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**Determinants of birth weight and length: an analysis of the 2020 mothers' cohort register data**

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## **Abstract**

A woman's nutritional status significantly impacts the qualities of the baby she delivers, as assessed by the baby's weight and length at birth. This study aimed to identify factors influencing birth weight and length using a retrospective case-control design with secondary data collected from the mothers' cohort register at the Community Health Center in 2020-2021. The study included 100 samples, comprising 25 cases and 75 controls. Several determinants of

birth weight and length were examined: the mother's age (OR=4.1, 95% CI 1.41-12.0), weight gain during pregnancy (OR=3.6, 95% CI 1.051-12.553), mid-upper arm circumference (OR=2.9, 95% CI 1.061-8.220), hemoglobin level (OR=4.711, 95% CI 1.57-14.11), and iron supplement intake (OR=1.837, 95% CI 0.600-5.624), with hemoglobin level identified as the most influential factor on birth qualities. Mothers with less than normal hemoglobin levels have a 4.7 times higher risk of delivering babies of lower weight and length than mothers with normal hemoglobin levels. The impact of low hemoglobin in pregnant women includes reduced oxygen supply for both the mother and fetus, resulting in low birth weight, child anemia, premature birth, and child mortality. Given these significant effects, it is crucial to establish standards for health services in Indonesia, ensuring that pregnant women with low hemoglobin receive comprehensive care aligned with Indonesia's Sustainable Development Goals (SDGs) standards.

## **Introduction**

A woman's nutritional status significantly impacts the health of the child she gives birth to. For instance, a woman's well-being during pregnancy influences the newborn's health. Conversely, poor nutritional status in pregnant women increases the risk of delivering babies with low birth weight.<sup>1,2</sup> The health outcomes of babies can be assessed based on their body weight and length at birth. Healthy newborns typically weigh  $\geq 2500$  grams and have a body length  $\geq 48$  cm, falling within  $> -2$  SD and  $< 2$  SD. Babies with birth weights  $< 2500$  grams are considered Low Birth Weight (LBW), and those with body lengths  $< 48$  cm are classified as stunted (short).<sup>3-5</sup>

LBW remains a global problem, especially in developing countries. The worldwide incidence of LBW is 15.5%, meaning that out of 20.6 million births, 3.2 million babies are born with

LBW every year. A significant majority, 96.5%, of these cases occur in developing countries.<sup>6</sup>

LBW is a leading cause of neonatal mortality in Indonesia, with a prevalence rate of 6.2%.<sup>7</sup>

According to Open Data Jabar, in 2021, the prevalence of LBW in West Java was 96.5%, with Banjar City having the highest rate (21%) and Bekasi the lowest (0.5%).<sup>8</sup>

The 2022 Indonesian Nutrition Status Survey reported a national prevalence of stunting at 21.6%.<sup>9</sup> The Asian Development Bank (ADB) reveals that Indonesia has the second-highest prevalence of stunted children under five years old (toddlers) in Southeast Asia, reaching 31.8% in 2020. This figure surpasses stunting rates in Laos (30.2%), Cambodia (29.9%), and the Philippines (28.7%).<sup>10</sup> The 2018 Basic Health Research results show that 22.7% of babies born are classified as short, with a length <48 cm. This represents an increase from 2013 (20.2%),<sup>7</sup> while the prevalence of babies born with a weight <2500 grams was 6.2%.<sup>11</sup>

Monitoring infant growth and development in the first 1000 days of life is crucial for preventing LBW and stunting. The first 1000 days span from the early stages of life in the womb until the first 2 years of life.<sup>12</sup> During this period, children are at a high risk of malnutrition, and disruptions can have lasting effects on growth and development.<sup>13</sup> The nutritional status and food intake of pregnant women during these 1000 days significantly influence the qualities of the baby. Research by Retni (2016)<sup>14</sup> indicates that low energy, protein, folic acid, and iron intake in teenage pregnant women is a risk factor for giving birth to an LBW baby. Low protein and folic acid intake in pregnant women create a 13-times greater risk of delivering an LBW baby, low energy intake has a six-times greater risk, and low iron intake has a four-times greater risk.<sup>15</sup> Woldeamanuel *et al.* (2019)<sup>16</sup> demonstrated that the nutritional status of pregnant women, as assessed through anthropometry and hemoglobin levels, correlates with the birth

weight of the baby. Therefore, maintaining good nutritional status and intake during pregnancy is crucial for delivering babies in good health.

Monitoring the nutritional status of pregnant women can be achieved through the mothers' cohort register, a valuable data source for pregnancy and maternity services that describes the mother's condition or risks. The mothers' cohort register benefits by helping determine the prognosis of diseases or events related to the mother's pregnancy, allowing immediate intervention measures. Nutritional indicators in the mothers' cohort register include the mother's weight and height measurement, weight gain during pregnancy, hemoglobin level, upper arm circumference measurement, blood pressure, consumption of iron supplement tablets, age, and blood pressure measurement. Therefore, this study aimed to determine the mother's factors that may affect the health outcomes of babies.

The findings of this study will provide a comprehensive overview for developing policies related to health monitoring systems for expectant mothers and their newborns at various levels, including hospitals, community health centers, and families. The national Ministry of Health guidelines recommend a system for monitoring babies, recognizing issues, especially warning signs, and referring patients to the appropriate healthcare professionals if a baby or pregnant woman has a health issue. The achievement of Sustainable Development Goals (SDGs) will be impacted positively by this policy.

## **Materials and Methods**

### ***Research design***

This study adopted a retrospective design, collecting secondary data where outcomes occurred, with a sequential variable tracing direction initiated from the independent variable. The

secondary data were sourced from the mothers' cohort registers at the Community Health Center in Cimahi City, Indonesia, spanning from 2020 to 2021. Employing an observational approach, the research utilized a case-control design to compare groups and ascertain event proportions based on exposure history. The study encompassed the entire population of pregnant women who underwent pregnancy checks and were recorded in the mothers' cohort register. Inclusion criteria for both case and control groups stipulated registration in the mothers' cohort register between 2020 and 2021, availability of birth data, including weight and length, attendance at pregnancy checks at least four times, and a normal birth record. Exclusion criteria comprised records of multiple pregnancies, chronic illnesses such as gestational diabetes mellitus or Human Immunodeficiency Virus (HIV), or pregnancy disorders like severe pre-eclampsia.

### ***Sample size determination***

The sample size was determined using the Sastroasmoro formula (2011)<sup>17</sup> for case-control research. Each case and control group comprised 50 individuals, selected through sample calculation results. However, as only 25 cases were obtained, the total sample size was recalculated using a 1:3 case-to-control ratio, resulting in a total of 25 cases and 75 controls.

Sample size formula:

$$n = \frac{\{ 1,96 \sqrt{1 + \frac{1}{c} \times \rho\phi(rata2) + z\beta \sqrt{(\rho1\phi1 + \rho0\phi0)}} \} / c^2}{(\rho1 - \rho0)^2}$$

Remarks:

n, number of research samples

R, two-times greater risk of LBW deviation

$\alpha$ , the alpha standard variate (5%) is 1.960

$z_{\beta}$ , the standard beta deviate/estimated error (10%) is 1.282  
 $p_0$ , the proportion of exposure among controls (3.19%) of 0.03  
 $q_0$ ,  $1-P=1-0.03=0.97$   
 $p_1$ ,  $(p_0 \times R)/(1+p_0(R-1))=0.058$   
 $q_1$ ,  $1-p_1=0.94$   
 $C$ , number of controls =3

### ***Data collection***

Data collection commenced after receiving research permission from the Educational Institution and the Ethics Commission. Secondary data on pregnant women's examination records at the Community Health Center in Cimahi City from January 2020 to April 2021 were gathered from the cohort register. A questionnaire was employed to collect pregnant women's data, focusing on birth weight and length, with infants categorized into case or control groups based on their normalcy. Additionally, maternal monitoring records during pregnancy were examined, comprising seven variables, including the mother's age, weight gain during pregnancy, blood pressure, hemoglobin levels, iron supplement tablet consumption, height, and upper arm circumference.

### ***Variables and instruments***

The dependent variable in this study were the qualities of the newborn, assessed by the birth weight and length of the baby. Independent variables included the mother's age, weight gain during pregnancy, height, mid-upper arm circumference, blood pressure, hemoglobin levels, and iron supplement tablet intake.

The instrument used for data collection was a questionnaire of pregnant women's data. Data collection commenced by examining infant birth data, specifically birth weight and length. Infants with below-normal length and/or weight were categorized into the case group, while



those with normal length and weight were placed in the control group. The qualities of the newborn variable was categorized into good and poor health. Birth weight and length measurements were compared with World Health Organization (WHO) standards, with poor health defined as birth weight <2500 grams and/or body length <48 cm, and good health as body weight  $\geq$ 2500 grams and body length  $\geq$ 48 cm.

Furthermore, maternal monitoring records during pregnancy, serving as independent variables, were examined at least four times, with data collected monthly. These records included seven variables: mother's age (considered high risk if the mother's age was <20 years or >35 years and low risk if the mother was 20-35 years old), weight gain during pregnancy (classified as less weight gain if <9 kg and normal weight gain if  $\geq$ 9 kg), mother's height (classified as high risk if <145 cm and normal if  $\geq$ 145 cm), upper arm circumference (classified as indicative of Chronic Energy Deficiency, CED, if <23.5 cm and non-CED if  $\geq$ 23.5 cm), blood pressure (classified as hypertension if  $\geq$ 140/80 mmHg and normal if <140/80 mmHg), hemoglobin levels (considered anemia if Hb <11 g/dl and no anemia if Hb  $\geq$ 11 g/dl), and iron supplement tablets intake (considered inadequate if <90 tablets were taken during pregnancy and adequate if  $\geq$ 90 tablets were taken).

### ***Data analysis***

Data analysis was performed using SPSS version 20 software, aiming to test the null hypothesis (H<sub>0</sub>) utilizing Chi-Square and Odds Ratio (OR) at a significance level of 5%. Permission to conduct the research was obtained from the Educational Institution and the Ethics Commission, with clarifications sought where necessary due to the use of secondary data.

## **Results**

The sample consisted of 100 pregnant women who underwent examinations at the Community Health Center in Cimahi City, with 25 individuals in the case group and 75 in the control group. Table 1 presents factors contributing to the qualities of babies born at the Community Health Center. The data indicate that among mothers classified as high risk due to age, the majority of newborns were classified as of poor health (36.0%). Additionally, 24.0% of newborns born to mothers with less weight gain during pregnancy were categorized as of poor health. Among mothers with a height below 145 cm, 32.0% of newborns fell into the poor health category. Furthermore, newborns born to mothers with CED accounted for 36.0% of the poor health category. In terms of maternal hypertension, 32.0% of newborns were classified as of poor health. Newborns born to mothers with anemia constituted 36.0% of the poor health category. Lastly, among newborns born to mothers with inadequate intake of iron supplement tablets, 24.0% were categorized as of poor health.

Table 2 reveals variables associated with birth qualities, with a p-value <0.05, including mother's age (OR=4.1, 95% CI 1.41-12.0), weight gain during pregnancy (OR=3.6, 95% CI 1.051-12.553), mid-upper arm circumference (OR=2.9, 95% CI 1.061-8.220), hemoglobin level (OR=4.711, 95% CI 1.57-14.11), and iron supplement intake (OR=1.837 95% CI 0.600-5.624). These variables are equally linked to birth qualities, with hemoglobin level emerging as the most influential factor. Mothers delivering babies with hemoglobin levels below the normal threshold (<11g/dL) were 4.7 times more likely to have babies of poor health than mothers with normal hemoglobin levels.

## **Discussion**

Mother's age in high risk is associated with a 4.1 times greater chance of giving birth to children with poor health compared to mothers aged 20-35 years, indicating a significant relationship. These findings align with Manuaba's theory (2012), which identifies high-risk maternal age, specifically <20 years and >35 years, as a factor disrupting the optimization of both mother and fetus.<sup>18</sup> The incidence of diseases during pregnancy is higher in mothers <20 years due to reproductive organ immaturity, leading to potential health risks for both the mother and fetal growth. Additionally, mothers aged >35 years, experiencing reduced fertility and often having cardiovascular diseases, are at risk of LBW. The optimal age for pregnancy is considered to be between 20-35 years.<sup>19,20</sup>

There was a significant association between weight gain during pregnancy and birth qualities, with mothers who gained less than 9 kg during pregnancy being 3.6 times more likely to give birth to children with poor health. This finding aligns with the research of Fabella *et al.* in 2015, which concluded that there is a significant relationship between weight gain during pregnancy and the incidence of LBW.<sup>21</sup> Pregnancy causes increased energy metabolism and other nutrients for fetal growth and development. The nutritional status of pregnant women determines the baby's weight at birth. The nutritional adequacy of pregnant women can be gauged from their weight gain during pregnancy.<sup>22</sup> Low or inappropriate weight gain poses a high risk of delivering LBW babies, emphasizing the importance of appropriate weight gain during pregnancy to reduce this risk.<sup>23</sup>

There is no association between the mother's height and birth qualities. However, it is noteworthy that our research diverges from observational epidemiological studies, which indicate that the mother's height correlates with gestational age at birth and fetal growth measures. Shorter mothers tend to deliver infants at earlier gestational ages with lower birth weight and birth length. Additionally, exploring parental transmission in mother-offspring

pairs allows us to assess the impact of parental Single Nucleotide Polymorphisms (SNPs) associated with height on length and birth weight. This analysis reveals exaggerated differences between maternally and paternally transmitted alleles, with maternally transmitted alleles generally exhibiting a larger effect size than paternally transmitted ones.<sup>24</sup>

Mothers experiencing Chronic Energy Deficiency have a 2.9 times greater chance of giving birth to children with poor health. This finding aligns with Amima's research (2018),<sup>25</sup> which indicates that mothers classified as having Chronic Energy Deficiency face a 6.6 times greater risk of giving birth to LBW infants. According to Ohlsson and Shah (2008),<sup>26</sup> mothers classified as having Chronic Energy Deficiency experience prolonged energy deficiency, even preceding pregnancy. Inadequate nutritional intake during embryo implantation can have detrimental effects on fetal development in subsequent trimesters. For optimal fetal growth and development, mothers require adequate nutritional intake before and during pregnancy. Malnourishment in the mother can impede nutritional fulfillment for the fetus, resulting in obstacles to fetal growth and contributing to low birth weight.<sup>26</sup>

The results revealed no association between blood pressure and birth qualities. This finding contrasts with Moura *et al.*'s research (2021),<sup>27</sup> which asserts that newborns from mothers with hypertension exhibit significantly lower birth weight and head circumference. It is plausible that Moura's study involved samples from different ethnicities. Infants born to mothers with hypertension also showed a higher incidence of necrotizing enterocolitis.<sup>27</sup> However, our study aligns with Jayanti's 2017 research, which found no relationship between systolic and diastolic blood pressure and the incidence of LBW. According to Jayanti, systolic blood pressure is not a risk but a protective factor.<sup>28</sup>

The relationship between hemoglobin levels and birth qualities suggests that pregnant women with hemoglobin levels <11 g/dL have a 4.7-times greater chance of giving birth to children

with poor health. The Confidence Interval (CI) data (1.57-14.11) indicates that the effect of Hemoglobin (Hb) ranges from a minimum of 1.57-times to a maximum of 14.11-times. This finding aligns with Rajashree *et al.* (2015),<sup>29</sup> who reported a relationship between Hb levels and the incidence of LBW. Mothers experiencing anemia have a 4.6-times greater risk of giving birth to LBW infants. The Hb level of pregnant women significantly influences the weight of the newborn. Both high and low hemoglobin levels during pregnancy can lead to impaired fetal growth in the womb. It is crucial for pregnant women to undergo at least four prenatal check-ups, with a focus on checking Hb levels in the first and third trimesters due to blood dilution. This examination helps identify whether the pregnant woman is anemic, as anemia can impact fetal growth and development in the womb.<sup>30,31</sup>

There is a significant relationship between the consumption of iron supplement tablets and birth qualities, and it was found that mothers who consumed fewer than 90 tablets during pregnancy had a 1.8 times greater chance of giving birth to children with poor health. This finding aligns with Aprisia's research (2022), which states that iron supplement tablet consumption during pregnancy is related to the birth weight of the baby, and mothers who consume iron supplement tablets not according to recommendations have the risk of giving birth to LBW babies.<sup>32</sup> According to Basic Health Research (2018), providing iron supplement tablets is one of the important efforts to prevent anemia due to iron and folate deficiency. The Ministry of Health recommends that pregnant women consume a minimum of 90 tablets during pregnancy.<sup>11</sup> Pregnant women are advised to consume more iron intake than when they are not pregnant because, as the time of birth approaches, the iron needs of pregnant women increase. This is because the blood volume needed by pregnant women and fetuses is increasing. Iron deficiency during pregnancy can increase the risk of premature birth and LBW babies.<sup>33</sup>

Pregnant women are encouraged to consume more iron than when not pregnant. Based on the Nutrition Adequacy Rate in 2019, it is recommended that pregnant women consume iron. In 2019, there was no additional need for iron for pregnant women in the first trimester. However, in pregnant women in the second and third trimesters, the additional requirement for iron is 9 mg/day.<sup>34</sup> Additional iron needs during pregnancy are fulfilled by consuming iron supplement tablets.<sup>35</sup> The provision of iron supplement tablets aims to prevent and overcome anemia due to iron deficiency in pregnant women, which is one of the factors causing LBW. This indicates that the provision of iron supplement tablets to pregnant women is indirectly related to the occurrence of LBW.<sup>33</sup>

The limitations of this study include incomplete data and necessitating contact with the intended respondents. Additionally, the researcher encountered difficulty in obtaining the targeted number of case groups, which should have amounted to 50 samples; however, only 25 were obtained.

## **Conclusions**

The mother's age, Hb level, upper arm circumference, weight gain, and the consumption of iron supplement tablets are factors associated with birth weight and length. There is a greater risk for mothers giving birth with lower-than-normal hemoglobin levels. Based on this research, it is recommended that midwives enhance the early detection of pregnancy risk factors through Antenatal Care (ANC) and maternal cohort registers. Additionally, midwives should take proactive measures and closely monitor high-risk mothers to prevent the birth of babies with poor health. Considering the significant impact of low hemoglobin levels, it should be standard practice for health services in Indonesia to provide comprehensive care for pregnant women with low hemoglobin levels, aligning with Indonesia's SDGs standards.

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**Table 1.** Risk factors distribution for newborns' health (N=100).

Independent variables	Newborns' health				Total	
	Poor health (BW<2500 gr and/or BL <48 cm)		Good health (BW ≥2500 gr and BL ≥48cm cm)			
	n	%	n	%	n	%
<b>Mother's age</b>						
High risk	9	36.0	9	12.0	18	18.0
Low risk	16	64.0	66	88.0	82	82.0
<b>Weight gain during pregnancy</b>						
Less weight gain	6	24.0	6	8.0	12	12.0
Normal weight gain	19	76.0	69	92.0	88	88.0
<b>Mother's height</b>						
High risk	8	32.0	13	17.3	21	21.0
Low risk	17	68.0	62	82.7	79	79.0
<b>Upper arm circumference</b>						
CED	9	36.0	12	16.0	21	21.0
No CED	16	64.0	63	84.0	79	79.0
<b>Blood pressure</b>						
Hypertension	8	32.0	17	22.7	25	25.0
Normal	17	68.0	58	77.3	75	75.0
<b>Hemoglobin levels</b>						
Anemia	9	36.0	8	10.7	17	17.0
No anemia	16	64.0	67	89.3	83	83.0
<b>Iron supplement tablets intake</b>						
Inadequate	6	24.0	11	14.7	17	17.0
Adequate	19	76.0	64	85.3	83	83.0

CED, Chronic Energy Deficiency; BW, Birth Weight; BL, Birth Length

**Table 2.** Relationship of risk factors with newborns' health.

<b>Independent variables</b>	<b>p-value</b>	<b>OR</b>	<b>95% CI</b>
<b>Mother's age</b>			
High risk	0.014*	4.125	1.41 - 12.0
Low risk			
<b>Weight gain during pregnancy</b>			
Less weight gain	0.058*	3.632	1.051 - 12.553
Normal weight gain			
<b>Mother's height</b>			
High risk	0.156	2.244	0.800 - 6.295
Low risk			
<b>Mid-upper arm circumference</b>			
CED	0.047*	2.953	1.061 - 8.220
No CED			
<b>Blood pressure</b>			
Hypertension	0.425	1.606	0.591 - 4.361
Normal			
<b>Hemoglobin levels</b>			
Anemia	0.011*	4.711	1.57 - 14.11
No anemia			
<b>Iron supplement tablets intake</b>			
Inadequate	0.035*	1.837	0.600 - 5.624
Adequate			

\*p-value<0.05

CED, Chronic Energy Deficiency; OR, Odds Ratio; CI, Confidence Interval

