Arch Iran Med. October 2018;21(10):443-451

http www.aimjournal.ir

ARCHIVES OF IRANIAN MEDICINE

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Original Article

The Association Between Major Dietary Patterns and Pregnancy-related Complications

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Abstract

Background: Most pregnancy-related complications are associated with increased risks of adverse outcomes for mother and her infant. Although, relations between diet and pregnancy's complications indicate that there may be some benefits of nutritional factors to prevent such disorders, there are rare studies regarding the associations of dietary patterns and mentioned complications. So, the aim of the present study was to determine the relationship between dietary patterns and risk of pregnancy-related complications.

Methods: The current prospective observational study was based on the data collected from 812 pregnant women. Dietary data was collected using a validated semi-quantitative food frequency questionnaire.

Results: Three major dietary patterns identified according to the results from the factor loading matrix were: (i) 'western dietary pattern'; (ii) 'traditional dietary pattern'; (iii) 'healthy dietary pattern'. Overall, this study demonstrated a marginal significant inverse association between high adherence to healthy dietary pattern and chance of having pre-eclampsia. Also, a high chance of pre-eclampsia was observed among women with the most adherence to western dietary pattern.

Conclusion: We found that dietary patterns might be associated with the risk of pregnancy-related complications. Further studies are required to confirm these findings.

Keywords: Healthy dietary patterns, Pregnancy-related complications, Traditional dietary patterns, Western dietary patterns

Cite this article as: Hajianfar H, Esmaillzadeh A, Feizi A, Shahshahan Z, Azadbakht L. The association between major dietary patterns and pregnancy-related complications. Arch Iran Med. 2018;21(10):443–451.

Received: November 9, 2017, Accepted: May 27, 2018, ePublished: October 1, 2018

Introduction

Most pregnancy-related complications including gestational diabetes mellitus (GDM), hypertensive disorders, and nausea and vomiting in pregnancy (NVP) are associated with increased risks of adverse outcomes for mother and her infant.[1-5] Women with GDM are at a greater risk of experiencing pre-eclampsia, high blood pressure, giving birth by caesarean section, having their labor induced and experiencing perineal trauma. Developing type 2 diabetes in later life is another adverse effect of GDM. In addition, the babies of women who have been diagnosed with GDM are at risk of developing metabolic disorders such as diabetes and metabolic syndrome in childhood and later life.[1,2]

On the other hand, hypertensive disorders including pre-eclampsia and gestational hypertension are major contributors to maternal-fetal and perinatal morbidity and mortality.[6] The mentioned disorders are associated with earlier onset of chronic hypertension and a higher risk of stroke and ischemic heart diseases.[7,8]

Although, some risk factors (such as age and ethnicity) associated with the development of pregnancy-related complications are non-modifiable, some special preventive programs showed a significant reduction in pregnancy's complications with lifestyle modifications.[9,10]

Recent studies about relations between diet and pregnancy's complications indicate that there may be some benefits of nutritional factors to prevent such disorders.[10] Regular intake of some kind of foods such as fried foods are associated with increased GDM risk.[11] Inconsistently, certain foods such as vegetables and fruits are related to lower GDM risk.[12]

Findings about hypertensive disorders are controversial. Although one study revealed no association between dietary patterns and changes of blood pressure levels during pregnancy and at early postpartum,[13] other study suggested that a dietary pattern characterized by high intake of vegetables, plant foods, and vegetable oils could decrease

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the preeclampsia risk, whereas a high intake of processed meat, sweet drinks, and salty snacks could increase the risk.[14]

However, according to our knowledge, there are few studies regarding the association of dietary patterns and pregnancy-related complications. Compared to the intake of single nutrients or foods, considering the general pattern of a diet to assess diet quality could provide a better vision into diet–disease relations and may be more predictive of chronic disease risk.[15] In addition, assessing the relationship between intake of single nutrient and risk of diseases may be complicated due to the nutrient-nutrient interactions.[16]

Dietary patterns are based on cultural, geographical and regional influences which have effects on health outcomes. Therefore, studies from developed countries may not offer appropriate evidence for global public health policies.[17,18] and specific studies in this area are needed in developed countries.

Although limited data are available regarding the association of major dietary patterns and risk of pregnancy-related complications in Western nations, we found no study in this regard in the Middle East, where almost all lifestyle components are significantly different from those in Western countries.[19]

So, the purpose of the current study was to investigate the association between major dietary patterns during gestational period and pre-eclampsia, gestational hypertension, GDM and NVP risk among Iranian women. Such findings will be used to implement informative interventional programs to reduce mentioned complications and develop practical policies to improve the diet quality among women at risk of complications.

Materials and Methods

Study Design and Participants

This was a prospective observational study that assessed the relationship between major dietary patterns and pre-eclampsia, gestational hypertension, GDM and NVP risk among pregnant women who were referred to health centers during the first-trimester of pregnancy in Isfahan in 2015–2016.

The inclusion criteria were pregnant women with gestational age of 8–16 weeks without any medical condition or use of medications, with following a specific diet. Exclusion criteria was avoiding of follow-up during the study. The study population consisted of 812 pregnant women aged 20–40 years selected by the multi-stage cluster random sampling method. Sample size for this study was calculated by considering 20 samples for each food group which estimated 30 to 40 groups. So, according to this formula, 800 pregnant women were required for the study.

Data Collection

Assessment of Dietary Intake

During the first visit at gestational age of 8–16 weeks, dietary intakes were assessed by the validated and reliable 117-item semi-quantitative food-frequency questionnaire (FFQ). The validity and reliability of the questionnaire were previously confirmed.[20] For each item, participants were asked about the portion-sizes and frequency of food consumption in the previous year, on a daily, weekly, or monthly basis. Portion sizes of foods were converted to grams using household measures. We included supplements to total intake of specific nutrients. All nutrient values were energy-adjusted using the residuals method. Then nutrient and energy intakes were computed by using Nutritionist IV software (version 7.0; N-Squared Computing, Salem, OR), which was designed for Iranian foods.

Assessment of Gestational Diabetes Mellitus

GDM was defined as the abnormal glucose homeostasis including fasting plasma glucose concentration more than 95 mg/dL and 1-hour plasma glucose after eating 50 g of glucose, more than 140 mg/dL) at 24-28 gestational weeks,[21] which was assessed during the second visit at gestational age.

Assessment of Pre-eclampsia

Pre-eclampsia was diagnosed in the presence of hypertension associated with proteinuria. Hypertension was defined as a blood pressure of at least 140 mm Hg (systolic) or at least 90 mm Hg (diastolic) on at least two occasions and at least 4–6 hours apart after the 20th week of gestation in women known to be normo-tensive beforehand. Proteinuria was also defined as a protein concentration of 300 mg/L or more in 24-h urine sample.[22]

Assessment of NVP

Interviewers asked participants whether or not they had any NVP during the first visit. Participants answered yes or no.

Assessment of Gestational Hypertension

Blood pressure was measured twice after the participants sat for 15 min during the first visit, at 8–16 weeks. SBP ≥140 mm Hg or DBP ≥90 mm Hg during or after the 20th week of amenorrhea was considered as gestational hypertension.[23]

Assessment of Biochemical Factors

Fasting blood samples for measurement of glucose concentrations were drawn after an overnight fast of 12 hours, and measured on the day of blood collection by using the glucose oxidase method with commercially available reagents (Bio System, Tehran, Iran) adapted to a Selecta auto analyzer.

Serum insulin concentrations were measured by using an enzyme-linked immunosorbent assay (ELISA) with commercial reagents (Monobind, Tehran, Iran). Glycohemoglobin (by using immunoturbidimetric method), serum total cholesterol, triglycerides, HDL cholesterol concentration, blood urea nitrogen and proteinuria (by using photometric method), LDL cholesterol (by using enzymatic method) and urine and serum creatinine (by using Jaffe method), were measured with commercially available enzymatic reagents (Pars Azmoon, Tehran, Iran) adapted to a Selecta auto analyzer.

Assessment of Other Variables

Data on the anthropometric measurements as well as

demographic and clinical information were collected during the first visit.

To assess participants' knowledge on demographic and lifestyle factors, we used a standard self-reported questionnaire.

Subjects' weight was measured using a balanced digital scale to the nearest 100 g, in light clothing without shoes. Height was measured with a tape measure while the subjects were in a standing position. Body mass index (BMI), defined as weight in kilograms divided by height in meters squared, was calculated.

Statistical Analysis

Principal component factor analysis was applied to identify major dietary patterns. Food items similar in nutrient profile were combined into 33 predefined food groups (Table 1). Certain items which were unique in their nutrient profile were not combined (eg, salt). The factors were rotated by varimax rotation. We used the Scree plot (eigenvalues >1.5) to determine number of factors to retain Factor scores of dietary patterns were calculated by summing intakes of foods weighed by their factor loading for each participant. Participants were categorized by quartiles of dietary pattern scores.

The distribution of participants in terms of categorical variables across quartiles of dietary pattern scores was examined using χ^2 test. We applied one-way analysis of variance to compare means of continuous variables across quartiles of dietary pattern scores. Analysis of covariance was used for assessment of adjusted intakes of foods and nutrients across quartiles of dietary patterns. The association of major dietary patterns with pregnancy complications was assessed using logistic regression in different models. Adjustments for energy intake, age and BMI were done in the first statistical model. Further statistical control was made for physical activity and social-economic levels in the second model. All models were done by treating the first category (quartile 1) of dietary patterns as the reference.

Statistical analyses were performed using SPSS software version 19.0 (SPSS Inc, Chicago, IL, USA). The significance level was set at P less than 0.05.

Table 1. Food Grouping Used in the Dietary Patterns

Food Groups	Food Items
Bulky vegetables	Eggplant, cabbage, turnip, mushroom, squash, stewed pumpkin
Leafy vegetables	Leafy vegetables, cooked vegetables, celery, spinach, lettuce
Colored vegetables	Tomato, carrot, pepper, tomato paste, ketchup
Green vegetables	Green peas, green beans, cucumber
Garlic,Onion	Garlic, onion
Fruits	Cantaloupe ,watermelon, pear, apricot, sweet cherry, sour cherry, apple, peach, green tomato, pomegranate, plum, banana
Sweet fruits	Melon, persimmon, date, fig, grapes, raisin, berries
Citrus	Kiwi, orange, tangerine, lemon and sour lemon, strawberry
Olive	Olive, olive oils
Nuts	Peanuts, almonds, pistachios, hazelnuts, roasted seeds, walnuts
Legumes	Beans, peas, lima beans, broad beans, lentils, soy
Saturated fat	Cream, butter, animal oil, mayonnaise, solid oil
Unsaturated fat	Liquid oil, olive oil
Low fat dairy	Yogurt, whey, cheese, dough, low fat milk
High fat dairy	Full fat milk, Chocolate milk, Ice cream
Whole grains	Dark breads (Iranian bread), barley bread, wheat germ, Bulgur, Barley
Refined grains	White bread (lavash, baguettes), rice, toasted bread, sweet bread, white flour, biscuits, corn, macaroni, noodle
Potato	Fries, Potato
Red meat	All kinds of meat, minced meat
Fish	Fish, Tuna
Poultry	Chicken with or without skin
Eggs	Eggs
Fruit juice	Fruit juice, lemon juice, compote
Soft drinks	Soft drinks
Sweets and desserts	Sweets, gaz, sohan, chocolate, halva
Marinades	Salty pickles
Sugar	Sugar, candies, sugar cubes, honey, jam
Salt	Salt
Spices	Spices
Pizza	Pizza
Coffee	Coffee
Tea	Tea
Processed meat	Sausages

Results

Identified Major Dietary Patterns

Three factors were considered as major dietary patterns labeled based on the earlier literature and our interpretation of the data**.** (*i*) 'western dietary pattern' which was highly loaded by processed meats, fruits, fruits juice, citrus, nuts, fish, desserts and sweets, sugar, saturated fat, sweet fruit(Melon- Persimmon- Date- Fig- Grapes- Raisin- Berries that have high glycemic index), potato, legumes, coffee, egg, pizza, high fat dairy, whole grain and soft drinks; (*ii*) 'traditional dietary pattern' which was high in refined grains, colored vegetables, olive, sugar, salt, spices, unsaturated fat, garlic, onion and tea; (*iii*) 'healthy dietary pattern' which was high in green vegetables, leafy vegetables, colored vegetables, fruits, low fat dairy, poultry, bulky vegetables, red meat, citrus, nuts, fish, olive, marinades, sweet fruit, egg and unsaturated fat.

General Characteristics and Dietary Intakes of Study Participants

The overall characteristics of the study participants across different categories of western, traditional and healthy dietary patterns are presented in Table 2.

Women in the highest quartile of healthy dietary pattern were more likely to be employed and graduated from the university and also have an employed husband, history of IUGR or history of early delivery compared with those in the lowest quartile. In addition, the distribution of the women across category of western dietary pattern showed that those with the highest adherence to western dietary pattern were significantly more likely to have high social-economic level, employed husband, history of cesarean and history of IUGR and stillbirth. Furthermore, there were significant statistical differences in distribution of women regarding social-economic level, education, and husband's education across category of traditional dietary pattern.

Biochemical factors of the study participants across categories of dietary patterns were also illustrated in Table 3.

There were significant differences in Hb and MCH levels across quartiles of healthy dietary pattern.

Multivariable-adjusted odds ratios for NVP, pre-eclampsia, GDM and high systolic and diastolic blood pressures among pregnant women across quartile categories of dietary patterns are shown in Table 4.

The comparison of NVP risks in different categories of dietary patterns showed that greater adherence to western dietary pattern was significantly associated with higher NVP risk in the crude (odds ratio [OR]: 1.88; 95% CI: 1.09–3.24, $P = 0.04$), and model 1 (OR: 1.84; 95% CI: 1.04–3.26, $P = 0.04$). This association did not remain significant even after taking potential confounders into account in the model 2 (OR: 1.90; 95% CI: 1.03–3.51, $P = 0.09$). However, healthy and traditional dietary patterns were not associated with NVP risk in all crude and adjusted models (Table 4).

Findings about pre-eclampsia (Table 4) showed that those in the top quartile of adherence to healthy dietary pattern had a significant lower chance of having pre-eclampsia compared with those in the lowest quartile in the crude model (OR 0.73, 95% CI [0.44–1.20], $P = 0.04$) and in the model 1 (OR 0.52, 95% CI [0.27–1], $P = 0.03$). After adjusting for potential confounding variables in model 2 [OR 0.49, 95% CI [0.24–1], $P = 0.05$], this association attenuated.

On the contrary, higher significant chance of having pre-eclampsia was found among women with more adherence to western dietary pattern (OR 2.08, 95% CI [1–4.36], $P = 0.02$) in the final adjusted model.

We also found significant association between western dietary pattern and high systolic blood pressure in the crude model (OR 0.16, 95% CI [0.06–0.43], $P = 0.001$), model 1 (OR 0.15, 95% CI [0.05–0.43], $P = 0.001$), and model 2 (OR 0.13, 95% CI [0.04–0.42], $P = 0.002$) (Table 4).

Furthermore, lower risk of diastolic blood pressure was marginal significantly associated with a western dietary pattern (OR 0.08, 95% CI [0.01–0.67], P = 0.05) (Table 4).

However, adherence to mentioned dietary patterns was not related to GDM in all crude and adjusted models (Table 4).

Discussion

The effect of diet does not occur through the addition of single nutrients or food. So, dietary pattern approach would allow holistic identification of diet and disorder relations to provide information beyond those assessed by single nutrient.

To our knowledge, studies evaluating the association of dietary patterns and pregnancy-related complications are scarce, and current study, with 812 subjects is one of the largest studies in this field.

This study demonstrated a marginally significant inverse association between high adherence to healthy dietary pattern and chance of having pre-eclampsia. Consistently, a significant chance of having pre-eclampsia was observed among women with the most adherence to western dietary pattern.

Earlier systematic review and meta-analysis study showed the beneficial effect of a diet rich in fruits and vegetables on pre-eclampsia, although not all results were statistically significant.[24]

A healthy diet can contribute to mitigating the metabolic stress such as systemic oxidative stress and inflammation that occur during pregnancy.[25-27] Such pathological inflammation and oxidative stress lead to vascular endothelial cell dysfunction following the damage of biological molecules which is the initiator of the pathophysiological events of pre-eclampsia.[28,29] So, healthy dietary pattern, in contrast to western dietary pattern, can result in such protective effects on the pre-eclampsia.

Our findings about NVP showed a positive non-significant relationship between western dietary pattern and NVP risk.

Other studies revealed that cereal consumption, high intake of carbohydrates and added sugar,[30] alcohol and meat[31] were significantly associated with NVP rate among pregnant women. In addition, increasing severity of nausea was also related to decreasing healthy diet score from before to early pregnancy.[32]

Table 2. General Characteristics of the Study Participants Across Different Categories of Dietary Patterns

		Healthy					Western					Traditional				
		Q1	Q2	Q3	Q4	*P* Value[a]	Q1	Q2	Q3	Q4	*P* Value[a]	Q1	Q2	Q3	Q4	*P* value[a]
BMI (kg/m²)	Normal	25.7[a]	23.7	26.5	24.1	0.5	25.2	23.5	25.2	26.1	0.6	24.1	24.1	27.2	24.6	0.4
	Overweight	24.2	26.7	23	26.1		24.7	27	24.7	23.6		26.1	26.1	22.2	25.6	
Mother's occupation	Housekeeper	25.3	26.6	25.9	22.2	0.01	23.9	25.2	25.3	25.6	0.4	24.5	26.4	25	24.1	0.3
	Employed	21.4	19.8	20.6	38.1		29.4	25.4	20.6	24.6		27.8	19.8	24.6	27.8	
	Teacher	28.9	15.8	26.3	28.9		26.3	18.4	36.8	18.4		23.7	15.8	23.7	36.8	
Father's occupation	Employed	17.4	22.3	29.3	31	<0.001	22.7	23.1	23.1	31	0.001	26.9	21.9	23.1	28.1	0.5
	Self-employed	27	29.3	22.7	21.1		24.5	23.3	26.3	25.9		23.6	27	26.3	23.1	
	Worker	33.9	14.2	25.2	26.8		32.3	33.1	23.6	11		26.8	23.6	23.6	26	
Mother's education	Undergraduate	25.4	25.4	25.1	24	0.9	25.7	23.5	27.3	23.5	0.4	21.3	28.1	27.6	23	0.03
	Graduate	24.8	24.6	24.6	26		24.4	26	23.3	26.4		28.2	22.3	23	26.4	
Father's education	Undergraduate	28.3	26.7	23.1	21.8	0.01	22.5	23.8	27.6	26.1	0.1	22.7	28.5	25.4	23.4	0.02
	Graduate	21.2	22.9	26.7	29.2		27.5	26.4	22	24		28.1	20.1	24.5	27.3	
Socio-economic status	Low	28.1	23.4	31.2	17.2	0.5	32.8	31.2	21.9	14.1	0.02	12.5	37.5	29.7	20.3	<0.001
	Moderate	25.2	27.6	25.2	22.1		20.1	21.8	31	27.2		20.7	32.3	26.2	20.7	
	High	23.7	25.6	24	26.6		24.3	24	23.2	28.5		27.2	19	23.5	30.3	
Delivery	Cesarean	26.9	24.1	25.5	23.4	0.7	22.4	22	30.8	24.8	0.02	24.8	24.8	24.1	26.2	0.9
	Normal	24	25.2	24.8	26		26.5	26.7	21.6	25.2		25.2	25	25.4	24.4	
IUGR	No	25.3	24.8	25.8	24.1	0.02	23.9	24.5	25.9	25.7	0.002	24.1	25.4	25.2	25.3	0.3
	Yes	24.3	24.3	8.1	43.2		45.9	32.4	8.1	13.5		37.8	18.9	21.6	21.6	
Preterm Birth	No	24.6	25.2	25.2	25.1	0.04	25.2	24.7	24.8	25.3	0.1	24.4	24.8	25.6	25.2	0.1
	Yes	52.9	5.9	23.5	17.6		17.6	41.2	35.3	5.9		41.2	35.3	5.9	17.6	
Stillbirth	No	24.8	25.1	25.2	24.9	0.16	25.2	24.5	25.1	25.1	0.01	24.8	25	25.2	25	0.3
	Yes	50	12.5	0	37.5		0	75	12.5	12.5		50	25	0	25	
Abortion	No	25.8	25.8	24	24.3	0.3	25.4	24.6	24.8	25.2	0.9	24.8	25.1	24.8	25.4	0.9
	Yes	21.6	21.6	29	27.8		23.5	26.5	25.9	24.1		25.9	24.7	25.9	23.5	
Activity	Very low	55.6	22.2	11.1	11.1	0.02	22.2	44.4	22.2	11.1	0.1	11.1	22.2	22.2	44.4	0.5
	Low	25.8	28.9	21.3	24.1		25.2	26.2	23.9	24.7		27.8	24.3	24.9	23	
	Moderate	22.5	19.1	31.3	27.1		24.8	26	26	23.3		22.5	26.3	25.6	25.6	
	High	20	27.7	30.8	21.5		23.1	9.2	30.8	36.9		16.9	29.2	24.6	29.2	

BMI, Body mass index; IUGR, Intrauterine growth retardation, Q, quartile.

[a] Resulted from ANOVA for quantitative variables and chi-square test for categorical data

Values are presented as percent.

Table 3. Biochemical Factors of Study Participants Across Categories of Dietary Patterns

	Healthy				*P*	Western				*P*	Traditional				*P**
	Q_1	Q_2	Q_3	Q_4		Q_2	Q_3	Q_4	Q_1		Q_3	Q_4	Q_1	Q_2	
T3	128.27±38.21	125.35±32.14	132.08±26.93	118.67±26.82	0.43	124.69±32.07	129.08±31.63	115.59±28.63	132.63±26.32	0.33	136.04±31.36	116.03±29.34	126.25±29.15	123.43±31.28	0.15
T4	9.45±1.65	9.85±1.36	9.95±1.71	9.59±2.01	0.74	9.47±1.87	9.91±1.57	9.26±1.76	10.51±1.43	0.13	10.32±1.44	9.78±1.47	9.46±2.16	9.41±1.64	0.25
TSH	2.8±1.77	2.76±1.73	2.69±1.63	2.61±1.49	0.76	2.94±1.95	2.73±1.74	2.6±1.43	2.64±1.55	0.27	2.84±1.78	2.7±1.52	2.65±1.51	2.67±1.83	0.71
FBS	88.23±13.15	88.27±9.75	88.65±10.85	87.28±11.27	0.70	87.57±10.76	86.83±10.68	89.91±12.73	88±10.66	0.06	87.7±13.5	87.73±9.9	88.64±11.35	88.57±10.24	0.82
LDL	100.25±24.71	95±24.71	91.12±22.35	109.4±15.46	0.59	104.71±22.35	95.33±30.66	94.65±12.02	101±14.20	0.87	103.25±14.22	94.5±22.15	66±17.22	106.93±19.81	0.27
Cr	0.75±0.11	0.78±0.12	0.76±0.15	0.76±0.14	0.34	0.75±0.12	0.77±0.18	0.75±0.11	0.76±0.11	0.52	0.76±0.16	0.77±0.12	0.75±0.11	0.76±0.13	0.86
BUN	12.48±4.27	12.07±4.44	12.96±4.59	13.03±5.05	0.24	13.35±4.94	12.42±4.27	12.97±4.58	11.97±4.57	0.05	1.99±4	12.29±4.5	13.25±4.99	12.92±4.75	0.08
Hb	12.74±1.02	13.09±1.12	12.85±1.02	12.95±1.04	0.008	12.91±1	12.92±1.16	12.87±1.02	12.93±1.04	0.92	12.92±1.1	12.89±1.05	12.9±1.08	12.93±0.99	0.98
Hc	38.63±2.47	39.23±2.55	38.85±2.66	39.09±2.49	0.14	39.29±2.37	38.97±2.71	38.84±2.6	38.84±2.49	0.38	38.98±2.58	38.99±2.65	38.84±2.58	39.01±2.41	0.92
MCV	86.20±4.79	85.66±4.98	85.15±4.85	84.80±5.06	0.08	85.69±4.98	85.92±5.13	84.91±4.80	85.54±4.87	0.31	85.82±5.14	85.56±4.77	84.55±5	86.07±4.73	0.03
MCH	28.52±2	28.80±1.97	28.36±2	28.05±1.88	0.01	28.16±1.99	28.54±2.06	28.37±2.02	28.68±1.86	0.12	28.23±2	28.72±1.91	28.29±2.11	28.54±1.86	0.1
MCHC	33.21±1.26	32.95±1.20	33.47±1.25	33±1.29	0.24	33.11±1.30	33.25±1.23	33.07±1.26	32.6±1.19	0.54	33.13±1.41	33.49±1.19	33.3±1.33	32.82±1.06	0.07
RBC	4.51±0.36	4.55±0.43	4.56±0.40	4.53±0.39	0.60	4.51±0.38	4.52±0.41	4.58±0.39	4.54±0.40	0.41	4,56±0.42	4.5±0.4	4.56±0.37	4.53±0.39	0.39

T3, Triiodothyronine, T4, Thyroxine, TSH, Thyroid Stimulating Hormone, FBS, Fasting Blood Sugar, LDL, Low-density Lipoprotein, Cr, Creatinine, BUN, Blood Urea Nitrogen, Hb, Hemoglobin, Hc, Hematocrit, MCV, Mean Corpuscular Volume, MCH, Mean Corpuscular Hemoglobin, MCHC, Mean Corpuscular Hemoglobin concentration, RBC, Red Blood Cell

*Resulted from ANOVA.

Values are presented as mean ± SD.

Table 4. The Comparison of NVP, Pre-eclampsia, GDM, High Diastolic Blood Pressure, High Systolic Blood Pressure Risk in Different Levels of Dietary Patterns

	Model	Healthy Dietary Pattern					Western Dietary Pattern					Traditional Dietary Pattern				
		Q_1	Q_2	Q_3	Q_4	*P*-Value*	Q_1	Q_2	Q_3	Q_4	*P*-Value*	Q_1	Q_2	Q_3	Q_4	*P*-Value*
NVP	Crude	1	1.3 (0.78-2.15)	0.88 (0.51-1.49)	0.66 (0.38-1.16)	0.09	1	1.06 (0.6-1.89)	1.63 (0.94-2.81)	1.88 (1.09-3.24)	0.04	1	1.39 (0.84-2.30)	1.01 (0.59-1.73)	0.99 (0.57-1.70)	0.5
	Model 1	1	1.41 (0.83-2.40)	0.96 (0.55-1.67)	0.72 (0.39-1.30)	0.12	1	0.92 (0.5-1.69)	1.54 (0.87-2.72)	1.84 (1.04-3.26)	0.04	1	1.40 (0.82-2.37)	0.97 (0.55-1.70)	0.95 (0.54-1.70)	0.4
	Model 2	1	1.24 (0.72-2.16)	0.96 (0.54-1.72)	0.65 (0.34-1.22)	0.2	1	1.07 (0.55-2.06)	1.67 (0.91-3.07)	1.90 (1.03-3.51)	0.09	1	1.24 (0.71-2.17)	0.8 (0.44-1.45)	0.85 (0.47-1.55)	0.4
Pre-eclampsia	Crude	1	1.14 (0.721.81)	0.58 (0.35-0.98)	0.73 (0.44-1.20)	0.04	1	1.62(0.98-2.69)	1.49 (0.89-2.48)	1.31 (0.78-2.21)	0.21	1	1.1 (0.67-1.81)	1.03 (0.62-1.71)	1.24 (0.76-2.02)	0.8
	Model 1	1	0.95 (0.50-1.79)	0.44 (0.22-0.86)	0.52 (0.27-1)	0.03	1	1.94(1.01-3.74)	1.51 (0.782.91-)	1.49 (0.76-2.91)	0.26	1	1.28 (0.68-2.41)	1.59 (0.82-3.11)	1.71 (0.9-3.23)	0.3
	Model 2	1	0.92 (0.46-1.82)	0.44 (0.21-0.92)	0.49 (0.24-1)	0.05	1	3.25 (1.51-6.99)	2.02 (0.97-4.20)	2.08 (1-4.36)	0.02	1	1.27 (0.64-2.55)	1.41 (0.68-2.93)	1.25 (0.63-2.49)	0.8
GDM	Crude	1	0.6 (0.29-1.24)	0.74 (0.36-1.49)	0.88 (0.44-1.75)	0.5	1	0.66 (0.31-1.4)	1.1 (0.56-2.16)	0.58 (0.27-1.23)	0.2	1	0.8 (0.36-1.81)	1.42 (0.69-2.91)	1.35 (0.65-2.80)	0.4
	Model 1	1	0.6 (0.27-1.31)	0.9 (0.43-1.89)	1.06 (0.51-2.2)	0.5	1	0.71 (0.32-1.57)	1 (0.49-2.03)	0.6 (0.27-1.34)	0.49	1	0.97 (0.41-2.25)	1.76 (0.82-3.81)	1.82 (0.84-3.95)	0.2
	Model 2	1	0.61 (0.27-1.43)	0.95 (0.43-2.12)	1.04 (0.46-2.31)	0.6	1	0.62 (0.25-1.52)	0.91 (0.42-1.98)	0.52 (0.22-1.25)	0.39	1	0.8 (0.32-1.99)	1.36 (0.58-3.14)	1.71 (0.75-3.88)	0.28
DBP	Crude	1	0.71 (0.22-2.27)	0.85 (0.28-2.58)	0.71 (0.22-2.26)	0.92	1	0.62 (0.23-1.63)	0.35 (0.11-1.11)	0.08 (0.01-0.67)	0.05	1	0.99 (0.34-2.89)	0.7 (0.22-2.25)	0.56 (0.16-1.94)	0.75
	Model 1	1	0.53 (0.15-1.85)	0.75 (0.24-2.37)	0.57 (0.17-1.88)	0.72	1	0.63 (0.22-1.77)	0.38 (0.11-1.27)	0.07 (0.00-0.64)	0.07	1	1.13 (0.37-3.48)	0.66 (0.19-2.20)	0.56 (0.15-2.04)	0.65
	Model 2	1	0.49 (0.13-1.78)	0.68 (0.2-2.2)	0.22 (0.04-1.14)	0.31	1	1.03 (0.33-3.2)	0.44 (0.11-1.63)	0.1 (0. 01-0.95)	0.13	1	1.44 (0.41-5.09)	0.57 (0.13-2.38)	0.86 (0.21-3.45)	0.58
SBP	Crude	1	0.82 (0.4-1.68)	1.06 (0.54-2.08)	0.7 (0.33-1.47)	0.68	1	0.83 (0.45-1.50)	0.33 (0.15-0.71)	0.16 (0.06-0.43)	<0.001	1	0.99 (0.5-1.97)	0.75 (0.36-1.56)	0.81 (0.4-1.67)	0.83
	Model 1	1	0.77 (0.36-1.63)	0.98 (0.48-1.97)	0.61 (0.28-1.33)	0.57		0.77 (0.41-1.46)	0.35 (0.16-0.77)	0.15 (0.05-0.43)	0.001	1	1.08 (0.53-2.2)	0.75 (0.35-1.59)	0.82 (0.39-1.73)	0.76
	Model 2	1	0.83 (0.37-1.86)	0.81 (0.36-1.80)	0.58 (0.24-1.40)	0.7	1	0.63 (0.3-1.3)	0.36 (0.15-0.81)	0.13 (0.04-0.42)	0.002	1	1.03 (0.44-2.36)	0.74 (0.31-1.76)	1.07 (0.47-2.44)	0.83

*Using Mantel–Haenszel extension χ2 test.
Model 1: adjusted for energy intake, age and BMI
Model 2: adjusted for energy intake, age, BMI, socio economic and physical activity.

Furthermore, in the current study, adherence to mentioned dietary patterns was not related to GDM. Some findings suggest that although the vegetable pattern was associated with a decreased risk of GDM, a prudent pattern (healthy dietary style) was not related to mentioned disorder.[33] However, others reported that a dietary pattern rich in fruits, vegetables, whole grains, and fish, and low in red and processed meat, refined grains, and high-fat dairy could have an association with a lower risk of GDM.[34]

In this study, we interestingly found that a lower risk of high systolic blood pressure was marginally associated with a western dietary pattern. A similar result was obtained about diastolic blood pressure which was a marginally significant association.

Most other publications have reported no association between dietary patterns and changes of SBP and DBP levels during pregnancy and at early postpartum.[13,35]

In this study, we found that there is a high consumption of red meats in the healthy dietary pattern, and refined grains, salt and sugar in the traditional dietary pattern. Mentioned unhealthy foods, might have given an adverse score to the healthy and traditional dietary patterns.

This might be a reason why we failed to report a significant negative association between high adherence to healthy dietary pattern and some pregnancy-related complications.

It should be mentioned that refined grains are a major source of carbohydrate intake in Iranian diet, which has been shown to be associated with higher risk of some chronic disorders. Iranian usual diet also contains high amounts of salt, and mean salt intake is almost two fold higher than the recommended intake. In addition, consumption of fruits, vegetables, and low-fat dairy is low; however, legumes intake is good.[36] Therefore, understanding the differences between healthy, western and traditional dietary patterns and Iranian usual dietary pattern might help interpreting the findings we obtained.

Also, pre-pregnancy consumption of unhealthy diets should be considered as a risk factor for some pregnancy-related complications. We cannot overlook that the long time adherence to a specific diet can affect health outcomes.[37] Even, transient NVP at the early pregnancy should be taken into account as an important factor to change the diet quality from before pregnancy.

Beside the diet, another point that needs to be considered is other lifestyle factors during early pregnancy that are associated with pregnancy-related complications. Interestingly, each healthy lifestyle behavior (eating a healthy diet, being physically active, not smoking, or having low stress levels) showed 23% reduction in risk of GDM.[25]

In the present study, some odds ratios and 95% CIs for association between major dietary patterns and pregnancy complications were inflated which is a hallmark of sparse data bias. This bias happens when the data lack adequate case numbers for some combination of exposure and outcome levels.[38-40] Hence, the interpretation of our findings must be done with caution.

Although we adjusted the effect of several confounder variables like energy intake, age, BMI, socio economic and physical activity in statistical analysis, the impact of gene variation was not considered. Future studies should stratified subjects according to the gene variation. Therefore, these potential limitations should be considered in interpretation of our results.

However, the main strength of the current study is that few studies have collected data on dietary patterns and pregnancy-related complications.

In summary, evaluations carried out in the present study indicate that different dietary patterns have an association with the risk of pre-eclampsia and hypertension in pregnant women.

Larger studies are needed to determine whether dietary patterns lead to significant modifications in pregnancy-related complications. Also, future studies are required to evaluate causal relationships between diet quality indices and pregnancy complications.

Authors' Contribution

HH, AE, AF, ZS and LA collected data. HH, AE, AF, and LA performed statistical analysis. HH, AE, and LA wrote the manuscript.

Conflict of Interest Disclosures

The authors have no conflicts of interest.

Ethical Statement

We obtained written informed consent from all participants. This study was approved by the research council (research project number: 193053) and ethics committee (research ethics number: IR.MUI.REC193053).

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