Check for updates

RESEARCH ARTICLE

REVISED Comparison of WHO growth standard and national Indonesian growth reference in determining prevalence and determinants of stunting and underweight in children under five: a cross-sectional study from Musi sub-district [version 4; peer review: 2 approved]

Previously titled: Comparison of WHO growth standard and Indonesian growth standards in determining prevalence and determinants of stunting and underweight in children under five: a cross-sectional study from Musi sub-district

Jeannie Flynn [ID] 1*, Firas Farisi Alkaff [ID] 2*, William Putera Sukmajaya 3, Sovia Salamah 4

1 Oeolo Primary Healthcare, Jln. Tetu Neno, Timor Tengah Utara District, East Nusa Tenggara Province, 85662, Indonesia
2 Department of Pharmacology, Faculty of Medicine, Universitas Airlangga, Jl. Mayjend Prof. Dr. Moestopo No 47, Surabaya, East Java, 60132, Indonesia
3 Department of Orthopedics and Traumatology, Faculty of Medicine, Brawijaya University, Jl. Jaksa Agung Suprapto No 2, Malang, East Java, 65111, Indonesia
4 Department of Public Health and Preventive Medicine, Faculty of Medicine, Universitas Airlangga, Jl. Mayjend Prof. Dr. Moestopo No 47, Surabaya, East Java, 60132, Indonesia

* Equal contributors

Open Peer Review

Reviewer Status ✓ ✓

	Invited Reviewers	
	1	2
version 4 (revision) 15 Mar 2021		
version 3 (revision) 17 Jun 2020		
version 2	✓ report	✓ report

Abstract

Background: Determination of stunting and wasting always uses the WHO growth standard in Indonesia. However, it is believed that Indonesian children are "below" the global standard, thus the WHO standard is not reliable to present the actual prevalence. This study aims to compare the prevalence and determinants of stunting and underweight using WHO growth standard and national Indonesian growth reference.
Methods: This was a cross-sectional study carried out in Musi sub-district, East Nusa Tenggara province in July 2019. East Nusa Tenggara

province had the highest prevalence of stunting and underweight in Indonesia. The study population were children under five, and total sampling method was used for this study. Length/height-for-age and weight-for-age were plotted using WHO standard and national Indonesian reference. Univariate and multivariate binomial logistic regression were used for statistical analysis.

Results: The prevalence of stunting and underweight were higher for the WHO standard than the national reference (53.9% vs 10.7% and 29.17% vs 17.7%; all p < 0.001). After adjusted for confounding factors, when the WHO standard was used, determinants of stunting were maternal mid-upper arm circumference below 23.5cm and maternal height below 150cm; determinants of underweight were intrauterine growth restriction, young maternal age during pregnancy, and multiple parities. When the national reference was used, no determinants was found for stunting; the determinants of underweight were intrauterine growth restriction and maternal education.

Conclusions: The WHO standard is not suitable for representing child growth in Musi sub-district. Future studies should be done to re-evaluate the prevalence and determinants of stunting and underweight nationwide using the national Indonesian reference.

Keywords
growth chart, Indonesia, risk factors, stunting, underweight

Corresponding author: Firas Farisi Alkaff (firasfarisialkaff@fk.unair.ac.id)

Author roles: Flynn J: Conceptualization, Formal Analysis, Investigation, Project Administration, Writing – Review & Editing; **Alkaff FF**: Conceptualization, Data Curation, Formal Analysis, Supervision, Writing – Original Draft Preparation; **Sukmajaya WP**: Formal Analysis, Methodology, Writing – Original Draft Preparation; **Salamah S**: Formal Analysis, Methodology, Writing – Review & Editing

Introduction

According to the data from 2011, the global incidence of stunting, underweight, and wasting were approximately 164.8 million (25.7%), 100.7 million (15.7%), and 51.5 million (8%) among children under five, respectively. Meanwhile, the global deaths attributed to stunting, underweight, and wasting were approximately 1.017 million (14.7%), 999,000 (14.4%), and 875,000 (12.6%)[1]. Until 2018, stunting and wasting rates remained alarming, although the prevalence was declining. Among continents, Asia has the highest prevalence of stunting (55%) and wasting (68%). Based on country income classification, 65% of all stunted and 73% of all wasted children live in lower- and middle-income countries[2]. However, in the 2018 report, there is no updated data regarding the prevalence of underweight.

The latest basic health survey in Indonesia in 2018 showed that the prevalence of stunting, underweight, and wasting was 30.8%, 17.7%, and 10.2%, respectively. Among other provinces in Indonesia, East Nusa Tenggara province has the highest prevalence of stunting and underweight, at 42.6% and 29.5%, respectively. Meanwhile, the prevalence of wasting was lower, ranked 8th out of 35 provinces[3]. According to child growth severity classification, the severity of stunting is high and underweight is medium in Indonesia. In East Nusa Tenggara province, the severity of stunting is very high, and the severity of underweight is high[4].

However, determination of stunting and wasting always uses the WHO growth standard in Indonesia. It is believed that Indonesian children are "below" the global standard in general, thus the WHO standard is not reliable to present the actual prevalence. Therefore, the national Indonesian growth reference was made using data from National Basic Health Survey[5]. To this date, no study has been done to scrutinize the difference between WHO growth standard and national Indonesian growth references. This study aims to compare the prevalence and determinants of stunting and underweight using WHO growth standard and Indonesian growth reference. We use the data from one of the sub-districts in East Nusa Tenggara province because this province had the highest prevalence of stunting and underweight among children under five in Indonesia.

Methods
Ethical statement
This study followed the principles of the Declaration of Helsinki and was approved by the Department of Health Timor Tengah Utara district (approval number: DINKES.440/995/XI/2019). This study also complies with STROBE guidelines[6,7]. All parents gave their written informed consent prior to their children's inclusion in the study. Information for informed consent was given before the informed consent form was signed. Details that might disclose the identity of the study subjects were omitted from the published data file.

Study design and population
This study was an observational cross-sectional study conducted in Musi sub-district, one of the sub-districts in East Nusa Tenggara province. Participant recruitment and data collection were conducted in July 2019. Data analysis was conducted in October – December 2019. There were six villages in Musi sub-district. The study population were children aged less than five years old. Total sampling was used for this study. The children and their parents were approached face-to-face by JF during the monthly growth monitoring program in Posyandu ("Pos Pelayanan Terpadu"), a healthcare program by the Indonesian government. Inclusion criteria were children under five who attended the growth monitoring program during the study period, who were born and live with their parents in Musi sub-district, and had maternal and child health books (*Buku Kesehatan Ibu dan Anak* / KIA) published by the Ministry of Health Republic Indonesia. Children with incomplete KIA was excluded from the determinants analysis.

Data collection
Both primary and secondary data was used in this study. Primary data for this study consisted of data obtained through interviews with parents, child anthropometry measurements, and maternal height measurements. The interviews took place in the same location as the Posyandu and were conducted by JF using a predetermined questionnaire. The length of the interview was around five minutes. JF is a female general practitioner who worked in primary healthcare in the sub-district where the study took place. She had worked there for seven months when the study was conducted. Interviews with parents was carried out to obtain information regarding village of origin, parents' highest education, number of parities, delivery method, and sex and age of their children. Anthropometry measurements of maternal height and child length/height were done by healthcare workers from Oeolo Primary Healthcare. Secondary data from KIA was used to obtain data regarding birthweight, gestational age, maternal mid-upper arm circumference, and maternal age during pregnancy.

Categorization of variables
Underweight and stunting were categorized using WHO growth standard and national Indonesian growth reference for the same sex[5,8]. Underweight is defined as weight for age below -2 standard deviations (SD), and severe underweight is defined as weight for age below -3 SD. Stunting is defined as length/height for age below -2 SD, and severe stunting is defined as length/height for age below -3 SD. The cut-off level for maternal mid-upper arm circumference was 23.5 cm, for maternal height was 150 cm, and for children's birthweight was 2500 g. The cut-off level for maternal mid-upper arm circumference was according to the Indonesian national cut-off[9], while for maternal height and children's birthweight, the cut-off was based on a previous study[10]. Maternal age during pregnancy was categorized

to <20 years old, 20–35 years old, and >35 years old. Gestational age and intrauterine growth were categorized based on Lubchenco charts. It categorizes the gestational age to preterm (<37 weeks), term (37–42 weeks), or postterm (>42 weeks) and the intrauterine growth to small for gestational age (SGA) (<10th percentile), appropriate for gestational age (AGA) (10th – 90th percentile), or large for gestational age (LGA) (>90th percentile)[11].

Statistical analysis

Acquired data was analysed using SPSS Statistic for Windows, version 25.0 (IBM Corp., Armonk, N.Y., USA). Data analysis was conducted in two phases. In the first phase, univariate logistic regression was used to identify independent variables that were associated with stunting or underweight. Variables with $p < 0.1$ were included in the next phase. In second phase, multivariate logistic regression using backward selection was used. Variables with $p < 0.05$ from multivariate analysis were considered as the determinants.

Results

There was a total of 408 children under five in Musi sub-district. Based on WHO standard, the prevalence of stunting and underweight were 53.9% and 29.17%, respectively[12,13]. Using national reference, the prevalence of stunting and underweight were 10.7% and 17.7%, respectively. There was

a significant difference of stunting and underweight between the prevalence from the WHO standard and national reference (both $p < 0.001$). However, there were only 218 children that fulfilled the criteria to be included for the determinants analysis (Table 1) (Figure 1).

Sociodemographic characteristics

The prevalence of stunting and underweight among this study population were 51.4% and 31.7% according to WHO standard and 8.3% and 19.3% according to national reference (Table 1). The number of male and female children were almost equal. More than half of the children were aged between 24 and 59 months old. Majority of the children were born term with a birthweight of more than 2500 g. The education level of both parents was mainly elementary school graduates. Almost half of the mothers had a height of less than 150 cm and more than half of the mothers had a mid-arm circumference of ≤23.5 cm during pregnancy (Table 2).

Determinants of stunting according to WHO standard and national reference

Based on WHO standard, univariate logistic regression analysis indicated that children with maternal height below 150 cm (COR = 2.844; 95% CI = 1.632 – 4.956) were more likely to be stunted (Table 3). In the multivariate logistic regression analysis,

---

Table 1. Prevalence of stunting and underweight of children aged 0 – 59 months in Musi sub-district.

Variable	Total prevalence (N = 408) n (%)		p-value	Study participants (N = 218) n (%)		p-value
	WHO	**National**		**WHO**	**National**	
Stunting (length/height for age index) Normal (-2 SD and above) Stunted (<-2 SD to ≤-3 SD) Severely stunted (<-3 SD)	188(46.1) 148(36.3) 72(17.6)	364(89.22) 41(10.05) 3(0.73)	< 0.001*	106(48.6) 75(34.4) 37(17)	200(91.7) 17(7.8) 1(0.5)	< 0.001*
Underweight (weight for age index) Normal (-2 SD and above) Underweight (<-2 SD to ≤-3 SD) Severely underweight (<-3SD)	289(70.83) 96 (23.53) 23 (5.64)	336(82.3) 57(14) 15(3.7)	< 0.001#	149(68.3) 55(25.3) 14(6.4)	176(80.7) 33(15.2) 9(4.1)	< 0.001#

Chi square test was used.

*p-value between stunted (and severely stunted) and normal.

#p-value between underweight (and severely underweight) and normal.

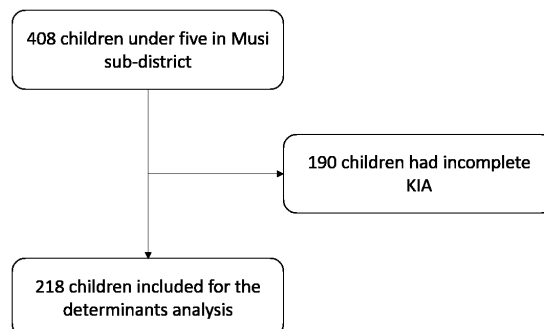p <0.05 was considered statistically significant.

Figure 1. Flow chart of the study population selection for determinants analysis.

Table 2. Sociodemographic characteristics among children aged 0–59 months in Musi Sub-district.

Characteristic	Total		WHO		National	
	(N = 218)		Stunted	Underweight	Stunted	Underweight
	n	%	%	%	%	%
Infant						
Child's sex						
Male	108	49.5	52.8	30.6	7.4	16.7
Female	110	50.5	50	32.7	9.1	21.8
Child's age group						
0–23 months	98	45	45.9	29.6	9.2	17.3
24–59 months	120	55	55.8	33.3	7.5	20.8
Child's birthweight						
<2500 g	35	16.1	65.7	54.3	17.1	40
≥2500 g	183	83.9	48.6	27.3	6.6	15.3
Intrauterine growth						
SGA	38	17.4	65.8	57.9	15.8	44.7
AGA	174	79.8	48.9	27	6.9	14.4
LGA	6	2.8	33.3	0	0	0
Gestational age						
Preterm	13	6	61.5	30.8	15.4	23.1
Term	204	93.6	51	31.9	7.8	19.1
Postterm	1	0.4	0	0	0	0
Parents						
Paternal education						
No formal education	6	2.8	83.3	50	33.3	50
Primary school graduates	126	57.8	54.8	31.7	9.5	22.2
Secondary school graduates	32	14.7	50	28.1	6.3	15.6
High secondary school graduates	42	19.3	45.2	38.1	4.8	14.3
University graduates	12	5.5	25	8.3	0	0
Maternal education						
No formal education	4	1.8	75	75	25	75
Primary school graduates	103	47.2	52.4	29.1	8.7	20.4
Secondary school graduates	35	16.1	65.7	40	8.6	22.9
High secondary school graduates	48	22	47.9	35.4	10.4	18.8
University graduates	28	12.8	32.1	17.9	0	3.6
Maternal MUAC						
≤23.5 cm	125	57.3	43.2	31.2	10.4	22.4
>23.5 cm	93	42.7	44.1	32.3	5.4	15.1
Maternal height						
<150 cm	96	44	65.6	40.6	12.5	26
≥150 cm	122	56	40.2	24.6	4.9	13.9
Maternal age during pregnancy						
<20 years old	20	9.2	70	65	15	40
20–35 years old	166	76.1	50.6	25.9	8.4	15.7
>35 years old	32	14.7	43.8	40.6	3.1	25
Number of parities						
1	51	23.4	56.9	35.3	9.8	19.6
2	65	29.8	43.1	24.6	7.7	18.5
3	51	23.4	60.8	37.3	9.8	27.5
4	30	13.8	36.7	16.7	0	3.3
>4	21	9.6	61.9	52.4	14.3	23.8

SGA, small for gestational age; AGA, appropriate for gestational age; LGA, large for gestational age; MUAC, mid-upper arm circumference.

Table 3. Univariate analysis of determinants for stunting among children aged 0–59 months in Musi Sub-district.

Variables	WHO			National		
	COR	95% CI	p value	COR	95% CI	p value
Infant factors						
Child's sex Male Female (ref)	1.118 -	[0.657 – 1.902] -	0.682 -	0.8 -	[0.303 – 2.111] -	0.652 -
Child's age group 0–23 months 24–59 months (ref)	0.672 -	[0.393 – 1.148] -	0.146 -	1.247 -	[0.475 – 3.274] -	0.654 -
Child's birthweight <2500 g ≥2500 g (ref)	**2.024** -	**[0.951 – 4.310]** -	**0.067** -	**2.948** -	**[1.025 – 8.476]** -	**0.045** -
Intrauterine growth SGA AGA (ref) LGA	**2.014** - 0.524	**[0.967 – 4.192]** - [0.093 – 2.933]	**0.061** - 0.462	**2.531** - 0.0	**[0.885 – 7.239]** - [0]	**0.083** - 0.999
Gestational age Preterm Term (ref) Postterm	1.538 - 0.0	[0.487 – 4.862] - [0]	0.463 - 1.0	2.136 - 0.0	[0.435 – 10.484] - [0]	0.350 - 1.0
Parent factors						
Paternal education No formal education Primary school graduates Secondary school graduates High secondary school graduates (ref) University graduates	6.053 1.465 1.211 - 0.404	[0.65 – 56.365] [0.727 – 2.956] [0.482 – 3.042] - [0.096 – 1.705]	0.114 0.286 0.685 - 0.217	**10** 2.105 1.333 - 0.0	**[1.094 – 91.441]** [0.451 – 9.817] [0.178 – 10.014] - [0]	**0.041** 0.343 0.780 - 0.999
Maternal education No formal education Primary school graduates Secondary school graduates High secondary school graduates (ref) University graduates	3.261 1.198 2.083 - 0.515	[0.316 – 33.614] [0.603 – 2.378] [0.848 – 5.118] - [0.194 – 1.364]	0.321 0.606 0.109 - 0.182	2.867 0.823 0.806 - 0.0	[0.249 – 33.065] [0.260 – 2.604] [0.179 – 3.623] - [0]	0.399 0.741 0.779 - 0.998
Maternal MUAC ≤23.5 cm >23.5 cm (ref)	**1.668** -	**[0.971 – 2.865]** -	**0.064** -	2.043 -	[0.702 – 5.947] -	0.190 -
Maternal height <150 cm ≥150 cm (ref)	**2.844** -	**[1.632 – 4.956]** -	**< 0.001** -	**2.762** -	**[0.997 – 7.655]** -	**0.051** -
Maternal age during pregnancy <20 years old 20–35 years old (ref) >35 years old	2.278 - 0.759	[0.835 – 6.214] - [0.354 – 1.626]	0.108 - 0.479	1.916 - 0.350	[0.500 – 7.346] - [0.044 – 2.762]	0.343 - 0.319
Number of parities 1 (ref) 2 3 4 >4	- 0.574 1.176 **0.439** 1.233	- [0.274 – 1.204] [0.534 – 2.589] **[0.174 – 1.109]** [0.435 – 3.490]	- 0.142 0.687 **0.082** 0.693	- 0.767 1.0 0.0 1.533	- [0.209 – 2.807] [0.271 – 3.689] [0] [0.332 – 7.092]	- 0.688 1.0 0.998 0.584

SGA, small for gestational age; AGA, appropriate for gestational age; LGA, large for gestational age; MUAC, mid-upper arm circumference; COR, crude odds ratio.

other variables with p-value between 0.05 and 0.1 from the univariate analysis (child's birthweight, child's intrauterine growth status, maternal mid-upper arm circumference, and number of parities) were included. Multivariate analysis indicated that children with maternal height below 150 cm (AOR = 2.936; 95% CI = 1.672 – 5.154) or maternal mid-upper arm circumference below 23.5 cm (AOR = 1.769; 95% CI = 1.008 – 3.105) were more likely to be stunted (Table 4).

Based on national reference, univariate logistic regression analysis indicated that children with birthweight below 2500 g (COR = 2.948; 95% CI = 1.025 – 8.476) or with a father without formal education (COR = 10; 95% CI = 1.094 – 91.441) were more likely to be stunted (Table 3). In multivariate logistic regression analysis, other variables with p-value between 0.05 and 0.1 from the univariate analysis (child's intrauterine growth status and maternal height) were included. No determinant was found in the multivariate analysis (Table 4).

Determinants of underweight according to WHO standard and national reference

Based on WHO standard, univariate logistic regression analysis indicated that children with a birthweight below 2500 g (COR = 3.159; 95% CI = 1.507 – 6.622) or intrauterine growth restriction (COR = 3.715; 95% CI = 1.798 – 7.677) were more likely to be underweight. Children with maternal height below 150 cm (COR = 2.098; 95% CI = 1.176 – 3.745) or maternal age under 20 years old during pregnancy (COR = 5.312; 95% CI = 1.989 – 14.186) were also more likely to be underweight (Table 5). In multivariate logistic regression analysis, other variables with p-value between 0.05 and 0.1 from the univariate analysis (paternal education and number of parities) were included. Multivariate analysis indicated that children with intrauterine growth restriction (AOR = 3.182; 95% CI = 1.450 – 6.980) were more likely to be underweight. Children with maternal age under 20 years old during pregnancy (AOR = 6.252; 95% CI = 1.911 – 20.457) or with mother that had more than four parities (AOR = 4.319; 95% CI = 1.189 – 15.689) were also more likely to be underweight (Table 6).

Based on national reference, univariate logistic regression analysis indicated that children with birthweight below 2500 g (COR = 3.690; 95% CI = 1.680 – 8.107) or intrauterine growth restriction (COR = 4.825; 95% CI = 2.241 – 10.389) were more likely to be underweight. Children with mother without formal education (COR = 13.95%; CI = 1.207 – 139,959), with height below 150 cm (COR = 2.175; 95% CI = 1.095 – 4.318), or aged under 20 years old during pregnancy (COR = 3.590; 95% CI = 0.011) were also more likely to be underweight (Table 5). In multivariate logistic regression analysis, other variables with p-value between 0.05 and 0.1 from the univariate analysis (paternal education and number of parities) were included. Multivariate analysis indicated that children with intrauterine growth restriction (AOR = 4.191; 95% CI = 1.820 – 9.649) were more likely to be underweight. Children with mother without formal education (AOR = 27.341; 95% CI =1.281 – 583,318) were also more likely to be underweight (Table 6).

Discussion
In our study, the prevalence of both stunting and underweight were significantly lower when measured using national Indonesian reference compared to when using WHO standard. It has been suggested that overdiagnoses of stunting or underweight are more likely to occur in developing countries[14]. There are many countries that already proposed their own national growth reference, which are: Korea[15], Thailand[16], Argentina[17], China[18], India[14], and 18 European countries[19]. It is argued that the national growth reference of each country is more suitable to reflect the condition in its own population[16]. However, there were only few published studies that compare the difference between national growth reference and WHO growth standard. A comparison study among Thai children in the first two years of life showed that the prevalence of stunting was higher when using WHO standard in both sexes, but at 24 months the only significant difference was in girls. The prevalence of underweight showed a monotonic increment when using WHO standard, but the Thailand national reference showed a fluctuation[16]. In Argentina, the prevalence of underweight using WHO standard was 2 times higher than when using their national reference. Meanwhile for stunting, the prevalence when using WHO standard was 1.5 times higher[17].

Table 4. Multivariate analysis of determinants for stunting among children aged 0–59 months in Musi Sub-district.

Variables	WHO			National		
	AOR	95% CI	p value	AOR	95% CI	p value
Infant factors						
Maternal MUAC						
≤23.5 cm	1.769	[1.008 – 3.105]	0.047			
>23.5 cm (ref)	-	-	-			
Maternal height						
<150 cm	2.936	[1.672 – 5.154]	<0.001			
≥150 cm (ref)	-	-	-			

AOR, adjusted odds ratio; MUAC, mid-upper arm circumference.

Table 5. Univariate analysis of determinants for underweight among children aged 0–59 months in Musi Sub-district.

Variables	WHO			National		
	COR	95% CI	*p* value	COR	95% CI	*p* value
Infant factors						
Child's sex Male Female (ref)	0.904 -	[0.511 – 1.601] -	0.730 -	0.717 -	[0.363 – 1.413] -	0.336 -
Child's age group 0–23 months 24–59 months (ref)	0.841 -	[0.472 – 1.496] -	0.555 -	0.798 -	[0.403 – 1.580] -	0.517 -
Child's birthweight <2500 g ≥2500 g (ref)	**3.159** -	**[1.507 – 6.622]** -	**0.002** -	**3.690** -	**[1.680 – 8.107]** -	**0.001** -
Intrauterine growth SGA AGA (ref) LGA	**3.715** - 0.0	**[1.798 – 7.677]** - [0]	**< 0.001** - 0.999	**4.825** - 0.0	**[2.241 – 10.389]** - [0]	**< 0.001** - 0.999
Gestational age Preterm Term (ref) Postterm	0.950 - 0.0	[0.282 – 3.200] - [0]	0.935 - 1.0	1.269 - 0.0	[0.333 – 4.831] - [0]	0.727 - 1.0
Parent factors						
Paternal education No formal education Primary school graduates Secondary school graduates High secondary school graduates (ref) University graduates	1.625 0.756 0.636 - **0.148**	[0.292 – 9.050] [0.365 – 1.564] [0.236 – 1.713] - **[0.017 – 1.255]**	0.579 0.450 0.370 - **0.080**	**6.0** 1.714 1.111 - 0	**[0.973 – 36.986]** [0.656 – 4.481] [0.307 – 4.026] - [0]	**0.054** 0.272 0.873 - 0.999
Maternal education No formal education Primary school graduates Secondary school graduates High secondary school graduates (ref) University graduates	5.474 0.749 1.216 - 0.396	[0.527 – 56.714] [0.362 – 1.553] [0.495 – 2.985] - [0.128 – 1.232]	0.154 0.438 0.670 - 0.110	**13.0** 1.110 1.284 - **0.160**	**[1.207 –139.959]** [0.465 – 2.646] [0.440 – 3.748] - **[0.019 – 1.342]**	**0.034** 0.814 0.647 - **0.091**
Maternal MUAC ≤23.5 cm >23.5 cm (ref)	0.952 -	[0.535 – 1.695] -	0.868 -	1.629 -	[0.803 – 3.303] -	0.176 -
Maternal height <150 cm ≥150 cm (ref)	**2.098** -	**[1.176 – 3.745]** -	**0.012** -	**2.175** -	**[1.095 – 4.318]** -	**0.026** -
Maternal age during pregnancy <20 years old 20–35 years old (ref) >35 years old	**5.312** - **1.957**	**[1.989 – 14.186]** - **[0.892 – 4.296]**	**0.001** - **0.094**	**3.590** - 1.795	**[1.337 – 9.638]** - [0.728 – 4.428]	**0.011** - 0.204
Number of parities 1 (ref) 2 3 4 >4	- 0.599 1.089 **0.367** 2.017	- [0.274 – 1.204] [0.534 – 2.589] **[0.174 – 1.109]** [0.435 – 3.490]	- 0.212 0.837 **0.079** 0.182	- 0.928 0.1551 **0.141** 1.281	- [0.365 – 2.360] [0.615 – 3.913] **[0.017 – 1.166]** [0.379 – 4.336]	- 0.876 0.352 **0.069** 0.690

SGA, small for gestational age; AGA, appropriate for gestational age; LGA, large for gestational age; MUAC, mid-upper arm circumference; COR, crude odds ratio.

Table 6. Multivariate analysis of determinants for underweight among children aged 0–59 months in Musi Sub-district.

Variables	WHO			National		
	AOR	95% CI	*p* value	AOR	95% CI	*p* value
Intrauterine growth SGA AGA (ref) LGA	3.182 - 0.0	[1.450 – 6.980] - [0]	0.004 - 0.999	4.191 - 0.0	[1.820 – 9.649] - [0]	0.001 - 0.999
Maternal education No formal education Primary school graduates Secondary school graduates High secondary school graduates (ref) University graduates				27.341 1.147 1.409 0.193	[1.281 - 583.318] [0.412 – 3.188] [0.444 – 4.468] - [0.022 – 1.674]	0.034 0.793 0.561 - 0.136
Maternal age during pregnancy <20 years old 20–35 years old (ref) >35 years old	6.252 - 1.449	[1.911 – 20.467] [0.565 – 3.718]	0.002 - 0.441			
Number of parities 1 (ref) 2 3 4 >4	- 1.283 2.601 0.827 4.319	- [0.480 – 3.430] [0.938 – 7.210] [0.220 – 3.101] [1.189 – 15.689]	- 0.619 0.066 0.778 0.026			

SGA, small for gestational age; AGA, appropriate for gestational age; LGA, large for gestational age; AOR, adjusted odds ratio.

In contrary, a comparison study from China showed that the prevalence of stunting and underweight was significantly higher when measured using their national reference[18].

The marked difference in measurements using national Indonesian reference and WHO standard probably stems from the difference in methodology during the development of both growth references. The WHO standard was developed using data from six study sites: Brazil, Ghana, India, Norway, Oman, and the USA. The children included in the study were healthy children with suitable sociodemographic conditions for growth. Moreover, all participants agreed to follow the feeding recommendation by WHO[20]. In contrary, the development of national Indonesian reference did not have any inclusion and exclusion criteria for study participants. It also did not mention the sociodemographic background of the participants or their feeding habits. The study, however, collected data from all 33 provinces of Indonesia to better reflect the growth of Indonesian children. The rationale to develop national Indonesian growth reference was because there is a size difference between Indonesian and US Americans[5].

Review article by Beal *et al.* concluded that the determinants of stunting in Indonesia are maternal height and education, child's sex, premature birth and birth length, exclusive breastfeeding for six months, living area, and household socio-economic status[21]. In our study, the determinants of stunting according to WHO standard were maternal height less than 150 cm and maternal upper mid-arm circumference <23.5 cm. In contrast, no determinant was found when Indonesian reference was used. It is because the prevalence of stunting

according to Indonesian reference was low. The significant difference in stunting prevalence calculated using national Indonesian reference and WHO standard might be because the WHO standard does not represent local growth appropriately due to population differences in height[19], and Indonesian people are generally shorter than the rest of the world.

Regarding underweight, the determinants were also different according to the two different references. However, there was one common determinant: intrauterine growth restriction. The difference of underweight prevalence between WHO standard and national Indonesian reference was not as marked as the difference in stunting prevalence; this may explain that there was still one overlapping determinant. The increased odds of stunting, underweight, and wasting in SGA infants are more relevant in low- and middle-income countries[22]. It is suggested that SGA children are born with lower intrinsic potential for growth due to the persistent effect of growth restriction in utero[23,24].

There were several limitations of this study. Data regarding socioeconomic status could not be obtained due to parents' unstable monthly income. Data on exclusive breastfeeding cannot be obtained because some of our samples have not yet completed the exclusive breastfeeding period. Data regarding the frequency of diarrhea could not be obtained because this was not well documented in primary healthcare medical records. The sample size of this study was small, particularly the number of stunting children using national Indonesian growth reference was only 18 children. Therefore, it was not adequate to analyze the determinants. These above-mentioned factors should be

accounted for in the ensuing studies. Nevertheless, despite all of the limitations, this is the first study that compare the prevalence and determinants of stunting and underweight among Indonesian children under five using WHO growth standard and national Indonesian growth reference.

Conclusion

The WHO standard is not suitable for representing child growth in Musi sub-district. Future studies should be done to re-evaluate the prevalence and determinants of stunting and underweight nationwide using the national Indonesian reference. An national Indonesian reference for weight-for-height should also be made to re-evaluate the prevalence and determinants of wasting in Indonesia.

Data availability

Underlying data

Figshare: Growth standard comparison between WHO and Indonesian Growth Chart-Population Data. https://doi.org/10.6084/m9.figshare.12121938.v5[12]

Figshare: Growth standard comparison between WHO and Indonesian Growth Chart-Determinants Data. https://doi.org/10.6084/m9.figshare.12127425.v3[13]

Reporting guidelines

Figshare: STROBE Checklist-Indonesian and WHO Growth Standard Comparison. https://doi.org/10.6084/m9.figshare.12127689.v2[6]

Data are available under the terms of the Creative Commons Attribution 4.0 International license (CC-BY 4.0).

Acknowledgements

The authors thank Dr. Aman Bhakti Pulungan for providing the National Indonesian Growth Reference Charts and to Oeolo primary healthcare workers for their assistance during data collection.

References

1. Black RE, Victora CG, Walker SP, *et al.*: **Maternal and child undernutrition and overweight in low-income and middle-income countries.** *Lancet.* 2013; **382**(9890): 427–51.
   PubMed Abstract | **Publisher Full Text**

2. United Nations Children's Fund (UNICEF), World Health Organization, International Bank for Reconstruction and Development/The World Bank: **Levels and trends in child malnutrition: key findings of the 2019 Edition of the Joint Child Malnutrition Estimates.** Geneva: World Health Organization; 2019.
   Reference Source

3. **Badan Penelitian dan Pengembangan Kementerian Kesehatan Republik Indonesia**. *Hasil Utama RISKESDAS 2018*. Jakarta: Kemenkes RI; 2018.
   Reference Source

4. World Health Organization: **Global Database on Child Growth and Malnutrition.** [cited 9 February 2020].
   Reference Source

5. Pulungan AB, Julia M, Batubara JRL, *et al.*: **Indonesian National Synthetic Growth Charts.** *Acta Scientific Paediatrics.* 2018; **1**: 20–34.
   Reference Source

6. Flynn J, Alkaff FF, Sukmajaya WP, *et al.*: **STROBE Checklist-Indonesian and WHO Growth Standard Comparison.** *figshare.* Online resource. 2020.
   http://www.doi.org/10.6084/m9.figshare.12127689.v2

7. von Elm E, Altman DG, Egger M, *et al.*: **The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies.** *Bull World Health Organ.* 2007; **85**(11): 867–872.
   PubMed Abstract | **Publisher Full Text** | **Free Full Text**

8. World Health Organization: **Training Course on Child Growth Assessment**. Geneva: WHO; 2008.
   Reference Source

9. **Indonesian Minister of Health Decree Number 97/2014 on Health Care Before Pregnancy, During Pregnancy, During Labor, and After Labor, Implementation of Contraception Services, and Sexual Health Services.** Jakarta; 2014.

10. Berhe K, Seid O, Gebremariam Y, *et al.*: **Risk factors of stunting (chronic undernutrition) of children aged 6 to 24 months in Mekelle City, Tigray Region, North Ethiopia: An unmatched case-control study.** *PLoS One.* 2019; **14**(6): e0217736.
    PubMed Abstract | **Publisher Full Text** | **Free Full Text**

11. Lubchenco LO, Hansman C, Dressler M, *et al.*: **Intrauterine Growth As Estimated From Liveborn Birth-Weight Data At 24 To 42 Weeks Of Gestation.** *Pediatrics.* 1963; **32**: 793–800.
    PubMed Abstract

12. Flynn J, Alkaff FF, Sukmajaya W, *et al.*: **Growth standard comparison between WHO and Indonesian Growth Chart-Population Data**. *figshare.* Dataset.
    http://www.doi.org/10.6084/m9.figshare.12121938.v5

13. Flynn J, Alkaff FF, Sukmajaya W, *et al.*: **Growth standard comparison between WHO and Indonesian Growth Chart-Determinants Data**. *figshare.* Dataset. 2020.
    http://www.doi.org/10.6084/m9.figshare.12127425.v3

14. Khadilkar V, Khadilkar A: **Growth charts: A diagnostic tool.** *Indian J Endocrinol Metab.* 2011; **15**(Suppl 3): S166–71.
    PubMed Abstract | **Publisher Full Text** | **Free Full Text**

15. Kim JH, Yun S, Hwang SS, *et al.*: **The 2017 Korean National Growth Charts for children and adolescents: development, improvement, and prospects.** *Korean J Pediatr.* 2018; **61**(5): 135–49.
    PubMed Abstract | **Publisher Full Text** | **Free Full Text**

16. Hong SA, Mongkolchati A, Chompikul J, *et al.*: **Comparison of Prevalence of Nutritional Status of Thai Children in the First 2 Years of Life Using National and International Growth Charts.** *J Med Assoc Thai.* 2016; **99**(1): 58–64.
    PubMed Abstract

17. Padula G, Seoane AI, Salceda SA: **Variations in estimates of underweight, stunting, wasting, overweight and obesity in children from Argentina comparing three growth charts.** *Public Health Nutr.* 2012; **15**(11): 2086–90.
    PubMed Abstract | **Publisher Full Text**

18. Yang Z, Duan Y, Ma G, *et al.*: **Comparison of the China growth charts with the WHO growth standards in assessing malnutrition of children.** *BMJ Open.* 2015; **5**(2): e006107.
    PubMed Abstract | **Publisher Full Text** | **Free Full Text**

19. Bonthuis M, van Stralen KJ, Verrina E, *et al.*: **Use of national and international growth charts for studying height in European children: development of up-to-date European height-for-age charts.** *PLoS One.* 2012; **7**(8): e42506.
    PubMed Abstract | **Publisher Full Text** | **Free Full Text**

20. Zorlu G: **New WHO child growth standards catch on.** *Bull World Health Organ.* 2011; **89**(4): 250–1.
    PubMed Abstract | **Publisher Full Text** | **Free Full Text**

21. Beal T, Tumilowicz A, Sutrisna A, *et al.*: **A review of child stunting determinants in Indonesia.** *Matern Child Nutr.* 2018; **14**(4): e12617.
    PubMed Abstract | **Publisher Full Text** | **Free Full Text**

22. Christian P, Lee SE, Donahue Angel M, *et al.*: **Risk of childhood undernutrition related to small-for-gestational age and preterm birth in low- and middle-income countries.** *Int J Epidemiol.* 2013; **42**(5): 1340–55.
    PubMed Abstract | **Publisher Full Text** | **Free Full Text**

23. Blake RA, Park S, Baltazar P, *et al.*: **LBW and SGA Impact Longitudinal Growth and Nutritional Status of Filipino Infants.** *PLoS One.* 2016; **11**(7):

e0159461.
PubMed Abstract | **Publisher Full Text** | **Free Full Text**

24. Sania A, Spiegelman D, Rich-Edwards J, *et al.*: **The contribution of preterm birth and intrauterine growth restriction to childhood undernutrition in Tanzania.** *Matern Child Nutr.* 2015; **11**(4): 618–30.
PubMed Abstract | **Publisher Full Text** | **Free Full Text**

Open Peer Review

Current Peer Review Status: ✔ ✔

Version 2

Reviewer Report 08 June 2020

https://doi.org/10.5256/f1000research.26741.r63966

✔ **Aaroonsri Mongkolchati**

ASEAN Institute for Health Development, Mahidol University, Nakhon Pathom, Thailand

Even though there was some limitation of analysis due to the small sample size but the author has already discussed this.

Competing Interests: No competing interests were disclosed.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Reviewer Report 04 June 2020

https://doi.org/10.5256/f1000research.26741.r63965

✔ **Michael Hermanussen** (iD)

University of Kiel, Kiel, Germany

There are just two minor comments:
1. It is not clear according to what criteria the authors rejected 190 children reducing the total number analyzed from formerly 408 to 218 children. The authors may add this information.

2. Please check. The authors write: "The WHO standard was developed using data from five cities in five different countries: United States, Turkey, Norway, Brazil, and India". This is not quite true. See [https://www.who.int/mediacentre/news/releases/2006/pr21/en/; or: https://www.who.int/bulletin/volumes/89/4/11-040411/en/]

Competing Interests: No competing interests were disclosed.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Author Response 14 Jun 2020

Firas Farisi Alkaff, Faculty of Medicine Universitas Airlangga, Jl. Mayjend Prof. Dr. Moestopo No 47, Surabaya, Indonesia

Dear reviewer,
Thank you for the comments and suggestions for our manuscript.

1. It is not clear according to what criteria the authors rejected 190 children reducing the total number analyzed from formerly 408 to 218 children. The authors may add this information.

Response: We have added the information why we rejected 190 children for the determinants analysis.

2. The authors write: "The WHO standard was developed using data from five cities in five different countries: United States, Turkey, Norway, Brazil, and India". This is not quite true.

Response: We have checked and revised our manuscript according to the given reference.

Competing Interests: No competing interests were disclosed.

Version 1

Reviewer Report 14 May 2020

https://doi.org/10.5256/f1000research.25560.r63061

? **Aroonsri Mongkolchati**
ASEAN Institute for Health Development, Mahidol University, Nakhon Pathom, Thailand

The abstract was unclear of the result of this study, it should be addressed that after the authors control variable or adjust for confounding factors including mother height and socioeconomic factors. What were the factors have been found to be the determinants factors and this lead to the recommendation and conclusion to be more clear.

The statistic was used for data explanation should be more clear such as OR mean Cluded OR, COR, by bivariate whereas Adjusted OR, AOR, used for multivariate analysis.

The conclusion should consider one more limitation is that the small sample size of the data particularly on child stunning number on national WHO standard in comparing. As a result, the next research should be more explored.

Is the work clearly and accurately presented and does it cite the current literature?
Yes

Is the study design appropriate and is the work technically sound?
Yes

Are sufficient details of methods and analysis provided to allow replication by others?
Yes

If applicable, is the statistical analysis and its interpretation appropriate?
Yes

Are all the source data underlying the results available to ensure full reproducibility?
Yes

Are the conclusions drawn adequately supported by the results?
Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Maternal and Child Health

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 19 May 2020

Firas Farisi Alkaff, Faculty of Medicine Universitas Airlangga, Jl. Mayjend Prof. Dr. Moestopo No 47, Surabaya, Indonesia

Dear reviewer,
Thank you for the comments and suggestions to our manuscript.

1. The abstract was unclear of the result of this study, it should be addressed that after the authors control variable or adjust for confounding factors including mother height and socioeconomic factors. What were the factors have been found to be the determinants factors and this lead to the recommendation and conclusion to be more clear.

Response: We have edited the abstract section according to your suggestion.

2. The statistic was used for data explanation should be more clear such as OR mean Cluded OR, COR, by bivariate whereas Adjusted OR, AOR, used for multivariate analysis.

Response: We have changed the OR in the bivariate analysis to Crude OR and OR in multivariate analysis to Adjusted OR throughout the manuscript

3. The conclusion should consider one more limitation is that the small sample size of the data particularly on child stunning number on national WHO standard in comparing. As a result, the next research should be more explored

Response: We have added the small sample size particularly in the number of stunted children according to national Indonesian reference as one of the limitations in our study

Competing Interests: No competing interests were disclosed.

Reviewer Report 05 May 2020

https://doi.org/10.5256/f1000research.25560.r63062

? **Michael Hermanussen** (iD)
University of Kiel, Kiel, Germany

The authors aimed to compare Indonesian growth references for height, weight, and BMI with WHO standards. The authors conclude that the WHO standards over-diagnose stunting and underweight in the Musi sub-district.

This is an important study as it examines whether the globally used WHO growth charts are applicable also for infants and children of the Musi sub-district, Indonesia.

Yet, the manuscript needs clarification.

The authors do not clearly distinguish between the terms "standard" and "reference":
Growth references are statistical summaries of anthropometry, conditioned (usually) on age and sex. References describe how children do grow.
Growth standards describe how children should grow. (Garza C, de Onis M. Rationale for developing a new international growth reference. Food Nutr Bull 2004;25(1 Suppl):S5-14.). This is an important distinction. The data presented in this study provide a growth "reference" for the

children of the Musi sub-district as they describe how these children grow. They do not describe how these children might grow under different conditions.

The authors use the terms "stunting", "wasting", and "underweight". These terms refer to body size, they do not describe the nutritional situation.
Underweight is defined as: weight for age < –2 standard deviations (SD) of the WHO Child Growth Standards median. Stunting is defined as height for age < –2 SD of the WHO Child Growth Standards median. Wasting is defined as weight for height < –2 SD of the WHO Child Growth Standards median[1]). The three terms relate to an internationally used "standard", suggesting that this standard is also applicable to the Indonesian population. But this has been questioned. Healthy Indonesians are shorter and lighter than healthy white US citizens (who grow similar to what the WHO considers their growth standard). The difference in size between Indonesian and US Americans was the rational to develop national Indonesian growth references (Pulungan et al. 2018).

In addition, the authors use the term "undernutrition". Undernutrition refers to food: Undernutrition can be defined as "lack of proper nutrition, caused by not having enough food or not eating enough food containing substances necessary for growth and health" (https://www.lexico.com/en/definition/undernutrition). Chronic undernutrition has an impact on body size as it results in poor growth, but being short (stunting) is not a synonym of mal- or undernutrition (Scheffler C et al. Stunting is not a synonym of malnutrition. Eur J Clin Nutr. 2019 May 29[2]). Short people may be short for other than nutritional reasons.

It is not clear whether the authors wanted to study size (length and weight), or the nutritional situation of the children of Musi. They start the manuscript with the words: "Undernutrition among children under five …". Later it is written: "There are three indicators to measure nutritional imbalance that lead to undernutrition …" suggesting that the manuscript is on nutrition. But where is the data on food? The authors need to provide information on food, or at least on energy deposits in terms of skinfold thickness, arm circumferences etc., or in the case of mal- or undernutrition, show clinical signs of protein or calorie malnutrition, or signs of micronutrient deficiencies. This is not the case.

It is known to the reviewer that there is international confusion about the terms stunting and malnutrition. Calculating the portion of stunted children refers to the question of how many children are below height for age < –2 SD of the WHO Child Growth Standards median. This does not necessarily mean that this portion of children is also undernourished.

The manuscript needs major rethinking and re-evaluating of the measurements of height and weight. It is necessary to describe growth of the children of Musi, and to publish these data. The children of Musi are shorter and lighter than suggested by the WHO standard. But this does NOT mean that these children suffer from food shortage. It rather appears that the WHO standard is not applicable for these children, and thus does NOT indicate malnutrition of this child population. This needs to be stressed. The authors should carefully read some of the recent papers discussing the misinterpretation of stunting as a sign of undernutrition (Hermanussen et al. The impact of social identity and social dominance on the regulation of human growth. A viewpoint. Acta Paediatr. 2019 Aug 16[3]).

The tables show odds ratios. It is much more informative when data are presented as true values.

The reader is not so much interested in what proportion of children ranges above or below a certain cut-off, but what are the mean values of height, weight, etc. in this child population.

Minor comments:
Correct the term "national standard". What you mean is: "national reference".
Correct the term "gender". What you mean is probably "sex".
Table 4 needs to be shortened, there is no need to show empty boxes. The same applies for table 6

Discussion: The authors write: "SGA is a result of poor maternal nutrition during pregnancy". This is not quite true. Ample evidence obtained from European countries during periods of war and post-war starvation illustrates that even when pregnant women are severely undernourished, the newborn infants only suffer from minor decreases in body weight (Keys A, Brozek J, Henschel A, Mickelsen O, Longstreet Taylor H. The biology of human starvation. The University of Minnesota Press. Minneapolis. 1950.).

See various comments in the text.

References
1. Nutrition Landscape Information System: Country Profile Indicators Interpretation Guide. *WHO*. 2010. Reference Source
2. Scheffler C, Hermanussen M, Bogin B, Liana DS, et al.: Stunting is not a synonym of malnutrition.*Eur J Clin Nutr*. 2020; **74** (3): 377-386 PubMed Abstract | Publisher Full Text
3. Hermanussen M, Bogin B, Scheffler C: The impact of social identity and social dominance on the regulation of human growth: A viewpoint.*Acta Paediatr*. **108** (12): 2132-2134 PubMed Abstract | Publisher Full Text

Is the work clearly and accurately presented and does it cite the current literature?
Yes

Is the study design appropriate and is the work technically sound?
Yes

Are sufficient details of methods and analysis provided to allow replication by others?
Yes

If applicable, is the statistical analysis and its interpretation appropriate?
No

Are all the source data underlying the results available to ensure full reproducibility?
No

Are the conclusions drawn adequately supported by the results?
Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: child growth, pediatrics, endocrinology

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 19 May 2020

Firas Farisi Alkaff, Faculty of Medicine Universitas Airlangga, Jl. Mayjend Prof. Dr. Moestopo No 47, Surabaya, Indonesia

Dear reviewer,
Thank you for the comments and suggestions to our manuscript.

1. The authors do not clearly distinguish between the terms "standard" and "reference"

Response: We have distinguished the "standard" and "reference" in our revised manuscript. We use the term "reference" for Indonesian growth chart and use the term "standard" for WHO growth chart.

2. The authors use the terms "stunting", "wasting", and "underweight". These terms refer to body size, they do not describe the nutritional situation.

Response: We do not refer stunting and underweight as nutritional status in our revised manuscript.

3. It is not clear whether the authors wanted to study size (length and weight), or the nutritional situation of the children of Musi.

Response: We have revised the manuscript and limited the aim of our study to body size (length and weight) of the Musi children, not about nutritional status because we do not have the data regarding food, energy deposits, or any clinical sign of undernutrition.

4. It is necessary to describe growth of the children of Musi, and to publish these data.

Response: Unfortunately, we do not have the growth record of children in Musi sub-district. The design of our study is cross-sectional, thus we only have one-time height and weight measurement of the Musi children. We have published the measurement data in online repository (https://doi.org/10.6084/m9.figshare.12121938.v5 for population data and https://doi.org/10.6084/m9.figshare.12127425.v3 for determinants data)

5. The authors should carefully read some of the recent papers discussing the misinterpretation of stunting as a sign of undernutrition

Response: We have read the corresponding references, and we have made sure to not misinterpret stunting as the sign of undernutrition because the aim of our study is to compare the prevalence of body size using WHO growth standard and Indonesian growth reference.

6. The tables show odds ratios. It is much more informative when data are presented as true values. The reader is not so much interested in what proportion of children ranges above or below a certain cut-off, but what are the mean values of height, weight, etc. in this child population.

Response: We would like to give more informative data by presenting the true values of weight and height. However, since the children are not in the same age, we are not sure whether it is appropriate or not.

7. Correct the term "national standard". What you mean is: "national reference".
Correct the term "gender". What you mean is probably "sex".
Table 4 needs to be shortened, there is no need to show empty boxes. The same applies for table 6

Response: We have corrected the term "national standard" to "national reference" and term "gender" to "sex". We also have shortened the table 4 and 6 by omitting the empty boxes.

8. Discussion: The authors write: "SGA is a result of poor maternal nutrition during pregnancy". This is not quite true.

Response: We have removed the discussion regarding the relationship between SGA and poor maternal nutrition.

9. You might better conclude that "the WHO standard are not suitable for representing child growth in Musi sub-district".

Response: We have edited our conclusion according to your suggestion.

Competing Interests: No competing interests were disclosed.

The benefits of publishing with F1000Research:

- Your article is published within days, with no editorial bias

- You can publish traditional articles, null/negative results, case reports, data notes and more

- The peer review process is transparent and collaborative

- Your article is indexed in PubMed after passing peer review

- Dedicated customer support at every stage

For pre-submission enquiries, contact research@f1000.com

F1000Research