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Gestational anemia and physiological decrease in hemoglobin in women living at high altitudes

Anemia gestacional y descenso fisiológico de hemoglobina en mujeres que viven a gran altitud

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Abstract

Gestational anemia is a public health problem, especially in high-altitude contexts, where hemoglobin levels present relevant physiological variations. Monitoring their evolution during pregnancy allows us to identify hematological changes and guide timely interventions. The objective was to analyze the variation of hemoglobin levels between the first and third trimester, its association with clinical factors and obstetric history in pregnant women treated in comprehensive health centers of District 1 of the city of El Alto, Bolivia, management 2024. A quantitative, observational, longitudinal and analytical study was carried out, based on the retrospective review of medical records. A total of 251 complete records with hemoglobin records were included. An average decrease of 0.59 g dL^{-1} was observed between the first and third trimesters ($p < 0.05$), along with an increase in the prevalence of anemia from 62.2 to 83.3 % ($p < 0.05$). The hematological classification showed an increase mainly in the moderate category. No statistically significant association was identified between the presence of anemia and maternal age, body mass index, interreproductive period, history of miscarriage, or diagnosis of genitourinary infection. The results refer to a decrease in hemoglobin during pregnancy in women living at high altitude, compatible with the expected physiological decrease, but accompanied by a high prevalence of anemia according to altitude-adjusted cut-off points. It is recommended to reinforce prenatal control and adjust diagnostic cut-off points considering altitude, to improve the identification and management of anemia in high-altitude pregnant women.

Key words: Gestational anemia, high-altitude hemoglobin, multiparity, clinical factors, maternal-fetal health.

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Resumen

La anemia gestacional constituye un problema de salud pública, especialmente en contextos de altitud, donde los niveles de hemoglobina presentan variaciones fisiológicas relevantes. El monitoreo de su evolución durante el embarazo permite identificar cambios hematológicos y orientar intervenciones oportunas. El objetivo fue analizar la variación de los niveles de hemoglobina entre el primer y el tercer trimestre, su asociación con factores clínicos y antecedentes obstétricos en gestantes atendidas en centros integrales de salud del Distrito 1 de la ciudad de El Alto, Bolivia, gestión 2024. Se realizó un estudio cuantitativo, observacional, longitudinal y analítico, basado en la revisión retrospectiva de historias clínicas. Se incluyeron 251 expedientes completos con registros de hemoglobina. Se observó una disminución promedio de 0.59 g dL^{-1} entre el primer y tercer trimestre ($p < 0.05$), junto con un incremento de la prevalencia de anemia de 62.2 a 83.3 % ($p < 0.05$). La clasificación hematológica evidencio un aumento principalmente en la categoría moderada. No se identificó asociación estadísticamente significativa entre la presencia de anemia y edad materna, índice de masa corporal, periodo intergenésico, antecedente de aborto ni diagnóstico de infección genitourinaria. Los resultados refieren una disminución de hemoglobina durante la gestación en mujeres residentes a gran altitud, compatible con el descenso fisiológico esperado, pero acompañada de una elevada prevalencia de anemia según puntos de corte ajustados por altitud. Se recomienda reforzar el control prenatal y ajustar los puntos de corte diagnósticos considerando la altitud, para mejorar la identificación y el manejo de la anemia en gestantes de altura

Palabras clave: Anemia gestacional, hemoglobina en altura, multiparidad, factores clínicos, salud materna-fetal.

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Introduction

Anemia during pregnancy, defined by the World Health Organization (WHO) as a hemoglobin (Hb) concentration below normal values according to age, sex, pregnancy status, and altitude, is a global public health problem because of its high prevalence and clinical consequences for both mother and child[1,2].

Its etiology is multifactorial; however, iron deficiency is the most common cause during pregnancy because of the progressive increase in maternal and fetal requirements and the depletion of iron stores as pregnancy advances. This condition is associated with a higher risk of adverse perinatal outcomes and maternal mortality[3-5].

During pregnancy, erythroid hyperplasia occurs in the bone marrow, increasing red blood cell mass by 15-25 % in singleton pregnancies. This is accompanied by a 40-50 % expansion in plasma volume and a decrease in hematocrit (Hct) to approximately ~34 % in singleton pregnancies and ~30 % in multiple pregnancies[6,7].

Population-based and prospective cohort studies have shown that maternal anemia, particularly when moderate or severe, is associated with a higher risk of adverse maternal and perinatal outcomes, including severe postpartum hemorrhage, preterm birth, impaired fetal growth, lower gestational age at birth, and unfavorable neonatal outcomes[8-10]. The WHO estimates that more than one-third of pregnant women have anemia, with iron-deficiency anemia being the most common form because of a negative iron balance[11-13].

In low-resource settings, iron and folic acid supplementation remains an important strategy for the prevention and management of gestational anemia. Recent clinical studies have evaluated different oral supplementation regimens in pregnant women with iron-deficiency anemia and found no significant differences between daily and alternate-day administration in terms of short-term increases in Hb levels[8-15]. Studies have reported increases in anemia prevalence between trimesters, including from 47-65 % in Egypt and from 29-31 % in Peru[16]. Evidence from Bolivia remains limited; in El Alto, altitude complicates comparisons with international standards[17], while a study conducted in Chuquisaca reported iron-deficiency anemia in 60.35 % of pregnant and postpartum women[18]. The definition of anemia during pregnancy varies. The WHO defines it as Hb <11 g dL^{-1} or Hct <33 % during any trimester[19]. However, recent studies have questioned the universal validity of traditional cutoff values, particularly among populations living at high altitude, where Hb levels may be modified by physiological adaptation to chronic hypoxia[7,13]. For altitudes ranging from 3,800 to 4,380 m above sea level, cutoff values for the general population have been reported to range from (12.77 ± 0.18 to 13.16 ± 0.25 g dL^{-1})[20].

Altitude modifies Hb levels. Pregnant women living in La Paz at 3,600 m above sea level have a mean Hb concentration of 13.6 ± 2.3 g dL^{-1} and a mean Hct of 40.9 ± 6.4 %, values that are higher than those observed at sea level but lower than those reported among nonpregnant women[21]. Consistently, a primary study conducted among pregnant women living in the highlands of Nepal reported an elevated mean Hb concentration and an anemia prevalence that varied according to adjustments for altitude, age, parity, and sociodemographic characteristics[22]. The WHO recommends considering geographical elevation when interpreting Hb concentrations to define anemia. Nevertheless, recent studies involving adult high-Andean women have questioned the universal validity of altitude adjustments and have warned of the risk of diagnostic overestimation in populations living at very high altitudes[19,20]. In El Alto, located at

more than 4,000 m above sea level, the Bolivian Ministry of Health recommends an adjustment of (+3.5 to +4.0 g dL^{-1})[23].

The objective of this study was to analyze changes in Hb levels between the first and third trimesters and their association with clinical factors and obstetric history among pregnant women receiving care at comprehensive health centers in District 1 of El Alto, Bolivia, during 2024, thereby providing original evidence to strengthen prenatal care in high-altitude populations.

Material and methods

A quantitative, longitudinal, and analytical study was conducted through a retrospective review of the medical records of pregnant women who received care during 2024 at three comprehensive health centers in District 1 of El Alto. Women with complete hemoglobin records from the first trimester (≤13 weeks) and the third trimester (≥28 weeks), as well as relevant clinical data, were included.

Non-probability convenience sampling was used. A total of 613 medical records were reviewed; records of women with previous hematological diagnoses, undocumented medical interventions, incomplete data, or incomplete prenatal follow-up were excluded. Ultimately, 251 records met the inclusion criteria.

Data were collected using a validated structured form. The variables recorded included maternal age, body mass index (BMI), obstetric history previous deliveries and miscarriages presence of urinary tract infection, and laboratory hemoglobin values from the first and third trimesters. Hemoglobin cutoff values were adjusted for altitude according to WHO recommendations, with a threshold of ≥14.0 g dL^{-1} considered normal at 4,125 m above sea level.

Statistical analysis was performed using SPSS, version 26. Descriptive statistics, Chi-square tests of association, and McNemar's test were applied. Statistical significance was established at $p < 0.05$.

Results

The obstetric and reproductive profile showed a predominance of women aged 20-34 years. The most frequent obstetric histories were one to two previous deliveries or no previous deliveries. Regarding the interpregnancy interval, most women had intervals longer than two years, while a substantial proportion were nulliparous. A history of miscarriage was less frequent than the absence of such a history, as shown in Table 1.

Table 1 Distribution of obstetric characteristics and reproductive history among pregnant women

Obstetric Profile	Category	n	%
Age	15-19 years	23	9.2
	20-34 years	193	76.9
	35-42 years	35	13.9
Previous deliveries	0 births	92	36.7
	1-2 births	122	48.6
	3-4 births	31	12.4
	5 or more births	6	2.4
	Nulípara	86	34.3
Intergenic period	Less than 6 months	5	2.0
	6 months to 1 year	11	4.4
	1-2 years	30	12.0
	Plus 2 years	119	47.4
History of abortion	Yes	85	33.9
	No	166	66.1

Table 2 Distribution of body mass index and type of infection during pregnancy among the women evaluated

Profile clinical	Category	n	%
BMI	Normal weight	71	28.3
	Overweight	110	43.8
	Obesity	70	27.9
Infection	No infection	119	47.4
	Urinary tract infection	129	51.4
	Vaginal infection	3	1.2

Table 3 Descriptive hemoglobin values (g dL^{-1}) among pregnant women during the first and third trimesters

Parameter	1st trimester	3rd trimester
Mean (SD)	13.89 ± 1.47	13.30 ± 1.25
Median (IQR)	14.0 (1.9)	13.4 (1.5)
Minimum–maximum	9.4 - 17.4	9.0 - 16.5
Range	8	7.5
95% CI of the mean	13.71 - 14.07	13.15 - 13.45
Skewness	-.29	-.48
Kurtosis	.37	.37

The clinical profile showed a predominance of excess body weight, particularly overweight, followed by obesity and normal weight. Among infections recorded during pregnancy, urinary tract infection was the most frequent, whereas vaginal infection was uncommon. These findings describe the baseline clinical characteristics of the sample before the analysis of hemoglobin levels and anemia status, as presented in Table 2.

Descriptive hemoglobin values showed a decrease between the first and third trimesters, with downward shifts in both the mean and median. The dispersion of the observed values remained relatively similar between both periods, while skewness and kurtosis indicated a distribution compatible with the assumption of normality. These findings support the use of parametric tests for within-subject comparisons of Hb levels during gestational follow-up, as shown in Table 3.

The hematological classification showed an increase in anemia as pregnancy progressed, accompanied by a reduction in the proportion of women with values classified as normal. This pattern was more evident for moderate anemia, whereas severe anemia remained less frequent. Overall, the findings indicate a progressive shift toward greater hematological impairment during the third trimester, consistent with the gestational decrease in Hb observed in the sample. Table 4.

The inferential comparison confirmed a significant change in anemia prevalence between the first and third trimesters. McNemar's test showed that the observed increase was not attributable to random variation but represented a statistically significant change in hematological status during follow-up. The complementary Chi-square tests produced consistent results, strengthening the evidence of a significant change in anemia status as pregnancy progressed. Table 5.

The distribution of anemia across maternal age groups followed a similar pattern during the first and third trimesters, with no statistically significant differences among adolescents, women of adult reproductive age, and older pregnant women.

Although most cases occurred among women aged 20-34 years, this pattern reflected the predominant age composition of the sample rather than an independent association between maternal age and gestational anemia. Therefore, maternal age was not identified as a factor associated with anemia during the periods evaluated, as shown in Table 6.

Table 4 Prevalence of anemia during the first and third trimesters of pregnancy

Hematologic classification		1st trimester		3rd trimester	
		n	%	n	%
Anemia	Yes < 14 g dL^{-1}	156	62.2	209	83.3
	No > 14 g dL^{-1}	95	37.8	42	16.7
Hematological classification	Normal	97	38.6	39	15.5
	Moderate	144	57.4	198	78.9
	Severe	10	4.0	14	5.6

Table 5 McNemar and chi-square tests comparing anemia prevalence between the first and third trimesters

Test	Value	df	Asymptotic significance, two-sided
Pearson's chi-square	39.839	1	< .001
Continuity correction	37.669	1	< .001
Likelihood ratio	39.691	1	< .001
Linear-by-linear association	39.680	1	< .001
McNemar's test	-	1	< .001

Table 6 Association between anemia and maternal age during the first and third trimesters of pregnancy

Pregnant age		With anemia		No anemia		Chi-square test		
		n	%	n	%	χ^2	df	*p*
1st trimester	15 - 19	15	9.6	8	8.4			
	20 - 34	123	78.8	70	73.7	2.007[a]	2	.367
	35 - 42	18	11.5	17	17.9			
3rd trimester	15 - 19	19	9.1	4	9.5	2.437[a]	2	.296

The interpregnancy interval was not significantly associated with anemia during either trimester. Cases were mainly concentrated among women with intervals longer than two years and among nulliparous women; however, this pattern was similar among women with and without anemia. Therefore, the interval between pregnancies did not act as a differentiating factor in hematological status within the study population, as presented in Table 7.

Body mass index classification was not significantly associated with anemia during either the first or third trimester. The distribution of cases was similar across the nutritional categories evaluated, suggesting that weight status did not act as a differentiating factor in hematological impairment within this sample. Therefore, the high frequency of anemia observed during pregnancy may be more closely related to other physiological, nutritional, or contextual factors associated with pregnancy at high altitude than to BMI classification considered independently, as shown in Table 8.

A history of miscarriage and diagnoses of genitourinary infection during pregnancy were not significantly associated with anemia during either trimester. The distribution of cases was comparable between women with and without these clinical and obstetric histories, suggesting that these conditions did not act as differentiating factors in hematological status. Consequently, anemia appears to be less closely related to these specific clinical and obstetric

factors and more closely associated with other physiological or contextual determinants of pregnancy at high altitude, as shown in Table 9.

Table 7 Association between anemia and the interreproductive period in the first and third trimesters of pregnancy

Pregnant age	Intergenic period	With anemia		No anemia		Chi-square test		
		n	%	n	%	χ^2	df	*p*
1st trimester	Nulípara	51	32.7	35	36.8	1.037[a]	4	.904
	Less than 6 months	3	1.9	2	2.1			
	6 months to 1 year	8	5.1	3	3.2			
	1 year to 2 years	18	11.5	12	12.6			
	Plus 2 years	76	48.7	43	45.3			
3rd trimester	Nulípara	69	33.0	17	40.5	7.584a	4	.108
	Less than 6 months	4	1.9	1	2.4			
	6 months to 1 year	8	3.8	3	7.1			
	1 year to 2 years	30	14.4	0	.0			
	Plus 2 years	98	46.9	21	50.0			

Table 8 Association between body mass index (BMI) classification and the presence of anemia in the first and third trimesters of pregnancy

Clasificación del IMC		With anemia		No anemia		Chi-square test		
		n	%	n	%	χ^2	df	*p*
1st trimester	Normal Weight	44	28.2	27	28.4	.021[a]	2	.990
	Overweight	68	43.6	42	44.2			
	Obesity	44	28.2	26	27.4			
3rd trimester	Normal Weight	64	30.6	7	16.7	3. 42a	2	.181
	Overweight	88	42.1	22	52.4			
	Obesity	57	27.3	13	31.0			

Tabla 9 Asociación entre anemia y antecedentes obstétricos (abortos) e infecciones genitourinarias durante el embarazo

History of abortions		With anemia		No anemia		Chi-square test		
		n	%	n	%	χ^2	df	*p*
1st trimester	Yes	54	34.6	31	32.6	.104[a]	1	0.747
	No	102	65.4	64	67.4			
3rd trimester	Yes	72	34.4	13	31.0	.191[a]	1	0.662
	No	137	65.6	29	69.0			
Vaginal infections		n	%	n	%	χ^2	gl	p
1st trimester	Yes	89	57.1	46	48.4	1.769[a]	1	0.183
	No	67	42.9	49	51.6			
3rd trimester	Yes	114	54.5	21	50.0	.291[a]	1	0.590
	No	95	45.5	21	50.0			

Table 10 Hemoglobin levels between the first and third trimesters of pregnancy in pregnant women

Parameter	1st trimester	3rd trimester	Average difference (95% CI)	t (df)	*p* (bilateral)
Hemoglobin (g dL^{-1})	13.89 ± 1.47	13.30 ± 1.25	0.586 (.457 - .715)	8.93 (250)	< .001

The within-subject comparison of Hb levels showed a significant decrease between the first and third trimesters. This result confirms a consistent hematological change during prenatal follow-up, compatible with the expected decline in hemoglobin as pregnancy progresses. Among pregnant women living at high altitude, this pattern requires particular clinical attention because physiological changes may coexist with greater vulnerability to gestational anemia, as presented in Table 10.

Discussion

The present study demonstrated a statistically significant decrease in Hb levels between the first and third trimesters among pregnant women living at high altitude who received care at comprehensive health centers in District 1 of El Alto. This finding is consistent with maternal physiological changes described in recent primary studies, which have reported a progressive decline in Hb as gestational age advances, with the lowest values occurring during the third trimester[24-26]. The mean reduction observed in this study (.59 g dL^{-1}; $p < .001$) was within the expected physiological range of .5-1.5 g dL^{-1} reported in recent studies[27], supporting the occurrence of hemodilution as a consequence of plasma volume expansion relative to the increase in erythropoiesis required to meet fetoplacental demands[26,28].

The prevalence of anemia increased significantly from 62.2 % during the first trimester to 83.3 % during the third trimester ($p < .001$, McNemar's test), showing an upward trend as pregnancy progressed. These results are consistent with studies reporting a higher prevalence of anemia during later stages of pregnancy, mainly attributed to dietary factors, the progressive increase in iron requirements, and the depletion of iron stores throughout gestation[5,29].

Physiological adaptation to high altitude should also be considered, because reference values differ from those established for populations living at sea level[30].

Regarding clinical factors, no significant association was identified between previous deliveries and anemia during the first trimester. This finding partially agrees with studies describing greater iron depletion among multiparous women[31]. No significant associations were found with maternal age, parity, interpregnancy interval, history of miscarryage, or urinary and vaginal infections ($p > .05$). This suggests that, in this population, anemia may be more closely related to physiological and environmental factors, such as altitude and increased iron requirements, than to specific obstetric or infectious characteristics. Differences from previous studies may be explained by variations in study design or in the diagnostic criteria applied[32].

Most participants were classified as overweight or obese; however, no statistically significant association was found between BMI classification and anemia during either the first or third trimester.

This finding differs from recent studies that have described variations in Hb levels and anemia prevalence according to maternal nutritional status during pregnancy[33]. Therefore, the results suggest that, in this high-altitude population, weight status did not act as a differentiating factor for hematological impairment. The anemia observed may instead be more closely related to physiological changes associated with pregnancy, increased iron requirements, and contextual conditions related to residence at high altitude.

The analysis was performed using Hb cutoff values adjusted for altitudes above 4,000 m above sea level, in accordance with current WHO recommendations for interpreting Hb concentrations in populations living at high altitude and with Bolivian evidence involving pregnant women residing at very high elevations[19,21]. This adjustment is essential to reduce the risk of diagnostic misclassification in the Andean highlands.

From a clinical and preventive perspective, these findings reinforce the need to strengthen nutritional education and adherence to iron and folic acid supplementation during prenatal care, particularly among vulnerable and low-resource populations[34]. Maintaining adequate Hb levels during pregnancy is also important for reducing the risk of adverse maternal and perinatal outcomes, including preterm birth, low birth weight, and fetal growth restriction[35,36].

In conclusion, the findings demonstrate a significant decline in Hb levels between the first and third

trimesters, consistent with the physiological changes of pregnancy. However, the high prevalence of anemia observed among pregnant women living at high altitude highlights the need for careful interpretation of altitude-adjusted cutoff values, because distinguishing physiological adaptation from pathological anemia may be complex in settings characterized by chronic hypoxia. These findings reinforce the importance of strengthening prenatal care in El Alto, with emphasis on early anemia detection, timely hematological monitoring, and the implementtation of preventive strategies adapted to populations living at high altitude.

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Conflicts of interest

The authors declare that they have no financial, academic, institutional, or personal conflicts of interest that could have influenced the development of the study, the analysis and interpretation of the findings, or the publication of this article.

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Ethical considerations

The study was conducted in accordance with the ethical principles applicable to health research. Because this was a retrospective study based on the review of medical records, no direct intervention was performed on the pregnant women, and their usual clinical care was not modified. Data were collected using a structured form and processed anonymously, thereby ensuring the confidentiality of the participants' personal and clinical information. The information was used exclusively for scientific purposes. Institutional authorization was obtained for the review of the medical records.

Authors' contribution

All authors contributed to the conceptualization of the study, methodological design, documentary review of the medical records, and data curation. They also participated in the analysis and interpretation of the findings, manuscript preparation, critical revision of the intellectual content, and approval of the final version. All authors share responsibility for the methodological integrity, analytical coherence, and accuracy of the information presented.

Limitations in research

The findings should be interpreted in light of the retrospective design and the use of information recorded in medical records, which restricted the analysis to variables that were available in a complete and consistent manner. Hemoglobin was assessed only during the first and third trimesters; therefore, it was not possible to describe its behavior throughout the entire course of pregnancy. The absence of specific biomarkers of iron status, such as serum ferritin, transferrin saturation, and C-reactive protein, prevented differentiation among iron-deficiency anemia, physiological hemodilution, and other

possible causes of decreased hemoglobin. Complete information was also unavailable regarding adherence to iron and folic acid supplementation, dietary intake, socioeconomic conditions, and other potentially associated factors. Finally, the data were obtained from three health centers in a single district of El Alto; therefore, the generalizability of the findings should be limited to populations with similar clinical, geographical, and healthcare characteristics. Nevertheless, the availability of paired measurements from the same pregnant women allowed for a consistent evaluation of changes in hemoglobin levels during pregnancy.

Literature Cited

1. Anaemia in women and children [Internet]. World Health Organization. 2025 [cited September 5, 2025]. Retrieved from: https://www.who.int/data/gho/data/themes/topics/anaemia_in_women_and_children
2. Sowe A, Wood E, Gautam SK. Maternal anemia as a predictor of childhood anemia: evidence from Gambian health data. Nutrients 2025;17(5):879. DOI: https://doi.org/10.3390/nu17050879
3. Teichman J, Nisenbaum R, Lausman A, Sholzberg M. Suboptimal iron deficiency screening in pregnancy and the impact of socioeconomic status in a high-resource setting. Blood Adv 2021;5(22): 4666-73. DOI: https://doi.org/10.1182/bloodadvances.2021004352
4. Mei Z, Addo OY, Jefferds MED, Flores-Ayala RC, Brittenham GM. Physiologically based trimester-specific serum ferritin thresholds for iron deficiency in US pregnant women. Blood Adv 2024;8(14):3745-53. DOI: https://doi.org/10.1182/bloodadvances.2024013460

   Angeles Oblitas MY; Ortiz Montalvo YJ, Ortiz Romaní KJ, Leon Fernandez MS. Prevalencia de anemia ferropénica y factores asociados en embarazadas peruanas. Index Enferm 2023; 32(4): e14558. DOI: https://doi.org/10.58807/indexenferm20235827
5. American College of Obstetricians and Gynecologists' Committee on Practice Bulletins: Practice Bulletin, Number 233, Anemia in Pregnancy. Obstet Gynecol 2021;138(2):e55-e64. DOI: https://doi.org/10.1097/AOG.0000000000004477
6. Addo OY, Yu EX, Williams AM, Young MF, Sharma AJ, Mei Z, et al. Evaluation of hemoglobin cutoff levels to define anemia among healthy individuals. JAMA Netw Open 2021;4(8): e2119-123. DOI: https://doi.org/10.1001/jamanetworkopen.2021.19123
7. Shi H, Chen L, Wang Y, Sun M, Guo Y, Ma S, et al. Severity of anemia during pregnancy and adverse maternal and fetal outcomes. JAMA Netw Open 2022;5(2):e2147046. DOI: https://doi.org/10.1001/jamanetworkopen.2021.47046
8. Flores-Venegas SR, Germes-Piña F, Levario-Carrillo M. Complicaciones obstétricas y perinatales en pacientes anémicas. Ginecol Obstet Mex 2019;87(2):85-92. https://doi.org/10.24245/gom.v87i2.2436
9. Lauer JM, Bhaise S, Dhurde V, Gugel A, Shah M, Hibberd PL, et al. Maternal anemia during pregnancy and infant birth outcomes: a prospective cohort study in Eastern Maharashtra, India. Curr Dev Nutr 2024;8(11):104476. https://doi.org/10.1016/j.cdnut.2024.104476
10. Tunçalp Ö, Pena-Rosas JP, Lawrie T, Bucagu M, Oladapo OT, Portela A, et al. WHO recommenddations on antenatal care for a positive pregnancy experience-going beyond survival. BJOG 2017; 124(6): 860-2. DOI: https://doi.org/10.1111/1471-0528.14599
11. Castellanos Hernández D, Borja Velázquez M, Rosales Ortiz S. Anemia ferropénica en el embarazo: esquema de sulfato ferroso intermitente en comparación con el continuo. Ginecol Obstet

Mex 2024;92(1):1-7. DOI: https://doi.org/10.242-45/gom.v92i1.8876

12. Stoffel NU, Zeder C, Brittenham GM, Moretti D, Zimmermann MB. Iron absorption from supplements is greater with alternate day than with consecutive day dosing in iron-deficient anemic women. Haematologica 2020;105(5):1232-9. DOI: https://doi.org/10.3324/haematol.2019.220830
13. Lam MC, Khandakar B, Heon I, Hussain F, Feldman K, Kaplowitz E, et al. Daily versus alternate-day iron supplementation for pregnant women with iron deficiency anemia: a randomized controlled trial. Am J Perinatol 2025;42(6):699-707. DOI: https://doi.org/10.1055/a-2405-1381
14. McCarthy EK, Schneck D, Basu S, Xenopoulos-Oddsson A, McCarthy FP, Kiely ME, et al. Longitudinal evaluation of iron status during pregnancy: a prospective cohort study in a high-resource setting. Am J Clin Nutr 2024;120(5): 1259-68. DOI: https://doi.org/10.1016/j.ajcnut.2024.08.010
15. Cueva Rossell ML, Reyna Gallegos SL, Villanueva Espinoza ME. Factores asociados a anemia en gestantes ingresadas en hospitales de referencia Puno, Perú. Nutr Clin Diet Hosp 2024;44(2):180-7. DOI: https://doi.org/10.12873/442cueva
16. Laflamme EM. Maternal hemoglobin concentration and pregnancy outcome: a study of the effects of elevation in El Alto, Bolivia. Mcgill J Med 2011;13(1):47.
17. Caihuara Villafuerte MF, Ortega Blanco MA, Arteaga Vera FAM. Ferropenic anemia. Prevalence in Pregnant and Puerperas. Integral Health Center Santiago de Presto. September 2017 to February 2018. Arch Boliv Med 2018;29(97): 75-89.
18. World Health Organization. Guideline on haemoglobin cutoffs to define anaemia in individuals and populations [Internet]. Geneva: World Health Organization; 2024. Disponible en: https://www.who.int/publications/i/item/9789240088542
19. Vásquez-Velásquez C, Gonzales GF. Evaluation of the hemoglobin cutoff point for anemia in adult women residents of different altitudinal levels in Peru. PLoS One 2024;19(7):e0307502. DOI: https://doi.org/10.1371/journal.pone.0307502
20. Araoz R, Alvarez G, Villarroel L, Quispe T, Quisbert E, Amaru R. Valores hematológicos en mujeres gestantes residentes a 3.600 msnm. Rev Méd (La Paz) 2018;24(1):27-33.
21. Sharma D, Amgain K, Panta PP, Pokhrel B. Hemoglobin levels and anemia evaluation among pregnant women in the remote and rural high lands of mid-western Nepal: a hospital based study. BMC Pregnancy Childbirth 2020;20(1):182. DOI: https://doi.org/10.1186/s12884-020-02870-7
22. Ministerio de Salud. Atención integrada al continuo del curso de la vida [Internet]. La Paz: Ministerio de Salud; 2021 [citado 2024 May 22]. Disponible en: https://es.scribd.com/document/615134878/Continuo-de-La-Vida-2021
23. Zeng Y, He G. Association of blood parameters in early pregnancy with anemia during late pregnancy: a multicenter cohort study in China. J Matern Fetal Neonatal Med 2024;37(1):2299110. DOI: https://doi.org/10.1080/14767058.2023.2299110
24. Ohuma EO, Young MF, Martorell R, Ismail LC, Peña-Rosas JP, Purwar M, et al. International values for haemoglobin distributions in healthy pregnant women. EClinicalMedicine 2020;29-30: 100660. DOI: https://doi.org/10.1016/j.eclinm.2020.100660
25. Sun M, Gu T, Wu T, Gong X, Li X, Huang J, et al. Variation patterns of hemoglobin levels by gestational age during pregnancy: a cross-sectional analysis of a multi-center retrospective cohort study in China. Nutrients 2023;15(6):1383. DOI: https://doi.org/10.3390/nu15061383

26. Churchill D, Nair M, Stanworth SJ, Knight M. The change in haemoglobin concentration between the first and third trimesters of pregnancy: a popular-tion study. BMC Pregnancy Childbirth 2019;19 (1):359. DOI: https://doi.org/10.1186/s12884-019-2495-0
27. Abdullahi AS, Suliman A, Khan MA, Khair H, Ghazal-Aswad S, Elbarazi I, et al. Temporal trends of hemoglobin among pregnant women: The Mutaba'ah study. PLoS One 2023;18(12): e0295549. DOI: https://doi.org/10.1371/journal.pone.0295549
28. Tan J, He G, Qi Y, Yang H, Xiong Y, Liu C, et al. Prevalence of anemia and iron deficiency anemia in Chinese pregnant women (iron women): a national cross-sectional survey. BMC Pregnancy Childbirth 2020;20(1):670. DOI: https://doi.org/10.1186/s12884-020-03359-z
29. Cohen JH, Haas JD. Hemoglobin correction factors for estimating the prevalence of iron deficiency anemia in pregnant women residing at high altitudes in Bolivia. Rev Panam Salud Publica 1999;6(6):392-9. DOI: https://doi.org/10.1590/s1020-49891999001100004
30. Imai K. Parity-based assessment of anemia and iron deficiency in pregnant women. Taiwan J Obstet Gynecol 2020;59(6):838-841. DOI: https://doi.org/10.1016/j.tjog.2020.09.010
31. Alreshidi MA, Haridi HK. Prevalence of anemia and associated risk factors among pregnant women in an urban community at the North of Saudi Arabia. J Prev Med Hyg 2021;62(3):E653-E663. DOI: https://doi.org/10.15167/24214248/jpmh2021.62.3.1880
32. Eltayeb R, Binsaleh NK, Alsaif G, Ali RM, Alyahyawi AR, Adam I. Hemoglobin levels, anemia, and their associations with body mass index among pregnant women in Hail Maternity Hospital, Saudi Arabia: A cross-sectional study. Nutrients 2023;15(16):3508. DOI: https://doi.org/10.3390/nu15163508
33. Anato A, Reshid M. Effect of nutrition education and iron-folic acid supplementation on anemia among pregnant women in Ethiopia: a quasi-experimental study. Sci Rep 2025;15(1):3556. DOI: https://doi.org/10.1038/s41598-025-87957-x
34. Wu L, Sun R, Liu Y, Liu Z, Chen H, Shen S, et al. High hemoglobin level is a risk factor for maternal and fetal outcomes of pregnancy in Chinese women: A retrospective cohort study. BMC Pregnancy Childbirth 2022;22(1):290. DOI: https://doi.org/10.1186/s12884-022-04636-9
35. Moghaddam Tabrizi F, Barjasteh S. Maternal hemoglobin levels during pregnancy and their association with birth weight of neonates. Iran J Ped Hematol Oncol 2015;5(4):211-7.

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