.2% (88/243), and 14.4% (35/243), respectively. There was no significant difference in the prevalence of underweight, stunting, and wasting between the boys and girls (Table 1).

The mean hemoglobin concentration in the children was 107.8 ± 11.1g/L, with concentrations in boys (n = 137) and girls (n = 106) being 108 ± 10.7 g/L and 107 ± 11.6 g/L, respectively. From the total study population, 55.6% (135/243) of the children were found to be anemic and none of these children had severe anemia. Geometric mean (CI 95%) concentration of serum ferritin was 48.7 (43.4; 54.6) µg/L. The prevalence of iron deficiency (serum ferritin<12 µg/L for children <60 months, <15 µg/L for children 60-72 months) was 9.8% (Table 1). The geometric mean serum retinol concentration in the study subjects was 1.02 µmol/L, and the overall prevalence of vitamin A deficiency was 11.3% (26/243). The prevalence of vitamin A deficiency did not differ significantly with regard to underweight, stunting, and wasting. On the other hand, a large proportion of the children (41.2%) had serum retinol in the range of 0.70 to 1.04 µmol/L, thus just above the cut-off level for vitamin A deficiency (Table 1).

The serum levels of trace elements among preschool children are shown in Table 1. The mean ± SD, or geometric mean (95% CI) concentration of zinc, copper, selenium, and magnesium were 514 (501; 528) µg/L, 1067 (1041; 1093) µg/L, 65.3 ± 18.4 µg/L, and 18.0 ± 1.7 mg/L, respectively. There was no significant difference in serum concentration of trace elements with regard to

underweight, stunting, and wasting. The prevalence of zinc deficiency, selenium deficiency, and magnesium deficiency was 86.9%, 62.3%, and 51.9%, respectively, whereas four children (1.7%) had copper deficiency.

Figure 1 shows the prevalence of multiple micronutrient deficiencies. In this study 79.4% (n = 193) of the preschool children had two or more coexisting micronutrient deficiencies. Furthermore, 17.3% (n = 42) of the children had co-existing deficiencies with four micronutrients and 5.3% (n = 13) had co-existing deficiencies with five micronutrients. A combination of anemia and zinc deficiency occurred in 45.7% (n = 111) of the subjects, 39.9% (n = 97) had anemia and selenium deficiency and 30.0% (n = 73) had anemia and magnesium deficiency. Further more, 32.5% (n = 79) of these children had anemia and low serum retinol levels (<1.05 μmol/L). The logistic regression was conducted in order to examine the risk factors associated with anemia and deficiency in micronutrients (Table 2). Selenium deficiency (OR 2.80 95% CI 1.63-4.80) and the lower concentration of serum retinol (OR 1.83, 95% CI 1.10-3.05) were significantly associated with an increased risk of anemia, and vice versa. Magnesium deficiency (OR 3.09 95% CI 1.36-7.03) was also significantly associated with zinc deficiency, and vice versa.

DISCUSSION

The present study demonstrated that micronutrient deficiencies were found to be very common among preschool children living in the northern mountainous regions of Vietnam. Our findings showed that the prevalence of anemia is extremely high; occurring in about 55% of the study population, indicating that anemia remains a major public health problem for children living in the rural areas of the country. It is of interest that little of the observed anemia reported here appeared to be associated with storage iron depletion (Table 1). In fact, a few (15.5%) of the anemic subjects, noted in the present study, was associated with iron deficiency. This finding was unexpected in light of the assumed role of nutritional iron deficiency in the etiology of anemia but was nevertheless consistent with previous reports from Thai children.[31,32]

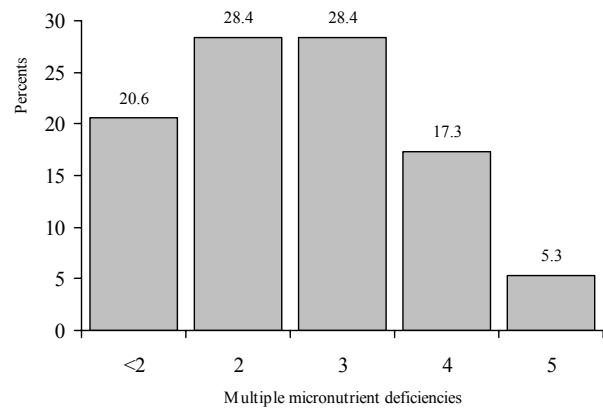Traditionally, the prevalence of anemia has been used to estimate the prevalence of iron deficiency and iron de-

Figure 1. Prevalence of multiple micronutrient deficiencies among preschool children in Vietnam

ficiency anemia. However, the cause of anemia is multifactorial,[28] and our results show that hemoglobin concentration alone is not a reliable variable to estimate the prevalence of iron deficiency anemia in the children. Anemia can be caused by malaria, intestinal parasitic infections, general inflammatory disorders, or nutritional deficiencies of folate and vitamin B12.[28] Malaria no longer exits, but parasitic infections are common in northern Vietnam. Although we did not assess the prevalence of intestinal parasites in the present study, a prevalence value as high as 88% and a high prevalence of hookworm infection (52%) have been reported from northern Vietnam,[33] which may indicate the role of intestinal parasites in the etiology of anemia. Furthermore, chronic inflammatory reactions due to various chronic infections could have played a role in the etiology of anemia, although we did not measure the markers of inflammation, such as C reactive protein, which might have helped in understanding the phenomenon. In this context, future studies should target the issue from various angles to fully understand the causes of anemia among children and other populations in Vietnam.

Two nutritional factors are related to anemia among preschool children in the northern mountainous regions of Vietnam. Serum retinol is positively associated with hemoglobin levels in this study. This finding is in agreement with our previous result[34] and the results from other

Table 2. Risk factors for suboptimal levels of biochemical indices of micronutrient status

Dependent variable	Independent variables	OR	95% CI	*p*-value
Anemia[†]	Serum retinol <1.05 μmol/L	1.83	1.10-3.05	0.021
	Selenium deficiency[‡]	2.80	1.63-4.80	0.0002
	Age (per year)	0.77	0.64-0.92	0.04
	Sex, stunting			NS
Serum retinol <1.05 μmol/L	Anemia	1.83	1.10-3.05	0.021
	Sex, age (per year), stunting			NS
Zinc deficiency[§]	Magnesium deficiency[‡]	3.09	1.36-7.03	0.007
	Sex, age (per year), stunting			NS
Selenium deficiency[‡]	Anemia	2.80	1.63-4.80	0.0002
	Sex, age (per year), stunting			NS
Magnesium deficiency	Zinc deficiency	3.09	1.36-7.03	0.007
	Age (per year)	0.79	0.66-0.94	0.009
	Sex, stunting			NS

[†]Hemoglobin <110 g/L (children 12-<60 months); hemoglobin <115 g/L (children 60-72 months); [‡]Cutoffs according to Sauberlich (1999); [§]Cutoff according to Hotz (2004); NS: not significant

studies.[3,35,36] Vitamin A deficiency definitely impairs hemoglobin synthesis.[37] This was most clearly demonstrated in controlled clinical trials involving anemic adults who were depleted of vitamin A and were responsive to supplementation of the vitamin.[37] In fact, it has been reported that vitamin A supplementation improved hemoglobin response to iron supplements in Malawian infants,[38] Tanzanian school children,[39] and Indonesian pregnant women.[40,41]

To our knowledge, this is the first study to shows a strong association between selenium deficiency and anemia in children. Selenium is contained in glutathione peroxidase, an enzyme that plays a major role in the protection against free radicals and oxidative stress.[42] A possible biological mechanism by which selenium deficiency could cause anemia is through upregulation of heme oxygenase-1, which catalyzes the initial step of heme metabolism and reduces heme to biliverdin, carbon monoxide, and free divalent iron. Heme oxygenase-1 has anti-inflammatory properties and may cause a chronic inflammatory syndrome. In addition, Heme oxygenase-1 releases Fe^{2+} from the core of the heme molecule, leading to the rapid expression of the iron-sequestering protein ferritin, as well as an ATPase pump that actively removes intracellular iron from the cell.[43,44] It has also been shown that selenium deficiency causes anemia among animals and this has been associated with a hemolytic anemia.[45] Maintenance of an optimal concentration of glutathione peroxidase in erythrocytes was shown to protect hemoglobin against oxidation in erythrocytes, in animal studies.[46] This suggests that increased oxidative stress could be another mechanism by which selenium deficiency could contribute to anemia.[46] However; further studies are required to emphasize and elaborate the association between selenium deficiency and anemia among children and other population.

The total prevalence of vitamin A deficiency was 10.7% in the study population. In addition, our study showed that 41.2% of the children had concentrations indicative of marginal vitamin A status (0.70 - 1.04 μmol/L) and, thus, they are very vulnerable to deficiency. This indicates that vitamin A deficiency is still a public health problem in school-age children in Vietnam. Vitamin A capsule distribution programs are the main strategy for reducing vitamin A deficiency in many developing countries. Annually Vietnamese children receive high dose vitamin A capsules through two distribution campaigns throughout the effective network of existing preventive health infrastructure at all administrative levels with a coverage rate of 70 – 90% at national level. Low consumption of vitamin A-rich food has been reported in several studies in Vietnam.[19,47] It is suggested that the strategy for reducing the prevalence of vitamin A deficiency and improving vitamin A status of preschool children in Vietnam should be based on vitamin A capsule distribution programs, dietary improvement through promotion of food production and consumption at the family level and the development of nutrition educational activities for the community.

In the present study, 86.9% of the study subjects were deficient in zinc, indicating that storage of zinc was severely lower than normal, although information on expected prevalence of zinc deficiency in high risk populations is still limited in Vietnam.[48] However, this prevalence is extremely high in comparison to the 20% prevalence set by the International Zinc Nutrition Consultative Group as an indicator for the need of a national intervention program.[30] By comparison, in a study conducted in 2002-2003 among Thai school children aged 6-13 years, 57% had zinc deficiency,[23] based on the same collection and cutoff values.[30] Like zinc, selenium and magnesium levels were also very low among children. Therefore the prevalence of selenium and magnesium deficiency (62.3% and 51.9%) was extremely high in the subjects. It appears that more work is required to define acceptable requirements for selenium and magnesium intakes, the prevalence of their deficiencies, and their public health significance.

Assessing the prevalence of multiple micronutrient deficiency is also important. It is of concern that, according to this study, about 80% of the Vietnamese preschool children suffered from two or more coexisting micronutrient deficiencies. Micronutrient deficiencies often coexist and the interactions between micronutrients are also important, not only at the site of absorption, such as for zinc and iron, but also in functional terms. To our knowledge, there are very few studies on the concentrations of serum trace elements in children.[22,23,31] This is the first study to demonstrate the distribution of copper, zinc, selenium, and magnesium among preschool children in Vietnam. The results showed that zinc, selenium, and magnesium status were extremely low in the study population. Our study was in line with the study in Thailand[23] where about two-third of the Thai school children were also at risk of two or more coexisting micronutrient deficiencies. Thus, we suppose that multiple deficiencies are widespread. Also, these findings explain why some interventions based on single micronutrients have had limited success in developing countries.[49,50] In this context, this is of interest to note that the etiology for some disorders, such as anemia or vitamin A deficiency, are not specific to the deficiency of a single micronutrient. Therefore, strategies for the prevention and control of micronutrient deficiencies, for improving public health nutrition, should be carried out with varying methods for comprehensive achievement.

A limitation of the present study is that no information on dietary intakes and socio- economic status is available. Such data may provide useful information to explain the situation of vitamin A deficiency, anemia, and trace element status in the population studied.

In conclusion, this study shows that micronutrient deficiencies is a severe public health problem among preschool children in Vietnam. The findings highlight that 79.4% of these children suffered from at least two micronutrient deficiencies. It is suggested that strategies such as micronutrient supplementation, promotion of food production and consumption together with nutrition educational activities might help in reducing multiple micronutrient deficiencies in the country.

AUTHOR DISCLOSURES

Nguyen Van Nhien, Nguyen Cong Khan, Nguyen Xuan Ninh, Phan Van Huan, Le Thi Hop, Nguyen Thi Lam, Fusao Ota, Tomoki Yabutani, Vu Quynh Hoa, Junko Motonaka, Takeshi Nishikawa and Yutaka Nakaya, no conflicts of interest.

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Short Communication

Micronutrient deficiencies and anemia among pre-school children in rural Vietnam

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越南鄉村學齡前兒童微量營養素缺乏和貧血狀況

一橫斷性研究，調查 243 位 12-72 個月(一歲到六歲)的越南鄉村兒童的微量元素、維生素A的缺乏盛行率，及其與貧血間的相關。血清中銅、鋅、硒及鎂的濃度是用感應耦合電漿質譜儀測量，維生素A是用高效液相層析儀(HPLC)，而全血中血紅素濃度則是以氰變性血紅素方法分析。這群兒童的鋅、硒、鎂及銅缺乏盛行率分別為 86.9%、62.3%、51.9%及 1.7%。另一方面，55.6%兒童有貧血及 11.3%有維生素 A 缺乏的情形。79.4%的兒童缺乏 2 個或以上的微量營養素。與貧血有顯著相關的參數為硒 (OR 2.80 95% CI 1.63-4.80, *p* = 0.0002) 和血中維生素 A <1.05 µmol/L (OR 1.83, 95% CI 1.10-3.05, *p* = 0.021)。鎂缺乏是鋅缺乏的危險因子(OR 3.09 95% CI 1.36-7.03)；反之亦然。結果指出微量營養素缺乏普遍存在越南學齡前兒童中。另外，結果也顯示硒缺乏與貧血有極大相關。顯然，這國家迫切需要重要的策略來克服這些問題。

關鍵字：血紅素、微量元素、維生素A、硒、鎂。