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ORIGINAL RESEARCH

Maternal Dietary Patterns During Pregnancy Are Linked to Hypertensive Disorders of Pregnancy Among a Predominantly Low-Income US Hispanic/Latina Pregnancy Cohort

Luis E. Maldonado, PhD, MPH; Theresa M. Bastain, PhD, MPH; Claudia M. Toledo-Corral, PhD; Genevieve F. Dunton, PhD, MPH; Rima Habre, ScD; Sandrah P. Eckel, PhD; Tingyu Yang, MS; Brendan H. Grubbs, MD; Thomas Chavez, MS; Laila A. Al-Marayati, MD; Carrie V. Breton, ScD; Shohreh F. Farzan, PhD

BACKGROUND: Diet during pregnancy may be a potential intervention for preventing hypertensive disorders of pregnancy that disproportionally burdens Hispanic/Latina women.

METHODS AND RESULTS: The MADRES (Maternal And Developmental Risks from Environmental and Social stressors) study (n=451) is a prospective pregnancy cohort of predominantly low-income Hispanic/Latina women in Los Angeles, California, who completed up to 2 staff-administered 24-hour dietary recalls in the third trimester of pregnancy. Hypertensive disorders of pregnancy were abstracted from medical records and based on a physician's diagnosis or systolic or diastolic blood pressure (≥140 or ≥90 mm Hg, respectively) at ≥2 consecutive prenatal visits. Using multivariable logistic regression, we evaluated associations of 2 previously derived dietary patterns in this population (solid fats, refined grains, and cheese and vegetables, oils, and fruit) and the Healthy Eating Index 2015 with (1) gestational hypertension, (2) preeclampsia, and (3) any hypertensive disorder of pregnancy (either gestational hypertension or preeclampsia). In separate models, we additionally tested interactions with prepregnancy body mass index. Comparing highest-to-lowest quartiles, the solid fats, refined grains, and cheese dietary pattern was associated with an increased odds of any hypertensive disorder of pregnancy (odds ratio [OR], 3.99 [95% CI, 1.44–11.0]; P_{trend}=0.014) and preeclampsia (OR, 4.10 [95% CI, 1.25–13.5]; P_{trend}=0.036), whereas the vegetables, oils, and fruit pattern was associated with reduced odds of preeclampsia (OR, 0.32 [95% CI, 0.10–0.99]; P_{trend}=0.041). Among the overweight prepregnancy body mass index category, inverse associations of vegetables, oils, and fruit and Healthy Eating Index 2015 with preeclampsia were more pronounced (both $P_{interactions}$=0.017). Healthy Eating Index 2015 findings were generally nonsignificant.

CONCLUSIONS: While the solid fats, refined grains, and cheese diet was strongly associated with preeclampsia during pregnancy, findings suggest the vegetables, oils, and fruit diet may be more relevant than Healthy Eating Index 2015 for preventing preeclampsia among low-income Hispanic/Latina women.

Key Words: dietary patterns ■ health disparities ■ Healthy Eating Index ■ Hispanic/Latina women ■ hypertensive disorders of pregnancy ■ MADRES ■ preeclampsia

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Correspondence to: Luis E. Maldonado, PhD, MPH, Department of Population and Public Health Sciences, Keck School of Medicine, University of Southern California, 1845 N Soto St, Suite 102G, Los Angeles, CA 90032. Email: lemaldon@usc.edu

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CLINICAL PERSPECTIVE

What Is New?

- The prevalence of hypertensive disorders of pregnancy is alarmingly high among low-income Hispanic/Latina pregnant women residing in urban Los Angeles, California.
- A diet characterized by higher intakes of solid fats, refined grains, and cheese was strongly associated with greater odds of having had a hypertensive disorder of pregnancy, including preeclampsia, during pregnancy.
- Overall, a diet characterized by higher intakes of vegetables, oils, and fruit, but not Healthy Eating Index 2015, was linked to lower odds of preeclampsia during pregnancy, with findings being stronger among women with overweight prepregnancy body mass index.

What Are the Clinical Implications?

- Population/cultural-specific versus predefined diets, such as the 2015 Healthy Eating Index, may be more relevant for preventing preeclampsia among low-income Hispanic/Latina women.

Nonstandard Abbreviations and Acronyms

GHTN	gestational hypertension
HDP	hypertensive disorder of pregnancy
HEI-2015	Healthy Eating Index 2015
MADRES	Maternal And Developmental Risks from Environmental and Social stressors
SRC	solid fats, refined grains, and cheese
VOF	vegetables, oils, and fruit

Hypertensive disorders of pregnancy (HDPs), including gestational hypertension (GHTN) and preeclampsia, are obstetric complications linked to maternal and neonatal mortality and morbidity.[1–4] Although greater risks of HDPs among Hispanic/Latina versus non-Hispanic White women have been documented,[5] research among Hispanic/Latina women is scarce and highlights a critical gap in the identification of effective HDP preventive strategies during pregnancy to help reduce health disparities.[6,7]

Serving as a potential intervention point, maternal diet during pregnancy has been previously linked to HDPs. Previous findings linking prenatal dietary patterns and HDPs, however, have been inconsistent.[3,8–16] Study differences may be attributed to inconsistent approaches in defining and assessing diet, particularly among underrepresented pregnant populations, such as Hispanic/Latina women. Previous studies have mostly defined dietary patterns using either theory-driven (eg, Alternative Healthy Eating Index)[11,13–20] or data-driven (eg, exploratory factor analysis) approaches.[3,9,10,12] Theory-driven diets, however, may fail to reflect the eating behaviors of the study population or include dietary components irrelevant to HDPs, both of which could attenuate dietary associations with HDPs.[21] Meanwhile, data-driven diets are based on actual diet intake data and, therefore, better reflect patterns of eating behaviors in the study population and may be especially important for pregnant populations underrepresented in research, such as Hispanic/Latina women. To our knowledge, links between data-driven diets and HDPs among Hispanic/Latina pregnant women have not been previously documented.

Among a predominantly low-income Hispanic/Latina pregnant population, we previously identified 2 data-driven prenatal dietary patterns (solid fats, refined grains, and cheese [SRC] and vegetables, oils, and fruit [VOF]).[22] Whether HDP findings are consistent between data- and theory-driven prenatal dietary patterns with similar diet composition among groups at high risk for HDPs, such as Hispanic/Latina women, has not been previously investigated. Last, few studies have evaluated whether prepregnancy body mass index (BMI), an independent risk factor for HDPs,[23,24] modifies prenatal dietary pattern relationships with HDPs.[3,9,12,13]

This study aims to: (1) evaluate associations between data- and theory-driven prenatal dietary patterns and HDPs; and (2) examine variation of these associations by prepregnancy BMI.

METHODS

Study Population

The data that support the findings of this study are available from the corresponding author upon reasonable request. We used data from the MADRES (Maternal And Developmental Risks from Environmental and Social stressors) study, an ongoing, prospective pregnancy cohort of predominantly low-income Hispanic/Latina women in Los Angeles, California. The MADRES study began study enrollment in November 2015 and has been previously described.[25] Briefly, participants were mostly recruited from 4 prenatal care facilities serving low-income Hispanic/Latino communities in Los Angeles. Study inclusion criteria encompassed being ≥18 years of age, having a singleton pregnancy, being <30 weeks of gestation, and having language fluency in English or Spanish. Of the 584 participants with relevant data in the third trimester, we excluded a total of 133 based on the following: missing/incomplete

24-hour dietary recalls (n=92) or recalls with implausible daily total energy intake (<500 or >5000 kcal; n=3); missing data from medical records (n=20); and missing key covariates (n=18), resulting in a final analytic sample of 451 participants (Figure S1). Written informed consent and approval were obtained from all participants and the University of Southern California's institutional review board, respectively.

Hypertensive Disorders of Pregnancy

HDP (any, GHTN, and preeclampsia) diagnoses were abstracted from maternal medical records. We defined GHTN based on maternal prenatal medical records of systolic (≥140 mm Hg) or diastolic (≥90 mm Hg) blood pressure measurements on at least ≥2 consecutive prenatal visits after 20 weeks of gestation when previous blood pressure was normal. We defined preeclampsia based on a physician's diagnosis[26] and included eclampsia and HELLP (hemolysis, elevated liver enzymes, low platelet count) syndrome in our preeclampsia definition. Only 1 case of eclampsia was reported in our study; no HELLP cases were reported. Because eclampsia is a severe complication of preeclampsia marked by the new onset of seizures or coma,[4] we included it in our preeclampsia definition. Any HDP and preeclampsia definitions include women with prepregnancy hypertension who developed preeclampsia during pregnancy.

Dietary Assessment

Dietary intake was assessed 2 times (1 weekday and 1 weekend) over the telephone during the third trimester of pregnancy by trained staff using the validated and web-based National Cancer Institute's Automated Self-Administered 24-Hour Dietary Assessment Tool (versions 2016-2018).[27,28] The second Automated Self-Administered 24-Hour Dietary Assessment Tool dietary recall interviews were completed within 2 weeks of the first interview. Participants were asked to recall all food and beverages consumed in the past 24 hours during their scheduled interview. Detailed questions were asked with respect to food preparation, portion size (with the help of images to assist in estimation), and additions (eg, sugar and coffee cream). Day-level nutrient and food group values were estimated by the Automated Self-Administered 24-Hour Dietary Assessment Tool using the Food and Nutrient Database for Dietary Studies (version 4.1; 2010) and MyPyramid Equivalents Database (version 2.0; 2008).[29]

Prenatal Dietary Patterns

Data-driven identification of dietary patterns in the MADRES study has been previously described.[22] Briefly, we performed factor analysis on 25 MyPyramid Equivalent food groups and identified the following 2 dietary patterns based on higher-loading foods: (1) SRC and (2) VOF. At the individual level, scores were generated for each dietary pattern by multiplying the food group loadings by the individual's corresponding food group intake and summing across food groups.

The Healthy Eating Index 2015 (HEI-2015) is a diet quality indicator measuring how closely an eating pattern or mix of foods matches the 2015 to 2020 Dietary Guidelines for Americans recommendations.[30,31] Comprising 13 dietary components, HEI-2015 includes 9 components centered on adequacy (total fruit, whole fruit, total vegetables, greens and beans, whole grains, dairy, total protein foods, seafood and plant proteins, and fatty acids) and 4 focused on moderation (refined grains, sodium, added sugars, and saturated fats). HEI-2015 scores were calculated using the simple HEI scoring to assess overall diet quality on the individual level and ranged from 0 to 100, with higher scores indicating greater diet quality.[32]

To evaluate linearity between dietary patterns and HDPs, we divided dietary pattern scores by quartiles, with highest quartile (quartile 4) indicating highest dietary pattern adherence, and examined whether the proportion of HDPs for any, GHTN, and preeclampsia followed a nonlinear pattern with increasing quartiles of each prenatal dietary pattern. Because we found evidence of nonlinearity across all dietary patterns (Table S1), we modeled quartiles versus continuous scores for each dietary pattern.

Covariates

Interviewer-administered questionnaires collected data on covariates, including maternal age (years), education (less than high school or high school/equivalent or more), total household income (<\$15 000, \$15 000–\$29 999, \$30 000–\$49 999, >\$50 000, and do not know [nonmissing]), ethnicity and nativity (non-Hispanic/Latina, US-born Hispanic/Latina, and foreign-born Hispanic/Latina), nulliparous (yes or no), study entry (<20 or ≥20 weeks of gestation), recruitment site (community clinic or private practice at the University of Southern California), prepregnancy BMI (calculated using weight [kg] divided by height [m^2]), and daily total energy intake (kcal/d), which were calculated for each Automated Self-Administered 24-Hour Dietary Assessment Tool recall and averaged for participants with multiple 24-hour dietary recalls. We further categorized prepregnancy BMI into underweight (BMI <18.5 kg/m^2), normal (18.5 kg/m^2≤BMI<25 kg/m^2), overweight (25 kg/m^2≤BMI<30 kg/m^2), and obese (BMI ≥30 kg/m^2) categories using standard criteria.[33] Because of a limited number of participants in the "underweight" category (n=11 [2.4%]), we combined these individuals with the normal weight group. Last, physician-diagnosed prepregnancy diabetes was abstracted from maternal prenatal medical records.

Statistical Analysis

We summarized HDPs and maternal characteristics in the study sample using descriptive statistics and by comparing highest-to-lowest quartiles (quartile 4 versus quartile 1) of each prenatal dietary pattern using ANOVA for continuous variables and Pearson χ^2 tests for categorical variables. We calculated Pearson correlation coefficients to examine associations among the SRC, VOF, and HEI-2015 dietary patterns. To investigate links between HDPs (any HDP, GHTN, and preeclampsia) and prenatal dietary patterns, we used logistic regression and adjusted for the following covariates based on previous literature: maternal age and education, total household income, ethnicity and nativity, parity, study entry, recruitment site, prepregnancy BMI, prepregnancy diabetes, energy intake, and quartiles of the only other dietary pattern (except in models with HEI-2015).[21,34] Similar to previous work, we also tested linear trends by using the midpoint value of each quartile in each dietary pattern as a continuous measure.[11] To examine variation in these associations by prepregnancy weight, we additionally included appropriate interaction terms between continuous prenatal dietary pattern (scores) and prepregnancy weight status (underweight/normal, overweight, and obese). To aid interpretation of interaction models, we calculated adjusted predicted probabilities and 95% CIs[35] of having had a diagnosis of any HDP, GHTN, and preeclampsia during pregnancy by scores of each prenatal dietary pattern.

Sensitivity Analyses

We excluded participants with prepregnancy hypertension because these individuals may be characteristically different and more likely to develop preeclampsia compared with women without this condition. We then excluded women with a history of preeclampsia in a previous pregnancy because these participants may be more likely to modify their dietary behaviors in subsequent pregnancies. We conducted all analyses in Stata, version 16.1 (Stata Corp, College Station, TX) and considered statistical significance at $P<0.05$.

RESULTS

Table 1 summarizes participant characteristics overall and by highest and lowest quartiles of each maternal dietary pattern in the third trimester of pregnancy (see Table S1 for results across all quartiles). Among the overall study sample, 19.5% of participants were diagnosed with any HDP during their pregnancy. Of these diagnoses, 6.9% were GHTN and 12.6% were preeclampsia. The average participant age was 28.9±5.9 years. Most participants reported a total household income of <$30 000 (44.4%) or reported not knowing their household income (31.9%). Last, most individuals self-reported as Hispanic/Latina ethnicity (78.2%). Among Hispanic/Latina women, 44.1% reported being born outside the United States.

Compared with the lowest quartile, women in the highest quartile of the SRC dietary pattern were significantly more likely to be younger, report a high school education or greater, and report being Hispanic/Latina ethnicity and born in the United States, and they were less likely to have prepregnancy diabetes. Conversely, participants in the highest quartile of the VOF dietary pattern were significantly more likely to be older, report being Hispanic/Latina ethnicity and born outside the United States, and report a higher household income compared with the lowest quartile. Similarly, women in the highest quartile of the HEI-2015 were significantly more likely to be older, report being Hispanic/Latina ethnicity and born outside the United States, and have prepregnancy diabetes compared with those in the lowest quartile.

Last, we examined bivariate associations between the SRC and VOF dietary patterns and HEI-2015. We found significantly inverse associations between the SRC dietary pattern and HEI-2015 (r=−0.35) and significantly positive relationships between the VOF dietary pattern and HEI-2015 (r=0.62).

Table 2 shows findings from multivariable associations between maternal dietary patterns in the third trimester of pregnancy and HDPs. Compared with those in the lowest quartile, women in the highest quartile of the SRC dietary pattern had a significantly higher odds of a diagnosis of any HDP (odds ratio [OR], 3.99 [95% CI, 1.44–11.0]; P_{trend}=0.014) and preeclampsia (OR, 4.10 [95% CI, 1.25–13.5]; P_{trend}=0.036) during pregnancy. By contrast, participants in the highest quartile of the VOF dietary pattern had significantly lower odds of a preeclampsia diagnosis during pregnancy versus the lowest quartile (OR, 0.32 [95% CI, 0.10–0.99]; P_{trend}=0.041). Although we did not find significant associations between HEI-2015 and HDPs overall, HEI-2015 findings showed similar patterning to those observed for the VOF dietary pattern. We also did not find any significant associations between either of our study-derived dietary patterns or HEI-2015 with GHTN alone. We did observe, however, consistently greater odds of GHTN comparing higher-versus-lowest quartiles of the SRC dietary pattern, albeit statistically nonsignificant.

In sensitivity analyses, results showed stronger, positive associations for the SRC dietary pattern after excluding women with prepregnancy hypertension and history of preeclampsia (Table S2). Although findings for the VOF dietary pattern became nonsignificant in

Table 1. Overall Participant Characteristics and by Highest and Lowest Quartiles of Each Maternal Dietary Pattern in the Third Trimester of Pregnancy (n=451)

Characteristic	Overall sample	Solid fats, refined grains, and cheese*			Vegetables, oils, and fruit*			2015 Healthy Eating Index*		
		Quartile 1	Quartile 4		Quartile 1	Quartile 4		Quartile 1	Quartile 4	
		n=111	n=111	*P*	n=113	n=111	*P*	n=113	n=113	*P* value
Hypertensive disorders										
Any	88 (19.5)	21 (18.9)	24 (21.6)	0.761	29 (25.7)	24 (20.7)	0.167	24 (21.2)	20 (17.7)	0.704
Gestational hypertension	31 (6.9)	7 (6.3)	6 (5.4)	0.794	11 (9.7)	9 (8.1)	0.183	8 (7.1)	6 (5.3)	0.754
Preeclampsia	57 (12.6)	14 (12.6)	18 (16.2)	0.272	18 (15.9)	8 (7.2)	0.229	16 (14.2)	14 (12.4)	0.883
Sociodemographics										
Age, y	28.9±5.9	30.4±6.4	27.9±5.6	0.013	27.2±5.8	31.2±5.9	<0.001	27.7±5.5	31.8±6	<0.001
Cohort entry										
Early	323 (71.6)	75 (67.6)	83 (74.8)	0.292	77 (68.1)	76 (68.5)	0.486	76 (67.3)	76 (67.3)	0.23
Late	128 (28.4)	36 (32.4)	28 (25.2)		36 (31.9)	35 (31.5)		37 (32.7)	37 (32.7)	
Recruitment site										
Public practice	408 (90.5)	104 (93.7)	99 (89.2)	0.570	108 (95.6)	92 (82.9)	0.006	100 (88.5)	98 (86.7)	0.177
Private practice[†]	43 (9.5)	7 (6.3)	12 (10.8)		5 (4.4)	19 (17.1)		13 (11.5)	15 (13.3)	
Education										
Less than high school	118 (26.2)	40 (36)	26 (23.4)	0.030	31 (27.4)	29 (26.1)	0.512	30 (26.5)	42 (37.2)	0.004
High school education or more	333 (73.8)	71 (64)	85 (76.6)		82 (72.6)	82 (73.9)		83 (73.5)	71 (62.8)	
Total household income, $										
<15 000	87 (19.3)	25 (22.5)	19 (17.1)	0.384	27 (23.9)	17 (15.3)	0.016	26 (23.0)	18 (15.9)	0.078
15 000–29 999	113 (25.1)	25 (22.5)	26 (23.4)		33 (29.2)	26 (23.4)		25 (22.1)	27 (23.9)	
30 000–49 999	57 (12.6)	12 (10.8)	21 (18.9)		10 (8.8)	19 (17.1)		15 (13.3)	15 (13.3)	
≥50 000	50 (11.1)	9 (8.1)	14 (12.6)		3 (2.7)	21 (18.9)		11 (9.7)	22 (19.5)	
I do not know	144 (31.9)	40 (36)	31 (27.9)		40 (35.4)	28 (25.2)		36 (31.9)	31 (27.4)	
Ethnicity and nativity										
Non-Hispanic	98 (21.7)	20 (18.0)	34 (30.6)	0.001	27 (23.9)	23 (20.7)	0.014	37 (32.7)	22 (19.5)	0.002
US-born Hispanic	154 (34.1)	29 (26.1)	48 (43.2)		52 (46.0)	29 (26.1)		43 (38.1)	30 (26.5)	
Foreign-born Hispanic	199 (44.1)	62 (55.9)	29 (26.1)		34 (30.1)	59 (53.2)		33 (29.2)	61 (54.0)	
Reproductive health										
Parity										
Nulliparous	160 (35.5)	35 (31.5)	47 (42.3)	0.206	42 (37.2)	41 (36.9)	0.915	71 (62.8)	76 (67.3)	0.778
Multiparous	291 (64.5)	76 (68.5)	64 (57.7)		71 (62.8)	70 (63.1)		42 (37.2)	37 (32.7)	

(Continued)

Table 1. Continued

Characteristic	Overall sample	Solid fats, refined grains, and cheese*			Vegetables, oils, and fruit*			2015 Healthy Eating Index*		
		Quartile 1	Quartile 4		Quartile 1	Quartile 4		Quartile 1	Quartile 4	
		n=111	n=111	*P*	n=113	n=111	*P*	n=113	n=113	*P* value
Prepregnancy diabetes										
Yes	28 (6.2)	13 (11.7)	2 (1.8)	0.004	5 (4.4)	10 (9.0)	0.518	4 (3.5)	14 (12.4)	0.019
No	423 (93.8)	98 (88.3)	109 (98.2)		108 (95.6)	101 (91)		109 (96.5)	99 (87.6)	
Prepregnancy BMI, kg/m^2	28.6±6.7	29.8±7.4	27.5±5.8	0.073	29.2±7	28.3±6.4	0.708	28.8±6.6	29.3±7.8	0.473
Energy intake, kcal	1916±579	1409±407	2520±489	<0.001	1756±552	2147±574	<0.001	2028±589	1829±538	0.25

Values are mean±SD or number (percentage). *P* values were calculated using ANOVA for continuous variables and χ^2 tests for categorical variables. Data are from the MADRES (Maternal And Developmental Risks from Environmental and Social stressors) study. BMI indicates body mass index.

*P<0.001 was found using Pearson correlations between the Healthy 2015 Eating Index and the solid fats, refined grains, and cheese (r=−0.35) and vegetables, oils, and fruit dietary patterns (r=0.62).

†Private obstetrics and gynecology prenatal care facility at the University of Southern California vs public.

both sensitivity analyses, the direction and magnitude of the estimates did not substantially change.

We examined interactions between prepregnancy weight status and dietary patterns for each HDP dichotomous dependent variable. With respect to preeclampsia only, we found statistically significant interactions between prepregnancy weight status and the VOF dietary pattern ($P_{interaction}$=0.017) and HEI-2015 ($P_{interaction}$=0.017) index and present findings stratified by prepregnancy BMI in Table 3. Among participants in the overweight prepregnancy BMI category, a 1-SD score increase in the VOF dietary pattern (OR, 0.41 [95% CI, 0.24–0.69]) or the HEI-2015 index (OR, 0.50 [95% CI, 0.33–0.77]) was significantly associated with lower odds of preeclampsia.

To aid interpretation of these interactions, we present adjusted predicted probabilities and 95% CIs of having had a preeclampsia diagnosis during pregnancy in 0.5-SD score intervals for the VOF dietary pattern and HEI-2015 index (Figure). Among participants in the overweight prepregnancy BMI category, the predicted probability of preeclampsia steadily declined, with higher scores for the VOF dietary pattern and HEI-2015 index, whereas for individuals with normal and obese prepregnancy BMI categories, the predicted probability remained generally constant with increasing scores for both diets.

DISCUSSION

Among a predominantly low-income Hispanic/Latina pregnancy cohort, we observed strong and significant associations between the SRC dietary pattern and having had any HDP (GHTN or preeclampsia) or preeclampsia alone during pregnancy. We also found significant inverse relationships between the VOF dietary pattern and preeclampsia, with stronger associations among participants with overweight prepregnancy BMI (also for HEI-2015). We found no significant associations between dietary patterns and GHTN alone.

Our dietary findings corroborate previous findings for similar prenatal dietary patterns found associated with HDPs and biomarkers implicated in HDP pathogenesis.[3,9,10,12] Dietary patterns characterized by higher intakes of fats and processed meats have been linked to mechanisms associated with HDPs, such as markers of systemic inflammatory responses (eg, higher CRP [C-reactive protein] and interleukin 6), and endothelial dysfunction (eg, CRP, interleukin 6, and homocysteine), whereas VOF were shown as major contributors to dietary patterns found inversely associated with HDPs and relevant markers.[36–38] Together, findings across studies suggest similar key food groups are shared among prenatal dietary patterns associated with HDPs.

Table 2. Multivariable Associations of Maternal Dietary Patterns During the Third Trimester of Pregnancy and Having Had a Diagnosis of Any HDP, GHTN, and Preeclampsia During Pregnancy in the MADRES Study (n=451)

HDPs by dietary patterns	Dietary pattern score (quartiles)				P_{trend}
	Quartile 1	Quartile 2	Quartile 3	Quartile 4	
	Referent	OR (95% CI)	OR (95% CI)	OR (95% CI)	
Any HDP					
SRC	Referent	1.80 (0.81–4.00)	1.89 (0.81–4.40)	3.99 (1.44–11.0)*	0.014*
VOF	Referent	0.52 (0.25–1.09)	0.70 (0.34–1.44)	0.49 (0.21–1.12)	0.109
HEI-2015	Referent	0.99 (0.50–1.95)	1.03 (0.52–2.06)	0.50 (0.23–1.10)	0.110
GHTN					
SRC	Referent	1.73 (0.48– 6.20)	3.10 (0.84–11.4)	2.40 (0.56–10.4)	0.226
VOF	Referent	0.25 (0.06–0.95)	0.71 (0.21–2.36)	1.11 (0.34–3.64)	0.872
HEI-2015	Referent	1.46 (0.50–4.23)	0.95 (0.32–2.82)	0.83 (0.26–2.69)	0.632
Preeclampsia					
SRC	Referent	1.68 (0.69–4.11)	1.16 (0.41–3.28)	4.10 (1.25–13.5)*	0.036*
VOF	Referent	0.83 (0.35– 1.96)	0.77 (0.35–1.70)	0.32 (0.10–0.99)*	0.041*
HEI-2015	Referent	0.89 (0.40–1.95)	1.05 (0.48–2.30)	0.43 (0.18–1.07)	0.102

Estimates are ORs (95% CIs) from multivariable logistic regression, adjusting for maternal age and education, total household income, ethnicity and nativity, parity, late cohort entry, recruitment site, prepregnancy body mass index, and total energy intake. GHTN indicates gestational hypertension; HDP, hypertensive disorder of pregnancy; HEI-2015, Healthy Eating Index 2015; MADRES, Maternal And Developmental Risks from Environmental and Social stressors; OR, odds ratio; SRC, solid fats, refined grains, and cheese; and VOF, vegetables, oils, and fruit.

*Estimates indicate statistical significance at $P<0.05$.

Our findings demonstrating pronounced and inverse VOF and HEI-2015 associations with preeclampsia among women with overweight prepregnancy BMI were inconsistent with previous work reporting either no differences in diet-preeclampsia relationships by prepregnancy BMI[9,12] or patterning tracking our findings for similar diets but only among the normal weight group.[3,13] Our study sample had greater mean prepregnancy BMI values compared with those in previous work; variation in prepregnancy weight across study samples may be 1 factor that could explain study differences. For instance, although obesity

Table 3. Multivariable Associations of Maternal Dietary Patterns (Scores) During the Third Trimester of Pregnancy and Having Had a Diagnosis of Any HDP, GHTN, and Preeclampsia During Pregnancy, Stratified by Prepregnancy Weight Status in the MADRES Study (n=451)

HDPs by dietary patterns (scores)	Prepregnancy BMI classification*			Px†
	Underweight/normal	Overweight	Obese	
Any HDP				
SRC	0.92 (0.51–1.67)	1.57 (0.75–3.30)	1.37 (0.56–3.34)	0.420
VOF	0.84 (0.45–1.54)	0.49 (0.31–0.78)	0.94 (0.64–1.37)	0.084
HEI-2015	0.94 (0.52–1.68)	0.62 (0.41–0.93)	1.01 (0.73–1.41)	0.149
GHTN				
SRC	0.85 (0.42–1.71)	1.46 (0.39–5.46)	1.80 (0.76–4.23)	0.332
VOF	0.65 (0.24–1.73)	1.01 (0.46–2.22)	1.11 (0.57–2.15)	0.607
HEI-2015	0.75 (0.30–1.92)	1.25 (0.57–2.76)	1.03 (0.61–1.73)	0.724
Preeclampsia				
SRC	1.18 (0.56–2.49)	1.63 (0.69–3.87)	1.13 (0.41–3.13)	0.723
VOF	1.18 (0.61–2.29)	0.41 (0.24–0.69)‡	0.88 (0.59–1.32)	0.017‡
HEI-2015	1.15 (0.64–2.06)	0.50 (0.33–0.77)‡	1.02 (0.71–1.47)	0.017‡

Estimates are odds ratios (95% CIs) estimated using multivariable logistic regression, adjusting for maternal age and education, total household income, ethnicity and nativity, parity, late cohort entry, recruitment site, total energy intake, and interaction terms (dietary pattern[s]×prepregnancy BMI categories). BMI indicates body mass index; GHTN, gestational hypertension; HDP, hypertensive disorder of pregnancy; HEI-2015, Healthy Eating Index 2015; MADRES, Maternal And Developmental Risks from Environmental and Social stressors; SRC, solid fats, refined grains, and cheese; and VOF, vegetables, oils, and fruit.

*Prepregnancy BMI categorization was based on standard criteria.

†P value for interaction term, Px.

‡Estimates indicate statistical significance at $P<0.05$.

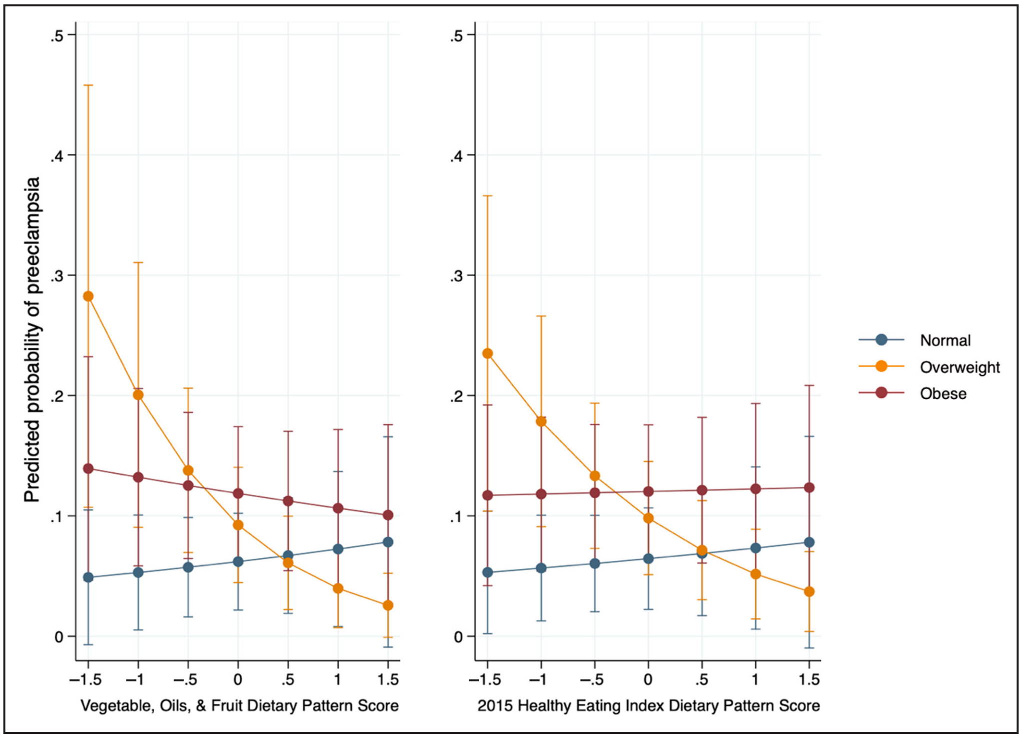

Figure. Predicted probability of preeclampsia by vegetables, oils, and fruit and HEI-2015 maternal dietary pattern scores during the third trimester of pregnancy, stratified by prepregnancy weight.

Estimates are marginal predicted probabilities (95% CIs) of preeclampsia by 0.5-SD score intervals of the vegetables, oils, and fruit and HEI-2015 dietary patterns from multivariable logistic regression, indicating significant interaction terms between dietary patterns and prepregnancy body mass index categories (normal [blue]; overweight [yellow]; and obese [red]). Models were adjusted for maternal age and education, total household income, ethnicity and nativity, parity, late cohort entry, recruitment site, prepregnancy body mass index, and total energy intake. Data are from the MADRES study. Vegetables, oils, and fruit, $P_{interaction}$=0.017; HEI-2015, $P_{interaction}$=0.017. HEI-2015 indicates Healthy Eating Index 2015; and MADRES, Maternal And Developmental Risks from Environmental and Social stressors.

is a well-established clinical risk factor for preeclampsia,[1,23,24,39] our findings suggest a beneficial role of the VOF and HEI-2015 in the prevention of preeclampsia in this population may not extend to those with prepregnancy obesity. Relatedly, obesity promotes systemic and cardiovascular inflammatory mechanisms (eg, increased CRP levels) implicated in HDP pathogenesis.[23,24] These mechanisms may undermine the protective role of the VOF and HEI-2015 diets. Indeed, when we combined overweight and obesity prepregnancy BMI categories, we found no significant dietary interactions for preeclampsia (data not shown).

The prevalence of preeclampsia was higher than expected in our study. Preeclampsia occurred in 12.6% of pregnancies in the sample of MADRES study participants compared with 3.8% among Hispanic/Latina women in a previous study.[5] That said, compared with the study by Wolf et al,[5] our study, on average, had participants who were older (28.9±5.9 versus 22.6±5.2 years), had higher prepregnancy BMI (28.6±6.7 versus 25.6±5.4 kg/m^2), and had a greater proportion of prepregnancy diabetes (6.2% versus 0%), all of which are known high-risk factors for preeclampsia.[1]

Racial and ethnic disparities in preeclampsia may be greater in major urban areas, partly explaining the higher-than-expected proportion of preeclampsia observed in our study. One population-based study assessing 10-year trends in hospitalization rates with HDPs at the time of delivery in New York found a gradual positive association between residential poverty level and preeclampsia rates only among Hispanic/Latina women in New York City but no differences by race and ethnicity across residential poverty levels outside of New York City. Although California is the most densely populated state and holds the second-largest Hispanic/Latino population in the United States,[40] the generalizability of our findings may be limited to low-income Hispanic/Latina women in Los Angeles. Thus, studies in California and the United States using larger population-based samples of diverse Hispanic/Latina women are needed to evaluate differences in preeclampsia and other HDPs by geographic region.

We demonstrate that adherence to the combinations of higher-intake foods in the VOF dietary pattern may lower the likelihood of developing preeclampsia among pregnant women overall and especially among women with prepregnancy overweight BMI. Our results suggest data-driven diets versus HEI-2015 may better capture culturally relevant and distinct eating behaviors and, consequently, be more relevant to HDPs among Hispanic/Latina women. Furthermore, because data-driven diets, such as the VOF diet, reflect the current eating behaviors of the study population, in clinical practice, VOF may have greater success of uptake and adherence versus HEI-2015 among Hispanic/Latina women. Last, our findings suggest the type of diet (ie, dietary composition) during pregnancy may be pivotal for the prevention of preeclampsia among Hispanic/Latina women.

Future work is needed to identify optimal relative intakes of foods to better inform dietary counseling during pregnancy for the prevention of HDPs among Hispanic/Latina women. Research evaluating HDP relationships with other theory-driven diets (eg, Dietary Approaches to Stop Hypertension) among this population are also needed.

A strength of our study is the use of multiple 24-hour recalls (80.9% of study sample), which have been shown to explain a relatively greater proportion of the variance in dietary pattern derivation using factor analysis compared with food frequency questionnaires.[41] In addition, 24-hour recalls versus food frequency questionnaires have relatively less systematic error in dietary intake estimates associated with participant recall.[42] A key study limitation involves the timing of dietary assessment and HDP diagnosis. For instance, HDP development before dietary assessment in the third trimester of pregnancy could influence changes in dietary behaviors before dietary data collection. This would lead to differential dietary misclassification, which would bias findings either toward or away from the null. Because GHTN is typically diagnosed earlier than preeclampsia, the timing of data collection in our study may have impacted analyses of GHTN more than preeclampsia. Furthermore, we believe differential dietary misclassification is not significantly impacting our findings based on the robustness of our findings after excluding pregnant women with prepregnancy hypertension and history of preeclampsia (Table S2) and their consistency with previous work demonstrating similar dietary pattern associations with risk of HDPs. Although we were unable to account for changes in dietary patterns throughout pregnancy, which could provide evidence of dietary misclassification and influence HDP development, previous work suggests dietary patterns in early pregnancy tend to persist for the remainder of pregnancy.[43,44] In addition, analyzing dietary patterns in quartiles versus absolute values minimizes the role of differential dietary misclassification, because ranking in a dietary pattern (eg, quartile 4) is likely preserved over time.[13] Last, we cannot exclude the possibility of unmeasured confounding given the observational design of the study.

At present, there are no clinical guidelines on dietary pattern recommendations for the prevention of preeclampsia.[26] Among Hispanic/Latina pregnant women, we found that a diet characterized by higher intakes of solid fats, refined grains, and cheese during pregnancy was associated with a greater odds of having had any HDP, including preeclampsia. Conversely, a diet with higher intakes of vegetables, oils, and fruit during pregnancy was associated with reduced odds of preeclampsia and especially in women with overweight prepregnancy BMI. Last, the type of diet may be pivotal for preeclampsia prevention in this population. Our study contributes novel data and provides direction for dietary counseling for the prevention of HDPs among a high-risk population.

ARTICLE INFORMATION

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Affiliations

Department of Population and Public Health Sciences, Keck School of Medicine, University of Southern California, Los Angeles, CA (L.E.M., T.M.B., G.F.D., R.H., S.P.E., T.Y., T.C., C.V.B., S.F.F.); Department of Health Sciences, California State University, Northridge, CA (C.M.T.); Department of Psychology, University of Southern California, Los Angeles, CA (G.F.D.); and Department of Obstetrics and Gynecology, Keck School of Medicine, Los Angeles, CA (B.H.G., L.A.A.).

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Disclosures

None.

Supplemental Material

Tables S1–S2
Figure S1

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