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Research article

Association between inadequate prenatal care and low birth weight of newborns in Peru: Evidence from a peruvian demographic and health survey

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A R T I C L E I N F O

Keywords:
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Peru

A B S T R A C T

Objective: To assess the association between inadequate prenatal care (IPNC) and Low birth weight (LBW) in newborns of singleton gestation mothers in Peru.
Methods: We performed a secondary analysis of data from the 2019 Demographic and Health Survey. We included a total of 10,186 women of reproductive age (15 – 49 years) who had given birth to a singleton child in the last 5 years. The dependent variable was LBW (< 2500 g). The independent variables were IPNC (inadequate: when at least one of the IPNC components was absent [number of PNC visits ≥ 6, first PNC visit during the first trimester, compliance with PNC visit contents, and PNC visits provided by trained health personnel]) and each of its components. We evaluated the association using logistic regression models to estimate crude odds ratios and adjusted odds ratios (aOR) and their respective 95% confidence intervals (95% CI).
Results: We found that approximately six out of 100 live births had LBW and that seven out of 10 women had received IPNC. We observed that receiving IPNC (aOR: 1.39; 95% CI: 1.09 – 1.77) and having less than six prenatal control visits (aOR: 3.20; 95% CI: 2.48 – 4.13) were associated with higher odds of LBW regardless of the mother's age, educational level, occupation, wealth, region, rural origin, ethnicity, sex of the newborns, and place of delivery. While, regarding to the other PNC components, first prenatal control in the first trimester (aOR: 0.99; 95% CI: 0.76 – 1.28) and compliance with prenatal control contents (aOR: 1.07; 95% CI: 0.86 – 1.34), they were associated with lower and higher odds of LBW, respectively, regardless of the same adjustment variables, but it was not statistically significant.
Conclusions: IPNC and having less than six PNC visits were associated with higher odds of LBW. Therefore, it is very important to implement strategies that ensure access to quality prenatal care is necessary to reduce the consequences of LBW.

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1. Introduction

Neonatal disorders remain the leading cause of death in children under 5 years of age [1]. Among these disorders, low birth weight (LBW) represents an important public health issue as it increases morbidity and mortality in the short and long term [2–5]. In 2015, the estimated worldwide LBW prevalence was 14.6% (~20.5 million), with 91% of the cases in low- and middle-income countries [6]. Furthermore, in the long term (in adult life), LBW has been associated with increased risk of mortality, cardiometabolic diseases (such as diabetes mellitus, obesity, dyslipidemia, hypertension, metabolic syndrome, stroke), cancer, asthma, and even increased mortality, which opens up unique opportunities for primary prevention of chronic diseases [7].

Among the factors related to a higher incidence of LBW, prematurity has been described as one of the most important risk factors [4]. However, LBW has also been associated with maternal characteristics, such as age and obstetric history [8–12]; characteristics of the newborn, such as sex [8,9]; and socioeconomic aspects, such as education, marital status, income, rural background, region of residence, and home conditions [8,10,12–14]. Consequently, the identification of these factors during pregnancy, as well as interventions performed in healthcare facilities, are crucial to reduce LBW, prematurity, and pregnancy-related complications [15].

The role of prenatal care (PNC, defined as the series of scheduled care or visits to the health center where a health team monitors the progress of the pregnancy), including the number of prenatal visits as well as the quality of the content of each visit has been reported to ensure better perinatal outcomes such as LBW [8,16]. The absence of PNC has been proposed as a risk factor for the presence of LBW in preterm and at-term deliveries [17]. On the contrary, a number of PNC visits greater than four or six [18,19], and having the first PNC visit during the first trimester [20,21], have been associated with a decreased prevalence of LBW. These factors correspond to the components of an adequate PNC (a minimum number of PNC visits, having the first prenatal assessment during the first trimester, compliance with the components of the PNC, and PNC by trained health personnel); therefore, it is important to know the overall effect [20,22].

Although adequate PNC plays an important role in the prevention of obstetric and neonatal complications [23], its global coverage in 2013 was only 58.6%. There were remarkable variations among regions, with a proportion of 24.0% in low-income countries and 81.9% in high-income countries [24]. The coverage of PNC is becoming stronger annually worldwide; however, it continues to exhibit many deficiencies and inequities [25,26]. In Peru, a middle-income country with a fragmented health system, an LBW prevalence of 7.3% was reported for 2015 [27], a rate similar to that described in Latin America and Caribbean countries (8.7%) in the same year [6]. In Peru, according to the National Institute of Statistics and Informatics (INEI, for its acronym in Spanish), the LBW rate decreased by 0.7% in 2020. However, differences continue to exist between the different social groups, with a prevalence of 8.2% in rural areas and 6.2% in urban areas [27]. Because adequate PNC is an important factor in reducing LBW rates, and, in Peru, the sustained increase in the number of pregnant women with a minimum number of prenatal visits is not equivalent to receiving quality PNC [27], this study aimed to examine the association between inadequate prenatal care (IPNC) and LBW in the Peruvian population.

2. Methods

2.1. Study design and setting

We performed an analytical cross-sectional study, based on a secondary database provided by the Peruvian Demographic and Health Survey (ENDES, by its Spanish acronym) for the year 2019.

In Peru, the health system is fragmented and segmented in terms of its organization and structure, which severely restricts the State's ability to provide high quality health care for all. In addition, accessibility and availability of health services differ between rural and urban areas, limiting timely access to medical care in some regions [28].

The ENDES is a population-based survey conducted between January and December 2019 by the INEI, which applies three questionnaires: one addressed to the household and its members through a competent informant (household questionnaire), a second questionnaire addressed to all women aged 15–49 years (individual women's questionnaire), and a third questionnaire applied to a randomly selected person aged 15 years or older (health questionnaire). For the present study, we used information from the women's questionnaire. The method used to collect the information was by direct interview during a visit to the selected households conducted by trained personnel. The ENDES survey is a reliable source of information, with national, regional, and rural representativeness.

2.2. Population, sample, and sampling

The study population consisted of women of childbearing age (15–49 years) from whom information was obtained on their sociodemographic characteristics, as well as on their pregnancies in the last five years.

The ENDES is a national survey conducted on an annual basis. The sample is characterized by being two-stage, probabilistic, stratified, and independent at the regional level and by urban and rural area. The primary sampling unit consisted of selected conglomerates (geographic area consisting of one or more blocks with an average of 140 private dwellings). The secondary sampling unit included the private dwelling or households that is part of a conglomerate [27]. Because the survey design employed a complex design, considering the effects of stratification and conglomeration, the survey has national, regional, and rural representativeness, as well as annual and semi-annual representativeness for all indicators.

The ENDES included 21,139 women of reproductive age (15–49 years) during 2019. The effective sample for our study comprised 10,186 women of reproductive age, who reported having had a singleton pregnancy and who had complete data on the variables of interest) (Fig. 1).

It should be noted that the data of those women who reported multiple pregnancies were excluded because the weight of each newborn could indicate one as LBW and the other as not LBW. This is due to the prevalence of weight discordance ≥20% of weight in dizygotic pregnancies, reaching 23.4%, and in monozygotic pregnancies it reaches 26.7% [29].

2.3. Dependent variable

The dependent variable of the study was the newborn's LBW, which was collected using the question: "How much did (name of the child) weigh at birth?" For the answer to this question to be valid, the mother was asked to show the growth and development card to transcribe the information on the weight of her child at birth. LBW was considered if the weight was less than 2500 g. Otherwise, it was considered without LBW (weight greater than or equal to 2500 g).

2.4. Independent variable

The independent variable was IPNC, which was built based on the no compliance with the recommendations of the World Health Organization (WHO) [30], and the methodology of previous studies [20,21,31]. The following survey questions were used to build the independent variable: "How many PNC visits did you have when you were pregnant with (name of the child)?", with six or more PNC visits being considered appropriate based on the indications of the Technical Standard of the Ministry of Health (MINSA) of Peru [32]. If the woman attended the first PNC visit during the first trimester, it was evaluated with the question: "How many months pregnant were you when you had your first prenatal care visit?", considering it appropriate when the first PNC visit took place during the first trimester of the pregnancy.

Compliance with the programs included in each prenatal visit was taken into account, according to WHO recommendations for the care of pregnant women during each prenatal visit [30] and a previous study [33]. Therefore, the interviewee should have received the following components during each prenatal visit: HIV/AIDS, Syphilis, blood, and urine tests, to explain the complications during pregnancy, to tell where to go in case of complications, to measure blood pressure, to take iron supplements as recommended by health personnel and tetanus vaccine.

Finally, for the PNC variable construct, whether the health personnel who provided it to the pregnant woman were trained was considered, which was defined with the question: "Who attended you during the birth of (name of the child)?", with the possible answers being: a doctor, a nurse, an obstetrician, a nursing technician, or a midwife. Doctors, nurses, obstetricians, and nursing technicians were considered as trained personnel.

Thus, an IPNC was considered when at least one component was not compliant: the number of PNC visits was less than six, when the woman received her first PNC visit after the first trimester, when there was not compliance with all the PNC contents, or when she was not attended by trained health personnel.

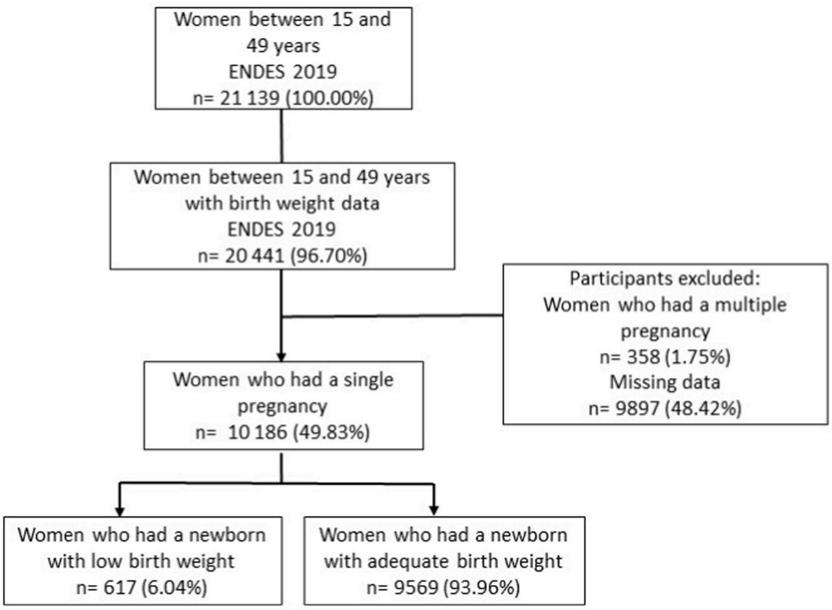

Fig. 1. Flow chart for sample selection.

Table 1
Characteristics of the study population, ENDES 2019 (n = 10,186).

Characteristics	n	%[a]	95%CI[a]
Demographic characteristics			
Mother's age			
Adolescent (15–19 years)	484	4.5	4.0–5.1
Young (20–29 years)	4140	39.2	37.9–40.5
Adult (30–49 years)	5562	56.3	55.0–57.6
Marital status			
Having a partner	9622	94.7	94.1–95.2
Single	564	5.3	4.8–5.9
Educational level			
Primary or lower	1857	17.5	16.5–18.5
Secondary school	4498	42.5	41.1–43.8
Tertiary	3831	40.1	38.7–41.5
Employment status			
Working	7037	68.4	67.1–69.6
Not working	3149	31.6	30.4–32.9
Wealth quintiles			
First Quintile	2554	21.7	20.7–22.8
Second Quintile	2578	22.2	21.1–23.4
Third Quintile	2029	19.0	17.9–20.1
Fourth Quintile	1728	18.9	17.8–20.1
Fifth Quintile	1297	18.2	17.0–19.4
Region			
Lima	1328	31.2	29.9–32.4
Coast without Lima	3092	25.3	24.2–26.5
Mountain	3550	28.9	27.6–30.4
Jungle	2216	14.6	13.6–15.6
Residence			
Urban	7393	75.8	74.7–76.8
Rural	2793	24.2	23.2–25.3
Ethnicity			
Mestizo	4256	46.1	44.8–47.5
Quechua	2983	24.3	23.2–25.4
Black/brown/zambo	1031	11.3	10.5–12.2
Other	1916	18.2	17.2–19.4
Reproductive characteristics			
Place of birth			
Institutional	9633	93.3	92.4–94.2
Non-institutional	553	6.7	5.8–7.6
Pregnancies			
First child	3350	33.8	32.6–35.0
Second child	3332	33.4	32.1–34.7
Third child or higher	3504	32.8	31.6–34.0
Interpregnancy interval			
Adequate	2951	29.1	27.9–30.3
Short	256	2.6	2.2–3.1
Long	6979	68.3	67.0–69.5
Sex of the newborn			
Male	5219	51.1	49.8–52.3
Female	4967	48.9	47.6–50.2
Number of prenatal care visits			
Equal or more than 6	8729	85.9	85.0–86.9
Less than 6	1457	14.1	13.1–15.0
First prenatal care visit in the first trimester			
No	1884	17.1	16.1–18.1
Yes	8302	82.9	81.8–83.9
Compliance with prenatal care components			
Inadequate	6336	62.6	61.2–63.9
Adequate	3850	37.4	36.1–38.8
Prenatal care by trained personnel			
Yes	10,178	99.9	99.8–99.9
No	8	0.1	0.00–0.2
Inadequate prenatal care			
No	3063	29.8	28.6–31.1
Yes	7123	70.2	68.9–71.4
Low birth weight			
No	9569	94.0	93.3–94.5
Yes	617	6.0	5.5–6.7

[a] Weighted percentages according to survey complex sampling.

2.5. Other variables

The following covariates were included based on a review of previous studies reporting them as associated with LBW [21,24–36]. Sociodemographic characteristics, such as the age of the mother (15–19, 20–29, or 30–49 years), the region (Lima, Coast without Lima, Mountains, or Jungle), area of residence (urban or rural), educational level (initial or preschool, primary, secondary, or tertiary), ethnic group (Quechua, mestizo, black, brown or zambo, or others), labor status (works or does not work), and wealth (first quintile, second quintile, third quintile, fourth quintile, or fifth quintile; the cut-off points are established according to Peru's own distribution for the year of the survey), were included. Likewise, the characteristics of pregnancy and delivery, such as the order of birth (first child, second child, third child, or more), interpregnancy interval (short, adequate, or long), sex of the newborn (male or female), and place of delivery (institutional or non-institutional) were considered.

It should be noted that the variables needed to construct the "IPNC" variable, age, educational level, ethnic group, labor status, and the place of delivery were collected only by self-report, while the rest of the variables were checked by the ENDES enumerators.

More details on the sampling process, the design, and the contents of the ENDES can be found in the technical datasheet [27].

2.6. Statistical analysis

The 2019 ENDES databases were downloaded and imported into the Stata® v.16.0 software (Stata Corporation, College Station, Texas, USA). The databases were merged based on common identifying variables in each database according to the previously described methodology [37]. The analyses were performed by considering the ENDES's complex sampling and weighting factors via Stata's "svy" module. This module considers weighting according to strata, complex design, and weighting factor into analysis.

The absolute frequencies and weighted proportions for the descriptive analysis of the categorical variables were calculated. The association between the categorical variables was evaluated using the chi-square test with the Rao–Scott correction for the bivariate analysis.

Logistic regression models were created to assess the association between LBW and IPNC and the association between LBW and each of the PNC components (except for the variable "PNC per trained provider" owing to the scarcity of observations in one of its categories). The logistic regression analysis was conducted because the prevalence of the dependent variable was less than 10%.

An epidemiological approach was used for the adjusted model, including potential confounders [38], whose association with the independent and dependent variable has been described in previous studies (11,19–21). The crude odds ratio (cOR) obtained from the bivariate logistic regression carried out between the variable of interest and independent variable and adjusted odds ratio (aOR) obtained from the multivariate logistic regression with their respective 95% confidence intervals (95%CI) were reported.

Furthermore, an exploratory analysis assessing the association between IPNC and LBW as well as the association with each of the PNC components (except for the variable "PNC per trained provider" owing to the scarcity of observations in one of its categories) using generalized linear models (GLMs) from Poisson family with a link log function estimating crude (cPR) and adjusted (aPR) prevalence ratios was performed. Crude and adjusted models were created by considering the epidemiological criteria (Supplementary Material 1).

To evaluate collinearity, the variance inflation factor (VIF) was used, where a value > 10 determined multicollinearities between the variables; however, all the values obtained were less than 10.

3. Ethical issues

This study did not require ethics committee approval because it is a secondary data analysis. In addition, the ENDES 2019 database is in the public domain (http://iinei.inei.gob.pe/microdatos/) and ensures the confidentiality of the participants' data. The primary data collection of this survey, conducted by the INEI team, required prior consent to participate from the respondents.

4. Results

The cases of 21,139 women of reproductive age (15 – 49 years) during the study period were assessed. However, 698 cases were excluded owing to lack of data on the dependent variable (LBW), 9897 owing to incomplete data on the variables of interest, and 358 owing to a history of multiple gestation, which resulted in a final study population of 10,186 (Fig. 1).

The highest percentage of the study population corresponded to adults (30 – 49 years of age) (56.3%), women who had a partner (94.7%), who had a secondary education degree (42.5%), who had a labor relationship (68.4%), who belonged to the second quintile of wealth (22.2%), who belonged to the mestizo ethnic group (46.1%), and who lived in the mountains (28.9%) and in an urban area (75.8%). Likewise, those who had an institutional delivery (93.3%), a long interpregnancy interval (68.3%), number of PNC visits equal or more than six (85.9%), a first PNC visit within the first trimester (82.9%), compliance with PNC components (62.6%), and those who had an IPNC (70.2%) represented a higher proportion of our study population (Table 1).

The prevalence of LBW was 6.0%, with a higher proportion among women with a primary education level or lower (8.8%; $p < 0.001$), those who did not have a labor relationship (7.3%; $p = 0.006$), who belonged to the first wealth quintile (8.4%; $p = 0.001$), those whose ethnicity was black, brown, or zambo (9.8%; $p < 0.001$), those who belonged to the mountain and jungle regions (7.3% and 6.7% respectively; $p = 0.010$) as well as to rural areas (8.5%; $p < 0.001$). Regarding obstetric characteristics, women aged 15 – 49 years who had a non-institutional delivery (9.2%; $p = 0.014$), less than 6 PNC visits (14.1%; $p < 0.001$), and those who had an IPNC (6.7%; $p < 0.001$), had a higher prevalence of LBW (Table 2).

Table 2
Prevalence of the low birth weight according to the characteristics of the study population, ENDES 2019 (n = 10,186).

Characteristics	Low birth weight						
	No			Yes			P value[b]
	n	%[a]	95%CI[a]	n	%[a]	95%CI[a]	
Demographic characteristics							
Mother's age							0.031
Adolescent (15–19 years)	444	90.3	86.1–93.3	40	9.7	6.7–13.9	
Young (20–29 years)	3895	93.9	92.9–94.8	245	6.1	5.2–7.1	
Adult (30–49 years)	5230	94.3	93.4–95.0	332	5.7	5.0–6.6	
Marital status							0.152
Having a partner	9051	94.1	93.4–94.6	571	5.9	5.4–6.6	
Single	518	92.1	88.6–94.6	46	7.9	5.4–11.4	
Educational level							<0.001
Primary or lower	1705	91.2	89.4–92.7	152	8.8	7.3–10.6	
Secondary school	4227	93.8	92.9–94.7	271	6.2	5.3–7.1	
Tertiary	3637	95.3	94.3–96.1	194	4.7	3.9–5.7	
Employment status							0.006
Working	6633	94.6	93.9–95.2	404	5.5	4.8–6.1	
Not working	2936	92.7	91.4–93.8	213	7.3	6.2–8.6	
Wealth quintiles							0.001
First Quintile	2348	91.6	90.2–92.8	206	8.4	7.2–9.8	
Second Quintile	2412	93.6	92.3–94.6	166	6.4	5.4–7.7	
Third Quintile	1925	95.0	93.7–96.1	104	5.0	3.9–6.3	
Fourth Quintile	1653	95.2	93.5–96.5	75	4.8	3.5–6.5	
Fifth Quintile	1231	94.8	93.0–96.2	66	5.2	3.8–7.0	
Region							0.010
Lima	1262	95.3	93.8–96.3	66	4.8	3.7–6.1	
Coast without Lima	2935	94.2	93.0–95.2	157	5.8	4.8–7.0	
Mountain	3299	92.7	91.5–93.7	251	7.3	6.3–8.5	
Jungle	2073	93.3	91.9–94.4	143	6.7	5.6–8.1	
Residence							<0.001
Urban	6991	94.7	94.0–95.4	402	5.3	4.6–6.0	
Rural	2578	91.5	90.1–92.8	215	8.5	7.2–9.9	
Ethnicity							<0.001
Mestizo	4032	95.2	94.3–96.0	224	4.8	4.0–5.7	
Quechua	2819	95.1	94.1–95.9	164	4.9	4.1–5.9	
Black/brown/zambo	941	90.2	87.7–92.2	90	9.8	7.8–12.3	
Other	1777	91.7	89.9–93.2	139	8.3	6.8–10.1	
Reproductive characteristics							
Place of birth							0.014
Institutional	9071	94.2	93.6–94.7	562	5.8	5.3–6.4	
Non-institutional	498	90.9	87.2–93.5	55	9.2	6.5–12.8	
Pregnancies							0.195
First child	3124	93.4	92.2–94.4	226	6.6	5.6–7.8	
Second child	3157	94.7	93.6–95.6	175	5.3	4.4–6.4	
Third child or more	3288	93.8	92.7–94.7	216	6.2	5.3–7.3	
Interpregnancy interval							0.665
Adequate	2793	94.4	93.1–95.4	158	5.6	4.6–6.9	
Short	240	93.2	88.2–96.1	16	6.8	3.9–11.8	
Long	6536	93.8	93.0–94.5	443	6.2	5.5–7.0	
Sex of the newborn							0.223
Male	4918	94.3	93.4–95.1	301	5.7	4.9–6.6	
Female	4651	93.6	92.6–94.4	316	6.4	5.6–7.4	
Number of prenatal care visits							<0.001
Equal or more than 6	8313	95.3	94.7–95.8	416	4.7	4.2–5.3	
Less than 6	1256	85.9	83.3–88.1	201	14.1	11.9–16.7	
First prenatal care visit in the first trimester							0.141
No	1756	93.0	91.4–94.3	128	7.0	5.7–8.6	
Yes	7813	94.2	93.5–94.8	489	5.9	5.2–6.5	
Compliance with prenatal care components							0.923
Inadequate	5964	93.9	93.1–94.7	372	6.1	5.3–6.9	
Adequate	3605	94.0	93.0–94.8	245	6.0	5.2–7.0	
Prenatal care by trained personnel							0.523
Yes	9561	94.0	93.3–94.5	617	6.1	5.5–6.7	
No	8	100.0	Omitted	0	0.0	Omitted	
Inadequate prenatal care							<0.001
No	2909	95.5	94.5–96.3	154	4.5	3.7–5.5	
Yes	6660	93.3	92.5–94.0	463	6.7	6.0–7.5	

P-values <0.05 are in bold.
[a] Weighted percentages according to survey complex sampling.
[b] Calculated by Chi 2 test of independence with Rao Scott correction for complex sampling.

In the adjusted logistic regression model, IPNC (aOR: 1.39; 95% CI: 1.09 – 1.77) and having less than 6 PNC visits (aOR: 3.20; 95% CI: 2.48 – 4.13) were associated with higher odds of LBW regardless of the mother's age, educational level, occupation, wealth, region, rurality, ethnicity, sex of the newborn, and place of delivery. While, regarding to the other PNC components, first PNC visit in the first trimester (aOR: 0.99; 95% CI: 0.76–1.28) and compliance with prenatal control components (aOR: 1.07; 95% CI: 0.86 – 1.34), they were associated with lower and higher odds of LBW, respectively, even it was not statistically significant (Table 3). Measures of association between confounding variables and LWB can be reviewed in the supplementary material (Supplementary Material 2). Finally, when analyzing the association between IPNC (as well as its components) and LBW using Poisson GLM models with log link function, similar results were obtained (Supplementary Material 1).

5. Discussion

This study aimed to assess the association between IPNC and LBW in a sample of 10,186 women of reproductive age whose last pregnancy resulted in the birth of a single child. The evidence showed that 60 out of every 1000 live newborns from women aged 15–49 years with a singleton gestation had LBW and that 70.2% of these women received IPNC. Likewise, it was found that an IPNC was independently associated with higher odds of LBW.

Furthermore, seven out of 10 women aged 15–49 years with a singleton gestation received an IPNC, which implies an inadequate number of PNC visits, a first PNC visit outside the first trimester, inappropriate content, or care by untrained health personnel, which are against the recommendations of the WHO [30]. Previous studies have reported similar proportions of IPNC in low- and middle-income countries as well as in rural areas [39,40]. Likewise, in a previous study in Peru, an IPNC rate of 65% has been reported [22]. Because IPNC could be associated with multiple negative maternal–fetal outcomes [2–5], the promotion of national strategies that ensure access to comprehensive medical care during pregnancy and cover all pregnant women is highly recommended, thus guaranteeing timely interventions after the identification of low fetal weight during pregnancy.

Regarding the prevalence of LBW, the reported proportion represent approximately six cases per 100 women aged 15–49 years who had a singleton pregnancy. This value is lower than the prevalence of LBW reported worldwide in 2015 (14.6%) [6], and in Latin American and Caribbean countries (8.7%) [6]. Regarding these differences, the role of Peru's policies in the fight to reduce low birth weight should be highlighted. Interventions such as the minimum number of six PNC visits and nutritional counseling were established to prevent LBW [32]. On the other hand, the slow but progressive reduction of LBW is possibly due to the increase in the Human Development Index in the different regions, since higher income and better education could be directly related to better PNC [41,42]. The observed prevalence of LBW is similar to the prevalence levels of 5.3%–8.5% reported in low- and middle-income countries [43–45], and to those reported in a previous nationwide study (6.2%) [46]. Although the proportion of LBW is lower than that reported in the region, efforts toward the reduction of LBW should be continued, which would represent an achievement for the Peruvian policies that seek to promote interventions in defense of pregnant women's health and prenatal care.

IPNC was associated with a higher odds of LBW regardless of other associated factors previously described, such as maternal characteristics [8–12], characteristics of the newborn [8,9], and socioeconomic aspects [12–14]. The criteria used for the assessment of IPNC were specific to the locality and were in accordance with the recommendations of the WHO [30], and the methodologies of previous studies [20,21,31]. Other methodologies have been used in the literature to assess adequate PNC, including those based on the number of PNC visits and the time of the first PNC visit, and the positive effects of receiving an adequate or quality PNC have been reported [1,31,47–49]. However, this study also considered compliance with the content provided during the PNC, which includes performing laboratory tests, administering the tetanus vaccine, measuring blood pressure, and providing iron supplementation. This difference could have influenced the results because the classification of an IPNC is becoming increasingly demanding. Despite these

Table 3
Association between inadequate prenatal care and low birth weight of newborns, ENDES 2019.

Characteristics	Crude Model			Adjusted Epidemiological Model[a]		
	cOR	95%CI	P value	aOR	95%CI	P value
Inadequate prenatal care						
No	Reference			Reference		
Yes	**1.51**	**1.19–1.92**	**0.001**	**1.39**	**1.09–1.77**	**0.009**
Number of prenatal care visits						
Equal or more than 6	Reference			Reference		
Less than 6	**3.33**	**2.62–4.22**	**<0.001**	**3.20**	**2.48–4.13**	**<0.001**
First prenatal care visit in the first trimester						
No	Reference			Reference		
Yes	0.83	0.64–1.06	0.141	0.99	0.76–1.28	0.913
Compliance with prenatal care components						
Inadequate	Reference			Reference		
Adequate	0.99	0.80–1.22	0.923	1.07	0.86–1.34	0.545

cOR: crude odds ratio; aOR: adjusted odds ratio; 95%CI: 95% confidence Interval.
Odds ratios and confidence intervals were calculated considering the complex sampling of the survey.
P-values <0.05 are in bold.
[a] Each model presented was adjusted for mother's age, educational level, occupation, wealth, region of residence, rurality, ethnicity, sex of newborn and place of delivery.

methodological differences, our findings add to international evidence for the relevance of PNC. Moreover, in the Peruvian context, it is essential to continue improving the PNC services in all sectors of the country.

Number of PNC visits more or equal than six was associated with better birth weight outcomes. This PNC component was associated to a great extent with LBW and was possibly the factor that contributed the most within the adequate PNC variable. While WHO recommend eight prenatal contacts to reduce perinatal mortality and improve women's experience of care [30], in this study, a cut-off point of equal or more than six was used because Peruvian technical standard ensures these favorable maternal outcomes with six prenatal contacts in the Peruvian population [32,50]. Despite this cut-off point, the association with birth weight remained consistent with the rest of the literature [20,31].

Our findings provide additional evidence for the importance of adequate PNC during pregnancy and the independent benefits of an adequate number of PNC visits. Therefore, health policies should be implemented to ensure adequate prenatal care based on its components and thus reduce the prevalence of LBW. These measures could reduce neonatal morbidity and mortality in the short term as well as in the long term [2–5]. Additionally, by ensuring the health of the women and that of the fetus during pregnancy, a greater contribution to the economic productivity and the long-term development of countries can be achieved [51]. Thus, investment in health policies and strategies that maximize an adequate PNC should be a priority for governments.

With respect to the trimester in which the first PNC visit was received, it was associated with a lower odd of LBW in the adjusted model. In this regard, it has been reported in the literature that first PNC visit after the first trimester is associated with an increased probability of presenting with LBW [21]. Therefore, because it is a reasonably viable strategy, it is recommended that the healthcare personnel stress on the importance of an early first PNC visit among the women of reproductive age and adopt measures for the prompt identification of pregnant women.

Adequate PNC and compliance with its components described in this article remain important in reducing negative outcomes as well as neonatal and maternal complications [52]. Therefore, the correct monitoring of gestational weight gain; the timely detection of obstetric complications, such as preeclampsia; and the identification of high-risk pregnant women are objectives that must be met in routine PNC to ensure an adequate weight of the newborn [20,53]. Therefore, it is important to carry out prospective studies to evaluate the scenarios in which the PNC could influence newborn weight. Nevertheless, our results reinforce the evidence on the association between LBW and PNC, highlighting the importance of strengthening PNC programs in low and medium-resource countries such as Peru.

6. Limitations and strengths

Being a secondary data study, this research has a few limitations. First, some variables of interest regarding the determinants of LBW, such as previous births with LBW, prematurity, poor weight gain during pregnancy, maternal nutrition and diet, previous abortions, and obstetric and neonatal pathologies [25,26,54,55], were not included in the measurements made by the ENDES; hence, they could not be considered in the analysis. Second, the design of the ENDES does not allow causality between IPNC and LBW to be assessed. Third, there might have been recall bias or inadequate understanding of the questions in some subgroups because the women surveyed were required to recall details about their previous pregnancies and births. Fourth, in the present study, only data from women aged 15–49 years who had a single pregnancy were included; thus, the results cannot be extrapolated to other groups of women. Despite these limitations, we believe that the findings of this study can provide an overall insight into the relationship addressed. Likewise, the ENDES survey, which is conducted annually and involves methodological quality control processes, has a nationwide and regional representativeness and therefore allows the assessment of the health status of the newborn population [22,56,57].

7. Conclusions

The findings from our study indicated that the prevalence of LBW was 6.0% and that of IPNC was 70.2% in Peruvian mothers who had a singleton gestation. Furthermore, having an IPNC and having less than six PNC visits were significantly associated with higher odds of LBW. Therefore, our study reinforces the need for the implementation of regional and national strategies that ensure access to quality PNC for all pregnant women with the aim of reducing the risk of LBW and its key short-term and long-term consequences.

Author contribution statement

Daniel Fernandez-Guzman, Brenda Caira-Chuquineyra: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

Humberto Giraldez-Salazar: Analyzed and interpreted the data; Wrote the paper.

Diego Urrunaga-Pastor: Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

Guido Bendezu-Quispe: Conceived and designed the experiments; Analyzed and interpreted the data; Wrote the paper.

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Data availability statement

Data associated with this study has been deposited at https://proyectos.inei.gob.pe/endes/.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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