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EFFECT OF PROCESSED AND ULTRA-PROCESSED FOOD CONSUMPTION AND IRON PROFILE IN PREGNANT WOMEN

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ABSTRACT

This study was cross-sectional and examined the relationship between iron-index factors and the intake of processed (PF) and ultra-processed (UPF) foods in 100 pregnant women in the second and third trimesters and 100 non-pregnant women (as a control group) in Baghdad, Iraq. In addition to laboratory-based measurements of blood parameters (hemoglobin, MCV, serum iron, ferritin, transferrin, and TIBC), dietary consumption was evaluated twice using a 24-hour recall questionnaire and categorized using the NOVA system. The findings indicated that while there was no significant difference in the intake of ultra-processed meals (P=0.491), pregnant women consumed considerably more processed foods (mean 2.34 vs. 1.96; P=0.003). Correlation analyses showed the most startling finding: in both groups (pregnant and non-pregnant), there was a strong negative association (P=0.001) between the consumption of processed and ultra-processed foods and levels of hemoglobin, MCV, serum iron, ferritin, and transferrin. This was true even though there were no significant differences in iron marker variables (such as hemoglobin and ferritin) between the two groups (apart from elevated platelets (P=0.002) and WBC counts (P=0.006) in pregnant women). Additionally, there was a significant positive correlation (P=0.001) between the two groups' TIBC levels and the meals they consumed. The study comes to the conclusion that indices of iron storage (ferritin) and circulation iron (hemoglobin) are adversely correlated with greater intake of processed and ultra-processed meals.and significantly affects iron homeostasis in women of reproductive age, regardless of pregnancy status.

KEYWORDS: processed foods, ultra-processed foods, iron, pregnant women, nutrition.

INTRODUCTION

The consumption of processed and ultra-processed foods is a growing concern in nutrition science, with increasing evidence linking these foods to a wide range of chronic conditions (**Srour & Touvier, 2020**).

Definition

Processed foods refer to items that have undergone basic modifications from their original state, typically to enhance shelf life, safety, or palatability. These modifications often include the addition of salt, sugar, oil, or other culinary ingredients, as well as physical processes such as smoking, fermentation, or drying. Importantly, processed foods still retain a substantial proportion of their original food matrix and are often recognizable as derivatives of whole foods. Examples include canned vegetables preserved with brine, smoked fish, cheese, and freshly baked bread made with traditional ingredients (**Braesco et al., 2022**).

Ultra-processed foods (UPFs) are industrial formulations that contain little to no intact whole food components. These products are typically manufactured through a series of complex physical and chemical processes and incorporate additives designed to enhance flavor, texture, color, and shelf stability. Common additives include emulsifiers, flavor enhancers, artificial sweeteners, preservatives, and colorants—many of which are not used in home cooking. UPFs are often engineered for hyper-palatability and convenience, and they tend to be energy-dense, nutrient-poor, and aggressively marketed. Examples include carbonated soft drinks, packaged snacks, instant noodles, reconstituted meat products, and ready-to-eat meals (**Elizabeth et al., 2020**).

The NOVA Food Classification System

The NOVA food classification system is a pioneering approach developed by researchers at the University of São Paulo, Brazil, in 2009. Unlike traditional systems that categorize foods based on their macronutrient content—such as carbohydrates, fats, and proteins—NOVA focuses on the extent and purpose of food processing. This shift in perspective allows for a deeper understanding of how industrial processing influences nutritional quality, dietary patterns, and public health outcomes (**Petrus et al., 2021**).

NOVA divides foods into **four distinct groups**, each reflecting a different level of processing (**Louzada & Gabe, 2025**):

1. **Group 1: Unprocessed or Minimally Processed Foods**: These are edible parts of plants or animals that have undergone minimal alteration. Processes such as cleaning, peeling, freezing, or fermenting may be used, but the food remains close to its natural state. Examples include fresh fruits, vegetables, grains, eggs, and pasteurized milk.
2. **Group 2: Processed Culinary Ingredients**: This group includes substances extracted from Group 1 foods or nature, used in cooking and food preparation. These ingredients—such as oils, butter, sugar, and salt—are typically not consumed on their own but serve as building blocks in culinary practices.
3. **Group 3: Processed Foods**: Foods in this category are made by combining Group 1 foods with Group 2 ingredients. They undergo preservation or cooking methods that enhance shelf life or palatability, but the original food remains recognizable. Examples include canned vegetables with added salt, cheese, and freshly baked bread.
4. **Group 4: Ultra-Processed Foods (UPFs)**: These are industrial formulations containing little to no whole food content. They often include additives such as flavor enhancers, emulsifiers, colorants, and artificial sweeteners—ingredients rarely used in home kitchens. UPFs are designed for convenience, hyper-palatability, and long shelf life. Examples include soft drinks, packaged snacks, instant noodles, and reconstituted meat products.

The NOVA system has gained traction globally as a tool for researchers, policymakers, and health professionals to assess dietary patterns and their health implications. It has been instrumental in linking high UPF consumption to increased risks of obesity, cardiovascular disease, diabetes, and other chronic conditions (**Louie, 2025**).

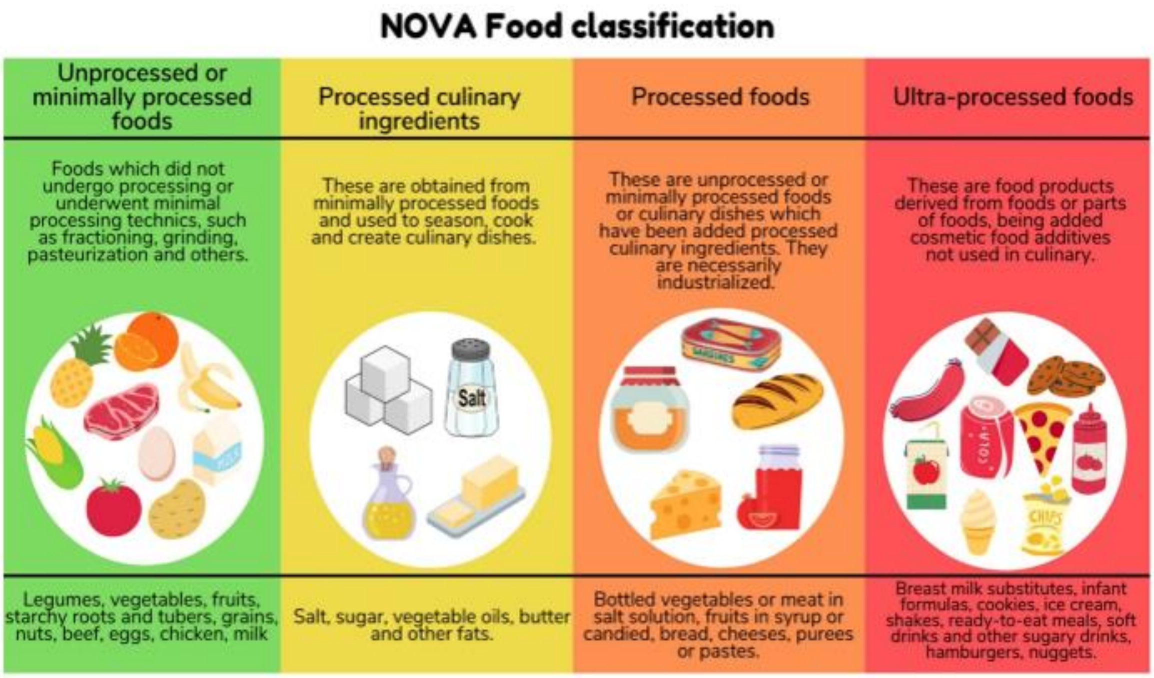


Figure (1): NOVA Food Classification System (Oliveira et al., 2022)

Health effects of processed and ultra-processed food consumption Consumption of processed and ultra-processed food exerts several effects on lipid profile and hence obesity, increases cardiovascular diseases risk and affects mental health (**Lane et al., 2024**).

1) Obesity

Obesity is a multifactorial condition driven by genetic, behavioral, and environmental influences, but dietary patterns remain central to its development. Among these, the consumption of UPFs has emerged as a potent contributor to the global obesity epidemic. These foods are designed for convenience and hyper-palatability, often overriding natural satiety signals and promoting excessive caloric intake (**Juul et al., 2025**).

A previous study demonstrated that participants consuming an ultra-processed diet ingested approximately 500 more calories per day than those on a minimally processed diet, despite both diets being matched for macronutrients and palatability. Over just two weeks, this led to significant weight gain, highlighting the obesogenic potential of UPFs through mechanisms such as delayed satiety, increased eating rate, and altered hormonal responses (**Monda et al., 2024**).

Observational studies and meta-analyses have consistently shown positive associations between UPF intake and increased body mass index (BMI), waist circumference, and risk of overweight and obesity. These associations are particularly important in adults, though emerging data suggest similar trends in children and adolescents. Mechanistically, UPFs may disrupt hunger regulation via their high energy density and low fiber content, while certain additives—such as emulsifiers and artificial sweeteners—may impair gut microbiota and promote systemic inflammation, further exacerbating metabolic dysfunction (**Dicken & Batterham, 2024**).

PATIENTS AND METHODS

Study setting

The current cross-sectional study included 100 pregnant women in addition to 100 non-pregnant females of matching age. Women were recruited from Kendah Primary Health Center, Baghdad-Iraq/Baghdad between May 2025 to June 2025.

The verbal consent was acquired from the participants. Formal approvals were obtained from scientific committee of Arab board of health & specializations.

Inclusion criteria

- ❖ Pregnant nullipara women in the second and third trimester pregnancy) and non-pregnant females of matching age were included.

Exclusion criteria

- ❖ Pregnant women with any GIT bleeding including the piles.
- ❖ Recent history of blood transfusions and or iv iron therapy.
- ❖ Pregnant women with already diagnosed hematological diseases as iron deficiency anemia or other hematological malignancies.
- ❖ Pregnant women with chronic illness as severe renal, hepatic or cardiac diseases.
- ❖ Pregnant women with connective tissue disease, hereditary blood disorder, history pulmonary embolism or thrombosis.
- ❖ Pregnant women with current systemic infection.

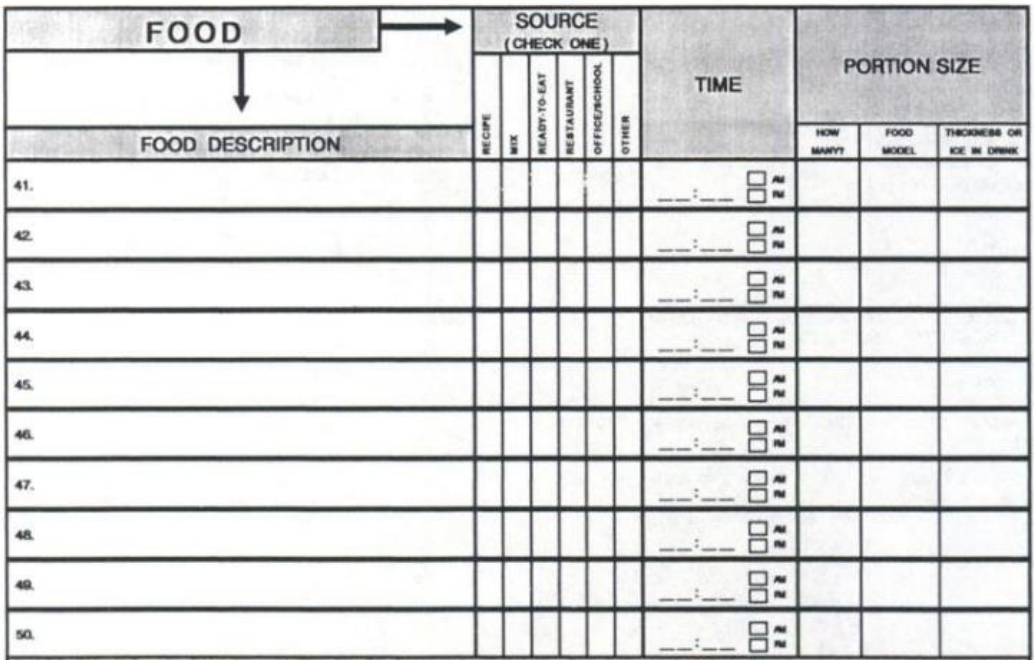
Study procedure

Patients were subjected to the following:

- ❖ Full personal history recording including: age, residence, education, occupation and socioeconomic status.
- ❖ Socioeconomic status (SES): to calculate the SES, the, data of following variables was collected in addition to the above variables (**Omer & Al-Hadithi, 2017**):
  - o Education of family provider: Illiterate, Primary (or can read and write), Intermediate, High school or vocational, Institute (2 years), College (bachelor’s degree), College (master’s degree), PhD or equivalent.
  - o Occupation of family provider: Government employee, private sector employee, self-employed, retired, unemployed, deceased.
  - o Presence of private car: yes or no
  - o Owning a house: yes or no
- ❖ The following equation was used to calculate the SES; SES=Education +occupation +house*0.5+car*0.1+age-20/100-1 (unemployed /retired /deceased) (**Omer & Al-Hadithi, 2017**).
- ❖ Clinical data recorded from included women included; menstrual cycle regularity, pre-Pregnancy body mass index, use of multivitamins including folic acid, pregnancy nature either natural or induced, and pregnancy trimester (either second or third).
- ❖ Included women were interviewed and the 24 hr recall instrument was be applied twice: at time of blood sampling and at time of lab results handling (Appendix 1). Servings intake of processed and ultra-processed food was recorded. Identification of processed and ultra-processed food was doe according to NOVA Food Classification System (**Petrus et al., 2021**).
- ❖ Venous blood samples were collected, and laboratory data were conducted including; haemoglobin concentration, mean corpuscular volume (MCV), Platelet count, WBC count, serum iron, ferritin, transferrin and Total iron binding capacity (TIBC).

Statistical analysis

Data was presented as frequencies and proportions. Analysis was completed using SPSS version 25. Chi-square test was used to examine the relationship between two qualitative variables. Pearson Correlation analysis was performed to assess the strength of association between two quantitative variables. The correlation coefficient defines the strength and direction of the linear relationship between two variables.



FOOD / FOOD DESCRIPTION	SOURCE (CHECK ONE): RECIPE	MIX	READY-TO-EAT	RESTAURANT	OFFICE/SCHOOL	OTHER	TIME	PORTION SIZE: HOW MANY?	FOOD MODEL	THICKNESS OR ICE IN DRINK
41.							__:__ ☐ am ☐ pm			
42.							__:__ ☐ am ☐ pm			
43.							__:__ ☐ am ☐ pm			
44.							__:__ ☐ am ☐ pm			
45.							__:__ ☐ am ☐ pm			
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Appendix 1: 24-hour recall instrument.

RESULTS

The current study included 100 pregnant females and 100 non-pregnant females.

I- Demographic data

Mean age of pregnant females was 21.93 ± 4.2 years and of non-pregnant females was 23.1 ± 4.8 years with no significant difference. Most of females of both groups were residing in urban areas. Non-pregnant females were significantly more educated than pregnant females (p=0.001). Moreover, pregnant females were significantly more employed compared to non-pregnant females (p=0.001). There was no significant difference between both groups as regards socioeconomic status as most of females of both groups were of medium socioeconomic status (Table 1).

Table (1): Comparison of demographic data of included participants.

Variable		**Pregnant females No. 100**	**Non-pregnant females No. 100**	**P value**
Age (years)	Mean ± SD	21.93 ± 4.2	23.1 ± 4.8	0.068*
Residence	Rural	7 (7%)	3 (3%)	0.353+
	Urban	93 (93%)	97 (97%)	
Education	Read & write	41 (41%)	13 (13%)	**0.001+**
	Primary	35 (35%)	53 (53%)	
	Secondary	12 (12%)	27 (27%)	
	High	12 (12%)	7 (7%)	
Occupation	Employed	48 (48%)	24 (24%)	**0.001+**
	Housewife	52 (52%)	76 (76%)	
Socioeconomic status	Low	6 (6%)	1 (1%)	0.099+
	Medium	93 (93%)	96 (96%)	
	High	1 (1%)	3 (3%)	

**Student T test, +Chi-square test, p value ≤ 0.05 is significant*

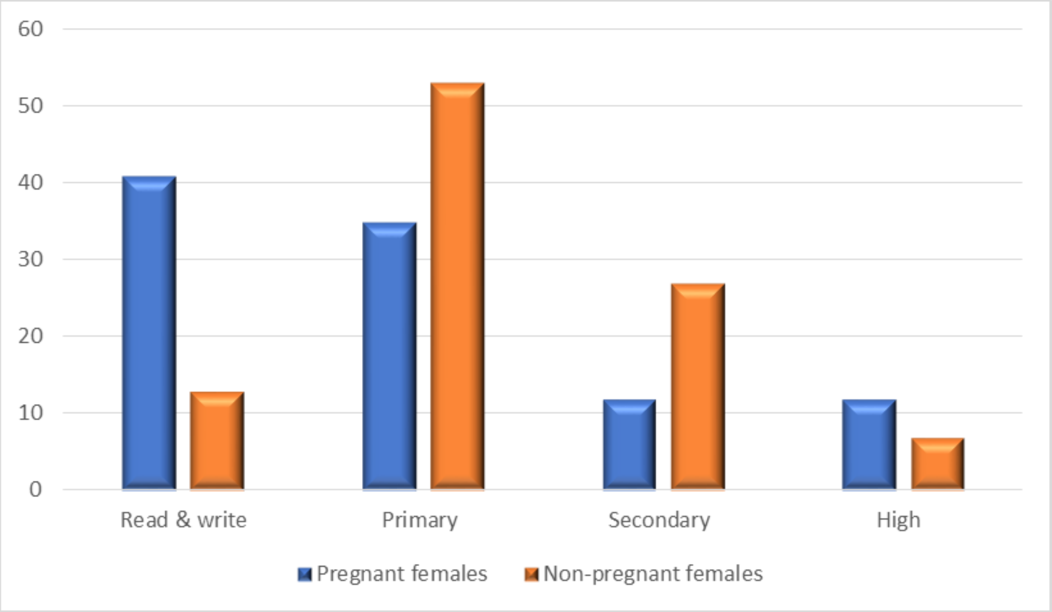

Figure (1): Education of included participants.

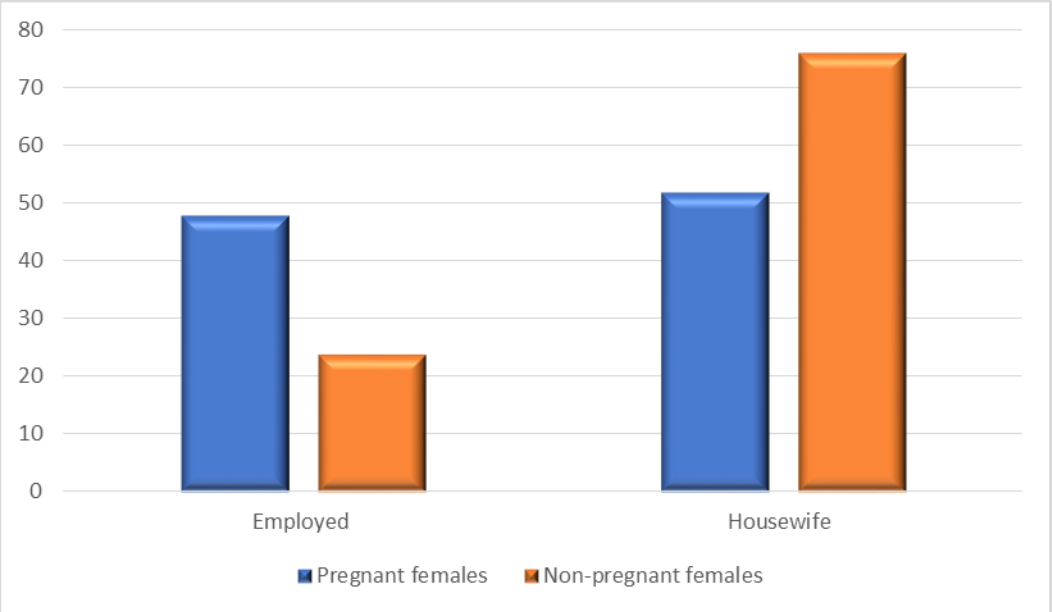

Figure (2): Occupation of included participants.

II- Clinical data

Menstrual cycle regularity differed notably between the groups, with 89% of non-pregnant women reporting regular cycles compared to 72% of pregnant women (p= 0.002). Pre-Pregnancy body mass index (BMI) distributions were different across categories, pregnant females were more obese compared to non-pregnant females (p = 0.001). In addition, use of multivitamins including folic acid were significantly more prevalent among pregnant females compared to non-pregnant females (p = 0.001). The vast majority of pregnant females had natural pregnancy and 65% were in second trimester and 35% were in third trimester (Table 2).

Table (2): Comparison of clinical data of included participants.

Variable		**Pregnant females No. 100**	**Non-pregnant females No. 100**	**P value**
Menstrual cycle	Regular	72 (72%)	89 (89%)	**0.002+**
	Irregular	28 (28%)	11 (11%)	
Body mass index	Underweight	0 (0%)	4 (4%)	**0.001+**
	Average	4 (4%)	37 (37%)	

	Overweight	27 (27%)	35 (35%)	
	Obese	69 (69%)	24 (24%)	
Use of multivitamins	Yes	95 (95%)	21 (21%)	**0.001+**
	No	5 (5%)	79 (79%)	
Use of folic acid	Yes	65 (65%)	0 (0%)	**0.001+**
	No	35 (35%)	100 (100%)	
Pregnancy nature	Natural	97 (97%)	-	-
	Induced	3 (3%)	-	
Pregnancy trimester	Second	65 (65%)	-	-
	Third	35 (35%)	-	

Chi-square test, p value ≤ 0.05 is significant

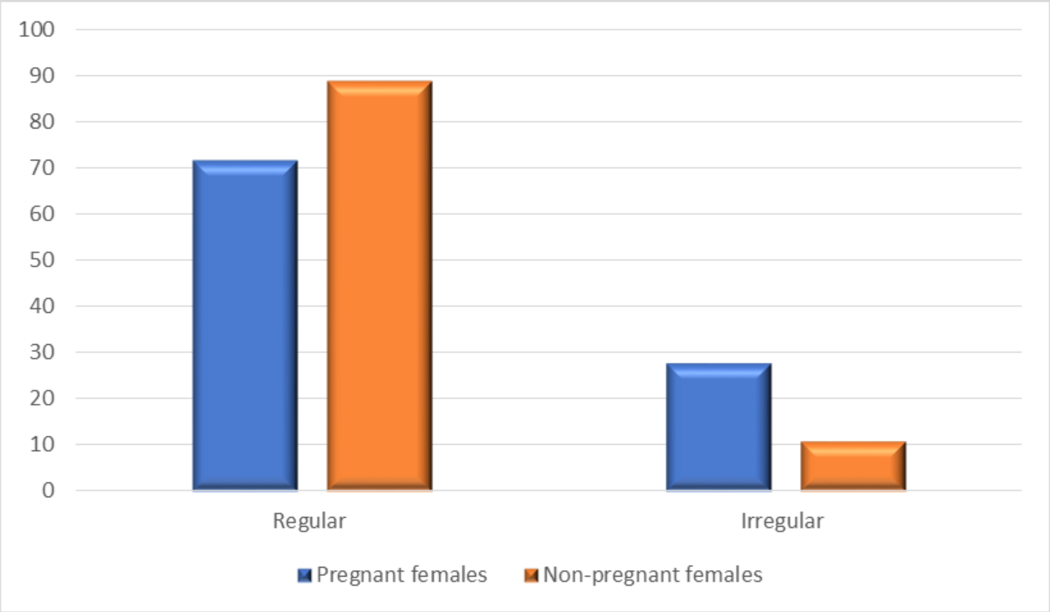

Figure (3): Menstrual cycle of included participants.

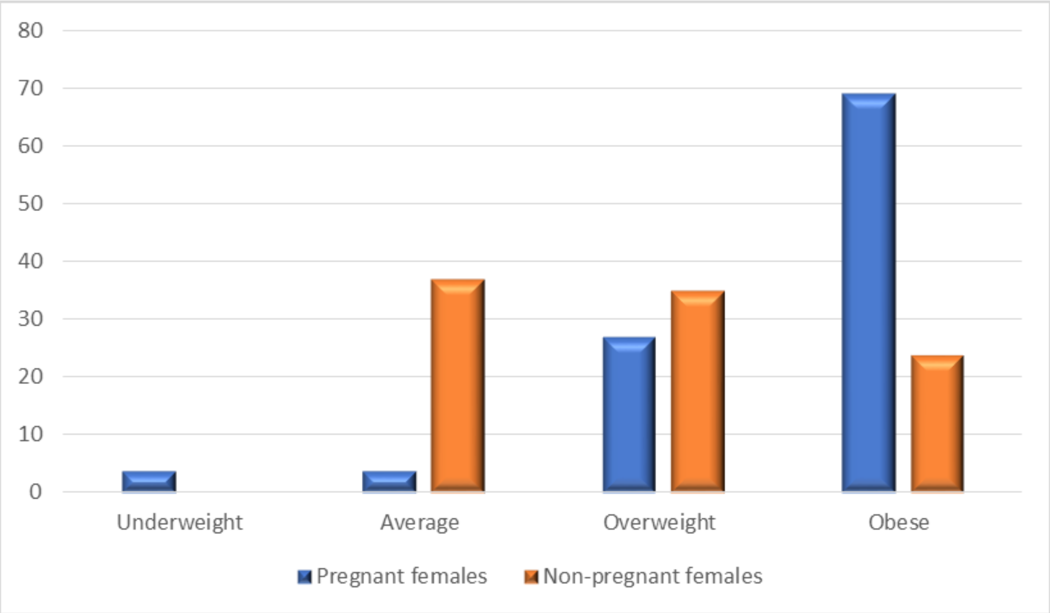

Figure (4): Body mass index of included participants.

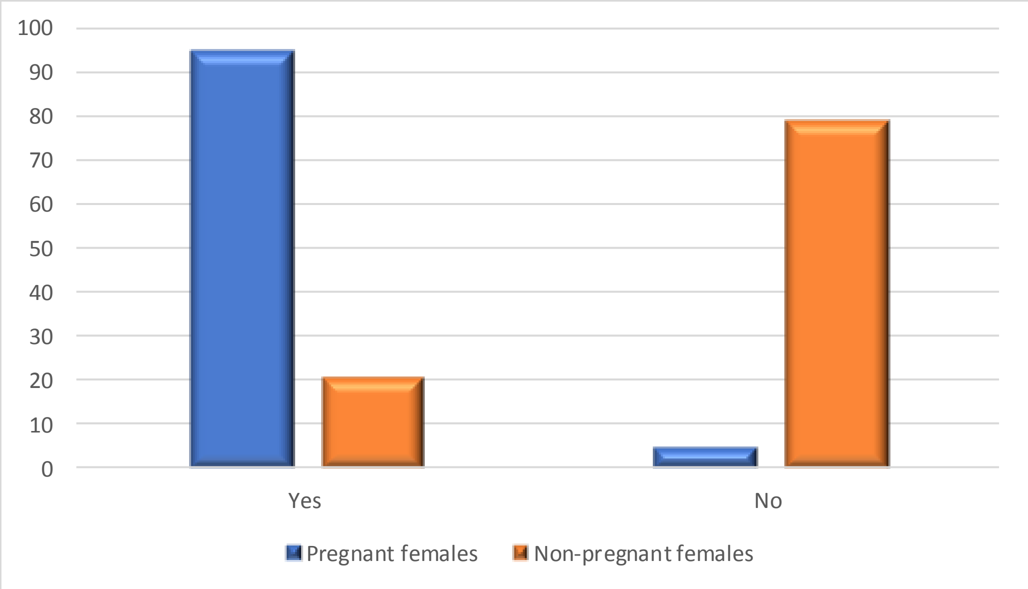

Figure (5): Use of multivitamins in included participants.

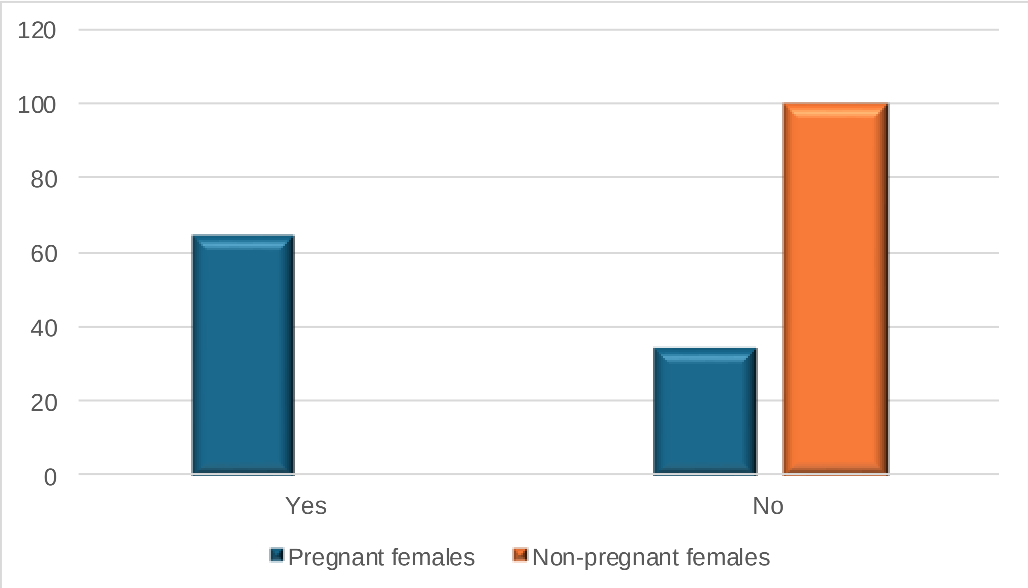

Figure (6): Use of folic acid in included participants.

III- Laboratory data

The mean of hemoglobin levels was slightly lower in pregnant women (9.57 ± 1.4 g/dL) compared to non-pregnant women (9.95 ± 1.4 g/dL), though the difference did not reach statistical significance (P = 0.064). Mean corpuscular volume (MCV) values were comparable between groups (79.12 ± 5.9 vs. 78.34 ± 6.1 fL), with no significant difference (P = 0.474). Platelet counts, however, were significantly elevated in pregnant women ($193.6 \pm 13.5 \times 10^9$/L) compared to non-pregnant women ($188.8 \pm 7.1 \times 10^9$/L), with a P value of 0.002. White blood cell (WBC) counts also differed significantly, with pregnant women showing higher levels ($4.66 \pm 0.9 \times 10^9$/L) than non-pregnant women ($4.09 \pm 0.8 \times 10^9$/L), P = 0.006. Iron metabolism markers—including serum iron, ferritin, transferrin, and total iron-binding capacity (TIBC)—did not differ significantly between groups (Table 3).

Table (3): Comparison of laboratory data of included participants.

Variable		Pregnant females No. 100	Non-pregnant females No. 100	P value
Hemoglobin (g/dL)	Mean ± SD	9.57 ± 1.4	9.95 ± 1.4	0.064*
MCV (fL)	Mean ± SD	79.12 ± 5.9	78.34 ± 9.1	0.474*
Platelet count (10^9/L)	Mean ± SD	193.6 ± 13.5	188.8 ± 7.1	**0.002***
WBC count (10^9/L)	Mean ± SD	4.66 ± 0.9	4.33 ± 0.6	**0.006***
Serum iron (µg/dL)	Mean ± SD	59.8 ± 23.5	64.58 ± 26.1	0.174*
Serum ferritin (ng/mL)	Mean ± SD	24.43 ± 23.92	16.65 ± 13.28	0.194+
Serum transferrin (mg/dL)	Mean ± SD	211.1 ± 30.4	216.2 ± 34.5	0.264*
TIBC (µg/dL)	Mean ± SD	405.6 ± 84.8	412.8 ± 82.2	0.539*

**Student T test, +Mann Whitney test, p value ≤ 0.05 is significant, MCV: Mean corpuscular volume, WBC: white blood cell count, TIBC: Total iron binding capacity.*

IV- Dietary assessment

Pregnant women reported a higher mean intake of processed food servings (2.34 ± 0.99) compared to non-pregnant women (1.96 ± 0.8), with a P value of 0.003. In contrast, the intake of ultra-processed foods was similar across both groups. Pregnant women consumed an average of 1.61 ± 1 servings, while non-pregnant women reported 1.5 ± 0.89 servings, with no statistically significant difference (P = 0.491) (Table 4).

Table (4): Comparison of servings intake of processed and ultra-processed food between the two groups.

Variable		Pregnant females No. 100	Non-pregnant females No. 100	P value
Processed food servings	Mean ± SD	2.34 ± 0.99	1.96 ± 0.8	**0.003***
Ultra-processed food servings	Mean ± SD	1.61 ± 1	1.5 ± 0.89	0.491+

**Student T test, +Mann Whitney test, p value ≤ 0.05 is significant*

V- Correlations

In pregnant females, both processed and ultra-processed food servings were negatively correlated with hemoglobin levels (P = 0.001). Similarly, MCV showed significant inverse correlations with both food categories (P = 0.001). Platelets count also showed significant negative correlation with processed food servings only (P = 0.010). Serum iron, ferritin and transferrin levels also demonstrated significant negative correlations with both food categories (P = 0.001 for both food categories). TIBC was positively correlated with both processed and ultra-processed food intake (P = 0.001) (Table 5).

Table (5): Correlation between servings intake of processed and ultra-processed food and laboratory data in pregnant females.

Variable	Processed food servings		Ultra-processed food servings	
	r value	P value	r value	P value
Hemoglobin (g/dL)	-0.744	**0.001**	-0.728	**0.001**
MCV (fL)	-0.640	**0.001**	-0.633	**0.001**
Platelet count (10^9/L)	-0.257	**0.010**	-0.190	0.058
WBC count (10^9/L)	0.069	0.496	0.018	0.863
Serum iron (µg/dL)	-0.598	**0.001**	-0.548	**0.001**
Serum ferritin (ng/mL)	-0.526	**0.001**	-0.505	**0.001**
Serum transferrin (mg/dL)	-0.710	**0.001**	-0.683	**0.001**
TIBC (µg/dL)	0.616	**0.001**	0.547	**0.001**

Pearson correlation test, p value ≤ 0.05 is significant, MCV: Mean corpuscular volume, WBC: white blood cell count, TIBC: Total iron binding capacity.

In non-pregnant females, both processed and ultra-processed food servings were strongly and negatively correlated with hemoglobin levels (P = 0.001). Similarly, MCV showed significant inverse correlations with both food categories (P = 0.001). Serum iron, ferritin and transferrin levels also demonstrated significant negative correlations with both food categories (P = 0.001 for both food categories). TIBC was positively correlated with both processed and ultra-processed food intake (P = 0.001) (Table 6).

Table (6): Correlation between servings intake of processed and ultra-processed food and laboratory data in non-pregnant females.

Variable	Processed food servings		Ultra-processed food servings	
	r value	P value	r value	P value
Hemoglobin (g/dL)	-0.577	**0.001**	-0.496	**0.001**
MCV (fL)	-0.549	**0.001**	-0.501	**0.001**
Platelet count (10^9/L)	-0.044	0.664	-0.025	0.808
WBC count (10^9/L)	0.145	0.151	0.070	0.491
Serum iron (µg/dL)	-0.494	**0.001**	-0.439	**0.001**
Serum ferritin (ng/mL)	-0.350	**0.001**	-0.299	**0.003**
Serum transferrin (mg/dL)	-0.422	**0.001**	-0.374	**0.001**
TIBC (µg/dL)	0.572	**0.001**	0.479	**0.001**

Pearson correlation test, p value ≤ 0.05 is significant, MCV: Mean corpuscular volume, WBC: white blood cell count, TIBC: Total iron binding capacity.

DISCUSSION

Ultra-processed foods (UPFs) are industrially engineered goods that generally have minimal to no whole food components and are created for convenience, extended shelf life, and heightened palatability. Recent evidence indicates that excessive intake of ultra-processed meals may lead to iron dysregulation via many mechanisms. These foods often supplant nutrient-dense alternatives, resulting in diminished consumption of vital micronutrients like iron and folate. The nutrient displacement effect is most alarming at times of heightened physiological demand, such as pregnancy and childhood development (**Elizabeth et al., 2020**).

The current study evaluated the association between food consumption in terms of processing level and iron profile in pregnant Iraqi women. The study included 100 pregnant females and 100 non-pregnant females. There was no significant difference between pregnant and non-pregnant as regards age, residence and socioeconomic status.

Non-pregnant females were significantly more educated than pregnant females (p=0.001). Similar findings were reported in other studies as non-pregnant females often exhibiting significantly higher levels of education. In Egypt, **El-Shrqawy er al., (2024)** reported that lower educational levels were significantly presented in pregnant women and this was associated with reduced awareness of maternal health risks. This was also agreed by another study by **Fegita et al., (2022)** who reported that pregnant women with lower educational levels were less likely to complete recommended antenatal care visits.

Moreover, pregnant females were significantly more employed compared to non-pregnant females (p=0.001). This can be explained by the fact that women engagement in physically demanding jobs had significantly higher rates of adverse outcomes, including preterm birth and small-for-gestational-age infants (**Reda et al., 2024**). Contradicting results were reported by **Simsek Kucukkelepce et al., (2025)** as the researchers found no statistically significant difference in employment status between pregnant and non-pregnant females. This reflects that that employment during pregnancy was influenced by multiple factors, including age, education, and prior reproductive history (**Rocheleau et al., 2017**).

In the present study, menstrual cycle regularity differed notably between the groups, with 89% of non-pregnant women reporting regular cycles compared to 72% of pregnant women (p= 0.002). In agreement with our results, **Wang et al., (2020)** found that childbirth experience was significantly associated with menstrual irregularity. Women who had previously given birth were more likely to report disrupted cycle patterns.

Pre-Pregnancy body mass index (BMI) distributions were different across categories as pregnant females were more obese compared to non-pregnant females (p = 0.001). Women who become pregnant are often older, more likely to have had prior pregnancies, and may have accumulated weight over time due to lifestyle, parity, or metabolic alterations. These factors contribute to a higher proportion of overweight and obesity among pregnant women compared to their non-pregnant women (**Xie et al., 2021**).

Use of multivitamins including folic acid were significantly more prevalent among pregnant females compared to non-pregnant females (p = 0.001). One of the most important medical instructions to pregnant females is to adhere to multivitamins especially folic acid on regular routine. Folic acid is very important in preventing fetal malformations especially neural tube defects (**King et al., 2021**).

In this study, the blood indices showed that platelet and WBCs counts were significantly higher in pregnant compared to non-pregnant women (p = 0.001). Pregnancy induces a range of physiological adaptations, including immunological and hematopoietic shifts, which contribute to elevated WBC counts and dynamic changes in platelet indices. Similar to our data, **Raychaudhuri et al., (2018)** reported that pregnant women had significantly higher WBC counts compared to non-pregnant women. This leukocytosis is considered a normal immunological response to pregnancy, reflecting increased neutrophil activity and maternal immune modulation. In contrast, some studies report a mild thrombocytopenia during pregnancy due to hemodilution and increased platelet consumption in the uteroplacental circulation, others have found elevated platelet indices in early gestation (**Reese et al., 2018**). **Reese et al., (2017)** found that platelet counts were highest during the first trimester and declined progressively through the second and third trimesters. However, the overall platelet count remained within normal reference ranges, and the differences were not always statistically significant.

Pregnant women reported a higher mean intake of processed food servings (2.34 ± 0.99) compared to non-pregnant women (1.96 ± 0.8), with a P value of 0.003. This may reflect a combination of increased caloric demands, convenience-driven choices, and shifts in taste preferences during pregnancy. However, the elevated intake of UPFs during gestation has raised concerns due to its potential impact on maternal and fetal health (**Akyakar et al., 2024**).

Large-scale studies indicate that both pregnant and non-pregnant women report high consumption of ultra-processed foods. In a Brazilian survey, nearly 95% of pregnant women consumed ultra-processed products on the previous day, a rate comparable to non-pregnant women. However, pregnant women reported a slightly lower frequency of soft drink and sauce consumption, but a higher frequency of fruit and juice intake compared to their non-pregnant counterparts. Despite these differences, the overall daily frequency of processed food intake did not significantly differ between the groups, highlighting a widespread pattern of high UPF consumption among women of reproductive age (**Ruiz et al., 2021**).

Multiple studies across different populations have found that UPF intake during pregnancy typically accounts for 20–33% of total energy intake, with some studies in the US and Europe reporting even higher proportions (up to 53%). The intake of UPFs is often higher among younger, less educated, and lower-income women, and is associated with lower consumption of nutrient-dense foods such as fruits, vegetables, and protein sources (**Nansel et al., 2022; Ben-Avraham et al., 2023; Granich-Armenta et al., 2024**).

The present study revealed that in both pregnant and non-pregnant females, both processed and ultra-processed food servings were negatively correlated with hemoglobin, MCV, platelet count, serum iron, ferritin and transferrin. In addition, processed and ultra-processed food servings were positively correlated with TIBC.

Similar to our study, a study from Brazil found that individuals with higher UPF intake had significantly lower hemoglobin and ferritin levels, independent of socioeconomic status and caloric intake (**Martini et al., 2021**). Furthermore, another study from Mexico reported inverse associations between UPF servings and serum iron, ferritin, and transferrin, alongside a positive correlation with TIBC. These findings were consistent across trimesters and were more pronounced in women with elevated pre-gestational BMI (**Akyakar et al., 2024**).

This pattern reflects the nutritional inadequacy of UPFs, which are often energy-dense but micronutrient-poor. Diets high in UPFs were associated with lower intakes of iron, folate, and vitamin B12—nutrients essential for erythropoiesis and iron metabolism (**Akyakar et al., 2024).**

In addition, UPFs may impair iron absorption through several pathways. Many contain additives such as phosphates, calcium salts, and polyphenols that inhibit non-heme iron uptake. Additionally, chronic consumption of UPFs has been linked to low-grade inflammation, which elevates hepcidin levels and disrupts iron mobilization from stores. This inflammatory blockade can reduce serum iron and transferrin saturation while paradoxically increasing TIBC due to compensatory upregulation of transferrin synthesis (**Queiroz et al., 2025).**

UPF indirectly affect iron metabolism via systemic inflammation. Consumption of UPF had a positive correlation with C-reactive protein (CRP) and a negative correlation with insulin-like growth factor-1 (IGF-1) and sex hormone-binding globulin (SHBG). This indicates inflammatory and hormonal processes that are recognized to regulate iron homeostasis (**Pagliai et al., 2021**). Chronic low-grade inflammation, intensified by the intake of UPF, can increase hepcidin levels—a crucial regulator that obstructs intestinal iron absorption and the mobilization of iron from reserves. This explains why individuals consuming higher amounts of UPF display iron dysregulation, despite sufficient or even excessive iron consumption (**Martini et al., 2021**).

CONCLUSION

The present study revealed that in both pregnant and non-pregnant females, both processed and ultra-processed food servings were negatively correlated with hemoglobin, MCV, platelet count, serum iron, ferritin and transferrin. In addition, processed and ultra-processed food servings were positively correlated with TIBC. These findings reflect the significant effect of processed and ultra-processed food consumption and iron homeostasis.

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