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Risk Factors of Stunting among School-Aged Children from Eight Provinces in Indonesia

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Abstract: Stunting adversely affects the physical and cognitive outcome of school-aged children. However, very limited information available on risk factors of stunting among Indonesian school-aged children (ISC). This study was aimed to analyze risk factors of stunting among ISC. This study used electronic files data of Basic Health Research 2010 of the Health Research and Development Agency of the Ministry of Health, which was designed as cross-sectional survey. A total of 8710 children aged 6-12 years from eight provinces in Indonesia were selected for the analysis. Stunting and severe stunting were defined as height-for-age z-score (HAZ) of <-2 Standard Deviation (SD) and <-3 SD of the WHO reference, respectively. A logistic regression was used to analyze risk factors of stunting. The result showed that 28.11% of ISC were stunting and of the stunted children, 11.38% were severely stunting. In multivariate logistic regression analyses adjusted for all factors, stunting was associated with low household expenditure, low Healthy Eating Index score, low maternal height, low maternal education, higher family member, low energy and protein adequacy level, older age, living in rural area, male sex, low sanitation score and higher phosphor and vitamin C adequacy level.

Key words: Stunting, school-aged children, risk factors, Indonesia

INTRODUCTION

One of the essential early life cycle stage is school-aged children. Based on the results of Indonesia Basic Health Research (Riskesdas) in 2010, the national prevalence of stunting among school aged children (6-12 years old) was 35.6 and 15.1% categorized as severe stunting (Balitbangkes, 2010). Stunting or linear growth disorder is the long-term impact of the problem of malnutrition that occurs in children in developing countries. Stunting is a major public-health problem in low and middle income countries because of its association with increased risk of mortality during childhood. Apart from causing significant childhood mortality, stunting also leads to significant physical and functional deficits among survivors. Stunting contributes to 14.5% of annual deaths and 12.6% of disability adjusted life-years (DALYs) in under-five children (ACC/SCN, 2000; WHO, 2000; Lancet, 2008). The long-term consequences of stunting include short stature, reduced capacity of work and increased risk of poor reproductive performance (Lancet, 2008). Stunting can also affect the development of cognitive functions. Research on school-aged children who experienced stunting showed poor tests of attention, working memory, learning and the visuospatial ability. Stunting affects the development of cognitive processes during school-aged period (Kar *et al*., 2008). In developing countries, most deaths in children are among the under-five children (Senbanjo *et al*., 2011) and it is commonly believed that stunting occurs mainly in young children (Martorell *et al*., 1994; Partnership for Development, 2002). Therefore, there was paucity of research that focuses on the stunting of school-aged children (Friedman *et al*., 2005). In addition, there was still the assumption that school-aged children can survive in the most critical period and were no longer susceptible to nutritional and health problems. However, many infectious diseases suffered by school-aged children (ACC/SCN, 2000). The high level of nutrition problem combined with disease infection during school-aged period has negative consequences for children's development in the long-term period (Partnership for Development, 2002). Several studies have shown that during school-aged period, children was less experienced catch-up growth or remain stable even experienced stunting (Friedman *et al*., 2005) which may affect attendance and learning process in school (ACC/SCN, 2000). The degree of severity of stunting in stunted school-aged children is likely to increase during the school-aged period (Partnership for Development, 2002). Longitudinal studies demonstrate that weight and height decline further from the international reference median over time (Stoltzfus *et al*., 1997).

Internationally, there were few studies that examine the various factors related to the risk of stunting in school-aged children (Friedman *et al*., 2005; Khuwaja *et al*., 2005; Dekker *et al*., 2010; Mushtaq *et al*., 2011;

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Senbanjo *et al*., 2011). In Indonesia, study of risk factors of stunting so far mostly done in under-five children. There have been some researches to analyze relationship of several factors with stunting in school aged children in Indonesia but only on small scale (Ginting, 2005; Norliani, 2005; Aramico, 2011; Dewi, 2012). In addition, Health Research and Development Agency of the Ministry of Health has conducted a Basic Health Research at national scale (Riskesdas) in 2010 that could potentially be analyzed to determine the risk factors for stunting in school-aged children in Indonesia. Therefore, the objectives of this study were to analyze relationship between characteristics of children and families, health care facilities and environmental sanitation, the incidence of infectious diseases (malaria), as well as the quantity and quality of food consumption stunting children with stunting among school-aged children.

MATERIALS AND METHODS

Subjects: This study used secondary data from Basic Health Research (Riskesdas) by Health Research and Development Agency of the Ministry of Health Indonesia in 2010 with a cross-sectional study design. The data analyzed in this study were from eight Provinces which selected according category of prevalence of stunting (WHO, 1997) were very high (≥40%) in East Nusa Tenggara and North Sumatra, high (30-39%) in West Nusa Tenggara and West Java, moderate (20-29%) in Bangka Belitung, Jakarta and Yogyakarta and low (<20%) in Bali. Subjects of this research are children aged 6-12 years from eight provinces. After a cleaning process, the number of children analyzed was 8710. Criteria for inclusion in this analysis are children of 6-12 years, the data -6 SD ≤HAZ ≤+6 SD (WHO, 2009) and had complete data.

Anthropometric data: Height data measured with a gauge height with a capacity of 2 m and precision measuring 0.1 cm. Weight data were measured with a digital weight scales which is calibrated every day. Anthropometric data were processed using software examples WHO Anthro Plus v1.0.4 (WHO, 2009). Z-scores based on HAZ, subjects are classified into two groups: children with normal nutritional status (≥-2 SD) and groups of children with stunting (<-2 SD) (WHO, 2007).

Dietary intake: Food consumption data obtained by the method of food recalls 1x24 h. Energy and protein adequacy levels were classified into three categories: (1) severe deficit levels (<70%), (2) moderate/mild deficit (70-89.99%), (3) sufficient (>90%) (Indonesian Ministry of Health, 1996). Percentage of energy from carbohydrate was categorized as deficit (<55%) and sufficient (≥55%), percentage of energy from protein was categorized as deficit (<10% for age 6-9 years and <15% for age 10-12 years) and sufficient (≥10% for age 6-9 years and ≥15% for age 10-12 years) and percentage of energy from fat was categorized as deficit (<35% for age 6-9 years and <30% for age 10-12 years) and sufficient (≥35% for age 6-9 years and ≥30% for age 10-12 years) (Hardinsyah *et al*., 2012). Adequacy levels of vitamins (A, B1 and C) and minerals (Ca, P, Fe and Zn) were categorized deficit (<77%) and sufficient (≥77%) (Gibson, 2005).

Quality of food consumption was analyzed by using the Healthy Eating Index (HEI). HEI used in this analysis has adapted to the Indonesia Nutrition Guideline (*Pedoman umum gizi seimbang*) by Nurdiani (2011). Score of HEI was categorized as poor if the score less than 50, need improvement when the score between 51 to 80 and categorized as good if the score more than 80 (Kennedy, 2008).

Social economic data: Subjects were asked using a questionnaire to determine subject characteristics (age and sex), family characteristics (maternal height, education level, age, smoking habits, pulmonary TB disease and anthropometric data of parents), the availability and utilization of health services, environmental sanitation and malaria infection on the subject.

Statistical analysis: Analysis data used Microsoft Excel 2007 and SPSS for Windows version 17.0. The t-test and one way ANOVA was used to determine mean difference of variable with data continues and mean HAZ. Chi-square test was used to determine relationship between independent variable with stunting. Multivariate analyzes were performed using logistic regression with Backward Wald method with statistical significance criteria of $p<0.05$ and the value of the confidence interval (CI) of 95%.

RESULTS

Prevalence of stunting in eight provinces was 28.11 and 11.38% were categorized as severe stunting. Provinces with the lowest and highest prevalence of stunting were Yogyakarta (15.5%) and East Nusa Tenggara (46.5%), respectively. Mean HAZ of stunted children (-3.06±0.93 SD) was significantly lower than normal children (-0.45±1.16 SD) ($p<0.05$). Mean WAZ (weight-for-age z-score) of stunted children (-1.77±1.41 SD) was significantly lower than normal children (-0.49±1.36 SD) ($p<0.05$). However mean BAZ (Body Mass Index-for-age z-score) significantly higher (0.05±1.89 SD) than normal children (-0.40±1.60 SD) ($p<0.05$).

There were significant relationship between children with older age (10-12 years), male children, low maternal height (<145 cm), paternal smoking habits,

Table 1: Children and family characteristics, health facilities, environmental sanitation and infection diseases

	-- Normal (n = 6262) --		-- *Stunting* (n = 2448) --		-- Total (n = 8710) --			
Variables	n	%	n	%	n	%	HAZ[(1)]	p-value[(2)]
Age								
6-9 years	3771	73.80	1339	26.20	5110	58.67	-1.09±1.67[a]	0.000
10-12 years	2491	69.19	1109	30.81	3600	41.33	-1.32±1.50[b]	
Mean±SD[(1)]	------- 8.84±1.96[a] --------		-------- 9.10±1.95[b] ---------		------- 8.91±1.96 --------			
Sex								
Female	3141	73.70	1121	26.30	4262	48.93	-1.15±1.58[a]	0.000
Male	3121	70.17	1327	29.83	4448	51.07	-1.21±1.63[a]	
Maternal height								
≥145 cm	5753	73.09	2118	26.91	7871	90.37	-1.13±1.63[a]	0.000
<145 cm	509	60.67	330	39.33	839	9.63	-1.67±1.34[b]	
Mean±SD[(1)]	----- 152.34±5.93[a] ------		------ 151.10±6.29[b] --------		----- 152.02±6.06 ------			
Father's age								
<40 years	2822	71.90	1103	28.10	3925	45.06	-1.22±1.60[a]	0.994
≥40 years	3440	71.89	1345	28.11	4785	54.94	-1.15±1.62[a]	
Mean±SD[(1)]	------ 41.36±7.67[a] -------		------- 41.25±8.12[a] --------		------ 41.33±7.80 --------			
Mother's age								
<40 years	4227	71.73	1666	28.27	5893	67.66	-1.18±1.61[a]	0.620
≥40 years	2035	72.24	782	27.76	2817	32.34	-1.18±1.60[a]	
Mean±SD[(1)]	------ 36.81±6.70[a] ------		------- 36.62±6.83[a] ---------		------- 36.75±6.73 ------			
Fathers's level education								
College	644	83.20	130	16.80	774	8.89	-0.64±1.58[a]	0.000
Middle-high school	2836	75.09	941	24.91	3777	43.36	-1.05±1.61[b]	
≤elementary school	2782	66.89	1377	33.11	4159	47.75	-1.40±1.57[c]	
Mothers's level education								
College	515	85.83	85	14.17	600	6.89	-0.50±1.52[a]	0.000
Middle-high school	2653	75.18	876	24.82	3529	40.52	-1.05±1.61[b]	
≤elementary school	3094	67.54	1487	32.46	4581	52.59	-1.37±1.58[c]	
Father's pulmonary TB status								
No	6118	71.82	2400	28.18	8518	97.80	-1.19±1.61[a]	0.333
Yes	144	75.00	48	25.00	192	2.20	-1.02±1.42[a]	
Mother's pulmonary TB status								
No	6164	71.87	2413	28.13	8577	98.47	-1.18±1.61[a]	0.644
Yes	98	73.68	35	26.32	133	1.53	-1.09±1.43[a]	
Father's smoking habits								
No	990	74.72	335	25.28	1325	15.21	-1.01±1.71[a]	0.013
Yes	5272	71.39	2113	28.61	7385	84.79	-1.21±1.59[b]	
Mother's smoking habits								
No	5881	72.08	2278	27.92	8159	93.67	-1.17±1.61[a]	0.138
Yes	381	69.15	170	30.85	551	6.33	-1.31±1.57[a]	
Father's BMI								
<18.5 kg/m^2	519	70.90	213	29.10	732	8.43	-1.31±1.48[a]	0.000
18.5-24.99 kg/m^2	4325	69.65	1885	30.35	6210	71.54	-1.26±1.63[a]	
≥25 kg/m^2	1394	80.21	344	19.79	1738	20.02	-0.84±1.54[b]	
Mean±SD[(1)]	------ 22.70±3.40[a] ------		------- 22.05±2.95[b] --------		------ 22.51±3.29 -------			
Mother's BMI								
<18.5 kg/m^2	352	64.23	196	35.77	548	6.29	-1.38±1.70[a]	0.000
18.5-24.99 kg/m^2	3639	69.86	1570	30.14	5209	59.81	-1.26±1.63[a]	
≥25 kg/m^2	2271	76.90	682	23.10	2953	33.90	-1.02±1.53[b]	
Mean±SD[(1)]	------ 24.11±4.14[a] ------		------- 23.22±3.84[b] --------		------ 23.86±4.08[a] ------			
Family member								
≤4	2867	75.71	920	24.29	3787	43.48	-1.04±1.61[a]	0.000
5-7	3025	70.60	1260	29.40	4285	49.20	-1.23±1.59[b]	
≥8	370	57.99	268	42.01	638	7.32	-1.73±1.59[c]	
Mean±SD[(1)]	------ 4.94±1.48[a] -------		-------- 5.31±1.66[b] --------		------- 5.04±1.54 --------			
Household expenditure								
Quintile 3-5	3743	79.83	946	20.17	4689	53.83	-0.88±1.55[a]	0.000
Quintile 1-2	2519	62.65	1502	37.35	4021	46.17	-1.54±1.60[b]	
Living area								
Urban	3718	77.06	1107	22.94	4825	55.40	-0.94±1.63[a]	0.000
Rural	2544	65.48	1341	34.52	3885	44.60	-1.48±1.52[b]	
Health facilities								
Minimum there was 1 and have utilized	4823	72.47	1832	27.53	6655	76.41	-1.17±1.58[a]	0.031
No facilities and never utilized	1439	70.02	616	29.98	2055	23.59	-1.21±1.69[a]	
Environment sanitation score								
Good (>80%)	2179	76.81	658	23.19	2837	32.57	-0.94±1.66[a]	0.000
Moderate (60-80%)	3178	72.31	1217	27.69	4395	50.46	-1.19±1.55[b]	
Poor (<60%)	905	61.23	573	38.77	1478	16.97	-1.63±1.57[c]	
Mean±SD[(1)]	----- 73.97±13.55[a] ------		------ 70.14±14.90[b] -------		----- 72.90±14.05 -------			

Table 1: Continued

	-- Normal (n = 6262) --		-- *Stunting* (n = 2448) --		-- Total (n = 8710) --			
Variables	n	%	n	%	n	%	HAZ[(1)]	p-value[(2)]
Children's malaria status								
No	6122	71.91	2391	28.09	8513	97.74	-1.18±1.61[a]	0.794
Yes	140	71.07	57	28.93	197	2.26	-1.29±1.56[a]	
Total	6262	71.89	2448	28.11	8710	100.00		

[(1)]t-test (2 categories), one way Anova (3 categories), different letters at the same row/column showed p<0.05; [(2)]chi-square

parental BMI <18.5 kg/m^2, large family (≥8 member), low household expenditure (quintiles 1 and 2), living in rural areas, there is no and never used health care facilities and low environmental sanitation score (<60%) with stunting in school-aged children. There is no significant relationship between malaria with stunting in school aged children.

Mean energy and nutrients adequacy level of stunted children significantly lower than normal children, except for vitamin A and C. Mean vitamin A and C adequacy level were higher in stunted children than normal children but only vitamin C which significantly different between stunted and normal children (p<0.05). Percentage of energy from carbohydrate, fat and protein is significantly lower in stunted children compared to normal children (p<0.05). Energy and nutrients adequacy level significantly associated with stunting in school-aged children (p<0.05), except for vitamin A adequacy level. There was a significant relationship between the percentage of energy from carbohydrate, fat and protein with stunting in school-aged children (p<0.05). There were 65.03% of children who have poor quality food consumption and only 12.23% children have good quality food consumption. There was a significant relationship between categories of HEI score with stunting in school-aged children (p<0.05).

Based on logistic regression analysis, risk factors of stunting in school-aged children are low household expenditure (quintile 1 and 2), low Healthy Eating Index score (<50), low maternal height (<145 cm), low maternal education (middle-high school and ≤elementary school), higher family member (≥8 member), low energy and protein adequacy level (<70%), older age (age 10-12 years), living in rural area, male sex, low sanitation score (<60%) and higher phosphor and vitamin C adequacy level (≥77%).

DISCUSSION

The average prevalence of stunting in eight provinces based on the analysis was 28.11%, lower than the national average (35.6%). Prevalence of stunting based on this analysis tends to be lower compared to the report of Basic Health Research (Riskesdas) 2010, except in Bali province. Those differences, presumably because the calculation of the prevalence of stunting in this analysis consider multiple inclusion and exclusion criteria.

Mean BAZ of stunted children significantly higher (0.05±1.89 SD) than normal children (-0.40±1.60 SD) (p<0.05). This data showed that stunted children tend to be overweight than normal children. Popkin *et al*. (1996) showed that there was a significant relationship between stunting with overweight status in children aged 3-9 years in four countries (Russia, Brazil, South Africa and China). Popkin *et al*. (1996) also showed that risk of stunted children to become overweight was 1.7 to 7.8 times higher than normal children. Similar results were also obtained by Bove (2012) which showed that risk of stunted infant is almost three times higher to become overweight (OR = 2.7, 95% CI:1.8-4.1). The relationship between stunting with overweight/obesity can be explained by the mechanism of a slowdown in growth and response to hormonal changes combined with poor quality of food consumption. Stunted children have less lean body mass, therefore resulting in a decreased basal metabolic rate and physical activity. When energy intake was insufficient, there was a difference between the linear growth potential with adipose tissue deposition. This can happen for several reasons, children consumed diet which did not contain enough essential nutrients for linear growth but contain enough nutrients that can improve adipose tissue deposition. Early nutrition programming process is likely to produce a limited hormonal influence on linear growth but for potential weight gain there was no limited of hormonal influences. Stunting causes a series of important changes include lower energy expenditure, more susceptible to the effects of a fat high diet, lower fat oxidation (Sawaya and Roberts, 2003) as well as impaired lipid metabolism (Li *et al*., 2010). Coexisting of stunting and overweight in school-aged children can describe aspects of the nutrition transition (Jinabhai *et al*., 2003).

Children with older age increases the risk of child stunting is also in line with Friedman *et al*. (2005), Mushtaq *et al*. (2011) and Senbanjo *et al*. (2011). Longitudinal research by Friedman *et al*. (2005) suggests that school-aged children in the developing world do not experience significant 'type A' catch-up growth (accelerated growth velocity following an insult to growth) or remain stable. School-aged children, who remain in the same environments, continue to deviate from NCHS standards, accruing greater height deficits with age. It is possible that these deficits are made up through Type B catch-up growth, a later onset of pubertal growth spurt, which allows a longer period of middle childhood growth (Friedman *et al*., 2005). In addition,

Table 2: Energy and nutrient adequacy level and Healthy Eating Index score

	Normal (n = 6262)		*Stunting* (n = 2448)		Total (n = 8710)			
Variables	n	%	n	%	n	%	HAZ[(1)]	p-value[(2)]
Energy adequacy level								
Sufficient (≥90%)	1948	77.98	550	22.02	2498	28.68	-0.95±1.55[a]	0.000
Mild-moderate deficit (70-89.99%)	1697	75.22	559	24.78	2256	25.90	-1.01±1.69[a]	
Severe deficit (<70%)	2617	66.15	1339	33.85	3956	45.42	-1.43±1.56[b]	
Protein adequacy level								
Sufficient (≥90%)	2717	77.52	788	22.48	3505	40.24	-0.93±1.63[a]	0.000
Mild-moderate deficit (70-89.99%)	1453	73.05	536	26.95	1989	22.84	-1.20±1.59[b]	
Severe deficit (<70%)	2092	65.05	1124	34.95	3216	36.92	-1.44±1.56[c]	
Calsium adequacy level								
Sufficient (≥77%)	1129	74.18	393	25.82	1522	17.47	-1.02±1.67[a]	0.029
Deficit (<77%)	5133	71.41	2055	28.59	7188	82.53	-1.21±1.59[b]	
Phospor adequacy level								
Sufficient (≥77%)	3144	75.31	1031	24.69	4175	47.93	-1.02±1.66[a]	0.000
Deficit (<77%)	3118	68.75	1417	31.25	4535	52.07	-1.33±1.54[b]	
Fe adequacy level								
Sufficient (≥77%)	2875	75.16	950	24.84	3825	43.92	-1.03±1.64[a]	0.000
Deficit (<77%)	3387	69.33	1498	30.67	4885	56.08	-1.30±1.57[b]	
Vit A adequacy level								
Sufficient (≥77%)	1985	71.95	774	28.05	2759	31.68	-1.17±1.62[a]	0.941
Deficit (<77%)	4277	71.87	1674	28.13	5951	68.32	-1.19±1.60[a]	
Vit B1 adequacy level								
Sufficient (≥77%)	2497	73.44	903	26.56	3400	39.04	-1.06±1.65[a]	0.010
Deficit (<77%)	3765	70.9	1545	29.10	5310	60.96	-1.26±1.57[b]	
Vit C adequacy level								
Sufficient (≥77%)	1397	67.82	663	32.18	2060	23.65	-1.35±1.56[a]	0.000
Deficit (<77%)	4865	73.16	1785	26.84	6650	76.35	-1.13±1.62[b]	
Zn adequacy level								
Sufficient (≥77%)	616	75.96	195	24.04	811	9.31	-0.95±1.59[a]	0.007
Deficit (<77%)	5646	71.48	2253	28.52	7899	90.69	-1.21±1.61[b]	
Energy from carbohydrate								
Sufficient (≥55%)	2299	74.84	773	25.16	3072	35.27	-1.08±1.59[a]	0.000
Deficit (<55%)	3963	70.29	1675	29.71	5638	64.73	-1.24±1.61[b]	
Energy from fat								
Sufficient (≥35% (6-9 yrs); ≥30% (10-12 yrs))	607	79.66	155	20.34	762	8.75	-0.75±1.64[a]	0.000
Deficit (<35% (6-9 yrs); <30% (10-12 yrs))	5655	71.15	2293	28.85	7948	91.25	-1.22±1.60[b]	
Energy from protein								
Sufficient (≥10% (6-9 yrs); ≥15% (10-12 yrs))	1583	77.90	449	22.10	2032	23.33	-0.88±1.68[a]	0.000
Deficit (<10% (6-9 yrs); <15% (10-12 yrs))	4679	70.07	1999	29.93	6678	76.67	-1.28±1.57[b]	
HEI score								
Good (>80)	17	85.00	3	15.00	20	0.23	-0.82±1.34[ab]	0.000
Need improvement (51-80)	2401	79.35	625	20.65	3026	34.74	-0.83±1.54[a]	
Poor (<50)	3844	67.87	1820	32.13	5664	65.03	-1.37±1.61[b]	
Mean±SD[(1)]	--- 46.63±12.00[a] ---		--- 41.88±12.12[b] ----		---- 45.30±12.22 ----			
Total	6262	71.89	2448	28.11	8710	100.00		

[(1)]t-test, for energy and protein adequacy level and HEI score used one way Anova, different letters at the same column showed p<0.05; [(2)]chi-square

older children have increased nutritional needs due to the acceleration of growth but these needs were not met (Dekker *et al*., 2010).

Results of this analysis showed that male children have higher risk than female children to become stunted because of the same age, male children needed more nutrients such as pyridoxine, zinc and manganese according to Indonesia Recommended Dietary Intake (WNPG, 2004). However, those nutritional needs were not met properly. Moreover, female children had gone through growth spurt than male children, therefore male children experienced greater deficits of height than female children when compared with international reference standards. Lwambo *et al.* (2000) showed that after age 12 years, female children HAZ showed improvement but the male children HAZ continued to decline until the age of 16 years old.

This analysis showed that low maternal height associated with stunting in school-aged children. This is suggestive of the importance of early life factors. Conditions that lead to chronic malnutrition in the mother during pregnancy can affect the offspring. The association of maternal height and offspring health has a biomechanical plausibility (shorter women have narrower pelves that increase the likelihood of cephalopelvic disproportion and obstructed labor) and a

Table 3: Risk factors of stunting in school-aged children based on logistic regression

Variables	β	OR (95% CI)	p-value(1)
Household expenditure (quintile 3-5 = 0)			
Quintile 1 and 2	0.545	1.724 (1.548-1.920)	0.000
HEI score (good, >80 = 0)			
Poor (<50)	0.499	1.647 (1.475-1.840)	0.000
Maternal height (≥145 cm = 0)			
<145 cm	0.460	1.585 (1.359-1.848)	0.000
Mother's level of education (college = 0)			
Middle-high school	0.377	1.458 (1.137-1.869)	0.003
≤elementary school	0.400	1.491 (1.158-1.922)	0.002
Member of family (≤4 member = 0)			
≥8 member	0.315	1.370 (1.151-1.630)	0.000
Energy adequacy level (sufficient, ≥90% = 0)			
Severe deficit (<70%)	0.289	1.335 (1.193-1.493)	0.000
Children's age (6-9 years = 0)			
10-12 years	0.282	1.326 (1.176-1.496)	0.000
Living area (urban = 0)			
Rural	0.213	1.238 (1.112-1.377)	0.000
Children's sex (female = 0)			
Male	0.197	1.218 (1.105-1.342)	0.000
Protein adequacy level (sufficient, ≥90% = 0)			
Severe deficit (<70%)	0.159	1.172 (1.035-1.327)	0.012
Environmental sanitation score (good, >80% = 0)			
Poor (<60%)	0.132	1.141 (1.001-1.301)	0.049
Phospor adequacy level (sufficient, ≥77% = 0)			
Deficit (<77%)	-0.136	0.873 (0.763-0.998)	0.046
vit C adequacy level (sufficient, ≥77% = 0)			
Deficit (<77%)	-0.167	0.846 (0.754-0.949)	0.004
Constant	-2.520	0.080	0.000

(1)logistic regression, significant at $p<0.05$

biological plausibility (in shorter mothers who may have lower health stock, the supply of nutrients to the fetus may be inadequate, leading to intra uterine growth restriction and low birth weight, which can influence offspring health and survival). For mothers, limited nutrient supply at the cellular level during their development may lead to maintenance of basic metabolic functions taking precedence and resources being diverted away from growth, resulting in growth retardation and shortened stature. Because attained adult height reflects the stressful nutritional environment of the mother in early life, a plausible interpretation of an association between maternal stature and offspring health also reflects the intergenerational transfer of socioeconomic adversity (Ozaltin *et al*., 2010).

Low mother's education level also one of a risk factor stunting in school-aged children. Educated parents will earn more, more exposed to the media, not illiterate, higher participation in the labor market, better knowledge of nutrition and health and mother have greater authority in the home (Aslam and Kingdon, 2012). Higher mother's education level will support the increased contribution to the family income so that she can improve the socioeconomic status of the family and child nutritional status. If mothers have a better education and knowledge on health care, they may have better knowledge of proper health and nutrition behaviors for their families (Shang *et al*., 2010).

This analysis shows the majority of fathers have smoking habits and there was significant association with stunting. Percentage of fathers who have smoking habits in this analysis was higher than results of Semba *et al*. (2007) and Best *et al*. (2008) which showed that 73.8 and 73.1% fathers of the poorest families in urban and rural Indonesia have smoking habits, respectively. Semba *et al*. (2007) and Best *et al*. (2008) also showed a significant relationship between father smoking status with stunted infants in the urban and rural poor families Indonesia. No significant association between mother smoking status with stunting in school-aged children in this analysis, probably because the percentage of mother who have smoking habits very low (6.33%), although there was a trend of higher prevalence of stunted children on mothers who have smoking habits (30.85%) than non-smokers mothers (27.92%). In the household with father who has smoking habits, the proportion of weekly expenditure per capita for food with good quality such as eggs, fish, fruits and vegetables reduced. Semba *et al*. (2007) showed that smoking contribute for household expenditure per capita weekly by 22% in urban poor households in Indonesia.

This analysis showed children from large family have higher risk of stunting. Senbanjo *et al*. (2011) also showed similar results. There was significantly higher prevalence of stunting among children from polygamous families (families with a large number of members). The more family members who live in one house, the smaller the amount of food obtained by children, especially in poor families. Moreover, this situation also increases the risk of overcrowding that will lead to spreading of diseases such as acute respiratory infections and diarrhea which can lead to malnutrition.

Lower household expenditure also increases the risk of stunting in school-aged children. Households with lower socioeconomic status are more susceptible to food insecurity due to low food consumption and will have limited access to food in the long-term period due to low purchasing power of animal food (Dekker *et al.*, 2010) as well as limited access to health services because of the high cost of health care. Parents from lower social class households also typically have low education level (Mushtaq *et al.*, 2011).

This analysis showed that children who living in the rural area have higher risk of stunting. That can be explained due to socioeconomic status gap between rural and urban area (Mushtaq *et al.*, 2011). Children who living in the rural area tend to be from lower socioeconomic status, so they have limited access to food consumption with good quality (animal food), environmental sanitation conditions are worse and have limited access to health care and good education and other social support systems.

This analysis showed that there was a relationship between the facility availability and the utilization of health services with stunting in school-aged children ($p<0.05$). The result is in line with Hidayat and Jahari (2012) who analyzed the Basic Health Research data 2007. The result showed that there was a significant association ($p<0.001$) between mother's behavior to utilize more health care services with nutritional status of under-five children. Ginting (2005) also proved that the mother's participation in health activities associated with height of elementary school children (OR = 2.12).

This analysis proves that children with poor environmental sanitation score have HAZ significantly lower compared to children with moderate and good environmental sanitation score ($p<0.05$). This result is in line with Merchant *et al.* (2003) who showed that the mean HAZ at baseline and end of study (-1.66 and -1.55) for the group with water and sanitation facilities, higher than the mean HAZ of the group without water and sanitation facilities (-2.03 and -1.94). Fink *et al.* (2011) also proved that access to improved sanitation can significantly reduce the risk of stunting (OR = 0.73, 95% CI: 0.71-0.75). Access to good quality of drinking water also can significantly reduce the risk of stunting (OR = 0.92, 95% CI: 0.89-0.94) in more than 1 million under-five children from 70 developing countries during 1986-2007. Merchant *et al.* (2003) showed that among stunted under-five children at baseline and homes with water and sanitation facilities have a 17% greater chance to get back to normal nutritional status compared with the infants without such facilities (RR = 1.17, 95% CI: 0.99-1.38).

This analysis has not been able to prove an association between malaria with stunting in school-aged children ($p>0.05$). This is presumably because very few children that have been diagnosed with malaria. Moreover, this analysis is only performed on the eight provinces which were not malaria-endemic regions, except East Nusa Tenggara. Results of this analysis were not able to prove an association between malaria with stunting in school-aged children also presumably because subjects of this analysis were older children (6-12 years old). Malaria is an important cause of child malnutrition only in certain age groups, especially under-five children, so that the burden of malaria in school-aged children is lower because they have better immunity. Malaria can cause malnutrition through several mechanisms, including decreased intake due to anorexia or triggered catabolic conditions (Nyakeriga *et al.*, 2004).

This analysis showed that the children had multiple micronutrient deficiencies. Mineral deficiencies usually occur together, such as iron and zinc deficiency. This is due to factors food consumption, such as the high content of phytate and fibers (Neumann *et al.*, 2003) in the diet so that the bioavailability of iron and zinc is low (Dijkhuizen *et al.*, 2008). In this analysis, stunted children significant consume more vegetables than normal children ($p<0.05$). Vegetables were high phytate and fiber food which can reduce bioavailability of minerals particularly calcium, iron and zinc. In addition, stunted children also consume low animal food which was known to be sources of heme iron and zinc with higher bioavailability.

Results of this analysis showed that the energy and nutrients intake of stunted children were lower than normal children. That results in line with Gibson *et al.* (2007) who analyzed 567 children aged 6-13 years in Thailand. Gibson *et al.* (2007) showed that stunted boys have average intake of energy, protein, calcium, phosphorus and zinc lower than normal boys. Lee *et al.* (2012) who analyzed the nutrient intake of 143 children aged 2-14 years in South Korea showed that the intake of protein, fat, calcium and iron of stunted children also lower than normal children.

Children with energy and protein adequacy level <70% have risk 1.335 and 1.172 times higher for stunting compared with children with energy and protein adequacy level $\geq$90%. Energy intake can be a risk factor for stunting because at low energy intake, intake of other nutrients will also be low (Allen, 1994). Results of cohort study in the Philippines by Eckhardt *et al.* (2005) showed that every additional energy intake of 100 kcal significantly associated with an increase in height of 0.05 cm in men and 0.02 cm in women. Significant interaction with socioeconomic status indicates that any increase in energy intake of 100 kcal associated with an increase in height of 0.08 cm in sample with low socioeconomic status. Protein intake was a risk factor for stunting was also shown by Assis *et al.* (2004) and Stephenson *et al.* (2010). Assis *et al.* (2004) who studied 461 children aged 7-14 years in Brazil showed that total protein intake less than the median value

(47.8 g/day) increased the risk of stunting 1.59 times higher (95% CI: 1.02-2.48, p = 0.04) but energy intake was not proved as risk factor for stunting (OR = 1.29, 95% CI: 0.83-2.01, p = 0.25). Stephenson *et al.* (2010) prove that the HAZ was directly related to protein intake in children aged 2-5 years in Kenya and Nigeria. Low protein intake also coexisted with low intake of nutrients, such as iron, zinc, copper, calcium and vitamin A (Allen, 1994).

Healthy Eating Index (HEI) score as indicator of quality of the food consumption proved to be the risk factors of stunting in school-aged children. HEI score even become the second biggest risk factor after household expenditure with OR of 1.647 (95% CI: 1.475-1.840). That showed that children with poor HEI score (<50), the risk for stunting 65% higher than the children with a good HEI score (>80). Based on our knowledge, this study is the first to analyze the relationship between qualities of food consumption using HEI with stunting in school-aged children in Indonesia. Although the results of this study indicate that HEI score was a significant risk factor for stunting in school-aged children but these results need to be interpreted carefully. This is because the HEI has not been validated on the subject of Indonesian population. Based on our knowledge, only one study in Indonesia has been using the HEI (Nurdiani, 2011). Nurdiani (2011) measured the quality of the lunch menu primary school children in Bogor and did not measure the quality of food consumption and analyzed with any nutritional status indicator, particularly stunting. So far, HEI has not been adapted to the Indonesian Nutrition Guideline like HEI Thailand (Taechangam *et al.*, 2008) and validated on the subject of Indonesian population. Waijers and Feskens (2005) also stated that HEI may not be a good predictor of health status or be able to predict health outcomes, such as nutritional status. However, with a proven relationship the HEI score with of stunting based on this analysis, at least some components of the HEI was closely associated with stunting such as consumption of animal and plant protein (as an indicator of protein and micronutrients intake with high bioavailability), consumption of vegetables and fruit (as indicator of micronutrient intake), Fe intake and food diversity proved to be a factor that can affect stunting in the school-aged children.

Conclusion: Risk factors of stunting in school-aged children are low household expenditure (quintile 1 and 2), low Healthy Eating Index score (<50), low maternal height (<145 cm), low maternal education (middle-high school and ≤elementary school), higher family member (≥8 member), low energy and protein adequacy level (<70%), older age (age 10-12 years), living in rural area, male sex, low sanitation score (<60%) and higher phosphor and vitamin C adequacy level (≥77%).

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