KORESPONDENSI PAPER

Judul : **Micronutrient Deficiencies and Stunting Were Associated with Socioeconomic Status in Indonesian Children Aged 6-59 Months**

Jurnal : **Nutrients**

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Status : Jurnal Internasional Terindeks Scopus

	Aktivitas	**Tanggal**	**Halaman**
1.	Submission Received	2 April 2021	1-11
2.	Article Processing Charge Confirmation	6 April 2021	12-13
3.	Editor Assigned	6 April 2021	14-15
4.	Balasan "Article Processing Charge Confirmation"	6 April 2021	15
5.	Letter of Major Revisions: Hasil Reviewer 1	6 Mei 2021	16-18 19-20
6.	Hasil Perbaikan Artikel	13 Mei 2021	21-24
7.	Letter of Major Revisions: Hasil Reviewer 2	6 Mei 2021	25-34
8.	Hasil Perbaikan Artikel	13 Mei 2021	35-41
9.	Letter of Resubmit the Revised Manuscript	13 Mei 2021	42-43
10.	Accepted for Publication	20 Mei 2021	44-45
11.	APC Invoice	20 Mei 2021	46-47
12.	Final Proofreading Before Publication	21 Mei 2021	48-61
13.	Letter of Resubmit the Revised Manuscript (Proofreading)	22 Mei 2021	62-63
14.	Letter of Published	26 Mei 2021	64-66
15.	Artikel Published	26 Mei 2021	66
16.	Artikel Final	Vol. 13, No. 6, Mei 2021	67-75

[Nutrients] Manuscript ID: nutrients-1190203 - Submission Received

Eksterne l

Kotak Masuk

Editorial Office <nutrients@mdpi.com>

Jum, 2 Apr 2021 22.38

kepada saya, Fitrah, Aya, Moesijanti

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Title: Micronutrient deficiencies and stunting were associated with socioeconomic status in Indonesian children aged 6-59 months
Authors: Fitrah Ernawati, Ahmad Syauqy *, Aya Yuriestia, Moesijanti Y. E. Soekatri
Received: 2 April 2021
E-mails: fitrahernawati@yahoo.com, syauqy@fk.undip.ac.id, ayaarifin@gmail.com, moesijanti@yahoo.com
Submitted to section: Nutrition and Public Health,
https://www.mdpi.com/journal/nutrients/sections/Nutrition_Public_Health
Nutritional Status among Vulnerable Populations
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Micronutrient deficiencies and stunting were associated with socioeconomic status in Indonesian children aged 6-59 months

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Abstract: Micronutrient deficiencies and stunting are known as a significant problem in most developing countries, including Indonesia. The objective of this study was to analyze the associations of micronutrient deficiencies and stunting with socioeconomic status (SES) among Indonesian children aged 6-59 months. This cross-sectional study was part of the South East Asian Nutrition Surveys (SEANUTS). A total of 1008 Indonesian children were included in the study. Anemia, iron deficiency, vitamin A deficiency, vitamin D deficiency, and stunting were identified in this study. Structured questionnaires were used to measure SES. Differences between micronutrient parameters and anthropometric indicator with the SES groups were tested using one way ANOVA with post-hoc test after adjusted for age, area resident (rural and urban), and sex. The highest prevalence of anemia, serum ferritin deficiency, serum retinol deficiency, and stunting were found in the lowest SES group as 32.6%, 36.1%, 33.3%, and 47.4%, respectively. Children from the lowest SES group had significantly lower means of Hb, ferritin, retinol, and HAZ. Severely stunted children had significantly lower mean of Hb concentration compared to stunted and normal height children. Micronutrient deficiencies, except vitamin D, and stunting were associated with low SES among Indonesian children aged 6-59 months.

Keywords: micronutrient deficiency; stunting; socioeconomic status; malnutrition; Indonesian children

Citation: Lastname, F.; Lastname, F.; Lastname, F. Title. *Nutrients* **2021**, *13*, x. https://doi.org/10.3390/xxxxx

Academic Editor: Firstname Lastname

Received: date
Accepted: date
Published: date

1. Introduction

Sustainable Development Goal-2 (SDG-2) aims to eradicate the global burden of malnutrition [1]. Malnutrition is one of the primary causes of mortality in children less than five years of age [2]. Decreasing malnutrition is a challenge for many countries, mainly developing countries [3]. In Indonesia, malnutrition remains a significant problem among children under 5-years-old, especially micronutrient deficiencies and stunting [4-6]. Both micronutrient deficiencies and stunting can influence physical and cognitive development in children and increase the risk of infection [7].

A previous study in Indonesia indicated a high prevalence of anemia and vitamin D deficiency [7]. Almost 60% of Indonesian children under 2-years-old were reported to be anemic [7,8], whereas the prevalence of anemia at the aged 2-5-years-old was 16.6%. Additionally, the prevalence of Iron deficiency based on serum ferritin levels and vitamin D deficiency were around 15% and 40%, respectively [7]. On the other hand, the prevalence of stunting is also high in Indonesia [6,9]. Indonesian Basic Health Survey (Riskesdas) stated that the prevalence of stunting children was almost 31% in 2018 [10]. Compared with the Association of Southeast Asian Nations (ASEAN) countries, the prevalence of stunting in Indonesia is much higher [9].

Many factors are known to be involved in the etiology of micronutrient deficiency and stunting. Previous studies in Korea and China showed that socioeconomic status (SES) was linked to micronutrient deficiency, including anemia, iron deficiency anemia (IDA), and vitamin D deficiency [11,12]. Moreover, some studies in Sri Lanka and Bangladesh also found that SES, overcrowding, and educated parents were associated with undernutrition among children [13-15]. In order to better address malnutrition in Indonesia, including micronutrient deficiencies and stunting, detailed information of the determining factors is needed to design a more effective intervention/approach. Accordingly, there is a need for an in-depth understanding between micronutrient status and anthropometric indicators with SES in Indonesia. Therefore, the objective of this study was to analyze the associations of micronutrient deficiencies (anemia, iron, vitamin A, and vitamin D) and stunting with socioeconomic status (SES) among Indonesian children aged 6-59 months.

2. Materials and Methods

Subjects and study design

The South East Asian Nutrition Survey (SEANUTS) was a multicenter study in nutrition funded by FrieslandCampina, The Netherlands. The SEANUTS in Indonesia utilized a cross-sectional study in 48 out of 440 cities/districts in 2011 [7,9]. A multi stage cluster sampling and stratified for area of residence (urban/rural) were performed [7,9]. Details of the sampling procedure are described elsewhere [16]. A total of 1008 children aged 6-59 months lived in rural and urban areas were included in the study. The participants were representatives of the target population. In this study, blood samples for hemoglobin (Hb), serum ferritin, serum retinol, and serum 25-hydroxy vitamin D (25OHD) were taken in sub-samples after being examined by medical doctors of 1008, 475, 489, and 103 subjects, respectively. Sub samples were used due to budget limitation, and this sub samples were chosen proportionately to represent age groups. Moreover, anthropometric measurements, including length and height, were taken for 983 children because some of them refused to be measured [7].

The study followed the guidelines of the Helsinki Declaration for human research. The design and methodologies were approved by the Committee of Health Research Ethics, the National Institute of Health Research and Development, the Ministry of Health of the Republic of Indonesia, number LB.03.02/KE/6430/2010. and the Ministry of Home Affairs, number 440.02/1751.D.I. The study was registered in the Netherland Trial Registry (NTR 2462). Explanation of the study and the procedure applied as well as the possible side effects and its management were given to the parents before written informed consent was obtained.

Anthropometric data

The length was measured supine using a flat wooden measuring board in children below two years of age . Height was measured using a wall-mounted stadiometer accurate to 0.1 cm in children aged two years old and older. All the measurements were done in duplicate with an accuracy of 0.1 cm. The average value was used in the calculations [9]. Height for age Z-scores (HAZ score) was calculated using the WHO software [17]. We used the WHO Child Growth Standards 2005 [18] to define severe stunting (as having a HAZ score of < -3) and stunting (as a HAZ score of < -2).

Biochemical indicators

Blood samples for Hb measurements were taken through the finger prick procedure in children younger than 2-years-old and from venipuncture in older children. Hemoglobin concentration was measured with the HemoCue Hb 201 (HemoCue Diagnostics B.V. in children < 2 years) and Spectrophotometry, ADVIA 2120; Siemens for older children. Anemia was defined as Hb concentrations of <110 g/l for children aged between 6-59 months. Serum ferritin was measured with Immunochemiluminescence ECLIA, Roche Cobas e 601; Roche Diagnostics. Iron deficiency was considered as having serum ferritin concentrations of <12 mg/l for children under aged 6-59 months. Serum retinol was measured with an HPLC-UV detector, Agilent, 1200; Agilent Technologies (all-trans-retinol) and Serum 25(OH)D was measured with ELISA, IDS 25-Hydroxy Vitamin D; Immunodiagnostic Systems (D3 and D2 metabolites) Capillary. Children with serum retinol concentrations of <0.70 mmol/l and circulating 25 hydroxyvitamin D < 50 mol/l were considered vitamin A or vitamin D deficiency, respectively [7,19].

Socioeconomic status

Structured questionnaires were employed to obtain information regarding income, education, housing type, flooring, ventilations, type of walls, ownership of valuable goods, and electronic appliances as well as type of household sanitation facilities. Socioeconomic status was calculated and categorized into 5 groups or quintiles, namely: lowest, low, middle, upper middle, and upper. Details for the data collection methodology and wealth classification were published earlier [16,20].

Data analysis

Data were analyzed using SPSS version 24 (IBM Corp., Armonk, NY, USA) [7]. Weight factors were based on the 2010 Census data on the number of children in specific age groups [7]. Chi-square test was used to analyze the differences between characteristic variables across the groups of SES. While, differences between micronutrient parameters and anthropometric indicator with the groups of SES were tested using One way ANOVA with the Duncan post-hoc test after adjusted for age, area resident (rural and urban), and sex. Values are presented as mean and standard deviation for continuous variables or n (%) for categorical variables with p <0.05 as significant.

3. Results

Overall, the total mean of age was 31.7 ± 16.1 month old. The characteristics of the children in the 5 SES groups are presented in Table 1. Most of the children with lowest SES lived in rural area (42.0%). The highest prevalence of anemia and serum ferritin deficiency were found in the lowest SES group with 32.6% and 36.1%, respectively. The highest prevalence of serum retinol deficiency was found in the lowest SES and the low SES groups with 33.3% and 33.3%, respectively. While, surprisingly, the highest prevalence of vitamin D deficiency was found the middle SES group (31.8%). Moreover, the highest prevalence of stunted and severe stunted were found in the lowest SES group with 36.0% and 47.4%, respectively.

Table 1. Characteristics of children in the 5 socioeconomic groups[1]

Variables	SES					P-Value
	Lowest	Low	Middle	Upper Middle	Upper	
Age (years), n=1008	31.5 ± 15.6	33.1 ± 16.5	31.5 ± 16.1	31.9 ± 16.1	32.4 ± 16.5	0.976
Sex, n=1008						
Boys	144 (28.0)	98 (19.1)	107 (20,8)	89 (17.3)	76 (14.8)	0.483
Girls	142 (28.8)	99 (20.0)	93 (18.8)	71 (14.4)	89 (18)	
Area of residence, n=1008						
Urban	42 (9.8)	84 (19.7)	89 (20.8)	90 (21.1)	122 (28.6)	0.000
Rural	244 (42.0)	114 (19.6)	111 (19.1)	70 (12.1)	42 (7.2)	
Hemoglobin, n=1008						
Normal	156 (25.7)	108 (17.8)	115 (19.0)	104 (17.2%)	123 (20.3%)	0.000
Anemia	131 (32.6)	89 (22.2)	85 (21.1)	56 (13.9)	41 (10.2)	
Serum Ferritin, n=475						0.087
Normal	112 (27.1)	78 (18.8)	82 (19.8)	67 (16.2)	75 (18.1)	

Deficiency	22 (36,0)	15 (24,6)	14 (23,0)	4 (6,6)	6 (9,8)	
Serum retinol, n=489						
Normal	136 (28.6)	89 (18.8)	97 (20.5)	69 (14.6)	83 (17.5)	0.128
Deficiency	5 (33.3)	5 (33.3)	1 (6.7)	4 (26.7)	0 (0)	
Serum 25(OH)D, n=103						
Normal	22 (37.3)	12 (20.3)	8 (13.5)	11 (18.7)	6 (10.2)	0.164
Deficiency	9 (20.5)	8 (18.2)	14 (31.8)	6 (13.6)	7 (15.9)	
HAZ, n=983						
Normal height	151 (22.8)	124 (18.7)	132 (19.9)	116 (17.5)	140 (21.1)	0.000
Stunted	81 (36.0)	50 (22.2)	48 (21.4)	32 (14.2)	14 (6.2)	
Severe stunted	45 (47.3)	21 (22.1)	13 (13.7)	7 (7.4)	9 (9.5)	

[1]Values are presented as mean ± standard deviation for continuous variables and n (%) for categorical variables.

The differences between micronutrient parameters and anthropometric indicator across the groups of SES are shown in Table 2. Children from the lowest SES group had significantly lower means of Hb (112.0 ± 13.2 g/dl), ferritin (30.9 ± 19.9 μg/l), retinol (1.28 ± 0.41 μml/l), and HAZ (-1.77 ± 1.30). Differences in micronutrient status across HAZ indicator are shown in Table 3. Severely stunted children had significantly lower mean of Hb concentration (110.8 ± 14.0 g/l) compared to stunted (114.0 ± 11.4 g/l) and normal height children (114.6 ± 13.2 g/l). In addition, children with normal height had significantly higher retinol concentration (1.54 ± 0.55 μml/l) compared to severely stunted children (1.32 ± 0.39 μml/l). However, ferritin and 25(OH)D concentrations were not significant difference between normal height and stunted or severe stunted.

Table 2. Micronutrient parameters and anthropometric indicator across the 5 socioeconomic groups[1]

Variables	SES					P-Value
	Lowest	Low	Middle	Upper Middle	Upper	
Hemoglobin, g/l	112.0 ± 13.2^{a}	113.3 ± 13.0^{a}	113.3 ± 12.7^{a}	115.7 ± 12.7^{b}	118.7 ± 11.9^{b}	0.002
Serum Ferritin, µg/l	30.9 ± 19.9^{a}	33.4 ± 21.2^{a}	34.4 ± 20.7^{a}	43.6 ± 24.4^{b}	44.1 ± 10.9^{bc}	0.000
Serum retinol, µmol/l	1.28 ± 0.41^{a}	1.35 ± 0.44^{a}	1.56 ± 0.45^{b}	1.67 ± 0.47^{bc}	1.70 ± 0.74^{bc}	0.000
Serum 25(OH)D, nmol/l	56.1 ± 10.7	52.0 ± 11.7	52.2 ± 16.4	55.3 ± 11.1	52.5 ± 20.8	0.721
HAZ	-1.77 ± 1.30^{a}	-1.65 ± 1.13^{a}	-1.47 ± 1.12^{ab}	-1.03 ± 1.39^{c}	-0.77 ± 1.46^{c}	0.000

HAZ: height for age Z-score, SES: socioeconomic status. [1]Values are presented as mean ± standard deviation for continuous variables and n (%) for categorical variables. Values corrected for sex, age, and area of residence. [a-c] Different superscripts indicate significant differences across SES groups.

Table 3 Micronutrient status across HAZ indicator[1]

Variables	HAZ			P-Value
	Normal height	Stunted	Severely stunted	
Hemoglobin, g/l	114.6 ± 13.2^{a}	114.0 ± 11.4^{a}	110.8 ± 14.0^{b}	0.000
Serum Ferritin, µg/l	37.7 ± 24.2	33.6 ± 22.5	34.3 ± 19.6	0.598
Serum retinol, µmol/l	1.54 ± 0.55^{a}	1.37 ± 0.47^{ab}	1.32 ± 0.39^{b}	0.012
Serum 25(OH)D, nmol/l	54.1 ± 14.7	51.9 ± 13.4	56.3 ± 9.8	0.722

HAZ: height for age Z-score. [1]Values are presented as mean ± standard deviation for continuous variables and n (%) for categorical variables. Values corrected for sex, age, and area of residence. [a-c] Different superscripts indicate significant differences across SES groups.

4. Discussion

The study provided insight into the relationship between micronutrient deficiencies and stunting regarding SES. Children from lower SES had higher risks of anemia, iron deficiency, vitamin A deficiency, and stunting. The results were similar to previous studies in middle and lower-income countries where anemia is more prevalent in children from lower SES groups [21]. Moreover, children below school age had a higher risk compared to school-aged children [22]. Another study showed that SES, especially household wealth, was a causal factor for anemia [23]. A previous study showed that children living in the lowest wealth quintile had significantly lower means of hemoglobin, ferritin, retinol, and HAZ than those in the highest wealth quintile. They found that family income is considered an important determinant of micronutrient status and anthropometric indicators [9,24]. When household income increased, the prevalence of anemia, IDA, and stunting decreased, and serum Hb and ferritin levels increased [9,11].

Iron, in the form of ferritin, is stored in the body. The body will take from these ferritin stores if the dietary iron needs are not reached. If it is not treated, ferritin will be depleted, and the blood plasma levels of iron will decrease. This condition will cause iron-deficiency anemia. It can be treated by consuming food high in iron, especially animal-based food, because it contains iron in heme form, which absorbed better than the non-heme iron form found in plant-derived foods [19,25]. However, animal source foods are often more expensive than plant-derived foods [25]. Therefore, the low consumption of animal-based food may cause iron deficiency and anemia in the Low SES group because they are often inaccessible [24,25]. Moreover, sources of vitamin A from foods are mostly found in animal-based food compared to plant-derived food that may affect the consumption. Vitamin A also plays an important role in hematopoiesis, and it is involved in the mobilization and utilization of iron stored [25].

The result of SEANUTS study in Indonesia regarding food consumption also showed that animal protein and milk intake are positively correlated to SES [26]. The study also highlighted that only around 30% of the household from the lowest SES had access to adequate sanitation facilities [26]. Moreover, lower SES is often related to poor living conditions such as inadequate access to clean water and sanitation facilities, thus increasing the risk of infection and then increased risk of developing anemia [27].

Interestingly, children in the lowest SES were at the highest risk for iron deficiency. The successful countrywide vitamin A supplementation program might offer an insight into this result. Serum retinol levels in children under 5-years-old were higher on those who had received supplementation regularly than those who did not [27,28]. Children living in rural areas, as the majority of the lowest SES children in this study, generally had higher adherence to the vitamin A supplementation program compared to children living in urban areas [27,29,30].

However, it is also important to know that the ignorance among caregivers was the reason for missing doses in vitamin A supplementation. Hence, it might be noted for the future supplementation program [27,31]. It is also important to develop awareness about the health importance of vitamin A supplementation. Besides, the current cooking oil fortification program with vitamin A should offer an alternative solution. Fortification of oils with vitamin A is one of the low-cost and effective ways to improve vitamin A intake, reducing the risk of vitamin A deficiency in developing countries [32].

From this study, children from the middle SES families showed the lowest mean 25(OH)D concentration. However, no significant difference between vitamin D and SES groups was found. Vitamin D is mostly made in the skin supported by sunlight exposure. Moreover, pigmentation of the skin is also responsible for vitamin D status [7,33,34]. Future studies regarding vitamin D should include coverage across the socioeconomic spectrum and couple a nutritional approach with sunlight exposures.

Regarding anthropometric indicators, a higher HAZ was correlated with a higher SAS. Moreover, this study revealed that stunted children had a higher risk of anemia than children with normal height, the same result was also found in other studies [35,36]. Ayoya et al. found that child's age, HAZ score < −2. and mother's anemia predicted the occurrence of childhood anemia in 6–59-months-old children in Haiti [37]. We also found significant differences in the risk of vitamin A deficiency between different anthropometric indicators. This findings were in line with other study that stunting was associated with vitamin A deficiency [38].

This study has a strength. To the best of our knowledge, this is the first study to discuss the relationship between micronutrient deficiencies (anemia, iron, vitamin A and vitamin D) and nutritional status defined by anthropometric measurement with SES in Indonesia, especially children under five years old. Thus, this study will provide insights for better targeting when it comes to nutrition intervention. However, as a consequence of using subsamples from a larger study, it has to be kept in mind that micronutrient status, in this study, were determined from a relatively small set of samples. Hence, the results should be interpreted carefully. The current study is a cross-sectional study; consequently, it is unable to explain causal relationships. Another note is that the study did not include analysis of data on food intake and outdoor physical activity; thus, it is unable to explain the role of both behaviors concerning micronutrient status.

5. Conclusions

This study shows that micronutrient status and anthropometric indicators have an association with SES among Indonesian children aged 6-59 months. Anemia, iron deficiency, vitamin A deficiency, and stunting were associated with low SES. While vitamin D status shows no association with SES. In addition, severely stunting children aged 6-59 months have significantly associated with anemia. The study suggests doing more comprehensive nutrition programs to improve the micronutrient status of children based on SES. Additional studies are needed to explore the association of micronutrient status and stunting with SES using a longitudinal study.

Supplementary Materials: The following are available online at www.mdpi.com/xxx/s1, Figure S1: title, Table S1: title, Video S1: title.

Author Contributions: Conceptualization, F.E., A.Y., M.Y.E.S., and A.S.; methodology, F.E.; formal analysis, F.E.; investigation, F.E., and A.S.; writing—original draft preparation, F.E.; writing—review and editing, F.E., and A.S.; All authors have read and agreed to the published version of the manuscript.

Funding: The study was sponsored by FrieslandCampina, the Netherlands.

Institutional Review Board Statement: This study was conducted according to the guidelines of the Declaration of Helsinki, and all procedures involving research study participants were approved by the Committee of Health Research Ethics, the National Institute of Health Research and Development, the Ministry of Health, Republic of Indonesia, number LB.03.02/KE/6430/2010, and was also registered in the Netherlands Trial Registry number NTR 2462.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Acknowledgments: We thank to FrieslandCampina for providing funding for the present study; FrieslandCampina representatives, particularly Victoria Valentina, Anne Schaafsma, Panam Parikh, and Marjolijn Bragt-van Wijngaarden are greatly appreciated for their valuable guidance throughout the study. The authors are also indebted to the government and health representatives at all levels especially the National Institute of Health Research and Development for their contribution to the study, as well as to all the children and their families for their willingness to participate in the present study.

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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[Nutrients] Manuscript ID: nutrients-1190203 - Article Processing Charge Confirmation

Kotak Masuk

N

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Sel, 6 Apr 2021 10.54

kepada saya, Nutrients, Anne

Inggris

Indonesia

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Dear Dr. Syauqy,

Thank you very much for submitting your manuscript to Nutrients:

Journal name: Nutrients
Manuscript ID: nutrients-1190203
Type of manuscript: Article
Title: Micronutrient deficiencies and stunting were associated with socioeconomic status in Indonesian children aged 6-59 months
Authors: Fitrah Ernawati, Ahmad Syauqy *, Aya Yuriestia, Moesijanti Y. E. Soekatri
Received: 2 April 2021
E-mails: fitrahernawati@yahoo.com, syauqy@fk.undip.ac.id, ayaarifin@gmail.com, moesijanti@yahoo.com
Submitted to section: Nutrition and Public Health,
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Kind regards,
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[Nutrients] Manuscript ID: nutrients-1190203 - Assistant Editor Assigned

Kotak Masuk

Anne Huang <anne.huang@mdpi.com>

Sel, 6 Apr 2021 11.04

kepada saya, Anne, Fitrah, Aya, Moesijanti, Nutrients

Inggris

Indonesia

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Nonaktifkan untuk: Inggris

Dear Dr. Syauqy,

Your manuscript has been assigned to Anne Huang for further processing who will act as a point of contact for any questions related to your paper.

Journal: Nutrients
Manuscript ID: nutrients-1190203
Title: Micronutrient deficiencies and stunting were associated with socioeconomic status in Indonesian children aged 6-59 months
Authors: Fitrah Ernawati, Ahmad Syauqy *, Aya Yuriestia, Moesijanti Y. E. Soekatri

Received: 02 April 2021
E-mails: fitrahernawati@yahoo.com, syauqy@fk.undip.ac.id, ayaarifin@gmail.com, moesijanti@yahoo.com

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Best regards,
Ms. Anne Huang
Assistant Editor

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A

Ahmad Syauqy **<syauqy@fk.undip.ac.id>** **Sel, 6 Apr 2021 11.36**

kepada Anne, Nutrients

Dear Ms. Mosa Zhang,
I accept that Journal APC: 2400 CHF (Total APC: 2400 CHF).
Best regards,
Ahmad Syauqy

[Nutrients] Manuscript ID: nutrients-1190203 - Major Revisions

Eksternal

Kotak Masuk

N

Nutrients Editorial Office <nutrients@mdpi.com>

Kam, 6 Mei 2021 08.52

kepada saya, Fitrah, Aya, Moesijanti, Nutrients

Inggris

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Dear Dr. Syauqy,

Thank you for submitting the following manuscript to Nutrients:

Manuscript ID: nutrients-1190203
Type of manuscript: Article
Title: Micronutrient deficiencies and stunting were associated with socioeconomic status in Indonesian children aged 6-59 months
Authors: Fitrah Ernawati, Ahmad Syauqy *, Aya Yuriestia, Moesijanti Y. E. Soekatri
Received: 2 April 2021
E-mails: fitrahernawati@yahoo.com, syauqy@fk.undip.ac.id, ayaarifin@gmail.com, moesijanti@yahoo.com
Submitted to section: Nutrition and Public Health, https://www.mdpi.com/journal/nutrients/sections/Nutrition_Public_Health
Nutritional Status among Vulnerable Populations
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It has been reviewed by experts in the field and we request that you make major revisions before it is processed further. Please find your manuscript and the review reports at the following link:
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Peer-Review Record

Micronutrient Deficiencies and Stunting Were Associated with Socioeconomic Status in Indonesian Children Aged 6–59 Months

Nutrients **2021**, *13*(6), 1802; https://doi.org/10.3390/nu13061802

by Fitrah Ernawati [1], Ahmad Syauqy [2,3,*], Aya Yuriestia Arifin [1], Moesijanti Y. E. Soekatri [4] and Sandjaja Sandjaja [5]

Reviewer 1: Anonymous

Reviewer 2: Anonymous

Nutrients **2021**, *13*(6), 1802; https://doi.org/10.3390/nu13061802
Received: 2 April 2021 / Revised: 20 May 2021 / Accepted: 20 May 2021 / Published: 26 May 2021
(This article belongs to the Special Issue Nutritional Status among Vulnerable Populations)

Round 1

Reviewer 1 Report

Main concerns

In the current study, Ernawati and coauthors evaluated the associations among socioeconomic status (SES) and the risk of micronutrient deficiency and stunting in infant and young children aged 6 to 59 months in Indonesia. Biochemical markers and anthropometric data were analyzed and collected from all or subgroups of participants. As the current work is part of a cross-section study of which other results have been published before, not all details of data collection methods including how SES were categorized were provided in the current study. In addition, some terms used in questionnaire for assessment of SES were uncommon (see in minor comments listed below); additional explanation/clarification should be provided. Moreover, I disagree with authors as to how prevalence of micronutrient deficiencies and stunting were calculated and presented in the table 1. In the current study, the prevalence was calculated and presented as the percentage of deficient or stunted participants from each SES group in all deficient or stunted participants. This is incorrect as the total number of participants are different in each of the SES groups. The prevalence should be calculated as the percentage of deficient or stunted participants and total participants within each of the SES groups. All data presented in the parenthesis in table 1 should be recalculated, and corresponding results and interpretation should be rewritten. The results of serum 25(OH)D should be interpreted with cautions given the much smaller pool of participants (103) compared to that in other measurements.

Minor comments

L99: The cut-off of serum ferritin for iron deficiency should be 12 μg/L? Please correct.

L103: The cut-off of circulating 25 hydroxyvitamin D should be ~ 50 nmol/L. Please correct.

L105-111: Some of the terms listed in the questionnaire (e.g. type of walls, flooring, and are not commonly used for evaluation of socioeconomic status in other studies. Please provide more details about how SES was assessed in the current study and justify the use of these terms in evaluation of social economic status.

Table 1:

- "%" should be removed from some values in parenthesis.
- I would suggest to report the percentage of deficient and normal individuals for the measured variables within each SES group rather than reporting the percentage of either deficient or normal individuals across SES groups.

Table 2:

- Superscripts for ferritin, retinol and 25(OH)D are not correct; please edit.
- Round up P-value to 3 decimal places (or per requirements of the journal) or use P < 0.001; Check P-values in all the other tables and make same change accordingly.

PERBAIKAN REVIEWER 1

Author Response

Please see the attachment. (File: **Author Response.pdf)**

Dear Reviewer,

We thank you for your comments and suggestions for improving the manuscript. The authors have considered the comments and revised the manuscript accordingly. Thank you very much.

We replied your comments as below:

Our responses here follow →

Yours sincerely,

Ahmad Syauqy, Ph.D

Reviewer 1.

Main concerns

In the current study, Ernawati and coauthors evaluated the associations among socioeconomic status (SES) and the risk of micronutrient deficiency and stunting in infant and young children aged 6 to 59 months in Indonesia. Biochemical markers and anthropometric data were analyzed and collected from all or subgroups of participants.

As the current work is part of a cross-section study of which other results have been published before, not all details of data collection methods including how SES were categorized were provided in the current study. In addition, some terms used in questionnaire for assessment of SES were uncommon (see in minor comments listed below); additional explanation/clarification should be provided.

Answer → We added information related to SES categories to make it clearer. "We used national guidelines from Central Bureau of Statistics (Indonesia) to categorized the SES [20]. The components of the SES included income, education, house (type, status, and valuable goods), and electricity [20]." (line 125)

Moreover, I disagree with authors as to how prevalence of micronutrient deficiencies and stunting were calculated and presented in the table 1. In the current study, the prevalence was calculated and presented as the percentage of deficient or stunted participants from each SES group in all deficient or stunted participants. This is incorrect as the total number of participants are different in each of the SES groups. The prevalence should be calculated as the percentage of deficient or stunted participants and total participants within each of the SES groups. All data presented in the parenthesis in table 1 should be recalculated, and corresponding results and interpretation should be rewritten.

Answer → We revised table 1. We recalculate the prevalence as the percentage of micronutrient deficient or stunted participants and total participants within each of the SES groups.

Table 1. Characteristics of children in the 5 socioeconomic groups[1]

Variables	SES					P-Value
	Lowest	Low	Middle	Upper Middle	Upper	
Age (years), n=1008	31.5 ± 15.6	33.1 ± 16.5	31.5 ± 16.1	31.9 ± 16.1	32.4 ± 16.5	0.976
Sex, n=1008						
Boys	144 (50.3)	98 (49.7)	107 (53.5)	89 (55.6)	76 (46.3)	0.483
Girls	142 (49.7)	99 (50.3)	93 (46.5)	71 (44.4)	89 53.7)	
Area of residence, n=1008						
Urban	42 (14.6)	84 (42.4)	89 (44.5)	90 (56.3)	122 (74.4)	<0.001
Rural	244 (85.4)	114 (57.6)	111 (55.5)	70 (43.8)	42 (25.6)	
Hemoglobin, n=1008						
Normal	156 (54.4)	108 (54.8)	115 (57.5)	104 (65.0)	123 (75.0)	<0.001
Anemia	131 (45.6)	89 (45.2)	85 (42.5)	56 (35.0)	41 (25.0)	
Serum Ferritin, n=475						
Normal	112 (83.6)	78 (83.9)	82 (85.4)	67 (94.4)	75 (92.6)	0.087
Deficiency	22 (16.4)	15 (16.1)	14 (14.6)	4 (5.6)	6 (7.4)	
Serum retinol, n=489						
Normal	136 (96.5)	89 (94.7)	97 (99.0)	69 (94.5)	83 (100)	0.128
Deficiency	5 (3.5)	5 (5.3)	1 (1.0)	4 (5.5)	0 (0)	
Serum 25(OH)D, n=103						
Normal	22 (71.0)	11 (57.9)	9 (39.1)	11 (64.7)	6 (46.2)	0.164
Deficiency	9 (29.0)	8 (42.1)	14 (60.9)	6 (35.3)	7 (53.8)	
HAZ, n=983						
Normal height	151 (22.8)	124 (63.6)	132 (68.4)	116 (74.9)	140 (85.9)	<0.001
Stunted	81 (29.3)	50 (25.6)	48 (24.9)	32 (20.6)	14 (8.6)	
Severe stunted	45 (54.5)	21 (10.8)	13 (6.7)	7 (7.5)	9 (5.5)	

[1]Values are presented as mean ± standard deviation for continuous variables and n (%) for categorical variables.

The results of serum 25(OH)D should be interpreted with cautions given the much smaller pool of participants (103) compared to that in other measurements.

Answer → We added interpretation related to the serum 25(OH)D result. "This may be due to the small sample size, particularly the smaller sub-samples for serum vitamin D analysis" (line 219)

Minor comments

L99: The cut-off of serum ferritin for iron deficiency should be 12 μg/L? Please correct.

Answer → We revised it accordingly (μg/l). (line 114)

L103: The cut-off of circulating 25 hydroxyvitamin D should be ~ 50 nmol/L. Please correct.

Answer → We revised it accordingly (nmol/l). (line 119)

L105-111: Some of the terms listed in the questionnaire (e.g. type of walls, flooring, and are not commonly used for evaluation of socioeconomic status in other studies. Please provide more details about how SES was assessed in the current study and justify the use of these terms in evaluation of social economic status.

Answer → We added information related to SES categories to make it clearer. In this study, SES was assessed using a structure questionnaire and we used national guidelines from Central Bureau of Statistics (Indonesia) to categorize the SES.
"We used national guidelines from Central Bureau of Statistics (Indonesia) to categorized the SES [20]. The components of the SES included income, education, house (type, status, and valuable goods), and electricity [20]." (line 125)

Table 1:

- **"%" should be removed from some values in parenthesis.**
  Answer → We revised it accordingly

- **I would suggest to report the percentage of deficient and normal individuals for the measured variables within each SES group rather than reporting the percentage of either deficient or normal individuals across SES groups.**
  Answer → We revised it accordingly. We revised table 1. We recalculate the prevalence as the percentage of micronutrient deficient or stunted participants and total participants within each of the SES groups.

Table 2:

- **Superscripts for ferritin, retinol and 25(OH)D are not correct; please edit.**
  Answer → We revised it accordingly.

- Round up P-value to 3 decimal places (or per requirements of the journal) or use $P < 0.001$; Check P-values in all the other tables and make same change accordingly.
  Answer → We revised it accordingly. And also we revised P-value (<0.001) in all tables.

Table 2. Micronutrient parameters and spesific indicator used (HAZ) across the 5 socioeconomic groups[1]

Variables	SES					P-Value
	Lowest	Low	Middle	Upper Middle	Upper	
Hemoglobin, g/l	112.0 ± 13.2[a]	113.3 ± 13.0[a]	113.3 ± 12.7[a]	115.7 ± 12.7[b]	118.7 ± 11.9[b]	0.002
Serum Ferritin, µg/l	30.9 ± 19.9[a]	33.4 ± 21.2[a]	34.4 ± 20.7[a]	43.6 ± 24.4[b]	44.1 ± 10.9[b]	<0.001
Serum retinol, µmol/l	1.28 ± 0.41[a]	1.35 ± 0.44[a]	1.56 ± 0.45[b]	1.67 ± 0.47[b]	1.70 ± 0.74[b]	<0.001
Serum 25(OH)D, nmol/l	56.1 ± 10.7	52.0 ± 11.7	52.2 ± 16.4	55.3 ± 11.1	52.5 ± 20.8	0.721
HAZ	-1.77 ± 1.30[a]	-1.65 ± 1.13[a]	-1.47 ± 1.12[ab]	-1.03 ± 1.39[c]	-0.77 ± 1.46[c]	<0.001

HAZ: height for age Z-score, SES: socioeconomic status. [1]Values are presented as mean ± standard deviation for continuous variables and n (%) for categorical variables. [a-c] Different superscripts indicate significant differences across SES groups.

HASIL REVIEWER 2

Reviewer 2 Report

I have attached a word version of the manuscript with annotated comments/questions and edits. The major comments follow:

1. The description of methods is insufficient. It could use similar language and previously published papers as done by one of the co-authors (Dr. Soekatri) in the 2020 paper on determinants of stunting in children 0.5 to 12 years.
2. The references are numbered in the text but not in the bibliography section, which makes checking the appropriateness of citations difficult. The paragraph (lines) in the discussion is very confusion regarding the sources being used to support the statements therein. More descriptors (e.g., country of study, age group, etc.) are needed to assess whether the authors are comparing apples with apples. Please correct this.
3. The discussion of the role of vitamin A and VA supplements to explain iron (ferritin) and anemia results is confusing and even contradictory.
4. The study aims to explore the association of basic determinants of MN deficiencies (vit. D, Vit. A, iron) and stunting. However, only socioeconomic status is included in the analysis. The association between SES and nutritional status is a well known fact.
5. Discuss the impact of sample size (particularly the smaller subsamples for some of the micronutrient analyses) on inferences about the association of SES with the prevalence of some of these deficiencies. Include this discussion as part of weaknesses of the study. Note: for Vit. A deficiency prevalence, for instance, the expected progressive decline of deficiency (%) as SES improves is not apparent, particularly for some cells with very few observations. The trend is very clear as expected for stunting and anemia data points, which are higher than for other micronutrients.
6. It is very important for readers to understand how the SES was calculated (its components: income, household items, electricity, etc.?). Please describe the standard reference (and method) used to create the SES categories.

Comments for author File: **Comments.pdf**

Round 2

Reviewer 2 Report

Thank you for the extensive and conscientious review.

The word version with comments is attached for your consideration. A number of said comments were not visible to authors in the pdf document submitted previously with my review.

Comments for author File: **Comments.docx**

HASIL REVIEWER 2

nutrients

MDPI

Article

Micronutrient deficiencies and stunting were associated with socioeconomic status in Indonesian children aged 6-59 months

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Abstract: Micronutrient deficiencies and stunting are known as a significant problem in most developing countries, including Indonesia. The objective of this study was to analyze the associations of micronutrient deficiencies and stunting with socioeconomic status (SES) among Indonesian children aged 6-59 months. This cross-sectional study was part of the South East Asian Nutrition Surveys (SEANUTS). A total of 1008 Indonesian children were included in the study. Anemia, iron deficiency, vitamin A deficiency, vitamin D deficiency, and stunting were identified in this study. Structured questionnaires were used to measure SES. Differences between micronutrient parameters and anthropometric indicator with the SES groups were tested using one way ANOVA with post-hoc test after adjusted for age, area resident (rural and urban), and sex. The highest prevalence of anemia, serum ferritin deficiency, serum retinol deficiency, and stunting were found in the lowest SES group as 32.6%, 36.1%, 33.3%, and 47.4%, respectively. Children from the lowest SES group had significantly lower means of Hb, ferritin, retinol, and HAZ. Severely stunted children had significantly lower mean of Hb concentration compared to stunted and normal height children. Micronutrient deficiencies, except vitamin D, and stunting were associated with low SES among Indonesian children aged 6-59 months.

Keywords: micronutrient deficiency; stunting; socioeconomic status; malnutrition; Indonesian children

Citation: Lastname, F.; Lastname, F.; Lastname, F. Title. *Nutrients* **2021**, *13*, x. https://doi.org/10.3390/xxxxx

Academic Editor: Firstname Lastname

Received: date
Accepted: date
Published: date

1. Introduction

Sustainable Development Goal-2 (SDG-2) aims to eradicate the global burden of malnutrition [1]. Malnutrition is one of the primary causes of mortality in children less than five years of age [2]. Decreasing malnutrition is a challenge for many countries, mainly developing countries [3]. In Indonesia, malnutrition remains a significant problem among children under 5-years-old, especially micronutrient deficiencies and stunting [4-6]. Both micronutrient deficiencies and stunting can influence physical and cognitive development in children and increase the risk of infection [7].

A previous study in Indonesia indicated a high prevalence of anemia and vitamin D deficiency [7]. Almost 60% of Indonesian children under 2-years-old were reported to be anemic [7,8], whereas the prevalence of anemia at the aged 2-5-years-old was 16.6%. Additionally, the prevalence of Iron deficiency ~~based on serum ferritin~~ levels and vitamin D deficiency were ~~around~~ 15% and 40%, respectively [7]. On the other hand, the prevalence of stunting is also high in Indonesia [6,9]. Indonesian Basic Health Survey (Riskesdas) stated that the prevalence of stunting ~~children~~ was almost 31% in 2018 [10]. Compared

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Many factors are known to be involved in the etiology of micronutrient deficiency and stunting. Previous studies in Korea and China showed that socioeconomic status (SES) was linked to micronutrient deficiency, including anemia, iron deficiency anemia (IDA), and vitamin D deficiency [11,12]. Moreover, some studies in Sri Lanka and Bangladesh also found that SES, overcrowding, and educated parents were associated with undernutrition among children [13-15]. In order to better address malnutrition in Indonesia, including micronutrient deficiencies and stunting, detailed information of the determining factors is needed to design a more effective intervention/approach. Accordingly, there is a need for an in-depth understanding between micronutrient status and anthropometric indicators with SES in Indonesia. Therefore, the objective of this study was to analyze the associations of micronutrient deficiencies (anemia, iron, vitamin A, and vitamin D) and stunting with socioeconomic status (SES) among Indonesian children aged 6-59 months.

2. Materials and Methods

Subjects and study design

The South East Asian Nutrition Survey (SEANUTS) was a multicenter study in nutrition funded by FrieslandCampina, The Netherlands. The SEANUTS in Indonesia utilized a cross-sectional study in 48 ~~out~~ of 440 cities/districts in 2011 [7,9]. A multi stage cluster sampling ~~and~~ stratified for area of residence (urban/rural) was performed [7,9]. Details of the sampling procedure are described elsewhere [16]. A total of 1008 children aged 6-59 months lived in rural and urban areas were included in the study. The participants were representatives of the target population. In this study, blood samples for hemoglobin (Hb), serum ferritin, serum retinol, and serum 25-hydroxy vitamin D (25OHD) were taken in sub-samples after being examined by medical doctors of 1008, 475, 489, and 103 subjects, respectively. Sub samples were used due to budget limitation, and this sub samples were chosen proportionately to represent age groups. Moreover, anthropometric measurements, including length and height, were taken for 983 children because some of them refused to be measured [7].

The study followed the guidelines of the Helsinki Declaration for human research. The design and methodologies were approved by the Committee of Health Research Ethics, the National Institute of Health Research and Development, the Ministry of Health of the Republic of Indonesia, number LB.03.02/KE/6430/2010. and the Ministry ofHome Affairs, number 440.02/1751.D.I. The study was registered in the Netherlands Trial Registry (NTR 2462). Explanation of the study and the procedure applied as well as the possible side effects and its management were given to the parents before written informed consent was obtained.

Anthropometric data

The length was measured supine using a flat wooden measuring board in children below two years of age. Height was measured using a wall-mounted stadiometer accurate to 0.1 cm in children aged two years old and older. All the measurements were done in duplicate with an accuracy of 0.1 cm. The average value was used in the calculations [9]. Height for age Z-scores (HAZ-~~score~~) was calculated using the WHO software [17]. We used the WHO Child Growth Standards 2005 [18] to define severe stunting (~~as having a~~ HAZ ~~score of~~ < -3) and stunting (~~as a~~ HAZ ~~score of~~ < -2).

Biochemical indicators

Blood samples for Hb measurements were taken through the finger prick procedure in children younger than 2-years-old and from venipuncture in older children. Hemoglobin concentration was measured with the HemoCue Hb 201 (HemoCue Diagnostics B.V. in children < 2 years) and Spectrophotometry, ADVIA 2120; Siemens for older children. Anemia was defined as Hb concentrations of <110 g/l for children aged between 6-59

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Commented [ebg 5]: Add "low" before SES since the outcomes are all for deficiencies.

Commented [ebg 6]: Low SES

Commented [ebg 7]: Underlying determinants or **basic determinants**? "Malnutrition is caused by one or a combination of factors. The immediate determinants of child nutritional status are poor dietary intake (i.e., energy, protein, and micronutrients) and disease. These factors are interdependent. For instance, a child with inadequate dietary intake is more susceptible to disease, which in turn depresses appetite, inhibits the absorption of food nutrients, and competes for a child's energy [27]. Dietary intake must be adequate in quantity and quality, and nutrients must be appropriately consumed in right combinations for adequate absorption. The **immediate determinants** of child malnutrition are influenced by three **underlying determinants**, which are food security, adequate care for mothers and children, and a proper health environment, including access to health services [28–30]. Finally, the underlying determinants are influenced by the ***basic* determinants**: the potential resources available to a country or community, and a host of ...

Commented [ebg 8]: SES (or poverty) is a basic determinant of undernutrition.

Commented [ebg 9]: Insert % after rural (%) and urban (%) to describe the actual proportions in the study sample.

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Commented [ebg 11]: Netherlands (not Netherland)

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Commented [ebg 17]: Capillary blood is a combination of arterial and venous blood. Although the issue is still controversial, results from these two ...

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months. Serum ferritin was measured with Immunochemiluminescence ECLIA, Roche Cobas e 601; Roche Diagnostics. Iron deficiency was considered ~~as having~~ serum ferritin concentrations of <12 mg/l for children under aged 6-59 months. Serum retinol was measured with an HPLC-UV detector, Agilent, 1200; Agilent Technologies (all-trans-retinol) and Serum 25(OH)D was measured with ELISA, IDS 25-Hydroxy Vitamin D; Immunodiagnostic Systems (D3 and D2 metabolites) Capillary. Children with serum retinol concentrations of <0.70 mmol/l and circulating 25 hydroxyvitamin D < 50 mol/l were considered vitamin A or vitamin D deficiency, respectively [7,19].

Socioeconomic status

Structured questionnaires were employed to obtain information regarding income, education, housing type, flooring, ventilations, type of walls, ownership of valuable goods, and electronic appliances as well as type of household sanitation facilities. Socioeconomic status was calculated and categorized into 5 groups or quintiles, namely: lowest, low, middle, upper middle, and upper. Details for the data collection methodology and wealth classification were published earlier [16,20].

Data analysis

Data were analyzed using SPSS version 24 (IBM Corp., Armonk, NY, USA) [7]. Weight factors were based on the 2010 Census data on the number of children in specific age groups [7]. Chi-square test was used to analyze the differences between characteristic variables across the groups of SES. While, differences between micronutrient parameters and anthropometric indicator with the groups of SES were tested using One way ANOVA with the Duncan post-hoc test after adjusted for age, area resident (rural and urban), and sex. Values are presented as mean and standard deviation for continuous variables or n (%) for categorical variables with $p < 0.05$ as significant.

3. Results

Overall, the ~~total~~ mean ~~of~~ age was 31.7 ± 16.1 months ~~old~~. The characteristics of the children in the 5 SES groups are presented in Table 1. Most of the children with lowest SES lived in rural area (42.0%). The highest prevalence of anemia and serum ferritin deficiency were found in the lowest SES group with 32.6% and 36.1%, respectively. The highest prevalence of serum retinol deficiency was found in the lowest SES and the low SES groups with 33.3% and 33.3%, respectively. While, surprisingly, the highest prevalence of vitamin D deficiency was found the middle SES group (31.8%). Moreover, the highest prevalence of stunted and severe stunted were found in the lowest SES group with 36.0% and 47.4%, respectively.

Table 1. Characteristics of children in the 5 socioeconomic groups[1]

Variables	SES					P-Value
	Lowest	Low	Middle	Upper Middle	Upper	
Age (years), n=1008	31.5 ± 15.6	33.1 ± 16.5	31.5 ± 16.1	31.9 ± 16.1	32.4 ± 16.5	0.976
Sex, n=1008						
Boys 514	144 (28.0)	98 (19.1)	107 (20,8)	89 (17.3)	76 (14.8)	0.483
Girls 494	142 (28.8)	99 (20.0)	93 (18.8)	71 (14.4)	89 (18)	
Area of residence, n=1008						
Urban	42 (9.8)	84 (19.7)	89 (20.8)	90 (21.1)	122 (28.6)	0.000
Rural	244 (42.0)	114 (19.6)	111 (19.1)	70 (12.1)	42 (7.2)	
	85.3	57.6	55.5	43.7	25.6	
Hemoglobin, n=1008						
Normal	156 (25.7)	108 (17.8)	115 (19.0)	104 (17.2%)	123 (20.3%)	0.000
Anemia	131 (32.6)	89 (22.2)	85 (21.1)	56 (13.9)	41 (10.2)	
	45.6	45.2	42.5	35.0	25.0	
Serum Ferritin, n=475						0.087
Normal	112 (27.1)	78 (18.8)	82 (19.8)	67 (16.2)	75 (18.1)	

Commented [ebg 19]: ID was defined as SFerr concentrations below 12….

Commented [ebg 20]: Delete? The word "capillary" seems to be here by error.

Commented [ebg 21]: Were the SES categories based on national guidelines or income quartiles or another referable standard method?

Commented [ebg 22]: Were the ferritin results log transformed for regression analyses and back transformed to describe results? Given nonnormally distributed residuals, serum ferritin is log transformed to fit the model and then back transformed to describe the results analyzed as log transformed values. Logarithmic transformation of the results is performed in order to stabilize the variance.

Commented [ebg 23]: Iron deficiency

Commented [ebg 24]: Should say "found **in** the middle SES…."

Commented [ebg 25]: Stunting (HAZ)and severe stunting (HAZ<3 SD)

Deficiency	22 (36,0) 16.4%	15 (24,6) 16.1%	14 (23,0) 14.5	4 (6,6) 5.6	6 (9,8) 7.4	
Serum retinol, n=489						
Normal	136 (28.6)	89 (18.8)	97 (20.5)	69 (14.6)	83 (17.5)	0.128
Deficiency	5 (33.3) 3.5%	5 (33.3) 5.3%	1 (6.7) 1.0%	4 (26.7) 5.5%	0 (0) 0%	
Serum 25(OH)D, n=103						
Normal	22 (37.3)	12 (20.3)	8 (13.5)	11 (18.7)	6 (10.2)	0.164
Deficiency	9 (20.5) 29%	8 (18.2) 40%	14 (31.8) 63.6%	6 (13.6) 35.3%	7 (15.9) 53.8%	
HAZ, n=983						
Normal height	151 (22.8)	124 (18.7)	132 (19.9)	116 (17.5)	140 (21.1)	0.000
Stunted	81 (36.0)	50 (22.2)	48 (21.4)	32 (14.2)	14 (6.2)	
Severe stunted	45 (47.3) 45.5	21 (22.1) 36.4	13 (13.7) 31.6	7 (7.4) 25.1	9 (9.5) 8.7	

[1]Values are presented as mean ± standard deviation for continuous variables and n (%) for categorical variables.

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The differences between micronutrient parameters and anthropometric indicator across the groups of SES are shown in Table 2. Children from the lowest SES group had significantly lower ~~means of~~ Hb (112.0 ± 13.2 g/dl), ferritin (30.9 ± 19.9 µg/l), retinol (1.28 ± 0.41 µml/l), and HAZ (-1.77 ± 1.30). Differences in micronutrient status across HAZ indicator are shown in Table 3. Severely stunted children had significantly lower ~~mean of~~ Hb concentration (110.8 ± 14.0 g/l) compared to stunted (114.0 ± 11.4 g/l) and normal height children (114.6 ± 13.2 g/l). In addition, children with normal height had significantly higher retinol concentration (1.54 ± 0.55 µml/l) compared to severely stunted children (1.32 ± 0.39 µml/l). However, ferritin and 25(OH)D concentrations were not significantly differen t~~ce~~ between normal height and stunted or severe stunted.

Table 2. Micronutrient parameters and anthropometric indicator across the 5 socioeconomic groups[1]

Variables	SES					P-Value
	Lowest	Low	Middle	Upper Middle	Upper	
Hemoglobin, g/l	112.0 ± 13.2^{a}	113.3 ± 13.0^{a}	113.3 ± 12.7^{a}	115.7 ± 12.7^{b}	118.7 ± 11.9^{b}	0.002
Serum Ferritin, µg/l	30.9 ± 19.9^{a}	33.4 ± 21.2^{a}	34.4 ± 20.7^{a}	43.6 ± 24.4^{b}	44.1 ± 10.9^{bc}	0.000
Serum retinol, µmol/l	1.28 ± 0.41^{a}	1.35 ± 0.44^{a}	1.56 ± 0.45^{b}	1.67 ± 0.47^{bc}	1.70 ± 0.74^{bc}	0.000
Serum 25(OH)D, nmol/l	56.1 ± 10.7	52.0 ± 11.7	52.2 ± 16.4	55.3 ± 11.1	52.5 ± 20.8	0.721
HAZ	-1.77 ± 1.30^{a}	-1.65 ± 1.13^{a}	-1.47 ± 1.12^{ab}	-1.03 ± 1.39^{c}	-0.77 ± 1.46^{c}	0.000

HAZ: height for age Z-score, SES: socioeconomic status. [1]Values are presented as mean ± standard deviation for continuous variables and n (%) for categorical variables. Values corrected for sex, age, and area of residence. $^{a-c}$ Different superscripts indicate significant differences acrossSES groups.

Commented [ebg 27]: Change to specific indicator used (HAZ)

Table 3 Micronutrient status across HAZ indicator[1]

Variables	HAZ			P-Value
	Normal height	Stunted	Severely stunted	
Hemoglobin, g/l	114.6 ± 13.2^{a}	114.0 ± 11.4 ^{a}	110.8 ± 14.0 ^{b}	0.000
Serum Ferritin, µg/l	37.7 ± 24.2	33.6 ± 22.5	34.3 ± 19.6	0.598
Serum retinol, µmol/l	1.54 ± 0.55^{a}	1.37 ± 0.47^{ab}	1.32 ± 0.39 ^{b}	0.012
Serum 25(OH)D, nmol/l	54.1 ± 14.7	51.9 ± 13.4	56.3 ± 9.8	0.722

HAZ: height for age Z-score. [1]Values are presented as mean ± standard deviation for continuous variables and n (%) for categorical variables. Values corrected for sex, age, and area of residence. $^{a-c}$ Different superscripts indicate significant differences across SES groups.

Commented [ebg 28]: Linear growth categories

4. Discussion

The study provided insight into the relationship between micronutrient deficiencies and stunting regarding SES. Children from lower SES had higher risks of anemia, iron deficiency, vitamin A deficiency, and stunting. The results were similar toprevious studies in middle and lower-income countries where anemia is more prevalent in children from lower SES groups [21]. Moreover, children below school age had a higher risk compared to school-aged children [22]. Another study of DHS data from 32 LMICs showed that SES, especially household wealth, was a causal factor for anemia [23]. A previous study showed that children living in the lowest wealth quintile had significantly lower ~~means~~ of hemoglobin, ferritin, retinol, and HAZ than those in the highest wealth quintile. They found that family income is considered an important determinant of micronutrient status and anthropometric indicators [9,24]. When household income increased, the prevalence of anemia, IDA, and stunting decreased, and serum Hb and ferritin levels increased [9,11].

Iron, in the form of ferritin, is stored in the body. The body will take from these ferritin stores if the dietary iron needs are not reached. If it is not treated, ferritin will be depleted, and the blood plasma levels of iron will decrease. This condition will cause iron-deficiency anemia. It can be treated by consuming food high in iron, especially animal-based food, because it contains iron in heme form, which absorbed better than the non-heme iron form found in plant-derived foods [19,25]. However, animal source foods are often more expensive than plant-derived foods [25]. Therefore, the low consumption of animal-based food may cause iron deficiency and anemia in the Low SES group because they are often inaccessible [24,25]. Moreover, sources of vitamin A from foods are mostly found in animal-based food compared to plant-derived food that may affect the consumption. Vitamin A also plays an important role in hematopoiesis, and it is involved in the mobilization and utilization of iron storess~~d~~ [25].

The result of SEANUTS study in Indonesia regarding food consumption also showed that animal protein and milk intake are positively correlated to SES [26]. The study also highlighted that only around 30% of the household from the lowest SES had access to adequate sanitation facilities [26]. Moreover, lower SES is often related to poor living conditions such as inadequate access to clean water and sanitation facilities, thus increasing the risk of infection and then increased risk of developing anemia [27].

Interestingly, children in the lowest SES were at the highest risk for iron deficiency. The successful countrywide vitamin A supplementation program might offer an insight into this result. Serum retinol levels in children under 5-years-old were higher on those who had received supplementation regularly than those who did not [27,28]. Children living in rural areas, as the majority of the lowest SES children in this study, generally had higher adherence to the vitamin A supplementation program compared to children living in urban areas [27,29,30].

However, it is also important to know that the ignorance among caregivers was the reason for missing doses in vitamin A supplementation. Hence, it might be noted for the future supplementation program [27,31]. It is also important to develop awareness about the health importance of vitamin A supplementation. Besides, the current cooking oil fortification program with vitamin A should offer an alternative solution. Fortification of oils with vitamin A is one of the low-cost and effective ways to improve vitamin A intake, reducing the risk of vitamin A deficiency in developing countries [32].

From this study, children from the middle SES families showed the lowest mean 25(OH)D concentration. However, no significant difference between vitamin D and SES groups was found. Vitamin D is mostly made in the skin supported by sunlight exposure. Moreover, pigmentation of the skin is also responsible for vitamin D status [7,33,34]. Future studies regarding vitamin D should include coverage across the socioeconomic spectrum and couple a nutritional approach with sunlight exposures.

Regarding anthropometric indicators, a higher HAZ was correlated with a higher SAS. Moreover, this study revealed that stunted children had a higher risk of anemia than

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Commented [ebg 32]: State that this study in Lancet by Belarajan et al included nationally representative Demographic and Health Surveys undertaken in 32 ...

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Commented [ebg 35]: Anemia prevalence? (Soekatri, 2020)

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Commented [ebg 43]: Ignorance or lower education level? Education was found to be significantly associated with stunting in the 2020 paper by soekatri ...

children with normal height, the same result was also found in other studies [35,36]. Ayoya et al. found that child's age, HAZ score < −2. and mother's anemia predicted the occurrence of childhood anemia in 6–59-months-old children in Haiti [37]. We also found significant differences in the risk of vitamin A deficiency between different anthropometric indicators. This findings were in line with other study that stunting was associated with vitamin A deficiency [38].

This study has a strength. To the best of our knowledge, this is the first study to discuss the relationship between micronutrient deficiencies (anemia, iron, vitamin A and vitamin D) and nutritional status defined by anthropometric measurement with SES in Indonesia, especially children under five years old. Thus, this study will provide insights for better targeting when it comes to nutrition intervention. However, as a consequence of using subsamples from a larger study, it has to be kept in mind that micronutrient status, in this study, were determined from a relatively small set of samples. Hence, the results should be interpreted carefully. The current study is a cross-sectional study; consequently, it is unable to explain causal relationships. Another note is that the study did not include analysis of data on food intake and outdoor physical activity; thus, it is unable to explain the role of both behaviors concerning micronutrient status.

5. Conclusions

This study shows that micronutrient status and anthropometric indicators have an association with SES among Indonesian children aged 6-59 months. Anemia, iron deficiency, vitamin A deficiency, and stunting were associated with low SES. While vitamin D status shows no association with SES. In addition, severely stunting children aged 6-59 months have significantly associated with anemia. The study suggests doing more comprehensive nutrition programs to improve the micronutrient status of children based on SES. Additional studies are needed to explore the association of micronutrient status and stunting with SES using a longitudinal study.

Supplementary Materials: The following are available online at www.mdpi.com/xxx/s1, Figure S1: title, Table S1: title, Video S1: title.

Author Contributions: Conceptualization, F.E., A.Y., M.Y.E.S., and A.S.; methodology, F.E.; formal analysis, F.E.; investigation, F.E., and A.S.; writing—original draft preparation, F.E.; writing—review and editing, F.E., and A.S.; All authors have read and agreed to the published version of the manuscript.

Funding: The study was sponsored by FrieslandCampina, the Netherlands.

Institutional Review Board Statement: This study was conducted according to the guidelines of the Declaration of Helsinki, and all procedures involving research study participants were approved by the Committee of Health Research Ethics, the National Institute of Health Research and Development, the Ministry of Health, Republic of Indonesia, number LB.03.02/KE/6430/2010, and was also registered in the Netherlands Trial Registry number NTR 2462.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Acknowledgments: We thank to FrieslandCampina for providing funding for the present study; FrieslandCampina representatives, particularly Victoria Valentina, Anne Schaafsma, Panam Parikh, and Marjolijn Bragt-van Wijngaarden are greatly appreciated for their valuable guidance throughout the study. The authors are also indebted to the government and health representatives at all levels especially the National Institute of Health Research and Development for their contribution to the study, as well as to all the children and their families for their willingness to participate in the present study.

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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PERBAIKAN REVIEWER 2

Author Response

Please see the attachment.

Author Response File: **Author Response.pdf** / Author Response.docx

Dear Reviewer,

We thank you for your comments and suggestions for improving the manuscript. The authors have considered the comments and revised the manuscript accordingly. Thank you very much.

We replied your comments as below:

Our responses here follow →

Yours sincerely,

Ahmad Syauqy, Ph.D

Reviewer 2.

I have attached a word version of the manuscript with annotated comments/questions and edits. The major comments follow:
Answer → Thank you for your comments/questions. We only found a pdf version in the system. Some comments/questions are missing in the pdf version. However, we answered all the comments/questions. And revised any corrections from reviewer in the file. Please find below:

Commented [ebg 1]: "national prevalence"
Answer → This has been changed (line 40)

Commented [ebg 2]: Change to: among children 2-5 years of age
Answer → This has been changed (line 40)

Commented [ebg 3]: Lower case "iron"
Answer → This has been changed (line 41)

Commented [ebg 4]: Since this paragraph is describing the situation of MALNUTRITION in Indonesia, 1) consider inserting figures on how Indonesia's micronutrient deficiency and overweight/obesity prevalence in children compare with ASEAN countries, and 2) is there similar national zinc deficiency data for Indonesian children? Other than resources limitations, why was zinc not measured? Zinc is associated with chronic malnutrition and linear growth.
Answer →
1) we added more explanation to compare micronutrient deficiency and stunting/overweight/obesity prevalence in Indonesian children with other ASEAN countries

- "This figure was higher than Malaysia (6.6%) and Thailand (13.7%) [7]". (line 41)
- "The vitamin D deficiency was quite high in Indonesia but this prevalence lies between Malaysia (47.5%) and Thailand (36.7%). However, the prevalence of vitamin A deficiency in Indonesia (0.9%) was the lowest compared to Malaysia (4.4%) and Thailand (2.1%). [7]". (line 43)

- "Overweight prevalence among subjects in Indonesia (4.4%) was the lowest compared to Malaysia (9.8%) and Thailand (7.5%). The same situation was also found in obesity, the prevalence in Indonesia (3.5%) was also the lowest compared to Malaysia (10.5%) and Thailand (8.8%). [7]" (line 49)

2) We did not measured zinc in this study. We stated it in the limitation "We did not measured zinc in this study. Zinc is known to play a role in chronic malnutrition and linear growth [37]." (line 239)

Commented [ebg 5]: Add "low" before SES since the outcomes are all for deficiencies.
Answer → This has been changed (line 55, 58)

Commented [ebg 7]: Underlying determinants or **basic determinants**?
Answer → We changed "determining factors" to "basic determinants". (line 60)

Commented [ebg 8]: SES (or poverty) is a basic determinant of undernutrition.
Answer → We revised it accordingly. (line 60)

Commented [ebg 9]: Insert % after rural (%) and urban (%) to describe the actual proportions in the study sample.
Answer → We added the percentages: rural "(57.64%)" and urban "(42.36%)". (line 75)

Commented [ebg 10]:
Were the subsampled children selected randomly? How so?
Answer → We added some information related to the sub-sampled "Sub-samples were taken based on district in which each district consisted of two villages. From these villages, one was randomly selected for blood analysis. All sample aged 6 to 23 months and 24 to 59 months who lived in the area were taken their blood after examined by local doctor for eligibility." (Line 79)

Reword this sentence to "Given resource constraints in this study, blood … in…..
Answer → Some comments are missing in the PDF version. We cannot read it.

Commented [ebg 11]: Netherlands (not Netherland)
Answer → This has been changed (line 90)

Commented [ebg 12]: Plural: procedures
Answer → This has been changed (line 91)

Commented [ebg 13]: Change to "was". Explanation….. "was given…."
Answer → This has been changed (line 92)

Commented [ebg 14]: were calculated
Answer → This has been changed (line 99)

Commented [ebg 15]: WHO Anthro Software (version and link to source) https://www.who.int/tools/child-growth-standards/software
Answer → We added WHO Anthro Software version 1.0.3 (https://www.who.int/tools/child-growth-standards/software) (line 99)

Commented [ebg 16]: WHO standards were published in 2006.

Answer → We revised accordingly (line 101)

Commented [ebg 17]: Capillary blood is a combination of arterial and venous blood. Although the issue is still controversial, results from these two
Answer → Some comments are missing in the PDF version. We cannot read it.
We changed "blood finger prick procedure" to "capillary" (line 104)

Commented [ebg 18]: Add one line to describe sample handling, centrifugation, and preservation, or give published reference for how this was done. Were the….
Answer → Some comments are missing in the PDF version. We cannot read it.
We added information to describe this methods "Five milliliters of blood was taken from venous, then 2 ml of blood was inserted into an EDTA-coated tube, and the rest went into a tube without EDTA. EDTA blood was for Hb. Plain blood was centrifuged to take serum. Serum is for ferritin, vitamin A, and vitamin D analysis." (line 106)

Commented [ebg 19]: ID was defined as SFerr concentrations below
Answer → We revised accordingly (line 114)

Commented [ebg 20]: Delete? The word "capillary" seems to be here by error.
Answer → We revised it accordingly (line 117)

Commented [ebg 21]: Were the SES categories based on national guidelines or income quartiles or another referable standard method?
Answer → We added information related to SES categories and the reference to make it clearer. "We used national guidelines from Central Bureau of Statistics (Indonesia) to categorized the SES [20]. The components of the SES included income, education, house (type, status, and valuable goods), and electricity [20]." (line 125)

Commented [ebg 22]: Were the ferritin results log transformed for regression analyses and back transformed to describe results? Given nonnormally distributed residuals, serum ferritin is log transformed to fit the model and then back transformed to describe the results analyzed as log transformed values. Logarithmic transformation of the results is performed in order to stabilize the variance.
Answer → We used ANNOVA to test the associations, not regression analyses.

Commented [ebg 23]: Iron deficiency
Answer → We revised it accordingly (line 142)

Commented [ebg 24]: Should say "found in the middle SES…"
Answer → We revised it accordingly (line 145)

Commented [ebg 25]: Stunting (HAZ)and severe stunting (HAZ<3 SD)
Answer → We revised it accordingly "Stunting (HAZ)and severe stunting (HAZ<3 SD)" (line 146)

Commented [ebg 26]: VA deficiency prevalence does not increase gradually as SES decreases. Why? Stunting, iron deficiency and anemia prevalence does show the trend more consistently. Is this a problem of sample size?
Answer →

- We added in the results ", but it does not increase gradually as SES decreases." (Line 144)
- We added in the discussion "However, the trend was not found in vitamin A deficiency prevalence. This may be due to the different sample size, particularly the smaller sub-samples for some micronutrient analyses." (line 175)
- We added in the conclusions "However, the trend was not found in vitamin A deficiency." (line 247)

Commented [ebg 27]: Change to specific indicator used (HAZ)
Answer → We revised it accordingly (Table 2)

Commented [ebg 28]: Linear growth categories
Answer → We revised it accordingly (Table 3)

Commented [ebg 29]: Data from a cross sectional study can be used to estimate risk based the prevalence ratio or prevalence odds ratio. However, neither measure of risk was estimated in this paper, and therefore the interpretation of higher prevalence in lower socioeconomic groups as RISK is not supported by evidence. If the OR calculation were carried out, then the discussion can include a quantifiable "risk" derived from a continuous scale of socioeconomic status (composite score? Income?). "In **cross-sectional studies**, investigators assess all individuals in a sample at the same point in time, often to examine the prevalence of exposures, risk factors or disease. Some cross-sectional studies are analytical and aim to quantify potential causal associations between exposures and disease. Such studies may be analysed like a cohort study by….
Answer → Some comments are missing in the PDF version. We cannot read it.
We changed the sentence and deleted "risk". We added "The prevalence of anemia, iron deficiency, stunted and severe stunted proved highest among the lowest socioeconomic groups 45.6%, 16.4%, 29.3%, 54.5%, respectively". (line 173)

Commented [ebg 30]: Preschool children from Latin America and Caribbean region had….
Answer → The sentences are missing in the PDF version. We cannot read it.
We revised it accordingly (line 177)

Commented [ebg 31]: This statement refers to other studies – not this study. This paper does not include school age children. Consider deleting the statement
Answer → The sentences are missing in the PDF version. We cannot read it.
We deleted it accordingly (line 178)

Commented [ebg 32]: State that this study in Lancet by Belarajan et al included nationally representative Demographic and Health Surveys undertaken in 32
Answer → The sentences are missing in the PDF version. We cannot read it.
We revised it accordingly (line 179)

Commented [ebg 33]: Not causal, but **significantly associated with** anemia prevalence.
Answer → We revised it accordingly (line 180)

Commented [ebg 34]: Insert reference for this study here, please. Is this ref 20 for 0.5 to 12 yr old children from Indonesia, same survey data set?
Answer → It is not the same data set. We deleted the sentences to make clearer "~~Moreover, children below school age had a higher risk compared to school-aged children~~" (line 178)

Commented [ebg 35]: Anemia prevalence? (Soekatri, 2020)
Answer → We deleted Soekatri (2020) [9]. (line 185)

Commented [ebg 36]: I am guessing that these references (9 and 24) are for Soekatri (2020) and Osorio (2004), which studied stunting in Indonesian 5-12 yr
Answer → Yes we used Soekatri (2020) and Osorio (2004). We added the references (line 182)

Commented [ebg 37]: Not exactly. Chronic dietary iron insufficiency will deplete iron stores (mostly in the liver) as reflected by lower circulating ferritin
Answer → We revised it accordingly.

- We added "Chronic dietary iron insufficiency will deplete iron stores (mostly in the liver) as reflected by lower circulating ferritin" (line 187).
- We deleted "~~If it is not treated, ferritin will be depleted, and the blood plasma levels of iron will decrease~~" (line 187)
- We added "Previous study also found that high vitamin A deficiency at low SES, even though vitamin A also plays a role in the process of hematopoises and mobilization of iron in the body, so that vitamin A deficiency will aggravate iron status in the body (line 196)

Commented [ebg 38]: Prevented (and also treated when anemia is not severe)
Answer → We revised it accordingly (line 189)

Commented [ebg 39]: And the consumption of plant based foods that also contain iron absorption inhibitors (e.g. phytate, oxalate, polyphenols, etc.)
Answer → We added "as well as consumption of plant-based foods that also contain iron absorption inhibitors (e.g., phytate, oxalate, and polyphenols)" (line 193)

Commented [ebg 40]: Insert at beginning of this sentence: "These statements are also supported by the results of SEANUTS…..
Answer → We revised it accordingly (line 199)

Commented [ebg 41]: The term "risk" is not justified based on the data presented in this paper, at least not in epidemiological terms.
Answer → We changed "risk" to "proved had" (line 206)

Commented [ebg 42]: I do not follow the logic in this paragraph: lowest SES are in rural areas → lowest SES also have higher iron deficiency prevalence and very
Answer → We deleted the sentences to make it clearer "~~Children living in rural areas, as the majority of the lowest SES children in this study, generally had higher adherence to the vitamin A supplementation program compared to children living in urban areas [26, 28, 29]~~" (line 209)

Commented [ebg 43]: Ignorance or lower education level? Education was found to be significantly associated with stunting in the 2020 paper by soekatri
Answer → We change "ignorance" to "lower education level" (line 210)

1. **The description of methods is insufficient. It could use similar language and previously published papers as done by one of the co-authors (Dr. Soekatri) in the 2020 paper on determinants of stunting in children 0.5 to 12 years**.

Answer → We added more explanation related to SEANUTS study.

- "The SEANUTS was done in Indonesia, Malaysia, Thailand, and Vietnam in 2011" (line 70).
- …. "sex, and age" …. (line 73)

2. **The references are numbered in the text but not in the bibliography section, which makes checking the appropriateness of citations difficult. The paragraph (lines) in the discussion is very confusion regarding the sources being used to support the statements therein. More descriptors (e.g., country of study, age group, etc.) are needed to assess whether the authors are comparing apples with apples. Please correct this**.

Answer → We revised the reference style. We used number for the reference, as the guidelines of the journal use this style. And also we revised the discussion.

3. **The discussion of the role of vitamin A and VA supplements to explain iron (ferritin) and anemia results is confusing and even contradictory**.

Answer →

- We deleted line 196 to make it more clear and not contradictory "~~Moreover, sources of vitamin A from foods are mostly found in animal-based food compared to plant-derived food that may affect the consumption. Vitamin A also plays an important role in hematopoiesis, and it is involved in the mobilization and utilization of iron stored"~~
- we added "Previous study also found that high vitamin A deficiency at low SES, even though vitamin A also plays a role in the process of hematopoises and mobilization of iron in the body, so that vitamin A deficiency will aggravate iron status in the body [24] (line 196)

4. **The study aims to explore the association of basic determinants of MN deficiencies (vit. D, Vit. A, iron) and stunting. However, only socioeconomic status is included in the analysis. The association between SES and nutritional status is a well known fact.**

Answer → This study aims to explore the association between micronutrient deficiencies and stunting with SES. We used micronutrient deficiencies and stunting as malnutrition problems among children under 5-years-old.

5. **Discuss the impact of sample size (particularly the smaller subsamples for some of the micronutrient analyses) on inferences about the association of SES with the prevalence of some of these deficiencies. Include this discussion as part of weaknesses of the study. Note: for Vit. A deficiency prevalence, for instance, the expected progressive decline of deficiency (%) as SES improves is not apparent, particularly for some cells with very few observations. The trend is very clear as expected for stunting and anemia data points, which are higher than for other micronutrients.**

Answer →

- We added "The prevalence of anemia, iron deficiency, stunted and severe stunted proved highest among the lowest socioeconomic groups 45.6%, 16.4%, 29.3%, 54.5%, respectively. However, the trend was not found in vitamin A deficiency prevalence. This may be due to the different sample size, particularly the smaller subsamples for some micronutrient analyses." (line 173)
- We deleted "~~Children from lower SES had higher risks of anemia, iron deficiency, vitamin A deficiency, and stunting~~" (line 173)
- We already wrote the sample size as a limitation of the study "However, as a consequence of using subsamples from a larger study, it has to be kept in mind that micronutrient status, in this study, were determined from a relatively small set of samples." (238)
- We also revised the conclusions "However, the trend was not found in vitamin A deficiency." (line 247)

6. It is very important for readers to understand how the SES was calculated (its components: income, household items, electricity, etc.?). Please describe the standard reference (and method) used to create the SES categories.

Answer → We added information related to SES categories to make it clearer. "We used national guidelines from Central Bureau of Statistics (Indonesia) to categorized the SES [20]. The components of the SES included income, education, house (type, status, and valuable goods), and electricity [20]." (line 125)

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Kam, 13 Mei 2021 15.23

kepada saya, Fitrah, Aya, Moesijanti

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Nonaktifkan untuk: Inggris

Dear Dr. Syauqy,

Thank you very much for resubmitting the modified version of the following manuscript:

Manuscript ID: nutrients-1190203
Type of manuscript: Article
Title: Micronutrient deficiencies and stunting were associated with socioeconomic status in Indonesian children aged 6-59 months
Authors: Fitrah Ernawati, Ahmad Syauqy *, Aya Yuriestia, Moesijanti Y. E. Soekatri
Received: 2 April 2021
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Submitted to section: Nutrition and Public Health,
https://www.mdpi.com/journal/nutrients/sections/Nutrition_Public_Health
Nutritional Status among Vulnerable Populations
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A member of the editorial office will be in touch with you soon regarding progress of the manuscript.

Kind regards,

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Dear Dr. Syauqy,

Congratulations on the acceptance of your manuscript, and thank you for your interest in submitting your work to Nutrients:

Manuscript ID: nutrients-1190203
Type of manuscript: Article
Title: Micronutrient deficiencies and stunting were associated with socioeconomic status in Indonesian children aged 6-59 months
Authors: Fitrah Ernawati, Ahmad Syauqy *, Aya Yuriestia, Moesijanti Y. E. Soekatri
Received: 2 April 2021
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Submitted to section: Nutrition and Public Health,
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Received: 2 April 2021
E-mails: fitrahernawati@yahoo.com, syauqy@fk.undip.ac.id, ayaarifin@gmail.com, moesijanti@yahoo.com
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Received: 2 April 2021
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Micronutrient deficiencies and stunting were associated with socioeconomic status in Indonesian children aged 6-59 months

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Abstract: Micronutrient deficiencies and stunting are known as a significant problem in most developing countries, including Indonesia. The objective of this study was to analyze the associations of micronutrient deficiencies and stunting with socioeconomic status (SES) among Indonesian children aged 6-59 months. This cross-sectional study was part of the South East Asian Nutrition Surveys (SEANUTS). A total of 1008 Indonesian children were included in the study. Anemia, iron deficiency, vitamin A deficiency, vitamin D deficiency, and stunting were identified in this study. Structured questionnaires were used to measure SES. Differences between micronutrient parameters and anthropometric indicator with the SES groups were tested using one way ANOVA with post-hoc test after adjusted for age, area resident (rural and urban), and sex. The highest prevalence of anemia, serum ferritin deficiency, serum retinol deficiency, and stunting were found in the lowest SES group as 32.6%, 36.1%, 33.3%, and 47.4%, respectively. Children from the lowest SES group had significantly lower means of Hb, ferritin, retinol, and HAZ. Severely stunted children had significantly lower mean of Hb concentration compared to stunted and normal height children. Micronutrient deficiencies, except vitamin D, and stunting were associated with low SES among Indonesian children aged 6-59 months.

Keywords: micronutrient deficiency; stunting; socioeconomic status; malnutrition; Indonesian children

Citation: Lastname, F.; Lastname, F.; Lastname, F. Title. *Nutrients* **2021**, *13*, x. https://doi.org/10.3390/xxxxx

Academic Editor: Firstname Lastname

Received: date
Accepted: date
Published: date

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1. Introduction

Sustainable Development Goal-2 (SDG-2) aims to eradicate the global burden of malnutrition [1]. Malnutrition is one of the primary causes of mortality in children less than five years of age [2]. Decreasing malnutrition is a challenge for many countries, mainly developing countries [3]. In Indonesia, malnutrition remains a significant problem among children under 5-years-old, especially micronutrient deficiencies and stunting [4-6]. Both micronutrient deficiencies and stunting can influence physical and cognitive development in children and increase the risk of infection [7].

A previous study in Indonesia indicated a high prevalence of anemia and vitamin D deficiency [7]. Almost 60% of Indonesian children under 2-years-old were reported to be anemic [7,8], whereas the national prevalence of anemia among children 2-5 years of age ~~at the aged 2-5-years-old~~ was 16.6%. This figure was higher than Malaysia (6.6%) and Thailand (13.7%). Additionally, the prevalence of i~~I~~ron deficiency ~~based on serum ferritin~~ levels and vitamin D deficiency were ~~around~~ 15% and 40%, respectively [7]. The vitamin D deficiency was quite high in Indonesia but this prevalence lies between Malaysia

(47.5%) and Thailand (36.7%). However, the prevalence of vitamin A deficiency in Indonesia (0.9%) was the lowest compared to Malaysia (4.4%) and Thailand (2.1%) [7]. On the other hand, the prevalence of stunting is also high in Indonesia [6,9]. Indonesian Basic Health Survey (Riskesdas) stated that the prevalence of stunting ~~children~~ was almost 31% in 2018 [10]. Compared with the Association of Southeast Asian Nations (ASEAN) countries, the prevalence of stunting in Indonesia is much higher [9]. Overweight prevalence among subjects in Indonesia (4.4%) was the lowest compared to Malaysia (9.8%) and Thailand (7.5%). The same situation was also found in obesity, the prevalence in Indonesia (3.5%) was also the lowest compared to Malaysia (10.5%) and Thailand (8.8%) [7].

Many factors are known to be involved in the etiology of micronutrient deficiency and stunting. Previous studies in Korea and China showed that low socioeconomic status (SES) was linked to micronutrient deficiency, including anemia, iron deficiency anemia (IDA), and vitamin D deficiency [11,12]. Moreover, some studies in Sri Lanka and Bangladesh also found that low SES, overcrowding, and educated parents were associated with undernutrition among children [13-15]. In order to better address malnutrition in Indonesia, including micronutrient deficiencies and stunting, detailed information of the basic determinant~~ining~~ factors is needed to design a more effective intervention/approach. Accordingly, there is a need for an in-depth understanding between micronutrient status and anthropometric indicators with SES in Indonesia. Therefore, the objective of this study was to analyze the associations of micronutrient deficiencies (anemia, iron, vitamin A, and vitamin D) and stunting with socioeconomic status (SES) among Indonesian children aged 6-59 months.

2. Materials and Methods

Subjects and study design

The South East Asian Nutrition Survey (SEANUTS) was a multicenter study in nutrition funded by FrieslandCampina, The Netherlands. The SEANUTS was done in Indonesia, Malaysia, Thailand, and Vietnam in 2011. The SEANUTS in Indonesia utilized a cross-sectional study in 48 ~~out~~ of 440 cities/districts in 2011 [7,9]. A multi stage cluster sampling, ~~and~~ stratified for area of residence (urban/rural), sex, and age was~~ere~~ performed [7,9]. Details of the sampling procedure are described elsewhere [16]. A total of 1008 children aged 6-59 months lived in rural (57.64%) and urban (42.36%) areas were included in the study. The participants were representatives of the target population. In this study, blood samples for hemoglobin (Hb), serum ferritin, serum retinol, and serum 25-hydroxy vitamin D (25OHD) were taken in sub-samples after being examined by medical doctors of 1008, 475, 489, and 103 subjects, respectively. Sub-samples were taken based on district in which each district consisted of two villages. From these villages, one was randomly selected for blood analysis. All sample aged 6 to 23 months and 24 to 59 months who lived in the area were taken their blood after examined by local doctor for eligibility. Sub-samples were used due to budget limitation, and this sub-samples were chosen proportionately to represent age groups. Moreover, anthropometric measurements, including length and height, were taken for 983 children because some of them refused to be measured [7].

The study followed the guidelines of the Helsinki Declaration for human research. The design and methodologies were approved by the Committee of Health Research Ethics, the National Institute of Health Research and Development, the Ministry of Health of the Republic of Indonesia, number LB.03.02/KE/6430/2010. and the Ministry of Home Affairs, number 440.02/1751.D.I. The study was registered in the Netherlands Trial Registry (NTR 2462). Explanation of the study and the procedures applied as well as the possible side effects and its management was~~ere~~ given to the parents before written informed consent was obtained.

Anthropometric data

The length was measured supine using a flat wooden measuring board in children below two years of age . Height was measured using a wall-mounted stadiometer accurate to 0.1 cm in children aged two years old and older. All the measurements were done in duplicate with an accuracy of 0.1 cm. The average value was used in the calculations [9]. Height for age Z-scores (HAZ~~ score~~) were~~as~~ calculated using the WHO Anthro S~~s~~oftware version 1.0.3 (https://www.who.int/tools/child-growth-standards/software) [17]. We used the WHO Child Growth Standards 2006~~5~~ [18] to define severe stunting (~~as having a~~ HAZ ~~score of~~ < -3) and stunting (~~as a~~ HAZ ~~score of~~ < -2).

Biochemical indicators

Blood samples for Hb measurements were taken through the capillary blood ~~finger prick~~ procedure in children younger than 2-years-old and from venipuncture in older children. Five milliliters of blood was taken from venous, then 2 ml of blood was inserted into an EDTA-coated tube, and the rest went into a tube without EDTA. EDTA blood was for Hb. Plain blood was centrifuged to take serum. Serum is for ferritin, vitamin A, and vitamin D analysis. Hemoglobin concentration was measured with the HemoCue Hb 201 (HemoCue Diagnostics B.V. in children < 2 years) and Spectrophotometry, ADVIA 2120; Siemens for older children. Anemia was defined as Hb concentrations of <110 g/l for children aged between 6-59 months. Serum ferritin was measured with Immunochemiluminescence ECLIA, Roche Cobas e 601; Roche Diagnostics. Iron deficiency was defined ~~considered~~ as ~~having~~ serum ferritin concentrations of <12 µg/l~~mg/l~~ for children under aged 6-59 months. –Serum retinol was measured with an HPLC-UV detector, Agilent, 1200; Agilent Technologies (all-trans-retinol) and Serum 25(OH)D was measured with ELISA, IDS 25-Hydroxy Vitamin D; Immunodiagnostic Systems (D3 and D2 metabolites)~~ Capillary~~. Children with serum retinol concentrations of <0.70 mmol/l and circulating 25 hydroxyvitamin D < 50 nmol/l were considered vitamin A or vitamin D deficiency, respectively [7,19].

Socioeconomic status

Structured questionnaires were employed to obtain information regarding income, education, housing type, flooring, ventilations, type of walls, ownership of valuable goods, and electronic appliances as well as type of household sanitation facilities. Socioeconomic status was calculated and categorized into 5 groups or quintiles, namely: lowest, low, middle, upper middle, and upper. We used national guidelines from Central Bureau of Statistics (Indonesia) to categorized the SES [20]. The components of the SES included income, education, house (type, status, and valuable goods), and electricity [20]. Details for the data collection methodology and wealth classification were published earlier [16,21].

Data analysis

Data were analyzed using SPSS version 24 (IBM Corp., Armonk, NY, USA) [7]. Weight factors were based on the 2010 Census data on the number of children in specific age groups [7]. Chi-square test was used to analyze the differences between characteristic variables across the groups of SES. While, differences between micronutrient parameters and anthropometric indicator with the groups of SES were tested using One way ANOVA with the Duncan post-hoc test after adjusted for age, area resident (rural and urban), and sex. Values are presented as mean and standard deviation for continuous variables or n (%) for categorical variables with $p < 0.05$ as significant.

3. Results

Overall, the ~~total~~ mea~~n of~~ age was 31.7 ± 16.1 monts~~h old~~. The characteristics of the children in the 5 SES groups are presented in Table 1. Most of the children with lowest SES lived in rural area (85~~42~~.4~~0~~%). The highest prevalence of anemia and iron deficiency ~~serum ferritin deficiency~~ were found in the lowest SES group with 45~~32~~.6% and 1~~3~~6.4~~1~~%, respectively. The highest prevalence of serum retinol deficiency was found in the upper middle lowest SES_ and the low SES group s with 533.53%, but it does not increase gradually as SES decreases. and 33.3%, respectively. While, surprisingly, the highest prevalence of vitamin D deficiency was found in the middle SES group (6031.98%). Moreover, the highest prevalence of stunting (HAZ < -2)ed and severe stunting (HAZ <-3)ed were found in the lowest SES group with 2936.30% and 5447.54%, respectively.

Table 1. Characteristics of children in the 5 socioeconomic groups[1]

Variables	SES					P-Value
	Lowest	Low	Middle	Upper Middle	Upper	
Age (years), n=1008	31.5 ± 15.6	33.1 ± 16.5	31.5 ± 16.1	31.9 ± 16.1	32.4 ± 16.5	0.976
Sex, n=1008						
Boys	144 (50.3)144 (28.0)	98 (49.7)98 (19.1)	107 (53.5)107 (20,8)	89 (55.6)89 (17.3)	76 (46.3)76 (14.8)	0.483
Girls	142 (49.7)142 (28.8)	99 (50.3)99 (20.0)	93 (46.5)93 (18.8)	71 (44.4)71 (14.4)	89 (53.7)89 (18)	
Area of residence, n=1008						
Urban	42 (14.6)42 (9.8)	84 (42.4)84 (19.7)	89 (44.5)89 (20.8)	90 (56.3)90 (21.1)	122 (74.4)122 (28.6)	≤0.0010
Rural	244 (85.4)244 (42.0)	114 (57.6)114 (19.6)	111 (55.5)111 (19.1)	70 (43.8)70 (12.1)	42 (25.6)42 (7.2)	
Hemoglobin, n=1008						
Normal	156 (54.4)156 (25.7)	108 (54.8)108 (17.8)	115 (57.5)115 (19.0)	104 (65.0)104 (17.2%)	123 (75.0)123 (20.3%)	≤0.0010
Anemia	131 (45.6)131 (32.6)	89 (45.2)89 (22.2)	85 (42.5)85 (21.1)	56 (35.0)56 (13.9)	41 (25.0)41 (10.2)	
Serum Ferritin, n=475						
Normal	112 (83.6)112 (27.1)	78 (83.9)78 (18.8)	82 (85.4)82 (19.8)	67 (94.4)67 (16.2)	75 (92.6)75 (18.1)	0.087
Deficiency	22 (16.4)22 (36,0)	15 (16.1)15 (24,6)	14 (14.6)14 (23,0)	4 (5.6)4 (6,6)	6 (7.4)6 (9,8)	
Serum retinol, n=489						
Normal	136 (96.5)136 (28.6)	89 (94.7)89 (18.8)	97 (99.0)97 (20.5)	69 (94.5)69 (14.6)	83 (100)83 (17.5)	0.128
Deficiency	5 (3.5)5 (33.3)	5 (5.3)5 (33.3)	1 (1.0)1 (6.7)	4 (5.5)4 (26.7)	0 (0)0 (0)	
Serum 25(OH)D, n=103						
Normal	22 (71.0)22 (37.3)	11 (57.9)12 (20.3)	9 (39.1)8 (13.5)	11 (64.7)11 (18.7)	6 (46.2) 6 (10.2)	0.164
Deficiency	9 (29.0) 31(100)9 (20.5)	8 (42.1) 19(100)8 (18.2)	14 (60.9) 23 (100)14 (31.8)	6 (35.3) 17 (100)6 (13.6)	7 (53.8) 13 (100)7 (15.9)	
HAZ, n=983						≤0.0010

Normal height	151 (22.8)~~151 (22.8)~~	124 (63.6)~~124 (18.7)~~	132 (68.4)~~132 (19.9)~~	116 (74.9)~~116 (17.5)~~	140 (85.9)~~140 (21.1)~~
Stunted	81 (29.3)~~81 (36.0)~~	50 (25.6)~~50 (22.2)~~	48 (24.9)~~48 (21.4)~~	32 (20.6)~~32 (14.2)~~	14 (8.6)~~14 (6.2)~~
Severe stunted	45 (54.5) ~~45 (47.3)~~	21 (10.8)~~21 (22.1)~~	13 (6.7)~~13 (13.7)~~	7 (7.5)~~7 (7.4)~~	9 (5.5)~~9 (9.5)~~

[1]Values are presented as mean ± standard deviation for continuous variables and n (%) for categorical variables.

The differences between micronutrient parameters and anthropometric indicator across the groups of SES are shown in Table 2. Children from the lowest SES group had significantly lower ~~means of~~ Hb (112.0 ± 13.2 g/dl), ferritin (30.9 ± 19.9 μg/l), retinol (1.28 ± 0.41 μml/l), and HAZ (-1.77 ± 1.30). Differences in micronutrient status across HAZ indicator are shown in Table 3. Severely stunted children had significantly lower ~~mean of~~ Hb concentration (110.8 ± 14.0 g/l) compared to stunted (114.0 ± 11.4 g/l) and normal height children (114.6 ± 13.2 g/l). In addition, children with normal height had significantly higher retinol concentration (1.54 ± 0.55 μml/l) compared to severely stunted children (1.32 ± 0.39 μml/l). However, ferritin and 25(OH)D concentrations were not significant difference between normal height and stunted or severe stunted.

Table 2. Micronutrient parameters and HAZ ~~anthropometric indicator~~ across the 5 socioeconomic groups[1]

Variables	SES					P-Value
	Lowest	Low	Middle	Upper Middle	Upper	
Hemoglobin, g/l	112.0 ± 13.2[a]	113.3 ± 13.0[a]	113.3 ± 12.7[a]	115.7 ± 12.7[b]	118.7 ± 11.9[b]	0.002
Serum Ferritin, μg/l	30.9 ± 19.9[a]	33.4 ± 21.2[a]	34.4 ± 20.7[a]	43.6 ± 24.4[b]	44.1 ± 10.9[bc]	≤0.0010
Serum retinol, μmol/l	1.28 ± 0.41[a]	1.35 ± 0.44[a]	1.56 ± 0.45[b]	1.67 ± 0.47[bc]	1.70 ± 0.74[bc]	≤0.0010
Serum 25(OH)D, nmol/l	56.1 ± 10.7	52.0 ± 11.7	52.2 ± 16.4	55.3 ± 11.1	52.5 ± 20.8	0.721
HAZ	-1.77 ± 1.30[a]	-1.65 ± 1.13[a]	-1.47 ± 1.12[ab]	-1.03 ± 1.39[c]	-0.77 ± 1.46[c]	≤0.0010

HAZ: height for age Z-score, SES: socioeconomic status. [1]Values are presented as mean ± standard deviation for continuous variables and n (%) for categorical variables. Values corrected for sex, age, and area of residence. [a-c] Different superscripts indicate significant differences across SES groups.

Table 3 Micronutrient status across linear growth categories~~HAZ indicator~~[1]

Variables	HAZ			P-Value
	Normal height	Stunted	Severely stunted	
Hemoglobin, g/l	114.6 ± 13.2[a]	114.0 ± 11.4[a]	110.8 ± 14.0[b]	≤0.0010
Serum Ferritin, μg/l	37.7 ± 24.2	33.6 ± 22.5	34.3 ± 19.6	0.598
Serum retinol, μmol/l	1.54 ± 0.55[a]	1.37 ± 0.47[ab]	1.32 ± 0.39[b]	0.012
Serum 25(OH)D, nmol/l	54.1 ± 14.7	51.9 ± 13.4	56.3 ± 9.8	0.722

HAZ: height for age Z-score. [1]Values are presented as mean ± standard deviation for continuous variables and n (%) for categorical variables. Values corrected for sex, age, and area of residence. [a-c] Different superscripts indicate significant differences across SES groups.

4. Discussion

The study provided insight into the relationship between micronutrient deficiencies and stunting regarding SES. The prevalence of anemia, iron deficiency, stunted and severe stunted proved highest among the lowest socioeconomic groups 45.6%, 16.4%, 29.3%, 54.5%, respectively. However, the trend was not found in vitamin A deficiency prevalence. This may be due to the different sample size, particularly the smaller sub-samples for some micronutrient analyses. ~~Children from lower SES had higher risks of anemia, iron deficiency, vitamin A deficiency, and stunting.~~ The results were similar to previous studies in middle and lower-income countries where anemia is more prevalent in children from lower SES groups [22]. ~~Moreover, children below school age had a higher risk compared to school-aged children [22]. Another study~~The study in Lancet by Balarajan et al showed that SES, especially household wealth, was significantly associated with ~~a causal factor for~~ anemia [23]. A previous study showed that children living in the lowest wealth quintile had significantly lower ~~means~~ of hemoglobin, ferritin, retinol, and HAZ than those in the highest wealth quintile [9, 23]. They found that family income is considered an important determinant of micronutrient status [23] and anthropometric indicators [9]. When household income increased, the prevalence of anemia, IDA, and stunting decreased, and serum Hb and ferritin levels increased [11].

Iron, in the form of ferritin, is stored in the body. The body will take from these ferritin stores if the dietary iron needs are not reached. Chronic dietary iron insufficiency will deplete iron stores (mostly in the liver) as reflected by lower circulating ferritin. ~~If it is not treated, ferritin will be depleted, and the blood plasma levels of iron will decrease.~~ This condition will cause iron-deficiency anemia. It can be prevented~~treated~~ and treated by consuming food high in iron, especially animal-based food, because it contains iron in heme form, which absorbed better than the non-heme iron form found in plant-derived foods [19,24]. However, animal source foods are often more expensive than plant-derived foods [24]. Therefore, the low consumption of animal-based food as well as consumption of plant-based foods that also contain iron absorption inhibitors (e.g., phytate, oxalate, and polyphenols) may cause iron deficiency and anemia in the Low SES group because they are often inaccessible [24,25]. Previous study also found that high vitamin A deficiency at low SES, even though vitamin A also plays a role in the process of hematopoises and mobilization of iron in the body, so that vitamin A deficiency will aggravate iron status in the body [24]~~Moreover, sources of vitamin A from foods are mostly found in animal-based food compared to plant-derived food that may affect the consumption. Vitamin A also plays an important role in hematopoiesis, and it is involved in the mobilization and utilization of iron stored [24].~~

These statements are also supported by t~~T~~he results of SEANUTS study in Indonesia regarding food consumption also showed that animal protein and milk intake are positively correlated to SES [26]. The study also highlighted that only around 30% of the household from the lowest SES had access to adequate sanitation facilities [26]. Moreover, lower SES is often related to poor living conditions such as inadequate access to clean water and sanitation facilities, thus increasing the risk of infection and then increased risk of developing anemia [27].

Interestingly, children in the lowest SES proved had ~~were at~~ the highest risk of~~for~~ iron deficiency. The successful countrywide vitamin A supplementation program might offer an insight into this result. Serum retinol levels in children under 5-years-old were higher on those who had received supplementation regularly than those who did not [27,28]. ~~Children living in rural areas, as the majority of the lowest SES children in this study, generally had higher adherence to the vitamin A supplementation program compared to children living in urban areas [26,28,29].~~

However, it is also important to know that the lower education level ~~ignorance~~ among caregivers was the reason for missing doses in vitamin A supplementation. Hence, it might be noted for the future supplementation program [27,29]. It is also important to develop awareness about the health importance of vitamin A supplementation. Besides, the current cooking oil fortification program with vitamin A should offer an alternative solution. Fortification of oils with vitamin A is one of the low-cost and effective ways to improve vitamin A intake, reducing the risk of vitamin A deficiency in developing countries [30].

From this study, children from the middle SES families showed the lowest mean 25(OH)D concentration. However, no significant difference between vitamin D and SES groups was found. This may be due to the small sample size, particularly the smaller subsamples for serum vitamin D analysis. Vitamin D is mostly made in the skin supported by sunlight exposure. Moreover, pigmentation of the skin is also responsible for vitamin D status [7,31,32]. Future studies regarding vitamin D should include coverage across the socioeconomic spectrum and couple a nutritional approach with sunlight exposures.

Regarding anthropometric indicators, a higher HAZ was correlated with a higher SAS. Moreover, this study revealed that stunted children had a higher risk of anemia than children with normal height, the same result was also found in other studies [33,34]. Ayoya et al. found that child's age, HAZ score < −2. and mother's anemia predicted the occurrence of childhood anemia in 6–59-months-old children in Haiti [35]. We also found significant differences in the risk of vitamin A deficiency between different anthropometric indicators. This findings were in line with other study that stunting was associated with vitamin A deficiency [36].

This study has a strength. To the best of our knowledge, this is the first study to discuss the relationship between micronutrient deficiencies (anemia, iron, vitamin A and vitamin D) and nutritional status defined by anthropometric measurement with SES in Indonesia, especially children under five years old. Thus, this study will provide insights for better targeting when it comes to nutrition intervention. However, as a consequence of using subsamples from a larger study, it has to be kept in mind that micronutrient status, in this study, were determined from a relatively small set of samples. Hence, the results should be interpreted carefully. We did not measured zinc in this study. Zinc is associated with chronic malnutrition and linear growth [37]. The current study is a cross-sectional study; consequently, it is unable to explain causal relationships. Another note is that the study did not include analysis of data on food intake and outdoor physical activity; thus, it is unable to explain the role of both behaviors concerning micronutrient status.

5. Conclusions

This study shows that micronutrient status and anthropometric indicators have an association with SES among Indonesian children aged 6-59 months. Anemia, iron deficiency, ~~vitamin A deficiency,~~ and stunting were associated with low SES. However, the trend was not found in vitamin A deficiency. While vitamin D status shows no association with SES. In addition, severely stunting children aged 6-59 months have significantly associated with anemia. The study suggests doing more comprehensive nutrition programs to improve the micronutrient status of children based on SES. Additional studies are needed to explore the association of micronutrient status and stunting with SES using a longitudinal study.

Supplementary Materials: The following are available online at www.mdpi.com/xxx/s1, Figure S1: title, Table S1: title, Video S1: title.

Author Contributions: Conceptualization, F.E., A.Y., M.Y.E.S., and A.S.; methodology, F.E.; formal analysis, F.E.; investigation, F.E., and A.S.; writing—original draft preparation, F.E.; writing—review and editing, F.E., and A.S.; All authors have read and agreed to the published version of the manuscript.

Funding: The study was sponsored by FrieslandCampina, the Netherlands.

Institutional Review Board Statement: This study was conducted according to the guidelines of the Declaration of Helsinki, and all procedures involving research study participants were approved by the Committee of Health Research Ethics, the National Institute of Health Research and Development, the Ministry of Health, Republic of Indonesia, number LB.03.02/KE/6430/2010, and was also registered in the Netherlands Trial Registry number NTR 2462.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Acknowledgments: We thank to FrieslandCampina for providing funding for the present study; FrieslandCampina representatives, particularly Victoria Valentina, Anne Schaafsma, Panam Parikh, and Marjolijn Bragt-van Wijngaarden are greatly appreciated for their valuable guidance throughout the study. The authors are also indebted to the government and health representatives at all levels especially the National Institute of Health Research and Development for their contribution to the study, as well as to all the children and their families for their willingness to participate in the present study.

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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Received: 2 April 2021
E-mails: fitrahernawati@yahoo.com, syauqy@fk.undip.ac.id, ayaarifin@gmail.com, moesijanti@yahoo.com
Submitted to section: Nutrition and Public Health,
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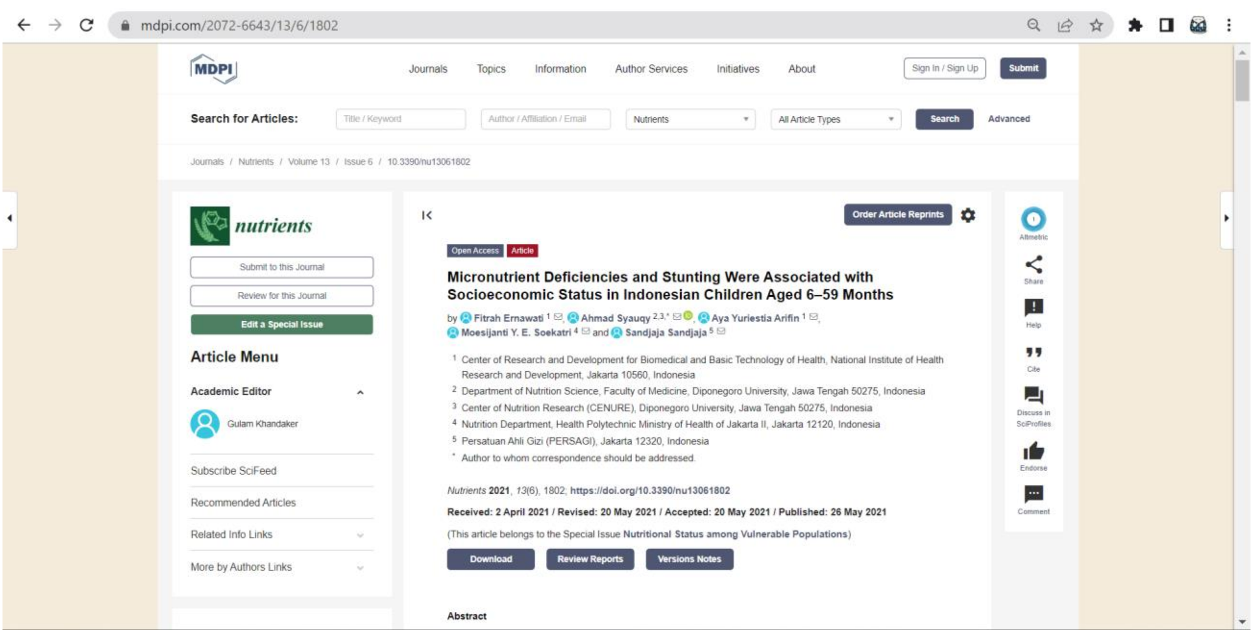
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Journals / Nutrients / Volume 13 / Issue 6 / 10.3390/nu13061802

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Micronutrient Deficiencies and Stunting Were Associated with Socioeconomic Status in Indonesian Children Aged 6–59 Months

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Nutrients **2021**, *13*(6), 1802; https://doi.org/10.3390/nu13061802

Received: 2 April 2021 / Revised: 20 May 2021 / Accepted: 20 May 2021 / Published: 26 May 2021

(This article belongs to the Special Issue Nutritional Status among Vulnerable Populations)

Abstract

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Micronutrient Deficiencies and Stunting Were Associated with Socioeconomic Status in Indonesian Children Aged 6–59 Months

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Abstract: Micronutrient deficiencies and stunting are known as a significant problem in most developing countries, including Indonesia. The objective of this study was to analyze the association between micronutrient deficiencies and stunting with socioeconomic status (SES) among Indonesian children aged 6–59 months. This cross-sectional study was part of the South East Asian Nutrition Surveys (SEANUTS). A total of 1008 Indonesian children were included in the study. Anemia, iron deficiency, vitamin A deficiency, vitamin D deficiency, and stunting were identified in this study. Structured questionnaires were used to measure SES. Differences between micronutrient parameters and anthropometric indicators with the SES groups were tested using one-way ANOVA with post-hoc test after adjusted for age, area resident (rural and urban), and sex. The highest prevalence of anemia, stunting, and severe stunting were found to be most significant in the lowest SES group at 45.6%, 29.3%, and 54.5%, respectively. Children from the lowest SES group had significantly lower means of Hb, ferritin, retinol, and HAZ. Severely stunted children had a significantly lower mean of Hb concentration compared to stunted and normal height children. Micronutrient deficiencies, except vitamin D, and stunting, were associated with low SES among Indonesian children aged 6–59 months.

Keywords: micronutrient deficiency; stunting; socioeconomic status; malnutrition; Indonesian children

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Citation: Ernawati, F.; Syauqy, A.; Arifin, A.Y.; Soekatri, M.Y.E.; Sandjaja, S. Micronutrient Deficiencies and Stunting Were Associated with Socioeconomic Status in Indonesian Children Aged 6–59 Months. *Nutrients* **2021**, *13*, 1802. https://doi.org/10.3390/nu13061802

Academic Editor: Gulam Khandaker

Received: 2 April 2021
Accepted: 20 May 2021
Published: 26 May 2021

1. Introduction

Sustainable Development Goal-2 (SDG-2) aims to eradicate the global burden of malnutrition [1]. Malnutrition is one of the primary causes of mortality in children less than five years of age [2]. Decreasing malnutrition is a challenge for many countries, mainly developing countries [3]. In Indonesia, malnutrition remains a significant problem among children under five years old, especially micronutrient deficiencies and stunting [4–6]. Both micronutrient deficiencies and stunting can influence physical and cognitive development in children and increase the risk of infection [7].

A previous study in Indonesia indicated a high prevalence of anemia and vitamin D deficiency [7]. Almost 60% of Indonesian children under two years old were reported to be anemic [7,8], whereas the national prevalence of anemia among children two to five years of age was 16.6%. This figure was higher than Malaysia (6.6%) and Thailand (13.7%). Additionally, the prevalence of iron deficiency levels and vitamin D deficiency was 15% and 40%, respectively [7]. The vitamin D deficiency was quite high in Indonesia, but this prevalence lies between Malaysia (47.5%) and Thailand (36.7%). However, the prevalence of vitamin A deficiency in Indonesia (0.9%) was the lowest compared to Malaysia (4.4%) and Thailand (2.1%) [7]. On the other hand, the prevalence of stunting is also high in Indonesia [6,9]. Indonesian Basic Health Survey (Riskesdas) stated that the prevalence of stunting was almost 31% in 2018 [10]. Compared with the Association of Southeast Asian Nations (ASEAN) countries, the prevalence of stunting in Indonesia is much higher [9]. Overweight prevalence among subjects in Indonesia (4.4%) was the lowest compared to Malaysia (9.8%) and Thailand (7.5%). The same situation was also found in obesity, and the prevalence in Indonesia (3.5%) was also the lowest compared to Malaysia (10.5%) and Thailand (8.8%) [7].

Many factors are known to be involved in the etiology of micronutrient deficiency and stunting. Previous studies in Korea and China showed that low socioeconomic status (SES) was linked to micronutrient deficiency, including anemia, iron deficiency anemia (IDA), and vitamin D deficiency [11,12]. Moreover, some studies in Sri Lanka and Bangladesh found that low SES, overcrowding, and educated parents were associated with undernutrition among children [13–15]. In order to better address malnutrition in Indonesia, including micronutrient deficiencies and stunting, detailed information of the basic determinant factors is needed to design a more effective intervention/approach. Accordingly, there is a need for an in-depth understanding between micronutrient status and anthropometric indicators with SES in Indonesia. Therefore, the objective of this study was to analyze the association between micronutrient deficiencies (anemia, iron, vitamin A, and vitamin D) and stunting with socioeconomic status (SES) among Indonesian children aged 6–59 months.

2. Materials and Methods

2.1. Subjects and Study Design

The South East Asian Nutrition Survey (SEANUTS) was a multicenter study in nutrition funded by FrieslandCampina, The Netherlands. The SEANUTS was conducted in Indonesia, Malaysia, Thailand, and Vietnam in 2011. The SEANUTS in Indonesia utilized a cross-sectional study in 48 of 440 cities/districts in 2011 [7,9]. A multi- stage cluster sampling, stratified for area of residence (urban/rural), sex, and age was performed [7,9]. Details of the sampling procedure are described elsewhere [16]. A total of 1008 children aged 6–59 months living in rural (57.64%) and urban (42.36%) areas were included in the study. The participants were representatives of the target population. Given resource constraints in this study, blood samples for hemoglobin (Hb), serum ferritin, serum retinol, and serum 25-hydroxy vitamin D (25OHD) were taken in sub-samples of 1008, 475, 489, and 103 subjects, respectively, after being examined by medical doctors. Sub-samples were taken based on district in which each district consisted of two villages. From these villages, one was randomly selected for blood analysis. All samples aged 6 to 23 months and 24 to 59 months who lived in the area had their blood taken after examination by a local doctor to determine eligibility. Sub-samples were used due to budget limitation, and these sub-samples were chosen proportionately to represent age groups. Moreover, anthropometric measurements, including length and height, were taken for 983 children because some of them refused to be measured [7].

The study followed the guidelines of the Helsinki Declaration for human research. The design and methodologies were approved by the Committee of Health Research Ethics, the National Institute of Health Research and Development, the Ministry of Health of the Republic of Indonesia, number LB.03.02/KE/6430/2010, and the Ministry of Home Affairs, number 440.02/1751.D.I. The study was registered in the Netherlands Trial Registry (NTR 2462). Explanation of the study and the procedures applied, as well as the possible side effects and its management, was given to the parents before written informed consent was obtained.

2.2. Anthropometric Data

The length was measured supine using a flat wooden measuring board in children below two years of age. Height was measured using a wall-mounted stadiometer accurate to 0.1 cm in children aged two years old and older. All the measurements were done in duplicate with an accuracy of 0.1 cm. The average value was used in the calculations [9]. Height for age Z-scores (HAZ) was calculated using the WHO Anthro Software version 1.0.3 (https://www.who.int/tools/child-growth-standards/software, accessed on 25 June 2012) [17]. We used the WHO Child Growth Standards 2006 [18] to define severe stunting (HAZ < -3) and stunting (HAZ < -2).

2.3. Biochemical Indicators

Blood samples for Hb measurements were taken through the capillary blood procedure in children younger than two years old and from venipuncture in older children. Five milliliters of blood was taken from venous, then two milliliters of blood was inserted into an EDTA-coated tube, and the rest went into a tube without EDTA. EDTA blood was used for Hb, plain blood was centrifuged to take serum, and serum was used for ferritin, vitamin A, and vitamin D analysis. All the tube samples, especially serum retinol, were covered with aluminium foil, to protect from UVL. Hemoglobin concentration was measured with the HemoCue Hb 201 (HemoCue Diagnostics B.V. in all children). Anemia was defined as Hb concentrations of <110 g/L for children aged between 6–59 months. Serum ferritin was measured with Immunochemiluminescence ECLIA, Roche Cobas e 601; Roche Diagnostics. Iron deficiency was defined as serum ferritin concentrations of <12 μg/L for children under aged 6–59 months. Serum retinol was measured with an HPLC-UV detector, Agilent, 1200; Agilent Technologies (Santa Clara, CA, USA) (all-trans-retinol), and Serum 25(OH)D was measured with ELISA, IDS 25-Hydroxy Vitamin D; Immunodiagnostic Systems (D3 and D2 metabolites). Children with serum retinol concentrations of <0.70 μmol/L and circulating 25 hydroxyvitamin D <50 nmol/L were considered vitamin A or vitamin D deficient, respectively [7,19].

2.4. Socioeconomic Status

Structured questionnaires were employed to obtain information regarding income, education, housing type, flooring, ventilations, type of walls, ownership of valuable goods, and electronic appliances as well as type of household sanitation facilities. Socioeconomic status was calculated and categorized into five groups or quintiles, namely: lowest, low, middle, upper middle, and upper. We used national guidelines from the Central Bureau of Statistics (Indonesia) to categorize the SES [20]. The components of the SES included income, education, house (type, status, and valuable goods), and electricity [20]. Details for the data collection methodology and wealth classification were published earlier [16,21].

2.5. Data Analysis

Data were analyzed using SPSS version 24 (IBM Corp., Armonk, NY, USA) [7]. Weight factors were based on the 2010 Census data on the number of children in specific age groups [7]. Chi-square test was used to analyze the differences between characteristic variables across the groups of SES. Differences between micronutrient parameters and anthropometric indicators with the groups of SES were tested using one-way ANOVA with the Duncan post-hoc test after adjusting for age, area resident (rural and urban), and sex. Values are presented as mean and standard deviation for continuous variables or n (%) for categorical variables with $p < 0.05$ as significant.

3. Results

Overall, the mean age was 31.7 ± 16.1 months. The characteristics of the children in the five SES groups are presented in Table 1. Most of the children with lowest SES lived in rural areas (85.4%). The highest prevalence of anemia and iron deficiency was found in the lowest SES group with 45.6% and 16.4%, respectively. The highest prevalence of serum retinol deficiency was found in the upper middle SES group with 5.5%, but it does not increase gradually as SES decreases. Surprisingly, the highest prevalence of vitamin D deficiency was found in the middle SES group (60.9%). Moreover, the highest prevalence of stunting (HAZ < −2) and severe stunting (HAZ < −3) was found in the lowest SES group, with 29.3% and 54.5%, respectively.

Table 1. Characteristics of children in the five socioeconomic groups [1].

Variables	SES					*p*-Value
	Lowest	Low	Middle	Upper Middle	Upper	
Age (years), n = 1008	31.5 ± 15.6	33.1 ± 16.5	31.5 ± 16.1	31.9 ± 16.1	32.4 ± 16.5	0.976
Sex, n = 1008						
Boys	144 (50.3)	98 (49.7)	107 (53.5)	89 (55.6)	76 (46.3)	0.483
Girls	142 (49.7)	99 (50.3)	93 (46.5)	71 (44.4)	89 (53.7)	
Area of residence, n = 1008						
Urban	42 (14.6)	84 (42.4)	89 (44.5)	90 (56.3)	122 (74.4)	<0.001
Rural	244 (85.4)	114 (57.6)	111 (55.5)	70 (43.8)	42 (25.6)	
Hemoglobin, n = 1008						
Normal	156 (54.4)	108 (54.8)	115 (57.5)	104 (65.0)	123 (75.0)	<0.001
Anemia	131 (45.6)	89 (45.2)	85 (42.5)	56 (35.0)	41 (25.0)	
Serum Ferritin, n = 475						
Normal	112 (83.6)	78 (83.9)	82 (85.4)	67 (94.4)	75 (92.6)	0.087
Deficiency	22 (16.4)	15 (16.1)	14 (14.6)	4 (5.6)	6 (7.4)	
Serum retinol, n = 489						
Normal	136 (96.5)	89 (94.7)	97 (99.0)	69 (94.5)	83 (100)	0.128
Deficiency	5 (3.5)	5 (5.3)	1 (1.0)	4 (5.5)	0 (0)	
Serum 25(OH)D, n = 103						
Normal	22 (71.0)	11 (57.9)	9 (39.1)	11 (64.7)	6 (46.2)	0.164
Deficiency	9 (29.0)	8 (42.1)	14 (60.9)	6 (35.3)	7 (53.8)	
	31(100)	19(100)	23 (100)	17 (100)	13 (100)	
HAZ, n = 983						
Normal height	151 (22.8)	124 (63.6)	132 (68.4)	116 (74.9)	140 (85.9)	<0.001
Stunted	81 (29.3)	50 (25.6)	48 (24.9)	32 (20.6)	14 (8.6)	
Severe stunted	45 (54.5)	21 (10.8)	13 (6.7)	7 (7.5)	9 (5.5)	

[1] Values are presented as mean ± standard deviation for continuous variables and n (%) for categorical variables.

The differences between micronutrient parameters and anthropometric indicators across the groups of SES are shown in Table 2. Children from the lowest SES group had significantly lower Hb (112.0 ± 13.2 g/dL), ferritin (30.9 ± 19.9 µg/L), retinol (1.28 ± 0.41 µmol/L), and HAZ (−1.77 ± 1.30). Differences in micronutrient status across HAZ indicator are shown in Table 3. Severely stunted children had significantly lower Hb concentration (110.8 ± 14.0 g/L) compared to stunted (114.0 ± 11.4 g/L) and normal height children (114.6 ± 13.2 g/L). In addition, children with normal height had significantly higher retinol concentration (1.54 ± 0.55 µmol/L) compared to severely stunted children (1.32 ± 0.39 µmol/L). However, ferritin and 25(OH)D concentrations were not significant in difference between normal height, stunted or severely stunted.

Table 2. Micronutrient parameters and HAZ across the five socioeconomic groups [1].

Variables	SES					*p*-Value
	Lowest	Low	Middle	Upper Middle	Upper	
Hemoglobin, g/L	112.0 ± 13.2 [a]	113.3 ± 13.0 [a]	113.3 ± 12.7 [a]	115.7 ± 12.7 [b]	118.7 ± 11.9 [b]	0.002
Serum Ferritin, μg/L	30.9 ± 19.9 [a]	33.4 ± 21.2 [a]	34.4 ± 20.7 [a]	43.6 ± 24.4 [b]	44.1 ± 10.9 [b]	<0.001
Serum retinol, μmol/L	1.28 ± 0.41 [a]	1.35 ± 0.44 [a]	1.56 ± 0.45 [b]	1.67 ± 0.47 [b]	1.70 ± 0.74 [b]	<0.001
Serum 25(OH)D, nmol/L	56.1 ± 10.7	52.0 ± 11.7	52.2 ± 16.4	55.3 ± 11.1	52.5 ± 20.8	0.721
HAZ	−1.77 ± 1.30 [a]	−1.65 ± 1.13 [a]	−1.47 ± 1.12 [ab]	−1.03 ± 1.39 [c]	−0.77 ± 1.46 [c]	<0.001

HAZ: height for age Z-score, SES: socioeconomic status. [1] Values are presented as mean ± standard deviation for continuous variables and *n* (%) for categorical variables. Values corrected for sex, age, and area of residence. [a–c] Different superscripts indicate significant differences across SES groups.

Table 3. Micronutrient status across linear growth categories [1].

Variables	HAZ			*p*-Value
	Normal Height	Stunted	Severely Stunted	
Hemoglobin, g/l	114.6 ± 13.2 [a]	114.0 ± 11.4 [a]	110.8 ± 14.0 [b]	<0.001
Serum Ferritin, μg/l	37.7 ± 24.2	33.6 ± 22.5	34.3 ± 19.6	0.598
Serum retinol, μmol/L	1.54 ± 0.55 [a]	1.37 ± 0.47 [a,b]	1.32 ± 0.39 [b]	0.012
Serum 25(OH)D, nmol/L	54.1 ± 14.7	51.9 ± 13.4	56.3 ± 9.8	0.722

HAZ: height for age Z-score. [1] Values are presented as mean ± standard deviation for continuous variables and n (%) for categorical variables. Values corrected for sex, age, and area of residence. [a–c] Different superscripts indicate significant differences across SES groups.

4. Discussion

This study provided insight into the relationship between micronutrient deficiencies and stunting regarding SES. The prevalence of anemia, iron deficiency, stunted, and severely stunted proved highest among the lowest socioeconomic groups 45.6%, 16.4%, 29.3%, 54.5%, respectively. However, the trend was not found in vitamin A deficiency prevalence. This may be due to the different sample sizes, particularly the smaller sub-samples for some micronutrient analyses. The results were similar to previous studies in middle and lower-income countries where anemia is more prevalent in children from lower SES groups [22]. A study in the Lancet by Balarajan et al. included nationally representative demographic and health surveys undertaken in 32 selected low-income and middle-income countries that conduct these surveys [23]. They showed that SES, especially household wealth, was significantly associated with anemia [23]. A previous study showed that children living in the lowest wealth quintile had significantly lower levels of hemoglobin [23], ferritin [24], retinol [25], and HAZ [9] than those in the highest wealth quintile [9,23]. They found that family income is considered an important determinant of micronutrient status [23] and anthropometric indicators [9]. When household income increased, the prevalence of anemia, IDA, and stunting decreased, and serum Hb and ferritin levels increased [11].

Iron, in the form of ferritin, is stored in the body. The body will take from these ferritin stores if the dietary iron needs are not reached. Chronic dietary iron insufficiency will deplete iron stores (mostly in the liver) as reflected by lower circulating ferritin. After iron depletion, hemoglobin synthesis is affected, lowering hemoglobin concentration progressively. This condition will cause iron-deficiency anemia. It can be prevented and treated by consuming foods high in iron, especially animal-based foods, because it contains iron in heme form, which is absorbed better than the non-heme iron form found in plant-derived foods [19,26]. However, animal-derived foods are often more expensive than plant-derived foods [26]. Therefore, the low consumption of animal-based foods as well as consumption of plant-based foods that also contain iron absorption inhibitors (e.g., phytate, oxalate, and polyphenols) may cause iron deficiency and anemia in the low SES group [26,27]. Previous studies have also found that high vitamin A deficiency within low

SES groups, even though vitamin A also plays a role in the process of hematopoises and mobilization of iron in the body; thus vitamin A deficiency will aggravate iron status in the body [24].

These statements are supported by the results of the SEANUTS study in Indonesia regarding food consumption showing that animal protein and milk intake are positively correlated to SES [28]. The study also highlighted that only around 30% of households from the lowest SES had access to adequate sanitation facilities [28]. Moreover, lower SES is often related to poor living conditions, such as inadequate access to clean water and sanitation facilities, thus increasing the risk of infection and then increasing risk of developing anemia [29]. Interestingly, in this study, children in the lowest SES group had the highest iron deficiency but not significant.

The successful countrywide vitamin A supplementation program might offer an insight into this result. Serum retinol levels in children under five years old were higher in those who had received supplementation regularly than those who did not [29,30]. However, it is important to note that the lower education level among caregivers was the reason for missing doses in vitamin A supplementation. Hence, it might be useful for the future supplementation program [29,31]. It is also important to develop awareness about the health importance of vitamin A supplementation. Besides, the current cooking oil fortification program with vitamin A should offer an alternative solution. Fortification of oils with vitamin A is one of the low-cost and effective ways to improve vitamin A intake, reducing the risk of vitamin A deficiency in developing countries [32].

From this study, children from the middle SES families showed the lowest mean 25(OH)D concentration. However, no significant difference between vitamin D and SES groups was found. This may be due to the small sample size, particularly the smaller sub-samples for serum vitamin D analysis. Vitamin D is mostly made in the skin supported by sunlight exposure. Moreover, pigmentation of the skin is also responsible for vitamin D status [7,33,34]. Future studies regarding vitamin D should include coverage across the socioeconomic spectrum and couple a nutritional approach with sunlight exposures.

Regarding anthropometric indicators, a higher HAZ was correlated with a higher SAS. Moreover, this study revealed that stunted children had a higher risk of anemia than children with normal height, the same result was also found in other studies [35,36]. Ayoya et al. found that child's age, HAZ score < -2 and mother's anemia predicted the occurrence of childhood anemia in 6–59-months-old children in Haiti [37]. We also found significant differences in the risk of vitamin A deficiency between different anthropometric indicators. These findings were in line with other studies showing stunting was associated with vitamin A deficiency [38].

This study has a strength. To the best of our knowledge, this is the first study to discuss the relationship between micronutrient deficiencies (anemia, iron, vitamin A, and vitamin D) and nutritional status defined by anthropometric measurement with SES in Indonesia, especially children under five years old. Thus, this study will provide insights for better targeting when it comes to nutrition intervention. However, as a consequence of using sub-samples from a larger study, it has to be kept in mind that micronutrient status, in this study, was determined from a relatively small set of samples. Hence, the results should be interpreted carefully. We did not measure zinc in this study. Zinc is associated with chronic malnutrition and linear growth [39]. The current study is a cross-sectional study; consequently, it is unable to explain causal relationships. Another note is that the study did not include analysis of data on food intake and outdoor physical activity; thus, it is unable to explain the role of both behaviors concerning micronutrient status.

5. Conclusions

This study shows that micronutrient status and anthropometric indicators have an association with SES among Indonesian children aged 6–59 months. Anemia, iron deficiency, and stunting were associated with low SES. However, the trend was not found in vitamin A deficiency. While vitamin D status shows no association with SES. In addition, severely stunted children aged 6–59 months are significantly associated with anemia. The study suggests doing more comprehensive nutrition programs to improve the micronutrient status of children based on SES. Additional studies are needed to explore the association of micronutrient status and stunting with SES using a longitudinal study.

Author Contributions: Conceptualization, F.E., A.S., A.Y.A., M.Y.E.S. and S.S.; methodology, F.E.; formal analysis, F.E.; investigation, F.E. and A.S.; writing—original draft preparation, F.E.; writing—review and editing, F.E. and A.S.; All authors have read and agreed to the published version of the manuscript.

Funding: The study was sponsored by FrieslandCampina, the Netherlands.

Institutional Review Board Statement: This study was conducted according to the guidelines of the Declaration of Helsinki, and all procedures involving research study participants were approved by the Committee of Health Research Ethics, the National Institute of Health Research and Development, the Ministry of Health, Republic of Indonesia, number LB.03.02/KE/6430/2010, and was also registered in the Netherlands Trial Registry number NTR 2462.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the first author. The data are not publicly available according to description of confidentiality and data sharing procedures described in the study's informed consent and assent documents.

Acknowledgments: We thank to FrieslandCampina for providing funding for the present study; FrieslandCampina representatives, particularly Victoria Valentina, Anne Schaafsma, Panam Parikh, and Marjolijn Bragt-van Wijngaarden are greatly appreciated for their valuable guidance throughout the study. The authors are also indebted to the government and health representatives at all levels especially the National Institute of Health Research and Development for their contribution to the study, as well as to all the children and their families for their willingness to participate in the present study.

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data, in the writing of the manuscript, or in the decision to publish the results.

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