Can stunting be corrected?: Lessons from Indonesia

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Research article

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Abstract

Background Impaired growth in children can starts during pregnancy and continue to a few years after birth. Age of 0-2 year is considered as the critical window of growth after birth. This study aimed to investigate the influence of early growth towards growth in the pre-pubertal period. Methods The study was utilizing the Indonesian Family Life Survey panel data of 1993, 1997, and 2000, covered 13 out of 27 provinces. The sample was children aged 0-2 years (year 1993), 4-6 years (1997) and 7-9 years old (2000).The data analysis was conducted using SPSS version 13.0. Results About 77% of children who were stunting at 0-2 years and continued at age 4-6 years, remained stunting at ages 7-9 years; 59.5% who were stunting at 4-6 years, remained stunting at age 7-9 years; 10% who were normal at ages 0-2 and 4-6 years become stunting at age 7-9 years, and 16% among those who were stunting at age 0-2 year become normal at age 4-6 years. Multivariate analysis showed that children who were stunting at age 0-2 years and continued until age 4-6 years have 27 times risk of becoming stunting at age 7-9 and those who were stunting at age 4-6 years have 14 times risk. On the other hand, those who were stunting at age 0-2 years but became normal at age 4-6 years, were not related to the risk of becoming stunting at later age. Conclusion Stunted at age 7-9 years is appointed by shortness at the previous period especially when it began at age of 0-2 years and extended into age of 4-6 years. Particular concern has to be carefully interpreted for the evidence of regaining height of stunted children at 0-2 years into normal height at 4-6 years.

Background

The first thousand days of life is the critical period for child development. Beginning in the womb, the health of the mother can have a direct impact on cell proliferation and differentiation of the fetus. Should the mother suffer from chronic malnutrition, intra-uterine growth retardation (IUGR) can occur, and result in low birth weight, even if the pregnancy is at full term. It can have a negative impact on fetoes growth and development that is potentially irrversible at the postnatal period [1-5].

Low birth weight (born <2500 grams) can be caused by either premature birth or from failure to achieve full growth potential from a full term pregnancy. This failure is related to chronic malnutrition of the mother or, acute malnutrition at the last trimester of pregnancy and is indicated by short stature, skinny or both [6]. The achievement of full growth potential is possible when the nutrition needs of mother and her fetus are fulfilled, however, growth retardation during the fetal period can continue to impact on the child following birth [7-9].

Nutrition intake and communicable diseases are inter-related factors that can lead to malnutrition in child. A child born with low birth weight (LBW) has a higher risk of communicable diseases that bring about malnutrition and growth restriction through the life cycle [10], with frequent re-infections also impacting on weight gain which can lead to stunting [11]. Other external variables potentially involved in growth restriction are: race, chronic malnutrition, mother's short stature, young age at pregnancy as well as other diseases [12]. There are also internal variables such as the synergism between the mother, fetus

and placenta, any abnormalities of the placenta and umbilical cord, the volume of amnionic fluid and multi-gravida [2].

Early growth retardation is a major cause of stunting in less developed countries. This early retardation of growth results in a mean birth weight which falls under the curve of the WHO anthropometry standard. Furthermore, growth spurts become slower at the age of 3-6 months and stay parrallel under the WHO curve up to the age of 3 years [13]. As a consquence, when the critical period of development ends, there can be ongoing effects of this early growth retardation. Children who are stunted under the age of five remain with a short stature into adulthood [14].

The high prevalence of stunting at the age of 13-24 months is related to limitation of food availability [15], improper food intake and care [16], mal-absorpsion due to infectious diseases [17], as well as socio-economics conditions [18]. Stunting is also related to the mother's level of education, age, parity and the number of children in the household [19, 20].

Socio-economic disparities are the root cause of problems related to stunting. The mother's level of education, household income, environmental health and social status can impact on child care, lifestyle and access to the health facilities [21-23]. It is possible however, for children to experience compensatory, or "catch-up" growth. A study on adopted children has shown that a better 'new' environment can improve a childs nutritional status and allow for compensatory growth, although despite this, they are unable to achieve their full growth potential due to the retain effects of growth retardation during the critical period of development [24]. As such, optimal growth may be achieved when a baby is able to catch up growth in the first 1000 days after birth through good care and a healthy environment [25].

This was an observational study with a retrospective design to observe growth and its determinants from the early age of 0-2 years towards the pre-pubertal period of ages 7-9. The aim of this study was to investigate the influence of early growth patterns on growth at the pre-puberty stage.

Methods

Data source and selection

Secondary data sets of *Indonesian Family Life Survey* (IFLS) 1993, 1997, 2000 were downloaded from http://www.rand.org. The survey was conducted by RAND Coorporation and Institute of Demography University of Indonesia at the baseline, supported by the National Institute of Child Health and Human Development, USAID, Ford Foundation and WHO.

The IFLS survey was designed as a longitudinal study and covered 13 out of 27 provinces in 1993, or 83% of Indonesian population representative at both the urban-rural and national level.

Data were collected by trained enumerators. To ensure the quality of the data, supervisors were engaged to check the completeness of the data as well as the logical route of the data every time enumerators

completed the field work. The completed data was then sent to the research center for coding, entry and cleaning data done by trained personnels, as has been published elsewhere [26].

Population and samples

The study population was Indonesian households in 1993. The sampling frame refers to Susenas, which is a national frame designed by the Indonesian Central Bureau for Statistics (BPS) to ensure representativeness of data at both the urban-rural and national level. The survey covered 13 out of 27 provinces all over Indonesia in 1993, accounting for 83% of the population of Sumatera, Java, Bali, West Nusa Tenggara and Sulawesi (classified as Celebes in the IFLS study).

The sampling was a two stage cluster sampling design; i.e. stratification at provincial level through 'PPS' proportional to population size. Households were randomly selected at the baseline (1993). As many as 60,000 households were covered at the baseline, and 7,730 households were selected based on the criteria. Of the eligible households, 7,039 participated, achieving a high contact rate of 91.1%.

The child population in this study was children born between July 1st, 1991 to 1993, and were followed up to age of 9 years old in 2000. Inclusion criteria were that they had to be the biological children of the mother, were a single birth (not a twin or triplets), were living with the parents, and had information on birth weight and age of pregnancy when delivered. The exclusion criteria was born with genetic abnormalities or developmental disorders .

Study variables

Several new variables were constructed to effectively observe growth patterns at the early postnatal period. As data on the birth length of newborns was unavailable in the data set, a new variable was constructed for children aged 0-2 to address this. LBW could not accurately represent the real birth length as she or he may have been born with a normal weight but short length, or normal length but short and/or skinny. As such, it was deemed necessary to transform the variable. Birth weight was defined as either normal (n=284) or low for less than 2500 grams (n=17). This variable was then merged with the height variable to determine stunting, which resulted in children with normal height (n=168) and children with stunting (n=133). Lastly, this merged data was classified into the results of the height measurement and categorized into children at age 0-2 year who were stunted (n=121) and not stunted (n=180) see graph 1.

Growth at the early age was calculated by creating a new variable which combined data on low birth weight (weight <2500 gram) and stunting (length <48 cm) at birth. At the following ages, growth was indicated by anthropomentric measurements of Z-score. Calculation of the Z-scores were based on body

length by age and converting a child's variables of identification number, gender, age (in months or year), and body length using WHO anthropometry software (WHO AnthroII.PC2007). Stunting was defined as a Z-score less minus two standard deviations (<-2SD) from the median [27].

Infants' demographic characteristics (i.e., gender, stunting, as well as morbidity at age 0-2 years old); feeding behaviors (i.e. beast-feeding initiation, whether the colostrum was taken, exclusive breast-feeding, age when weaned, the age at starting complementary feeding, quality of complementary feeding); Mother's characteristics (i.e., height of mother, mother's education), and the socioeconomic status of the household (household assets, expenditures, hygiene and sanitation of health and environment, rural-urban location). Morbidity was defined as whether or not the children were sick during the month before the interviews.

Breastfeeding initiation was defined as the baby being breast-fed less than or equal to three hours after birth. Exclusive breast-feeding means that no other drinks or food is given to the infant: the infant should feed frequently and for restricted periods. According to the policy during this period all women should be enabled to practice exclusive breastfeeding and all infants should be fed exclusively on breast milk at least 4 months [28]. Complementary feeding refers to the process of the baby consuming other food regularly as well as continuing to be breast-fed. The quality of complementary feeding was defined as the type of food or drinks given to the baby in the past 24 hours, which was converted into food groups including carbohydrates, protein and vitamins.

Mother's education was defined as formal education completed by mothers. With regard to socio-economic status, variable of household assets was defined as the possession of valuable assets such as land, building, mobile phone, savings, gold and jewels, converted into rupiahs during the field interview. Household expenditure was defined as percent of food expenditure over total household expenditures. The cut-off point of poor and not poor was taken from the Indonesian Central Bureau of Statistics that was 56.86; 55.34 and 65.81 in 1993, 1997 and the 2000. Household hygiene and sanitation was defined as the access of the households to clean water, source of drinking water, availability of toilet, materials of household floor, roof, wall, garbage bins, sewerage and the availability of electricity.

Statistical analysis

Data analysis was undertaken using SPSS version 13.0. At the beginning, the unit of analysis was households with children age of 0-2 years in 1993, and these children were followed up at the age of 4-6 and 7-9 years old. The original sample was 312 children. After the data was cleaned, and missing or extreme values were removed, the number remaining was 301 children. Before the removal of cases with

missing or extreme data, an analysis of comparability between these and remaining cases was undertaken to ensure that removal would not affect the outcome variable.

Normality of the distribution of numerical variables was tested using the Kolmogorov-Smirnov test. As the distribution was not normal, a binary binomial categorical variable was constructed by classifying stunted growth if the children had a height for age Z-score of less than -2 standard deviations (HAZ <-2 SD) and as normal growth if HAZ ≥-2 SD. Univariate analysis was used to understand the distribution of the growth-related variables at the age of 0-2, 4-6 and 7-9 years old. Cross-tabulations (Chi-square tests) were used to analyze the correlation of growth at early age (0-2 years old) consecutively to the following age (4-6 and 7-9 years old). Finally, stepwise logistic regressions were run by selecting the final list of variables used among all candidates based on whether they were significant. All variables with p <0.20 were included in the multiple logistic regression using forward selection.

Results

Stunting was defined as length or height by age (HAZ) of children less than minus two standard deviations from the (<-2 SD) WHO anthropometry standard. As this study is trying to prove that early growth is correlated to pre-pubertal growth, data on LBW was merged with height by age of <-2 SD from the WHO-defined mean to define growth at baseline. Table 1 depicts the proportion and distribution of stunting by age groups.

Out of 301 children involved in this analysis, 44.2% were stunted at age of 0-2 year. The proportion of children with stunting declined as age increased, with the improvement of mean Z-score from the baseline, with the HAZ score becoming closer to the WHO's standard curve.

To observe growth patterns at the early postnatal period, this study implemented a merge of child's data at the baseline for those who were LBW and or HAZ <-2SD. Children were considered LBW if they were born short or small or both. Merging data was conducted by reasons that there was no information of length at birth. Not all of LBW children having HAZ <-2 SD or stunting; similarly, not all of the non LBW children (birth weight ≥-2SD) having HAZ ≥-2SD as can be seen in table 2.

Merging data of LBW and stunting (Z-score <-2SD) found 56.8% children were categorized as normal length and 44.2% were short. This categorization was created due to there were no children's length information when the baby was born. The analysis of measurement during the surveys found 40.2% children stunting at age 0-2, decreasing to 37.2% at age 4-6 and 33.6% at age 7-9 year old.

Table 3 shows that as much as 33.6% children were stunted at pre-pubertal. 77.1% of children who were short at age 0-2 years and were stunted at age 4-6 years remained stunted at age 7-9 years. More than half (59.9%) children who were not stunting at early age or age of 0-2 years, but had delayed growth at age 4-6 years, were stunted at age of 7-9 years, or pre-puberty. As much as 15.7% of children who were short at early age but reached a normal height at age 4-6 continued to develop normally until pre-puberty. Stunted at earlier age have greater risk to become stunted at the later age. The highest risk were when stunting stayed persistently from the age of 0-2 to 4-6 year old, and the lowest risk was at those who were not stunting at 0-2 year and 4-6 year followed by stunting at 0-2 year but get normal or not stunting at 4-6 year.

To understand the correlation of early growth and growth at pre-puberty, a logistic regression analysis was conducted. The primary dependent variable was stunted and not stunted, classified from the *Z-score* of Height by Age at early age to age of 4-6 years and 7-9 by controlling all variables (Table 4).

The results of the logistic regression analysis found that after controlling for other variables, children who were stunted both at -early age and at 4-6 years of age were 27 times more likely to remain stunted at pre-puberty, compared to those who were normal from early age. In addition, children with normal growth at early age, but falter growth at the age of 4-6 years were 14 times more likely to be stunted at pre-puberty. Test of interaction and confonder (?)among the independent variables in the model (stunting at age of 0-2 year, poor, high of food expenditures, short stature of the mother, rural location, poor hygiene and sanitation and female) showed there were neither interaction nor confounder of growth at pre-puberty.

Discussion

Generally, Indonesian children in the study were born smaller than the WHO reference standard. This has been proved by the earlier analysis of the IFLS data set [29]. Independent of genetics, they may have experinced growth retardation in the womb. Children who were born with LBW (<-2 SD), the growth retardation effect continued to impact on later growth [7, 30]. A study in Bogor municiplity found that since birth the babies had lower HAZ compare to the WHO standard [31].

This is an important finding from Indonesia, as there has not yet been any research studying the relationship between early growth and growth at following stages of development to pre-puberty. A previous study found that low birth weight was the most dominant predictor associated with stunting in Indonesia, in spite of poverty, neonatal illness and sex (boy) at age of 12-23 months [30]. A cohort study based in Madura showed that birth weight, not length at birth and nutrient intake had a significant correlation to stunting in children under five [32].

Furthermore, a study in Indrarmayu district (West Java) focused on the nutritional intake pattern of babies and its social-health dimensions [33]. In this study, linear growth was studied based on birth weight and age of gestation, but unfortunately, measurements were only taken until the baby reached one year of age [6].

A cohort study utilizing IFLS data which modelled body mass index (BMI) based on the child's birth history and nutrition state found that short and very short stature at under five years old was prolonged, with children staying short and very short until adolescence [34]. Finally, using the same data set, another study found that stunting history at age 1-2 years were significantly correlated with body height at adolescence [35].

A study in Africa shown that there was little difference in body mass index between stunted and non stunted children at the age of 7-9 years. However, those who were stunted at age of 2 years were significantly skinnier and shorter compare to those who had developed normally at the same age [36]. Other research has found that birth weight is positively correlated to body mass index (BMI) at the age of 7 and 11 years. Children who were stunted in the early postnatal period had a smaller BMI and were skinnier at age of 7 and 11 years compared to those wo were not stunted or had a normal body weight [37].

There were significant growth pattern differences of children age 0-2 years towards the pre-pubertal period (7-9 years old) that were affected by growth in between those ages. More than half of the children who had normal height at an early age (0-2 years old) and experienced growth faltering around the age of 4-6 years old stayed stunted at pre-puberty (7-9 years old). This phenomenon indicates that a significant growth faltering occurred after the age of two years old. These findings are consistent with the results of analysis by Victoria et al, where there was dramatically slowing in growth after birth up until the age of 4-6 years, followed by a stable pattern up until pre-puberty [38]

Conclusions

In conclusion, early growth can impact on the growth of children at pre-puberty.. Those who were stunting at the age of 0-2 year and stayed stunting at 4-6 year had 27 times kept stunting at age 7-9 year, meanwhile those who were stunting at age 4-6 year were 14 times becoming stunting at the age of 7-9 year. The smallest risk of stunting at pre-pubertal was when the children grew normal at age 0-2 year and remain normal at age 4-6 year. Particular concern has to be carefully interpreted for the evidence of regaining height of stunted children at 0-2 years into normal height at 4-6 years and falling back into stunting at age 7-9 years.

Stunting at the age of 0-2 year were influenced by poor, rural location and improper environmental condition. Due to the data limitation we could not analyze deeper on when was exactly the growth faltering happening in between age of 0-2 and 4-6 year or set data of 1993 and 1997, either the age of

children before or after two years. We refer this statement as we believe that the first thousand days of life is the golden period of growth development.

These findings provide more insight into the size of the problem and risks of stunting in Indonesia. Unfortunately, the Provinces of East Nusa Tenggara and Papua, even though the population are small, were not covered in this study, which according to the recent surveys 'Riskesdas', have become the pockets of stunting nationally. It is recommended that more comprehensive data and analysis involving other provinces in Indonesia need to be conducted remembering that Indonesia is a large country with high disparities between regions. This recommendation would lead to a construction of a proper intervention in scale up nutrition and reduce stunting prevalence.

Abbreviations

HAZ – Height for Age Z-score

IFLS – Indonesia Family Life Survey

IUGR – Intrauterine growth restriction

LBW – Low Birth Weight

PPS – Proportional to Population Size

USAID – US Agency for International Development

Susenas – Survey Sosial Ekonomi Nasional (National Socio-economic Survey)

SD – Standard deviation

WHO – World Health Organization

Declarations

Ethics approval and consent to participate

Ethical clearance was received from the Ethical Committee of the Faculty of Public Health University of Indonesia number 24/H2.F10/PPM.00.02/2014.

Consent for publication

Not applicable

Availability of data and materials

All of the data supporting our findings are contained within the manuscript. The data were obtained from the website of www.rand.org/labor/FLS/IFLS.html.

Competing interests

I declare no competing interest of this publication.

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Author contribution:

NKA developed the concept, data extraction, analysis, wrote the manuscript; EA guiding and supervising the whole works.

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Tables

Table 1 Distribution of Height by Age *Z-score* by Age

Characteristics (N=301)	*Z-score* HAZ <-2 SD	
	n	%
Early age 0-2 years (at baseline)*	133	44,2
Age 4-6 years	112	37,2
Age 7-9 years	101	33,6

* *Collapse* data LBW and HAZ<-2 SD

Table 2 Correlation of growth at early ages and the later ages

Growth at early age* (n=301)	HAZ < -2 SD	
	Age 4-6 yrs	Age 7-9 yrs
Low birth weight or stunting	54.9	48.9
Normal	23.2	21.4
OR	4.02	3.51
95% CI	(2.45-6.60)	(2.12-5.79)
p	**0.000**	**0.000**

* *Collapse* data LBW and HAZ <-2SD at age of 0-2 years

Table 3 Changing in Proportion of Height by Age *Z-score* from early age up to pre-pubertal

Growth Characteristics (N=301)	Persentage of *Z-score* Height by Age at 7-9 years old		
	<-2 SD	>=-2 SD	Total (n)
02Normal_46Normal	10.1	89.9	138
02Stunting_46Stunting	77.1	22.9	70
02Normal_46Stunting	59.9	40.5	42
02Stunting_46Normal	15.7	84.3	51
Total	33.6	66.4	301

Note: 02=age 0-2 years; 46=age 4-6 years; N=normal; S=short

Table 4 Stunted at pre-pubertal, growth and the role of other factors (Multiple Logistic Regression Analisis)

Variables	B	p	OR	95% CI	
				LL	UL
Stunted 02S_46S	3.312	**0.000**	27.429	11.677	64.429
Stunted 02N_46S	2.639	**0.000**	14.002	5.950	32.951
Stunted 02S_46N	0.391	0.441	1.479	0.546	4.003
Mother's education (low)	0.580	0.192	1.787	0.748	4.269
Households assets (poor)	0.273	0.432	1.314	0.665	2.595
Food Expenditure (high)	0.035	0.918	1.035	0.535	2.003
Rural location	0.030	0.929	1.031	0.531	1.999
Hygiene & sanitation (poor)	0.355	0.277	1.426	0.752	2.703
Gender (female)	-0.553	0.085	0.575	0.306	1.000