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Racial/ethnic and socioeconomic inequalities in adherence to national dietary guidance in a large cohort of U.S. pregnant women

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Abstract

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The authors report no conflicts of interest.

Background—The significance of periconceptional nutrition for optimizing offspring and maternal health and reducing social inequalities warrants greater understanding of diet quality among U.S. women.

Objective—The objective was to evaluate racial/ethnic and education inequalities in periconceptional diet quality and sources of energy and micronutrients.

Design—Cross-sectional analysis of data from the Nulliparous Pregnancy Outcomes Study: Monitoring Mothers-to-be (nuMoM2b) cohort.

Participants and setting—Nulliparous women (n=7511) were enrolled across 8 U.S. medical centers from 2010 to 2013.

Main outcome measures—A semi-quantitative food frequency questionnaire assessing usual dietary intake in the 3 months around conception was self-administered in the first trimester. Diet quality, measured using the Healthy Eating Index-2010 (HEI-2010), and sources of energy and micronutrients were the outcomes.

Statistical analyses—Differences in diet quality were tested across maternal racial/ethnic and education groups using F-tests associated with analysis of variance and Chi-squared tests.

Results—HEI-2010 score increased with higher education, but the increase among non-Hispanic Black women was smaller than among non-Hispanic whites and Hispanics (interaction $p<0.0001$). For all groups, average scores for HEI-2010 components were below recommendations. Top sources of energy were sugar-sweetened beverages, pasta dishes, and grain desserts, but sources varied by race/ethnicity and education. Approximately 34% of energy consumed was from empty calories (the sum of energy from added sugars, solid fats, and alcohol beyond moderate levels). The primary sources of iron, folate, and vitamin C were juices and enriched breads.

Conclusions—Diet quality is suboptimal around conception, particularly among women who are non-Hispanic Black, Hispanic, or who had less than a college degree. Diet quality could be improved by substituting intakes of refined grains and foods empty in calories with vegetables, peas and beans (legumes), seafood, and whole grains.

Keywords

diet; dietary guidance; Healthy Eating Index; preconception; pregnancy

Introduction

Maternal nutritional status has a powerful influence on the offspring's health and susceptibility to disease later in life. Observational and experimental studies demonstrate that in-utero exposure to under- or over-nutrition is associated with poor health outcomes in adulthood, including metabolic disease, obesity, cancer, and osteoporosis.[1, 2] Suboptimal nutrition may have a critical influence in the periconceptional period, when fetal growth trajectory, placental capacity to supply nutrients to the fetus, fetoplacental immunology and inflammation, and maternal hormonal and metabolic regulatory systems are established.[3, 4] A poor quality diet in the periconceptional period may also threaten maternal health by promoting obesity,[5, 6] excessive gestational weight gain,[7] and postpartum weight retention.[8]

Little is known about the quality of periconceptional dietary intakes in the U.S. because too few pregnant women are included in national nutrition surveys. Diet quality of non-pregnant adults in the U.S. is generally poor,[9, 10] but some data indicate that diet improves when women are planning a pregnancy [11] or once they become pregnant.[12–14] There is a striking disparity in diet quality by socioeconomic position and race/ethnicity in the U.S. that has grown over time.[9] Understanding whether these trends apply to pregnant women is critical because poor diet is modifiable and associated with the long-standing inequalities in maternal and child health outcomes.[15]

The significance of maternal nutrition for optimizing offspring health, reducing maternal obesity, and lessening social inequalities demands a greater understanding of diet quality among U.S. pregnant women. Identifying the aspects of diet that conform to national recommendations and where diets fall short is necessary for targeting prevention efforts. Further, increasing our knowledge of pregnant women's major dietary sources of energy and nutrients provides an important context for dietary guidance. Therefore, the objective of the present study was to evaluate racial/ethnic and education inequalities in periconceptional diet quality of a large and geographically diverse contemporary cohort of U.S. pregnant women.

Materials and Methods

The Nulliparous Pregnancy Outcomes Study: Monitoring Mothers-to-be (nuMoM2b) is a prospective cohort study designed to evaluate maternal and environmental contributors to poor birth outcomes (Clinical trials.gov identifier NCT01322529).[16] Women who were <14 weeks' gestation in their first pregnancy were enrolled at 8 U.S. medical centers (Case Western Reserve University, Columbia University, Indiana University, University of Pittsburgh, Northwestern University, University of California at Irvine, University of Pennsylvania, and the University of Utah) from October 2010 to September 2013. Data were managed by a Data Coordinating and Analysis Center at RTI International. Eligible women were those who had: no previous delivery at 20 weeks of gestation or later; a viable singleton pregnancy with estimated gestational age from 6 weeks 0 days to 13 weeks 6 days; and intention to deliver at a participating clinical site hospital. Criteria for ineligibility included age <13 years, history of 3 or more pregnancy losses, donor oocyte pregnancy, planned pregnancy termination, malformations likely to be lethal and aneuploidies known at enrollment, previous enrollment, and inability to provide informed consent. Each site's local institutional review board approved the study prior to initiation and all women gave written, informed consent.

The nuMoM2b protocol has been described in detail previously.[16] Briefly, women participated in 3 study visits during pregnancy and one at delivery. At the first study visit (6–13 completed weeks' gestation), trained and credentialed study personnel administered structured questionnaires to ascertain data on demographics, medical history, behaviors, and psychosocial factors, obtained clinical measurements and biospecimens, and abstracted data from ultrasound reports conducted by certified sonographers. Additionally, a food frequency questionnaire inquiring about usual periconceptional dietary intake was self-administered.

A total of 10,038 women agreed to participate, and of those, 8,259 (82%) had complete dietary data available. This paper's interest was in racial/ethnic and education inequalities in diet quality, so 4 women with missing data on these variables and 744 women who self-identified as a racial/ethnic group other than non-Hispanic White, non-Hispanic Black, or Hispanic were excluded due to relatively small numbers within any individual group. The final analytic sample was 7,511 women.

Women self-reported their highest level of education, which were categorized as high school or less (less than high school, or high school graduate or GED completed), some college (some college credit, but no degree, or associate/technical degree), college graduate (bachelor's degree), or graduate degree (master's, doctorate, or professional degree). Self-reported race/ethnicity was classified as non-Hispanic White, non-Hispanic Black, or Hispanic. Other information self-reported at the first visit included marital status, smoking before pregnancy, gravidity, and medical insurance. Self-reported gross income and size of the household were classified relative to the 2013 Federal poverty levels for the 48 contiguous states and the District of Columbia[17] as <130% (the income eligibility guidelines for participation in the Supplemental Nutrition Assistance Program, or SNAP[18]), 130%–349%, or ≥350%. At the initial visit, women wearing only light clothes and no shoes had their weight measured using an electronic or balance scale and height measured using a stadiometer or measuring tape. Early pregnancy body mass index (BMI) (visit 1 weight (kg) / height (m)^2) was categorized as underweight (<18.5 kg/m^2), normal weight (18.5–24.9 kg/m^2), overweight (25–29.9 kg/m^2), obese (30–34.9 kg/m^2), or severely obese (≥35 kg/m^2).[19]

Dietary data

Usual dietary intake in the three months around conception was assessed at the first study visit using a self-administered modified Block 2005 food frequency questionnaire (FFQ), which was available in English and Spanish. The instrument assesses 52 nutrients and 35 food groups from approximately 120 food and beverage items. The FFQ's food list was developed from the National Health and Nutrition Examination Survey 1999–2002 dietary recall data,[20] and the nutrient database was developed from the U.S. Department of Agriculture Food and Nutrient Database for Dietary Studies.[21] Food groups were derived from the MyPyramid Equivalents Database, version 2.0.[22] The questionnaire uses a series of "adjustment" questions to improve the estimation of fat and carbohydrate intake. Portion size is asked for each food, and pictures are given to enhance accuracy. The instrument has been validated in many populations, including pregnant women.[23–28] The questionnaire was slightly modified to reflect a 3-month period and to include more sources of marine omega-3 fatty acids.

Participants completed the FFQ on a paper form during the first study visit. For easier recall of the 3 months around conception, a trained study staff member labeled each woman's FFQ with the months of interest. Study personnel checked all pages of the FFQ for completeness. Completed questionnaires were sent to Block Dietary Data Systems (Berkeley, CA, USA) for optical scanning and nutrient analysis using software developed at the National Cancer Institute.[29]

Adherence to the U.S. government's 2010 *Dietary Guidelines for Americans* was measured using the Healthy Eating Index-2010 (HEI-2010).[10, 30] The HEI-2010 assesses 12 key aspects of diet quality. Nine components measure adequacy of intake: Total Fruit; Whole Fruit (forms other than juice); Total Vegetables; Greens and Beans (dark-green vegetables and beans and peas); Whole Grains; Dairy (all milk products and soy beverages); Total Protein Foods; Seafood and Plant Proteins; and Fatty Acids (ratio of poly- and monounsaturated fat to saturated fat). Three components measure moderation of intake: Refined Grains; Sodium; and Empty Calories (all calories from solid fats and added sugars plus calories from alcohol beyond a moderate level). Scores for each component increase as intake reaches the recommended standard (higher intakes for the adequacy components and lower intakes of the moderation components). Usual intakes of the 12 components were expressed relative to energy before calculating component and total scores. Although there are many accepted measures of diet quality, including the alternate Mediterranean diet and DASH scores,[31, 32] the HEI-2010 was used because it reflects adherence to the national Dietary Guidelines.[10, 30] F-tests associated with analysis of variance (ANOVA) models were used to test for differences in mean HEI-2010 and component scores by race/ethnicity, education and the interaction between race/ethnicity and education. Linear trends in HEI-2010 with increasing level of education were evaluated in one-way ANOVA using contrasts for linear trend in the parameter estimates, computed with orthogonal polynomial coefficients. Chi-square tests were used to assess for differences by race/ethnicity in the percentage of women adhering to recommended standards on HEI-2010 components. Chi-squared tests were used to assess for differences in the distribution of HEI-2010 scores across overall quintiles by race/ethnicity and by education. A p-value less than 0.05 indicated statistical significance.

The major dietary sources of energy, energy from added sugars, energy from solid fats, and 7 nutrients of public health importance were determined by estimating the amount provided by each FFQ item. The population mean nutrient intake for each food/beverage was divided by the population mean total nutrient intake to calculate the percentage contribution of total intake.[33] FFQ line items were grouped into 79 mutually exclusive food groups for analysis (Online Supplemental Table 1).

Results

Non-Hispanic White women made up 69% of the cohort, while 18% were Hispanic and 13% were non-Hispanic Black. More than half of the sample had either a college or graduate degree (54%), and only 18% had a high school education or less. Most of the cohort did not smoke, was married, of normal weight in early pregnancy, and had a household income at 350% or more of the federal poverty index (Table 1).

HEI-2010 scores

The mean (standard deviation) HEI-2010 score of the sample was 63 (13) of 100 possible points. Non-Hispanic White women had the highest mean HEI-2010 scores, followed by Hispanic women and then non-Hispanic Black women (Table 2). More non-Hispanic White women (24%) had HEI-2010 scores that fell into the highest quintile of the distribution (median score: 79) compared with Hispanic (14%) and non-Hispanic Black women (4.6%). Almost half of non-Hispanic black mothers (44%) had an HEI-2010 score in the lowest quintile (median score: 46).

The mean HEI-2010 score and the percent of women in the highest quintile of HEI-2010 also increased with greater maternal education (Table 2). This rise in mean HEI-2010 score by education was observed in all 3 racial/ethnic groups, but the increase varied in magnitude (test of race/ethnicity-education interaction $p<0.0001$). An increasing level of education had the strongest relation with HEI-2010 score among non-Hispanic white women (18-point increase from the lowest to the highest levels of education) and the least change among Hispanics (12-point increase). At all levels of education, non-Hispanic Black mothers had the lowest mean HEI-2010 scores. Results were similar when levels of income or type of insurance as a marker of socioeconomic position were used (data not shown).

HEI-2010 component scores

Each component that made up the HEI-2010 had a mean score below the recommendation for the sample overall and for each racial/ethnic group (Table 3). Overall, only about half of women met the recommended standard for Total Fruit, Whole Fruit, Greens and Beans, and Total Protein Foods. Fewer than 10% of women met the dietary guideline for Whole Grains, Fatty Acids, Sodium, and Empty Calories. Nearly all differences in component scores were significantly different by race/ethnicity. Non-Hispanic Black women tended to have the lowest mean component scores. For 9 of 12 components, non-Hispanic White mothers had the highest mean scores.

As maternal education level increased, there were significant improvements towards meeting recommendations for all adequacy components (7 of 9 components shown in Figure 1, Panel A) and moderation components except Sodium (Figure 1, Panel B). Meaningful differences, defined as at least a 15 percentage point change from lowest to highest, were observed for all components except Dairy, Total Protein Foods, Refined Grains, and Sodium.

Dietary sources of energy

The top sources of energy (shown in bold in Table 4) were soda, pasta dishes, grain desserts (e.g., cookies, cakes), refined bread, and beer, wine and spirits. Soda was the primary contributor to energy intake among women who were non-Hispanic Black, Hispanic, high-school educated, and those completing some college. Women with a college or graduate degree consumed more energy from beer, wine, and spirits than any other source.

Intake of solid fat contributed an average of 18% of daily energy intake. Cheese, eggs and egg-mixed dishes, and pizza were the top sources of solid fats in the cohort. Primary sources of solid fat differed for non-Hispanic Black women and women with a high school education or less, in whom fatty meat and grain desserts were the top two contributors.

The mean daily intake from added sugars was 14% of total energy. By far, the greatest contributor to added sugar intake was soda, sports drinks, and energy drinks. All sugar-sweetened beverages (soda and fruit drinks) contributed 48%–56% of added sugars among women who were non-Hispanic Black, Hispanic, or who had less than a college degree, and

22%–35% among non-Hispanic White women and women with a college or graduate degree. Grain desserts and candy were other important sources of added sugar for all groups.

Empty calories (the sum of energy from solid fats, added sugars, and alcohol beyond moderate levels) represented 34% of energy consumed. The recommended allowance of empty calories is 9% to 13% of total energy[34].

Dietary sources of nutrients

The primary sources of iron were ready-to-eat cereals, yeast bread, pasta dishes, grain desserts, and pizza (Table 5). Green salad was the only vegetable in the top 10 sources of iron. Green salad and ready-to-eat cereals were the top 2 sources of folate for all groups except for non-Hispanic Black women, whose second highest folate intake came from 100% orange/grapefruit juice. Yeast bread, pasta, meal replacement (e.g., SlimFast), and rice were other primary sources of folate.

Reduced-fat milk and cheese were the top foods contributing to calcium intake. Skim milk was a top-five contributor only among non-Hispanic White women and women with at least a college degree, whereas whole milk was a top source of calcium for Hispanic women and women with a high-school education or less. 100% orange/grapefruit juice was a primary source of vitamin C intake among all groups. Juices and sugar-sweetened beverages combined for a much larger proportion of vitamin C intake (47%–60%) than solid fruits or vegetables (27%–36%) for non-Hispanic Black and Hispanic women and women with some college or less (some foods not shown in Table 4). The opposite was true for non-Hispanic White women or women who had at least a college degree (52%–59% vitamin C from solid fruits or vegetables and 24%–30% from juices and sugar-sweetened beverages; data not shown). Dietary sources of protein, carbohydrate, and total fat appear in Online Supplemental Table 2.

Discussion

Periconceptional diet quality in this U.S. cohort of women in their first pregnancy is suboptimal. Scores for none of the 12 components of the *Dietary Guidelines for Americans* met current recommendations. Consumption of whole grains, dairy products, and fatty acids were especially low, while empty calories and sodium intakes were too high. The foods that contributed most to energy intake were low in nutrients and rich in added sugars and solid fats, while primary sources of iron, folate, and vitamin C were juices and enriched breads. The gaps in adherence to dietary guidance by maternal race/ethnicity and education were pronounced. Compared with women who had at least a college degree and non-Hispanic White women, women who were Non-Hispanic Black, Hispanic, or not college graduates consistently reported a diet that was lower in quality. Their intakes of sugary drinks—which provide minimal nutritional value—contributed substantially to energy intake, while nutrient-dense foods (i.e., beans, nuts/seeds, seafood, fruits, and vegetables) were consumed too infrequently to be an important source of micronutrient intakes.

The authors are not aware of other studies that have evaluated periconceptional adherence to national dietary guidance in a large, geographically-diverse cohort of U.S. pregnant women.

Nevertheless, our findings—including the notable socioeconomic inequalities in diet quality—mirror national population trends.[34–37] The diet quality gap among nonpregnant individuals is thought to be a consequence of many factors, including the access to and price of healthy foods; knowledge of a healthful diet; and pressing needs that may take priority over a healthful diet.[38] SNAP was designed to reduce the socioeconomic gap in diet quality, but it is not clear if it has been effective.[39, 40] In contrast, the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) aligned its food packages with national guidance in 2007. Since then, diet quality and birth outcomes have meaningfully improved among participants.[41] In the periconceptional period, however, most women do not know they are pregnant and have not enrolled in WIC. Data in our cohort were lacking to determine whether the observed gaps in diet quality narrow after WIC enrollment.

Poor periconceptional diet quality and the racial/ethnic and socioeconomic inequalities in adherence to dietary guidance have considerable implications for maternal and child well-being. Healthy diet patterns have been linked to reduced risks of racially/ethnically-disparate health outcomes, including preterm birth,[42] fetal growth restriction,[43] preeclampsia,[44] maternal obesity,[5, 6] and postpartum weight retention,[8] though causality of these relations remains uncertain. Unlike many other risk factors that vary by socioeconomic position, dietary intake is modifiable. Future work is needed to quantify the degree to which diet quality may explain inequalities in adverse birth outcomes.

Estimates of usual dietary intake are likely imperfect.[45, 46] Systematic misreporting of diet, which is known to occur for individuals who are obese,[47] may differentially affect estimates of intake among low socioeconomic groups. However, self-reported dietary data, including those from FFQs, have been successful in informing dietary guidance and public health policy.[46] The HEI-2010 weights all dietary components equally, but it is possible that some components may be more impactful on health outcomes than others. Further, a deficiency of one nutrient may have a broader impact even if overall diet quality is high. Unfortunately, the study lacked repeated measures of dietary intake during pregnancy to evaluate trends in adherence to dietary guidance over gestation. There were too few women in other racial/ethnic groups (e.g., n=348 Asian women) for precise analysis. These results may generalize only to nulliparas receiving care at large medical centers. While this was not a nationally representative sample, this contemporary cohort is the most geographically and racially/ethnically-diverse cohort of U.S. pregnant women with dietary data of which the authors are aware.

While attention should be given to finding ways of improving nutrition counseling in clinical settings, individual behavior change may be less effective and efficient at improving diet than systems-level changes.[48] Therefore, structural interventions that promote an environment conducive to making healthy dietary choices should be considered. Such collective actions may be more likely to impact low socioeconomic populations, thereby reducing health disparities and improving health outcomes for women and their children.

Conclusions

Major gains can be made in diet quality of pregnant women by substituting dietary intakes of refined grains and foods empty in calories with vegetables, peas and beans (legumes), seafood, and whole grains; reducing sugary beverage consumption; and lowering sodium intakes. Future research should establish whether improvements in periconceptional diet quality lead to better pregnancy and birth outcomes.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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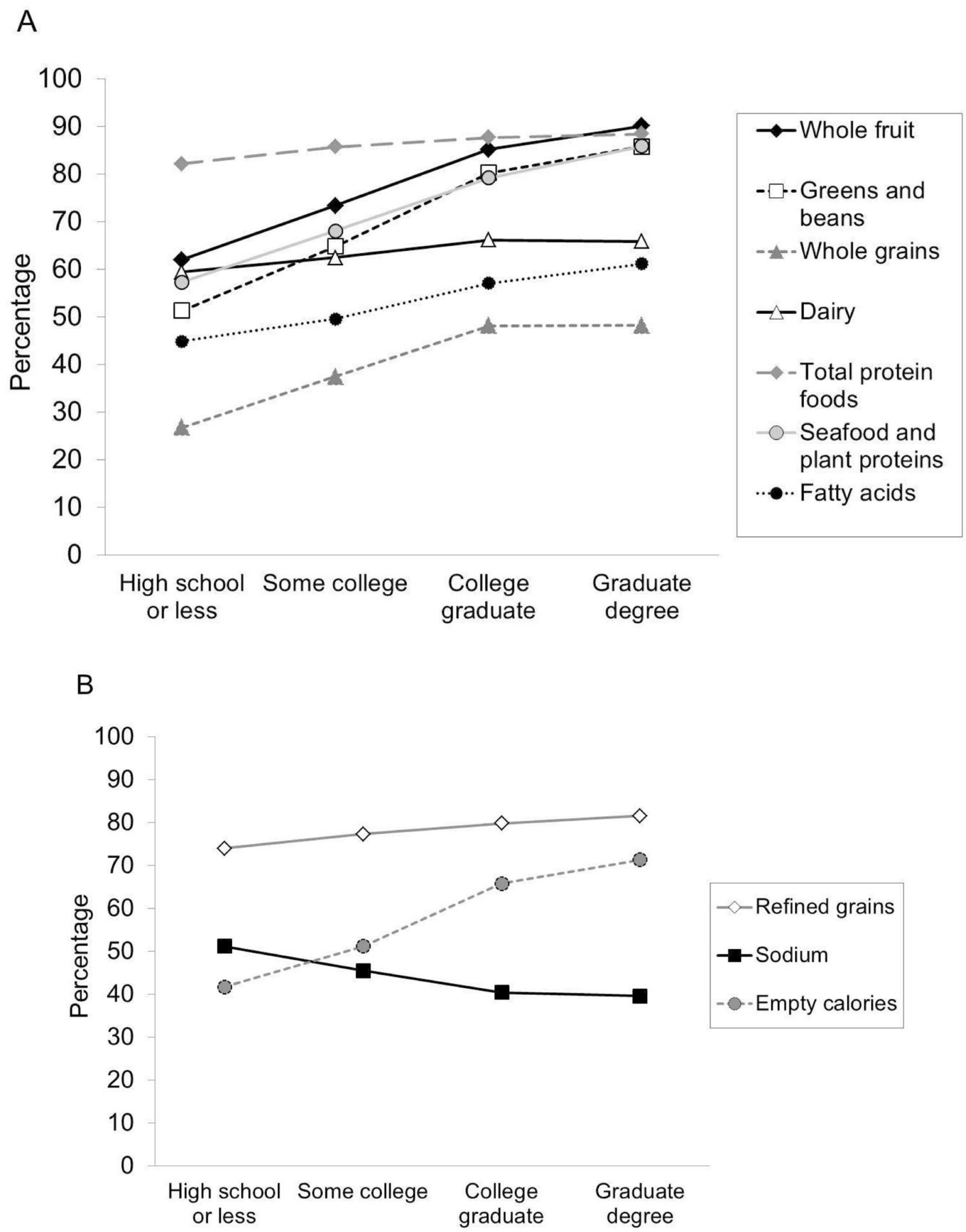

Figure 1.

Mean Healthy Eating Index – 2010 component scores, expressed as a percentage of the recommended score, by maternal education level, the Nulliparous Pregnancy Outcomes Study: Monitoring Mothers-to-be cohort (n=7,511), 2010–2013. Panel A shows 7 adequacy components. Panel B shows the 3 moderation components. Linear trends with education were significant at p<0.0001 for each component shown.

Table 1

Maternal characteristics at enrollment, the Nulliparous Pregnancy Outcomes Study: Monitoring Mothers-to-be cohort (n=7511), 2010–2013.[a]

	n (%) or mean (standard deviation)
Maternal race/ethnicity	
Non-Hispanic White	5193 (69)
Non-Hispanic Black	944 (13)
Hispanic	1374 (18)
Education	
High school or less	1354 (18)
Some college	2173 (29)
College graduate	2214 (30)
Graduate degree	1770 (24)
Age, years	27.2 (5.5)
Gravidity	
1	5599 (75)
2	1434 (19)
3 or more	478 (6.4)
Marital status	
Married	4708 (63)
Not married	2802 (37)
Smoked during the 3 months before pregnancy	
Yes	1277 (17)
No	6229 (83)
Early pregnancy body mass index	
Underweight (<18.5 kg/m^2)	160 (2.2)
Normal weight (18.5–24.9 kg/m^2)	3752 (51)
Overweight (25–29.9 kg/m^2)	1884 (25)
Obese (30–34.9 kg/m^2)	861 (12)
Severely obese (≥35 kg/m^2)	751 (10)
Household income and size relative to the US poverty level	
<130%	1177 (19)
130% to 349%	1853 (30)
≥350%	3197 (51)
Maternal report of father of the baby's race/ethnicity	
Same race/ethnicity as mother	5423 (72)
Different race/ethnicity as mother	1675 (22)
Unknown, refused to answer, or missing	413 (5.5)

[a]Not all numbers sum to 7,511 due to missing values for marital status, smoking status, body mass index, and household income. These variables were missing for 1, 5, 103 (1.4%), and 1,284 (17%) observations, respectively.

Table 2

Healthy Eating Index – 2010 score of periconceptional diet by maternal race/ethnicity and education, the Nulliparous Pregnancy Outcomes Study: Monitoring Mothers-to-be cohort (n=7,511), 2010–2013.

	Mean HEI-2010 score (SD)	*p-values* [a] *difference (trend w/ education)*	Quintiles of HEI-2010 score: Lowest Median: 46 Range: 25–50 n (%)	Quintile 2 Median 56 Range: 51–59 n (%)	Quintile 3 Median: 64 Range: 60–67 n (%)	Quintile 4 Median: 71 Range: 68–74 n (%)	Highest Median: 79 Range: 75–95 n (%)	*p-values* [a]
Overall	63 (13)		1502 (20)	1502 (20)	1503 (20)	1502 (20)	1502 (20)	
Maternal race/ethnicity		*<0.0001*						*<0.0001*
Non-Hispanic White	65 (12)		763 (15)	891 (17)	1064 (21)	1208 (23)	1267 (24)	
Non-Hispanic Black	54 (11)		413 (44)	266 (28)	145 (15)	77 (8.2)	43 (4.6)	
Hispanic	61 (12)		326 (24)	345 (25)	294 (21)	217 (16)	192 (14)	
Maternal education		*<0.0001 (<0.0001)*						*<0.0001*
High school or less	53 (11)		631 (47)	376 (28)	211 (16)	97 (7.0)	39 (2.9)	
Some college	59 (12)		586 (27)	553 (25)	458 (21)	363 (17)	213 (9.8)	
College graduate	67 (11)		202 (9.1)	358 (16)	481 (22)	571 (26)	602 (27)	
Graduate degree	70 (10)		83 (4.7)	215 (12)	353 (20)	471 (27)	648 (37)	
Maternal race/ethnicity and education								
Non-Hispanic White		*<0.0001 (<0.0001)*						*<0.0001*
High school or less	52 (10)		270 (51)	140 (26)	78 (15)	30 (5.7)	11 (2.1)	
Some college	61 (12)		292 (23)	294 (23)	266 (21)	258 (20)	151 (12)	
College graduate	68 (10)		143 (7.7)	269 (14)	413 (22)	504 (27)	529 (28)	
Graduate degree	70 (9.9)		58 (3.8)	188 (12)	307 (20)	416 (27)	576 (37)	
Non-Hispanic Black		*<0.0001 (<0.0001)*						*<0.0001*
High school or less	50 (9.3)		222 (56)	113 (28)	44 (11)	20 (5.0)	1 (0.3)	
Some college	54 (9.8)		158 (45)	105 (30)	62 (18)	17 (4.8)	10 (2.8)	
College graduate	61 (11)		23 (19)	38 (32)	24 (20)	22 (18)	12 (10)	
Graduate degree	66 (12)		10 (14)	10 (14)	15 (21)	18 (25)	20 (27)	
Hispanic		*<0.0001 (<0.0001)*						*<0.0001*
High school or less	57 (11)		139 (33)	123 (29)	89 (21)	47 (11)	27 (6.4)	

	Mean HEI-2010 score (SD)	*p-values* [a] *difference (trend w/ education)*	Quintiles of HEI-2010 score: Lowest, Median: 46, Range: 25–50, n (%)	Quintile 2, Median 56, Range: 51–59, n (%)	Quintile 3, Median: 64, Range: 60–67, n (%)	Quintile 4, Median: 71, Range: 68–74, n (%)	Highest, Median: 79, Range: 75–95, n (%)	*p-values* [a]
Some college	59 (11)		136 (24)	154 (28)	130 (23)	88 (16)	52 (9.3)	
College graduate	65 (12)		36 (15)	51 (22)	44 (19)	45 (19)	61 (26)	
Graduate degree	69 (12)		15 (9.9)	17 (11)	31 (20)	37 (24)	52 (34)	
p-value[a] *for interaction*		*<0.0001*						

[a]F-tests associated with analysis of variance (ANOVA) models were used to test for differences in mean HEI-2010 and component scores by race/ethnicity, education and the interaction between race/ethnicity and education. Linear trends in HEI-2010 with increasing level of education were evaluated in one-way ANOVA using contrasts for linear trend in the parameter estimates. These were computed with orthogonal polynomial coefficients. Chi-squared tests were used to assess for differences in the distribution of HEI-2010 scores across overall quintiles by race/ethnicity and by education.

Table 3

Estimated mean (standard deviation) periconceptional Healthy Eating Index - 2010 component scores and percentage of women adhering to recommended standards on components, overall and by maternal race/ethnicity, the Nulliparous Pregnancy Outcomes Study: Monitoring Mothers-to-be cohort (n=7,511), 2010–2013.

	Mean Score (Standard Deviation)[a]				Percentage Meeting Recommended Standard[b]			
HEI-2010 Component (recommended score)	**All**	**Non-Hispanic White**	**Non-Hispanic Black**	**Hispanic**	**All**	**Non-Hispanic White**	**Non-Hispanic Black**	**Hispanic**
Total Fruit (5)	3.8(1.4)	3.9(1.4)	3.7(1.4)	3.8(1.4)	45	46	39	43
Whole Fruit (5)	3.9(1.4)	4.2(1.3)	3.2(1.6)	3.7(1.5)	54	61	33	42
Total Vegetables (5)	3.7(1.2)	3.9(1.1)	2.9(1.2)	3.3(1.3)	30	36	10	21
Greens and Beans (5)	3.6(1.6)	3.8(1.5)	2.8(1.7)	3.3(1.8)	46	51	24	39
Whole Grains (10)	4.1(2.6)	4.5(2.7)	3.1(2.2)	3.4(2.4)	4.7	5.7	2.1	2.4
Dairy (10)	6.4(2.4)	6.7(2.3)	5.0(2.2)	6.1(2.5)	15	18	5.1	13
Total Protein Foods (5)	4.3(0.9)	4.3(0.8)	4.2(1.0)	4.4(0.9)	44	43	45	50
Seafood and Plant Proteins (5)	3.7(1.4)	3.8(1.3)	3.0(1.5)	3.6(1.4)	39	43	24	34
Fatty Acids (10)	5.4(2.7)	5.4(2.7)	5.2(2.3)	5.4(2.6)	9.2	9.7	5.7	9.6
Refined Grains (10)	7.8(2.3)	8.0(2.2)	7.8(2.2)	7.4(2.6)	29	30	25	25
Sodium (10)	4.4(2.6)	4.1(2.5)	5.1(2.7)	4.8(2.7)	2.6	1.5	6.0	4.1
Empty Calories (20)	12(5.0)	12(4.8)	8.1(4.6)	12(4.8)	3.3	3.8	1.0	3.0

[a] F-tests associated with one-way analysis of variance are used to test for differences by race/ethnicity in HEI-2010 component scores. All p-values are significant at p<0.001 with the exception of Fatty Acids with a p-value of 0.0920.

[b] Chi-square tests were used to assess for differences by race/ethnicity in the percentage of women adhering to recommended standards on HEI-2010 components. All p-values are significant at p<0.001.

Table 4

Periconceptional dietary sources of total energy, energy from solid fats, energy from added sugars, and energy from empty calories that rank in the top five in the overall sample or in one of the maternal race/ethnicity or education subgroups and their percent contribution of total energy intake, the Nulliparous Pregnancy Outcomes Study: Monitoring Mothers-to-be cohort (n=7,511), 2010–2013.[a]

	Overall		Maternal race/ethnicity			Maternal education			
			Non-Hispanic White	Non-Hispanic Black	Hispanic	High school or less	Some college	College graduate	Graduate degree
	Rank	%	%	%	%	%	%	%	%
Energy									
Soda, sports drinks, and energy drinks	1	5.6	**4.6**	**8.7**	**6.2**	**9.2**	**7.1**	3.4	2.4
Pasta dishes	2	4.9	**5.1**	**5.2**	**4.2**	**5.3**	**5.0**	**4.6**	**4.7**
Grain-based desserts	3	4.3	**4.0**	**5.7**	**4.4**	**5.4**	**4.3**	**3.9**	**3.9**
Yeast breads, not 100% whole wheat	4	4.0	**4.3**	3.5	3.3	3.6	**3.9**	**4.2**	**4.1**
Beer, wine, and spirits	5	3.8	**4.6**	1.9	2.9	1.8	3.2	**5.0**	**5.6**
Eggs and egg mixed dishes	6	3.7	3.4	4.0	**4.5**	**3.8**	**3.7**	**3.6**	3.6
Pizza	7	3.6	3.6	**4.1**	3.2	**3.9**	3.6	3.5	3.5
Mexican mixed dishes	9	2.7	2.7	1.8	**3.4**	2.8	3.0	2.7	2.4
Nuts/seeds and peanut butter	11	2.5	3.1	1.4	1.6	1.3	2.1	3.2	**3.6**
Sausage, franks, bacon, and ribs	15	2.2	1.6	**4.2**	2.2	3.3	2.4	1.6	1.4
Solid fats									
Cheese	1	9.7	**11.3**	6.4	**8.0**	**7.1**	**9.2**	**11.2**	**12.2**
Eggs and egg mixed dishes	2	7.8	**7.3**	**7.7**	**9.7**	**7.4**	**7.7**	**8.1**	**8.1**
Pizza	3	7.0	**7.2**	**7.3**	**6.1**	7.0	6.7	**7.1**	**7.4**
Grain-based desserts	4	6.8	**6.0**	**9.1**	**7.3**	**8.7**	**6.8**	**5.9**	**5.9**
Sausage, franks, bacon, and ribs	5	6.6	5.0	**11.7**	**6.7**	**9.1**	**7.2**	5.1	4.4
Pasta dishes	6	6.5	**6.7**	**6.8**	5.7	**7.0**	**6.7**	**6.1**	**6.1**
Added sugars									
Soda, sports drinks, and energy drinks	1	35.7	**32.1**	**42.5**	**38.8**	**46.3**	**40.7**	**25.7**	**19.8**
Grain-based desserts	2	9.1	**9.1**	**9.4**	**8.9**	**9.0**	**8.1**	**9.6**	**10.7**
Candy	3	7.8	**8.0**	**8.0**	**6.8**	**8.1**	**7.8**	**7.5**	**7.7**
Fruit drinks	4	6.5	3.1	**12.8**	**9.2**	**9.5**	**8.0**	3.5	2.0
Yogurt	5	5.5	**7.0**	2.3	4.5	2.4	3.8	**8.2**	**10.7**

	Overall		Maternal race/ethnicity			Maternal education			
			Non-Hispanic White	**Non-Hispanic Black**	**Hispanic**	**High school or less**	**Some college**	**College graduate**	**Graduate degree**
	Rank	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**
Sugar or honey in coffee/tea	6	5.3	**5.9**	3.5	**5.6**	3.3	**4.8**	**7.1**	**7.5**
Ready-to-eat cereals	7	4.7	4.9	**4.2**	4.7	**4.6**	4.5	5.1	4.7
Empty calories									
Soda, sports drinks, and energy drinks	1	14.6	**12.6**	**19.3**	**16.3**	**21.0**	**17.3**	**9.7**	**7.2**
Grain-based desserts	2	7.5	**7.0**	**9.0**	**7.7**	**8.6**	**7.0**	**7.0**	**7.4**
Cheese	3	5.4	**6.3**	3.4	**4.4**	3.7	**4.9**	**6.4**	**7.3**
Beer, wine, and spirits	4	4.9	**5.7**	3.0	**4.3**	2.8	**5.7**	**6.0**	**5.1**
Eggs and egg mixed dishes	5	4.4	**4.2**	4.1	**5.4**	4.0	**4.2**	**4.8**	**5.0**
Candy	7	3.9	3.9	**4.3**	3.5	**4.4**	4.0	3.5	3.5
Sausage, franks, bacon, and ribs	10	3.7	2.9	**6.2**	3.7	**4.8**	3.8	2.9	2.7
Fruit drinks	13	2.6	1.2	**5.8**	3.9	**4.3**	3.4	1.3	0.7

[a]The top 5 sources for racial/ethnic and education subgroups are emboldened.

Table 5

Periconceptional dietary sources of select nutrients that rank in the top five in the overall sample or in one of the maternal race/ethnicity or education subgroups and their percent contribution of total intake, the Nulliparous Pregnancy Outcomes Study: Monitoring Mothers-to-be cohort (n=7,511), 2010–2013.[a]

	Overall		Maternal race/ethnicity			Maternal education			
			Non-Hispanic White	Non-Hispanic Black	Hispanic	High school or less	Some college	College graduate	Graduate degree
	Rank	%	%	%	%	%	%	%	%
Iron									
Ready-to-eat cereals	1	14.1	**13.8**	**14.3**	**14.8**	**15.9**	**14.8**	**13.5**	**12.2**
Yeast bread, not 100% whole wheat	2	6.4	**6.8**	**6.2**	**5.4**	**6.4**	**6.7**	**6.5**	**6.2**
Pasta dishes	3	5.4	**5.5**	**5.9**	**4.7**	**6.0**	**5.6**	**5.0**	**5.1**
Grain-based desserts	4	4.2	**4.1**	**4.9**	3.9	**4.7**	**4.1**	4.0	4.0
Pizza	5	4.1	4.0	**5.2**	3.6	**4.9**	**4.2**	3.7	3.7
Green salad	6	3.9	**4.6**	2.0	3.3	2.1	3.2	**4.8**	**5.5**
Eggs and egg mixed dishes	7	3.8	3.4	4.4	**4.5**	4.1	4.0	3.6	3.4
Meal replacements (e.g., SlimFast)	8	3.2	3.8	1.7	2.3	1.6	2.8	3.8	**4.3**
100% whole wheat bread	9	3.1	3.7	1.6	2.3	1.2	2.7	**4.1**	4.1
Mexican mixed dishes	10	3.0	3.0	2.1	**3.9**	3.4	3.5	2.8	2.4
Folate [b]									
Green salad	1	12.3	**13.9**	**7.0**	**10.4**	**7.0**	**10.2**	**14.6**	**16.1**
Ready-to-eat cereals	2	11.8	**10.8**	**14.5**	**13.7**	**16.2**	**13.2**	**10.2**	**8.7**
Yeast bread, not 100% whole wheat	3	6.3	**6.5**	**6.8**	**5.3**	**6.8**	**6.7**	**6.1**	**5.6**
Pasta dishes	4	5.6	**5.6**	**6.9**	4.8	**6.9**	**6.0**	**5.0**	**4.9**
100% orange/grapefruit juice	5	5.1	4.1	**7.5**	**6.8**	**5.8**	**6.1**	4.8	3.8
Meal replacements (e.g., SlimFast)	6	4.9	**5.8**	2.8	3.2	2.4	4.2	**5.8**	**6.6**
Rice	9	2.9	2.3	2.8	**5.2**	3.1	3.3	2.8	2.5
Calcium									
Reduced fat milk	1	11.1	**11.1**	**9.6**	**12.5**	**15.0**	**14.0**	**9.1**	**6.8**
Cheese	2	9.3	**9.8**	**8.3**	**7.9**	**8.4**	**9.3**	**9.4**	**9.8**
Yogurt	3	6.6	**7.3**	4.3	**5.8**	4.2	**5.3**	**7.7**	**9.0**
Non-fat milk	4	5.7	**7.6**	0.3	2.8	0.9	3.4	**8.5**	**9.4**

	Overall		Maternal race/ethnicity			Maternal education			
			Non-Hispanic White	Non-Hispanic Black	Hispanic	High school or less	Some college	College graduate	Graduate degree
	Rank	%	%	%	%	%	%	%	%
100% orange/grapefruit juice	5	5.4	4.3	**7.9**	**7.5**	5.3	**6.5**	**5.4**	4.0
Pizza	6	4.7	**4.4**	**6.7**	4.3	**5.8**	4.8	4.2	**4.2**
Pasta dishes	7	4.6	4.4	**6.2**	4.1	**5.9**	**5.0**	3.9	3.8
Whole milk	14	2.4	1.5	4.3	**4.5**	**5.9**	2.8	1.0	0.6
Vitamin C									
100% orange/grapefruit juice	1	18.4	**16.0**	**21.3**	**23.2**	**19.7**	**20.7**	**17.8**	**15.0**
Fruit drinks	2	9.2	4.3	**22.1**	**12.6**	**17.9**	**12.8**	4.3	2.3
Citrus fruits	3	7.9	**8.6**	**5.3**	**8.0**	**6.4**	**7.2**	**8.6**	**9.4**
Other vegetables	4	6.7	**8.9**	2.4	3.6	2.7	4.7	**8.8**	**10.5**
Broccoli	5	6.1	**7.4**	4.4	3.7	3.7	5.0	**7.5**	**8.3**
Green salad	6	6.1	**7.5**	2.7	4.9	3.2	4.9	**7.7**	**8.7**
Other real juice	7	5.5	4.3	**7.7**	**7.0**	**7.8**	**6.6**	4.3	3.3
Soda, energy drinks, sports drinks	8	5.1	4.2	**8.4**	**5.1**	**8.7**	**6.0**	3.4	2.8

[a] The top 5 sources for racial/ethnic and education subgroups are emboldened.

[b] As dietary folate equivalents.