

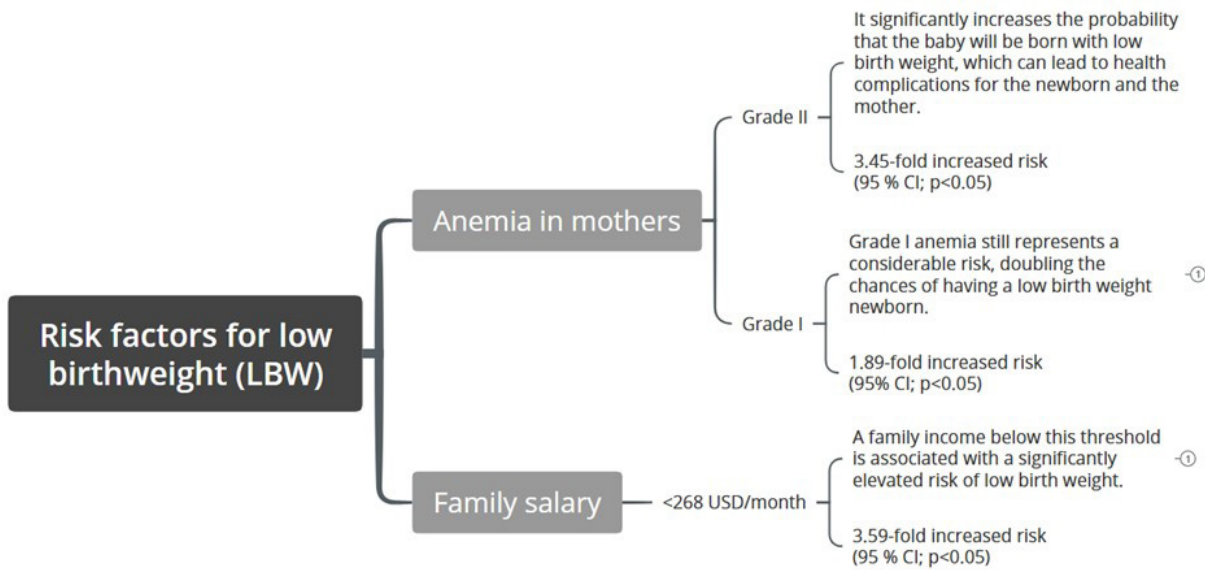
Socioeconomic factors associated with low birth weight in the Andean region of Peru

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Graphical Abstract



Abstract

Over 20 million newborns worldwide are born with low birth weight (LBW), prompting the WHO to establish a target of a 30% reduction by 2025. To achieve this goal, developing countries must implement effective policies to address contributing factors. This study aimed to identify the socioeconomic factors associated with low birth weight (LBW) in the Peruvian Andes, a region characterized by monetary poverty. A quantitative approach with an explanatory design was adopted, utilizing 2,408 records of women with singleton deliveries, assessed from the 22nd week of pregnancy with fetuses weighing ≥ 500 g, through term delivery, along with their newborns (NB) at the Regional Hospital of Ayacucho, Peru. The odds of socioeconomic factors associated with low birth weight (LBW) were evaluated using odds ratio and Pearson's Chi-Square test, with a p-value < 0.01 . The results of this study indicate that mothers with Grade II and Grade I anemia had a 3.45-fold and 1.89-fold increased risk, respectively, of delivering newborns with low birth weight (LBW) (95% CI; $p < 0.05$). Another significant factor was a household income below 1,000.00 soles (< 268 USD/month), which was associated with a 3.59-fold increased risk of having a newborn with LBW (95% CI: 1.58–5.51; $p < 0.05$).

Keywords: Maternal Anemia. Low Birth Weight. Andes Mountain Range. Risk Factor. Public Health.

INTRODUCTION

Low birth weight (LBW) represents a significant public health challenge globally, particularly in developing countries¹. This phenomenon has been identified as an important predictor of infant morbidity and mortality, with adverse impacts on cognitive development and an increased risk of chronic diseases in adulthood^{2,3}. It is estimated that over 20 million newborns worldwide are born with LBW, an alarming figure that prompted the World Health Organization (WHO) to set a goal of reducing LBW cases by 30% by 2025, requiring a 3% annual reduction². To achieve this target, developing countries must implement effective policies aimed at addressing the factors contributing to LBW⁴. Newborns with LBW face a significantly higher risk of perinatal death compared to those with normal weight^{2,3}, as well as an increased incidence of morbidities such as infections, growth restriction, neurological disorders, cognitive delays, and learning difficulties⁴.

LBW is associated with a wide range of multidimensional factors that significantly impact maternal and child health. These factors include the mother's educational level, which affects access to information about prenatal care and the ability to make informed decisions; the presence of anemia, which compromises the adequate supply of oxygen and nutrients to the fetus; and maternal age, as

both adolescents and women over 35 face higher obstetric risks. Furthermore, maternal weight and height, parity (number of previous deliveries), and weight gain during pregnancy play crucial roles in proper fetal development. Other determinants include maternal occupation and household income, which directly influence access to quality medical care and nutritional resources^{5,6}.

Socioeconomic status is also linked to the quality of prenatal care, with low-income women often facing barriers to accessing timely and adequate medical services. Engaging in strenuous physical activities, tobacco and alcohol consumption, and late initiation of prenatal care are factors that increase the risk of LBW by compromising the intrauterine environment. Moreover, the absence of gynecological and nutritional consultations prevents the early identification of problems and the correction of deficiencies, such as the lack of essential vitamins for fetal development. Thus, LBW reflects a complex interaction of biological, social, and behavioral determinants, highlighting the multifaceted nature of maternal and fetal health⁷.

The vast majority of LBW cases are concentrated in low- and middle-income countries, where vulnerable populations are the most affected. In the case of Peru, between 2018 and 2023, 93.06% of newborns had a

birth weight above 2,500 grams, while only 6.94% were born with a weight below this threshold⁸. However, this proportion has increased over time, currently standing at 7.4%, reflecting significant challenges related to LBW in the country⁸.

The department of Ayacucho, located on the eastern slopes of the Andes in Peru, lies at an altitude of 2,761 meters above sea level and has a population of 616,176 inhabitants. The majority of this population (62.6%) lives in poverty. This situation is even more severe in rural areas, where poverty incidence is significantly higher, and it worsens in indigenous communities, where 40.5% of the population lives in extreme po-

verty without access to basic services such as water, sanitation, and electricity⁹. In Ayacucho, over 21,000 children under the age of three suffer from anemia, and more than 15,000 experience chronic malnutrition, according to recent data¹⁰. These figures indicate a worrying upward trend. Furthermore, the Peruvian Ministry of Development and Social Inclusion (MIDIS) reports that more than 21% of young women and adolescents in the department of Ayacucho suffer from anemia¹¹.

Based on the aforementioned considerations, the present study aimed to identify the socioeconomic factors associated with low birth weight in Ayacucho, Peru.

METHOD

The study was conducted using records from 2,408 women who gave birth at term between April 2020 and January 2021 at the Regional Hospital of Ayacucho, located at Av. Alcides Carrión N° 212, Huamanga - Huamanga - Ayacucho, with the following geographic coordinates: -13.151233942106987, -74.2237247858276. The hospital is situated on the eastern slopes of the Andes at an altitude of 2,761 meters. Ayacucho is a region with significant consideration in monetary poverty¹². The inclusion criteria for the study were women with singleton deliveries, assessed from the 22nd week of gestation in the second trimester, with fetuses weighing 500 g or more up to term delivery.

The study considered the following parameters: low birth weight (LBW), defined as a weight below 2,500 g, and normal birth weight, defined as 2,500 g or more. Various maternal variables were analyzed to understand the factors associated with LBW and other neonatal conditions. These variables included maternal anemia, classified into three grades: Grade 0, when hemoglobin (Hb) levels are 11 g/dL or higher, considered within normal limits; Grade 1, with Hb levels between 10.0 and 10.9 g/dL, indicating

mild anemia; and Grade 2, with Hb levels between 7.0 and 9.9 g/dL, indicating moderate anemia, particularly relevant in pregnant women according to standard classification criteria¹³.

Another variable considered was the mother's marital status, classified into three categories: single, cohabiting, and married, as emotional and economic support from a partner can influence maternal and neonatal health. The mother's educational level was categorized into: no education, primary, secondary, and higher education, given that higher levels of education are generally associated with greater access to healthcare services and increased awareness of healthy practices during pregnancy. Household income was also assessed, dividing participants into three groups: less than 1,000 soles, between 1,000 and 2,000 soles, and more than 2,000 soles per month, reflecting socioeconomic differences that can affect access to adequate nutrition and medical care during pregnancy.

The mother's occupation was another relevant variable, classified into three categories: self-employed (independent workers), technical (specialized intermediate-level oc-

cupations), and professional (highly qualified occupations), as job stability and working conditions can impact health during pregnancy. Finally, maternal age was grouped into four categories: ≤ 20 years, 21–28 years, 29–36 years, and ≥ 36 years, as both young mothers and those over 36 years old face higher obstetric risks, potentially affecting pregnancy outcomes.

Data on maternal anemia, marital status, educational level, household income, maternal age, and occupation were collected from the medical record analysis forms provided by the Regional Hospital of Ayacucho. This data collection process involved a thorough review of clinical records, ensuring the accuracy and proper documentation of information for subsequent analysis.

The prevalence of LBW was determined as the proportion of newborns weighing less than 2,500 grams relative to the total number of births analyzed in the study¹⁴. Birth weight was precisely recorded by hospital staff using a calibrated electronic scale, ensuring accurate measurements. These measurements were conducted within the first hour after birth, in accordance with international neonatal care standards, contributing to the reliability of the data obtained.

After data collection, the information was organized into a structured database, ensuring quality criteria such as consistency and completeness of the records. This database was subsequently exported to the statistical software IBM SPSS Statistics V.25, widely

used in scientific research. Within the software, data coding and cleaning procedures were performed to ensure suitability for the planned statistical analyses, enabling descriptive, comparative, and inferential analyses that facilitated the interpretation of factors associated with LBW and other variables of interest.

Inferential analysis was conducted using Pearson's Chi-Square test to identify associations between independent variables and the incidence of LBW. This test evaluated the statistical relationship between factors such as maternal anemia, marital status, education, and other socioeconomic determinants and LBW among the births included in the study. Additionally, the odds ratio (OR) statistical technique was applied to measure the strength of association between variables that showed greater significance in the bivariate analysis. OR results were presented with a 95% confidence interval, and a significance level of $p < 0.01$ was considered to ensure the robustness of the findings. Adjusted OR values were calculated based on the most relevant independent variables, providing a more precise estimation of the risk of LBW as influenced by the analyzed factors. A p -value < 0.05 was adopted as the criterion for statistical significance. All statistical analyses for the study were performed using IBM SPSS Statistics version 25, a tool widely recognized in academic and scientific fields for its capacity to process large datasets and execute a broad range of statistical tests.

RESULTS

A total of 2,408 mothers participated in the study, distributed as follows: 1,719 (71.4%) without anemia (Grade 0), 642 (26.7%) with Grade I anemia, and 47 (1.9%) with Grade II anemia. Regarding marital status, 282 (11.7%) were single; 1,171 (48.6%) married; and 954 (39.6%) cohabiting. In terms of educational level, 7 (0.3%) mothers had no formal education; 217 (9.0%) had primary education; 850 (35.3%) had secondary education; and 1,334 (55.4%) had

higher education. Concerning household income, 1,614 (67.0%) mothers had a monthly income of less than 1,000 soles (approximately USD 257); 662 (27.5%) earned between 1,000 and 2,000 soles (USD 257–514); and 132 (5.4%) earned more than 2,000 soles ($>$ USD 514). Finally, regarding occupation, 1,796 (74.6%) mothers were self-employed; 361 (15.0%) held technical positions; and 251 (10.4%) were professionals.

Table 1 - Factors Associated with Low Birth Weight at the Regional Hospital of Ayacucho (n = 2,408), During the Year 2020.

Factor	Total	Newborn Weight		P-value*
		Low Birth Weight < 2,500g	Normal Birth Weight (≥ 2,500g)	
Maternal Anemia				
No Anemia	1719 (71.4%)	37 (10.0%)	1682 (82.5%)	P<0.001
Grade I Anemia	642 (26.7%)	296 (80.0%)	346 (17.0%)	
Grade II Anemia	47 (1.9%)	37 (10.0%)	10 (0.5%)	
Marital Status				
Single	282 (11.7%)	94 (25.3%)	189 (9.3%)	P<0.001
Married	1172 (48.7%)	30 (8.1%)	1141 (56.0%)	
Cohabiting	954 (39.6%)	247 (66.6%)	707 (34.7%)	
Educational Level				
No Education	7 (0.3%)	4 (1.1%)	3 (0.1%)	P<0.001
Primary Education	217 (9.0%)	138 (37.3%)	79 (3.9%)	
Secondary Education	850 (35.3%)	147 (39.7%)	703 (34.5%)	
Higher Education	1334 (55.4%)	81 (21.9%)	1253 (61.5%)	
Household Income				
Less than 1,000 soles	1614 (67.0%)	359 (97.0%)	1255 (61.6%)	P<0.001
Between 1,000 and 2,000 soles	662 (27.5%)	9 (2.4%)	653 (32.0%)	
More than 2,000 soles	132 (5.5%)	2 (0.5%)	130 (6.4%)	
Maternal age				
≤20 years	425 (17.7%)	83 (22.4%)	344 (16.9%)	P<0.001
21–28 years	824 (34.3%)	111 (29.9%)	713 (35.0%)	
29–36 years	706 (29.3%)	106 (28.6%)	600 (29.5%)	
≥36 years	453 (18.7%)	71 (19.1%)	380 (18.7%)	
Maternal occupation				
Independent	1796 (74.6%)	366 (98.9%)	1430 (70.2%)	P<0.001
Technical	361 (15.0%)	3 (0.8%)	358 (17.6%)	
Professional	251 (10.4%)	1 (0.3%)	250 (12.3%)	

Out of a total of 2,408 newborns, 296 were identified with low birth weight, whose mothers had Grade I anemia. In contrast, 1,682 newborns weighing more than 2,500 grams had mothers without anemia. This analysis suggests an association between the prevalence of anemia and neonatal birth weight (P<0.01), which may have significant implications for prenatal care and neonatal health.

Additionally, 247 newborns with a birth weight <2,500 g were born to mothers in cohabiting relationships at the time of delivery. Conversely, 1,141 newborns weighing more than 2,500 g were children of legally married

mothers. This suggests an association between the mother's marital status and birth weight (P<0.01), underscoring the need for further investigation into how marital status may influence prenatal care.

Among newborns with low birth weight (<2,500 g), 78.1% were children of mothers who had not completed formal education or had only completed primary or secondary education. In contrast, 21.9% of low-birth-weight newborns were children of mothers who had attained higher education. This disparity highlights the influence of maternal educational level on birth outcomes (P<0.01), suggesting

that lower educational attainment may be associated with a higher risk of low birth weight.

A significant majority, 99.5%, of low-birth-weight newborns were born to parents with household incomes below 2,000 soles (532 USD). Conversely, only 0.5% of low-birth-weight newborns came from families with incomes above 2,000 soles. This stark disparity underscores the potential impact of socioeconomic factors on birth outcomes, suggesting that lower household incomes are strongly associated with a higher risk of low birth weight ($P < 0.001$). These findings emphasize the need for public health interventions targeting social determinants of health, such as income inequality, to improve maternal and neonatal outcomes.

Regarding maternal age, 64.5% ($n = 1,313$) of newborns with a birth weight of 2,500 g or more were born to mothers aged 21–36 years,

an age range considered ideal for pregnancy and childbirth ($P < 0.001$). This age group is often associated with a lower risk of complications during pregnancy and delivery, representing a period when women are most likely to achieve favorable outcomes for both mother and fetus.

Among newborns with low birth weight ($< 2,500$ g), 98.9% were children of mothers with self-employed or independent occupations. In contrast, only 1.2% of low-birth-weight newborns were children of mothers employed in technical or professional roles. These findings indicate a notable predominance of low birth weight among newborns whose mothers have informal or self-employed occupations ($P < 0.001$). This may reflect socioeconomic factors such as limited access to healthcare, irregular income, or lower job stability, which can contribute to adverse pregnancy outcomes.

Table 2 - Risk Factors for Low Birth Weight at the Regional Hospital of Ayacucho ($n = 2,408$), During the Year 2020.

Factor	LBW	Multivariate Analysis	
		P-value	OR (95%CI)
Maternal Anemia			
No Anemia	37 (10.0%)	Ref.	
Grade I Anemia	296 (80.0%)	< 0.001	1,89 (0,21-2,69)
Grade II Anemia	37 (10.0%)	< 0.001	3,45 (1,57-5,53)
Marital Status			
Single	94 (25.3%)	< 0.001	1,71 (0,86-2,64)
Married	30 (8.1%)	Ref.	
Cohabiting	247 (66.6%)	< 0.001	1.33 (0.82-1.91)
Educational Level			
No Education	4 (1.1%)	< 0.001	2,63 (1,54-8,71)
Primary Education	138 (37.3%)	< 0.001	1,02 (0,62-5,59)
Secondary Education	147 (39.7%)	< 0.001	1,03 (0,53-4,61)
Higher Education	81 (21.9%)	Ref.	
Household Income			
Less than 1,000 soles	359 (97.0%)	< 0.001	3,59 (1,58-5,51)
Between 1,000 and 2,000 soles	9 (2.4%)	0.889	0,90 (0,19-4,19)
More than 2,000 soles	2 (0.5%)	Ref.	

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Factor	Multivariate Analysis		
	LBW	P-value*	OR (95%CI)
Maternal age			
≤20 years	83 (22.4%)	0.016	1.33 (0.97-3.83)
21–28 YEARS	111 (29.9%)	0.388	0.88 (0.66-1.17)
29–36 YEARS	106 (28.6%)	Ref.	
≥36 years	71 (19.1%)	0.20	1.04 (0.75- 5.913)
Maternal occupation			
Independent	366 (98.9%)	<0.001	3.99 (1.95-17.56)
Technical	3 (0.8%)	0.513585	2.09 (0.22-20.26)
Professional	1 (0.3%)	Ref.	

Mothers with Grade I anemia were 1.89 times more likely to have a newborn (NB) with low birth weight (LBW) (95% CI: 0.21–2.69), while mothers with Grade II anemia were 3.45 times more likely to have an NB with LBW (95% CI: 1.57–5.53), making anemia the most significant factor associated with LBW. Mothers with a household income below 1,000 soles (<536 USD per month) were 3.59 times more likely to have an NB with LBW (95% CI: 1.58–5.51) compared to mothers with an income above 2,000 soles. Self-employed mothers were 3.99 times more likely to have an NB with LBW (95% CI: 1.95–17.56), while

professional mothers did not exhibit this risk. Mothers without formal education were 2.63 times more likely to have an NB with LBW (95% CI: 1.54–8.71; $p < 0.05$). Mothers with primary, secondary, or higher education did not show significant probabilities of having an NB with LBW. Cohabiting mothers were 1.33 times more likely to have an NB with LBW (95% CI: 0.82–1.91; $p < 0.05$), while single mothers were 1.71 times more likely (95% CI: 0.86–2.64; $p < 0.05$). Additionally, mothers under 20 years old were 1.33 times more likely to have an NB with LBW (95% CI: 0.97–3.83) compared to mothers aged 29–36 years.

DISCUSSION

The prevalence of low birth weight (LBW) in Ayacucho, at 15.4%, is similar to the prevalence recorded in the Puno region (14.1%), yet it contrasts significantly with the coastal region (0.88%)¹¹. This highlights that the LBW issue is more pressing in the highland region than on the coast, underscoring the need for interventions to improve perinatal health outcomes in this area¹². When compared to other economically disadvantaged regions, the prevalence reported here surpasses that of Sub-Saharan Africa (9.76%), where the incidence is already considered high. This study also reveals disparities within Sub-Saharan Africa, with higher rates in Gambia (7.2%) and lower rates in Sierra Leone (2.9%)¹³. This analysis emphasizes the link between prenatal care and the risk of LBW, indicating the need to enhance maternal health

services in the Andean region of Peru¹⁴.

Iron deficiency during pregnancy affects more than 40% of pregnant women worldwide, negatively impacting LBW and the subsequent cognitive development of newborns (NB)⁷. In the Ayacucho region, one in two children under the age of three suffers from anemia, with over 21,000 children under three affected by this condition and more than 15,000 suffering from chronic malnutrition¹⁰. Research shows that 79.7% of mothers with Grade I anemia during pregnancy have children with LBW (Table 1), aligning with other studies reporting that more than 72% of anemic mothers give birth to babies with LBW¹⁵. It was observed that mothers with Grade II anemia were 3.45 times more likely to have children with LBW compared to those with Grade I anemia (95% CI: 1.57–5.53; $p < 0.05$).

The primary cause of anemia in pregnant women is iron deficiency, characterized by a reduction in the number of erythrocytes and, consequently, an insufficient capacity to transport oxygen in the blood to meet the body's needs¹⁶. Anemia is defined as a decrease in the number and size of red blood cells or in hemoglobin concentration below established thresholds: 11.0 g/dL for children, 12.0 g/dL for non-pregnant women, 11.0 g/dL for pregnant women, and 13.0 g/dL for men. This condition reduces the body's oxygen transport capacity and is associated with lower physical and mental performance, indicative of poor nutrition and overall health^{17,18,19,20}. One of the risks associated with this condition is LBW, which results from restricted fetal growth in the womb and is defined as a fetal weight below the 10th percentile for gestational age, estimated through prenatal ultrasound assessment. LBW affects 5–10% of pregnancies and is the second most common cause of perinatal mortality^{21,22,23}.

The department of Ayacucho has a poverty rate of 62.6%, making it the fifth poorest department in Peru and significantly above the national average (32.8%)¹². In this region, more than 15,000 children suffer from chronic malnutrition¹⁰. Household income is associated with LBW ($p < 0.05$), as 97.7% of mothers with a household income below 1,000 soles (equivalent to 268 USD) had children with LBW. Additionally, these mothers were 3.59 times more likely to have an NB with LBW (95% CI: 1.58–5.51). These findings align with other studies that conclude the vast majority of LBW cases occur in low- and middle-income countries²⁴.

Additionally, it is observed that over 60% of the

economically active population in the department of Ayacucho is employed in independent work, lacking the labor protections established by law¹¹.

The educational level of mothers is significantly associated with low birth weight (LBW) ($p < 0.05$). It was observed that 21.00% of mothers with higher education had children with LBW, in contrast to 79.00% of mothers with primary and secondary education whose newborns exhibited this condition. This relationship between educational level and LBW aligns with previous findings that also identify educational attainment as a risk factor associated with LBW⁴. Additionally, some studies have concluded that a high level of parental education acts as a protective factor against LBW in newborns.

In the Peruvian context, cohabitation faces criticism and is sometimes treated with disdain due to biases rooted in traditional conceptions. However, in the department of Ayacucho, a shift in marital dynamics has been observed: in 2007, only 28% of the population was married, a figure that decreased by 5% by 2017, reflecting an increase in cohabiting couples as marriages decline¹⁰. The research reveals a significant association between mothers' marital status and LBW ($p < 0.001$). Single mothers were 1.71 times more likely to have an LBW newborn (95% CI: 0.86–2.64; $p < 0.001$), while cohabiting mothers were 1.33 times more likely to have an LBW newborn (95% CI: 0.82–1.91; $p < 0.001$). These results align with previous studies that also demonstrated an association between the marital status of pregnant women and LBW. Furthermore, some studies suggest that marriage provides security, happiness, and a positive emotional state for couples.

CONCLUSION

Maternal anemia, particularly Grade II anemia, is identified as the factor with the highest incidence of low birth weight (LBW), with a significantly higher probability compared to mothers without anemia. Additionally, socioeconomic and occupational factors also play a crucial role, as mothers with a household income below 1,000 soles and those in self-employed occupations are more likely to have an LBW newborn.

Lack of education and certain marital statuses further increase the risk of LBW. Conversely, mothers with greater economic and educational stability, as well as those in professional occupations, do not show a significant increase in the likelihood of having an LBW newborn. These findings highlight the importance of addressing both medical and socioeconomic factors in preventing low birth weight.

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CRediT author statement

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