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Research Article

Indonesian National Synthetic Growth Charts

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Abstract

Indonesia is a transcontinental country with great ethnic diversity. More than 300,000 individual data on child and adolescent height and weight from 33 Indonesian provinces, were analysed. Marked mismatch exists between World Health Organisation (WHO) standards/references and Indonesian height and weight data. Indonesian children of both sexes are significantly shorter, and mature slightly earlier than the WHO standards/references suggest. Except for early infancy, children and adolescents of both sexes appear slightly heavier than WHO standards and references. Indonesian growth patterns resemble patterns observed in the healthy Japanese population. Relevant associations between per capita income and early weight gain (birth to age 1.5 years) do not exist in Indonesia ($r = 0.22$), nor relevant associations between per capita income and early adult height ($r = 0.35$) indicating that per capita income lacks major impact on child and adolescent growth in Indonesia. Height is related to population crowding. Even when excluding the densely populated Mega-city of Jakarta, height at 18 years and population density are significantly correlated ($r = 0.58$, $p < 0.001$). In view of a need for national references for infant, child and adolescent growth, new National Indonesian Growth Charts from birth to 18 years of age were synthesized, providing the full set of mean values, standard deviations and common centiles for height, and LMS parameters and common centiles for weight and BMI. In view of the absence of clinical evidence for undernutrition in the Indonesian population, the use of the term "stunting" and its implication for public health decisions, and the need for national growth charts is discussed.

Keywords: Indonesian Child Growth; Adolescent Growth; Synthetic Growth Chart; Stunting

Abbreviation

WHO: World Health Organization, GDP: gross domestic product BMI: body mass index, CDC: Centers for Disease Control and Prevention, NCHS: National Center For Health Statistics, UNICEF: United Nations International Children's Emergency Fund, UK: United Kingdom, NHBS: National Basic Health Survey

Introduction

Considering that stunting has been an issue in Indonesia, the authors ABP from the Indonesian Pediatric Society and JRLB as experts were invited to attend a meeting in the presidential office. ABP presented the difference between the terms "short stature" and "stunting" and also compared WHO growth charts to the JRLB chart data and other growth charts. Conclusion: we will reanalyze national 2013 research data and obtain data from research and development board at the Ministry of health. Furthermore, we will make synthetic growth charts in order to prevent overestimating stunting and improper intervention.

Indonesia is a transcontinental country with great ethnic diversity. Since its formal independence in 1949, Indonesia underwent rapid industrialisation, and major political and economic transition. Globally, Indonesia meanwhile ranks 7th in the World Bank list of GDP [1], but still great inequality exists between households in the various parts of the country [2].

Indonesians are short [3]. Even though average height of the population has increased by some 5 cm since the last 50 years, a secular trend in height similar to that seen in the European countries, and Japan, has not yet been detected [4,5]. Currently, Indonesian adult men are on average some 12 cm shorter than modern WHO reference males. Similar height discrepancy exists for young adult females [3].

Indonesian child growth has been documented since the first half of the 20th century [6-8]. Indonesian children are shorter than modern European children and shorter than suggested by so-called international standards. Thus, when comparing height of Indonesian children with these (WHO child growth standards [9], the WHO growth reference for 5-19 years [10], CDC growth charts [11], NCHS growth curves [12], or UK-WHO growth charts [13]), a significant portion of these children falls below critical cut-off limits, and are considered "stunted".

There is common agreement among most nutritionists to believe in a causal relation between stunting and poor child nutrition. They claim a multitude of subsequent developmental disadvantages to be caused by early stunting. E.g. Lartey [14] underscores this vision saying: "There is convergence among the nutrition community on the use of length-for-age as the indicator of choice in monitoring the long-term impact of chronic nutritional deficiency". The Lancet series on maternal and child undernutrition [15] reported critical associations between stunting (length/height-for-age z-score <-2 standard deviation) at age 2 years and the long-term consequences. They concluded that 'poor fetal growth or stunting in the first 2 years leads to irreversible damage, including shorter adult height, lower attained schooling, reduced adult income and decreased offspring birth weight'. They showed the link between stunting at age 2 years and lower human capital".

Yet, associations between nutrition and growth have long been questioned [16-18]. There is ample historic evidence from European countries of the late 19th and early 20th century, and from several war and post-war studies showing that the very short average stature of those European populations was not caused by malnutrition [19].

Leading Indonesian paediatricians question that the on average short stature of Indonesian children results from nationwide undernutrition, health impairment or economic failure. Using WHO 2006 Growth Standard as the reference, the latest Indonesian 2013 National Basic Health Survey (NHBS) [20] observed 37.2% prevalence of stunted and 12.1% prevalence of wasted children under the age of 5 years (Figure 1). Only 2.5% of the children were both wasted and stunted, most of the children were either short with normal weight (27.4%) or short but overweight (6.8%). The huge discrepancies between the prevalence of stunted and the prevalence of wasted, and the very low prevalence of children who are both stunted and wasted raised scepticism on the association between poor nutrition and ill health, and growth. Indonesian paediatricians argue that most of those so-called "stunted" children are short for other than nutritional or health reasons.

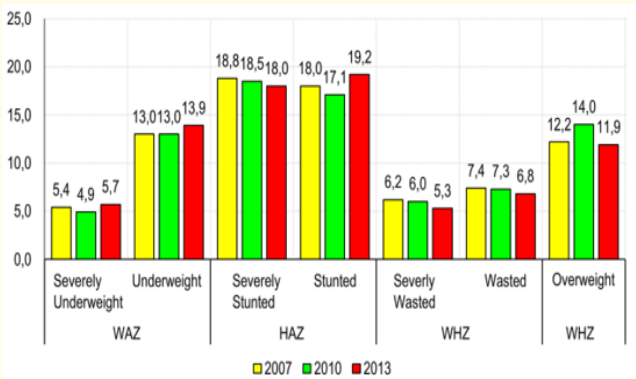

Figure 1: Comparation of prevalence of anthropometric indicators of 2007, 2010, and 2013 NBHS (Adapted from Riset Kesehatan Dasar Indonesia, 2013).

At present the Indonesian government plans to spend millions of dollars to combat shortness, but the belief that poor-nutrition or ill health may be the cause of the short stature of Indonesian children will lead to erroneous modes of intervention. WHO 2006 Growth Standards and WHO 2007 Growth References may not be appropriate references for assessing undernutrition in the Indonesian population. Quite in contrast, the Indonesian population needs growth references that clearly distinguish between children who are pathologically short among other short children, and truly need medical or nutrition interventions, and healthy children who are just short when compared with global references, and will not benefit from interventions. Correct targeting those who need appropriate care and intervention, was the main motive for creating national Indonesian growth references rather than continuing using global growth standards for this population.

Material and Methods

More than 300,000 individual data on child and adolescent height and weight from 33 Indonesian provinces were used to generate the New National Indonesian Growth Charts. Table 1 summarizes the total number of measurements used for the present analysis.

Province	Boys	Girls
Bali	3004	2923
Bangka Belitung	1915	1790
Banten	**4148**	**3905**
Bengkulu	2949	2798
DI Yogyakarta	**1319**	**1282**
DKI Jakarta	**1908**	**1891**
Gorontalo	2071	1915
Jambi	3674	3516
Jawa Barat	**12584**	**12287**
Jawa Tengah	**12306**	**11722**
Jawa Timur	**13788**	**12746**
Kalimantan Barat	5073	4647
Kalimantan Selatan	4083	3885
Kalimantan Tengah	3909	3698
Kalimantan Timur	4372	4221
Kepulauan Riau	2127	1955
Lampung	5165	4819
Maluku	3958	3856
Nusa Tenggara Timur	7730	7459
Maluku Utara	3174	2939
Nangroe Aceh Darussalam	7214	7083
Nusa Tenggara Barat	3965	3934
Papua	4632	4188
Papua Barat	2334	2341
Riau	5275	4942
Sulawesi Barat	2041	1959
Sulawesi Selatan	8658	8065
Sulawesi Tengah	3814	3714
Sulawesi Tenggara	4472	4296
Sulawesi Utara	3715	3503
Sumatra Barat	6895	6288
Sumatra Selatan	6524	5970
Sumatra Utara	14447	13488

Table 1: Number of children used for the present analysis.

Bold letters indicate Java provinces.

The data were obtained from the latest Indonesian 2013 National Basic Health Survey (NHBS), a periodic community based survey aimed to collect basic data and health indicators. The NHBS 2013 is designed as a descriptive cross-sectional household survey that represented the population at national, provincial and municipality levels. To ensure representativeness of the sample, the NHBS used multistage sampling methods at national, provincial and municipality levels. The sampling frame were the census blocks listed from the last nationwide population census in 2010. The population of this research covers households in 33 provinces, 497 regencies/municipalities. The NHBS 2013 managed to visit 11,986 of the target 12,000 census blocks (99.9%), 294,959 of 300,000 households (98.3%) and 1,027,763 household members (93.0%).

The quality of data of the NHBS 2013 was ensured before the data collection by proper training and try-outs of the enumerators, as well as by calibration of all of the measurement devices. The try-outs were done by researchers from the Ministry of Health, academicians and professional organizations. Weight scale (brand: Fesco) and aluminium-based stadiometer were used during this study. After the data collection, data validation were conducted by university teams, i.e. from University of Indonesia, Airlangga University and Hasanuddin University.

Publicly available summary information on population density [21] and on gross regional product nominal (GRP Nominal) per capita [22] were used as a proxy for crowding and population wealth, and related to the regional height and weight data from the 33 Indonesian provinces.

"National Synthetic Growth References" for Indonesian children were constructed as described earlier [23,24].

In short, the methodology comprises 2 steps:

Step 1: Principal Component Analysis was applied to characterize the global variance of the mean values for height, weight and BMI in 196 female and 197 male longitudinal and cross-sectional growth studies from 53 countries published since 1831 (all studies contained information on height, data on height and weight were available in 87 female and 89 male studies). Five principal components were able to explain 98.4% of the between-study variance in mean height, 99.2% of the between-study variance in mean weight, and 93% (females) and 94% (males) of the between-study variance in mean BMI. The five components define a growth model that describes the basic human growth patterns from birth to maturity.

Step 2: The five components can now be used for generating "synthetic" references for height, weight, and BMI of any population of interest that lacks complete annual data of these parameters. This is done by applying the Maximum Likelihood Principle and standard techniques for non-linear optimization.

By applying a Bayesian rational, a "synthetic" growth curve is generated that best compromises between the data available from the population of interest and the global patterns obtained from the Principal Component Analysis, given the following assumptions:

1. The curve belongs to a population similar to the ones for which the Principal Component Analysis was performed,
2. All differences between the curve and the observed mean heights are errors of these means distributed according to a known standard error of the mean.

In view of the marked ethnic diversity of the Indonesian population, and thus, the impracticality of using one single growth chart for all ethnic groups, it was decided to generate a synthetic chart that best represents the majority of the Indonesian population. We used weighed mean values for height-for-age ($H\_A_{0\text{-}18}$), weight-for-age ($W\_A_{0\text{-}18}$), and body mass index-for-age ($BMI\_A_{0\text{-}18}$) for all age groups from birth to 18 years ($_{0\text{-}18}$). We weighed regional averages according to population density. Weighing included the whole country ($_{whole}$), with particular respect to the six densely populated provinces of Java (Banten, DKI Jakarta, Jawa Barat, Java Tengah, Yogyakarta, and Java Timur) ($_{j1\ -\ j6}$), according to:

$$H\_A_0 = (H\_A_{0\,(j1)} + H\_A_{0\,(j2)} + \ldots + H\_A_{0\,(j6)} + H\_A_{0\,(whole)})/7$$
$$H\_A_{0.25} = (H\_A_{0.25\,(j1)} + H\_A_{0.25\,(j2)} + \ldots + H\_A_{0.25\,(j6)} + H\_A_{0.25\,(whole)})/7$$
...
$$H\_A_{18} = (H\_A_{18\,(j1)} + H\_A_{18\,(j2)} + \ldots + H\_A_{18\,(j6)} + H\_A_{18\,(whole)})/7$$
and
$$W\_A_0 = (W\_A_{0\,(j1)} + W\_A_{0\,(j2)} + \ldots + W\_A_{0\,(j6)} + W\_A_{0\,(whole)})/7$$
$$W\_A_{0.25} = (W\_A_{0.25\,(j1)} + W\_A_{0.25\,(j2)} + \ldots + W\_A_{0.25\,(j6)} + W\_A_{0.25\,(whole)})/7$$
...
$$W\_A_{18} = (W\_A_{18\,(j1)} + W\_A_{18\,(j2)} + \ldots + W\_A_{18\,(j6)} + W\_A_{18\,(whole)})/7$$
etc.

H_A indicates height at age (subscript), W_A indicates weight at age (subscript); $_{(j1)}$ to $_{(j6)}$ indicate the six Java provinces, $_{(whole)}$ indicates the average values of the whole of Indonesia.

The following age groups were used for the synthesis:

Birth, 0.5 years, 1 years, 2 years, 4 years, 6 years, 7 years, 9 years, 10 years, 11 years, 13 years, 15 years, 16 years, and 18 years. The age range within each age group were specified as follows:

_0 years included all children from birth to age 0.08 years
_0.25 years included all children from 0.1 to 0.4 years
_0.5 years included all children from 0.4 to 0.6 years
_0.75 years included all children from 0.6 to 0.9 years
_1.0 years included all children from 0.9 to 1.1 years
_1.5 years included all children from 1.2 to 1.8 years
_2.0 years included all children from 1.8 to 2.2 years
_3.0 years included all children from 2.5 to 3.5 years
...
_18.0 years included all children from 17.5 to 18.5 years

Centiles for height, weight and BMI were added based on lists of heuristic standard deviations for height, and lists of heuristic values for L and S for weight and BMI [25]. L, M, and S refer to a statistical method [26] to describe growth reference curves; M, stands for mean; S, stands for a scaling parameter; L, stands for the Box-Cox power. Tables of M, S, and L for all ages, can be transformed into z-scores and centiles.

Results

Body height and weight differs within Indonesia. Figure 2 and figure 3 summarize local averages of Indonesian child and adolescent height and body mass index (BMI) of the 33 Indonesian provinces. The figures include WHO height and BMI standards/references [9,10] and illustrate the mismatch between WHO standards/references and the Indonesian data. Indonesian children of both sexes mature slightly earlier than the WHO standards/references suggest. The figures underline the necessity for specially tailored growth references for the Indonesian population.

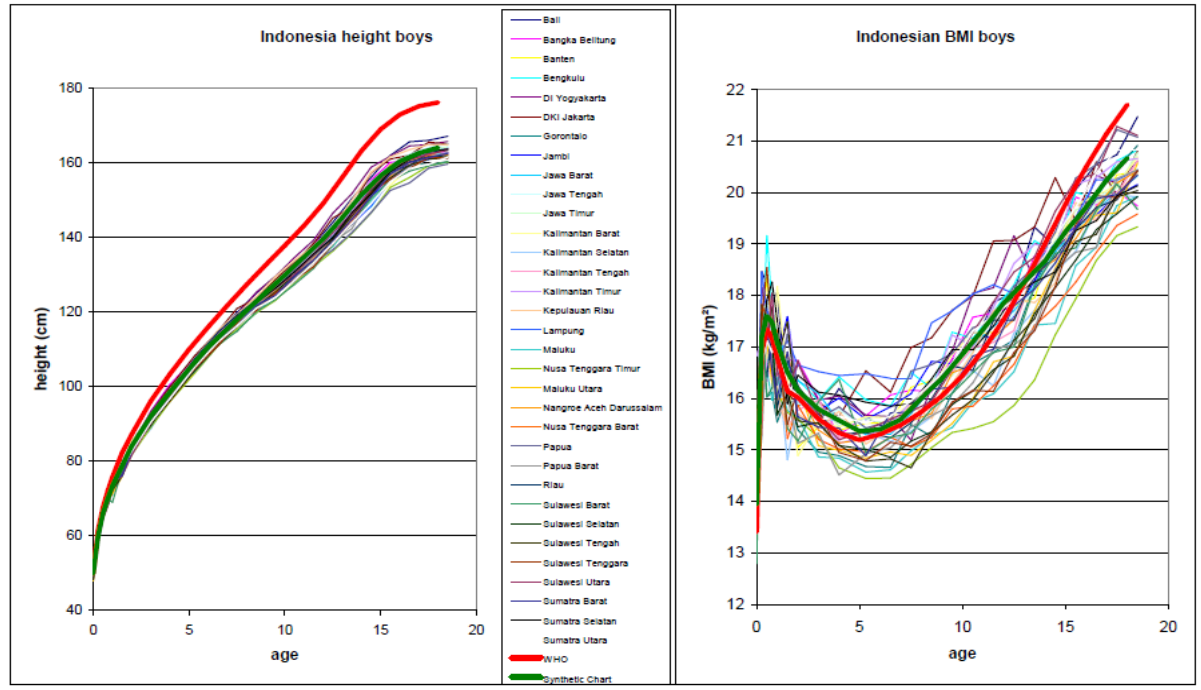

Figure 2: Mean values for height and BMI of Indonesian boys by Province. Red lines indicate WHO standards/references and illustrate poor matching between WHO reference and Indonesian growth data.

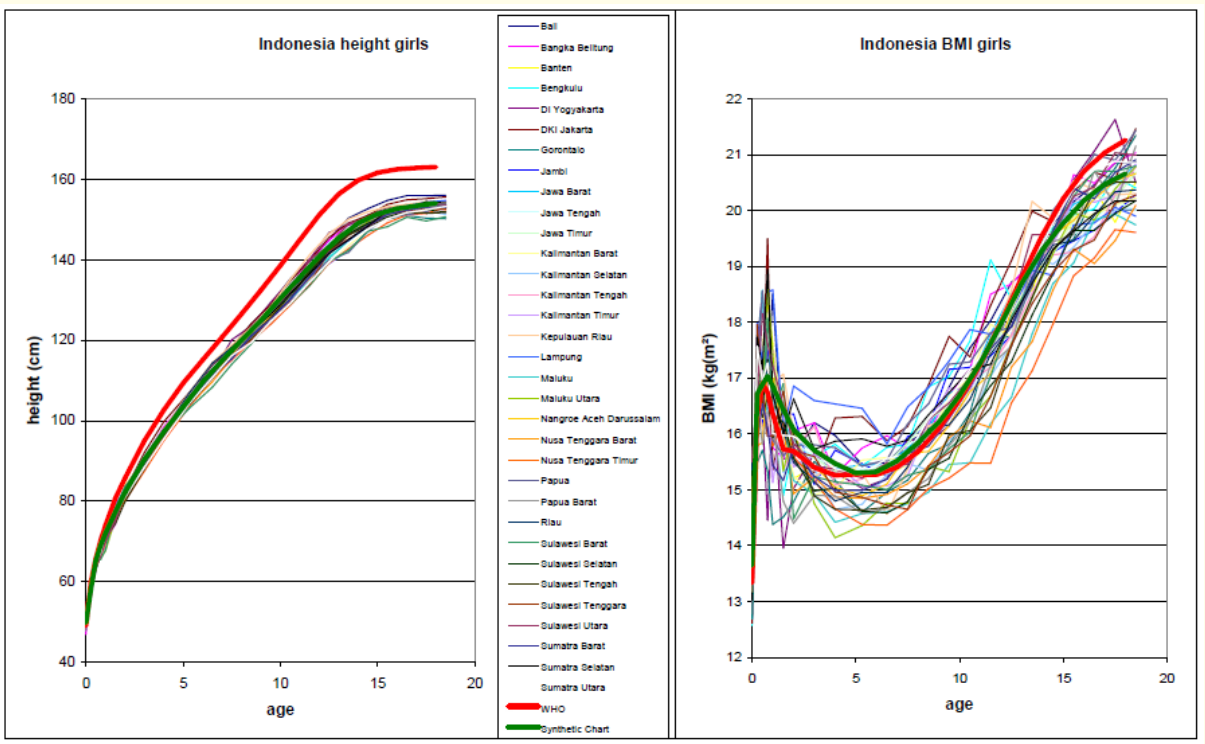

Figure 3: Mean values for height and BMI of Indonesian girls by Province. Red lines indicate WHO standards/references.

Figures 4a illustrates the association between per capita income as a general measure of wealth, and infant weight gain in male Indonesians. Figure 4b illustrates the association between per capita income and early adult height. Similar associations are found in females (data not shown).

Per capita infant grossly varies between the different districts (Figure 4a), with little over 1000 US$ for Nusa Tenggara Timur, and 15,000 US$ for Jakarta [22]. Relevant associations between per capita income and early weight gain (birth to age 1.5 years) do not exist in Indonesia (r = 0.22, not significant).

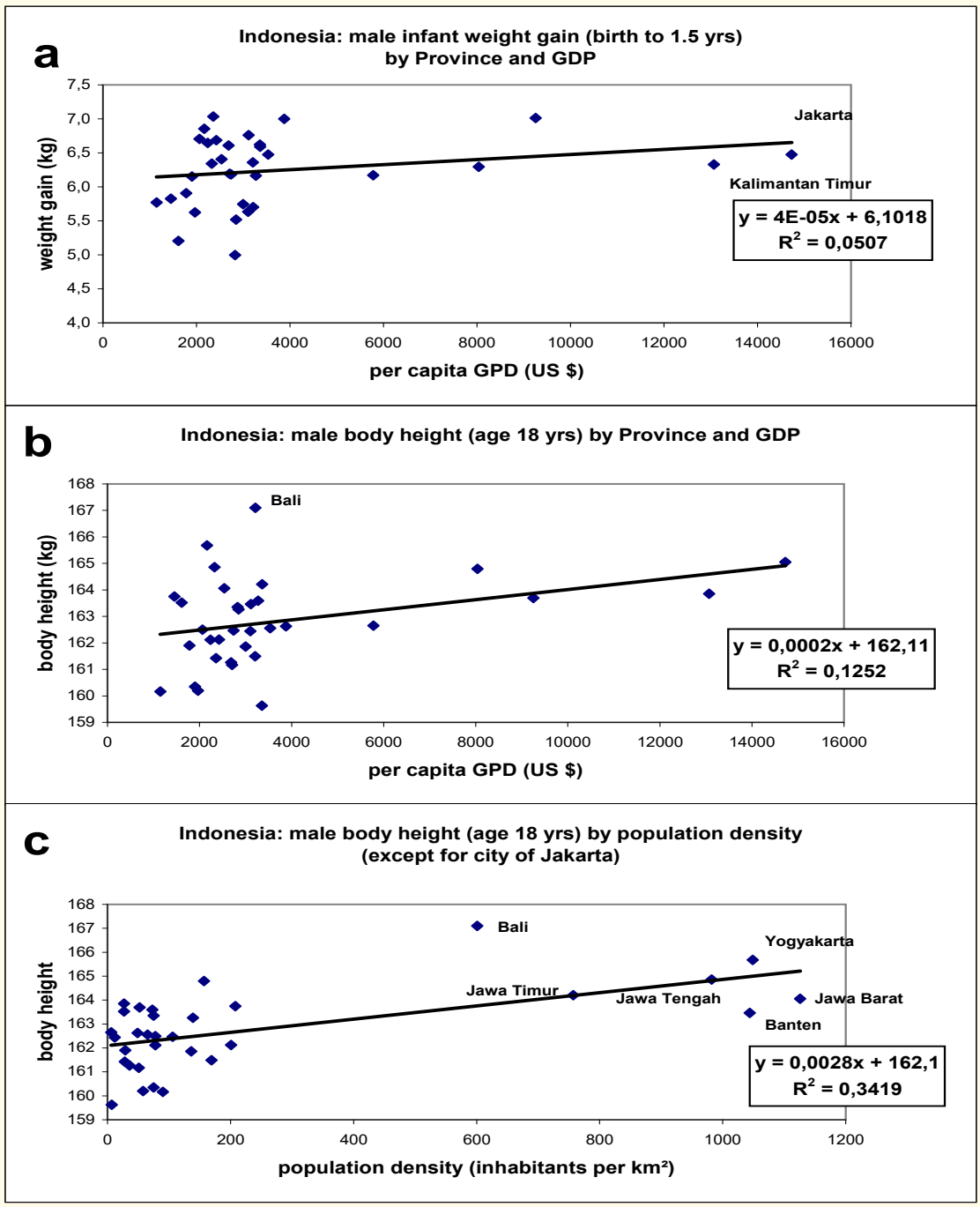

Figure 4a: Weight gain (birth to 1.5 yrs) of Indonesian male infant by Province and GDP.

Figure 4b: Body height of Indonesian young men (age 18 yrs) by Province and GDP.

Figure 4c: Body height of Indonesian young men (age 18 yrs) by population density. Data from DKI Jakarta are excluded.

The association between per capita income and early adult height (Figure 4b) is weak ($r = 0.35$, $p < 0.05$) indicating that per capita income lacks major impact also on adult height in Indonesia. E.g. the tall people from Bali have a per capita income of approximately 3200 $US, whereas the people from Jambi who enjoy similar per capita income, are on average 5 cm shorter.

Height is related to population crowding. Even when excluding the densely populated Mega-city of Jakarta, height at 18 years and population density [21] are significantly correlated ($r = 0.58$ ($p < 0.001$; Figure 4c) indicating that some 34% of height variance is explained by population density. Female heights distribute similarly though to a lesser extend (data not shown).

	At birth		At age 6.5		At age 18.5
Maluku Utara	47.93	Nusa Tenggara Timur	110.92	Papua	159.63
Sulawesi Tengah	48.15	Sulawesi Tenggara	111.00	Nusa Tenggara Timur	160.16
Papua Barat	48.44	Sulawesi Selatan	111.02	Sulawesi Barat	160.20
Kalimantan Barat	48.47	Sulawesi Tengah	111.03	Gorontalo	160.35
Kalimantan Tengah	48.65	Nusa Tenggara Barat	111.14	Sulawesi Tenggara	161.17
DKI Jakarta	48.88	Sulawesi Barat	111.18	Sulawesi Tengah	161.27
Riau	48.94	Maluku	111.38	Kalimantan Barat	161.43
DI Yogyakarta	49.30	Bengkulu	111.83	Sumatra Utara	161.49
Nusa Tenggara Barat	49.34	Nangroe Aceh Darussalam	111.85	Sulawesi Selatan	161.86
Gorontalo	49.43	Sumatra Utara	111.97	Maluku Utara	161.90
Jawa Barat	49.55	Papua Barat	112.01	Nangroe Aceh Darussalam	162.12
Kepulauan Riau	49.60	Lampung	112.13	Lampung	162.12
Papua	49.78	Maluku Utara	112.15	Kalimantan Tengah	162.44
Sulawesi Utara	49.85	Kalimantan Barat	112.33	Sumatra Barat	162.46
Lampung	49.95	Sumatra Barat	112.39	Bengkulu	162.50
Jawa Timur	50.09	Papua	112.46	Bangka Belitung	162.55
Nusa Tenggara Timur	50.09	Kalimantan Selatan	112.59	Jambi	162.62
Jawa Tengah	50.10	Gorontalo	112.81	Papua Barat	162.65
Sulawesi Tenggara	50.17	Jawa Timur	112.93	Sulawesi Utara	163.26
Nangroe Aceh Darussalam	50.23	Jawa Tengah	113.01	Kalimantan Selatan	163.35
Sumatra Selatan	50.34	Jawa Barat	113.03	Banten	163.46
Sumatra Barat	50.50	Sulawesi Utara	113.12	Maluku	163.52
Sulawesi Selatan	50.51	Kalimantan Tengah	113.13	Sumatra Selatan	163.59
Banten	50.57	Jambi	113.18	Riau	163.70
Bangka Belitung	50.86	Sumatra Selatan	113.34	Nusa Tenggara Barat	163.75
Sumatra Utara	50.88	Kalimantan Timur	113.45	Kalimantan Timur	163.85
Kalimantan Timur	51.02	Banten	113.66	Jawa Barat	164.06
Bengkulu	51.04	Bangka Belitung	113.99	Jawa Timur	164.21
Kalimantan Selatan	51.20	Bali	114.09	Kepulauan Riau	164.79
Jambi	51.22	DI Yogyakarta	114.40	Jawa Tengah	164.86
Maluku	52.12	Riau	114.53	DKI Jakarta	165.05
Bali	52.90	DKI Jakarta	114.71	DI Yogyakarta	165.68
Sulawesi Barat	53.77	Kepulauan Riau	115.00	Bali	167.10
Average	50.12		112.66		162.82

Table 2a: Male height sorted by province and magnitude.

Table 2a and 2b depict heights at birth, at age 6.5, and at age 18.5, sorted by province and magnitude. Additional multiple regression analyses were not performed as this was not the main focus of the present study.

Not only WHO height, but also WHO BMI standards and references do not match with the Indonesian population. Except for early infancy, children and Indonesian adolescents of both sexes

	At birth		At age 6.5		At age 18.5
Bangka Belitung	47.00	Sulawesi Barat	108.33	Gorontalo	150.24
Kalimantan Selatan	47.99	Nusa Tenggara Barat	109.73	Sulawesi Barat	150.71
Sulawesi Utara	48.01	Kalimantan Tengah	110.53	Kalimantan Selatan	151.32
Sulawesi Tengah	48.73	Sulawesi Selatan	110.67	Sulawesi Tengah	151.79
DI Yogyakarta	49.00	Sulawesi Tengah	110.68	Sulawesi Selatan	151.92
Kalimantan Barat	49.00	Nusa Tenggara Timur	110.69	Nusa Tenggara Barat	152.45
Riau	49.03	Sumatra Utara	110.76	Bangka Belitung	152.56
Kalimantan Tengah	49.04	Gorontalo	111.12	Sulawesi Tenggara	152.73
Jambi	49.14	Nangroe Aceh Darussalam	111.27	Maluku Utara	152.76
Maluku Utara	49.45	Maluku Utara	111.30	Kalimantan Tengah	152.93
Sumatra Selatan	49.50	Sumatra Barat	111.50	Sumatra Barat	152.97
Sulawesi Tenggara	49.51	Maluku	111.54	Nangroe Aceh Darussalam	153.04
Jawa Barat	49.51	Sulawesi Tenggara	111.60	Nusa Tenggara Timur	153.10
Jawa Tengah	49.52	Kalimantan Selatan	111.69	Riau	153.13
Kalimantan Timur	49.52	Kalimantan Barat	111.79	Kalimantan Barat	153.15
Nusa Tenggara Barat	49.66	DI Yogyakarta	111.92	Papua Barat	153.22
Papua	49.71	Jawa Timur	112.03	Sumatra Utara	153.26
Nusa Tenggara Timur	49.73	Sulawesi Utara	112.13	Jawa Timur	153.28
Jawa Timur	49.88	Jawa Tengah	112.25	Papua	153.68
Nangroe Aceh Darussalam	49.88	Jawa Barat	112.31	Maluku	153.76
Bali	49.91	Papua Barat	112.31	Jambi	153.76
Lampung	49.99	Bengkulu	112.34	Sulawesi Utara	153.79
Banten	50.05	Papua	112.40	Banten	153.83
Sulawesi Selatan	50.11	Kalimantan Timur	112.46	Kalimantan Timur	153.89
Papua Barat	50.18	Lampung	112.53	Jawa Barat	153.93
Sumatra Barat	50.76	Bangka Belitung	112.66	Jawa Tengah	154.08
Gorontalo	51.00	Banten	112.71	Sumatra Selatan	154.16
DKI Jakarta	51.03	Jambi	112.76	Bengkulu	154.19
Kepulauan Riau	51.10	Sumatra Selatan	112.79	Kepulauan Riau	154.20
Sulawesi Barat	51.17	Bali	113.91	DI Yogyakarta	154.57
Sumatra Utara	51.29	DKI Jakarta	114.01	Lampung	154.74
Bengkulu	51.87	Riau	114.30	DKI Jakarta	155.67
Maluku	52.47	Kepulauan Riau	114.45	Bali	156.07
Average	49.81		111.92		153.30

Table 2b: Female height sorted by province and magnitude.

appear slightly heavier than WHO standards and references. Only during late adolescence, BMI tends to slightly fall below the WHO references (Figures 2 and 3). Also weight differs from WHO standards. Whereas Indonesian birth weights appear similar, weight then tends to slightly drop below the standards though less than body length (Figures 2 and 3). Indonesian growth patterns resemble patterns observed in the healthy Japanese population [27].

The tables 3 (boys) and 4 (girls) provide the full synthetic set of mean values, standard deviations and common centiles for height, and LMS parameters and common centiles for weight and BMI, from birth to age 18. Table 5 exemplifies a synthetic growth reference for the short population of the province of Papua.

Boys Height cm											
Age	**Mean**	**SD**	**p3**	**p5**	**p10**	**p25**	**p50**	**p75**	**p90**	**p95**	**p97**
0.00	49.84	2.03	46.03	46.51	47.24	48.48	49.84	51.21	52.45	53.18	53.66
0.25	59.73	2.44	55.14	55.70	56.60	58.09	59.73	61.37	62.86	63.76	64.32
0.50	66.06	2.50	61.36	61.95	62.86	64.38	66.06	67.75	69.26	70.17	70.76
0.75	69.92	2.61	65.00	65.62	66.57	68.15	69.92	71.68	73.26	74.21	74.83
1.00	73.39	2.83	68.08	68.74	69.77	71.48	73.39	75.30	77.01	78.04	78.71
1.50	78.73	3.23	72.66	73.43	74.60	76.56	78.73	80.91	82.87	84.04	84.80
2.00	83.97	3.60	77.20	78.03	79.36	81.56	83.97	86.38	88.58	89.91	90.74
3.00	92.03	4.11	84.31	85.28	86.77	89.26	92.03	94.80	97.29	98.78	99.75
4.00	98.47	4.50	90.01	91.07	92.71	95.44	98.47	101.50	104.24	105.87	106.93
5.00	104.72	4.74	95.79	96.91	98.64	101.52	104.72	107.92	110.80	112.52	113.64
6.00	110.56	5.09	100.98	102.18	104.03	107.13	110.56	114.00	117.09	118.94	120.15
7.00	115.49	5.36	105.41	106.67	108.62	111.87	115.49	119.10	122.35	124.30	125.57
8.00	120.29	5.64	109.69	111.02	113.07	116.49	120.29	124.10	127.52	129.57	130.90
9.00	125.22	5.90	114.13	115.52	117.67	121.25	125.22	129.20	132.78	134.92	136.31
10.00	129.85	6.19	118.22	119.68	121.93	125.68	129.85	134.03	137.78	140.03	141.49
11.00	134.71	6.55	122.39	123.93	126.31	130.29	134.71	139.13	143.11	145.49	147.03
12.00	139.56	7.16	126.09	127.78	130.38	134.73	139.56	144.39	148.74	151.34	153.03
13.00	145.27	8.02	130.18	132.08	134.99	139.86	145.27	150.69	155.56	158.47	160.36
14.00	151.41	8.32	135.77	137.73	140.75	145.80	151.41	157.02	162.07	165.09	167.05
15.00	156.53	7.85	141.76	143.62	146.47	151.23	156.53	161.83	166.59	169.45	171.30
16.00	160.36	7.06	147.08	148.74	151.31	155.60	160.36	165.12	169.41	171.98	173.64
17.00	162.56	6.64	150.07	151.64	154.05	158.08	162.56	167.03	171.06	173.47	175.04
18.00	164.03	6.50	151.81	153.34	155.70	159.64	164.03	168.41	172.36	174.72	176.25
Boys Weight kg											
Age	**Mean**	**L**	**S**	**p3**	**p5**	**p10**	**p25**	**p50**	**p75**	**p90**	**p95**	**p97**
0.00	3.46	0.80	0.134	2.61	2.71	2.88	3.15	3.46	3.77	4.06	4.24	4.35
0.25	6.33	0.70	0.126	4.89	5.06	5.34	5.80	6.33	6.87	7.37	7.68	7.88
0.50	7.76	0.60	0.105	6.30	6.47	6.75	7.22	7.76	8.31	8.83	9.15	9.35
0.75	8.55	0.50	0.101	7.01	7.19	7.48	7.98	8.55	9.14	9.69	10.04	10.25
1.00	9.17	0.40	0.091	7.68	7.85	8.14	8.62	9.17	9.74	10.28	10.61	10.83
1.50	10.24	-0.10	0.091	8.63	8.81	9.11	9.63	10.24	10.88	11.51	11.91	12.17
2.00	11.22	-0.20	0.094	9.43	9.63	9.96	10.54	11.22	11.95	12.67	13.13	13.43
3.00	13.38	-0.30	0.105	11.05	11.31	11.73	12.48	13.38	14.37	15.35	15.99	16.40
4.00	15.15	-0.60	0.117	12.32	12.62	13.12	14.03	15.15	16.42	17.73	18.61	19.19
5.00	16.92	-0.70	0.121	13.71	14.04	14.61	15.64	16.92	18.39	19.92	20.96	21.65
6.00	18.99	-0.80	0.124	15.32	15.70	16.34	17.51	18.99	20.70	22.51	23.76	24.60
7.00	21.14	-0.90	0.136	16.79	17.22	17.98	19.36	21.14	23.25	25.55	27.17	28.27
8.00	23.48	-1.00	0.152	18.26	18.77	19.66	21.31	23.48	26.14	29.15	31.34	32.87
9.00	25.95	-1.00	0.161	19.91	20.50	21.51	23.42	25.95	29.09	32.69	35.35	37.23
10.00	28.58	-0.80	0.167	21.62	22.30	23.48	25.69	28.58	32.12	36.11	38.98	40.98
11.00	31.58	-0.80	0.179	23.45	24.23	25.60	28.17	31.58	35.82	40.66	44.21	46.71
12.00	34.81	-0.70	0.190	25.31	26.22	27.81	30.81	34.81	39.77	45.43	49.57	52.48
13.00	38.89	-0.50	0.195	27.77	28.86	30.74	34.27	38.89	44.52	50.79	55.25	58.33
14.00	43.04	-0.30	0.182	31.08	32.29	34.36	38.18	43.04	48.73	54.80	58.96	61.75
15.00	47.21	-0.20	0.160	35.27	36.52	38.64	42.47	47.21	52.61	58.17	61.89	64.35
16.00	50.59	-0.40	0.138	39.54	40.69	42.66	46.20	50.59	55.58	60.75	64.21	66.51
17.00	52.98	-0.50	0.124	42.50	43.61	45.48	48.84	52.98	57.67	62.50	65.73	67.87
18.00	54.66	-0.50	0.122	44.01	45.14	47.04	50.46	54.66	59.41	64.29	67.55	69.70
Boys BMI kg/m^2											
Age	**Mean**	**L**	**S**	**p3**	**p5**	**p10**	**p25**	**p50**	**p75**	**p90**	**p95**	**p97**
0.00	13.95	0.00	0.080	12.00	12.22	12.59	13.22	13.95	14.71	15.45	15.91	16.21
0.25	17.21	-0.10	0.077	14.90	15.17	15.60	16.34	17.21	18.12	19.00	19.55	19.91
0.50	17.60	-0.20	0.079	15.20	15.47	15.92	16.70	17.60	18.56	19.49	20.09	20.46
0.75	17.48	-0.30	0.085	14.95	15.24	15.71	16.52	17.48	18.51	19.53	20.17	20.59
1.00	17.08	-0.40	0.086	14.60	14.88	15.34	16.14	17.08	18.11	19.12	19.77	20.19
1.50	16.51	-0.60	0.087	14.13	14.39	14.82	15.59	16.51	17.52	18.53	19.19	19.61
2.00	16.15	-0.70	0.084	13.91	14.15	14.56	15.29	16.15	17.11	18.06	18.69	19.10
3.00	15.79	-1.00	0.076	13.82	14.03	14.39	15.03	15.79	16.64	17.49	18.06	18.42
4.00	15.57	-1.20	0.072	13.74	13.94	14.27	14.86	15.57	16.37	17.17	17.70	18.05
5.00	15.36	-1.40	0.075	13.51	13.71	14.04	14.64	15.36	16.19	17.03	17.60	17.98
6.00	15.40	-1.60	0.081	13.44	13.64	13.99	14.62	15.40	16.30	17.25	17.90	18.34
7.00	15.59	-1.70	0.092	13.40	13.62	14.00	14.70	15.59	16.64	17.78	18.58	19.13
8.00	16.01	-1.80	0.098	13.65	13.89	14.30	15.04	16.01	17.17	18.45	19.38	20.02
9.00	16.39	-1.90	0.102	13.92	14.16	14.58	15.37	16.39	17.63	19.04	20.07	20.80
10.00	16.86	-1.90	0.108	14.20	14.46	14.92	15.76	16.86	18.23	19.80	20.96	21.79
11.00	17.34	-1.90	0.112	14.53	14.80	15.28	16.17	17.34	18.80	20.50	21.77	22.69
12.00	17.85	-1.80	0.117	14.83	15.13	15.63	16.59	17.85	19.43	21.26	22.63	23.62
13.00	18.26	-1.80	0.119	15.13	15.43	15.96	16.95	18.26	19.90	21.82	23.27	24.31
14.00	18.67	-1.70	0.122	15.38	15.70	16.26	17.29	18.67	20.39	22.39	23.89	24.97
15.00	19.24	-1.60	0.117	15.94	16.26	16.82	17.87	19.24	20.92	22.83	24.24	25.23
16.00	19.71	-1.60	0.115	16.37	16.70	17.27	18.33	19.71	21.40	23.31	24.71	25.70
17.00	20.24	-1.60	0.115	16.81	17.15	17.74	18.82	20.24	21.98	23.94	25.38	26.39
18.00	20.67	-1.50	0.117	17.09	17.45	18.06	19.19	20.67	22.47	24.49	25.96	26.99

Table 3: National Synthetic Growth Reference Charts for Indonesian boys.

Girls Height cm											
Age	**Mean**	**SD**	**p3**	**p5**	**p10**	**p25**	**p50**	**p75**	**p90**	**p95**	**p97**
0.00	49.83	1.97	46.13	46.58	47.31	48.51	49.83	51.15	52.35	53.07	53.53
0.25	58.07	2.34	53.67	54.21	55.08	56.50	58.07	59.64	61.07	61.93	62.47
0.50	65.25	2.46	60.63	61.21	62.10	63.59	65.25	66.90	68.39	69.28	69.86
0.75	68.98	2.61	64.07	64.69	65.64	67.22	68.98	70.75	72.33	73.28	73.90
1.00	72.09	2.75	66.92	67.56	68.56	70.23	72.09	73.94	75.61	76.61	77.26
1.50	77.30	3.19	71.31	72.06	73.22	75.15	77.30	79.45	81.39	82.55	83.30
2.00	82.12	3.53	75.48	76.31	77.60	79.74	82.12	84.50	86.64	87.92	88.76
3.00	90.41	4.00	82.88	83.83	85.28	87.71	90.41	93.11	95.54	97.00	97.94
4.00	97.35	4.47	88.94	90.00	91.62	94.33	97.35	100.37	103.08	104.71	105.76
5.00	103.46	4.77	94.49	95.62	97.35	100.25	103.46	106.68	109.57	111.31	112.43
6.00	109.63	5.04	100.16	101.35	103.18	106.24	109.63	113.03	116.09	117.92	119.11
7.00	114.94	5.34	104.90	106.16	108.10	111.34	114.94	118.54	121.78	123.72	124.98
8.00	120.07	5.69	109.37	110.71	112.78	116.23	120.07	123.91	127.36	129.43	130.77
9.00	125.01	6.00	113.72	115.14	117.32	120.96	125.01	129.05	132.70	134.88	136.29
10.00	130.46	6.50	118.24	119.77	122.13	126.07	130.46	134.84	138.78	141.14	142.67
11.00	135.76	6.97	122.64	124.29	126.82	131.05	135.76	140.46	144.70	147.23	148.87
12.00	140.96	7.11	127.60	129.28	131.86	136.17	140.96	145.76	150.07	152.65	154.33
13.00	145.48	6.69	132.89	134.47	136.90	140.97	145.48	149.99	154.05	156.49	158.06
14.00	149.13	6.16	137.54	139.00	141.23	144.97	149.13	153.29	157.03	159.26	160.72
15.00	151.38	5.95	140.19	141.60	143.76	147.37	151.38	155.40	159.01	161.17	162.58
16.00	152.75	5.83	141.78	143.16	145.28	148.82	152.75	156.69	160.23	162.35	163.72
17.00	153.42	5.80	142.51	143.88	145.99	149.51	153.42	157.33	160.85	162.95	164.32
18.00	154.05	5.78	143.18	144.55	146.65	150.16	154.05	157.95	161.46	163.56	164.93
Girls Weight kg											
Age	**Mean**	**L**	**S**	**p3**	**p5**	**p10**	**p25**	**p50**	**p75**	**p90**	**p95**	**p97**
0.00	3.39	1.00	0.125	2.59	2.69	2.85	3.10	3.39	3.67	3.93	4.08	4.18
0.25	5.64	0.80	0.129	4.30	4.46	4.72	5.15	5.64	6.13	6.58	6.86	7.04
0.50	7.31	0.60	0.115	5.79	5.97	6.26	6.75	7.31	7.88	8.42	8.75	8.96
0.75	8.11	0.40	0.110	6.53	6.72	7.01	7.52	8.11	8.72	9.30	9.67	9.90
1.00	8.62	0.20	0.104	7.06	7.24	7.53	8.03	8.62	9.23	9.82	10.20	10.43
1.50	9.76	0.20	0.104	8.00	8.20	8.53	9.10	9.76	10.45	11.12	11.54	11.81
2.00	10.86	0.20	0.105	8.87	9.10	9.47	10.11	10.86	11.65	12.41	12.88	13.19
3.00	12.86	-0.20	0.112	10.46	10.73	11.17	11.94	12.86	13.87	14.87	15.52	15.94
4.00	14.68	-0.50	0.121	11.83	12.14	12.65	13.56	14.68	15.95	17.25	18.12	18.70
5.00	16.43	-0.70	0.136	12.99	13.34	13.95	15.04	16.43	18.05	19.78	20.97	21.77
6.00	18.32	-0.80	0.136	14.52	14.90	15.56	16.78	18.32	20.13	22.09	23.45	24.38
7.00	20.44	-0.80	0.153	15.78	16.25	17.05	18.53	20.44	22.75	25.29	27.10	28.34
8.00	23.03	-0.80	0.168	17.38	17.93	18.89	20.68	23.03	25.90	29.14	31.48	33.11
9.00	25.56	-0.70	0.177	18.95	19.59	20.71	22.81	25.56	28.93	32.72	35.46	37.35
10.00	28.51	-0.60	0.192	20.57	21.34	22.67	25.19	28.51	32.59	37.18	40.49	42.80
11.00	32.01	-0.50	0.204	22.55	23.46	25.05	28.05	32.01	36.87	42.32	46.24	48.96
12.00	35.48	-0.20	0.204	24.51	25.60	27.50	31.00	35.48	40.76	46.41	50.30	52.91
13.00	39.51	-0.30	0.177	28.78	29.87	31.74	35.17	39.51	44.58	49.95	53.62	56.09
14.00	43.02	-0.40	0.155	32.67	33.73	35.55	38.86	43.02	47.82	52.88	56.31	58.61
15.00	45.06	-0.50	0.137	35.36	36.36	38.08	41.19	45.06	49.50	54.15	57.29	59.39
16.00	46.65	-0.70	0.129	37.29	38.26	39.91	42.90	46.65	51.00	55.60	58.74	60.85
17.00	47.78	-0.80	0.129	38.27	39.25	40.91	43.94	47.78	52.26	57.05	60.35	62.58
18.00	48.75	-0.80	0.130	38.99	39.99	41.69	44.81	48.75	53.36	58.30	61.71	64.01
Girls BMI kg/m^2											
Age	**Mean**	**L**	**S**	**p3**	**p5**	**p10**	**p25**	**p50**	**p75**	**p90**	**p95**	**p97**
0.00	13.65	0.00	0.074	11.87	12.08	12.41	12.99	13.65	14.34	15.00	15.42	15.68
0.25	16.72	-0.10	0.080	14.40	14.66	15.10	15.85	16.72	17.64	18.53	19.09	19.45
0.50	16.88	-0.30	0.079	14.60	14.86	15.28	16.02	16.88	17.81	18.71	19.29	19.66
0.75	17.03	-0.50	0.083	14.66	14.92	15.36	16.13	17.03	18.02	19.00	19.63	20.04
1.00	16.85	-0.60	0.083	14.52	14.77	15.20	15.95	16.85	17.83	18.81	19.44	19.85
1.50	16.43	-1.00	0.085	14.17	14.41	14.82	15.55	16.43	17.42	18.44	19.11	19.56
2.00	16.08	-1.30	0.084	13.93	14.15	14.54	15.23	16.08	17.05	18.05	18.73	19.19
3.00	15.70	-1.50	0.083	13.65	13.87	14.23	14.89	15.70	16.64	17.63	18.31	18.76
4.00	15.47	-1.80	0.082	13.50	13.70	14.05	14.68	15.47	16.39	17.38	18.06	18.53
5.00	15.30	-1.90	0.089	13.23	13.44	13.80	14.46	15.30	16.30	17.39	18.17	18.71
6.00	15.32	-2.00	0.091	13.23	13.44	13.80	14.47	15.32	16.35	17.49	18.32	18.89
7.00	15.52	-1.90	0.102	13.18	13.41	13.81	14.55	15.52	16.70	18.03	19.01	19.70
8.00	15.84	-1.70	0.107	13.33	13.58	14.01	14.81	15.84	17.10	18.52	19.54	20.26
9.00	16.21	-1.60	0.112	13.52	13.79	14.25	15.10	16.21	17.56	19.08	20.18	20.96
10.00	16.69	-1.50	0.119	13.76	14.05	14.55	15.48	16.69	18.17	19.84	21.06	21.92
11.00	17.27	-1.40	0.124	14.11	14.43	14.96	15.96	17.27	18.86	20.67	21.98	22.90
12.00	17.97	-1.30	0.138	14.37	14.72	15.32	16.46	17.97	19.83	21.96	23.53	24.65
13.00	18.69	-1.30	0.139	14.93	15.29	15.93	17.12	18.69	20.65	22.89	24.55	25.73
14.00	19.30	-1.30	0.128	15.65	16.02	16.64	17.79	19.30	21.14	23.21	24.71	25.76
15.00	19.77	-1.30	0.116	16.32	16.67	17.26	18.36	19.77	21.46	23.32	24.64	25.55
16.00	20.18	-1.20	0.110	16.78	17.12	17.72	18.80	20.18	21.80	23.55	24.76	25.59
17.00	20.47	-1.20	0.107	17.09	17.44	18.03	19.11	20.47	22.06	23.77	24.96	25.77
18.00	20.66	-1.10	0.105	17.28	17.63	18.22	19.30	20.66	22.23	23.89	25.04	25.81

Table 4: National Synthetic Growth Reference Charts for Indonesian girls.

Figures 5 and 6 show the differences (DELTA) between regional heights and BMIs, and the synthetic National references for each of the 33 Indonesian provinces, and the differences (DELTA) between WHO and synthetic National references. The marked variation of BMI_DELTA at early age partially reflects high physiological variation, but may also partially be due to small numbers (e.g. there were only 15 girls from Bali in the 1-year age group of this island).

Figure 7 shows raw height and raw weight data from Bali (an example of tall girls) and from Gorontalo (an example of short girls) plotted on National Synthetic Growth Charts. The 50th centiles of WHO height standards/references illustrate the mismatch between National and global references

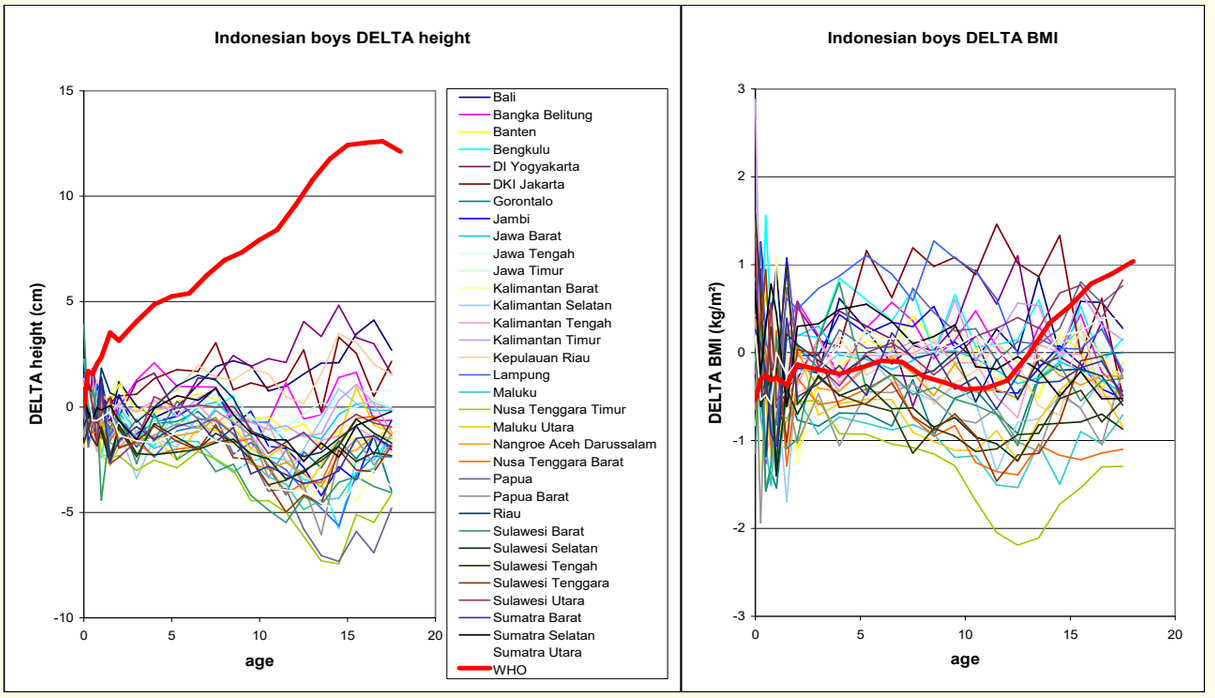

Figure 5: DELTA height and DELTA BMI of Indonesian boys. Red lines indicate WHO standards/references. The poor matching of height data is obvious, whereas BMI data deviate less from global references.

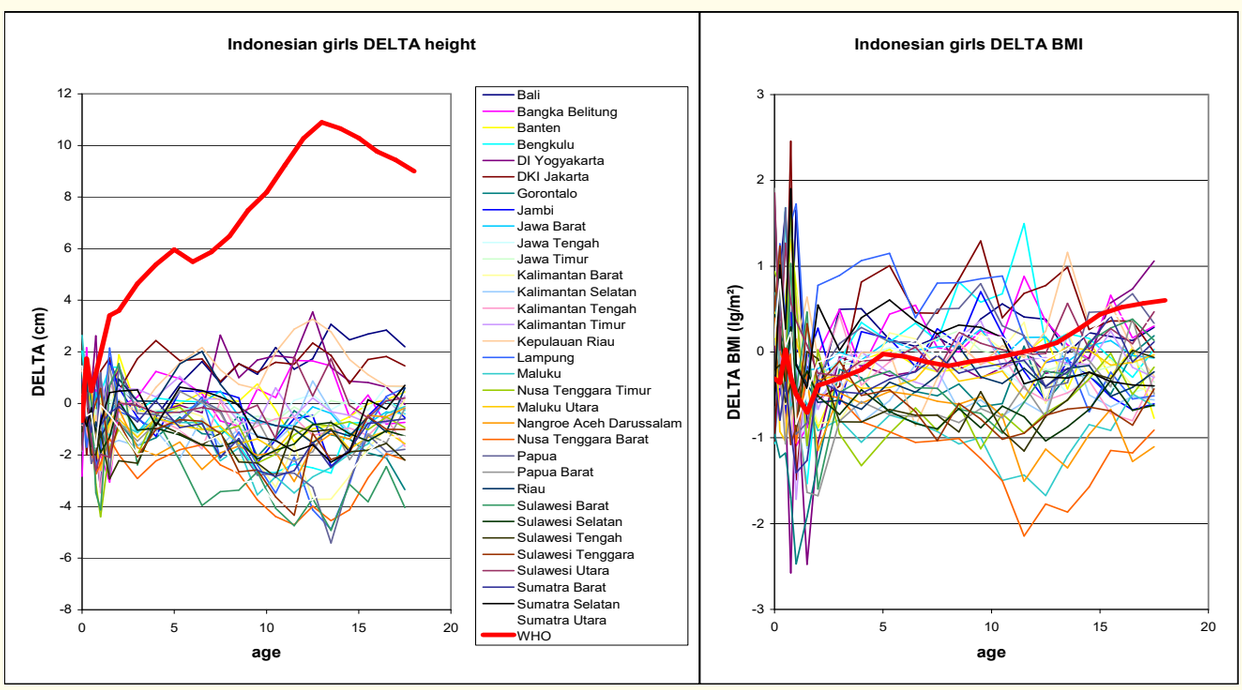

Figure 6: DELTA height and DELTA BMI of Indonesian girls. Red lines indicate WHO standards/references.

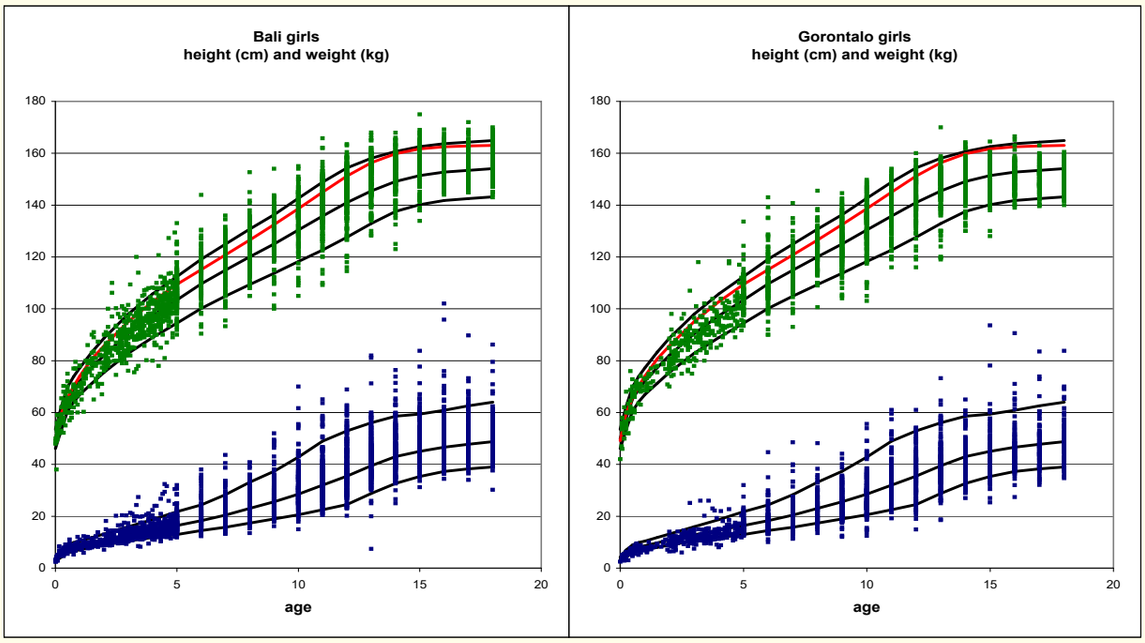

Figure 7: Raw data of height (green) and weight data (blue) from Bali (tall girls) and from Gorontalo (short girls) plotted on National Synthetic Growth Charts (black lines depict 3rd, 50th and 97th centile for height and weight). Red lines depict 50th centiles of WHO height standards/references.

Discussion

The rationale for normative growth charts reaches back to recommendations of a working group on infant growth, established in the early 1990s by the WHO. It emphasized the similarity in early childhood growth among diverse ethnic groups [28]. The recommendations are based on 6 longitudinal growth studies from birth to 24 months, followed by cross-sectional data up to 72 months. Most of the children were breastfed, grew up under affluent conditions, and appeared very similar in growth patterns [29]. Indonesian children were not included in these standards. Corresponding international normative charts for age 5 - 19 years were added based on 1977 US cross-sectional growth references [30]. These growth charts are widely used and considered normative. By April 2011, 125 countries had adopted WHO growth standards [31].

Height, weight, and BMI, vary among the different countries and even among different ethnic groups within the same country. Modern Europeans surpass WHO growth standards and references by up to one standard deviation in height, whereas populations from developing countries may range up to 2 standard deviations below [32]. In countries with tall populations, WHO standards lead to misclassification and misdiagnosis of clinically relevant causes of short stature [33,34], whereas underweight and stunting are likely to be over diagnosed in a large number of apparently normal children in the developing countries such as India [35].

The popular vision that poor nutrition causes short stature is universal, but so is the reciprocal vision that short stature is an indicator of poor nutrition. In 1973 Waterlow [36] defined "criteria of malnutrition" by certain lower cut-off limits for height and weight ("wasted", "stunted", or "wasted and stunted"). Today, UNICEF defines "stunting" as height below minus two standard deviations from median height for age, "wasting" as body weight below minus two standard deviations from median weight for height of reference population [37]. Since a 1988 workshop on Linear Growth Retardation in Less Developed Countries [38], the terms "stunting" and undernutrition tend to be synonymously used, and in consequence, are considered a major public health priority. Stunting is believed to be the most common form of undernutrition globally [39]. Black., *et al.* [40] claimed that the prevalence of stunting of children younger than 5 years is highest in South Asia and Sub-Saharan Africa. Without hesitation, these authors take stunting as a natural expression of undernutrition.

The synonymous use of the terms "stunting" and "undernutrition" is grossly misleading. According to such criteria, the complete European population during the second half of the 19th century [19,41] should have been classified as undernourished. Yet in those days, undernutrition was no longer an issue in the industrialized European countries. Quite in contrast, the historic medical literature is full of examples of overnutrition and child obesity, and already more than 100 years ago discusses the need for weight loss cures in children [42].

The present data obtained in the 33 Indonesian provinces reinforce doubts regarding any consistent association between nutrition and growth. Indonesian child growth patterns strongly resembles patterns observed in the healthy Japanese population [27] where infants drop in length by several centimetres compared with WHO standards, and thus, confirm the need for national growth reference charts.

In order not to neglect the more remote areas of Indonesia, one separate height chart was exemplarily provided for children of Papua (Table 5). The need for separate growth charts for certain regions should be re-evaluated. It is not obvious why children from remote areas grow differently. Growth differences may be caused by the particular socio-environmental circumstances. In this case, growth changes are to be expected when these areas economically stabilize and unify with the rest of Indonesia. If not, genetic differences also may play a role.

Boys Papua Height											
Age	**Mean**	**SD**	**P3**	**P5**	**P10**	**P25**	**P50**	**P75**	**P90**	**P95**	**P97**
0.00	50.18	2.03	46.36	46.84	47.58	48.81	50.18	51.55	52.78	53.52	53.99
0.25	60.00	2.44	55.41	55.98	56.87	58.35	60.00	61.65	63.13	64.02	64.59
0.50	65.95	2.50	61.25	61.84	62.75	64.26	65.95	67.63	69.15	70.06	70.65
0.75	69.66	2.61	64.75	65.37	66.32	67.90	69.66	71.43	73.01	73.96	74.58
1.00	73.04	2.83	67.72	68.39	69.42	71.13	73.04	74.95	76.66	77.69	78.36
1.50	77.85	3.23	71.78	72.54	73.71	75.67	77.85	80.02	81.98	83.15	83.92
2.00	82.32	3.60	75.55	76.40	77.71	79.89	82.32	84.75	86.93	88.24	89.09
3.00	90.99	4.11	83.27	84.24	85.73	88.22	90.99	93.76	96.25	97.74	98.71
4.00	97.03	4.50	88.56	89.63	91.26	93.99	97.03	100.06	102.79	104.42	105.49
5.00	103.28	4.74	94.35	95.47	97.20	100.08	103.28	106.48	109.36	111.08	112.20
6.00	109.25	5.09	99.67	100.87	102.72	105.82	109.25	112.69	115.78	117.63	118.83
7.00	114.08	5.36	104.01	105.27	107.22	110.47	114.08	117.70	120.95	122.90	124.16
8.00	118.22	5.64	107.62	108.95	111.00	114.42	118.22	122.03	125.45	127.50	128.83
9.00	122.70	5.90	111.61	113.00	115.14	118.72	122.70	126.68	130.26	132.40	133.79
10.00	126.85	6.19	115.22	116.68	118.93	122.68	126.85	131.02	134.78	137.03	138.49
11.00	131.21	6.55	118.89	120.43	122.81	126.79	131.21	135.63	139.61	141.99	143.54
12.00	134.92	7.16	121.45	123.14	125.74	130.09	134.92	139.75	144.10	146.70	148.39
13.00	139.28	8.02	124.19	126.09	129.00	133.87	139.28	144.70	149.57	152.48	154.37
14.00	143.97	8.32	128.33	130.29	133.31	138.36	143.97	149.58	154.63	157.65	159.61
15.00	148.60	7.85	133.83	135.68	138.53	143.30	148.60	153.89	158.66	161.51	163.36
16.00	153.19	7.06	139.90	141.57	144.14	148.42	153.19	157.95	162.24	164.80	166.47
17.00	156.57	6.64	144.09	145.65	148.06	152.09	156.57	161.05	165.08	167.49	169.05
18.00	159.06	6.50	146.84	148.37	150.73	154.68	159.06	163.44	167.39	169.75	171.28
Girls Papua Height											
Age	**Mean**	**SD**	**P3**	**P5**	**P10**	**P25**	**P50**	**P75**	**P90**	**P95**	**P97**
0.00	49.76	1.97	46.06	46.52	47.24	48.43	49.76	51.09	52.28	53.00	53.46
0.25	59.43	2.34	55.03	55.58	56.43	57.85	59.43	61.01	62.43	63.28	63.83
0.50	65.27	2.46	60.65	61.23	62.12	63.61	65.27	66.92	68.41	69.31	69.89
0.75	68.85	2.61	63.94	64.55	65.50	67.09	68.85	70.61	72.20	73.15	73.76
1.00	71.64	2.75	66.47	67.12	68.12	69.79	71.64	73.50	75.17	76.17	76.81
1.50	76.56	3.19	70.57	71.32	72.48	74.41	76.56	78.71	80.64	81.80	82.55
2.00	81.43	3.53	74.80	75.63	76.91	79.05	81.43	83.81	85.96	87.24	88.07
3.00	89.89	4.00	82.36	83.31	84.76	87.19	89.89	92.59	95.02	96.48	97.42
4.00	96.92	4.47	88.51	89.56	91.19	93.90	96.92	99.94	102.65	104.28	105.33
5.00	102.87	4.77	93.90	95.03	96.76	99.65	102.87	106.09	108.98	110.71	111.84
6.00	108.98	5.04	99.51	100.70	102.53	105.59	108.98	112.38	115.44	117.27	118.46
7.00	114.16	5.34	104.13	105.39	107.33	110.57	114.16	117.76	121.00	122.94	124.20
8.00	118.65	5.69	107.95	109.29	111.36	114.81	118.65	122.48	125.94	128.00	129.35
9.00	123.14	6.00	111.85	113.27	115.45	119.09	123.14	127.18	130.83	133.01	134.42
10.00	128.12	6.50	115.90	117.43	119.80	123.74	128.12	132.50	136.45	138.81	140.34
11.00	132.59	6.97	119.48	121.12	123.66	127.89	132.59	137.30	141.53	144.07	145.71
12.00	137.30	7.11	123.94	125.61	128.19	132.51	137.30	142.09	146.40	148.99	150.66
13.00	141.86	6.69	129.28	130.86	133.29	137.35	141.86	146.38	150.44	152.87	154.45
14.00	145.91	6.16	134.32	135.78	138.01	141.75	145.91	150.06	153.80	156.04	157.50
15.00	148.68	5.95	137.49	138.90	141.06	144.67	148.68	152.70	156.31	158.47	159.88
16.00	150.54	5.83	139.57	140.95	143.07	146.61	150.54	154.47	158.02	160.13	161.51
17.00	151.46	5.80	140.55	141.92	144.02	147.54	151.46	155.37	158.89	160.99	162.36
18.00	152.55	5.78	141.68	143.05	145.15	148.65	152.55	156.45	159.96	162.06	163.42

Table 5: Papua synthetic height chart.

Conclusion

Marked mismatch exists between WHO standards/references and Indonesian height and weight data. Indonesian children of both sexes are significantly shorter, and mature slightly earlier than the WHO standards/references suggest. We present synthetic new National Indonesian Growth Charts from birth to 18 years of age, providing the full set of mean values, standard deviations and common centiles for height, and LMS parameters and common centiles for weight and BMI. More studies may be necessary to further scrutinize the mismatch between WHO standards/references and national growth data, and to help improving current recommendations.

Authors' Contributions

ABP and MH wrote the manuscript.

MJ and JRLB obtained and provided the data and critically revised the draft.

MH generated the National Synthetic Growth Charts.

All authors approve the final version and agree to be accountable for all aspect of the work.

Conflict of Interest Statements

Dr. Hermanussen received payment from the Indonesian Pediatric Society.

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Ethics Committee Approval

This manuscript solely reports on secondary data obtained from Indonesian 2013 National Basic Health Survey. As the survey has obtained ethical approval from the Health Research Ethics Commission (KEPK) of the National Institute of Health Research And Development (Balitbangkes) of Ministry of Health Indonesia (Approval no. LB.02.01/5.2/KE.006/2013), there is no need for an additional ethics committee approval.

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Bibliography

1. https://en.wikipedia.org/wiki/List_of_countries_by_GDP_(PPP).

2. https://en.wikipedia.org/wiki/List_of_countries_by_income_equality.

3. https://en.wikipedia.org/wiki/List_of_average_human_height_worldwide.

4. Pierre van der Eng., *et al*. "Long-Term Economic Growth and the Standard of Living in Indonesia". Working Papers in Economics and Econometrics (2010).

5. Pierre van der Eng., *et al*. "The biological standard of living and body height in colonial and post-colonial Indonesia, 1770-2000". *Journal of Bioeconomics* 15 (2013): 103-122.

6. Gorter FJ and JH de Haas. "Gewicht en Lengte van 30 000 Schoolkinderen te Batavia". *Maandschrift voor Kindergeneeskunde* 15 (1947): 154-202.

7. Liem Tjay Tie S and de Haas JH. "Weight and height of native and Chinese infants at Batavia". *Indian Journal of Pediatrics* 5.4 (1938): 219-240.

8. Dhong TE., *et al*. "The growth of children of pre-school age in Batavia". *Indian Journal of Pediatrics* (1939): 163-185.

9. http://www.who.int/childgrowth/standards/en/.

10. http://www.who.int/growthref/en/.

11. http://www.cdc.gov/growthcharts/2000growthchart-us.pdf.

12. http://www.cdc.gov/nchs/data/series/sr_11/sr11_165.pdf.

13. http://www.rcpch.ac.uk/growthcharts.

14. Lartey A. "What would it take to prevent stunted growth in children in sub-Saharan Africa?" *Proceedings of the Nutrition Society* 74.4 (2015): 449-453.

15. Victora CG., *et al*. "Maternal and child undernutrition: consequences for adult health and human capital". *Lancet* 371.9609 (2008): 340-357.

16. Hermanussen M and Wit JM. "How Much Nutrition for How Much Growth?" *Hormone Research in Paediatrics* 88.1 (2017): 38-45.

17. Bogin B, et al. "Global effects of income and income inequality on adult height and sexual dimorphism in height". *American Journal of Human Biology* 29 (2017). doi: 10.1002/ajhb.22980.

18. Keys A., *et al*. "The biology of human starvation". The University of Minnesota Press. Minneapolis (1950).

19. Hermanussen M., *et al*. "Stunting, starvation and refeeding: a review of forgotten 19th and early 20th century literature". *Acta Paediatrica* 107.7 (2018): 1166-1176.

20. Indonesian Ministry of Health. National Basic Health Survey. Jakarta: Indonesian Health Ministry (2013).

21. https://en.wikipedia.org/wiki/Provinces_of_Indonesia.

22. https://en.wikipedia.org/wiki/List_of_Indonesian_provinces_by_GRP_per_capita.

23. Hermanussen M., *et al*. "Synthetic growth reference charts". *American Journal of Human Biology* 28 (2016): 98-111.

24. Pascanu I., *et al*. "Development of synthetic growth charts for Romanian population". *Acta Endocrinologica (Romanian Academy)* 12.3 (2016): 309-3018.

25. Hermanussen M. "Auxology - studying human growth and development". Stuttgart: Schweizerbart (2013).

26. Cole TJ and Green PJ. "Smoothing reference centile curves: the LMS method and penalized likelihood". *Statistics in Medicine* 11.10 (1992): 1305-1319.

27. Hermanussen M. "Absolute or relative measures of height and weight? An Editorial". *European Journal of Clinical Nutrition* 69 (2015): 647-648.

28. Garza C and de Onis M. "Rationale for developing a new international growth reference". *Food and Nutrition Bulletin* 25.1 (2004): S5-S14.

29. WHO Multicentre Growth Reference Study Group. "WHO Child Growth Standards based on length/height, weight and age". *Acta Paediatrica Supplement* 450 (2006): 76-85.

30. de Onis M., *et al*. "Development of a WHO growth reference for school-aged children and adolescents". *Bulletin of the World Health Organization* 85.9 (2007): 660-667.

31. de Onis M., *et al*. "Worldwide implementation of the WHO Child Growth Standards". *Public Health Nutrition* 15.9 (2012): 1603-1610.

32. NCD Risk Factor Collaboration (NCD-RisC). "A century of trends in adult human height". *Elife* 5 (2016): e13410.

33. Saari A., *et al*. "Multiethnic WHO growth charts may not be optimal in the screening of disorders affecting height: Turner syndrome as a model". *JAMA Pediatrics* 167.2 (2013): 194-195.

34. Christesen HT., *et al*. "Short stature: comparison of WHO and national growth standards/references for height". *PLoS One* 11.6 (2016): e0157277.

35. Khadilkar V and Khadilkar A. "Growth charts: a diagnostic tool". *Indian Journal of Endocrinology and Metabolism* 15.3 (2011): S166-S171.

36. Waterlow JC. "Classification and definition of protein-calorie malnutrition". *British Medical Journal* 2.5826 (1972): 566-569.

37. https://www.unicef.org/infobycountry/stats_popup2.html

38. Waterlow JC. "Linear Growth Retardation in Less Developed Countries". Nestle Nutrition Workshop Series 14 (1988).

39. Prendergast AJ and Humphrey JH. "The stunting syndrome in developing countries". *Paediatrics and International Child Health* 34.4 (2014): 250-265.

40. Black RE., *et al*. "Maternal and child undernutrition and overweight in low-income and middle-income countries". *Lancet* 382.9890 (2013): 427-451.

41. Hatton TJ and Bray BE. "Long run trends in the heights of European men, 19th-20th centuries". *Economics and Human Biology* 8.3 (2010): 405-413.

42. Orgler A. "Über Entfettungskuren im Kindesalter". *Jahrbuch der Kinderheilkunde Neue Folge* 61 (1905): 106-113.

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