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ORIGINAL RESEARCH

# The Correlation of Calcium and Hemoglobin Level Among Pregnant Women in ≥35 Weeks with the Anthropometry of Newborn Babies

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**Background:** Low birth length and low birth weight can be caused by nutritional deficiencies in pregnant women, including calcium and iron deficiency anemia because it retards fetal growth during pregnancy. This study aimed to explore the correlation between calcium and hemoglobin levels in third-trimester pregnant women with anthropometry of newborn babies.

**Methods:** This study employed a prospective cohort design, including 120 third-trimester among pregnant women in ≥35 weeks and their newborn aterm babies, using a convenience sampling technique. This study was conducted in March–May 2024. Data on complete blood count tests and calcium levels of the mothers were collected, and anthropometry of newborn including birth length and birth weight was measured. Data were analyzed using univariate, bivariate, and multivariate analysis.

**Results:** The mean maternal calcium and hemoglobin levels were 2.19 mmol/L (sd 0.135) and 11.55 gr/dL (sd 1.187), respectively. The mean birth weight and median birth length were 3.02 kg (sd 0.374) and newborn's length 48.29 (sd 1.86), respectively. There was a positive correlation between calcium levels ($p=0.007$; $r=0.246$), as well as between hemoglobin levels ($p=0.006$; $r=0.25$) of pregnant women and the length of newborn babies. Furthermore, hemoglobin level was also correlated with the weight the newborns ($p=0.001$; $r=0.29$).

**Conclusion:** Low calcium level and low hemoglobin level among pregnant women in third trimester tend to have short-born babies. In addition, low hemoglobin level is more likely to have low birth weight. Therefore, it is necessary to monitor the provision of calcium and iron supplements as an alternative, after prioritizing the consumption of natural foods.

**Keywords:** birth length, birth weight, calcium, hemoglobin, iron

## Introduction

Infant Mortality Rate (IMR) is a crucial gauge of public health achievement, reflecting the overall health status within a community. Lowering IMR requires critical preventive interventions during the First 1000 Days of Life (HPK) period from pregnancy until the age of two. If there is a growth disorder during this period, it will affect babies' growth and development, both physically and intellectually, in a serious and irreversible manner.[1] Indicators used to assess pregnancy outcomes in babies born are through birth anthropometry, including birth weight and length. Birth weight and length based on gestational age have been recognized as the most powerful predictors in assessing pregnancy outcomes.[2]

Body weight is an anthropometric measurement to diagnose whether a baby is of normal weight or classified as low birth weight (LBW). According to the World Health Organization (WHO) in 2015, the global prevalence of LBW in the world reached (14.6%).[3] The prevalence in Asia is (17.3%), Africa is (13.7%), Oceania is (9.9%), and Regional



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Developed Countries is (7.2%).[4] Babies with LBW have a higher risk of developing cerebral palsy, mental retardation, neurological defects, and lung disease. The long-term impact is long-term neurological disability, developmental language disorder, cognitive disorder, and an increased risk of chronic diseases including cardiovascular disease, diabetes, as well as a 20 times greater risk of death compared to normal-born babies.[5]

Birth length is considered short if the length is less than 48 cm.[6] Low birth length indicates that there is a disorder of linear growth related to the growth of bone mass.[7] Increased bone mass will follow an increase in body length and affect weight gain, including tissue growth. According to research, babies born with short length can affect babies under two years who experience stunting because there is a body disorder (growth faltering) from an early age, which results in non-optimized growth; thus, short-born babies have an impact on stunting of babies under two years old.[8]

Factors that have been predicted to cause fetal growth disorders are genetic, environmental, maternal nutrition, and placental function. Environmental and nutritional factors can alter gene expression patterns in influencing fetal growth. Placenta function becomes a factor that contributes as a significant influence on fetal growth due to its function as a nutrient transport to the fetus. If the mother lacks both macronutrients and micronutrients, it is proven to interfere with the transfer of nutrients from the placenta to the fetus, which can inhibit fetal growth. Other external factors that influence fetal growth include maternal education and age, body mass index (BMI) and parity.[9]

Calcium is a micronutrient that plays an important role in various processes, such as bone formation, maternal metabolism, muscle contraction, nervous system transmission, enzymatic activity, and hormonal function.[10] An increase in calcium transfer from mother to fetus occurs in the third trimester, due to the there is an increase in the production of parathyroid hormone that plays a role in increase calcium absorption from the intestine and stimulate calcium release from the mother's bones to meet the needs of the fetus.[11] Pregnant women who experience calcium deficiency can cause stunted fetal growth, one of which is a low birth length.[12] Similarly, iron is the main nutrient in the formation of hemoglobin. Iron deficiency can cause pregnant women to experience anemia.[13] Similar to calcium, pregnant women with anemia can give birth to babies with low birth length and experience growth faltering, leading to stunted children[8] Growth and development disorders both physically and intellectually during this period are persistent. Therefore, it is crucial to have a deep understanding about the correlation of calcium and hemoglobin levels with the length of the baby's body at birth and the baby's weight at birth as an effort to prevent stunting.

## Material and Methods

The research design employed a prospective cohort. A total of 120 pregnant women with 35–42 weeks who had received antenatal care checks at five health centers in the Kulon Progo Regency area were included with a convenience sampling technique. This study was conducted from March to May 2024. The initial data collection, conducted over three months at two health centers, yielded an insufficient sample. Consequently, further data collection was carried out, expanding the study to include three additional health centers until a sufficient sample size was achieved. This study was approved by the Research Ethics Committee of Padjadjaran University, Bandung No: 200/UN6.KEP/EC/2024 and complies with the Declaration of Helsinki.

The participants were pregnant women who met the inclusion criteria, which were single pregnancy, gestational age ≥35 weeks, had regular antenatal care checks, had a mother and child health book, and were willing to have their blood drawn. Newborn babies inclusion criteria were live-born babies and born aterm ≥37 weeks. Exclusion criteria were a history of low birth weight delivery, Intrauterine Growth Restriction (IUGR), chronic diseases, and malignancies such as diabetes mellitus, hypertension, preeclampsia/eclampsia, thyroid disorders, heart, parathyroid, kidney, liver, cancer/tumor, uterine cervical abnormalities, taking drugs or alcohol, and babies born with physical disabilities that affect body length measurements. The sample size was determined as follows: through the correlation value (r) from previous research literature, which is 0.278, alpha value of 1.64 and beta value of 1.28, and the sample size was calculated using the sample size formula for numerical correlation. Respondents provided their informed consent before data collection. Before the respondents gave their consent, they were informed about the purpose of the study, procedures, potential risks, and benefits. Respondents were also informed that the study was voluntary and that failure to participate or withdraw from the study was allowed without any penalty.

Venous blood samples were drawn into 5 mL EDTA tube and a 3 mL SST tube, were taken for complete blood count (CBC) examination (Sysmex XP 100), a calcium level. Haemoglobin values for anemia in pregnancy were determined based on the World Health Organization (WHO) classification of anemia in pregnant women, namely normal (≥11.0 gr/dL), mild anemia (10.0–10.9 gr/dL), moderate anemia (7.0–9.9 gr/dL), and severe anemia (≤7.0 gr/dL).[14] Then, 2 mL of blood was centrifuged for 15 minutes. Samples were stored at 2–8°C before being transported to Laboratory Installation of Dr Sardjito Hospital, Yogyakarta. Serum was examined for total calcium using an Automatic Chemistry Analyzer (Cobas Pro C503, Rotkreuz, Swiss). The total blood calcium cutoff was used and categorized as normal (2.15–-2.50 mmol/L), hypocalcemia (≤2.15 mmol/L), and hypercalcemia (≥2.50 mmol/L). The weight and length were measured using a calibrated baby scale. The birth weight was categorized as normal (2,5–4 kg), low birth weight (<2.5 kg), and high birth weight (>4 kg). Birth length was categorized as normal (≥48 cm) and low birth length (<48 cm).

The characteristics of pregnant women were recorded, including the age of pregnant women categorized into non-risk (20–35 years) and risk (<20 years and >35 years). Furthermore, the history of BMI before pregnancy was asked to assess the nutritional status of the mother. Other characteristics asked were last education and the gravida status (primigravida or multigravida) to explore any experience of the mother in caring for her pregnancy.

Data were collected into paper-based forms and inputted into pre-designed data sheets. Demographic and clinical characteristics of pregnant women were described and presented in frequency form. The characteristics were explored for significant associations with newborn length and weight using Pearson correlation test, Spearman rank test for numerical data. Chi-square test was used for categorical data with p value < 0.05 and 95% confidence interval (CI). Bivariate analysis between calcium levels and haemoglobin levels with length and birth weight used Pearson correlation test with p value <0.05 and multivariate analysis used multiple linear regression test. The collected data were processed and analyzed using the SPSS version 25.0 program.

# Results

## Characteristics of the Mothers and the Newborn Babies

In total, most (84.2%) pregnant women included were in the non-risk age category (20–35 yo) median age 29 years old range 18–45 years old. The nutritional status of these pregnant women based on pre-pregnant BMI was mostly normal (18.5–24.9 kg/m$^2$) was 55%; although obesity (>24.9 kg/m$^2$) was prevalent (32.5%) with mean 29.46 kg/m$^2$. Maternal education was mostly middle-educated (60.8%) with multigravida (66.7%).

The result revealed that the pre-pregnancy BMI was significantly associated with the newborn baby's birth length (p = 0.005), whereas other characteristics were not significant (Table 1). Interestingly, maternal age (p = 0.014) and gravidity (p = 0.048) were associated with newborn birth weight. The median baby's body length was 48 cm (range 42–53 cm) as shown in Table 1, and the mean baby birth weight was 3.02 kg (SD 1.86).

## A Comparison of Third Trimester Pregnant Women's Characteristics Based on Length and Birth Weight of Newborns

The prevalence of low birth weight newborns was significantly higher among mothers with primary education (p=0.009). Additionally, there was a higher prevalence of low birth length among hypocalcemic (p<0.001) and anemic (p=0.021) pregnant women, as depicted in Table 2.

## Correlation of Calcium Levels of Third Trimester Pregnant Women with Newborn Anthropometry

The average calcium level was 2.19 mmol/L (SD 0.135). There was a positive correlation between calcium levels of third-trimester pregnant women and the length of the body length of the newborn (*p-value* = 0.007; *r* = 0.246), suggesting that the higher the calcium levels of third-trimester pregnant women, the longer the body length of the newborn, as depicted in Figure 1. In contrast to previous results, there was no correlation between calcium levels of third-trimester pregnant women and newborn weight (p-value = 0.960) (data not shown).

**Table 1** Characteristics of the Mothers and Their Born-Baby Participating in the Study

| Variables | Total | | Mean (sd) | Median (Range) |
|---|---|---|---|---|
| | n | % | | |
| **Mother:** | | | | |
| Mother's age (years) | | | | 29 (18–45) |
| Not Risky (20–35 yo) | 101 | 84.2 | | |
| Risky (<20 and >35 yo) | 19 | 15.8 | | |
| **BMI Pre Pregnant** | | | | |
| BMI Pre Pregnancy (kg/m$^{2}$) | | | | 22.97 (15–38.11) |
| Underweight (<18.5) | 15 | 12.5 | 17.26 (0.96) | |
| Normal (18.5–24.9) | 66 | 55 | 21.67 (2.03) | |
| Obese (>24.9) | 39 | 32.5 | 29.46 (3.39) | |
| **Gravida** | | | | |
| Primigravida | 40 | 33.3 | | |
| Multigravida | 80 | 66.7 | | |
| **Calcium Level** | | | | |
| Calcium Level (mmol/L) | | | 2.19 (0.135) | |
| Normal (≥2.15 mmol/L) | 73 | 60.8 | 2.27 (0.09) | |
| Hypocalcemia (<2.15 mmol/L) | 47 | 39.2 | 2.06 (0.06) | |
| **Anemic Status** | | | | |
| Hemoglobin Level (gr/dL) | | | 11.55 (1.187) | |
| Normal (>11 gr/dL) | 88 | 73.3 | 12.06 (0.85) | |
| Anemia: | 32 | 26.7 | 10.13 (0.74) | |
| Mild Anemia (10.9–9 gr/dL) | 30 | 25 | 10.26 (0.52) | |
| Severe Anemia (7–8.9 gr/dL) | 2 | 1.7 | 8.05 (0.21) | |
| **Education** | | | | |
| Primary | 17 | 14.2 | | |
| Middle School | 73 | 60.8 | | |
| University | 30 | 25 | | |
| **Newborn:** | | | | |
| **Body Length** | | | | |
| Newborn's Length (cm) | | | 48.29 (1.86) | 48 (42–53) |
| Normal (≥48 cm) | 73 | 60.8 | 49.38 (1.31) | |
| LBL (<48 cm) | 47 | 39.2 | 46.51 (1.05) | |
| **Body Weight** | | | | |
| Newborn's Weight (kg) | | | 3.02 (0.374) | |
| Normal (≥2.5 kg) | 115 | 95.8 | 3.05 (0.35) | |
| LBW (<2.5 kg) | 5 | 4.2 | 2.28 (0.25) | |

**Notes**: Kolmogorov–Smirnov test, normally distributed data (p>0,05) using mean and standard deviation (SD), data does not normally distribute (p<0,05) with median and range.
**Abbreviations**: LBW, low birth weight; LBL, low birth length; BMI, body mass index.

## Correlation of Hemoglobin Levels of Third Trimester Pregnant Women with Newborn Anthropometry

The average hemoglobin level was 11.55 mg/dL (sd 1.18). There was a positive correlation between the hemoglobin level of pregnant women in the third trimester and the body length of the newborn (p-value = 0.006; $r$ = 0.250), suggesting that the higher the hemoglobin level of pregnant women in the third trimester, the more the newborn's weight increases, as depictable in Figure 1. There was a positive correlation between hemoglobin levels of third-trimester pregnant women and newborn weight (p-value = 0.001; $r$ = 0.290), suggesting that the higher the hemoglobin level of third-trimester pregnant women, the greater the birth weight of the newborn, as depicted in Figure 1.

**Table 2** Comparison of Characteristics of Third Trimester Pregnant Women based on Length and Weight of Newborn

| Variables | Birth Length | | | | p-value | Birth Weight | | | | p-value |
|---|---|---|---|---|---|---|---|---|---|---|
| | Normal | | LBL | | | Normal | | LBW | | |
| | n | % | n | % | | n | % | n | % | |
| **Mother:** | | | | | | | | | | |
| **Age** | | | | | | | | | | |
| Not Risky | 60 | 59.4 | 41 | 40.6 | 0.63[a] | 98 | 97 | 3 | 3 | 0.177[b] |
| Risky | 13 | 68.4 | 6 | 31.6 | | 17 | 89.5 | 2 | 10.5 | |
| **BMI Pre Pregnant** | | | | | | | | | | |
| Underweight | 5 | 33.3 | 10 | 66.7 | 0.063[a] | 14 | 93.3 | 1 | 6.7 | 0.271[a] |
| Normal | 42 | 63.6 | 24 | 36.4 | | 65 | 98.5 | 1 | 1.5 | |
| Obese | 26 | 66.7 | 13 | 33.3 | | 36 | 92.3 | 3 | 7.7 | |
| **Education** | | | | | | | | | | |
| Primary | 11 | 64.7 | 6 | 35.3 | 0.185[a] | 14 | 82.4 | 3 | 17.6 | 0.009[a]* |
| Middle School | 48 | 65.8 | 25 | 34.2 | | 71 | 97.3 | 2 | 2.7 | |
| High School | 14 | 46.7 | 16 | 53.3 | | 30 | 100 | 0 | 0 | |
| **Gravida** | | | | | | | | | | |
| Primigravida | 23 | 57.5 | 17 | 42.5 | 0.741[a] | 38 | 95 | 2 | 5 | 1[b] |
| Multigravida | 50 | 62.5 | 30 | 37.5 | | 77 | 96,3 | 3 | 3,8 | |
| **Calcium Level** | | | | | | | | | | |
| Normal | 55 | 75.3 | 18 | 24.7 | <0.001[a]* | 73 | 100 | 0 | 0 | 0.008[b]* |
| Hypocalcemia | 18 | 38.3 | 29 | 61.7 | | 42 | 89.4 | 5 | 10.6 | |
| **Anemic Status** | | | | | | | | | | |
| Normal | 58 | 65.9 | 30 | 34.1 | 0.093[a] | 87 | 98.9 | 1 | 1.1 | 0.018[b]* |
| Anemia: | 15 | 46.9 | 17 | 53.1 | | 28 | 87.5 | 4 | 12.5 | |
| Mild Anemia | 15 | 50 | 15 | 50 | | 26 | 86.7 | 4 | 13.3 | |
| Severe Anemia | 0 | 0 | 2 | 100 | | 2 | 100 | 0 | 0 | |

**Notes**: [a]Chi-square test, significant data p<0.05; [b]Fisher Exact test *significant <0,05.
**Abbreviations**: LBW, low birth weight; LBL, low birth length; BMI, body mass index.

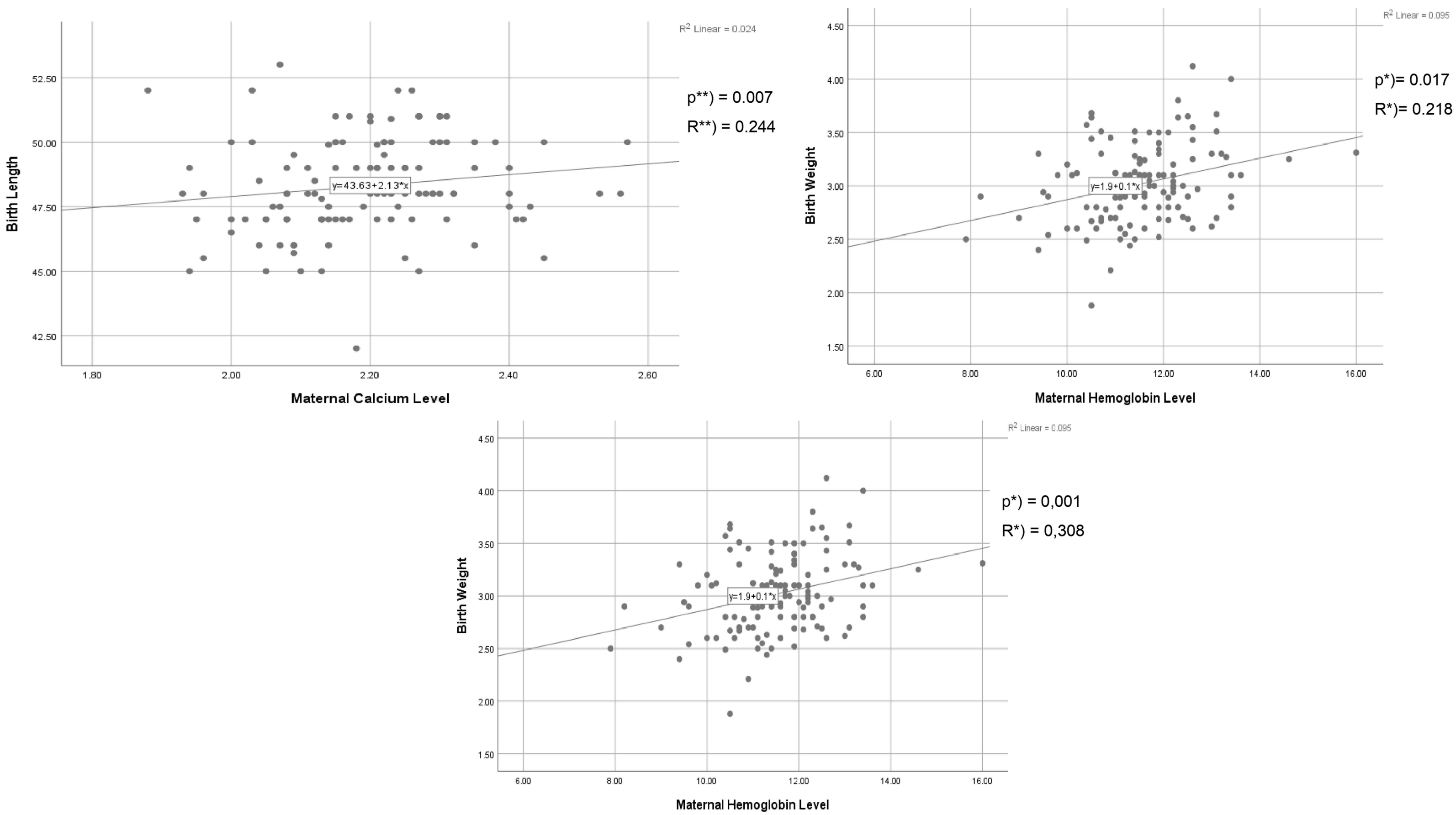
## Analysis of the Relationship Between Various Variables Based on Anthropometry of Newborn

The regression coefficient analyses of pre-pregnancy maternal BMI, maternal education, maternal hemoglobin level, and maternal calcium level ($p<0.25$). It was found that the variable most strongly associated with birth length was maternal hemoglobin level ($\beta=0.38$; $p=0.008$). Meanwhile, the variable that was strongly associated with birth weight was maternal hemoglobin ($\beta=0.096$; $p=0.001$).

# Discussion

This study explored the correlation between calcium levels and haemoglobin levels in third trimester pregnant women with newborn anthropometry, especially in the length and weight of newborns. Some mothers experienced hypocalcemia (39.2%). Factors that cause hypocalcemia in pregnant women might be the lack of calcium intake from the food consumed by the mother, the natural aging process with increasing parity, kidney failure disease, thyroid disorders, vitamin D deficiency, and consumption of certain drugs[15,16] Unfortunately, maternal illness and maternal calcium intake have not been studied further in this study.

There is a relationship between calcium levels of third trimester pregnant women and newborn length, indicating that the higher the calcium levels of third trimester pregnant women, the longer the newborn length, although the strength of the correlation is weak. Similar research was conducted by other studies.[17,18] This study shows that calcium levels during pregnancy affect the growth of fetal bone size, which impacts birth length. Low maternal calcium levels can increase




Note: *) Pearson Correlation test (data is normally distributed); **) Rank Spearman test (data is not normally distributed)

**Figure 1** The Correlation between Maternal Calcium Level and Maternal Hemoglobin Level at Third Trimester with The Anthropometry of Newborn Babies.

parathyroid and fetal peptides, resulting in poor bone mineralization.[17,19] The cause of poor bone mineralization in the fetus is multifactorial, one of which is the lack of micronutrient intake.[16] Calcium and iron are micronutrients, they interact to support baby's growth and development. Adequate calcium supports healthy bones and the nervous system, while hemoglobin ensures adequate oxygen distribution for the overall growth of body cells. Both support optimal baby body size at birth, including birth weight and length. The BMI of pregnant women before pregnancy was studied as an indicator to assess the nutritional status of pregnant women. In this study, it is proven that mothers who gave birth to short babies came from mothers who had BMI before pregnancy at underweight (66.7%). Neonatal birth growth parameters are associated with maternal BMI before pregnancy.[20] Good maternal nutritional health is essential to provide adequate nutrition for fetal development. Optimal maternal nutrition plays a role in regulating fetal metabolic pathways and influencing the fetal programming. This can affect the size of the baby at birth, either in terms of a large baby due to maternal obesity, or a small baby due to maternal chronic malnutrition.[21,22]

Pregnant malnourished women may become anemic. Anemia in pregnancy affects the growth and development of the fetus so that it can have a negative impact on the baby who is born. Neonates born to anemic mothers have a lower birth weight than non-anemic mothers.[23] Therefore, the various factors that cause anemia are social, demographic, and behavioral, such as gestational age, pregnancy spacing, diet and drinking patterns, and level of knowledge.[24] Age is one of the causes of anemia and susceptibility to chronic diseases because as the mother gets older, the quality of eggs begins to decline and can increase the risk of pregnancy including fetal growth.[21,23,24] Education affects the risk of anemia through knowledge and dietary habits. Mothers with good nutritional knowledge are more likely to take iron supplements, thus reducing the incidence of anemia, especially in mothers with higher education. A person's level of education also affects their ability to receive information more easily.[13,24]

This study has shown a correlation between hemoglobin levels in pregnant women and the length and weight of newborns. Changes in blood vessels in the placenta occur due to low hemoglobin levels, limiting the supply of oxygen to the fetus so that it can inhibit its growth in the womb. Hemoglobin is instrumental in distributing oxygen and nutrients from mother to fetus through the placenta.[25–27] The result of stunted fetal growth can affect anthropometric measurements in newborns, such as short babies and low birth weight.[28]

Efforts to prevent and treat micronutrient deficiencies in pregnant women so as to reduce the adverse effects on newborns include micronutrient supplementation for pregnant women, and food diversification that can be developed and promoted through education and dissemination of food-based dietary guidelines.[29] In addition, biofortification of staple crops, such as maize, beans, rice, and large-scale food fortification.[30] As for innovations that need to be developed and implemented, one of them as in the research[31] is chicken liver and eggshell crackers as a safe and affordable source of animal food and able to increase birth length and linear growth of infants.

This study is subject to several limitations. It did not investigate maternal calcium and iron intake during pregnancy, nor did it examine changes in calcium and hemoglobin levels over the course of pregnancy or assess these levels in newborns. The researchers propose conducting more comprehensive examinations of both mothers and newborns, as well as increasing sample sizes to enhance the statistical quality of the results.

## Conclusion

This study shows that low calcium levels in pregnant women in the third trimester are associated with giving birth to babies with low birth length. In addition, women who experience low calcium levels and anemia tend to give birth to babies with low body weight. Therefore, it is necessary to monitor the provision of calcium and iron supplements as an alternative next to efforts in consuming natural foods.

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## Disclosure

The authors report no conflicts of interest in this work.

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