Anemia Prevalence, Characteristics, and Hematological Profile among Stunted Children Under 2 Years Old in Bandung Regency, Indonesia

Grace Mediana Purnami[1,2] Kania Dyatika Praba[3] Iif Latifah Fauziah[3] Mia Milanti Dewi[4] Raden Tina Dewi Judistiani[5] Budi Setiabudiawan[4]

[1] Doctoral Programme, Faculty of Medicine, Universitas Padjadjaran, Bandung, Indonesia
[2] Bandung Regency Health Office, Soreang, Indonesia
[3] Bachelor of Medicine Programme, Faculty of Medicine, Universitas Padjadjaran, Sumedang, Indonesia
[4] Pediatric Health Department, Faculty of Medicine, Universitas Padjadjaran, Bandung, Indonesia
[5] Department of Public Health, Faculty of Medicine, Universitas Padjadjaran, Bandung, Indonesia

Address for correspondence Kania Dyatika Praba, S.Ked, Bachelor of Medicine Programme, Faculty of Medicine, Universitas Padjadjaran, Sumedang, Indonesia (e-mail: kania17001@mail.unpad.ac.id).

J Child Sci 2023;13:e75–e84.

Abstract

Anemia and stunted growth are major health problems with adverse consequences for children. This study aimed to determine the prevalence, characteristics, and hematological profile of anemia among stunted children under 2 years old. A nested cross-sectional study from a child cohort was conducted in Bandung Regency, West Java, Indonesia. Two hundred twenty-two children aged 6 to 24 months were randomly selected. These children were reexamined from November 2019 to March 2020 for anthropometric measurements and hematological assessment and interviewed for relevant risk factors of stunted growth and anemia. Ninety-eight stunted children were identified and distributed into stunted and severely stunted groups (47.96 vs. 52.04%). Around 85.4% of the children came from low-income families and 31.7% were severely underweight for age. Surprisingly most of these stunted children had normal birth weight and length and were born at term (68.3, 53.7, and 85.4%). The prevalence rate of anemia among stunted children was 41.8%, they had decreased mean corpuscular volume (56%), decreased mean corpuscular hemoglobin (73%), and normochromic mean corpuscular hemoglobin concentrations (51.2%). Leucocytosis was higher than leucopenia (10 vs. 3.7%) and thrombocytosis ($n = 15$, 36%) as compared to thrombocytopenia ($n = 5$, 12%). The prevalence of anemia was high among stunted children. The characteristics of stunted children with and without anemia were similar. The fact that these stunted children had few risk factors for stunting emphasizes the need to focus on improved postnatal care to prevent faltering. Based on the hematology profile, iron deficiency anemia was suspected to be the most etiology in these cases warranting further follow-up and management.

Keywords
- anemia
- stunted
- prevalence
- characteristics
- hematological profile

received
January 18, 2023
accepted after revision
April 5, 2023

DOI https://doi.org/10.1055/s-0043-1769483.
ISSN 2474-5871.

Georg Thieme Verlag KG, Rüdigerstraße 14, 70469 Stuttgart, Germany

Anemia is a condition where the hemoglobin (Hb) level in the blood is lower than normal. World Health Organization (WHO) data (2017) show that the global prevalence of anemia among children under 5 years was 41.7%.[1] Southeast Asia was estimated to have 51.4% of anemic children under the age of 5 years.[1] The 2018 Indonesian Basic Health Research (Riskesdas) showed a lower prevalence (38.5%) of anemia among children aged 0 to 59 months in Indonesia, but it remains a moderate public health problem.[2] By the time this article was written, there were no data on anemia prevalence among stunted children under 2 years of age in West Java or Bandung Regency (incomplete sentence).

The underlying cause of anemia in children is iron deficiency, which is caused by increased demand and use of iron reserves at birth, followed by a lack of iron intake.[3] Its adverse effects are related to neurodevelopment, particularly when it occurs before 2 years old, which is known as the golden period (the first 1,000 days of life).[1]

Some studies showed that the characteristics of anemic children are as follows: age group below 2 years, male sex, low birth weight, short birth length, preterm, having more than one sibling, low nutritional status (stunted, wasted, and underweight), smaller head circumference, no history of exclusive breastfeeding, introduction of complementary foods below 6 months of age, formula milk consumption, incomplete immunization, pale, low maternal education, younger maternal age, low-income families, and living in a rural area.[3–8]

Hb is a parameter for anemia related to hematocrit or packed cell volume (PCV) and the red blood cell (RBC) count. It is necessary to check the level of mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and mean corpuscular hemoglobin concentrations (MCHC) in the anemia diagnostic approach.[4] Some studies showed that Hb, PCV, MCV, and MCH levels were significantly lower in children with severely stunted growth as compared to normal stature.[9]

Anemia can impair cognitive, motor, verbal, and immune function, as well as inhibit linear growth in children. Decreased oxygen due to a lack of iron in the body causes hypoxia conditions in hepatocytes, which inhibits protein synthesis.[10] This condition causes a decrease in insulin-like growth factor-1 levels due to an increase in IGF binding protein-1 levels, resulting in growth inhibition and stunted children.[10]

Stunting is defined as a height lower than two standard deviations of the length/height-for-age-Z-score of WHO.[11] This condition could be due to a lack of nutrition, recurrent infections, and inadequacy of psychosocial stimulation.[11] Globally, about 21.3% of under 5 children are stunted.[12] In Indonesia, it affects 29.9% of children, while in West Java 29.1% of children under 2 years are stunted.[13] Bandung Regency is one of the 100 regency priorities in Indonesia for stunted children intervention, with a prevalence of 21.45% stunted and 10.52% severely stunted children under 2 years of age.[13] In the short term, stunted growth can cause inadequate cognitive, motor, and verbal development.[11] Stunted children are more likely to be short in adulthood, have an increased risk of obesity and other diseases, and have poor reproductive health, learning capacity, productivity, and work capacity in the long term.[11]

Children under 2 years are particularly vulnerable to anemia and stunted growth. If these two diseases occur simultaneously, there will be a double burden on the individual and the country. Those children tend to grow into adults with poor nutrition which can inhibit the economic growth of Indonesia by about 8% which is directly caused by decreased productivity, low education, and poor knowledge.[14] In addition, stunted growth is one of the sustainable development goal targets to reduce the stunting rate to 40% by 2025.[11] Bandung Regency Health Office has developed several efforts to reduce stunted growth, including nutrition improvements, especially in infants aged 0 to 23 months, improving availability of clean water, food security and nutrition, family planning (*Keluarga Berencana*, KB), health insurance, and poverty alleviation.[15] However, these efforts are not considered optimal to reduce the incidence of stunted growth and anemia. Therefore, there is a need to study the prevalence, clinical characteristics, and type of anemia (based on suspected hematological profiles) among stunted children under 2 years of age in Bandung Regency.

Methods

Study Design and Setting

This study was conducted at public health centers/*Puskesmas* (*Pusat Pelayanan Kesehatan Masyarakat*) and *Posyandu* (*Pos Pelayanan Terpadu*), Bandung Regency, West Java, Indonesia. Bandung Regency is 154.1 km far from Jakarta, the capital city of Indonesia. This study is a part of a large cohort study entitled "The Relationship among Vitamin D Levels, Vitamin D Binding Protein and Maternal Knowledge of Nutritional Adequacy in the First 1000 Days of Life with Stunted Children" funded by Academic Leadership Grant (ALG), Universitas Padjadjaran.

Study Participants

The population of this study was all under 2 children in Bandung Regency. The study subjects were selected samples that could represent the population. The sample size was calculated using the formula to test the difference between two proportions, stunted and non-stunted children. Simple random sampling, which is the process of randomly selecting samples from a list of populations, was used to collect samples (stunted and nonstunted under 2 years children). Based on this calculation, the sample size per group was obtained to be $n = 122$ samples. A total of 222 children were selected by simple random sampling. One hundred and thirteen were excluded due to normal length-for-age status, and an additional two children were not included due to refusal of blood sampling. The recruitment flow, including the inclusion and exclusion of study participants, is displayed in ►**Fig. 1**. Finally, the total sample of 98 children aged 6 to 24 months was included in the analysis.

The study protocol was granted approval by the Research Ethics Committee Universitas Padjadjaran, number 856/UN6.KEP/EC/2020.

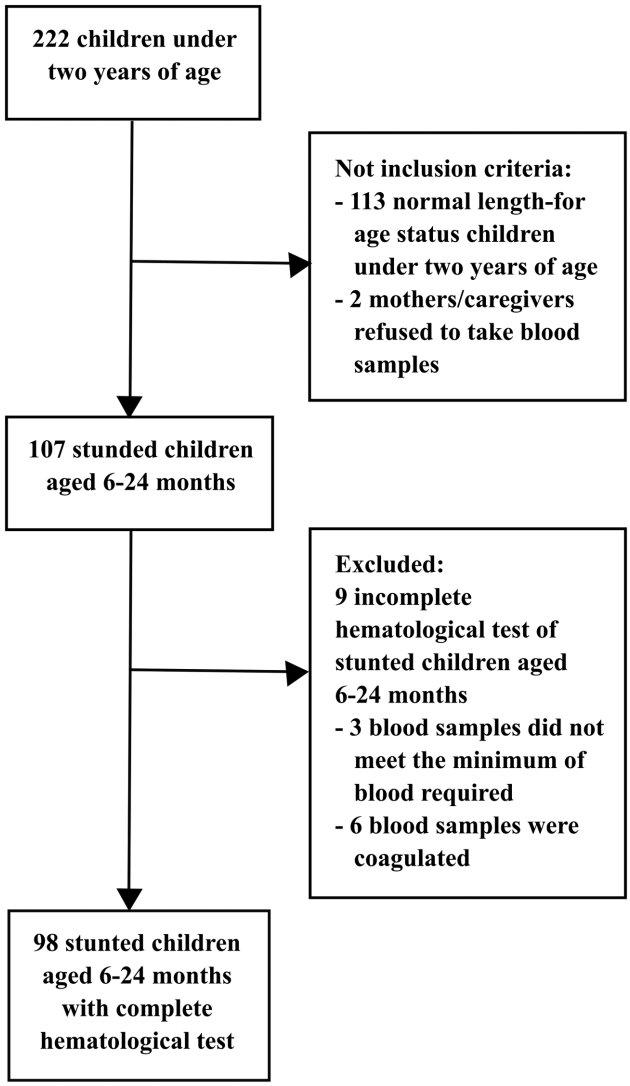

Fig. 1 Flow chart of sample study.

Study Instrument

At each *puskesmas/posyandu*, informed consent was obtained. Mothers/caregivers had to sign a written consent letter to participate in the study. Data on socioeconomic and childhood-related information were captured using a standard questionnaire at baseline during face-to-face interviews with mothers/caregivers. Key elements were (1) child information—gender, age, body weight and length at birth, gestational age, number of siblings, exclusive breastfeeding history, complementary food introduction age, formula milk consumption, immunization status, and pallor; (2) family-specific information—socioeconomic characteristics of parents/family, including maternal education level, maternal age, and family income. Weight and body length were measured using the Onemed Electronic Baby Scale, while the head circumference was measured using the Onemed tape OD235. The result was recorded in the child's information to determine his/her nutritional status.

The blood sample was collected in the ethylenediaminetetraacetic acid (EDTA) tubes via the venipuncture method with a safe, winged needle set for phlebotomy. Alcohol swabs were used to clean the hand before puncture. The blood sample in the EDTA tube was loaded in the calibrated automated Hb analyzer Sysmex in the Laboratory of Hasan Sadikin Hospital.

Children with Hb level <11 g/dL were considered anemic and classified as mild (10–10.9 g/dL), moderate (7–9.9 g/dL), and severe (<7 g/dL).[1] Normal values of hematocrit, RBC, MCV, MCH, MCHC, leucocyte, and thrombocyte count were obtained from Dr. Hasan Sadikin General Hospital's normal laboratory values.

Statistical Analysis

The data were checked for completeness, accuracy, and consistency before it was entered into the computer. Data were encoded and entered into Research Electronic Data Capture (REDCap) Universitas Padjadjaran and exported to Microsoft Excel2010 and Statistical Package for Social Sciences (Version 26.0; IBM Corp. United States) for analysis. The frequency and proportion were used to describe the clinical characteristics and hematological profile of the study sample, as well as to estimate the prevalence of anemia in Bandung Regency.

Results

A total of 98 stunted children aged 6 to 24 months participated in this study. The overall prevalence of anemia was 41.8% ($n=41$, 95% CI: 32 to 51.6%) consisting of 20.4 and 21.4% of anemic stunted and severely stunted children, respectively. The mean ($\pm$standard deviation [SD]) level of Hb was 9.74 ($\pm$0.962) g/dL. ►**Table 1** illustrates the distribution of stunted children with anemia based on age group. Stunted children aged 6 to 12 months had a higher rate of anemia (8/12, 67%) than aged 13 to 24 months (33/86, 38%). Either mild or moderate anemia was 20.4%, while severe anemia was 2.0%.

►**Table 2** summarizes the clinical, maternal, and socioeconomic characteristics of children, 70.7% were males. The

Table 1 Distribution of stunted children with anemia based on age group

	Anemia status				Total
Age group	No anemia n (%)	Mild *n* (%)	Moderate *n* (%)	Severe *n* (%)	
6–12 mo	4 (33)	2 (17)	6 (50)	0 (0)	12
13–24 mo	53 (63)	18 (20)	14 (16)	1 (1)	86
					98

Note: *n*, frequency.

Table 2 Distribution of anemia among stunted children aged 6 to 24 months based on clinical, maternal and socioeconomic characteristics

Characteristics	Anemia status		Total
	Anemia *n* (%)	Not anemia *n* (%)	*n*
Sex of the child			
Male	29 (70.7)	31 (54.4)	60
Female	12 (29.3)	26 (45.6)	38
Age of the child			
6–12 mo	8 (19.5)	4 (7.0)	12
13–24 mo	33 (80.5)	53 (93.0)	86
Birth weight status			
Low	13 (31.7)	18 (31.6)	31
Normal	28 (68.3)	39 (68.4)	67
Birth length status			
Short	19 (46.3)	26 (45.6)	45
Normal	22 (53.7)	31 (54.4)	53
Gestational age status			
Preterm	6 (14.6)	8 (14.0)	14
Normal	35 (85.4)	49 (86.0)	84
Number of siblings			
≤ 1	10 (24.4)	20 (35.1)	30
> 1	31 (75.6)	37 (64.9)	68
Weight-for-age status			
Severely underweight	13 (31.7)	14 (24.6)	27
Underweight	12 (29.3)	10 (17.5)	22
Normal	16 (39.0)	33 (57.9)	49
Weight-for-length status			
Severely wasted	5 (15.3)	10 (17.5)	15
Wasted	10 (24.4)	4 (7.0)	14
Normal	26 (63.4)	42 (73.7)	68
Obese	0 (0.0)	1 (1.8)	1
Head circumference status			
Microcephaly	12 (29.3)	15 (26.3)	27
Normal	28 (68.3)	42 (73.7)	70
Macrocephaly	1 (2.4)	0 (0.0)	1
Exclusive breastfeeding history			
Yes	32 (78.0)	39 (68.4)	71
No	9 (22.0)	18 (31.6)	27
Introduction age of complementary foods			
< 6 mo	9 (22.0)	18 (31.6)	27
≥ 6 mo	32 (78.0)	39 (68.4)	71
Formula milk consumption			
Yes	11 (26.8)	22 (38.6)	33
No	30 (73.2)	35 (61.4)	65

Table 2 (*Continued*)

Characteristics	Anemia status		Total
	Anemia *n* (%)	Not anemia *n* (%)	*n*
Immunization status			
Complete	21 (51.2)	40 (70.2)	61
Incomplete	20 (48.8)	17 (29.8)	37
Pale			
Yes	6 (14.6)	3 (5.3)	9
No	35 (85.4)	54 (94.7)	89
Educational status of mother			
No formal education	1 (2.4)	0 (0.0)	1
Elementary school	16 (39.0)	23 (40.4)	39
Junior high school	20 (48.8)	22 (38.6)	42
Senior high school	3 (7.3)	11 (19.3)	14
College	1 (2.4)	1 (1.8)	2
Age of mother			
15–19 y	3 (7.3)	6 (10.5)	9
20–24 y	7 (17.1)	17 (29.8)	24
25–29 y	10 (24.4)	11 (19.3)	21
>30 y	21 (51.2)	23 (40.4)	44
Family income			
Below RMW	35 (85.4)	50 (87.7)	85
Equal to the RMW	2 (4.9)	3 (5.3)	5
Above RMW	4 (9.8)	4 (7.0)	8

Abbreviation: RMW: regional minimum wage.

highest prevalence was recorded in the age group 13 to 24 months (80.5%) with the median (minimum-maximum) age of 18 (7–24) months. About 68.3% had a history of normal birth weight and birth length (53.7%), 85% had a history of normal gestational age (85%) and 75.6% had more than one sibling. About 31.7% were severely underweight, while 63.4% had normal weight-for-length. Sixty-eight percent were noted to have a normal head circumference and 78% were exclusively breastfed. About 78.0% were introduced to complementary foods at 6 months of age, while 73.2% were found with no formula milk consumption. Fifty-one percent of children were completely immunized. Only six children were found with complaints of pallor (14.6%). From the maternal background, the highest maternal education was predominantly junior high school (48.8%). About 51.2% of mothers were in the age group above 30 years old. Eighty-five percent of families had income below regional minimum wage.

The hematocrit values among stunted children with anemia based on age group (►**Table 3**) found among 6 to 12 months and 13 to 24 months with anemia mostly show decreased hematocrit (5/8 [63%] and 15/33 [45%] respectively). All children aged 6 to 12 months with anemia did not show any abnormalities of RBC count (8/8, 100%). For children aged 13 to 24 months, 6% (2/33) had low RBC counts and 24% showed erythrocytosis (8/33). Two subjects (2/8, 25%) aged 6 to 12 months with anemia had leucocytosis, three subjects (3/33, 9%) aged 13 to 24 months had leucopenia, and two subjects (2/33, 6%) had leucocytosis. In subjects aged 6 to 12 months with anemia, one subject (1/8, 12·5%) had thrombocytopenia and three subjects (3/8, 37.5%) had thrombocytosis. Four subjects (4/33,12%) had thrombocytopenia and 12 subjects (12/33, 36%) had thrombocytosis in children aged 13 to 24 months. ►**Table 4** shows that most subjects had microcytic anemia (23/41, 56%), decreased MCH (30/41, 73%), and equally distributed hypochromic (20/41, 49%) and normochromic (21/41, 51%) picture.

Discussion

This study indicated that out of 98 sampled stunted children aged 6 to 24 months old, 41.8% were anemic, which could be described as a severe public health challenge according to the WHO criteria.[1] There was no previous report on the magnitude of anemic stunted children under 2 years of age in West Java, limiting the comparison of our findings. The magnitude of anemia in our study was higher than that in the study conducted in South Purwokerto (35.07%),[16] Ethiopia

Table 3 Hematological profile among stunted children based on age group

	Anemia status			
Age group	Hematological profile	No anemia *n* (%)	Anemia *n* (%)	Total
	Hematocrit[a]			
6–12 mo	Decrease	0	5 (100)	5
	Normal	2 (40)	3 (60)	5
	Increase	2 (100)	0	2
13–24 mo	Decrease	0	15 (100)	15
	Normal	39 (68)	18 (32)	57
	Increase	14 (100)	0	14
				98
	RBC[b]			
6–12 mo	Low	0	0	0
	Normal	3 (27)	8 (72)	11
	Erythrocytosis	1 (100)	0	1
13–24 mo	Low	0 (0)	2 (100)	2
	Normal	44 (66)	23 (34)	67
	Erythrocytosis	9 (53)	8 (47)	17
				98
	WBC[c]			
6–12 mo	Leucopenia	1 (100)	0	1
	Normal	3 (33)	6 (67)	9
	Leucocytosis	0 (0)	2 (100)	2
13–24 mo	Leucopenia	5 (63)	3 (27)	8
	Normal	42 (60)	28 (40)	70
	Leucocytosis	6 (75)	2 (25)	8
				98
	Thrombocyte count			
6–12 mo	Thrombocytopenia	1 (50)	1 (50)	2
	Normal	3 (43)	4 (57)	7
	Thrombocytosis	0	3 (100)	3
13–24 mo	Thrombocytopenia	3 (43)	4 (57)	7
	Normal	36 (68)	17 (32)	53
	Thrombocytosis	14 (54)	12 (46)	26
				98

Note: *n*, frequency.
[a]Normal range hematocrit: 6–24 mo: 33 to 39%.
[b]Normal range RBC: 6–24 mo: $3.7–5.3 \times 10^6/mm^3$.
[c]Normal range of leucocyte count: 6–12 mo: 6–17.5 x $10^3/mm^3$; 13–24 mo: $6–17 \times 10^3/mm^3$.

(23.9%),[17] and Northeast Ethiopia (20.1%).[3] In the main cohort study, 41.4% of 99 sampled nonstunted children under 2 years old were anemic. This shows that the prevalence of anemia in stunted and nonstunted children is not considerably different.

However, it should be emphasized that if anemia occurs alongside stunting, the impact is worse than in those children who are not stunted.

Male children were more likely to be anemic (70.7%). This finding is similar to study reports in Northeast Ethiopia and China.[3,6] This could be because male stunted children are at risk of anemia, perhaps related to X-linked diseases such as glucose-6 phosphate dehydrogenase.[18] The stunted children group aged 13 to 24 months was found with the highest prevalence of anemia (80.5%). This finding is similar to the study in Ethiopia.[17] This could be due to inadequate nutrition

Table 4 Distribution of MCV, MCH and MCHC among stunted children with anemia aged 6 to 24 months

RBC indices		Anemia status		Total
		No anemia *n* (%)	Anemia *n* (%)	
MCV[a] (fL)	Microcytic	3 (11.5)	23 (88.5)	26
	Normocytic	52 (74)	18 (26)	70
	Macrocytic	2 (100)	0	2
MCH[b] (pg/cell)	Low	11 (27)	30 (73)	41
	Normal	45 (80)	11 (20)	56
	High	1 (100)	0	1
MCHC[c] (%)	Hypochromic	7 (26)	20 (74)	27
	Normochromic	50 (70.4)	21 (29.6)	71

Abbreviations: MCV, mean corpuscular volume; MCH, mean corpuscular hemoglobin; MCHC, mean corpuscular hemoglobin concentrations; *n*, frequency.
[a]Normal range MCV: 70–86 fL.
[b]Normal range MCH: 23–31 (pg/cell).
[c]Normal range MCHC: 30–36%.

and the longer time taken for stunted growth to manifest, resulting in anemic stunted children aged 13 to 24 months.[17]

Unexpectedly in this study, more stunted children with anemia had a history of normal birth weight (68.3%), normal birth length above 48 cm (53.7%), and normal gestational age (85.4%), which may indicate that postnatal nutritional and other environmental factors may lead to these conditions. Theoretically, after 6 months of age, the iron stores may reach the critical level for an increased risk of anemia.[19]

Those children with more than one sibling had the highest prevalence of anemia (75.6%), which was similar to the study conducted in China.[6] Having more children means more mouths to feed and unmet food needs resulting in stunted growth and anemia. Our study found that the subjects who were severely underweight (31.7%) and underweight (29.3%) had a greater prevalence rate of anemia, which was similar to studies conducted in Northeast Ethiopia[3] and China.[6] This condition could be due to low intake of balanced food in macronutrients and micronutrients such as iron, and vitamin A.[3] It was seen that 63.4% of children in our study with anemia had normal weight-for-length (63.4%). Anemia in the last group should have been preventable, had they taken adequate intake of essential micronutrients, especially protein to build up Hb in the erythrocytes.

Stunted children with normal head circumference status had the highest number of anemic (68.3%) subjects, because of the mechanism called "brain-sparing," which is redistribution of the arterial blood flow to maintain an adequate level of brain oxygenation, results in an increment of blood flow through the brain circulation and reduction in the peripheral circulation.[20] In utero, fetal brain sparing was not associated with brain volumes, which was indirectly indicated by normal head circumference measurements.[20] When iron deficiency has not yet resulted in abnormal neurotransmitter metabolism, myelin formation, and inhibition of brain energy metabolism, brain volume reduction may not occur.[7] Head circumference alone was not associated with cognitive, gross motor, or language skills at 6 to 24 months of age.[21] However, further investigation and proper management are needed for our study subjects.

The highest proportion of anemia was seen in children who had a history of exclusive breastfeeding (78.0%), proper complementary food introduction at 6 months of age (78.0%), and those who did not consume formula milk (73.2%). Breast milk contains essential substances for infants' growth and development, especially iron, which is more easily absorbed by infants (as much as 20–50%) compared to 4 to 7% absorption of iron in formula milk. Our study did not assess maternal conditions, leaving a gap for the more possible causes of anemia besides the possibility of infants' insufficient nutritional intake after 6 months of age. Considering the family's low-income status, poor quality and variety of complementary food may be the root of the problems.[19]

Although 51.2% of anemic children have complete immunization status, it is said that malnourishment may deter the effectiveness of vaccines. Lower antibody response to Hepatitis B and pertussis found in children with malnutrition results in a greater risk of infection.[22] The study conducted in Turkey reported that hepatitis was associated with aplastic anemia in which bone marrow failure develops after an acute attack of hepatitis.[23] Chaturvedi et al reported that pertussis toxin causes endothelial injury resulting in hemolytic anemia.[8] Unfortunately, our study failed to collect data on how often the children got ill and the type of illness that they encountered.

Most of the subjects in our study (85.4%) had no observable pallor noted by the caregivers. Generally, pallor in anemia can be seen on the conjunctiva, tongue, nail bed, and soft palate due to a lack of blood reaching the skin surface.[4] It can be expected when the Hb level is below 9 g/dL. In this study, the mean (±SD) of subjects' Hb level was 9.74 (±0.962) g/dL, leading to missed pallor recognition.

Most mothers of anemic children had the highest education at the secondary (48.8%) and primary school levels (39.0%). This finding is similar to a study conducted in Northern Ethiopia.[3] Well-educated mothers should be

more aware of their children's health and nutritional status improvement. Family education through health promotion programs can foster good health and healthy living. Most of the subjects who suffer from anemia have families with below-average income (85.4%). This finding is similar to a study conducted in Southeast Ethiopia.[24] This could be due to inadequacy of food needs, limited access to health services, and high exposure to infectious diseases.[24]

Anemia in children can be caused by various etiologies. According to WHO, most common etiology of anemia in children is iron deficiency due to lack of nutrition intake.[1] The previous study conducted by Adriyani and Hikmanti in Karangklesan Village, South Purwokerto, where 30% of stunted children aged 6 to 24 months had anemia, found that children who had anemia had a risk of 1.65 times of being stunted.[16] Both stunted growth and iron deficiency anemia (IDA) may be caused by malnutrition and thus follow a similar causal pathway. The study conducted in Indonesia reported that the most common causes of anemia in children are iron deficiency, thalassemia, and chronic blood loss due to parasitic infections and malaria.[25] The previous study conducted by Mohammed et al among infants in Ethiopia proved that there was a positive correlation between Hb level and linear growth, although this correlation was considered weak.[17] That statement is supported by a study conducted by Ashraf et al which stated that chronic anemia could cause hypoxic conditions in tissues, especially in hepatocytes. So, there could be a decrease in growth hormone secretion (GH) and IGF-1 induction by hepatocytes which contribute to suboptimal linear growth.[10]

The result of this study found that more stunted children aged 6 to 12 months had anemia than those aged 13 to 24 months. The result of this study was similar to the previous study by Huang et al in Huaihua, Hunan Province who found that children aged 6 to 11 months had more anemia (39.32%) than aged 12 to 23 months (25%).[26] The risk of anemia increases after 6 months of age in breastfed children because though the iron demand increases for rapid growth and development, the concentration of iron in breast milk is relatively low. Furthermore, the previous study by Xin et al revealed that feeding practice was an essential factor influencing anemia among 6 to 12 months. We suspected that inadequate complementary feeding took place among children aged 6 to 12 months in this study.[27] It is a situation of primary concern because uncorrected anemia would also contribute to the development of stunting at a later age.

This study found subjects with anemia had low hematocrit levels. According to Auerbach M and Johnson et al, low hematocrit levels indicated a low number of erythrocytes produced by bone marrow due to reduced plasma iron in the body.[28] This iron has the function to synthesize Hb synthesis, where it will be assembled into new erythrocytes.[29] Hence, the low hematocrit level in this study is suspected due to low plasma iron. MCV defines the size of the RBC so that it reflects the cell volume (MCV = HCT [%] x 10/RBC count [1,012/L]). MCH quantifies the amount of Hb per RBC (MCH = Hgb [g/dL] × 10/RBC count (1,012/L). MCHC indicates the amount of Hb per unit volume and correlates the Hb content with the volume of the cell (MCHC = Hgb (g/dL) × 100 / HCT (%)).[4] In this study, it was found that subjects had low hematocrit levels with a normal RBC count. Hematocrit is the volume of the erythrocyte compared to whole blood.[4] Hematocrit and RBC count are related to MCV (MCV = HCT [%] × 10/RBC count [1,012/L]).[4] Therefore, as MCV in this study decreases, it means the size of RBC is small (microcytic). The previous study revealed that low hematocrit levels indicated decreased production of RBC.[4] However, in this study, the subject had a normal RBC count. This could be due to a suspected compensatory mechanism that increases RBC production with consequences in the decrease of MCV (microcytic).

The majority of subjects in this study had decreased MCV (microcytic anemia) and decreased MCH and were equally distributed between normal MCHC (normochromic) and decreased MCHC (hypochromic). There is a correlation between MCHC, MCH, and MCV (MCHC = MCH/MCV). Microcytic anemia is often described as hypochromic based on peripheral blood smear examination. In this study, the equal distribution between normal and decrease MCHC is suspected due to decrease MCV and MCH; therefore, the result of MCHC can be normal or decreased.

According to the result of MCV and MCHC, most subjects can be included in the classification of microcytic, and hypochromic anemia. Possibility, types of anemia based on microcytic, and hypochromic are IDA, chronic disease, thalassemia, sideroblastic anemia (vitamin B6 deficiency), and lead poisoning.[5] IDA has diagnostic laboratory characteristics of hypochromic, microcytic red cell, low MCV, low MCH, low MCHC, high RDW, low serum iron, low serum ferritin, high TIBC (total iron binding capacity), high FEP (free erythrocyte protoporphyrin), and guaiac positive.[5] Thalassemia has characteristic findings of low MCV, and low MCH, peripheral blood smear examination is microcytic, hypochromic, target cells, and with or without inclusion bodies (Hb H), high serum iron, normal TIBC, and high serum ferritin (which is required to exclude IDA as differential diagnosis).[7] Anemia of chronic disease is marked by decreased erythropoiesis and decreased iron utilization and has characteristics of hypochromic microcytosis in peripheral blood smear, increase sedimentation rate, and usually, evidence of systemic illness.[7] Sideroblastic anemia characteristics are hypochromic microcytic red cells, sideroblastic bone marrow, and high serum ferritin and Basophilic stippling of red cell morphologic. Lead poisoning is usually marked with hypochromic microcytosis and very high FEP.[30] Overall, based on the hematological profile of the study subjects, the type of anemia was more likely due to IDA.

This study showed stunted children aged 13 to 24 months with anemia who had decreased RBC, leucopenia, and thrombocytopenia, a condition resembling pancytopenia. Pancytopenia may be caused by infection, myelosuppressive medication, aplastic anemia, hypersplenism, infection, and folic acid or vitamin B12 deficiency.[30] Iron is an essential component in erythropoiesis and also plays a role in the proper functioning of the host immune system. Iron deficiency can lead to anemia and may also increase the risk of

infection.[30] Leucocytes involved are in immune system function which helps the body against infection. Patients with leucopenia had a worse outcome to the reaction of infection than another infected patient. Therefore, stunted children with anemia had a double increase in susceptibility to infection. Stunted children aged 6 to 12 months with anemia and thrombocytopenia may be associated with hemolytic uremic syndrome, thrombotic thrombocytopenic purpura (TTP), and Evans syndrome. Leucocytosis occurring in both age groups with anemia may be caused by an infectious etiology or acute leukemia. Hypersegmented neutrophils suggest vitamin B12 deficiency. Therefore, to establish whether the anemia is only due to a one-cell line (red cell line) or part of a three-cell line abnormality (RBC, leucocyte, and thrombocyte count), one needs to see the result of leucocyte and thrombocytes with additional examination, for example, if suspected aplastic or leukemia anemia one should do bone marrow examination (aspiration and biopsy).[30]

Thrombocytosis frequently occurs among children. It can be classified into primary and secondary thrombocytosis. Primary thrombocytosis is very rare in children but may be associated with thromboembolism and hemorrhage. Secondary thrombocytosis, also known as reactive thrombocytosis, is very common and due to a variety of conditions, such as acute and chronic infections, bleeding, or iron deficiency.[6] Stunted children in both age groups with anemia had thrombocytosis as compared to thrombocytopenia, thus suspected to have acute and chronic infections, bleeding, or iron deficiency. The previous study conducted by Dan revealed that IDA is a cause of reactive thrombocytosis, usually with mild and moderate degrees.[31] That statement is supported by Kucine et al and Tüfekçi et al that thrombocytosis is concerning IDA because there is significant homology between erythropoietin and thrombopoietin. Therefore, the cross-reaction of increased erythropoietin in IDA with thrombopoietin receptors (MPL) in the megakaryocytes leads to increased thrombocyte count.[32]

Limited funding hindered this study to recruit more participants and investigation of exactly the different effects of factors affecting anemia patterns among stunted children in Bandung Regency. Case-control studies should be modified and developed in the future to address the risk factors. Recall bias may present as a result of face-to-face interviews with mothers/caregivers.

From the findings of anemia among stunted children in this study, the most important recommendation is to prioritize intervention. Additional nutrition and monitoring to find the etiology and whether there is a growth and development disturbance in the subject should be done. Improving maternal and community education on balance food of carbohydrate- protein and micronutrient food, including iron-rich food sources, fortification of iron supplementation, feeding practices, sanitation, and personal hygiene should be reinforced along with the eradication of parasitic infection.[1] American Academy of Pediatrics has recommended exclusive breastfeeding for 6 months, followed by iron-fortified complementary foods, and iron-rich foods for 1 to 2 years age. Cow milk could be introduced at 12 months but limited to no more than 500 mL per day.[33] To reduce the burden of disease, improving the entire household economy may be necessary by establishing a new lifestyle, such as growing a nutrition garden, chicken livestock, and other activities that can be coordinated with cadres of each village for prevention programs.[6,16,17]

As stated in the study protocol, the anemic and/or stunted children in this study had been referred for follow-up plans by pediatricians at Soreang Hospital, a government-owned hospital under Kabupaten Bandung District Health Office. Although the service was designed for free, unfortunately as the coronavirus disease 2019 pandemic hit globally the opportunity may not have been properly utilized. The pandemic also affected the follow-up program by the research team.

To conclude, the findings of this study showed that the prevalence rate of anemia among stunted children aged 6 to 24 months in Bandung Regency is 41.8%. It was classified as a severe public health problem. The highest prevalence of anemia was found in male stunted children, age group 13 to 24 months, severely underweight, exclusive breastfeeding, low maternal education, maternal age of 30 years or more, and low-income families. Based on the hematology profile, we suspect iron deficiency as the most common etiology for anemia. Special efforts should be immediately made, so as to intervene in the situations to avoid additional, long-term consequences of anemia and stunted growth.

Data Availability

The data sets for the present study are available with the corresponding author and will be made available on reasonable request.

Author's Contribution

All authors contributed to subject recruitment, data collection, review, and discussion of the manuscript.

Funding

This research was available from Universitas Padjadjaran (under the Academic Leadership Grant, 2019 awarded to Budi Seatiabudiawan) and Research Cooperation Fund of Bandung Regency Health Office and Universitas Padjadjaran 2019.

Conflict of Interest

None declared.

Acknowledgment

We would like to thank you for all the efforts of information dissemination up to data collection by midwives, nurses, and health cadres under the coordination of the Bandung Regency Health Office. The cooperation in laboratory work with staff at the Department of Clinical Pathology, Dr. Hasan Sadikin Hospital is highly appreciated.

References

1 World Health Organization. Nutritional anaemias: tools for effective prevention and control. 2017
2 Kementrian Kesehatan RI. Riset kesehatan dasar (Riskesdas) tahun 2018. Kementerian Kesehatan RI 2018. Accessed April 04, 2023 at: https://www.kemkes.go.id/resources/download/info-terkini/hasil-riskesdas-2018.pdf
3 Woldie H, Kebede Y, Tariku A. Factors associated with anemia among children aged 6–23 months attending growth monitoring at Tsitsika Health Center, Wag-Himra Zone, Northeast Ethiopia. J Nutr Metab 2015;2015:928632
4 Lokeshwar M. Textbook of Pediatric Hematology and Hemato-Oncology. Delhi, India: Jaypee Brothers Medical Publishers (P) Ltd; 2016:109–123
5 M Robert BK. Stanton Nelson Textbook of Pediatrics. Twentieth ed. Elsevier; 2016:2309–2326
6 Yang W, Li X, Li Y, et al. Anemia, malnutrition and their correlations with socio-demographic characteristics and feeding practices among infants aged 0-18 months in rural areas of Shaanxi province in northwestern China: a cross-sectional study. BMC Public Health 2012;12(01):1127
7 Miller LC, Joshi N, Lohani M, et al. Head growth of undernourished children in rural Nepal: association with demographics, health and diet. Paediatr Int Child Health 2016;36 (02):91–101
8 Chaturvedi S, Licht C, Langlois V. Hemolytic uremic syndrome caused by Bordetella pertussis infection. Pediatr Nephrol 2010;25 (07):1361–1364
9 Chowdhury SD, Ghosh T. Undernutrition in Santal children: a biochemical and hematological study. Homo 2013;64(03): 215–227
10 Soliman AT, De Sanctis V, Yassin M, Adel A. Growth and growth hormone-insulin like growth factor-I (GH-IGF-I) axis in chronic anemias. Acta Biomed 2017;88(01):101–111
11 World Health Organization. Global nutrition targets 2025: Stunting policy brief. World Health Organization; 2014
12 United Nations Children's Fund (UNICEF) WHO. Levels and trends in child malnutrition. 2019https://apps.who.int/iris/rest/bitstreams/1273507/retrieve
13 Badan Penelitian dan Pengembangan Kesehatan. Laporan Provinsi Jawa Barat RISKESDAS 2018 2018https://kesmas.kemkes.go.id/assets/upload/dir_519d41d8cd98f00/files/Hasil-riskesdas-2018_1274.pdf
14 Kemiskinan TNPP. 100 kabupaten/kota prioritas untuk intervensi anak kerdil (stunting). Jakarta: Tim Nasional Percepatan Penanggulangan Kemiskinan; 2017
15 Bupati Bandung. Peraturan Bupati Bandung Nomor 74 Tahun 2019 tentang Rencana Aksi Daerah Percepatan Pencegahan dan Penanggulangan Stunting di Kabupaten Bandung Tahun 2019-2021 2019. https://jdih.bandungkab.go.id/asset/file_hukum/No_74_Tahun_2019_15774183151.pdf
16 Adriyani FHN, Hikmanti A. Correlations of Anemia, Stunting, and Sociodemographic Characteristics and Energy Among Children Aged 6–23 Months at Karangklesem Village, South Purwokerto. Atlantis Press; 2020:196–203
17 Mohammed SH, Larijani B, Esmaillzadeh A. Concurrent anemia and stunting in young children: prevalence, dietary and non-dietary associated factors. Nutr J 2019;18(01):10
18 Ahmad A, Zulfah S, Wagustina S. Defisiensi Besi dan Anemia pada Anak Usia Bawah Dua Tahun (6-23 Bulan) di Kabupaten Aceh Besar. Gizi Indonesia 2014;37(01):63–70
19 Pacifici GM. Effects of iron in neonates and young infants: a review. Int J Pediatr 2016;4(07):2256–2271
20 Morsing E, Malova M, Kahn A, et al. Brain volumes and developmental outcome in childhood following fetal growth restriction leading to very preterm birth. Front Physiol 2018;9:1583
21 Nicolaou L, Ahmed T, Bhutta ZA, et al;MALED Network Investigators. Factors associated with head circumference and indices of cognitive development in early childhood. BMJ Glob Health 2020;5(10):e003427
22 Zimmermann P, Curtis N. The influence of BCG on vaccine responses—a systematic review. Expert Rev Vaccines 2018;17 (06):547–554
23 Tüfekçi Ö, Özdemir HH, Malbora B, et al. PB1856 hepatitis associated aplastic anemia: etiology, clinical characteristics and outcome. HemaSphere 2019;3(S1):846–847
24 Gutema B, Adissu W, Asress Y, Gedefaw L. Anemia and associated factors among school-age children in Filtu Town, Somali region, Southeast Ethiopia. BMC Hematol 2014;14(01):13
25 Nadiyah,Dewanti LP, Mulyani EY, Jus'at I. Nutritional anemia: Limitations and consequences of Indonesian intervention policy restricted to iron and folic acid. Asia Pac J Clin Nutr 2020;29 (Suppl 1):S55–S73
26 Huang Z, Jiang FX, Li J, Jiang D, Xiao TG, Zeng JH. Prevalence and risk factors of anemia among children aged 6-23 months in Huaihua, Hunan Province. BMC Public Health 2018;18(01): 1267
27 Xin Q-Q, Chen B-W, Yin D-L, et al. Prevalence of anemia and its risk factors among children under 36 months old in China. J Trop Pediatr 2017;63(01):36–42
28 Johnson-Wimbley TD, Graham DY. Diagnosis and management of iron deficiency anemia in the 21st century. Therapeutic advances in Gastroenterology 2011;4(03):177–184
29 Auerbach M. Patient education: anemia caused by low iron in adults (beyond the basics). UpToDate 2021
30 Powers JM, Sandoval C, Lorin MI. Approach to the child with anemia. UpToDate 2021
31 Dan K. Thrombocytosis in iron deficiency anemia. Intern Med 2005;44(10):1025–1026
32 Kucine N, Chastain KM, Mahler MB, Bussel JB. Primary thrombocytosis in children. Haematologica 2014;99(04):620–628
33 Baker RD, Greer FRCommittee on Nutrition American Academy of Pediatrics. Diagnosis and prevention of iron deficiency and iron-deficiency anemia in infants and young children (0-3 years of age). Pediatrics 2010;126(05):1040–1050