# Hematology Study on Stunting Children in Sampuabalo, Coastal Area of Buton: Effect of Nutritional Status on Red Blood Cell Profile

**Tiara Mayang Pratiwi Lio[1], Heri Wibowo[2], Mohamad Sadikin[3], Sri Widia A Jusman[3*]**

*[1]Doctoral Program in Biomedical Science, Faculty of Medicine, Universitas Indonesia, Jakarta, Indonesia.*
*[2]Department of Parasitology, Faculty of Medicine, Universitas Indonesia, Jakarta, Indonesia.*
*[3]Department of Biochemistry & Molecular Biology, Faculty of Medicine, Universitas Indonesia, Jakarta, Indonesia.*

*Corresponding author: Sri Widia A Jusman. E-mail: sriwidiaaj@gmail.com, sri.widia@ui.ac.id*
*Telp: +62-8569039969*

**KEYWORDS**

Stunting children, Coastal Areas, Red blood cell parameters

**ABSTRACT**

**Introduction**: Stunting, is driven by chronic malnutrition and adverse conditions. Analyzing red blood cell (RBC) profiles offers insights into nutritional status and anemia risk. This study assessed the RBC profiles of stunted children in a coastal area and the factors influencing them.

**Methods**: 103 children which consisted of normo-stature (NS), stunted (S) dan severely stunted (SS), aged 2-5 years lived in Sampuabalo, Buton, Southeast Sulawesi. Hemoglobin (HGB), hematocrit (HCT), erythrocyte indices (MCV, MCH, MCHC), and RDW were examined using a hematology analyzer and compared between the NS, S, and SS groups using SPSS program

**Results**: The MCV, MCH, and MCHC values were lower significantly in SS boys than NS boys ($p_{MCV} = 0.048$, $p_{MCH} = 0.045$, and $p_{MCHC} = 0.030$, respectively). Of stunted boys, 87% had low MCV (<76 fl) with an incidence risk (OR) of 4.706 times. The red cell distribution width (RDW) value in SS boys (15.85 (14.00-17.50) %) was significantly higher than NS boys (14.60 (12.60-16.70) %) ($p = 0.028$). The HGB in SS girls (11.40(6.30-16.70) g/dL) was lower significantly than S girls (12.00(5.80-20.20) g/dL) ($p= 0.036$). Erythrocytes and HCT were higher in S girls compared to NS girls (p=0.030 and p=0.031, respectively).

**Conclusions**: The lower MCV, MCH, and MCHC in boys, indicating possible microcytic hypochromic anemia, often associated with iron deficiency or iron metabolism disorders. Similarly, low HGB and higher HCT and erythrocytes in SS girls indicated possible anemia and dehydration...

## Introduction

Stunting is a major global health problem, especially in countries with inadequate access to food and medical care. Stunting impairs a child's immune system, cognitive development, and susceptibility to infectious diseases, and inhibits their physical growth. Due to exposure to less-than-ideal environmental conditions, limited availability of nutrient-dense foods, and inadequate sanitation, children in coastal areas are often more susceptible to stunting. (1-4) Hematological profile is one of the health parameters that can be used to observe and evaluate the condition of children who experience stunting. Children who experience stunting often show anemia, low hemoglobin levels, and other abnormal hematological characteristics in their hematological profile. (5) Deficiencies in iron and other micronutrients are often associated with anemia in stunted children, and these deficiencies are exacerbated by recurrent illnesses and unfavorable environmental factors. (6, 7) By assessing the hematological profile, we can better understand the impact of stunting and create more successful interventions for children in coastal areas.

Current stunting interventions that address micronutrient deficiencies alone may overlook the critical need for adequate protein intake, which is essential for proper growth and metabolic function; this gap in understanding has led to calls for more comprehensive strategies that integrate macro- and micronutrient support into public health programs. (8, 9) By expanding the scope of nutrition assessment to include these factors, health care providers can better tailor their approaches to meet the diverse needs of stunted children, ultimately driving improved health trajectories and breaking the cycle of deprivation. (9)

Analysis of red blood cell (RBC) profiles such as hemoglobin (HGB), erythrocytes, hematocrit (HCT), Mean Corpuscular Volume (MCV), Mean Corpuscular Hemoglobin (MCH), Mean Corpuscular Hemoglobin Concentration (MCHC), and Red Cell Distribution Width (RDW) **,** can provide insight into their overall nutritional status and potential for anemia. Understanding these indicators can help identify at-risk populations and inform targeted interventions to improve overall nutritional and health outcomes in affected children. (9) Evaluating these RBC indicators not only highlights the malnutrition experienced by stunted children but also emphasizes the urgent need for comprehensive strategies to address malnutrition and its long-term consequences on physical and cognitive development.

Analysis of red blood cell (RBC) profiles can provide insight into their overall nutritional status and potential for anemia. Evaluating these RBC indicators not only highlights the malnutrition experienced by stunted children but also emphasizes the urgent need for comprehensive strategies to address malnutrition and its long-term consequences on physical and cognitive development. This study aimed to assess the red blood cell profile of stunted children in a coastal area and examine the variables influencing this profile. Understanding the RBC profile is critical for health practitioners as it guides the development of effective nutrition programs that meet the unique needs of this vulnerable population, ultimately promoting better growth and developmental trajectories. Furthermore, the interaction between stunting and anemia extends beyond immediate undernutrition, as it can have profound long-term consequences on cognitive development and overall health outcomes.

## Method

**Research Design and Population** This study used an observational study design with a cross-sectional approach. The subjects of the study were 103 children aged 2-5 years from several villages in coastal areas with a high prevalence of stunting.

### Data collection

**Demographic Data and Nutritional Status:** Demographic data and nutritional status were collected through interviews with children's parents or guardians and anthropometric measurements. **Blood Samples:** Blood samples were taken from the cubital vein of the children and analyzed for hematological parameters, including hemoglobin, hematocrit, erythrocyte, MCV, MCHC, and RDW. **Data Analysis** Data were analyzed by comparing hematological parameters between groups of children with stunted (S), severe stunted (SS) and normo-stature (NS). The statistical test used was the Mann-Whitney U test because the data were not normally distributed.

## Results

### Characteristics of study participants

The sample involved in this study was 103 children aged 2–5 years, who live in Sampuabalo Village, Siontapina District, Buton Regency, Southeast Sulawesi Province.

### RBC parameters result and nutritional status

The average sample in this study had RBC values (HGB, erythrocytes, HCT, MCH, and MCHC) within the normal range except for MCV and RBC, although the Mann Whitney statistical test did not show any difference between the stunting (S) and normo-stature (NS) group. MCV in this study showed a low median value, both in the S and NS groups and the MCV value in the S group (73.00 (63-83) fl) tended to be lower than NS group (75.00 (67-81) fl). The median RDW value in this study did not show any statistically significant difference between the S and NS group, although the average value in all samples (14.60%) was higher than the normal reference value of 11.5-14.5 (%) (Table 1.)

**Table 1. Red Blood Cell (RBC) Parameters in the stunted and the normo-stature group**

| Red Blood Cell Parameter | Normo-Stature | Stunting Group | Median | p | Reference Value |
|---|---|---|---|---|---|
| | 53 | 50 | 103 | 103 | |
| Hemoglobin (g/dL) | 12.0(5.8-20.2) | 12.1(6.3-18.5) | 12.00 | 0.584 | 9.6-15.6 (g/dL) |
| Erythrocytes ($10^6$/uL) | 4.75(2.41-7.80) | 4.94(2.44-8.69) | 4.8.00 | 0.052 | 3.40-5.20 ($10^6$/uL |
| Hematocrit (%) | 36.00(17-60) | 37.00 (18-61) | 36.00 | 0.165 | 34-48 (%) |
| MCV (fl) | 75.00 (67-81) | 73.00 (63-83) | 74.00 | 0.250 | 76-92(fl) |
| MCH (pg) | 26.00 (21-30) | 25.00 (16-30) | 25.00 | 0.135 | 23-31 (pg) |

| | | | | | |
|---|---|---|---|---|---|
| MCHC (g/dL) | 34.00 (31-40) | 33.50(23-39) | 34.00 | 0.278 | 32-36 (g/dL) |
| RDW (%) | 14.60(12.6-26.1) | 14.60(12.4-23.7) | 14.60 | 0.588 | 11.5-14.5 (%) |

Note: p <0.05, Mann-Whitney test

**RBC parameters result and degree of stunting**

Based on the comparison between the degrees of stunting (normo-stature (NS), stunted (S), and severely stunted (SS)), HGB in SS children (11.45 (6.3-16.7) g/dL) was lower than S children 12.95 (9.0.-18.5) and was statistically significant (p = 0.035). Erythrocytes were higher in S children (5.24 (3.95-8.69) ($10^6$/uL)) than NS (4.75 (2.41-7.80) $10^6$/uL)) and showed significantly different values between the two groups (p = 0.018). HCT between NS and S children (p = 0.025) and between S and SS children (p = 0.047) showed significantly different values. HCT of S children (39(28-61) %) was higher than NS (36(17-60) %) and SS children (34.5(18-49) %). MCH in SS children (25(20-27) pg) was lower than NS children 926(21-30) pg) and showed a significantly different value (p=0.033). (Table 2.)

**Table 2. RBC Parameters based on degree of stunting (normo-stature (NS), stunted (S), and severely stunted (SS))**

| Red Blood Cell Parameter | Degree of stunting | | | p [ab] | p [ac] | p [bc] |
|---|---|---|---|---|---|---|
| | Normo-Stature [a] | Stunted [b] | Severely Stunted [c] | | | |
| | 53 | 30 | 20 | 83 | 73 | 50 |
| Hemoglobin (g/dL) | 12.0(5.8-20.2) | 12.95(9.0.-18.5) | 11.45(6.3-16.7) | 0.089 | 0.232 | 0.035* |
| Erythrocytes ($10^6$ /uL) | 4.75(2.41-7.80) | 5.24(3.95-8.69) | 4.72(2.44-6.39) | 0.018* | 0.586 | 0.16 |
| Hematocrit (%) | 36(17-60) | 39(28-61) | 34.5(18-49) | 0.025* | 0.752 | 0.047* |
| MCV (fl) | 75(67-81) | 74(69-83) | 72.5(63-82) | 0.512 | 0.193 | 0.354 |
| MCH (pg) | 26(21-30) | 25(16-30) | 25(20-27) | 0.605 | 0.033* | 0.209 |
| MCHC (g/dL) | 34(31-40) | 34(23-39) | 33(27-35) | 0.934 | 0.051 | 0.152 |
| RDW (%) | 14.6(12.6-26.1) | 14.5(12.4-20.0) | 15.5(13.2-23.7) | 0.656 | 0.11 | 0.122 |

Note: *p <0.05, Mann-Whitney test; p [ab] = test of difference between normo-stature and stunted groups; p [ac] = test of difference between normo-stature and severely stunted groups; p [bc] = test of difference between stunted and severely stunted groups

**Comparison of RBC parameters and stunting status**

In this study, it was found that children who suffered from stunted, both in the male and female groups, had significantly lower levels of MCV, MCH, and MCHC when compared to normal children, although statistically only the MCV value in boys showed a statistically

significant difference (p=0.046). MCV in stunted boys (74.00(63.00-83.00) fl) was lower than in normo-stature boys (75.00(67.00-80.00) fl) and in stunted girls the MCV value (73.00(69.00-82.00) fl) was lower than in normo-stature (74.00(67.00-81.00) fl). (Table 3.)

**Table 4. *Stunted and Normo-Stature* Children Based on Gender**

| Red Blood Cell Parameter | Boys | | p | Girls | | p |
|---|---|---|---|---|---|---|
| | Normo-Stature | Stunting | | Normo-Stature | Stunting | |
| | n=29 | n=23 | | n=24 | n=27 | |
| Hemoglobin (g/dL) | 12.00(7.90-17.60) | 11.90(9.00-15.80) | 0.934 | 12.00(5.80-20.20) | 12.70(6.30-18.50) | 0.380 |
| Erythrocytes ($10^6$ /uL) | 4.93(3.74-6.05) | 4.88(3.95-6.35) | 0.294 | 4.71(2.41-7.80) | 5.10(2.44-8.69) | 0.103 |
| Hematocrit (%) | 36.00(25.00-47.00) | 37.00(28.00-46.00) | 0.536 | 35.00(17.00-60.00) | 37.00(18.00-61.00) | 0.192 |
| MCV (fl) | 75.00(67.00-80.00) | 74.00(63.00-83.00) | 0.046* | 74.00(67.00-81.00) | 73.00(69.00-82.00) | 0.813 |
| MCH (pg) | 26.00(21.00-30.00) | 25.00(20.00-30.00) | 0.105 | 25.5(21.00-29.00) | 25.00(16.00-30.00) | 0.687 |
| MCHC (g/dL) | 34.00(31.00-40.00) | 33.00(27.00-39.00) | 0.197 | 34.00(31.00-38.00) | 34.00(23.00-39.00) | 0.870 |
| RDW (%) | 14.60(12.60-16.70) | 14.60(12.90-17.60) | 0.206 | 14.65(13.10-26.10) | 14.6(12.40-23.70) | 0.565 |

Note: *p <0.05, Mann Whitney test

**RBC parameters result and degree of stunting in girls**

Based on the comparison between the degrees of stunting (normo-stature (NS), stunted (S), and severely stunted (SS)) in boys, the MCV, MCH, and MCHC values were lower in SS children compared to NS and were statistically significantly different ($p_{MCV} = 0.048$, $p_{MCH} = 0.045$, and $p_{MCHC} = 0.030$) (Table 4.). Of the stunted boys, 87% had low MCV (<76 fl) with an incidence risk (OR) of 4.706 times (Table 5.). Likewise, the HGB and erythrocyte values in SS children were lower than NS although they did not show any significant differences. The RDW value in SS boys (15.85(14.00-17.50) %) was higher than in NS boys (14.60(12.60-16.70) %), and was statistically significantly different (p=0.028) (Table 4.).

Table 4. Median Values of Research Variables between *Stunted, Severely Stunted* and *Normo-Stature Children* in Boys

| Red Blood Cell Parameter | Normo-Stature [a] | Stunted [b] | Severely Stunted [c] | p [ab] | p [ac] | p [bc] |
|---|---|---|---|---|---|---|
| | 29 | 15 | 8 | 44 | 37 | 23 |
| Hemoglobin (g/dL) | 12.00(7.90-17.60) | 12.80(9.00-15.80) | 11.55(10.03-15.30) | 0.683 | 0.438 | 0.457 |
| Erythrocytes ($10^6$ /uL) | 4.93(3.74-6.05) | 5.01(3.95-6.14) | 4.75(4.51-6.35) | 0.293 | 0.593 | 0.846 |
| Hematocrit (%) | 36.00(25.00-47.00) | 39.00(28.00-46.00) | 36.00(33.00-45.00) | 0.332 | 0.838 | 0.497 |
| MCV (fl) | 75.00(67.00-80.00) | 75.00(70.00-83.00) | 72.00(63.00-81.00) | 0.172 | 0.048* | 0.169 |
| MCH (pg) | 26.00(21.00-30.00) | 25.00(22.000-30.00) | 24.50(20.00-26.00) | 0.403 | 0.045* | 0.251 |
| MCHC (g/dL) | 34.00(31.00-40.00) | 34.00(32.00=39.00) | 32.50(27.00-35.00) | 0.758 | 0.030* | 0.072 |
| RDW (%) | 14.60(12.60-16.70) | 14.40912.90-17.60) | 15.85(14.00-17.50) | 0.823 | 0.028* | 0.121 |

Note: *p <0.05, Mann-Whitney test; p [ab] = test of difference between normo-stature and stunted groups; p [ac] = test of difference between normo-stature and severely stunted groups; p [bc] = test of difference between stunted and severely stunted groups

**Table 5. Analysis of the risk of decreased MCV in the incidence of stunting in boys**

| Gender | | MCV Category | | p ¶ | OR |
|---|---|---|---|---|---|
| | | MCV <76 fl (n=37) | MCV 76-92 fl (n=15) | | |
| Boys | Stunted (n=23) | 20 (87.0%) | 3 (13.0%) | 0.025* | 4,706 |
| | Normo-Stature(n=29) | 17 (58.6%) | 12 (41.4%) | | |

Note: * *p* <0.05, Chi Square Test; Normal MCV Reference Value: 76-92 fl.

**RBC parameters result and degree of stunting in girls**

Based on the comparison between the degree of stunting (normo-stature (NS), stunted (S), and severely stunted (SS)) in girls, HGB in SS children (11.40(6.30-16.70) g/dL) was lower than S children (12.00(5.80-20.20) g/dL) and was statistically significant (p= 0.036). Erythrocytes were higher in S children (5.56(4.27-8.69) $10^6$/uL) compared to NS (4.71(2.41-7.80) $10^6$/uL) and showed significantly different values between the two groups (p=0.030). HCT between NS and S children (p=0.031) and between S and SS children (p=0.045) showed significantly different values.

HCT of S children (40.00(3.00-61.00) %) was higher than NS (35.00(17.00-60.00) %) and SS children (34.00(18.00-31.00) %). (Table 6.)

**Table 6. Median Values of Research Variables between *Stunted, Severely Stunted* and *Normo-Stature Children* in Girls**

| Red Blood Cell Parameter | Normo-Stature [a] | Stunted [b] | Severely Stunted [c] | p [ab] | p [ac] | p [bc] |
|---|---|---|---|---|---|---|
| | 24 | 15 | 12 | 39 | 36 | 27 |
| Hemoglobin (g/dL) | 12.00(5.80-20.20) | 13.10(11.00-18.50) | 11.40(6.30-16.70) | 0.053 | 0.491 | 0.036* |
| Erythrocytes ($10^6$ /uL) | 4.71(2.41-7.80) | 5.56(4.27-8.69) | 4.71(2.44-6.39) | 0.030* | 0.700 | 0.075 |
| Hematocrit (%) | 35.00(17.00-60.00) | 40.00(3.00-61.00) | 34.00(18.00-31.00) | 0.031* | 0.853 | 0.045* |
| MCV (fl) | 74.00(67.00-81.00) | 73.00(69.79.00) | 73.00(69.00-82.00) | 0.794 | 0.906 | 0.787 |
| MCH (pg) | 25.5(21.00-29.00) | 25.00(16.00-30.00) | 25.00(22.00-27.00) | 0.930 | 0.412 | 0.504 |
| MCHC (g/dL) | 34.00(31.00-38.00) | 34.00(23.00-39.00) | 33.50(32.00-35.00) | 0.930 | 0.691 | 0.653 |
| RDW (%) | 14.65(13.10-26.10) | 14.50(12.40-20.00) | 15.20(13.20-23.70) | 0.419 | 0.933 | 0.434 |

Note: *p <0.05, Mann-Whitney test; p [ab] = test of difference between normo-stature and stunted groups; p [ac] = test of difference between normo-stature and severely stunted groups; p [bc] = test of difference between stunted and severely stunted groups

**Discussion**

The average sample in this study had RBC values (HGB, erythrocytes, HCT, MCH, and MCHC) within the normal range except for MCV and RBC, although the Mann Whitney statistical test did not show any difference between the Stunting and normo-stature groups. MCV in this study showed a low median value, both in the Stunting and normo-stature groups and the MCV value in the stunting group (73.00 (63-83) fl) tended to be lower than normo-stature (75.00 (67-81) fl). The median RDW value in this study did not show any statistically significant difference between the stunting and normo-stature groups, although the average value in all samples (14.60%) was higher than the normal reference value of 11.5-14.5 (%) (Table 1.)

In this study, there was no significant difference between hematological values between stunting and normo-stature groups, but the MCV value in the stunting group (73.00 (63-83) fl) compared to normo-stature (75.00 (67-81) fl, Table 2.) and children who suffered from stunted, both in the male and female groups, had significantly lower levels of MCV, MCH, and MCHC when compared to normal children. A significant difference was seen in the MCV value of boys

(p = 0.046), where the MCV in stunted boys (74.00 (63.00-83.00) fl) was lower than in normo-stature boys (75.00 (67.00-80.00) fl; Table 3.). In addition, in SS boys, the MCV, MCH, and MCHC values were lower than NS and were statistically significantly different ($p_{MCV}$ = 0.048, $p_{MCH}$ = 0.045, and $p_{MCHC}$ = 0.030) (Table 4). Of stunted boys, 87% had low MCV (<76 fl) with an incidence risk (OR) of 4.706 times (Table 5). These results indicate a tendency for microcytic anemia, where the size of red blood cells is smaller than normal. With a value of 73 fL, the child is at the lower limit of the normal range, which may indicate a health problem, especially related to nutritional status. Iron deficiency anemia is a common cause of low MCV, and this often occurs in children with poor nutritional status.

In addition to the MCV value, the possibility of iron deficiency anemia is also indicated by the high RDW value in this population. The RDW value in SS boys (15.85 (14.00-17.50) %) was higher than NS boys (14.60 (12.60-16.70) %) and was statistically significantly different (p = 0.028) (Table 4.). RDW is a measure of the variation in the size of red blood cells (erythrocytes) in circulation and is often used to help diagnose various medical conditions, including anemia. For children, normal RDW values usually range from 11.5% to 14.5%. With a value of 14.60%-15.85%, the child is above the normal limit, which can indicate a larger than normal variation in the size of red blood cells. This can be caused by several things such as, Iron Deficiency Anemia : Increased RDW is often associated with iron deficiency anemia, where the body produces more small red blood cells to compensate for the lack of iron; Hemolytic Anemia : This condition can also cause an increase in RDW because red blood cells are destroyed faster than they can be produced; and other medical conditions : Increased RDW can also occur in other conditions such as chronic diseases or vitamin deficiencies (such as vitamin B12 and folate). (Table 1.)

HGB in SS children 11.45 (6.3-16.7) g/dL is lower than S children (12.95 (9.0.-18.5) g/dL), but still within the normal range for children, which generally ranges from 10.9 to 15.0 g/dL at the age of 2-5 years. Although this value is normal, children who experience stunting often have broader nutritional problems that can affect overall health. Stunted children may be at higher risk of developing iron deficiency anemia, even though their hemoglobin levels appear normal. Appropriate nutritional intervention programs should be implemented to ensure adequate nutrient intake, including iron and other micronutrients, to support optimal growth and development of children. Further examinations are important to assess the child's nutritional status and overall health. This includes measuring iron levels, ferritin, and other hematological parameters. (Table 2. And Table 6.)

In addition to HGB within normal limits, erythrocyte values in this study also showed values within normal limits in both NS, S and SS children (4.75 $10^6$ / µL, 5.24 $10^6$ / µL, and 4.72 $10^6$ / µL). However, erythrocytes in S children were in the upper limit of normal erythrocyte values and showed higher values and were statistically significantly different from NS (p = 0.018). Higher erythrocytes or red blood cells in stunted children compared to normo-stature children can be caused by several things, such as the effect of adaptation to low oxygen levels, dehydration, nutritional factors, or the presence of other diseases/disorders. Children who experience stunting may have lower oxygen levels in their bodies, which can trigger increased erythrocyte production

as an adaptive response. This condition often occurs when there is a disturbance in lung or heart function, which causes the body to try to increase oxygen-carrying capacity by increasing the number of red blood cells (10). In a study conducted by Nuzhat et al in Bangladesh, 43% of children with SS experienced dehydration (11). Dehydration can cause an increase in the concentration of erythrocytes in the blood. In stunted children, inadequate fluid intake can be a contributing factor, so that the ratio between blood volume and red blood cells increases. Hydration status affects hemoglobin and hematocrit equally. Patients with excess fluid in their blood will experience a decrease in hematocrit and hemoglobin values, while patients with fluid loss will experience an increase in hematocrit and hemoglobin values. (12)This is in line with the results of the examination in this study. In addition to higher erythrocytes in stunted children, HGB and HCT values in stunted children are higher than in NS children, which increases the possibility of dehydration in stunted children. Dehydration can occur due to low drinking habits in children, difficult access to clean water, or poor sanitation (1, 6, 13, 14). Prolonged nutritional deficiencies can cause an imbalance in red blood cell production. Although anemia is often associated with stunting, some children may experience an increase in the number of red blood cells in response to deficiencies in certain nutrients, such as vitamin B12 or iron, which are essential for the formation of red blood cells (5, 15)Stunted children may be more susceptible to certain diseases that can affect red blood cell production. For example, repeated infections or chronic diseases can stimulate the bone marrow to produce more red blood cells in response to the body's needs. (5, 10)

## Conclusion

The study findings showed lower MCV, MCH, and MCHC in boys, indicate possible microcytic hypochromic anemia, often associated with iron deficiency or iron metabolism disorders. This condition may also reflect chronic nutritional problems or infections that affect red blood cell formation. Similarly, low HGB and higher HCT and erythrocytes in SS girls indicated possible anemia and dehydration.

## Reference

1. Manalu SMH, Syaputri D, Tanjung N, Tanjung R, Damanik AP. The Effect of Clean Water Facilities and Household Food Sanitation Hygiene on Stunting in Toddlers. Contagion: Scientific Periodical Journal of Public Health and Coastal Health. 2023;5(3):969-78.
2. Suciyanti D, Wangge G, Iskandar E, Fahmida U, Supali T. Social determinants and access to Water-Sanitation-Hygiene as dominant risk factors of stunting among under-five children in rural area of East Indonesia. 2021.
3. Yusigania D, Dewanti L, Suryawan A. Food Intake, Infectious Disease, and Environmental Sanitation in Toddlers Aged 6-24 Months in Cibatu Health Center, Garut.
4. Yao M, Li L, Yang M, Wu Y, Cheng F. Household air pollution and childhood stunting in China: A prospective cohort study. Frontiers in Public Health. 2022;10:985786.

5. Purnami GM, Praba KD, Fauziah IL, Dewi MM, Judistiani RTD, Setiabudiawan B. Anemia Prevalence, Characteristics, and Hematological Profile among Stunted Children Under 2 Years Old in Bandung Regency, Indonesia. Journal of Child Science. 2023;13(01):e75-e84.
6. Kothari MT, Coile A, Huestis A, Pullum T, Garrett D, Engmann C. Exploring associations between water, sanitation, and anemia through 47 nationally representative demographic and health surveys. Annals of the New York Academy of Sciences. 2019;1450(1):249-67.
7. Akram HE, Al-Warid HS. Evaluation of hematological factors and micronutrients among children infected with Enterobius vermicularis. Iraqi Journal of Science. 2023:1625-34.
8. Savarino G, Corsello A, Corsello G. Macronutrient balance and micronutrient amounts through growth and development. Italian journal of pediatrics. 2021;47(1):109.
9. Syabariyah S, Anesti R, Nurhaliza A, Sari WP, Rahmanilah R. Health Education Mentoring on Sadar Seimbang Nutrisi (SSN) and The Dangers of Anemia through Student Empowerment Movements with Examination of Hematology (Hemoglobin Hematocrit) in Vocational High School and Junior High School AsSyarief Garut for Mountainous Area Community. ABDIMAS: Jurnal Pengabdian Masyarakat. 2021;4(2):606-11.
10. Nisa K, Islami S, Listiyaningsih E, Arisandi R, Nurhaniefah AA. Comparison of Red Blood Cell Parameters as Metabolic Indicator in Stunted and Nonstunted Children. International Journal of Nutrition, Pharmacology, Neurological Diseases. 2024;14(2):213-9.
11. Nuzhat S, Shahunja K, Shahid AS, Khan SH, Islam SB, Islam MR, et al. Diarrhoeal children with concurrent severe wasting and stunting compared to severe wasting or severe stunting. Tropical Medicine & International Health. 2020;25(8):928-35.
12. Hayuanta HH. Can hemoglobin-hematocrit relationship be used to assess hydration status? Cermin Dunia Kedokteran. 2016;43(2):139-42.
13. Bottin JH, Morin C, Guelinckx I, Perrier ET. Hydration in children: what do we know and why does it matter? Annals of Nutrition and Metabolism. 2019;74(Suppl. 3):11-8.
14. Torlesse H, Cronin AA, Sebayang SK, Nandy R. Determinants of stunting in Indonesian children: evidence from a cross-sectional survey indicate a prominent role for the water, sanitation and hygiene sector in stunting reduction. BMC public health. 2016;16:1-11.
15. Fadhilah S, Astuti DW, Dewi EU, Muhajir NF. Stunting Case Study In Grogol Bejiharjo Karangmojo Gunungkidul DI Yogyakarta, Indonesia Based On Routine Blood Examination. Jurnal eduhealth. 2022;13(02):1153-7.