Available online: http://journal.ipb.ac.id/index.php/jgizipangan **J. Gizi Pangan, March 2018, 13(1):17-26**
Accredited based on DGHE, Republic of Indonesia No.12/M/Kp/II/2015 *DOI: 10.25182/jgp.2018.13.1.17-26*
ISSN 1978-1059 EISSN 2407-0920

The Application of Probability Method to Estimate Micronutrient Deficiencies Prevalence of Indonesian Adults

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ABSTRACT

The objective of this study was to analyze micronutrient deficiencies (Ca, Fe, Zn, Vitamin A and C) of Indonesian adults using probability method (PBM) and cut-off point method (CPM). This research was conducted by analyzing secondary data from Total Diet Study of the Ministry of Health of Indonesia, obtained from 24-h food recall method. The subjects were 58, 014 adults aged 19-49 years. The nutrient requirement from Institute of Medicine were used as benchmark. Both PBM and CPM were applied to assess micronutrient deficiencies. The results showed that by applying PBM, the prevalence of calcium, iron, zinc, vitamin A and C deficiencies was 54.2%, 36.4%, 74.3%, 44.8% and 71.4% respectively; while the prevalence of calcium, iron, zinc, vitamin A and C deficiencies using CPM-100 was 63.9%, 42.5%, 80.7%, 55.8% and 81.7% respectively. PBM result showed more men than women were categorized as suffering from Zn, Vitamin A and C deficiencies; and more women were categorized as Ca and Fe deficiencies. The application of CPM-100 tended to result in overestimation compared to PBM. The nutrient densities of Ca, Fe, Zn, Vitamin A and C were higher in women than in men ($p < 0.05$). The nutrient densities of Ca, Zn, vitamin A and C were below the recommended level for both men and women. This implies micronutrient deficiencies are prevalent among Indonesian adults thus there is a need to improve the quality of their diet. This can be achieved by increasing the consumption of protein source foods (fish, meat and legume), fruits and vegetables as sources of micronutrients.

Keywords: cut-off point method, micronutrient deficiency, nutrient density, probability method

INTRODUCTION

Micronutrients are required by the body in small amount, but their existences is essential for metabolism, maintaining physiological functions of the body and achieving optimal health (Alpers *et al.* 2008). The consequences of micronutrient deficiencies, espescially iron, zinc, calcium, and vitamin A, among others, are an increased risk of infectious diseases, decreased intelligence, decreased work productivity, as well as increased risk in maternal and child mortality (Darnton-Hill *et al.* 2005; Leyshon *et al.* 2016). Furthermore, micronutrient deficiencies also affect global health status and posed a high-economic cost (Darnton-Hill *et al.* 2005).

Iron, vitamin A and zinc deficiencies are the most prevalent among adult women, especially pregnant women. The prevalence of anemia, which predominantly caused by iron deficiency, among Indonesian adults in 2013 was 18.4 – 20.1% and among pregnant women was 37.1% (Ministry of Health 2013). Iron deficiency may also related to vitamin A and zinc deficiencies (Alpers *et al.* 2008).

Iron, zinc and calcium have important roles in the body's metabolism. Zinc deficiency causes growth retardation, low birth weight, decreased immunity, congenital defects (Herman 2009; Wang *et al.* 2015) and increase the risk for atherosclerosis incidence (Jung *et al.* 2013). Calcium deficiency increases the incidence of osteoporosis and accelerates the incidence of menopause, increases the incidence of cardiovascular diseases and increases the risk of colorectal cancer (Theobald 2005; Huang *et al.* 2014; Wang *et al.* 2014, Anderson *et al.* 2016).

While, vitamin A deficiency (VAD) causes xerophtalmia, immune function and cell differentiation impairment thus increases total morbidity (WHO 2009; Bailey *et al.* 2015; Elvandari *et al.* 2017). VAD also increases the risk of growth impairment in infants (Pusparini *et al.* 2016) and the risk of bladder, breast and lung cancers (Fulan *et al.* 2011; Tang *et al.* 2014; Yu *et al.* 2015). WHO data (2009) shows that the prevalence of VAD in

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pregnant women in Indonesia was 17.1% which is categorized as “moderate public health problem”.

Micronutrient defficiency never stands alone, deficiency of one micronutrient is usually accompanied by deficiency of other micronutrients (Bailey *et al.* 2015). A study in Bogor among pre pregnant, pregnant and lactating women shows that micronutrient deficiency occurred concordantly. The prevalence of calcium, iron, zinc, vitamin C and vitamin A deficiency among pre pregnant women in this study was 68.0%, 63.0%, 30.0%, 88.0% and 62.5% respectively (Madanijah *et al.* 2013). The long-term consequences of micronutrient deficiencies are not only found at the individual level, but also in wider context of economic development and human resources within a country (Bailey *et al.* 2015). Therefore, an accurate figure regarding the magnitude of micronutrient deficiency is required as a basis for problem solving.

The prevalence of micronutrient deficiencies can be calculated using two methods; i.e. probability method (PBM) and cut-off point method (CPM). The CPM utilizes a fixed value to determine wheter a subject has inadequate nutrient intake. This method is simpler, thereby it is often used for determining nutritional adequacy level. However, it has a weakness which may causes misclassification of individuals with inadequate nutrient intake category (Jensen *et al*. 1992). To avoid the misclasification, Jensen *et al.* (1992) proposed the PBM to estimate the prevalence of nutrient deficiency. Various studies have concluded that using PBM is better than CPM in determining prevalence of nutrient deficiencies (Anderson & Peterson 1982; Jensen *et al.* 1992; Carriquiry 1999; Murphy & Poos 2002; Lauzon *et al.* 2004).

Up till now, no study has been done to assess micronuteients defficiency in Indonesia using the PBM applied for the national food consumption data. Therefore this study aimed to determine the prevalence of micronutrient deficiencies in Indonesian adults using both PBM and CPM.

METHODS

Design, location, and time

This study utilized secondary data obtained from the Individual Food Consumption Survey (IFCS) that was a part of the Total Diet Survey (TDS) in 2014. The data was in electronic file form. IFCS was conducted by National Institute of Health Research and Development (NIHRD), Ministry of Health of Republic of Indonesia. It was the latest nation-wide survey for collecting individual consumption data in Indonesia. This was a cross-sectional study that covered 191,524 individuals in 51,127 households and spread over 2,080 census blocks across provinces and regencies/cities in Indonesia. Processing, analysis and interpretation of the data were performed from October to December 2017 in the Department of Community Nutrition, Faculty of Human Ecology, Bogor Agricultural University.

Data collection

Total samples of subjects aged 19-49 years of IFCS were 66,651. The inclusion criteria for the present study were adult subjects aged 19-49 years who were in healthy condition and having normal daily consumption (not fasting, not on any diet, not sick, etc.); while exclusion criterion were pregnancy and incomplete data. After applying inclusion and exclusion criteria, total subjects of this study were 58,014 adult, consist of 26,268 men and 31,746 women from all provinces of Indonesia. The data used for this study and method for the data collection are as listed in Table 1.

Data analysis

After data were cleaned, data then processed using 2013 Microsoft Excel and analyzed using SPSS version 21. Nutrient intake were analyzed based on Indonesian food composition tables, Singaporean and USDA food composition tables. The calculation of micronutrient adequacy level was obtained from the ratio of intake and requirement of each nutrient (calcium - Ca, iron - Fe, zinc - Zn, vitamin A – Vit A and vitamin C – Vit C), according to individual nutritional requirement rate that modified from IOM with the assumption of normal body weight of American adults was 71 Kg for men and 59 for women (IOM 2005). The modification of IOM requirement for the PBM was made based on body weight of each subject; while for the CPM modification was made based on the normal body weight of Indonesian adults as suggested in the RDA for Indonesian. The nutrient requirement value used for this study were as follow (Table 2).

The density of nutrient intake was used to describe nutrient quality from individual food intake as well as the nutrient adequacy level. The density of micronutrient intake is defined as the ratio of each nutrient intake in 1,000 kcal of energy (Drewnowski 2005). Calculation of micronutrient density was performed using the following formula (Drewnowski 2005; Jayati *et al.* 2014; Ekaningrum *et al.* 2017) :

$$\text{Micronutrient density} = \frac{\text{Nutrient intake} - i}{\text{Energy intake}} \times 1000$$

i = Ca, Fe, Zn vitamin A and C

The micronutrient density, was then classified into two categories; i.e. inadequate and adequate based on FAO standard (Table 3). The use of probability method in the assessment of nutritional adequacy levels was introduced by Beaton in 1972. A study using the same method was also developed later by Anderson in 1982. The emergence of this new method then also became a consideration for USDA to evaluate nutritional adequacy based on food consumption survey. National Academy of Sciences, published the book "Nutrient Adequacy: Assessment Using Food Consumption Surveys", in which stated the two methods (i.e. probability and cut-off point methods) to determine nutritional adequacy level (National Academy of Sciences 1986).

The prevalence of micronutrient deficiencies was determine by using PBM through analyzing the percentage of subject whose intake are less than their requirements. This method requires distribution of requirement and distribution of nutrient intake of the subjects (Jensen et al. 1992; Gibson 2005). For this study, the intake distribution were obtained from micronutrient intake data derived from IFCS analysis; while the requirement distribution were obtained from the IOM requirement, which was modified based on body weight for each subject.

Table 1. Variables and categories in the study

Variable	Variable categories	Data source
Body weight	According to subject's weight	2014 IFCS
Food sources of micronutrients	According to the type of foods consumed by the subjects	2014 IFCS
Micronutrient intakes	Intake of micronutrients (Ca, Fe, Zn vitamin A and C)	
Adequacy level of micronutrients	According to age and sex categories	
Micronutrient density (Ca, Fe, Zn vitamin C and A)	Adequate and inadequate	
Prevalence of micronutrient deficiencies	Probability method 1. Deficient 2. Not deficient CPM 100 1 ≥100% adequacy: not deficient 2. <100% adequacy: deficient CPM-85 1. ≥85% adequacy: not deficient 2. <85% adequacy: deficient CPM-70 1. ≥70% adequacy: not deficient 2. <70% adequacy: deficient	

Table 2. Requirement of nutrients used for this study

Sex-age group	Body weight*	Ca (mg)	Fe (mg)	Zn (mg)	Vit A (ug)	Vit C (mg)
Men (years)						
19-29	60	676.1	9.1	7.9	528.2	63.4
30-49	62	698.6	9.4	8.2	545.8	65.5
Women (years)						
19-29	54	732.2	12.9	6.2	457.6	54.9
30-49	55	745.8	13.1	6.3	466.1	55.9

Source : *Modified from IOM (IOM 2000, 2001, 2005, 2011) based on normal body weight for Indonesian adult (Ministry of Health 2013)

Table 3. Standard of nutrient intake density

Components	Density
Ca	500-800 mg
Fe	7-40 mg
Zn	12-20 mg
Vit A	700-1,000 µg
Vit C	50-60 mg

Source: Drewnowski (2005)

Determination of nutrient deficiency using probability method was conducted in several stages based on Jensen *et al.* (1992). First, individual micronutrient intakes were calculated from 2014 IFCS data. Then individual nutrient requirement were calculated as a basis for requirement level for each individual. The value of this nutrient requirement is ddifferent for each individual according to age, sex and body weight. Mean individual intake and nutritional requirement were calculated based on the previous data calculation. The calculation was also performed to determine the standard deviation of intake and requirement data in each age group and sex.

The data regarding correlation between intake and requirement in each age group and sex were also required in this probability method. After the data concerning mean, standard deviation and correlation between intake and requirement were known, the next step was to determine Z0 value of the data. This step was followed by calculation of the probability of deficiency in each age category. Statistically, the calculation of micronutrient deficiencies can be explained using the following notation (Jensen *et al.* 1992).

$$\binom{I}{R} \sim N\left[\binom{\mu_I}{\mu_R}.\begin{pmatrix}\sigma_I^2 & \rho\sigma I\sigma R\\ \rho\sigma I\sigma R & \sigma_R^2\end{pmatrix}\right]$$

$$P\,(I<R) = P\,(I-R) = P\,((I-R)<0)$$

$$I-R \sim N\,[\mu_I - \mu_{R},\ \sigma_I^2 - 2\,\rho\sigma_I\sigma_R + \sigma_R^2]$$

$$P\,(I-R<0) = P\,\frac{(I-R)-(\mu I-\mu R)}{\sqrt{\sigma I^2 - 2\,\rho\sigma I + \sigma R^2}} < \frac{0-(\mu I-\mu R)}{\sqrt{\sigma I^2 - 2\,\rho\sigma I\sigma R + \sigma R^2}}$$

$$P\,(Z < Z_0)$$

$$Z_0 = \frac{0-(\mu I-\mu R)}{\sqrt{\sigma I^2 - 2\,\rho\sigma I\sigma R + \sigma R^2}} = \frac{(\mu I-\mu R)}{\sqrt{\sigma I^2 - 2\,\rho\sigma I\sigma R + \sigma R^2}}$$

Notes:

I : Intake

R : Requirement

ρ : Correlation between intake and requirement

σI : Standard deviation of intake

σI : Standard deviation of requirement

In order to compare the prevalence of micronutrient deficiency from PBM and CPM, the cut off points for identifying micronutrient deficiency using CPM were categorized into three levels i.e 100% of adequacy (CPM-100), 85% of adequacy (CPM-85), and 70% of adequacy (CPM-70).

RESULTS AND DISCUSSION

Food source of micronutrients

The present study identified and ranked twenty foods as major sources of each of the micronutrient analyzed namely, Ca, Fe, Zn, Vit A and C as shown in Table 4. The five largest food contributors for calcium intake were rice, tofu, mixed-soybean tempeh, pure-soybean tempeh, and unsalted anchovy. Rice, spinach, tofu, chicken eggs, and pure-soybean tempeh were the five largest contributors for iron intake. Rice, mackerel tuna, soybean tempeh, chicken meat, and wheat flour were the five foods contributed greatly to zinc. Vitamin A was obtained largely from chicken eggs, palm oil, carrots, water spinach, and chicken. Cassava leaves, long bean, tomatoes, cassava, and papaya contributed greatly to vitamin C intake.

Rice was one of the food with the greatest contribution to calcium, iron and zinc intakes with mean intakes of 324.3 mg, 4.0 mg and 1.1 mg, respectively and the percentage of contribution was 47.9%, 27.4% and 22.3%, respectively (Table 4). Rice was the food with the highest intake and consumed by most of the subject. In this study, 97.4% subject consumed rice, the mean intake was 220.6 ± 114.3 g/cap/day. These results were in line with other studies in which carbohydrate sources was dominated by rice (Apriani & Baliwati 2011; Anwar & Hardinsyah 2014). These results were also in line with the study indicating that the participation level of rice consumption was close to 100% (Mauludyani *et al.* 2008). However, the bioavailability of calcium, iron and zinc in rice or cereal is lower compared to animal based foods such as meat (Lim *et al.* 2013).

Cassava leaves contributed the largest to vitamin C intake, with mean intake of 6.9 mg and the percentage of contribution of 18.9%. Cassava leaves is commonly consumed as vegetable by Indonesian (Fasuyi 2005); and Indonesia was the third largest cassava producers in the world (Morgan & Choct 2016). The food that contributed the most to vitamin A intake was chicken eggs with mean intake of 169.3 µg and percentage of

Table 4. Mean and percentage of nutrient intake contribution by types of foods

No	Ca (mg,%)	Fe (mg,%)	Zn (mg,%)	Vit A (μg,%)	Vit C (mg,%)
1	rice (324.3,47.9)	rice (4.0,27.4)	rice (1.1,22.3)	chicken eggs (169.3,30.2)	cassava leaves (6.9,18.9)
2	tofu (44.4,6.5)	spinach 1.3,8.7)	mackerel tuna (0.3,5.4)	palm oil (77.9,13.9)	long bean (2.8,7.6)
3	mixed-soybean tempeh (26.2,3.9)	tofu (0.7,4.7)	soybean tempeh (0.2,5.0)	carrot (47.8,8.5)	tomato (2.3,6.2)
4	soybean tempeh (22.5,3.3)	chicken eggs (0.7,4.6)	chicken meat (0.2,4.9)	water spinach (33.7,6.0)	cassava (1.9,5.3)
5	unsalted anchovy (20.5,3.0)	soybean tempeh (0.6,4.0)	wheat flour (0.2,4.9)	chicken meat (33.7,6.0)	papaya (1.3,3.5)
6	mackerel (15.3,2.3)	wheat flour (0.5,3.7)	chicken eggs (0.2,4.1)	*Bimoli* cooking oil (29.5,5.3)	cabbage (1.2,3.4)
7	mackerel tuna (15.3,2.3)	greens mustard (0.3,2.4)	Tofu (0.2,3.2)	bird's eye chili (26.7,4.8)	bird's eye chili (1.1,3.1)
8	anchovy (12.6,1.9)	mackerel tuna (0.3,1.9)	palm sugar (0.2,3.2)	spinach (15.2,2.7)	potato (1.0,2.6)
9	Medan anchovy (11.8,1.7)	*Indomie* fried noodle (0.2,1.6)	cassava leaves (0.1,2.7)	cassava leaves (12.7,2.3)	saba banana (0.9,2.6)
10	cassava leaves (11.1,1.6)	*skipjack* tuna (0.2,1.5)	mackerel (0.1,2.5)	moringa leaves (10.2,1.8)	orange (0.9,2.5)
11	chicken eggs (9.3,1.4)	wet noodle (0.2,1.4)	*Sedap* fried noodle (0.1,1.9)	greens mustard (8.4,1.5)	sweet potato (0.8,2.3)
12	dried shrimp paste (7.0,1.0)	unsalted anchovy (0.2,1.4)	chicken breast (0.1,1.5)	*Fortune* cooking oil (8.2,1.5)	spinach (0.7,1.9)
13	cassava (4.8,0.7)	*Sedap* fried noodle (0.2,1.3)	coconut milk (0.1,1.4)	*Indomie* fried noodle (6.9,1.2)	papaya leaves (0.7,1.9)
14	peanuts (4.6,0.7)	chicken meat (0.2,1.3)	corn (0.1,1.3)	sweet-leaf bush (5.8,1.0)	water spinach (0.6,1.7)
15	snakehead murrel (4.4,0.6)	dried shrimp paste (0.1,1.0)	mixed-soybean tempeh (0.1,1.2)	melinjo leaves (3.4,0.6)	red chili peppers (0.6,1.6)
16	coconut milk (4.1,0.6)	mackerel scads (0.1,0.9)	chicken thigh (0.0,1.0)	long bean (3.0,0.5)	carrot (0.5,1.3)
17	long bean (3.6,0.5)	beef (0.1,0.8)	milkfish (0.0,0.9)	latundan banana (2.8,0.5)	tondano water spinach (0.4,1.2)
18	tilapia (3.2,0.5)	milkfish (0.1,0.7)	sardines (0.0,0.9)	catfish (2.8,0.5)	melinjo leaves (0.4,1.1)
19	instant coffee (3.1,0.5)	instant coffee (0.1,0.7)	skipjack tuna (0.0,0.9)	fern leaves (2.6,0.5)	chayote (0.4, 1.1)
20	potato (2.9,0.4)	onion chicken flavor *Indomie* (0.1,0.6)	onion chicken flavor *Indomie* (0.0,0.9)	milkfish (2.4,0.4)	garlic (0.4, 1.0)

Notes : values in the bracket (mg,%) showed the mean nutrient intake and percentage of nutrient intake contribution for each ype of foods. For example rice in the colum of Ca (324.3,47.9) means 324.3 mg of calcium from rice, which was contribute as much as 47.9% to total calcium intake.

contribution of 30.2%. This result supported by Lee DER (2014) that chicken egg is a common source for protein in Southeast Asia including in Indonesia (Lee 2014). The food sources for each of the micronutrients were diverse, but all can be simplified into four major food groups' i.e rice and wheat flour, protein source food (fish, meat and legumes) , fruits, and vegetables.

Nutrient intakes and adequacy

Mean nutrient intakes and nutrient adequacy of Indonesian adults by sex and age group are presented in Table 5. Overall, the nutrient adequacy of the micronutrient were less than hundred percent except for iron and vitamin A. Nutrient intakes of the male adults were greater than the female, except for vitamin C, both in total or for each age group ($p<0.05$). Nutrient intakes of men aged 30-49 years were greater than those of men aged 19-29 years, except for vitamin A. Nutrient intakes of women aged 19-29 years were greater than those of woman aged 30-49 years, except for calcium and vitamin A.

In addition to calculating the micronutrient adequacy, the nutrient density - nutrient content in 1,000 kcal of energy intake was also calculated (Table 5). Overall, the nutrient density in women was higher than in men. The micronutrient densities of Indonesian adults aged 30-49 years were higher than aged 19-29 years. Mann-Whitney comparative test showed that there was a significant difference ($p<0.05$) in nutrient density between different sex and age groups. The higher the value of nutrient density, the better the quality of the food consumed (Drewnowski 2005; Jayati *et al.* 2014; Ekaningrum *et al.* 2017). The density values of calcium, zinc, vitamin C and vitamin A of Indonesian adults were below the density of each micronutrient recommended by Drewnowski (2005), which were categorized as inadequate. This implies that the nutrient density was inadequate and need to be improved.

Although the Indonesian adults consume variety of food (Table 4) but it is inadequate in amount to fulfill the micronutrient requirement (Table 5). Eating variety of food in adequate amount is essential to meet the nutrient requirement for the body (Amrin *et al.* 2013; Perdana *et al.* 2014). Hardinsyah (2007) pointed that food intake and food diversity were influenced by various factors such as nutrition knowledge, food purchasing power, and time available for food processing. Thus, the inadequate amount of food consumed by Indonesian adult could be explained by lack of nutrition knowledge, poor food habit and the low income or low food purchasing power.

Micronutrient deficiencies

In the present study, two methods were applied to determine the magnitude of micronutrient deficiencies as suggested by Gibson (2005) namely probability method (PBM) and cut-off point method (CPM). By applying PBM, the results showed that the prevalence of micronutrient deficiencies in Indonesian adult was 54.2%, 36.4%, 74.3%, 44.8% and 71.4% for calcium, iron, zinc, vitamin A and C, respectively (Table 6).

The prevalence of calcium, iron, zinc, vitamin A dan C deficiencies in Indonesian adults aged 30-49 years were slightly higher than in those aged 19-29 years. The prevalence of calcium and iron deficiencies in women was higher than in men. Inversely, the prevalence of zinc, vitamin A and C in women was lower than in men. A PBM based study in France by de Lauzon (2004), showed a similar result in which the prevalence of calcium deficiencies among women was higher than in men.

CPM-100 analysis comparing the prevalence of the defeciencies in the sex group (men vs women) showed a similar pattern to the prevalence of micronutrient deficiencies calculated by PBM. CPM-100 application resulted in the prevalence of calcium and iron deficiencies in women was higher than in men. Inversely, the prevalence of zinc, vitamin A and C in women was lower than in men. While in the other hand CPM-100 results showed that the prevalence of micronutrient deficiencies in Indonesian adults was 63.9%, 42.5%, 80.7%, 55.8% and 81.7% for calcium, iron, zinc, vitamin A and C, respectively (Table 6). The lower the CPM cut-off point (CPM-85 and CPM-70) the lower the prevalence of micronutrient deficiencies. Which implies that the prevalence of micronutrient deficiencies calculated by applying CPM-100 was higher than the prevalence of micronutrient deficiencies calculated by applying PBM.

A study in a developed country, USA, utilizing a similar method of CPM showed that the prevalence of micronutrient deficiencies 37.7%, 2.7%, 32.5%, and 34.6% of calcium, iron, vitamin A and C, respectively (Blumberg *et al.* 2017). This figures were quite lower than the prevalence found in the present study. A PBM study among adult women in Mali, Africa, showed that the prevalence of calcium, iron, zinc, vitamin A and C deficiencies was 27%, 54%, 96%, 50% and 88%, respectively (Kennedy *et al.* 2010). It is evident that micronutrient deficiencies, especially zinc and vitamin C are more prevalent in developing countries then in developed countries.

Table 5. Mean (median) and standard deviation (coefficient of variation) of nutrient intake, nutrient adequacy, and nutrient density by age and sex groups

Components	19-29 years		30-49 years		Total		Total
	M	W	M	W	M	W	
Intake							
Energy	1800 (1704) 699 (0.4)	1537 (1456) 602 (0.4)	1852 (1776) 687 (0.4)	1517 (1440) 575 (0.4)	1836 (1755) 691 (0.4)	1523 (1445) 583 (0.4)	1665 (1578) 653 (0.4)
Protein	64.6 (59.7) 31.8 (0.5)	56.8 (52.3) 29.0 (0.5)	66.4 (61.8) 32.5 (0.5)	56.6 (51.8) 28.4 (0.5)	65.9 (61.1) 32.3 (0.5)	56.6 (52.0) 28.6 (0.5)	60.8 (56.0) 30.7 (0.5)
Ca	689.9 (619.8) 356.4 (0.5)	610.4 (532.4) 351.9 (0.6)	747.8 (673.1) 379.2 (0.5)	643.5 (562.7) 367.8 (0.6)	730.2 (658.2) 373.4 (0.5)	634.1 (554.7) 363.7 (0.6)	677.6 (600.6) 371.2 (0.5)
Fe	14.7 (13.3) 7.3 (0.5)	14.4 (11.8) 9.2 (0.6)	14.9 (13.5) 7.2 (0.5)	14.2 (11.7) 9.0 (0.6)	14.8 (13.5) 7.2 (0.5)	14.2 (11.7) 9.1 (0.6)	14.5 (12.5) 8.3 (0.6)
Zn	5.2 (4.5) 3.1 (0.6)	4.7 (4.1) 2.9 (0.6)	5.3 (4.6) 3.3 (0.6)	4.7 (4.0) 2.9 (0.6)	5.3 (4.5) 3.3 (0.6)	4.7 (4.0) 2.9 (0.6)	4.9 (4.2) 3.1 (0.6)
Vit A	589.6 (427.7) 509.7 (0.9)	554.5 (423.4) 451.8 (0.8)	578.7 (414.0) 508.1 (0.9)	538.1 (406.2) 443.8 (0.8)	582.0 (418.7) 506.6 (0.9)	542.8 (411.1) 446.1 (0.8)	560.6 (414.0) 475.8 (0.8)
Vit C	31.2 (19.5) 36.9 (1.2)	34.7 (22.7) 37.2 (1.1)	37.3 (23.6) 41.8 (1.1)	38.5 (25.9) 39.1 (1.0)	35.5 (22.3) 40.5 (1.1)	37.4 (25.0) 38.6 (1.0)	36.5 (23.7) 39.5 (1.1)
Adequacy							
Ca	102.0 (91.7) 52.7 (0.5)	83.4 (72.7) 48.1 (0.6)	107.0 (96.3) 54.3 (0.5)	86.3 (75.4) 49.3 (0.6)	105.5 (95.0) 53.9 (0.5)	85.5 (74.7) 49.0 (0.6)	94.5 (83.7) 52.2 (0.6)
Fe	161.4 (145.6) 80.1 (0.5)	111.5 (91.6) 70.9 (0.6)	158.6 (143.8) 76.6 (0.5)	108.2 (89.2) 69.0 (0.6)	159.4 (144.3) 77.6 (0.5)	109.2 (89.9) 69.5 (0.6)	131.9 (112.4) 77.5 (0.6)
Zn	65.4 (56.8) 39.7 (0.6)	76.3 (65.3) 47.3 (0.6)	64.5 (55.6) 40.5 (0.6)	73.9 (63.2) 45.5 (0.6)	64.8 (56.0) 40.2 (0.6)	74.6 (63.8) 46.0 (0.6)	70.1 (60.2) 43.8 (0.6)
Vit A	111.6 (81.0) 96.5 (0.9)	121.1 (92.5) 98.7 (0.8)	106.0 (75.8) 93.1 (0.9)	115.5 (87.1) 95.2 (0.8)	107.7 (77.4) 94.2 (0.9)	117.1 (88.6) 96.3 (0.8)	112.8 (83.6) 95.4 (0.8)
Vit C	49.2 (30.8) 58.3 (1.2)	63.2 (41.3) 67.8 (1.1)	57.0 (36.1) 63.8 (1.1)	68.9 (46.3) 69.9 (1.0)	54.6 (34.4) 62.3 (1.1)	67.3 (44.9) 69.4 (1.0)	61.5 (39.8) 66.6 (1.1)
Density							
Ca	399.4 (371.4) 186.5 (0.5)	413.4 (374.0) 217.9 (0.5)	418.0 (383.8) 192.5 (0.5)	438.0 (393.8) 225.4 (0.5)	412.3 (380.5) 190.9 (0.5)	431.0 (387.9) 223.6 (0.5)	422.6 (384.2) 209.6 (0.5)
Fe	8.4 (7.6) 4.1 (0.5)	9.7 (7.9) 6.6 (0.7)	8.3 (7.4) 4.1 (0.5)	9.7 (7.8) 6.8 (0.7)	8.3 (7.5) 4.1 (0.5)	9.7 (7.8) 6.7 (0.7)	9.1 (7.6) 5.7 (0.6)
Zn	2.9 (2.7) 1.3 (0.5)	3.1 (2.8) 1.5 (0.5)	2.8 (2.6) 1.4 (0.5)	3.1 (2.8) 1.5 (0.5)	2.8 (2.6) 1.4 (0.5)	3.1 (2.8) 1.5 (0.5)	3.0 (2.7) 1.5 (0.5)
Vit A	340.8 (249.3) 311.7 (0.9)	377.9 (293.5) 323.1 (0.9)	323.7 (233.6) 299.4 (0.9)	371.4 (279.5) 323.6 (0.9)	328.9 (238.3) 303.3 (0.9)	373.3 (283.8) 323.5 (0.9)	353.2 (262.5) 315.3 (0.9)
Vit C	19.3 (11.4) 26.4 (1.4)	24.9 (15.6) 29.6 (1.2)	22.1 (13.5) 28.6 (1.3)	27.6 (18.2) 30.8 (1.1)	21.3 (12.8) 28.0 (1.3)	26.8 (17.5) 30.5 (1.1)	24.3 (15.2) 29.5 (1.2)

Notes : M = Men, W = Women

The weaknesses of this study were inheren into the weaknesses of the food data collection (24-hr recall method), food composition tables and micronutrient requirement used for this study. However, both PBM and CPM were applied to the same data set derived from a nation-wide survey which provides very large sample size.

In summary, both PBM and CPM highlighted serious problem of micronutrient deficiencies among Indonesian adult; and there is an

Table 6. Percentage of subjects categorized as having micronutrient deficiency (%)

Components	19-29 years		30-49 years		Total		Total
	M	W	M	W	M	W	
Ca							
PBM	45.1	60.9	43.5	63.3	44.0	62.7	54.2
CPM-100	57.1	73.3	52.9	71.3	54.2	71.9	63.9
CPM-85	43.5	61.7	39.3	59.3	40.6	60.0	51.2
CPM-70	29.0	46.8	25.1	43.8	26.3	44.7	36.4
Fe							
PBM	20.5	42.4	21.5	47.8	21.2	46.2	36.4
CPM-100	23.9	56.3	24.0	58.3	24.0	57.7	42.5
CPM-85	16.6	44.8	15.5	46.2	15.8	45.8	32.2
CPM-70	9.2	31.3	8.8	32.5	8.9	32.2	21.7
Zn							
PBM	76.2	66.3	78.3	73.5	77.6	71.4	74.3
CPM-100	84.0	75.9	84.7	78.2	84.5	77.6	80.7
CPM-85	75.8	66.3	76.9	69.1	76.6	68.3	72.1
CPM-70	64.0	54.4	65.3	56.6	64.9	56.0	60.0
Vit A							
PBM	43.3	40.6	46.5	45.4	45.5	44.0	44.8
CPM-100	56.2	52.6	58.5	54.8	57.8	54.2	55.8
CPM-85	51.8	47.0	53.6	49.1	53.1	48.5	50.6
CPM-70	46.0	40.5	47.5	42.5	47.1	41.9	44.3
Vit C							
PBM	77.9	68.6	73.3	68.7	74.6	68.8	71.4
CPM-100	87.5	80.7	83.8	78.3	84.9	79.0	81.7
CPM-85	84.2	75.9	79.4	73.2	80.9	73.9	77.1
CPM-70	78.8	69.4	73.7	66.4	75.3	67.2	70.9

Notes : M = Men, W = Women, PBM = Probability method, CPM-100 = cut-off point 100% adequacy, CPM-80 = cut-off point 5% adequacy, CPM-75= cut-off point 70% adequacy.

urgent need to tackle this problem through food based approach. This can be achieved through increasing intake of protein source foods, fruits and vegetables as well as micronutrient fortified food.

CONCLUSION

The application of probability method for identifying micronutrient deficiencies in Indonesian adults showed that the prevalence of calcium, iron, zinc, vitamin A and C deficiencies was 54.2%, 36.4%, 74.3%, 44.8% and 71.4%, respectively. The results of this study also indicated the tendency of overestimation in prevalence of micronutrient deficiencies from CPM-100. More women categorized as calcium and iron deficiencies than men, in both calculation by PBM and CPM. Men were more likely to have zinc, vitamin A and C deficiencies than women, regardless of the calculation method applied, PBM or CPM. Based on nutrient density calculation, the diet quality of Indonesian adults, both in men and women were in needs of improvement.

Considering the high prevalence of micronutrient deficiencies among Indonesian adults, this study suggests to increase the consumption of fish, meat, legumes, fruits and vegetables, and to avoid overestimation to apply the PBM into other age-sex groups.

ACKNOWLEDGEMENTS

We would like to thank to NIHRD of Ministry of Health of Indonesia that allowed the researchers to use the data for the present study.

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