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# Nutritional and sociodemographic determinants related to anemia in indigenous-rural Mexican pregnant women

## *Determinantes nutricionais e sóciodemográfico relacionados à anemia em gestantes indígenas-rurais mexicanas*

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## ABSTRACT

### Objective
To identify nutritional indicators related to anemia considering the sociodemographic context of indigenous-rural Mexican pregnant women.

### Methods
Information was collected from 156 indigenous-rural pregnant women. A sociodemographic questionnaire was administered and nutritional indicators were obtained: Women's Dietary Diversity Score, pregestational body mass index, weight gain for gestational age, hemoglobin concentrations, and serum levels of ferritin, iron, zinc, vitamin C, vitamin B12, and erythrocyte folate. Statistical analysis was conducted to identify variables related to the presence of anemia, creating a binary logistic regression model with significant correlations.

### Results
24% of the participants had anemia and low iron reserves, 32.1% had low vitamin C concentrations. Furthermore, 37.8% experienced insufficient weight gain or weight loss. Adolescent women had lower pregestational body mass index (22.2±2.8 vs. 24.9±4.4; $p$=0.000) and lower Women's Dietary Diversity Score compared to adult women (35.8 vs. 21.8; $p$=0.020). Women living farther away from the municipal center also had lower Women's Dietary Diversity Score (r=-0.213; $p$=0.028). In adult women, being a homemaker (OR=6.06 [95% CI=1.35-27.28]; $p$=0.019), experiencing gestational weight loss or insufficient weight gain (OR=5.34 [95% CI=1.56-18.26]; $p$=0.008), having low ferritin concentrations (OR=13.12 [95% CI=3.48-48.34]; $p$=0.000) and low vitamin C levels (OR=6.01 [95% CI=1.36-16.00]; $p$=0.014), were contributors (Nagelkerke $r^2$=0.470) to the presence of anemia.

### Conclusion
When developing strategies for anemia prevention in pregnant women, it is necessary to consider their social, economic, and geographic contexts. Furthermore, public policies should

be established to ensure proper implementation of multivitamin supplementation and, in this kind of marginal population starting it from the onset of menstruation.

**Keywords:** Anemia. Indigenous peoples. Nutritional status. Pregnancy.


## *RESUMO*

***Objetivo***

*Identificar indicadores nutricionais relacionados à anemia considerando o contexto sociodemográfico de gestantes indígenas-rurais mexicanas.*

***Métodos***

*Foram coletados dados de 156 gestantes indígenas-rurais. Foi aplicado um questionário sociodemográfico e foram obtidos indicadores nutricionais: Women's Dietary Diversity Score (WDDS), índice de massa corporal (IMC) pré-gestacional, ganho de peso para a idade gestacional, concentrações de hemoglobina e níveis séricos de ferritina, ferro, zinco, vitamina C, vitamina B12 e folato eritrocitário. Utilizou-se análise estatística para identificar variáveis relacionadas à presença de anemia, criando modelo de regressão logística binária com correlações significativas.*

***Resultados***

*24% das participantes apresentavam anemia e baixas reservas de ferro, 32,1% baixas concentrações de vitamina C. Além disso, 37,8% experimentaram perda ou ganho de peso insuficiente. As adolescentes apresentaram menor IMC pré-gestacional (22,2±2,8 vs. 24,9±4,4; p=0,000) e menor WDDS em comparação às mulheres adultas (35,8 vs. 21,8; p=0,020). As grávidas que moravam mais longe da sede municipal apresentaram menor WDDS (r=-0,213; p=0,028). Em adultas, ser dona de casa (OR=6,06 [IC 95%=1,35-27,28]; p=0,019), apresentar perda ou ganho de peso insuficiente (OR=5,34 [IC 95%=1,56-18,26]; p= 0,008), baixas concentrações de ferritina (OR=13,12 [IC 95%=3,48-48,34]; p=0,000) e baixos níveis de vitamina C (OR=6,01 [IC 95%=1,36-16,00]; p=0,014), foram contribuintes (Nagelkerke $r^2$=0,470) à anemia.*

***Conclusão***

*Ao desenvolver estratégias para a prevenção da anemia em mulheres grávidas, é necessário considerar seus contextos sociais, econômicos e geográficos. Além disso, devem ser estabelecidas políticas públicas para garantir a implementação adequada da suplementação multivitamínica e, neste tipo de população marginal, iniciá-la desde o início da menstruação.*


***Palavras-chave***: *Anemia. Estado nutricional. Gravidez. Povos indígenas.*

## INTRODUCTION

Currently, anemia during pregnancy remains a global public health problem [1]. According to the World Health Organization (WHO), 40% of pregnant women worldwide are affected by anemia [2]. Although the global prevalence of anemia during pregnancy decreased from 43% to 38% between 1995 and 2011, the WHO emphasizes that this decrease is insufficient, and it is essential for all countries to implement policies, prevention strategies, resources, and infrastructure in the field of anemia prevention to achieve the global nutrition goals for 2025, which include a 50% reduction in anemia among women of reproductive age [3].

The presence of anemia during pregnancy is primarily associated with iron deficiency, especially in developing countries [4,1]. It has been shown that anemia during pregnancy is associated with increased maternal and fetal morbidity and mortality, including the risk of miscarriage, stillbirth, preterm birth, and low birth weight. It also compromises neurodevelopment and infant immune competence, leading to poor long-term occupational performance [3,5].

Currently, most of the research on anemia and pregnancy originates from Asia and Africa. Several studies have reported factors that contribute to the presence of anemia in pregnant women, including rural residence, low dietary diversity, inadequate food intake, insufficient consumption

of iron-rich foods, maternal age (young women between 15 and 24 years or older than 35 years), multiparous, low or no education, belonging to the poorest wealth quintile globally, lack of sanitation facilities and improved water sources, underweight women, and having more than one child born in the past five years in most countries [6–10].

On the contrary, research production in Latin America and the Caribbean is mainly focused on studying anemia in women of reproductive age. Factors that contribute to the presence of anemia in this context include precarious social conditions, rural-indigenous residency, poverty contexts leading to lower availability of healthy foods, and unsafe sanitary conditions such as lack of clean water [11,12]. This is further supported by findings from populations with predominantly high socioeconomic status, where only one-third fails to meet the adequate iron intake, as the rest have greater access and consumption of foods such as bread, cereals, vegetables, and animal products [13,14].

In the few studies conducted in the last five years in Latin America and the Caribbean on pregnant women with anemia, similar findings to those recorded in Asia and Africa have been reported [6–10]. These studies highlight the influence of rural residence, ethnic groups such as Afro-descendants, and multiparous [15–17]. They also emphasize the prevalence of anemia among primiparous women, who often enter pregnancy with anemia, coupled with a lack of knowledge about nutrition during pregnancy, inadequate prenatal care, or late initiation of prenatal care [18–20].

In the case of Mexico, the National Health and Nutrition Survey ENSANUT mentions that between 2012 and 2019, there was an increase in the prevalence of anemia in the entire population. From 2016 onwards, a higher percentage of anemia was observed in the population with a low socioeconomic level of 22%, where the indigenous-rural population is located. In particular in women of childbearing age in 2022 there was a prevalence of anemia of 35% [21,22].

The combination of factors related to the presence of anemia in pregnant women identified in previous research, coupled with the lack of significant research production in Latin America and the Caribbean in the past five years, emphasizes the need to continue conducting studies in vulnerable populations where anemia remains a serious public health problem [23,24]. In this context, this study aims to contribute to the discussion of anemia during pregnancy in Latin America and the Caribbean, specifically among indigenous-rural Mexican women. The study's objective is to identify the nutritional indicators related to anemia considering the sociodemographic context of indigenous-rural Mexican pregnant women.

## METHODS

This study is part of the research protocol "Aplicación y evaluación del Modelo Sociocultural para Prevenir Muertes Maternas en Cuetzalan del Progreso, Puebla". It is an observational, cross-sectional, and analytical study. In this protocol were investigated factors influencing maternal morbidity and mortality in indigenous-rural women, which has been carried out since 2012 in Cuetzalan del Progreso a marginalized area of the city of Puebla, Mexico [25,26].

### Fieldwork

Fieldwork was conducted with pregnant indigenous-rural women. Understanding as an indigent rural population those people living in their community with access to basic services such as health and education; they are also women who work on the land and have mobility to the cities.

The municipality de Cuetzalan del Progreso is one of the 217 municipalities that make up the State of Puebla. In this municipality there are total rural indigenous population of 33,308 [27], where indigenous speakers women represent 51.6% [28]. Geographically the municipality is composed of 8 Auxiliary Boards.

The geographical conditions in the municipality are varied, in the vicinity of the center of each Auxiliary Boards the streets are pavements; and in distant communities the roads are sidewalks and terracing. The climatic condition, is usually extreme, in warm season the ambient temperature can reach 35°, in cold weather down to 5 degrees; in rainy season, water is excessive so the streets and sidewalks turn into streams that complicate the roads.

Each Auxiliary Board has a Health Centre made up of a doctor, nurse, health promoter and a midwife. There is only one General Hospital for the whole municipality; this hospital has a Traditional Medicine Module, made up of midwives and healers.

To make money, the women are dedicated to creating crafts such as necklaces, bracelets, earrings and embroidered blouses for sale, especially to tourism. There are few midwives.

In the downtown of the municipal center Cuetzalan del Progreso is where basic products are obtained: butchers, stores selling chicken, green grocers, bakeries and other stores. Only on Sundays there are a street stalls that sell food and clothing cheaper, however not all women have access to food products, because the farther they live from the center of Cuetzalan access to food is less [26], leading to an inequality of dietary diversity within this population group.

One of the topic of this research line is related to the nutritional status of pregnant women, considering their food situation, i.e., the access to and types of food that define the diet of this group of women within the framework of their socially and economically vulnerable situation.

The collection of information was 156 pregnant women, who during the period of field work attended their prenatal control in local health services. Sample was nonprobabilistic for convenience. We relied on the General Hospital located in the municipal seat, as well as Health Centers and Rural Medical Units in six out of the eight Auxiliary Boards that make up the Municipality of Cuetzalan del Progreso, during the period from March to June 2018. The inclusion criteria were voluntary participation in the study, and the presence of pregnancy. The exclusion criteria were the lack of complete information from instruments and blood samples.

The project was reviewed by the Research Ethics, and Biosafety Committees of the National Institute of Perinatology (INPer) under registration number 2017-1-55. The women participation was voluntary and they were explained in detail what was their participation in the project and they were provided with an Informed Consent Letter.

**Sociodemographic analysis**

A sociodemographic and economic questionnaire semi-structured collected on paper was administered, considering variables such as gainful occupation, unpaid occupation, schooling, marital status, and age. Territorially, the municipality is composed of 8 Auxiliary Boards that, despite being in the same socially vulnerable zone, have sociodemographic and economic particularities that make some more marginalized than others based on their distance from the municipal seat. The distances was considered as a reference axis for the results, naming it the *long-distance factor.*

## Nutritional analysis

Nutritional indicators were also considered, such as the Women's Dietary Diversity Score (WDDS), pregestational Body Mass Index (BMI), weight gain for gestational age, serum concentrations of ferritin, iron, zinc, hemoglobin, vitamin C, vitamin B12, and erythrocyte folate. The consumption of dietary supplements was recorded. The WDDS is an indicator of food consumption to characterize diet quality and reflects a proxy for nutrient adequacy of the diet of women in reproductive age from low income populations since its low cost and simplicity to gather [29]. As a standardized questionnaire of universal applicability prior to using it in the field, it was adapted to the local context using the Spanish version, and the food lists were adapted to reflect locally available foods. Also it was reviewed by the survey team and women in the community on the appropriate wording of the questions and fill in the food group lists with all locally available foods, translated into commonly used, locally recognized names. The questionnaire was administered by trained personnel to obtain the WDDS. The WDDS is the sum of the presence (+1) or absence (0) of consumption in the previous day of the various food groups (grains, starchy vegetables, vegetables, fruits, meat and poultry, eggs, fish and seafood, legumes and nuts, and dairy products). As the questionnaire in this study was used as an indirect measure of the nutritional quality of the diet, the food groups sugar/honey, oils and fats, and spices and condiments were not included in the score calculation [29].

Weight and height measurements were taken by previously standardized health professional's. Weight was obtained using a digital scale (SECA professional model 703, Seca North America, Hanover, MD, USA) with women standing barefoot, wearing only a gown, and before 10 am. Height measurement was performed using a portable stadiometer (SECA 213, Seca North America, Hanover, MD, USA) using the Lohman technique [30]. For the analysis of pregestational BMI, women in the study were asked about their weight before pregnancy and classified according to the World Health Organization (WHO) guidelines: underweight < 18.5 kg/m$^2$, normal weight between 18.5 and 24.9 kg/m$^2$, overweight between 25.0 and 29.9 kg/m$^2$, and obesity with BMI ≥30.0 kg/m$^2$. Weight gain for the gestational week in which the participants were categorized as insufficient, adequate, or excessive according to the parameters of the Institute of Medicine of the United States [31].

## Biochemistry analysis

Additionally, a blood sample was obtained from each woman. A total of 15 mL of blood was collected from each participant using two Vacutainer tubes (EDTA and navy blue). The EDTA tube was used for complete blood count analysis, from which 50 μL was taken and mixed with 1 mL of ascorbic acid for erythrocyte folate analysis. The samples were centrifuged to obtain serum, which was then frozen at -70 °C at the General Hospital of Cuetzalan until analysis at the INPer. The transportation of samples to the INPer was carried out in special containers with controlled temperature and appropriately labeled.

To obtain the results of the nutritional indicators, ferritin and vitamin B12 concentrations in serum were analyzed, as well as erythrocyte folate, using the IMMULITE 1000 chemiluminescent immunoassay system from Siemens (Munich, Germany). Iron and zinc concentrations were quantified using the Analyst 400 atomic mass spectrophotometry equipment from PerkinElmer (Waltham, Massachusetts). Hemoglobin in blood was measured using the automated Beckman Coulter Ac.T 5 diff analyzer (Brea, California). Vitamin C was analyzed through HPLC with an electrochemical detector, using PerkinElmer equipment (Waltham, Massachusetts). Anemia was considered present when hemoglobin concentrations were <11.0 g/dL [32], low ferritin concentrations when <10 ng/mL,

erythrocyte folate <150 ng/mL, iron <41 μg/dL, zinc <75 μg/dL, and vitamin C <0.4 mg/dL, and vitamin B12 <279 pg/mL [33].

### Statistical analysis

Frequency measures were used for qualitative variables, and measures of central tendency were used for quantitative variables. To evaluate the differences in nutritional indicators by quarters, Kruskal Wallis test was used for non-parametric variables and ANOVA one factor test for parametric variables. Variables related to the presence of anemia, independent variables, were identified using Spearman correlations. Significant correlations ($p$-value <0.050) were used to create a binary logistic regression model with 95% confidence intervals for the presence of anemia, dependent variable, in all women and by age group. The adjustment parameters used to evaluate the quality of the final model were a test Hosmer and Lemeshow >0.05 and a percentage global more than 50% as was indicated in the footnote of Table 4. All statistical analyses were carried out using IBM®SPSS® Statistics for Windows, Version 20.0. (Armonk, NY: IBM Corp).

## RESULTS

It was found that 24% (n=38) of the women had anemia, and its prevalence was similar between adolescents and adults (24.5% vs. 24.3%; $p$>0.05). The Table 1 shows that the majority of women in the study were homemakers (65.4%), and nearly half (55.8%) had completed basic education. They were experiencing their first pregnancy (54.5%), and 40.4% already had one or two children. Thirty-four percent of the women in the study were adolescents, and the majority of them (51.9%) belonged to the more remote localities from the municipal center. Among all, only 5.8% were single, while the rest were in a relationship, with 83.3% in a common-law union and 10.9% married.

Regarding nutritional indicators, Table 1 also shows that 26.9% were overweight and 6.4% were obese before pregnancy and only 3.2 had low weight. A significant proportion of them showed insufficient weight gain for their gestational age or even weight loss (37.8%), while 23.7% exhibited excessive weight gain for gestational age. It is worth saying that the majority of women with adequate weight gain (86.7%) had no anemia ($p$=0.03). Also it was found that 32.1% and 24.4% had low concentrations of vitamin C and ferritin, respectively, and around 11% had low concentrations of iron and zinc. There was more frequency of anemia in those women whose values of ferritin and iron were low (50.0 and 61.1%) than those women with normal concentrations (16.4 and 20.1%) ($p$<0.001).

**Table 1 –** Sociodemographic characteristics and nutritional indicators in Indigenous-Rural Mexican pregnant women by presence of anemia % (f). Cuetzalan-Puebla, México, 2012.

1 of 2

| Variables | All | Without Anemia | With Anemia | $p^*$ |
|---|---|---|---|---|
| | % (f) 100 (156) | % (f) 65.6 (118) | % (f) 24.4 (38) | |
| Age group | | | | |
| Adolescents (≤19 years) | 34.0 (53) 66.0 | 75.5 (40) | 24.5 (13) | 0.972 |
| Adults (≥20 years) | (103) | 75.7 (78) | 24.3 (25) | |
| Educational attainment | | | | |
| Without studies | 6.4 (10) | 90 (9) | 10.0 (1) | 0.497 |
| Primary and Junior high school | 55.8 (87) | 72.4 (63) | 27.6 (24) | |
| High school | 28.8 (45) | 75.6 (34) | 24.4 (11) | |
| Professional | 9.0 (14) | 85.7 (12) | 14.3 (2) | |

**Table 1 –** Sociodemographic characteristics and nutritional indicators in Indigenous-Rural Mexican pregnant women by presence of anemia % (f). Cuetzalan-Puebla, México, 2012.



| Variables | All | Without Anemia | With Anemia | *p** |
|---|---|---|---|---|
| | % (f) 100 (156) | % (f) 65.6 (118) | % (f) 24.4 (38) | |
| Marital Status | | | | |
| Single | 5.8 (9) | 77.8 (7) | 22.2 (2) | 0.983 |
| Free union | 130 (83.3) | 75.4 (98) | 24.6 (32) | |
| Married | 10.9 (17) | 76.5 (13) | 23.5 (4) | |
| Occupation | | | | |
| Home | 65.4 (102) | 74.5 (76) | 16.7 (26) | 0.203 |
| Student | 7.7 (12) | 75.0 (9) | 1.9 (3) | |
| Handicrafts | 14.1 (22) | 63.6 (14) | 5.1 (8) | |
| Employee or Merchant | 9.6 (15) | 93.3 (14) | 0.6 (1) | |
| Professional | 3.2 (5) | 100.0 (5) | 0.0 (0) | |
| Auxiliary board | | | | |
| Closest | 34.0 (53) | 81.1 (43) | 18.9 (10) | 0.124 |
| Middle | 14.1 (22) | 59.1 (13) | 40.9 (9) | |
| Farthest | 51.9 (81) | 76.5 (62) | 23.5 (19) | |
| Quarter | | | | |
| First | 12.2 (19) | 78.9 (15) | 21.1 (4) | 0.379 |
| Second | 42.3 (66) | 80.3 (53) | 19.7 (13) | |
| Third | 45.5 (71) | 70.4 (50) | 29.6 (21) | |
| Parity | | | | |
| 0 | 54.5 (85) | 76.5 (65) | 23.5 (20) | 0.673 |
| 1-2 | 40.4 (63) | 76.2 (48) | 23.8 (15) | |
| ≥3 | 5.1 (8) | 62.5 (5) | 1.9 (3) | |
| Pregestational BMI (kg/m$^2$) | | | | |
| Low (<18.5) | 3.2 (5) | 60.0 (3) | 40.0 (2) | 0.658 |
| Normal (18.5-24.9) | 63.5 (99) | 73.7 (73) | 26.3 (26) | |
| Overweight (25.0-29.9) | 26.9 (42) | 81.0 (34) | 19.0 (8) | |
| Obesity (≥30.0) | 6.4 (10) | 80.0 (8) | 20.0 (2) | |
| Weight gain | | | | |
| Lost or insufficient | 37.8 (59) | 66.1 (39) | 33.9 (20) | 0.030 |
| Adequate | 38.5 (60) | 86.7 (52) | 13.3 (8) | |
| Excessive | 23.7 (37) | 73.0 (27) | 27.0 (10) | |
| Vitamin C | | | | |
| Low | 32.1 (50) | 70.0 (35) | 30.0 (15) | 0.260 |
| Normal | 67.9 (106) | 78.3 (83) | 21.7 (23) | |
| Ferritin | | | | |
| Low | 24.4 (38) | 50.0 (19) | 50.0 (19) | 0.000 |
| Normal | 74.4 (116) | 83.6 (97) | 16.4 (19) | |
| High | 1.3 (2) | 100.0 (2) | 0.0 (0) | |
| Iron | | | | |
| Low | 11.5 (18) | 38.9 (7) | 61.1 (11) | 0.000 |
| Normal | 85.9 (134) | 79.9 (107) | 20.1 (27) | |
| High | 2.6 (4) | 100.0 (4) | 0 (0) | |
| Zinc | | | | |
| Low | 10.9 (17) | 58.8 (10) | 41.2 (7) | 0.185 |
| Normal | 84.0 (131) | 77.1 (101) | 22.9 (30) | |
| High | 5.1 (8) | 87.5 (7) | 12.5 (1) | |

Note: *$X^2$: test was performed. BMI: Body Mass Index.

Eighty-three percent of the women consumed folic acid supplements, 49% consumed iron supplements, 34% consumed multivitamins, and 7% consumed dietary energy supplements. This data is not presented in the tables.

Table 2 presents some anthropometric and biochemical indicators of the women in the study. It can be observed that weight gain and the concentrations of ferritin, zinc, erythrocyte folate, and vitamin B12 vary according to the trimester of pregnancy in which the women are ($p$<0.05).

**Table 2 –** Indicators of nutritional status of study women, biochemical and anthropometric by quarter of pregnancy in Indigenous-Rural Mexican pregnant women. Cuetzalan-Puebla, México, 2012.

1 of 2

| Variables | Mean±SD/Median [IQR] (n=156) | Minimun | Maximun | *p* |
|---|---|---|---|---|
| Age[a] (years) | 24.0±6.0 | 13.0 | 38.0 | |
| Height[a] (m) | 1.51±0.1 | 1.38 | 1.75 | |
| Gestational weeks[a] | 26.0 [19.0-32.7] | 4.0 | 41.0 | |
| Pregestational weight[a] (kg) | 53.0 [49.0-61.0] | 35.0 | 89.0 | |
| Pregestational BMI[a] (kg/m$^2$) | 24.0±4.1 | 15.4 | 44.8 | |
| Weight (kg) | | | | 0.207* |
| 1st Quarter[b] | 57.2 [50.4-65.2] | 37.7 | 83.4 | |
| 2nd Quarter[c] | 58.0 [52.4-66.5] | 43.7 | 86.1 | |
| 3rd Quarter[d] | 60.4 [57.0-65.6] | 46.0 | 85.1 | |
| Weigth gain (kg) | | | | 0.000* |
| 1st Quarter[b] | 1.8 [0.0-4.2] | -6.8 | 12.4 | |
| 2nd Quarter[c] | 4.0 [1.2-6.6] | -6.5 | 12.5 | |
| 3rd Quarter[d] | 8.1 [5.0-12.1] | -4.8 | 24.0 | |
| Ferritin[a] (ng/mL) | 19.4 [10.1-31.2] | 3.7 | 197.0 | 0.000* |
| 1st Quarter[b] | 42.1 [19.4-58.5] | 8.4 | 168.0 | |
| 2nd Quarter[c] | 22.5 [11.1-32.4] | 4.3 | 97.7 | |
| 3rd Quarter[d] | 14.2 [7.0-23.7] | 3.7 | 197.0 | |
| Hemoglobin[a] (g/dL) | 11.8±1.3 | 6.8 | 15.7 | 0.181** |
| 1st Quarter[b] | 12.3±1.3 | 10.0 | 14.7 | |
| 2nd Quarter[c] | 11.7±1.2 | 6.8 | 14.1 | |
| 3rd Quarter[d] | 11.8±1.2 | 8.6 | 15.7 | |
| Vitamin C[a] (mg/dL) | 0.46±0.13 | 0.13 | 0.98 | 0.215** |
| 1st Quarter[b] | 0.51±0.14 | 0.32 | 0.86 | |
| 2nd Quarter[c] | 0.46±0.14 | 0.13 | 0.98 | |
| 3rd Quarter[d] | 0.45±0.12 | 0.23 | 0.81 | |
| Iron, serum[a] (µg/dL) | 86.3 [61.1-114.7] | 8.5 | 222.1 | 0.074* |
| 1st Quarter[b] | 88.6 [70.0-132.8] | 49.0 | 161.4 | |
| 2nd Quarter[c] | 87.0 [65.1-104.6] | 33.8 | 222.1 | |
| 3rd Quarter[d] | 81.7 [47.1-112.8] | 8.5 | 196.3 | |
| Zinc[a] (µg/dL) | 61.8 [55.6-68.3] | 29.4 | 140.2 | 0.000* |
| 1st Quarter[b] | 74.6 [67.0-81.5] | 56.4 | 140.2 | |
| 2nd Quarter[c] | 62.3 [56.6-71.8] | 39.9 | 105.9 | |
| 3rd Quarter[d] | 58.0 [52.4-63.5] | 29.4 | 75.1 | |
| Folate, red blood cell[a] (ng/mL) | 299.5 [227.0-402.0] | 103.0 | 1012.0 | 0.002* |
| 1st Quarter[b] | 231.0 [193.0-265.0] | 106.0 | 551.0 | |
| 2nd Quarter[c] | 300.5 [236.5-370.5] | 133.0 | 1012.0 | |

**Table 2 –** Indicators of nutritional status of study women, biochemical and anthropometric by quarter of pregnancy in Indigenous-Rural Mexican pregnant women. Cuetzalan-Puebla, México, 2012.



| Variables | Mean±SD/Median [IQR] (n=156) | Minimun | Maximun | *p* |
|---|---|---|---|---|
| 3rd Quarter[d] | 344.0 [221.0-463.0] | 103.0 | 766.0 | |
| Vitamina B12[a] (pg/mL) | 187.0 [155.0-255.5] | 113.3 | 1200.0 | 0.029* |
| 1st Quarter[b] | 224.0 [187.0-298.0] | 150.8 | 432.0 | |
| 2nd Quarter[c] | 187.5 [161.7-284.2] | 113.3 | 1200.0 | |
| 3rd Quarter[d] | 180.0 [147.0-242.0] | 117.6 | 1118.0 | |

Note: *Kruskal Wallis test for independent samples; **ANOVA one factor test. [a]All women values (n=156); Values by quarter: [b]First quarter (n=19); [c]Second quarter (n=66); [d]Third quarter (n=71). SD: Standard Deviation; IQR: Interquartile Range; BMI: Body Mass Index.

Figure 1 demonstrates the diversity of women's diets, highlighting that a higher proportion of adolescents are in the lowest quartile of dietary diversity, indicating that this age group has lower dietary diversity.

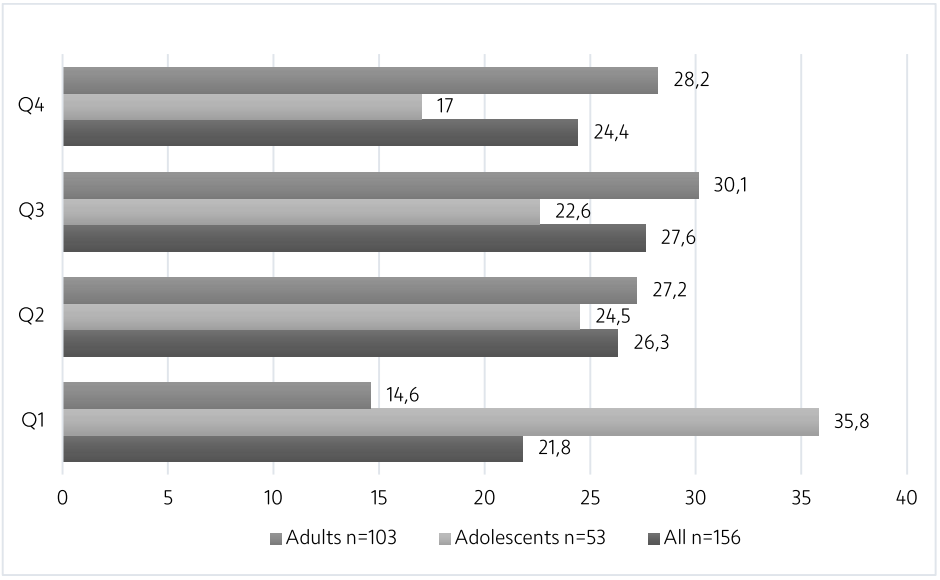


**Figure 1 –** Diet diversity by age group in study women in Indigenous-Rural Mexican pregnant women (%). Cuetzalan-Puebla, México, 2012.
Note: Q: Quartile of Women's Dietary Diversity Score.

In other analysis with diversity of women's diets, not shown in tables, it was observed a negative correlation between the auxiliary board and the dietary diversity score (r=-0.229; *p*=0.028), meaning that the farther their home was from the municipal center, the lower the diversity of their diet.

Table 3 shows some sociodemographic variables and nutritional status indicators that correlated with the presence of anemia in the women in the study. Among adult women, a mild negative correlation was observed between occupation and the presence of anemia (r=-0.20; *p*=0.045), indicating that those who earned some income from professional work, commerce, or employment had a lower incidence of anemia than those who did not earn income because they were homemakers or students.

In all cases, a negative correlation was found between anemia and concentrations of ferritin, iron, zinc, and erythrocyte folate. Among adult women, there was also a negative correlation between the presence of anemia and occupation, gestational weight gain, and concentrations of vitamin C.

**Table 3 –** Correlations between some socioeconomic and nutritional status variables with anemia by age group in Indigenous-Rural Mexican pregnant women. Cuetzalan-Puebla, México, 2012.

| Variables | All (n=156) | | Adolescents (n=53) | | Adults (n=103) | |
|---|---|---|---|---|---|---|
| | r | *p* | r | *p* | r | *p* |
| Parity (0/1-2/ ≥3) | 0.03 | 0.676 | 0.14 | 0.329 | -0.02 | 0.854 |
| Educational attainment[a] | -0.02 | 0.774 | 0.08 | 0.562 | -0.06 | 0.522 |
| Occupation[b] | -0.07 | 0.407 | 0.22 | 0.113 | -0.20 | 0.045 |
| Quarter[c] | 0.11 | 0.167 | -0.03 | 0.802 | 0.19 | 0.060 |
| Pregestational BMI[d] | -0.09 | 0.246 | -0.04 | 0.759 | -0.12 | 0.242 |
| Weight gain[e] | -0.08 | 0.310 | 0.10 | 0.485 | -0.21 | 0.031 |
| Iron Suplementation (yes/no) | -0.15 | 0.194 | -0.11 | 0.610 | -0.17 | 0.230 |
| Folate Suplementation (yes/no) | -0.21 | 0.074 | -0.16 | 0.458 | -0.23 | 0.107 |
| Vitamin B12 (pg/mL) | -0.04 | 0.641 | 0.07 | 0.595 | -0.08 | 0.404 |
| Folate, red blood cell (ng/mL) | -0.21 | 0.008 | -0.17 | 0.222 | -0.24 | 0.015 |
| Vitamin C (mg/dL) | -0.14 | 0.077 | -0.03 | 0.854 | -0.20 | 0.047 |
| Ferritin (ng/mL) | -0.37 | 0.000 | -0.17 | 0.210 | -0.48 | 0.000 |
| Iron, serum (µg/dL) | -0.38 | 0.000 | -0.21 | 0.130 | -0.45 | 0.000 |
| Zinc (µg/dL) | -0.16 | 0.041 | 0.11 | 0.413 | -0.29 | 0.003 |

Note: [a]Educational attainment: Without studies, Primary education and Junior high school, High school, Professional; [b]Occupation: Home, Student, Handicrafts, Merchant or Employee and Professional; [c]Quarter: First and Second (8-27 gestational weeks), Third (28-41 gestational weeks); [d]Pregestational BMI: Low, Normal, Overweight, Obesity; [e]Weight gain: Insufficient or Lost, Adequate, Excessive. BMI: Body Mass Index.

Table 4, the contribution of these variables to the presence of anemia in all women in the study and by age group. In all women the ferritin concentrations (OR=5.64 [95% CI=2.41-13.20]; *p*=0.000) and the loss or insufficient weight gain (OR=2.65 [95% CI=1.17-6.02]; *p*=0.020) that contribute in a 20% (Nagelkerke $r^2$=0.20) to the presence of anemia. Furthermore is worth noting that, when only was included adult women, being a homemaker (OR=6.06 [95% CI=1.35-27.28]; *p*=0.019), experiencing weight loss or insufficient gestational weight gain (OR=5.34 [95% CI=1.56-18.26]; *p*=0.008), as well as having low concentrations of ferritin (OR=13.12 [95% CI=3.48-48.34]; *p*=0.000) and vitamin C (OR=6.01 [95% CI=1.36-16.00]; *p*=0.014), explain a significant portion, 47% (Nagelkerke $r^2$=0.470) of the presence of anemia in this population.

**Table 4 –** Variables that favor anemia in the all study women and by age in Indigenous-Rural Mexican pregnant women. Cuetzalan-Puebla, México, 2012.

| Variables | [a]All (n=153) | | [b]Adolescents (n=53) | | [c]Adults (n=103) | |
|---|---|---|---|---|---|---|
| | OR [95% CI] | *p* | OR [95% CI] | *p* | OR [95% CI] | *p* |
| L Vitamin C | 1.44 [0.63-3.28] | 0.390 | 0.44 [0.10-1.97] | 0.283 | 6.01 [1.36-16.00] | 0.014 |
| L Ferritin | 5.64 [2.41-13.20] | 0.000 | 3.51 [0.61-20.03] | 0.158 | 13.12 [3.48-48.34] | 0.000 |
| L Zinc | 2.26 [0.70-7.30] | 0.174 | 1.15 [0.94-14.14] | 0.912 | 4.56 [0.86-24.28] | 0.075 |
| Lost/Insufficient* | 2.65 [1.17-6.02] | 0.020 | 1.15 [0.25-5.17] | 0.858 | 5.34 [1.56-18.26] | 0.008 |
| Home | 1.08 [0.46-2.66] | 0.858 | 0.24 [0.52-1.12] | 0.069 | 6.06 [1.35-27.28] | 0.019 |

Note: *WG: Weight Gain. Logistic regression was performed. Cox and Snell $r^2$ = [a]0.13; [b]0.11; [c]0.31. Nagelkerke $r^2$ = [a]0.20; [b]0.16; [c]0.47. Global percentage [a]75.6; [b]77.4; [c]85.4. OR: Odds Ratio; CI: Confidence Interval. L: Low.

## DISCUSSION

The presence of anemia in this group of pregnant women was closely related to their occupation; specifically, pregnant women without their own income had a higher prevalence of anemia. This leads us to reflect on the fact that women with certain economic independence are able to make decisions and have access to a greater variety and type of foods compared to those without

their own income [34], thus disadvantaging the latter in terms of their nutritional status [35]. This highlights the importance of women's mobility within the community in terms of occupation [36], but above all, it emphasizes the significance of paid work that provides them with a certain level of autonomy. Other studies have demonstrated that women of childbearing age who have economic support experience lower rates of anemia due to increased availability of iron-rich foods [13,14].

The place of residence in relation to the geographical area where basic services such as healthcare, education, and food are centralized limited their nutritional status due to two representative circumstances. Firstly, there was limited access to a daily variety of food, and secondly, there was a delay in receiving prenatal care [5], which resulted in a delayed start of supplementation. Therefore, the geographic location where pregnant women reside confirms findings from other international studies, affirming that pregnant women with greater social, economic, and geographical vulnerability have a higher proportion of anemia [6–10,15–20,37]. This clearly exemplifies gender inequality [33,38]. In this study, the factor of *long distance* was essential in understanding the presence of anemia, placing this factor as a representative finding to explain the presence of anemia in mexican rural indigenous population.

Furthermore, the group of pregnant adolescents reaffirms the vulnerability of rural indigenous women in the study. This age group exhibited a lower dietary diversity, which is concerning considering that they are still growing and, moreover, they live further away from the municipal center, experiencing the impact of the *long-distance* factor (limited access to a daily variety of food). This results in a deficient nutritional state, which can be aggravated by the fact that, due to their young age, they are more likely to experience multiple pregnancies considering the reproductive age cycle [39].

Taking into account that the presence of anemia in this group of pregnant women was influenced by their precarious social and economic conditions, impacting dietary diversity, particularly the lack of consumption of fruits, vegetables, and animal-based foods, reflected in low concentrations of vitamin C and ferritin [40], despite reporting that 83% were supplemented with folic acid and 49% with iron, we consider that the supplementation strategy provided by healthcare services is insufficient and ineffective for this type of population, namely rural indigenous women. Therefore, we confirm what other studies suggest, that public policies aimed at preventing anemia during pregnancy should adequately implement multivitamin supplementation [26,41–44]. In addition to this, we believe it would be beneficial for the intake of multivitamins to be recommended at the onset of menstruation, considering that anemia is globally high among women of reproductive age, especially in developing countries where early pregnancies are common [9,11,12,45,46]. By doing so, women who decide to become pregnant would enter this stage with better nutritional status, potentially contributing to the reduction of anemia prevalence.

Furthermore, it is necessary to analyze the study of anemia from a social perspective, such as considering the occupation of the pregnant woman, as a certain economic independence can determine access to a variety of foods, contributing to weight gain and adequate nutrient intake, thus preventing the occurrence of anemia in pregnant women. Considering these strategies as preventive measures could reduce the impacts derived from social, economic, and geographical conditions (*long distances*) on the nutritional status of pregnant women, thereby contributing to the prevention of maternal and neonatal morbidity and mortality, and strengthening maternal health programs.

The main limitation we had was the difficulty to access more pregnant women due to the territorial conditions of the study area. Another limitation was the lack of current literature on the subject did not allow for meaningful comparisons with other work in different areas with similar groups in the discussion.

## CONCLUSION

In conclusion, it is necessary to consider the sociodemographic (age) economic (gainful occupation) and geographical determinants of pregnant women's residences (*long distances*, early pregnancies, low dietary diversity) in the development of strategies and public policies for the prevention of anemia in pregnancy. This is crucial in order to understand and improve the nutritional conditions of women. Additionally, it is imperative to consider as a pressing strategy the provision of multivitamin supplementation from the onset of menarche, so that women can achieve better nutritional status prior to pregnancy.

We believe that it is urgent to reactivate research on the implications of anemia during pregnancy in various population groups, considering other factors such as socio-cultural and environmental to create specific preventive strategies for the population group under investigation that promote nutritional health during pregnancy and in turn contribute to the reduction of maternal morbidity.

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