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Hemoglobin Status, Iron Supplementation, and Consumption Frequency of Iron-Related Foods among Pregnant Women in Valencia: A Cross-Sectional Study Hemoglobin and diet in pregnancy

Estado de hemoglobina, suplementación con hierro y frecuencia de consumo de alimentos relacionados con el hierro en mujeres embarazadas de Valencia: estudio transversal

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ABSTRACT

Introduction: Anemia, mainly due to iron deficiency, is common in pregnancy. This study aimed to describe hemoglobin, iron supplementation and the consumption of iron-related foods and beverages among third-trimester pregnant women in Valencia, Spain, and to explore their relationship with hemoglobin.

Methods: Cross-sectional study conducted in 2021 in a convenience sample of 50 women with singleton third-trimester pregnancies recruited during prenatal consultations at La Fe University and Polytechnic Hospital. A structured questionnaire collected sociodemographic and anthropometric data, supplement use, coffee and tea consumption, the consumption frequency of nine food groups (Mediterranean Diet Score) and the Mediterranean Diet Adherence Screener (MEDAS). Hemoglobin was obtained from the routine third-trimester blood count; anemia was defined as hemoglobin <11 g/dL. Descriptive analyses and exploratory bivariate comparisons were performed.

Results: Mean age was 32.2 ± 6.7 years. Hemoglobin was available for 36 women: mean 11.83 ± 1.28 g/dL; eight (22.2%) had anemia. Iron supplementation was reported by 74% and multivitamin supplementation by 76%. The mean MEDAS score was 6.7 ± 1.9, and only 12% had high adherence (≥9). Hemoglobin did not differ by iron supplementation (11.76 ± 1.37 vs. 12.05 ± 0.95 g/dL; p=0.510) but was higher among multivitamin users (12.09 ± 1.23 vs. 11.04 ± 1.15 g/dL; p=0.035) and women of Spanish nationality (12.04 ± 1.26 vs. 10.94 ± 1.02 g/dL; p=0.034).

Conclusions: More than one in five women had third-trimester anemia despite frequent iron supplementation, and adherence to the Mediterranean diet was low. Given the small sample and cross-sectional design, the associations observed are exploratory.

Funding: The authors declare that no funding was received for this study.

Keywords: Pregnancy; Anemia; Hemoglobins; Iron, Dietary; Dietary Supplements

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RESUMEN

Introducción: La anemia, debida principalmente a deficiencia de hierro, es frecuente en el embarazo. El objetivo fue describir la hemoglobina, la suplementación con hierro y el consumo de alimentos y bebidas relacionados con el hierro en embarazadas del tercer trimestre en Valencia (España), y explorar su relación con la hemoglobina.

Métodos: Estudio transversal realizado en 2021 en una muestra de conveniencia de 50 mujeres con gestación única en el tercer trimestre, reclutadas en las consultas prenatales del Hospital Universitari i Politècnic La Fe. Mediante un cuestionario estructurado se recogieron datos sociodemográficos y antropométricos, uso de suplementos, consumo de café y té, frecuencia de consumo de nueve grupos de alimentos (Mediterranean Diet Score) y el cuestionario de adherencia a la dieta mediterránea MEDAS. La hemoglobina se obtuvo del hemograma rutinario del tercer trimestre; la anemia se definió como hemoglobina <11 g/dL. Se realizaron análisis descriptivos y comparaciones bivariadas exploratorias.

Resultados: La edad media fue 32,2 ± 6,7 años. La hemoglobina estaba disponible en 36 mujeres: media 11,83 ± 1,28 g/dL; ocho (22,2%) presentaron anemia. El 74% declaró suplementación con hierro y el 76% con multivitamínicos. La puntuación MEDAS media fue 6,7 ± 1,9 y solo el 12% alcanzó una adherencia alta (≥9). La hemoglobina no difirió según la suplementación con hierro (11,76 ± 1,37 vs. 12,05 ± 0,95 g/dL; p=0,510), pero fue mayor en las usuarias de multivitamínicos (12,09 ± 1,23 vs. 11,04 ± 1,15 g/dL; p=0,035) y en las de nacionalidad española (12,04 ± 1,26 vs. 10,94 ± 1,02 g/dL; p=0,034).

Conclusiones: Más de una de cada cinco mujeres presentó anemia en el tercer trimestre pese a la frecuente suplementación con hierro, y la adherencia a la dieta mediterránea fue baja. Dado el pequeño tamaño muestral y el diseño transversal, las asociaciones observadas son exploratorias.

Financiación: Los autores declaran que no ha existido financiación para realizar este estudio.

Palabras clave: Embarazo; Anemia; Hemoglobinas; Hierro de la Dieta; Suplementos Dietéticos

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HIGHLIGHTS

- More than one in five women with available data had hemoglobin below the WHO third-trimester cutoff of 11 g/dL, although three in four reported iron supplementation.
- Hemoglobin did not differ by iron supplementation, which may reflect prescription of iron to women with low hemoglobin; reported supplementation should not be interpreted as evidence of adequate iron status.
- Adherence to the Mediterranean diet was low (only 12% with a MEDAS score ≥9), and one third of women never consumed red meat.
- Larger studies with iron biomarkers, quantitative dietary methods and multivariable analyses are needed to confirm these exploratory findings.

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INTRODUCTION

Anemia is a common nutritional and hematological complication of pregnancy[1]. Because of physiological hemodilution, the World Health Organization (WHO) defines anemia in pregnancy as a hemoglobin concentration <11 g/dL in the first and third trimesters and <10.5 g/dL in the second trimester[2]. Iron deficiency is the main contributor to maternal anemia; however, other nutritional deficiencies, infections, inflammatory conditions, inherited hemoglobin disorders and blood loss may also contribute, making the etiology frequently multifactorial[3]. Maternal iron deficiency and anemia have been associated with adverse maternal and neonatal outcomes, including preterm birth and impaired fetal growth[4].

During pregnancy, iron requirements increase progressively to support expansion of maternal red cell mass and development of the fetoplacental unit, and they are highest in the third trimester[5]. Dietary iron is present in two forms: heme iron, found in meat and fish, which is well absorbed, and non-heme iron, found mainly in plant foods such as legumes and cereals, whose absorption is lower and strongly dependent on meal composition[6]. Absorption of non-heme iron is enhanced by ascorbic acid and by meat, fish and poultry, and is inhibited by polyphenols from tea and coffee, phytates and calcium[7,8]. Iron supplementation is therefore recommended during pregnancy according to the clinical and nutritional context[9,10], although both low and high maternal hemoglobin concentrations have been associated with adverse outcomes[11].

Maternal anthropometric characteristics may also be relevant to iron status. Maternal obesity has been associated with a low-grade inflammatory state, higher hepcidin concentrations and lower iron stores during pregnancy, which may reduce intestinal iron absorption[12]. In Spain, a large study in a Mediterranean area reported that the prevalence of anemia increased from 3.8% in the first trimester to 21.5% in the third trimester[13], which shows the relevance of assessing iron-related factors late in pregnancy.

Characterizing these factors in pregnant women receiving routine care may inform nutritional counseling and generate hypotheses for future studies. Therefore, this study aimed to describe hemoglobin status, iron supplementation, and the consumption frequency of foods and beverages relevant to iron intake and absorption among third-trimester pregnant women

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receiving care in Valencia, Spain, and to explore their relationship with hemoglobin concentration.

METHODS

Study design and setting

A cross-sectional study was conducted in 2021 among pregnant women belonging to the Valencia–La Fe Health Department (Valencia, Spain). The Department, served by La Fe University and Polytechnic Hospital (a public National Health Service hospital), 20 primary care centers and a specialty center, covers approximately 300,000 inhabitants; the hospital attended 4,126 births in 2021. The study is reported following the STROBE recommendations for cross-sectional studies. Participants were recruited and data were collected during 2021; the specific recruitment dates were not recorded in the study database.

Participants

Participants were recruited during their routine prenatal consultations at La Fe University and Polytechnic Hospital. Women attending these consultations who met the eligibility criteria were invited to participate, and those who gave informed consent were included. This was a non-probabilistic convenience sample; no a priori sample-size calculation was performed, and the sample size (n=50) was determined by the feasibility of recruitment within the period available for the study. The study should therefore be considered exploratory.

Inclusion criteria were pregnant women of any age in the third trimester of pregnancy who attended prenatal consultations at the hospital. Exclusion criteria were: (a) multiple pregnancy; (b) an altered neurological or mental state preventing reliable completion of the questionnaire; and (c) a physical disability preventing anthropometric measurements. Information on infections, inflammatory or chronic diseases, recent bleeding and concomitant medication other than supplements was not collected, and these conditions were not used as exclusion criteria.

Data collection

Data were collected through a structured questionnaire administered face-to-face by the investigator, together with anthropometric measurements and clinical data. Sociodemographic

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information included age, nationality, employment during pregnancy and educational level. Physical activity was classified into four categories: no exercise; light physical activity (e.g., walking or gentle gymnastics at least once per week); moderate physical activity (e.g., gymnastics, athletics, swimming or cycling at least twice per week); and sports training at least three times per week. Smoking before and during pregnancy was recorded (yes/no). Gestational age (weeks) was recorded for each participant.

Third-trimester body weight (kg) and height (m) were measured, while pre-pregnancy weight was self-reported. Pre-pregnancy body mass index (BMI) was calculated as weight divided by height squared (kg/m²) and categorized according to WHO criteria[14]. Gestational weight gain was calculated as the difference between third-trimester and pre-pregnancy weight and interpreted according to the recommendations of the Swiss Federal Office of Public Health[15].

Hemoglobin concentration and hematocrit were obtained from the routine third-trimester antenatal blood count performed as part of standard prenatal care at La Fe University and Polytechnic Hospital and recorded in each participant's clinical record; no additional blood samples were collected for the study. Anemia was defined as hemoglobin <11 g/dL, the WHO threshold for the third trimester, and classified as mild (10.0–10.9 g/dL) or moderate (7.0–9.9 g/dL)[2]. Because these values came from routine clinical care, blood sampling and analysis followed the hospital's standard procedures rather than a study-specific protocol, and details on sample collection and handling were not available to the investigators.

Supplement use during pregnancy was recorded (yes/no) for iron, folic acid and multivitamin preparations, together with the commercial name of the product; the dose, duration and adherence were not recorded. Iron products were classified as iron-only preparations or multivitamin–mineral preparations containing iron. Coffee and tea consumption during pregnancy was recorded (yes/no).

Food consumption was assessed with the food-frequency items of the Mediterranean Diet Score (MedDietScore)[16], which cover nine food groups (unrefined cereals, potatoes, fruits, vegetables, legumes, fish, red meat and derivatives, poultry and full-fat dairy products) with reference portion sizes and six frequency categories (never, 1–4, 5–8, 9–12, 13–18 and >18 servings), plus olive oil use and alcohol intake. Each item scores 0 to 5 points (reverse scoring for red meat,

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poultry and full-fat dairy), giving a total score of 0 to 55, with higher scores indicating greater adherence[16]. The items, portion sizes and response categories are shown in Supplementary Table S1. Adherence to the Mediterranean diet was also assessed with the 14-item Mediterranean Diet Adherence Screener (MEDAS) (score 0–14; ≥9 indicates high adherence; items and scoring criteria in Supplementary Table S2)[17]. Items of the KIDMED index[18] were also included in the questionnaire but were not analyzed, because this index was developed for children and adolescents and has not been validated in pregnant adults. No food-composition database was used because nutrient intakes were not estimated.

Strategies to reduce bias

To limit information bias, the questionnaire used closed response categories and reference portion sizes and was administered in person, third-trimester weight and height were measured rather than self-reported, and hemoglobin was obtained from clinical records rather than from participant report. To assess possible selection bias due to missing hemoglobin data, women with and without available hemoglobin were compared. Selection bias related to convenience sampling could not be excluded, and recall bias may affect pre-pregnancy weight and food-frequency data.

Ethical considerations

All participants provided informed consent before inclusion. The study was conducted in accordance with the principles of the Declaration of Helsinki and was approved by the Clinical Research Ethics Committee of La Fe University and Polytechnic Hospital (reference 2014/0116; 8 September 2014). Data were handled confidentially in accordance with Spanish data protection legislation (Organic Law 3/2018 on the Protection of Personal Data and Guarantee of Digital Rights) and Regulation (EU) 2016/679 (General Data Protection Regulation).

Statistical analysis

Data were analyzed with IBM SPSS Statistics. Quantitative variables are presented as mean ± standard deviation in the text and as mean (standard deviation) in the tables, together with the range, and categorical variables as n (%). Analyses were performed on complete cases for each

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variable, without imputation, and the number of valid observations is reported for each variable with missing data. The normality of hemoglobin concentration was assessed with the Shapiro–Wilk test. Hemoglobin concentration was compared between groups with Student's t-test (Welch correction) and, as a sensitivity analysis, with the Mann–Whitney U test; the proportion of women with anemia was compared with Fisher's exact test. Spearman's correlation coefficient was used to assess the relationship between hemoglobin and continuous or ordinal variables (age, gestational age, pre-pregnancy BMI, gestational weight gain, food-group frequencies and diet scores). Women with and without available hemoglobin were compared with the Mann–Whitney U test and Fisher's exact test. Statistical significance was set at $p<0.05$ (two-sided). Because of the small sample and the number of comparisons, no correction for multiple testing was applied and all bivariate analyses are considered exploratory; multivariable analyses were not performed.

RESULTS

Participant characteristics

A total of 50 pregnant women in the third trimester were included. The mean age was 32.2 ± 6.7 years (range: 19–46 years), mean gestational age was 39.2 ± 2.1 weeks (range: 31–41), and 39 participants (78%) were Spanish. Twenty-nine women (58%) were working during pregnancy. Nineteen participants (38%) reported no physical activity. Smoking was reported by 14 women (28%) before pregnancy and by 9 (18%) during pregnancy.

Pre-pregnancy weight was available for 49 women (mean 66.90 ± 12.46 kg) and mean pre-pregnancy BMI was 25.1 ± 4.8 kg/m²: 26 women (53.1%) had normal weight, 16 (32.7%) overweight, 6 (12.2%) obesity and 1 (2.0%) underweight. Mean third-trimester weight was 79.95 ± 11.92 kg and mean gestational weight gain was 12.74 ± 5.14 kg (range: 1–27 kg) (Table 1).

Table 1. Sociodemographic, lifestyle and anthropometric characteristics of participants (n=50)

Characteristic	Value
Age, years	32.2 (6.7) [19–46]
Gestational age, weeks	39.2 (2.1) [31–41]
Spanish nationality	39 (78%)

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Educational level: no formal education	3 (6%)
Educational level: primary	8 (16%)
Educational level: secondary	21 (42%)
Educational level: university or higher	18 (36%)
Working during pregnancy	29 (58%)
No physical activity	19 (38%)
Light physical activity	21 (42%)
Moderate physical activity	10 (20%)
Smoking before pregnancy	14 (28%)
Smoking during pregnancy	9 (18%)
Height, m	1.64 (0.06) [1.44–1.76]
Pre-pregnancy weight, kg (n=49)	66.90 (12.46)
Third-trimester weight, kg	79.95 (11.92)
Gestational weight gain, kg (n=49)	12.74 (5.14)
Pre-pregnancy BMI, kg/m² (n=49)	25.1 (4.8)
Pre-pregnancy BMI: underweight (n=49)	1 (2.0%)
Pre-pregnancy BMI: normal weight (n=49)	26 (53.1%)
Pre-pregnancy BMI: overweight (n=49)	16 (32.7%)
Pre-pregnancy BMI: obesity (n=49)	6 (12.2%)

Data are presented as mean (standard deviation) [range] or n (%). BMI: body mass index.

Hemoglobin status and supplementation

Hemoglobin values were available for 36 women (72%) and hematocrit values for 33. Mean hemoglobin was 11.83 ± 1.28 g/dL (range: 9.1–14.4 g/dL) and was normally distributed (Shapiro–Wilk W=0.981; p=0.779). Eight women (22.2%) had anemia (hemoglobin <11 g/dL): six mild and two moderate. Six women (16.7%) had hemoglobin ≥13 g/dL. Women with and without available hemoglobin did not differ in age (31.5 vs. 33.9 years; p=0.324), gestational age (39.5 vs. 38.3 weeks; p=0.290), iron supplementation (77.8% vs. 64.3%; p=0.474), nationality (p=0.476) or smoking during pregnancy (p=0.245).

Iron supplementation was reported by 37 women (74%), folic acid supplementation by 26 (52%) and multivitamin supplementation by 38 (76%). Of the 37 iron users, 25 used iron-only preparations, 8 multivitamin–mineral preparations containing iron and 1 both, while the product was not specified for 3 (Table 2).

Table 2. Hemoglobin status and supplementation

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Variable	Value
Hemoglobin, g/dL (n=36)	11.83 (1.28) [9.1–14.4]
Hematocrit, % (n=33)	35.56 (4.23) [26.9–42.9]
Anemia, hemoglobin <11 g/dL (n=36)	8 (22.2%)
Mild (10.0–10.9 g/dL)	6 (16.7%)
Moderate (7.0–9.9 g/dL)	2 (5.6%)
Hemoglobin ≥13 g/dL (n=36)	6 (16.7%)
Iron supplementation (n=50)	37 (74%)
Iron-only preparation	25
Multivitamin–mineral preparation with iron	8
Both	1
Product not specified	3
Folic acid supplementation (n=50)	26 (52%)
Multivitamin supplementation (n=50)	38 (76%)

Data are presented as mean (standard deviation) [range] or n (%).

Beverage and food consumption and Mediterranean diet adherence

Coffee consumption during pregnancy was reported by 29 women (58%) and tea consumption by 7 (14%). The most frequently reported category was 5–8 servings for legumes (58%), fish (48%), unrefined cereals (42%) and vegetables (38%), and 9–12 servings for fruit (36%). Red meat and derived products were never consumed by 34% of women and were most commonly consumed 1–4 times (42%); 44% never consumed poultry and 32% never consumed full-fat dairy products. Olive oil was used daily by 43 women (86%) (Table 3).

The mean MedDietScore was 34.1 ± 4.2 points (range: 24–44; possible range 0–55) and the mean MEDAS score was 6.7 ± 1.9 (range: 1–12). Only 6 women (12%) had high adherence to the Mediterranean diet according to MEDAS (score ≥9).

Table 3. Distribution of reported consumption frequencies of selected food groups (servings) (n=50)

Food group	Never	1–4	5–8	9–12	13–18	>18
Unrefined cereals	0%	12%	42%	36%	10%	0%
Potatoes	0%	54%	24%	12%	8%	2%
Fruits	4%	18%	22%	36%	10%	10%
Vegetables	0%	28%	38%	26%	8%	0%
Legumes	6%	6%	58%	26%	2%	2%

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Fish	8%	20%	48%	20%	4%	0%
Red meat and derivatives	34%	42%	14%	6%	4%	0%
Poultry	44%	24%	18%	8%	6%	0%
Full-fat dairy products	32%	22%	30%	16%	0%	0%

Frequency categories and reference portion sizes are given in Supplementary Table S1.

Exploratory analysis of factors related to hemoglobin

Hemoglobin did not differ by iron supplementation (11.76 ± 1.37 vs. 12.05 ± 0.95 g/dL; p=0.510), and seven of the eight women with anemia reported taking iron. Hemoglobin was higher among multivitamin users (12.09 ± 1.23 vs. 11.04 ± 1.15 g/dL; p=0.035; Mann–Whitney p=0.046) and among women of Spanish nationality (12.04 ± 1.26 vs. 10.94 ± 1.02 g/dL; p=0.034; Mann–Whitney p=0.029), although the proportion with anemia did not differ significantly (Table 4). Women with pre-pregnancy overweight or obesity had lower hemoglobin and more anemia (35.3% vs. 10.5%) than those with BMI <25 kg/m², but the differences were not statistically significant (p=0.101 and p=0.114). No significant differences were observed by physical activity, smoking, coffee or tea consumption, or educational level.

Hemoglobin was not significantly correlated with age, gestational age, pre-pregnancy BMI, gestational weight gain, MedDietScore, MEDAS score, or the consumption frequency of red meat, legumes, fish or poultry (all p>0.05).

Table 4. Hemoglobin concentration and anemia according to participant characteristics (n=36)

Characteristic	n	Hemoglobin, g/dL	Anemia, n (%)	p (Hb)[a]	p (anemia)[b]
Iron supplementation: yes	28	11.76 (1.37)	7 (25.0%)	0.510	0.651
Iron supplementation: no	8	12.05 (0.95)	1 (12.5%)		
Folic acid: yes	18	11.71 (1.14)	4 (22.2%)	0.592	1.000
Folic acid: no	18	11.94 (1.43)	4 (22.2%)		
Multivitamin: yes	27	12.09 (1.23)	4 (14.8%)	0.035	0.086
Multivitamin: no	9	11.04 (1.15)	4 (44.4%)		
Nationality: Spanish	29	12.04 (1.26)	5 (17.2%)	0.034	0.167
Nationality: other	7	10.94 (1.02)	3 (42.9%)		
Pre-pregnancy BMI ≥25 kg/m²	17	11.45 (1.36)	6 (35.3%)	0.101	0.114
Pre-pregnancy BMI <25 kg/m²	19	12.16 (1.14)	2 (10.5%)		

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Any physical activity	21	11.69 (1.40)	6 (28.6%)	0.420	0.424
No physical activity	15	12.03 (1.10)	2 (13.3%)		
Smoking during pregnancy: yes	5	12.20 (0.64)	0 (0%)	0.276	0.566
Smoking during pregnancy: no	31	11.77 (1.35)	8 (25.8%)		
Coffee: yes	23	11.63 (1.27)	6 (26.1%)	0.237	0.682
Coffee: no	13	12.17 (1.27)	2 (15.4%)		
Tea: yes	6	11.15 (2.01)	3 (50.0%)	0.375	0.109
Tea: no	30	11.96 (1.08)	5 (16.7%)		

Hemoglobin is presented as mean (standard deviation). [a]Student's t-test with Welch correction. [b]Fisher's exact test. Anemia: hemoglobin <11 g/dL. BMI: body mass index.

DISCUSSION

In this sample, more than one in five women had third-trimester anemia despite frequent iron supplementation, and adherence to the Mediterranean diet was low.

Hemoglobin status

The prevalence of third-trimester anemia (22.2%) was very similar to the 21.5% reported in the third trimester in a large population-based study in another Mediterranean area of Spain[13], although our estimate is imprecise because of the small sample. Because all women were in the third trimester, when hemodilution is most marked[5], the WHO cutoff of <11 g/dL applied to the whole sample[2]. Hemoglobin is a late and non-specific indicator of iron deficiency: without ferritin, iron deficiency without anemia could not be identified, and other causes of anemia, such as infection, inflammation, blood loss or hemoglobinopathies, could not be distinguished[3,19]. Conversely, 16.7% of women had hemoglobin ≥13 g/dL, which may reflect inadequate plasma volume expansion and has also been associated with adverse outcomes[11,20].

Supplementation

The absence of a difference in hemoglobin by iron supplementation, and the fact that seven of the eight women with anemia were taking iron, are probably explained by reverse causation: iron is often prescribed or intensified after a low hemoglobin result, and the cross-sectional design cannot establish whether supplementation preceded the measurement. Higher hemoglobin

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among multivitamin users may reflect other micronutrients involved in erythropoiesis, such as folate and vitamin B12, but may also be confounded by earlier prenatal care or socioeconomic factors. WHO recommends daily or intermittent iron and folic acid supplementation during pregnancy[10,21]; because both iron deficiency and excess iron may be harmful, supplementation should be individualized according to maternal iron status[11].

Sociodemographic and anthropometric characteristics

The lower hemoglobin observed in women of non-Spanish nationality is based on only seven women; it may reflect differences in diet, access to prenatal care, socioeconomic conditions or inherited hemoglobin disorders, which could not be evaluated. Almost half of the participants (44.9%) had pre-pregnancy overweight or obesity. Pre-pregnancy BMI and gestational weight gain are associated with maternal and perinatal outcomes[22,23], and maternal obesity has been associated with higher hepcidin concentrations and lower iron stores during pregnancy[12]. Women with excess weight had lower hemoglobin and more anemia, a direction consistent with this mechanism, although the differences were not significant, probably because of limited power.

Food consumption and Mediterranean diet adherence

Adherence to the Mediterranean diet was low, with only 12% of women reaching a MEDAS score ≥9. In a descriptive study of pregnant women in Poland, only 22% ate red meat two or more times per week, more than half consumed more than two portions of fruit per day and about one quarter consumed vegetables once a day[24]. In our sample, legume and fish consumption was comparatively frequent, consistent with a Mediterranean food context, whereas one third of women never consumed red meat and 44% never consumed poultry.

Infrequent consumption of meat and poultry may limit both heme iron intake and the enhancement of non-heme iron absorption[6,7]. Legumes and unrefined cereals provide non-heme iron whose absorption depends on enhancers and inhibitors in the meal[6,25]; ascorbic acid from fruits and vegetables is the main enhancer and can partly counteract the effect of inhibitors[26,27]. More than half of the women drank coffee; polyphenols in tea and coffee reduce non-heme iron

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absorption when consumed with meals[7,8], and separating tea from an iron-containing meal by one hour attenuates this effect[28]. Dairy products are important sources of calcium during pregnancy[29]; calcium can acutely reduce iron absorption, although this interaction appears to be of limited relevance in habitual mixed diets[30]. No food group or diet score was significantly correlated with hemoglobin, which may reflect the small sample, the use of frequency categories rather than quantified intakes, the influence of supplementation, and the late response of hemoglobin to iron deficiency.

Strengths and limitations

The strengths of the study include the combined assessment of hemoglobin, anthropometry, supplement use (including product names) and diet using two Mediterranean diet indices in pregnant women receiving routine hospital care, with measured anthropometry and hemoglobin values obtained from clinical records.

The study has several limitations. First, the small single-hospital convenience sample, without an a priori sample-size calculation, limits precision and generalizability and may introduce selection bias. Second, hemoglobin was available for only 36 of the 50 women (72%); although women with and without these data did not differ in the characteristics examined, selection bias cannot be excluded. Third, the cross-sectional design precludes causal inference, and the exploratory bivariate analyses were not adjusted for confounders or multiple comparisons, with some very small groups. Fourth, ferritin and other iron-store biomarkers were not available; infections, inflammatory or chronic diseases, bleeding and medications other than supplements were not recorded; and hemoglobin came from routine care without a study-specific sampling protocol. Fifth, supplementation was recorded without dose, duration or adherence. Finally, the short food-frequency instrument could not quantify iron intake or bioavailability, and dietary data may be affected by recall bias.

CONCLUSIONS

In this sample of third-trimester pregnant women, 22.2% of those with available data had anemia although 74% reported iron supplementation, and adherence to the Mediterranean diet was low.

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Hemoglobin did not differ by iron supplementation, whereas exploratory analyses showed higher hemoglobin among multivitamin users and women of Spanish nationality. These findings support assessing iron status, including ferritin, early in pregnancy, monitoring the response to supplementation, and providing dietary counseling on iron sources and on enhancers and inhibitors of iron absorption. Larger studies with iron biomarkers, quantitative dietary methods and multivariable analyses are needed to confirm these findings.

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AUTHORS' CONTRIBUTIONS

S.M. contributed to data collection, data analysis, interpretation of the results and drafting of the manuscript. M.M.S.-V. supervised the research and contributed to the methodology, interpretation of the findings and critical revision of the manuscript. Both authors reviewed and approved the final version.

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CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest related to this manuscript.

DATA AVAILABILITY

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The data supporting the findings of this study are available from the corresponding author upon reasonable request, subject to institutional approval and applicable data-protection requirements.

DECLARATION OF ARTIFICIAL INTELLIGENCE USE

During the preparation of the revised manuscript and of the response to reviewers, the authors used the generative AI tool Claude (Anthropic) for language editing, structuring the responses, drafting support, assistance with the statistical re-analysis and adaptation of the manuscript to the journal's requirements. The authors reviewed and verified all content and take full responsibility for the final version of the manuscript.

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