https://doi.org/10.53964/jmnpr.2024019

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Journal of
Modern Nursing Practice and Research

ISSN 2708-2202 (Online)

Open Access

Research Article

# Proportional Contribution of the Women, Infant and Children's Special Supplemental Nutrition Program on Pregnant Women's Diet Quality

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**Received:** July 4, 2024 **Revised:** August 22, 2024 **Accepted:** October 28, 2024 **Published:** November 6, 2024

**Abstract**

**Objective:** The purpose of this study was to identify the proportional contribution of the special Women's Infant and Children Food Package V for pregnant women (WIC) supplementation on pregnant women's diet quality.

**Methods:** Image-based diet data collection using FoodFoto™ from 63 primigravid women with singleton pregnancies in Baltimore, Maryland receiving the special WIC Food Package V for pregnant women was converted to Healthy Eating Index - 2015 (HEI-2015) total and component diet quality scores. Descriptive statistics were used to describe the total and component HEI diet quality scores. Independent *t*-tests and linear regression models were used to assess the contributions that the percent of WIC food in the diet and sociodemographic and health characteristics had on the components and the overall HEI score.

**Results:** The data showed a 1% rise in WIC approved foods in the diet was associated with a significant increase in the on the HEI-2015 score (b=0.77, t=6.35, $p$<0.001). Higher diet quality scores were accounted for by increased consumption of four HEI components representing healthy foods and significantly lower sodium intake. Furthermore, the healthy food component scores and fatty acids ratio were at or above the 50$^{th}$ percentile.

**Conclusion:** Small increases in consumption of WIC approved foods significantly improved diet quality among pregnant women in the program.

**Keywords:** diet quality, nutrition assistance, women's health, pregnancy, Special Supplemental Nutrition Program for Women, Infants, and Children (WIC)

**Citation:** Regan MJ, Zvenyach T, Zhu S. Proportional Contribution of the Women, Infant and Children's Special Supplemental Nutrition Program on Pregnant Women's Diet Quality. *J Mod Nurs Pract Res*, 2024; 4(4): 19. DOI: 10.53964/jmnpr.2024019.

## 1 INTRODUCTION

The detrimental effects of suboptimal diet during pregnancy are well established[1]. Moreover, recent research has shown that the effects can result in heritable alterations at the level of the epigenome, adversely altering physiologic function that can lead to the onset of chronic disease for up to four generations of offspring[2-5]. To address the problem of suboptimal diet in health-disparate populations in the United States (U.S.), the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) was established. The program provides food supplements, health care referrals, and nutrition education to 7 million nutritionally at-risk low income pregnant (7.8%), breastfeeding or postpartum women and children up to age 5[6]. Studies about the population-based program, consistently show that WIC food supplements are positively associated with improved birth outcomes, lower preterm birth rates, higher mean birth weights, and improved long-term health status and educational achievement among children[7]. By improving outcomes, the associated short and long-term health costs may be reduced, as demonstrated by one study which reported that among mothers on -Medicaid, a return on investment of $3.13 for every dollar spent on WIC[7,8]. Yet, despite overwhelming evidence of the program's effectiveness in improving birth outcomes and long-term health status, there is scant research about the proportional contribution that WIC food supplements make to help pregnant women enrolled in the program meet the Dietary Guide for Americans (DGA) recommendations[9-11]. That knowledge is critically needed to identify dietary percentages of the nutritional supplements necessary to optimize maternal and child health outcomes further.

In the study the HEI-2015 was used to measure diet quality[12]. The tool is valid and reliable and operationalizes the DGA recommendations to quantitively measure diet quality (see Table 1)[13]. The scoring system differentiates food quality from food quantity[14] by assessing nutrient density per 1,000 kilocalories (kcals), providing a quantified assessment of food quality regardless of the quantity consumed. Scores are assigned (range 0-100) for two diet quality components: (1) adequacy (foods providing essential vitamins and minerals) and (2) moderation (foods with limited nutritional value). A higher score for the adequacy components (total fruit, whole fruit, total vegetables, greens and beans, whole grains, dairy, total protein foods, seafood and plant proteins, and fatty acids) indicates a balanced diet consistent with the DGA recommendations. Whereas a higher scores for the moderation components (refined grains, sodium, added sugars, saturated fats) indicates higher consumption of dietary items that have low nutritional value and therefore have the potential to have a deleterious effect on health.

This paper reports findings from our study that used real-time individual-level dietary intake data to describe the total and component HEI-2015 diet quality scores from a nonprobability sample of pregnant women enrolled in the Maryland WIC program. The women were participating in a project examining how diet influences the vaginal microbiota and preterm birth (NR014826). The purpose of this study was to evaluate the proportional influence that WIC supplements have on HEI-2015 in the study population controlling for the potential effect personal demographic characteristics had on the scores. We hypothesized that pregnant women who consume proportionately more WIC approved foods in their diet would achieve higher HEI-2015 diet quality scores.

## 2 METHODS

### 2.1 Sample

This is a secondary data analysis using the data from a subsample of 63 women receiving WIC supplementation who were enrolled in federally funded project (Birth, Eating and the Microbiota Study [BEAM]: NR014826). The BEAM parent project recruited a non-probability sample of primigravid women with singleton pregnancies who were aged 18 to 33 between 12 to 22 weeks' gestation from ultrasound departments in the Baltimore metropolitan area. This paper focuses on a subset of women from that cohort who were followed 16-20 weeks gestation to six weeks post birth, who received WIC supplements, and had recorded an adequate amount of dietary intake data during pregnancy. The study received human subjects' approval from the university's Institutional Review Board and all women consented to participate.

### 2.2 Data Collection and Measures

#### 2.2.1 Sociodemographic and Health Characteristics

Demographic characteristics were obtained during the first monthly face-to-face interview conducted as part of the parent project. Race and ethnicity, education, employment, and insurance status were dichotomized as shown in Table 2. Participants self-reported their income based on grouping categories. Body mass index (BMI) was calculated during the first visit from the woman's weight and height collected at the clinic where the interviews were conducted. Because women who are eligible for WIC usually qualify to receive nutrition benefits from the Supplemental Nutrition Assistance Program (SNAP) information about enrollment in additional food assistance programs was collected and updated monthly. SNAP is also a federal program designed to support low-income families to achieve adequate nutrition.

#### 2.2.2 Dietary Intake Data

Nutritional data was collected using FoodFoto™ that is an image-based diet data collection, storage, and analysis system[14]. FoodFoto™ resides on iPhones and enables participants to take real-time photographs of their foods. The program also allowed participants to include audio and/or text annotations about the captured images. The specifics of the food data collection and analysis process

https://doi.org/10.53964/jmnpr.2024019

**Table 1. HEI-2015 Scoring Standards and WIC Monthly Allowance for Pregnant Women**

| | Max Pts | Standard for Maximum Score Per 1,000 kcal | Standard for Minimum Score of Zero | WIC Food Package V (Monthly Allowance for Pregnant) |
|---|---|---|---|---|
| Adequacy Components | | | | |
| Total Fruit[2] | 5 | ≥0.8 cup equivalent | No Fruit | 144 ounces, Fruit juice, single strength |
| Whole Fruit[3] | 5 | ≥0.4 cup equivalent | No Whole Fruit | $11/month total allowance, Fruits & Vegetables |
| Total Vegetables[4] | 5 | ≥1.1 cup equivalent | No Vegetables | (Included in $11) |
| Greens and Beans[4] | 5 | ≥0.2 cup equivalent | No Dark Green Vegetables or Legumes | (Included in $11) & Legumes, 1 pound dry or 64 ounces canned |
| Whole Grains | 10 | ≥1.5 ounce equivalent | No Whole Grains | 1 lb Whole Grain Bread, (may substitute brown rice, bulgur, oatmeal, barley, soft corn or whole wheat macaroni products, or soft corn or whole wheat tortillas)<br>36 ounces Cereal, Whole Grain |
| Dairy[5] | 10 | ≥1.3 cup equivalent | No Dairy | 22 qt, Milk, may substitute yogurt, cheese, soy beverage, and tofu |
| Total Protein Foods[6] | 5 | ≥2.5 ounce equivalent | No Protein Foods | 1 Dozen Eggs |
| Seafood and Plant Proteins[7,8] | 5 | ≥0.8 ounce equivalent | No Seafood or Plant Proteins | Seafood, none<br>18 ounces, Peanut Butter |
| Fatty Acids[9] | 10 | (PUFAs+MUFAs)/SFAs>2.5 | (PUFAs+MUFAs)/SFAs≤1.2 | |
| Moderation components: | | | | |
| Refined Grains | 10 | ≤1.8-ounce equivalents | ≥4.3 ounce equivalent per 1,000 kcal | |
| Sodium | 10 | ≤1.1g | ≥2.0 g per 1,000 kcal | |
| Added Sugars | 10 | ≤6.5% of energy | ≥26% of energy | |
| Saturated Fats | 10 | ≤8% of energy | ≥16% of energy | |

Notes: Adapted from: Krebs-Smith SM et al.[13] Intakes between the minimum and maximum standards are scored proportionately. [2]Includes fruit juice. [3]Includes all forms except juice. [4]Includes any beans and peas not counted as Total Protein Foods. [5]Includes all milk products, such as fluid milk, yogurt, and cheese, and fortified soy beverages. [6]Beans and peas are included here (and not with vegetables). [7]Includes seafood, nuts, seeds, soy products (other than beverages) as well as [8]legumes (beans and peas). [9]Fatty Acids, ratio of polyunsaturated fatty acids (PUFAs) and monounsaturated fatty acids (MUFAs) to saturated fatty acids (SFAs).

are described elsewhere[15]. Overall, most of the images captured for this study were of main meals and there were fewer photographs of drinks, snacks, and desserts submitted. In total 7554 food photographs were uploaded by the 63 women in the WIC sub-sample, all of which were coded and used in the analysis.

The number of photographs submitted by each participant ranged from 11 to 389 ($\bar{X}$=119.9, *SD*=100.1, *Mdn*=83). Participants who entered a minimum of 10 photographs over the course of enrollment in the parent project were included in this study. This selection was made to align with the industry standard for dietary assessment, which typically involves two 24 hour recalls[16]. In addition, a sensitivity analysis was conducted that indicated a minimum of 10 photos were needed to estimate the total diet quality score ($F(1, 61)=0.15$, $p=0.70$, $R^2=0.002$). Since the HEI index estimates diet quality by calculating nutrient density per 1,000 kcals, the number of photographs submitted by participants in this study was less relevant than the actual representativeness of the foods included in their daily dietary intake. However, an analysis conducted to determine if the number of images of different types of intake (drinks, snacks, desserts, and main meals) altered the total diet quality scores also showed that the mix of food types did not significantly influence the total HEI scores ($F(4, 58)=0.21$, $p=0.93$, $R^2=0.14$).

### 2.2.3 Diet Quality and WIC Food Density

Manual analysis of the FoodFotoTM images was conducted to convert photographs to food codes that form the basis of the diet quality estimates. Trained analysts selected appropriate food codes from the U.S. Department of Agriculture's Food Patterns Equivalents Database[17]. that accurately represented the foods in the photos. Images that contained multiple foods types (i.e. spaghetti with meatballs) were disaggregated into individual food items a[1]nd each assigned a unique food code. A cup equivalent or serving size of each food item was estimated to determine density. Coding reliability between analysts for diet density and diet quality was performed on a random sample of 20% of the images. Intraclass correlation coefficients between analysts for food codes and volume were 0.96 and 0.92, indicating excellent interrater reliability. A total of 7,554 photographs were analyzed generating 304 food codes averaging 48 (range 8 to 123) per participant.

https://doi.org/10.53964/jmnpr.2024019

**Table 2. Average Total HEI-2015 Scores by Personal Characteristics (n=63)**

| | n (%) | Mean (SD) | *t* (*p* - value) | *d* |
|---|---|---|---|---|
| Age (years) | | | -2.45 (0.02) | 1.2 |
| ≤22 | 36 (57.1) | 43.4 (9.1) | | |
| ≥23 | 27 (42.9) | 54.2 (9.6) | | |
| Education | | | -1.96 (0.06) | 1.3 |
| High School or less | 42 (66.6) | 42.2 (9.3) | | |
| Some college or more | 21 (33.4) | 54.2 (9.8) | | |
| Employment | | | -1.34 (0.19) | 0.3 |
| Student/Unemployed | 27 (42.9) | 49.0 (10.3) | | |
| Full/Part-time | 36 (57.1) | 52.3 (9.1) | | |
| Income | | | -1.80 (0.08) | 0.5 |
| ≤24,999 | 47 (74.6) | 49.6 (8.6) | | |
| > 25,000 | 16 (25.4) | 54.6 (11.8) | | |
| Food Supplement Program | | | -0.92 (0.38) | 0.3 |
| WIC only | 42 (66.6) | 50.1 (9.4) | | |
| WIC & SNAP | 21 (33.4) | 52.5 (10.2) | | |
| Body Mass Index (BMI) | | | -0.142 (0.89) | 0.4 |
| <25 | 18 (28.6) | 50.6 (10.6) | | |
| ≥25 | 45 (71.4) | 51.0 (9.4) | | |
| Health Insurance | | | -1.04 (0.30) | 0.3 |
| Medicaid | 52 (82.5) | 50.3 (9.2) | | |
| Private | 11 (17.5) | 53.6 (11.6) | | |

WIC approved foods in participants' diet were matched to the appropriate food codes from the Food and Nutrient Database for Dietary Studies[17]. We selected the 10 most common and available fruits and vegetables for the cash voucher items. In total, 35 specific food codes were identified and used to approximate the density of WIC approved foods in participants' diets. The proportion of WIC specific food codes in the total diet was computed to estimate the contribution that WIC foods made to the total HEI-2015 score.

#### 2.2.4 Diet Quality Measures and Statistical Analysis

Publicly accessible SAS code available from the National Cancer Institute was used to convert the Food Patterns Equivalent Database (FPED) food codes into HEI-2015 total and component scores[18]. The HEI-2015 total score captures the balance of the relative mix of foods by summing the ten adequacy and three moderation component scores (the maximum score is 100)[13]. High consumption of adequacy components increases the score, whereas high consumption of moderation food components lowers the total score (see Table 1).

Descriptive statistics (mean, median, standard deviation and range) were used to describe the total and component HEI diet quality scores. Independent sample t tests were conducted to compare HEI-2015 total scores and the components by sociodemographic and health characteristics. Individual simple linear regression models were used to assess the contributions that the percent of WIC food captured in the diet had on the components and the overall HEI score. STATA version 18 was used for all analyses except for determination of the HEI scores which was computed with SAS 9.4.

## 3 RESULTS

### 3.1 Participant Characteristics

Demographic characteristics of the WIC sample appear in Table 2. The ages of the WIC sample ranged from 18 to 33 ($\overline{X}$=22, *SD*=3.9). Most participants were African American (88.9%), 57% were employed full or part time, approximately 75% had a combined annual household income of $25,000 or less and 82.5% received Medicaid health insurance. A subset of the sample (33%) also received SNAP food supplementation. Furthermore, 60% were overweight or had obesity based on their BMI.

### 3.2 Diet Quality

The total HEI scores for the WIC sample ranged from 23.8 to 57.5 points ($\overline{X}$=40.0, *SD*=8) out of a possible 100 points. The average scores for several of the adequacy components (total vegetables, greens and beans, total protein, dairy, seafood plant protein and fatty acid ratio) exceeded the 50$^{th}$ percentile and the total protein component approached the maximum attainable score (see Table 3). Conversely, scores for total fruit, whole fruit and whole grains were all

**Table 3. HEI-2010 Scores by Food Component (WIC Subsample, n=63)**

| Food Component | Minimum (Points Possible) | Maximum (Points Possible) | Mean (SD) | Percentile |
|---|---|---|---|---|
| Total HEI-2010 | 32.2 (0) | 71.3 (100) | 50.8 (9.7) | 51st |
| Adequacy Components | | | | |
| Total vegetables | 0.4 (0) | 5.0 (5) | 3.4 (1.2) | 68th |
| Green and beans | 0.0 (0) | 5.0 (5) | 2.7 (1.8) | 54th |
| Total Fruit | 0.0 (0) | 5.0 (5) | 1.4 (1.4) | 28th |
| Whole Fruit | 0.0 (0) | 5.0 (5) | 1.7 (1.7) | 34th |
| Whole Grains | 0.0 (0) | 10.0 (10) | 1.8 (2.3) | 18th |
| Dairy | 1.7 (0) | 10.0 (10) | 5.0 (1.8) | 50th |
| Total protein | 2.7 (0) | 5.0 (5) | 4.8 (0.5) | 96th |
| Seafood and plant proteins | 0.0 (0) | 5.0 (5) | 3.0 (1.8) | 60th |
| Fatty acid ratio | 1.7 (0) | 10.0 (10) | 5.4 (1.9) | 54th |
| Moderation Components | | | | |
| Sodium | 0.0 (0) | 9.1 (10) | 1.7 (2.3) | 19th |
| Refined grains | 0.0 (0) | 10.0 (10) | 4.5 (2.7) | 45th |
| Empty calories | 0.0 (0) | 20.0 (20) | 15.2 (4.5) | 76th |

below the 35$^{th}$ percentile for HEI standards. Approximately 70% of the sample scored less than 2 of the 5 points on total fruit and whole fruit and 85% scored less than 4 out of 10 points on whole grains suggesting a very low intake on these components. Two of the moderation components (sodium and added sugars) had low average scores indicating high consumption of foods with little nutritional value.

The HEI scores varied by personal characteristics in the WIC sample but were not found to be significant. The average total HEI score for women who were older than 23 was 4 points higher than those who were age 22 or lower (Table 2). More differences were seen at the component level. Older women scored on average at least 1 HEI point higher (out of a possible 5 points) for whole fruit (1.1 HEI point, $p$=0.013) and greens and beans (0.9 HEI point, $p$=0.094) than the younger cohort. This finding suggests that older women consumed more foods belonging to adequacy components and subsequently had a higher diet quality. Women in the sample who had any college level education compared to those with less education had higher dietary intake of greens and beans (0.8 HEI point, $p$=0.098), whole fruit (1 HEI point, $p$=0.02), and total fruit (0.9 HEI point, $p$=0.02). Similarly, women who reported higher household income had more fruit in their diets and therefore had higher total and whole fruit component scores (1.2 HEI points, $p$=0.003 and 1.0 HEI point, $p$=0.037 HEI point respectively). Women with lower BMIs consumed more dairy products (1.2 HEI points higher, $p$=0.008) but less fatty acid (0.9 HEI point, $p$=0.049). For moderation components, women who were employed at least part time (1.6 HEI points, $p$=0.016) and had private health insurance (2.0 HEI points, $p$=0.024) consumed more refined grains than their counterparts. Due to space limitations this data is available in the supplemental materials.

### 3.3 WIC Food Density

As stated previously, women in the WIC sample submitted between 11 to 389 photographs containing 304 different food codes averaging 48 (range 8 to 123) per participant. Across the cohort, the 26 most popular food codes accounted for 50% of all food captured. Among the 304 food codes, 35 food codes were identified as WIC specific food which consisted of about 12.9% of the total food reported. Potatoes, rice, cooked corn, bananas, broccoli, and collard greens were the most reported WIC approved foods (See Table 4).

The proportion of WIC specific foods varied within the sample and the total reported WIC diet ranged from 0 to 27.3% with a mean of 12.5 ($SD$=6.5) among the pregnant women. The WIC specific food codes were found to contribute positively to the total diet quality scores, and women with lower diet quality scores consume fewer WIC approved foods in their diet. In relation to diet quality, higher proportions of WIC foods were associated with higher diet quality scores and for every 1% increase in the proportion of WIC approved foods in the diet there was a corresponding increase of 0.77 points to the total HEI score (b=0.77, $t$=6.35, $p$<0.001). Of the 1% increased consumption of WIC foods in the diet, HEI components that contributed significantly to the score were greens and beans (0.13, $p$=≤0.001), whole fruits (0.14, $p$=≤0.001), total vegetables (0.08, $p$=≤0.001), total fruit (0.11, $p$<0.001) and whole grains (0.13, $p$=0.002). Fatty acid ratio was associated with increased overall diet quality score (0.08, $p$=≤0.022). Finally, increased consumption of WIC foods was significantly associated with decreased sodium intake (-0.10, $p$=0.029).

## 4 DISCUSSION

The current study supports previous research showing

**Table 4. Density of WIC Foods in Participant's Diets**

| WIC Food Group | USDA 4-digit Food Code | WIC Food Count | WIC Food Percentage | Cumulative WIC Food Percentage |
|---|---|---|---|---|
| Yogurt | 1140 | 0 | 0 | 0 |
| Barley | 5180 | 0 | 0 | 0 |
| Corn pasta | 5614 | 0 | 0 | 0 |
| Cereal, cold, whole grain | 5741 | 0 | 0 | 0 |
| Bulgur | 5817 | 0 | 0 | 0 |
| Vegetable - Squash | 7213 | 0 | 0 | 0 |
| Vegetable – Peas, Bell pepper | 7512 | 1 | 0.01 | 0.01 |
| Soy Beverage | 1132 | 2 | 0.03 | 0.04 |
| Tortilla, Soft corn, Whole wheat | 5221 | 2 | 0.03 | 0.07 |
| Legumes – Blackeyed peas | 4130 | 3 | 0.04 | 0.11 |
| Tofu | 4142 | 3 | 0.04 | 0.15 |
| Fruit - Blueberries | 6320 | 3 | 0.04 | 0.19 |
| Whole wheat macaroni/pasta | 5613 | 4 | 0.05 | 0.24 |
| Legumes – Dried, Canned | 4110 | 5 | 0.07 | 0.31 |
| Vegetable - Tomato | 7410 | 5 | 0.07 | 0.38 |
| Vegetable - Okra Legumes | 7522 | 8 | 0.11 | 0.49 |
| Vegetable - Carrots | 7310 | 9 | 0.12 | 0.61 |
| Peanut Butter | 4220 | 11 | 0.15 | 0.76 |
| Vegetable - Cucumber | 7511 | 13 | 0.17 | 0.93 |
| Fruit - Pear | 6313 | 17 | 0.23 | 1.16 |
| Fruit - Orange | 6111 | 19 | 0.25 | 1.41 |
| White potato | 7110 | 21 | 0.28 | 1.69 |
| Fruit - Strawberries | 6322 | 22 | 0.29 | 1.98 |
| Cheese | 1401 | 23 | 0.3 | 2.28 |
| Fruit – Melon, Grapes, Mango | 6312 | 24 | 0.32 | 2.6 |
| Fruit - Watermelon, Pineapple | 6314 | 32 | 0.42 | 3.02 |
| Fruit Juice, single strength | 6410 | 37 | 0.49 | 3.51 |
| Eggs | 3110 | 45 | 0.6 | 4.11 |
| Bread, Whole grain | 5130 | 48 | 0.64 | 4.75 |
| Vegetable - Greens | 7210 | 60 | 0.79 | 5.54 |
| Vegetable - Broccoli | 7220 | 63 | 0.83 | 6.37 |
| Milk, fluid | 1111 | 74 | 0.98 | 7.35 |
| Fruit - Banana | 6310 | 103 | 1.36 | 8.71 |
| Vegetable - Corn | 7521 | 108 | 1.43 | 10.14 |
| Brown rice, Oatmeal | 5620 | 210 | 2.78 | 12.92 |

low total diet quality (HEI-2015) scores among pregnant women participating in WIC[8,19,20]. The Center for Nutrition Policy and Promotion at the USDA, conducts a routine retrospective analysis of diet quality in America using the National Health and Nutrition Examination Survey (NHANES) data, collected in two-year cycles. The most recent report found that the average HEI-2015 score for the general US population was 58 out of 100 possible points and 63 points among the pregnant women in that cohort[21,22]. The mean total HEI-2015 socre in the study cohort was only 40.0, which is significantly lower than the US national average.

Despite the low total HEI-2015 score in the study cohort, three novel findings in this study suggest that WIC supplementation has a positive effect on diet quality. The first was that for every 1% increase in the proportion of WIC approved foods in the diet there was a corresponding increase of 0.77 points in the total HEI score and study participants with lower scores consumed less WIC approved foods. Second, the specific HEI-2015 component scores for green and beans, whole fruits, total vegetables and total fruit contributed to higher diet quality scores. Further benefits were seen in the study participants on WIC who had lower odium intake leading to higher diet quality scores. This finding has considerable clinical implications because research in both human and animal models has shown that sodium intake during pregnancy is strongly associated with hypertension[23-26]. Third, the WIC sample of pregnant women scored at or above the 50th percentile on HEI food component scores for total vegetables, green beans, total dairy, seafood and plant proteins, total proteins, and fatty acids ratio. These findings demonstrated that even small increases in consumption of WIC foods improve diet quality among pregnant women enrolled in the program. Given that improved diet quality is associated with better health outcomes for mother and child, these findings have considerable national importance because of the implications that they have for health and subsequently healthcare costs. In our sample, 82.5% of the participants also received state and federally funded health care benefits such as Medicaid. One could infer that maximizing the WIC foods program would be associated with improvements in health outcomes that could have positive downstream budgetary savings.

It is important to recognize that WIC only provides monthly food supplemental assistance and recipients need to find additional resources to fill in the deficit. Higher socio-economic status is associated with improved diet quality presumably because more economic resources provide the means to afford healthier foods[27]. In our WIC sample, three quarters of the group reported a combined household income of less than $25,000 annually, suggesting that they may not be able to afford the higher cost of healthy foods. Low income and high unemployment rates within our sample also imply that the study participants lacked the necessary resources to purchase additional high quality, high-cost foods such as whole fruits, vegetables, and whole grains. Their economic circumstances also infer that they are reliant on WIC supplements for foods that otherwise would be unattainable. It is very possible that without WIC, the mean HEI scores in the study would have been significantly lower.

**4.1 Policy Implications**

The US Federal Government, has placed increased attention on nutrition and health with the White House Conference on Hunger, Nutrition, and Health. This convening was the second in history, spanned by half a century, to focus on nutrition and linkages to disease prevention[28]. The strategies developed include increasing access to federal food, human services, and health assistance programs such as the WIC program. Specifically, the strategy calls on the United States Department of Agriculture (USDA) to advance a WIC modernization strategy to invest in community-based outreach, streamline the participant experience, improve the in-store experience, expand access to farmers markets, and increase diversity and cultural competency in the WIC workforce[28].

As the Administration reviews policy proposals to modernize the WIC program, it is critical to establish a regular review cycle for the food packages in alignment with the DGA updates and current evidence to ensure the program maintains conformance with dietary recommendations. It is encouraging to see that the USDA is using the rulemaking process to adopt many of the National Academies' proposed WIC food package revisions to further enhance diet quality for pregnant women and other WIC groups[29]. The current WIC food package proposed revisions increase fruit and vegetable consumption by expanding the amount and types of produce funded by the program and simultaneously reducing the quantity of high sugar juice. The proposed rule food package update provides four times the amount of money for pregnant women in the WIC program, an increase from $11 to $43 to go toward fruits and vegetables[30]. The findings from this study validate the value of the WIC food program and support the proposed increase to the cash vouchers for fruits and vegetables.

The revised WIC program food allowances were not used in the study because the timeframe when the data was collected preceded implementation of the final rule. However, once implemented, the revised WIC program foods will facilitate a proportional increase of higher diet quality for low-income pregnant women in the program and across communities. Longitudinal studies that assess diet quality and pregnancy outcomes focused on optimizing epigenetic modification could highlight the impact that diet quality has on multiple generations[5,31]. This supports that even small increases in the amount of WIC foods consumed in the diet improves diet quality that is associated with enhancements in maternal, neonatal and child health outcomes[32,33]. More income eligible pregnant women should have access to the diet quality benefits provided by the WIC program.

**4.2 Limitations**

Our findings should be interpreted in the context of several methodological limitations. First, a convenience sample of women was enrolled from one major metropolitan area in a single state. This is relevant because WIC programs, administered at the state level, vary in terms of the types and quality of food packages provided; therefore, direct comparison across states is not possible. In addition, a large proportion of the sample was African American and diet choices are known to be influenced by cultural and ethnic preferences[34]. Further, the sample size of 63 women appears small; however, important findings have been demonstrated using similarly sized nationally representative samples from pregnant women surveyed in NHANES. In the NHANES 2015-2016 and 2017-2018, pregnancy status sample sizes were 70 and 55, respectively[35,36]. Future studies should target larger and more diverse probability samples

Potentially important factors that were not collected in the parent project included the fact that many women reported sharing food with other members of their household. Household size was not controlled for in this study so there was no way to determine how much of the total supplement the individuals on WIC personally consumed or if the supplements were shared with other residents in the house. Additionally, we did not compare the WIC study participants to the other women in the parent (BEAM) project who did not receive WIC foods to determine differences within the same population. Finally, the use of FoodFoto™ to collect real-time nutritional intake data[15] still remains subject to selection bias because participants decide what foods are photographed and the number of photographs they take. The number of photos submitted by participants varied considerably. Therefore, we were not able to determine if women with a low proportion of WIC approved foods in their diet did not fully utilize the WIC foods or if they simply omitted to take photographs of those foods. Additionally, the sample size limited our ability to compute the influence that receiving WIC and SNAP may have on diet quality.

## 5 CONCLUSION

Despite the limitations, this study provides important new information that supports the critical need for WIC food supplementation for low-income pregnant women and demonstrates its contribution to higher diet quality. More research is needed about the role of diet quality and health outcomes for pregnant women and children. Additionally, longitudinal studies that examine interventions to improve diet quality in low socio-economic, minority populations who face significant health disparities are needed. This research is critical considering evidence linking diet to epigenetic modifications that influence health in multiple generations of offspring since recent studies have clearly shown that the benefits of higher quality diet extend well beyond the current pregnancy[5,37,38].


## Acknowledgements

This work was supported by the Science and Technology Plan Project of Beichen District, Tianjin, China (No.SHGY-2020018).


## Conflicts of Interest

The opinions or assertions contained herein are the private ones of the author/speaker and are not to be construed as official or reflecting the views of the Department of Defense or the Uniformed Services University of the Health Sciences.

## Author Contribution

Regan MJ was the principal and was responsible for study design, participant recruitment, oversight of data collection and all other aspects of the study. She also wrote and edited the manuscript, and completed the requested revisions and the original submission, plus revised paper in response to the reviews feedback, and resubmitted the paper. Zhu S conducted all of the statistical analysis and helped with all revisions of the manuscript. Zvenyach T was the co-investigator on the study. She sorted and cleaned the data, and did the primary analysis. She drafted the first version of the paper with Regan MJ and assisted with subsequent revisions of the manuscript.

## Abbreviation List

BEAM, Birth, Eating and the Microbiota Study (NR014826)
BMI, Body mass index
DGA, Dietary Guide for Americans
FPED, Food Patterns Equivalent Database
HEI-2015, Healthy Eating Index - 2015
NHANES, the National Health and Nutrition Examination Survey
SNAP, Supplemental Nutrition Assistance Program
U.S., United States
USDA, the United States Department of Agriculture
WIC, Special Supplemental Nutrition Program for Women, Infants, and Children

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