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# Probability Method for Analyzing the Prevalence of Calcium, Iron, Zinc, and Vitamin D Deficiencies among Indonesian Adolescents

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## ABSTRACT

The objective of this study was to analyse the prevalence of Ca, Fe, Zn, and vitamin D deficiency (micronutrient deficiency-MD) in adolescents using probability method (PBM) and cut-off point method (CPM). This study utilized secondary data from nation-wide Basic Health survey (Riskesdas) 2010 from the Ministry of Health, in which data on nutrient intakes were collected using 24-hour recall. The total subjects were 24,833 Indonesian males and females aged 13-18 years. The nutrient requirement of each micronutrient was derived from the Institute of Medicine (IOM). The prevalence of MD using PBM was analysed by calculating the proportion of subjects with intake of below their requirement in the population. The prevalence of MD using CPM analysed by applying three cut-off point i.e. less than 100% (CP-100), less than 85% (CP-85), and less than 70% (CP-70) of the micronutrient requirement. Results showed that the prevalence of MD was high both calculated by PBM and CPM. In both methods, the prevalence of MD deficiencies were slightly higher in females than in males, and in older age group than younger age group. The prevalence of MD calculated using PBM was higher compared to the CPM-85 and CPM-70, but not always higher compared to CPM-100. Overall, the nutrient density of Ca, Fe, Zn, and vitamin D for both male and female adolescents were below recommendations, however the nutrient density of Ca, Zn, and vitamin D in females were higher than in males ($p<0,05$). This study concludes that the intakes of micronutrient (Ca, Fe, Zn, and vitamin D) among Indonesian adolescent were far below the requirement based on PBM and CPM calculations. In addition, the nutrient density of each micronutrient was classified as inadequate. This implies the importance of improvement in the quantity and quality of micronutrient intakes among Indonesian adolescents through increasing the consumption of fish, meat, eggs, legumes, milk, and green vegetables.

**Keywords**: food source, micronutrient deficiency, nutrient density, probability method

## INTRODUCTION

The adolescence period is a critical time within the life stage, physical growth during adolescence is considered as faster than any other life stage except for the first year of life. Good nutrition is critical to meet the demands of physical and cognitive growth and development, provide adequate storage of energy for illnessess and pregnancy as well as to prevent nutrition-related diseases (Rogol *et al.* 2002; Stang & Story 2005; WHO 2006). However, many studies showed that the adolescents tend to have an imbalanced diet thus failed to meet sufficient nutritional requirements, including micronutrients (Hardinsyah *et al.* 2008, Toselli *et al.* 2010; Naeeni *et al.* 2014). Nutrient deficiency during adolescence can impede cognitive abilities and productivity while also increased the risk of non-communicable diseases (Cusick & Kuch 2012; Stewart *et al.* 2013; Bloem *et al.* 2013; de Onis & Branca 2016). Furthermore, adolescents are prospective fathers or mothers who need better nutritional status to be healthy parents (Black *et al.* 2013). Many factors may increase the risk of nutrient deficiency such as lack of nutrient intake, food habit, nutrition knowledge, infection, and socioeconomic status (Aounallah-Skhiri *et al*. 2011; Paudel *et al.* 2012; Bloem *et al.* 2013). Micronutrients that play important roles in adolescents are calcium and vitamin D (Bueno & Czepielewski 2008; Bueno *et al.* 2010) as well as zinc and iron (Kamal *et al.* 2010; Soliman *et al.* 2014).

The role of calcium is primarily related to bone growth and cannot be separated from phosphorus, however, phosphor deficiency is rare due to the fact that almost all of foods (plant and animal) contain phosphor (MOH 2014). A

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meta analysis done by Tai *et al.* (2015) showed that calcium deficiency decreases bone mineral density. Adequate calcium intake was associated with faster linear growth in adolescent; and calcium intake below 300 mg/d may result in shorter adult stature (Fang *et al.* 2017). In addition, calcium and vitamin D insufficiency may effect on glycaemia through glucose metabolism disorder (Pittas *et al.* 2007). Regarding physical growth, zinc deficiency might also inhibit linear growth (Wessells & Brown 2012; Riyadi 2007). Zinc supplementation has shown significant positive effect on linear growth of children (Imdad & Bhutta 2011).

Another important role of vitamin D is its association to increase risk of anaemia, especially iron deficiency anaemia in children and adolescent (Lee *et al.* 2015). The prevalence of anaemia in Indonesian adolescents was 22.4% (MOH 2013). Smaller studies in various areas showed higher prevalence in which about 35% of adolescent experienced anaemia (Briawan *et al*. 2011; Hardiansyah *et al.* 2013). Iron deficiency may lead to anaemia that associated with impairments of cognitive developments, immunity function and work capacity (Abbaspour *et al.* 2014). Worse still is the prevalence of vitamin D deficiency in Southeast Asia, which was 6-70% (Nimitphong & Holick 2013) while for calcium and zinc deficiencies were about 90% (Kumssa *et al.* 2015). Therefore micronutrient deficiency is prevalent and could negatively effect on metabolism, cognitive function, linear growth and productivity of the adolescent in which may influence their capacity as they move into adulthood.

The selection of the appropriate method for determining the prevalence of micronutrient deficiency is important. As proposed by Jensen *et al.* (1992) and Carriquiry (1998), the assessment of the MD in adolescent can be calculated using two methods, namely by the cut-off point method (CPM) and the probability method (PBM). The CPM uses a fixed value to categorize the nutritional adequacy level of a person. This method is often used in the determination of nutrient deficiency until now, as it has the advantage of being simpler. However, it may lead to misclassification of individuals who should belong to inadequate categories (Jensen *et al.* 1992; Murphy & Poss 2002). On the other hand, the PBM is proposed to determine the prevalence of inadequacy intake to avoid the misclassification. The PBM uses a statistical method that combines the distribution of needs and intakes into a group to produce the expected proportional estimates of individuals at risk for inadequacy (Jensen *et al.* 1992; Murphy & Poos 2002). The advantage of PBM, compared to the CPM, is that it calculates more accurately the prevalence of inadequacy (de Lauzon *et al.* 2004). The PBM was first used in 1972 by Beaton and later on in the United States and France (Jensen 1992; de Lauzon *et al*. 2004; Taylor *et al.* 2013) but has never been used in Indonesia for a larger nation-wide data set.

Based on the above considerations, this study was intended to apply the PBM in analysing calcium, iron, zinc, and vitamin D deficiencies among adolescent in Indonesia; and their nutrient density.

## METHODS

### Design, location, and time

This study utilized secondary data obtained from the Indonesia Basic Health Research (*Riskesdas*) in 2010, through the National Institute of Health Research and Development (NIHRD), Ministry of Health (MOH), Indonesia. The data were nation-wide food consumption survey data which included body weight and height measurements. The study design was cross-sectional; as used in the Riskesdas 2010. The processing, analysis, and interpretation of the research data were conducted in the Department of Community Nutrition, Faculty of Human Ecology, at Bogor Agricultural University, from September to December 2017.

### Sampling

The Riskesdas 2010 covered 251,388 individuals from 66,906 households. The initial subjects of this study were 26,208 adolescents aged 13-18 year. The inclusion criteria for this study were adolescents aged between 13-18 years old, in good health conditions with a normal daily consumption (not fasting, no diet, no illness, and others).

Exclusion criteria applied was physiological conditions such as pregnancy. The cleaning process was carried out on the obtained subjects i.e. on body weight, body height, and incomplete food consumption. In addition, the subject had nutritional status of BMI-for-age z-score (BAZ) > +5 and <-5, and height-for-age z-score (HAZ) <-6 and >+5 (WHO 2009), food consumption with <2 types of food, and nutritional requirement level of >400%. The total subjects after data cleaning in this study were 24,833 adolescent aged 13-19 years and consist of 12,715 males and 12,118 females.

**Data analysis**

The data processing and analysis were done after data cleaning process, the obtained data were processed using Microsoft Excel 2013 and analysed using SPSS 16.0 software. The Ca, Fe, Zn, and vitamin D content in foodstuffs were obtained from various sources which were the List of Food Nutrition Composition of Indonesia, ASEAN Food Composition Database (FAO), USDA National Nutrient Database for Standard References, and nutrition fact. Variables and categories in the present study are listed in Table 1.

The analysis of food consumption as sources of Ca, Fe, Zn, and vitamin D was done by analysing types of foods and percentage of nutrient contribution from each food. The nutrient intake of each food was calculated using the following formula (Hardinsyah & Briawan 1994):

$$KGij = (Bj/100) \times Gij \times (BDD/100)$$

Description:

KGij : The nutrient content of i from food j with a weight of B gram

Bj : type of food j(g)

Gij : Nutrient content of i in 100 g of BDD food j

BDD : Percentage of edible food j (%BDD)

The requirement references for this study for calcium, iron, zinc, and vitamin D are as shown in Table 2. The nutritional adequacy level was calculated by comparing the intake of each micronutrient to the individual requirement adapted from IOM (2011) which use the assumption of normal body mass index (BMI) of American adolescents (the mean BMI was 21.6 for male and 21.2 for female). The PBM used the modified IOM requirement based on BMI of each subject;

Table 1. Variable and categories used in the study

| Data | Variables | Categories of variables | References |
|---|---|---|---|
| Individual characteristics | Age | 1-15 year<br>16-18 year | MOH 2014 |
| | Gender | Male<br>Female | MOH 2010 |
| Nutritional status | Body weight | - | - |
| | Body height | Stunting<br>Normal | MOH 2011 |
| Consumption of nutrients (24-hour recall) | Foodstuff | - | - |
| | Household measure | - | - |
| | Weight (g) | - | - |
| Prevalence of calcium, iron, zinc, and vitamin D deficiencies | Cut off point 100 (CP-100) | Enough (≥ 100%)<br>Deficient (<100%) | Gibson 2005 |
| | Cut off point 85 (CP-85) | Enough (≥ 85%)<br>Deficient (<85%) | |
| | Cut off point 70 (CP-70) | Enough (≥ 70%)<br>Deficient (<70%) | Gibson 2005 |
| | Probability method | % Deficient | Jensen *et al.* 1992 |

Table 2. Nutrient requirement of Ca, Fe, Zn, and vitamin D

| Age categories (year) | Body weight (kg)* | Body height (cm)* | Calcium (mg) | Iron (mg) | Zinc (mg) | Vitamin D (mcg) |
|---|---|---|---|---|---|---|
| Male | | | | | | |
| 13-15 | 46 | 158 | 1040.5 | 10.2 | 8.0 | 9.5 |
| 16-18 | 56 | 165 | 1043.0 | 10.2 | 8.1 | 9.5 |
| Female | | | | | | |
| 13-15 | 46 | 155 | 1063.0 | 13.6 | 7.1 | 9.7 |
| 16-18 | 50 | 158 | 1041.6 | 13.4 | 6.9 | 9.5 |

Source: Modified from IOM (2011) based on normal BMI for Indonesian adolescents (MOH 2013)* while the CPM used the normal BMI of Indonesian adolescents from the RDA for Indonesian.

The nutrient density was also calculated to describe the nutritional quality of the diet of each subject based on the energy intake. It is the ratio of the amount of nutrient intake consumed per day per 1,000 kcal of energy (Drewnowski 2005), calculated using the following formula:

$$Density\ of\ nutrients = \frac{Nutrient\ intake - i}{Energy\ intake}\ x\ 1000$$

i = Ca, Fe, Zn, and Vitamin D

The classification of nutrient density in this study was based on the FAO standard. It was categorized as "inadequate" if the nutritional density value was lower than the FAO standard; and it was "adequate" if the nutritional density value was equal to or greater than the FAO standard (Table 3).

Table 3. Nutrient density standard

| Nutrients | Densities |
|---|---|
| Calcium | 500-800 mg |
| Iron | 7-40 mg |
| Zinc | 12-20 mg |
| Vitamin D | 5-10 µg |

Source: Drewnowski 2005

The prevalence of Micronutrient Deficiency (MD) of each nutrient was determined using two methods, 1) probability method (PBM) and 2) cut off point method (CPM). The adequacy level of Ca, Fe, Zn, and vitamin D were performed by comparing the intakes to the requirements which was adjusted to the nutritional status of each individual. Afterwards, the values were classified according to categories of deficiency levels. The CPM was classified into three categories, which are 1) CPM-100 (if the adequacy level <100%); 2) CPM-85 (if the adequacy level <85%); and 3) CPM-70 (if the adequacy level <70%).

The PBM estimates the prevalence of MD in the population with intakes below the requirements (Jensen *et al.* 1992). There are several steps to determine the prevalence of nutrient deficiency using PBM. The first step was to calculate the Ca, Fe, Zn and vitamin D intakes; the second step was to calculate the individual requirement according age, sex and BMI and the third was to calculate the mean, standard deviation, and correlation between intake and requirement. The last step was to calculate the probability of deficiency ($Z_0$), using the formula as follows (Jensen *et al.* 1992):

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

$$I - R \sim N(\mu_I - \mu_R, \sigma_I^2 - 2\rho\sigma_I\sigma_R + \sigma_R^2)$$

$$P(I - R < 0) = P\left(\left(\frac{I - R - (\mu_I - \mu_R)}{\sqrt{\sigma_I^2 - 2\rho\sigma_I\sigma_R + \sigma_R^2}}\right) < \left(\frac{0 - (\mu_I - \mu_R)}{\sqrt{\sigma_I^2 - 2\rho\sigma_I\sigma_R + \sigma_R^2}}\right)\right)$$

$$= P\left(Z < \frac{-(\mu_I - \mu_R)}{\sqrt{\sigma_I^2 - 2\rho\sigma_I\sigma_R + \sigma_R^2}}\right)$$

$$= P\ (Z < Z0\ )$$

$$Z0 = \frac{-(\mu_I - \mu_R)}{\sqrt{\sigma_I^2 - 2\rho\sigma_I\sigma_R + \sigma_R^2}} = \frac{\mu_R - \mu_I}{\sqrt{\sigma_I^2 - 2\rho\sigma_I\sigma_R + \sigma_R^2}}$$

Description :
I = Intake
$\sigma_I$ = Standard deviation of intakes
R = Requirement
$\sigma_R$ = Standard deviation of requirements
N = population
$\sigma_I^2$ = Intake variant
$\mu_I$ = Average intakes
$\sigma_R^2$ = Requirement variant
$\mu_R$ = Average requirements
ρ = Correlation between intakes and requirements

## RESULTS AND DISCUSSION

**Food sources of iron, calcium, zinc, and vitamin D**

Ca, Fe, Zn, and vitamin D intakes were obtained from the consumption of various types of food in a day. Table 4 shows 20 food items consumed ranked by their percentage of nutrient contribution for each micronutrient (Ca, Fe, Zn, and vitamin D). Adolescent Fe intake was mostly from fried tempeh, white rice, *"bakwan'* (vegetables fritters), spinach and omelettetete. Results from the present study were in line with Briawan *et al.* (2012) findings. The types of food greatly contributed to the Fe intake in adolescent were fish, tempe, rice, eggs, and milk.

The type of food as the main source of Ca in this study were similar to the types of food found by Hardinsyah *et al.* (2008) namely milk, animal food sources, nuts, processed foods, and vegetables. Meanwhile, Zn intake in adolescent was obtained from white rice, chicken, meatballs, tofu, and fish. According to Osredkar & Sustar (2011), Zn intake can be derived from meat, beans, seafood, and cereals.

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

| Calcium (mg;%) | Iron (mg;%) | Zinc (mg;%) | Vitamin D (µg; %) |
|---|---|---|---|
| Salted fried fish (42.62;14.50) | Fried tempe (2.23; 25.03) | White rice (1.62; 35.29) | Fried fish (0.28; 11.89) |
| Fried tempe (32.94; 11.33) | White rice (2.03; 22.96) | Fried chicken (0.16; 3.47) | Fried anchovy (0.16; 6.88) |
| Fried anchovy (24.87; 8.55) | Bakwan (vegetable fritters) (0.26; 2.82) | Beef meatballs (0;11; 2.41) | Mackerel tuna (0.14; 6.14) |
| White rice (20.29; 6.98) | Swamp cabbage (0.20; 2.15) | Fried rice (0.10; 2.32) | Catfish (0.14; 5.84) |
| Salted anchovy (12.21; 4.20) | Fried egg (0.19; 2.06) | Fried tofu (0.09; 1.92) | Fried eggs (0.13; 5.72) |
| Fried tofu (10.70; 3.68) | Spinach (0.18; 1.91) | Meatballs noodles+gravy (0.08; 1.84) | Salted anchovy (0.12; 5.18) |
| Spinach (6.68; 2.30) | Omelette (0.17; 1.89) | Fried anchovy (0.08; 1.65) | Omelette (0.12; 5.04) |
| Omelette (4.34; 1.49) | Fried rice (0.15; 1.57) | Fried fish (0.07; 1.63) | Mackerel (0.11; 4.58) |
| Mackerel tuna (4.24; 1.46) | Salted fried anchovy (0.13; 1.38) | Omelette (0.07; 1.52) | *Siomay* (dumplings) (0.11; 4.48) |
| Fried egg (3.77; 1.29) | Fried chicken (0.13; 1.37) | Spinach (0.07; 1.49) | Fresh corkfish (0.06; 2.54) |
| Sautéed Kale (3.50; 1.20) | Fried carp fish (0.12; 1.31) | Fried egg (0.06; 1.33) | Salted fried fish (0.05; 2.25) |
| *Rendang* (3.37; 1.16) | *Rendang* (0.11. 1.15) | *"Pentol"*(flour based meatballs) (0.06; 1.21) | Chicken eggs (0.05; 2.09) |
| Tamarind vegetable soup (3.28; 1.13) | *Batagor* (deep fried tofu mixed with flour and served with peanut sause) (0.08; 0.88) | Salted anchovy (0.05; 1.15) | Fresh anchovy (0.05; 1.95) |
| Swamp cabbage (2.84; 0.98) | Vegetable tofu (0.08; 0.86) | Sautéed Chinese cabbage (0.05; 1.08) | Milkfish (0.04; 1.83) |
| Cassava leaves (2.62; 0.90) | Beef meatballs (0.08; 0.82) | Noodles (*Supermie*) (0.05; 1.04) | Mackerel tuna (0.03; 1.46) |
| Salted dried anchovy (2.54; 0.87) | egg (0.07; 0.72) | Noodles+gravy (0.05; 1.00) | Tilapia (0.03; 1.45) |
| Muffins (2.53; 0.87) | Fried tofu (0.06; 0.68) | Fried tempeh (0.04; 0.96) | Mackerel scads (0.03; 1.29) |
| Powdered milk (*Dancow*) (2.28; 0.78) | Fresh shrimp (0.06; 0.67) | *Uduk* rice (rice cooked with coconut milk and spices) (0;04; 0.91) | Mackerel (0.03; 1.25) |
| Sweetened condensed milk (2.12; 0.73) | Milkfish (0.06; 0.62) | Noodles *(Sarimie)* (0.03; 0.70) | *Banjar* fish (0.03; 1.15) |
| Sautéed Chinese cabbage (1.95; 0.67) | Fried fish (0.06.;0.61) | Vegetable soup (0.03; 0.66) | *Awu-awu* fish (0.03; 1.08) |

*Notes: values in the bracket (mg,%) showed the mean nutrient intake and percentage of nutrient intake contribution for each type of foods. For example white rice in the column of Zn (1.62; 35.29) means 1.62 mg of Zn from white rice, which was contribute as much as 35.29% to total Zn intake

The types of food with the largest supply of vitamin D identified in this study were various types of fish, such as anchovy, catfish, and tuna. In addition, egg was also a common source of vitamin D widely consumed by the adolescent. These results were in accordance with Valentina *et al.*(2014) findings which indicated that vitamin D intake from diet was mostly obtained from fish, shellfish, shrimp, eggs, and milk.

**Nutrient intake and adequacy**

The nutrient intake and nutrient adequacy of energy, Ca, Fe, Zn, and vitamin D were varied among age and sex groups. The results showed that the mean intakes of energy, Ca, Fe, Zn, and vitamin D were lower than their requirement, which showed by the mean nutrient adequacy of these micronutrients were ranged only from 25.8 -72.2% (Table 5). The nutrient adequacy of each micronutrients was higher in males compared to females for both age groups, 13-15 years and 16-18 years. Although nutrient adequacy in males were higher than in females, the density of these micronutrients in females was slightly higher than in males. Both male and female adolescents had nutrient density which were categorized as inadequate. Elliot *et al.* (2015) highlighted that the adolescents in low and middle country had low consumption of nutrient dense foods.

The study by Majid *et al.* (2016) conducted among adolescents in Middle-Income Country also showed that the nutrient intake was low compared to the requirement, and the intake of Fe and Ca in male adolescent was higher than in female

Table 5. Average, median, standard deviation and coefficient of variations of nutrient intake and nutrient adequacy based on age and gender

| Components | 13-15 years old | | 16-18 years old | | Total | | Total |
|---|---|---|---|---|---|---|---|
| | M | F | M | F | M | F | |
| | Mean (Med)<br>SD (CV) | | | | | | |
| Intake | | | | | | | |
| Energy | 1,545 (1,470)<br>576 (0.4) | 1,422 (1,349)<br>551 (0.4) | 1,599 (1,526)<br>570 (0.4) | 1,438 (1,366)<br>531 (0.4) | 1,570 (1,500)<br>574 (0.4) | 1,430 (1,358)<br>542 (0.4) | 1,502 (1,431)<br>563 (0.4) |
| Ca | 294.2(183.5)<br>362.5 (1.2) | 278.4(169.9)<br>346.8 (1.2) | 304.6(191.6)<br>367.6 (1.2) | 284.8(171.6)<br>379.0 (1.3) | 299.0(187.4)<br>364.9 (1.2) | 281.4(171.0)<br>362.1 (1.3) | 290.4(179.6)<br>363.6 (1.3) |
| Fe | 9.4 (7.6)<br>6.4 (0.7) | 8.8 (7.1)<br>6.0 (0.7) | 9.9 (7.9)<br>6.7 (0.7) | 8.8 (7.3)<br>6.1 (0.7) | 9.7 (7.8)<br>6.5 (0.7) | 8.8 (7.2)<br>6.0 (0.7) | 9.2 (7.5)<br>6.3 (0.7) |
| Zn | 4.7 (4.1)<br>2.5 (0.5) | 4.4 (3.8)<br>2.5 (0.6) | 4.8 (4.2)<br>2.5 (0.5) | 4.6 (3.9)<br>2.6 (0.6) | 4.7 (4.1)<br>2.5 (0.5) | 4.5 (3.9)<br>2.6 (0.6) | 4.6 (4.0)<br>2.5 (0.5) |
| Vitamin D | 2.4 (1.2)<br>3.7 (1.6) | 2.3 (1.1)<br>3.7 (1.6) | 2.4 (1.2)<br>3.9 (1.6) | 2.2 (1.2)<br>3.5 (1.6) | 2.4 (1.2)<br>3.8 (1.6) | 2.3 (1.2)<br>3.6 (1.6) | 2.3 (1.2)<br>3.7 (1.6) |
| Adequacy | | | | | | | |
| Ca | 30.9 (19.1)<br>38.4 (1.2) | 28.3 (17.2)<br>35.2 (1.2) | 29.9 (18.6)<br>36.3 (1.2) | 27.4 (16.4)<br>36.5 (1.3) | 30.4 (18.9)<br>37.4 (1.2) | 27.9 (16.8)<br>35.8 (1.3) | 29.2 (17.8)<br>36.7 (1.3) |
| Fe | 76.7 (62.0)<br>52.4 (0.7) | 69.3 (56.2)<br>49.0 (0.7) | 75.6 (60.1)<br>52.1 (0.7) | 66.3 (53.8)<br>46.7 (0.7) | 76.2 (61.3)<br>52.3 (0.7) | 67.9 (54.9)<br>48.0 (0.7) | 72.2 (58.3)<br>50.4 (0.7) |
| Zn | 73.9 (64.3)<br>40.5 (0.5) | 67.5 (57.9)<br>39.6 (0.6) | 70.8 (62.3)<br>37.7 (0.5) | 66.4 (57.2)<br>38.6 (0.6) | 72.5 (63.4)<br>39.2 (0.5) | 67.0 (57.6)<br>39.1 (0.6) | 69.8 (60.6)<br>39.3 (0.6) |
| Vitamin D | 27.0 (14.0)<br>41.6 (1.5) | 25.8 (12.8)<br>40.8 (1.6) | 26.2 (13.0)<br>41.6 (1.6) | 23.7 (12.4)<br>37.1 (1.6) | 26.6 (13.5)<br>41.6 (1.6) | 24.8 (12.7)<br>39.1 (1.6) | 25.8 (13.1)<br>40.4 (1.6) |
| Density | | | | | | | |
| Ca | 194.8(126.1)<br>227.8 (1.2) | 199.0(128.6)<br>228.8 (1.2) | 194.3(128.3)<br>222.2 (1.1) | 198.5(125.6)<br>234.2 (1.2) | 194.6(127.2)<br>225.2 (1.2) | 198.7(127.4)<br>231.3 (1.2) | 196.6(127.3)<br>228.2 (1.2) |
| Fe | 6.2 (5.1)<br>3.6 (0.6) | 6.2 (5.2)<br>3.6 (0.6) | 6.2 (5.1)<br>3.6 (0.6) | 6.2 (5.1)<br>3.7 (0.6) | 6.2 (5.1)<br>3.6 (0.6) | 6.2 (5.2)<br>3.7 (0.6) | 6.2 (5.1)<br>3.6 (0.6) |
| Zn | 3.1 (2.7)<br>1.4 (0.5) | 3.2 (2.8)<br>1.6 (0.5) | 3.0 (2.7)<br>1.3 (0.4) | 3.2 (2.8)<br>1.6 (0.5) | 3.1 (2.7)<br>1.4 (0.4) | 3.2 (2.8)<br>1.6 (0.5) | 3.1 (2.8)<br>1.5 (0.5) |
| Vitamin D | 1.6 (0.8)<br>2.6 (1.6) | 1.7 (0.9)<br>2.8 (1.6) | 1.6 (0.8)<br>2.6 (1.6) | 1.6 (0.9)<br>2.6 (1.6) | 1.6 (0.8)<br>2.6 (1.6) | 1.7 (0.9)<br>2.7 (1.6) | 1.6 (0.8)<br>2.6 (1.6) |

Note : M = Males, F = Females; data nutrient presented in mean, median, standard deviation, and coeficient of variations respectively counterpart. The factors that may affect micronutrient intake in adolescents were socioeconomic status, gender, and lifestyle (Serra-Majem *et al.* 2006; Salamoun *et al.* 2005). As well as nutrition knowledge, food purchasing power, and time available for food processing (Hardinsyah 2007).

**Micronutrient deficiencies**

The magnitude of the prevalence of MD using the PBM were varied. The prevalence of Ca, Fe, Zn, and vitamin D deficiencies in adolescent were 96.63%, 71.85%, 77.48%, and 95.99%, respectively (Table 6). The prevalence of Ca, Fe, Zn and vitamin D deficiencies were higher in female compared to male. Another important finding was the prevalence in prevalence within the same sex but within different age groups; the Fe deficiency was higher in adolescent female aged 16-18 years compared to adolescent females aged 13-15 years and the prevalence of Zn deficiency was higher in adolescent males aged 16-18 years compared to adolescent males aged 13-15 years. A systematic review by Elliot *et al.* (2015) in low and middle country showed that the MD among female adolescent was high (>50%). More recently, Berg *et al.* (2017) revealed that MD among female adolescents in Uganda using PBM was also above 50%.

Applying the CPM-100, the prevalence of Ca, Fe, Zn, and vitamin D deficiencies in adolescent were 95.50%, 78.60%, 84.10% and 94.30%, respectively (Table 6). The prevalence of MD with CPM-70 was lower than the prevalence of MD with the CPM-85 as well as CPM-100. It was rational that the lower the cut off point for CPM the lower the prevalence of MD (de Lauzon 2004; Gibson 2005).

Compared to PBM, the prevalence of Ca and vitamin D deficiency by CPM-100, were relatively similar. While for Fe and Zn, the prevalence of Fe and Zn deficiency from CPM 100 were higher compared to PBM. The different results from these methods are due to the differences in mean and standard deviation of the micronutrients' intake (Jensen *et al.* 1992). The lower the mean intake of the subject, the higher the prevalence of MD obtained from the PBM.

Table 6. Prevalence of micronutrient deficiencies, using cut off point method and probability approach, based on age and gender.

| Methods | 13-15 years old | | 16-18 years old | | Total | | |
|---|---|---|---|---|---|---|---|
| | M | F | M | F | M | F | Total |
| Calcium | | | | | | | |
| PBM | 95.83 | 97.19 | 96.77 | 97.04 | 96.32 | 97.08 | 96.63 |
| CPM-100 | 95.17 | 95.84 | 95.28 | 95.63 | 95.22 | 95.74 | 95.50 |
| CPM-85 | 93.41 | 94.36 | 93.71 | 94.67 | 93.55 | 94.50 | 94.00 |
| CPM-70 | 91.04 | 91.82 | 91.45 | 92.91 | 91.23 | 92.33 | 91.80 |
| Iron | | | | | | | |
| PBM | 68.00 | 74.44 | 68.69 | 77.23 | 68.36 | 75.75 | 71.85 |
| CPM-100 | 76.12 | 80.21 | 76.24 | 82.23 | 76.18 | 81.15 | 78.60 |
| CPM-85 | 67.96 | 72.85 | 68.38 | 74.99 | 68.16 | 73.84 | 70.90 |
| CPM-70 | 57.17 | 61.31 | 58.78 | 64.09 | 57.92 | 63.60 | 60.70 |
| Zinc | | | | | | | |
| PBM | 74.77 | 79.87 | 78.24 | 80.85 | 76.45 | 80.39 | 77.48 |
| CPM-100 | 81.43 | 84.93 | 83.84 | 86.46 | 82.55 | 85.64 | 84.10 |
| CPM-85 | 72.20 | 77.59 | 74.95 | 77.94 | 73.47 | 77.75 | 75.60 |
| CPM-70 | 57.91 | 64.96 | 60.46 | 65.66 | 59.09 | 65.28 | 62.10 |
| Vitamin D | | | | | | | |
| PBM | 95.07 | 95.97 | 95.62 | 97.41 | 95.27 | 96.68 | 95.99 |
| CPM-100 | 93.88 | 94.30 | 94.09 | 95.19 | 93.98 | 94.71 | 94.30 |
| CPM-85 | 92.47 | 92.68 | 92.61 | 93.75 | 92.54 | 93.18 | 92.80 |
| CPM-70 | 90.34 | 90.63 | 90.62 | 91.72 | 90.47 | 91.14 | 90.80 |

Notes : M = Males, F = Females, PBM = Probability method, CPM-100 = cut-off point 100% adequacy, CPM-80 = cut-off point 85% adequacy, CPM-75= cut-off point 70% adequacy

The advantage of the PBM compared to the CPM is that the MD prevalence was closer to the actual prevalence of inadequacy (de Lauzon *et al.* 2004). Meanwhile, the CPM was simpler to calculate, but this method may lead to misclassification of individuals who belong to inadequate categories (Jensen *et al.* 1992; Murphy & Poss 2002). Jensen *et al*. (1992) proposed to use the PBM to avoid this misclassification. The weakness of the PBM is, it is unable to identify any particular individual as having an adequate or inadequate intake. It is only able to assess the MD of a group or population (de Lauzon *et al.* 2004).

## CONCLUSION

The present study concludes that the intakes of micronutrient (Ca, Fe, Zn, and vitamin D) among Indonesian adolescent were far below the requirement. The prevalence of Ca, Fe, Zn and vitamin D calculated using the PBM were 96.63%, 71.85%, 77.48%, and 95.99%, respectively. These prevalence were higher than the prevalence obtained from CPM-85 and CPM-70. The density of each of the micronutrient was also classified as inadequate. This implies that micronutrient deficiencies were prevalent among Indonesian adolescents and their nutrient density were also largely inadequate. This findings emphasize the importance of improvement in the quantity and quality of micronutrient intakes among Indonesian adolescents through increasing the consumption of fish, meat, eggs, milk (animal source food) as well as legumes and green vegetables.

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