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Evaluation of nutrient intakes of pregnant and non-pregnant women

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ABSTRACT

During pregnancy, women need to increase their energy intake and certain vitamins and minerals to ensure that both the mother and fetus remain healthy. Therefore, it is crucial that women-- both pregnant and those capable of becoming pregnant-- are properly nourished to provide a healthy environment for their child. The objective of this study was to determine if pregnant women's dietary intakes meet their dietary reference intakes (DRIs) independent of supplementation and to determine if non-pregnant women of childbearing age have adequate intakes of key nutrients important for conception and pregnancy. Our study examined 15 pregnant and 15 non-pregnant women between the ages of 20 and 33 years recruited from the Urbana-Champaign area. Study participants completed the National Health and Nutrition Examination Survey (NHANES) Food Frequency Questionnaire (FFQ). FFQ data was then analyzed using Diet*Calc (2013, NCI) and Statistical Analysis System (SAS). Nutrient data was compared to the 2001 Dietary Reference Intake values. There were no differences in mean nutrient intakes between pregnant and non-pregnant women. Both pregnant and non-pregnant women exceeded the DRIs for vitamins A, B_{12}, and C, riboflavin, and n-3 polyunsaturated fatty acids (PUFAs). Our findings indicate that both pregnant and non-pregnant women from the Champaign-Urbana area may benefit from dietary education and/or supplementation in order to prevent development of adverse health effects in the fetus.

INTRODUCTION

According to the Centers for Disease Control and Prevention, in the United States 10% or less of the general U.S. population (approximately 31.4 million people) had nutrient deficiencies between 1999 and 2006. For most of these deficiencies, prevalence varied by age, gender, or race and ethnicity. All of the nutrients studied play vital roles in fetal development during pregnancy. Specifically, 9.5% of American women were deficient in iron and <1% of the American population was deficient in both vitamin E and folate (Second National 2012). The leading causes of infant deaths in 2012 were congenital malformations, deformations, and chromosomal abnormalities. Disorders related to short gestation and low birth weight, as well as sudden infant death syndrome, were also among these causes (FastStats 2015). Many of these problems can be prevented by proper nutrition practice. Intervention programs such as Women, Infants, and Children (WIC) aim to reduce these issues in individuals of low socioeconomic status, however this remains a problem across socioeconomic status lines. Thus, further research is needed to determine if women of childbearing age are obtaining adequate nutrition in order to decrease the number of infant deaths and abnormalities.

During pregnancy, women need to increase their energy intake and consumption of certain vitamins and minerals to ensure that the mother and fetus remain healthy. It is important for these women to consume the appropriate Dietary Reference Intake (DRI) values and use supplementation if necessary to make sure they are providing adequate nutrients for the proper growth and development of their baby (Picciano 2003).

Although nutrient needs are higher throughout pregnancy, caloric needs do not increase until the second trimester. During the second trimester, caloric needs increase by 340-360 calories per day. In the third trimester, energy needs are increased by another 112 calories per day. In general, daily calorie consumption for pregnant women should be between 2,200 and 2,900 calories. A deficiency in a pregnant woman's calorie intake and inadequate weight gain may result in growth retardation and low birth weight, while an excess can lead to high birth weight and complications during labor and delivery (Bredbenner 2009).

Fatty acids are essential for fetal growth and development, especially of the brain and eyes. Consuming the appropriate amount can enhance gestation and infant birth weight, length, and head circumference (Bredbenner 2009). The DRIs for n-3 polyunsaturated fatty acids (PUFAs) for non-pregnant and pregnant women are 1.1 g/d and 1.4 g/d, respectively. These fatty acids can be obtained from vegetable oils, fish oil, and fatty fish (Macronutrients 2001).

During pregnancy, folate needs are increased by 50%, from 400 μg/d to 600 μg/d. Sources of folate include enriched cereal, dark leafy vegetables, enriched and whole-grain breads and bread products, and fortified ready-to-eat cereals. Vitamin B_{12} can also be obtained from fortified cereals, as well as meat, fish, and poultry (Vitamins 2001). Folate and vitamin B_{12} are crucial for the formation of DNA and fetal and maternal cells. Deficiencies of folate can also lead to premature birth, low birth weight, fetal growth retardation, spontaneous abortion, poor placental development, and other problems. In the early stages of pregnancy, inadequate folate and B_{12} can contribute to neural tube defects (Bredbenner 2009).

The need for iron increases greatly because of the increased formation of red blood cells and fetal stores (Bredbenner 2009). Non-pregnant women require 18 mg/d, while pregnant women require 27 mg/d (Elements 2001). This increased demand puts pregnant women at a greater risk of iron deficient anemia. Iron deficiency can lead to low birth weight, premature birth, and increased risk of fetal or infant death (Bredbenner 2009). Excess iron (45 mg/d for both non-pregnant and pregnant women (Elements 2001)) may inhibit maternal absorption of zinc, copper, and calcium (Bredbenner 2009). In order to meet their iron requirements, women can consume both heme (meat and poultry) and non-heme (fruits, vegetables, and fortified bread and grain products, like cereal) iron sources (Elements 2001).

Riboflavin can be found in organ meats, milk, bread products, and fortified cereals. Non-pregnant women should consume 1.1 mg/d, while pregnant women should consume 1.4 mg/d (Vitamins 2001). Riboflavin deficiency affects the immune system. However, there is little evidence to show that deficiency results in adverse outcomes (Lapido 2000).

The consumption of vitamin C helps to enhance iron absorption (Bredbenner 2009). Non-pregnant women should consume 75 mg/d of vitamin C, while pregnant women need 85 mg/d. Dietary sources of vitamin C include citrus fruits, tomatoes, tomato juice, potatoes, Brussels sprouts, cauliflower, broccoli, strawberries, cabbage, and spinach (Vitamins 2001). As an antioxidant, vitamin C works along with vitamin E (Hovdenak 2012). Both non-pregnant and pregnant women require 15 mg/d of vitamin E and can obtain this from vegetable oils, unprocessed cereal grains, nuts, fruits, vegetables, and meats. Vitamin C deficiency may result in premature birth, while excess (2000 mg/d for both non-pregnant and pregnant women (Vitamins 2001)) can lead to an abrupt drop in vitamin C levels after birth, which can cause deficiency symptoms (Bredbenner 2009).

During pregnancy, women require 770 μg/d of vitamin A while non-pregnant women require 700 μg/d. Vitamin A can be obtained from liver, dairy products, fish, and darkly colored leafy vegetables (Vitamins 2001). Inadequate consumption of vitamin A during pregnancy can lead to premature birth, eye abnormalities, and impaired vision, as well as maternal death (Bredbenner 2009). An excess (1000 μg/d for both non-pregnant and pregnant women (Vitamins 2001)) can potentially lead to birth defects that affect the nervous and cardiovascular systems and cause facial deformities (Bredbenner 2009).

Adequate intake of each of these nutrients is crucial to ensuring optimal fetal development. Our study aimed to determine if pregnant and non-pregnant women were fulfilling their dietary needs in comparison to the DRIs independent of supplementation. Specifically, we utilized diet history questionnaires completed by study participants to assess kilocalories, fat, protein, vitamins A, B_{12}, C, D, and E, thiamin, riboflavin, folate, iron, zinc, calcium, and n-3 PUFAs.

MATERIALS AND METHODS

This study includes secondary data from two research trials in our laboratory. Our observational study included 15 pregnant and 15 non-pregnant women recruited from Carle Foundation Hospital and the University of Illinois. Pregnant women were enrolled from September 2012-March 2013. Data from non-pregnant women was collected in January 2013. For non-pregnant women, inclusion criteria included: (1) be between 20 and 40 years of age; (2) have a body mass index <29.5 kg/m^2; (3) be free of any known metabolic or GI diseases, with no history of metabolic or GI diseases. Non-pregnant women were excluded from the study if they were lactating or had a menstrual cycle <27 days or >29 days in length. There were no age or BMI inclusion criteria for the pregnant women. The Institutional Review Board at the University of Illinois approved both studies. Informed consent was obtained from all participants before enrollment.

Participants completed the National Health and Nutrition Examination Survey (NHANES) Food Frequency Questionnaire (FFQ) downloaded from the National Cancer Institute to assess dietary patterns over the past year. The FFQ is a validated instrument that collects data showing the usual dietary intake of participants for the past year. Pregnant women completed the FFQ during the third trimester (> 34 weeks gestation) to assess nutrient intakes during their pregnancy. Studies have shown that the NHANES FFQ generates reproducible and valid nutrient intake data (Hu et al. 1999, Martin et al. 1997, Shu et al. 2004). FFQ responses were analyzed using Diet*Calc, a free software developed by the National Institutes of Health (NIH). Dietary supplementation was not included in the analyses. Nutrient intakes of pregnant and non-pregnant women were compared using T-tests (SAS software). Mean nutrient intake values were compared to the DRI values.

RESULTS

The nutritional supplement information of the 15 pregnant women and 15 non-pregnant women in our study is shown in **Table 1**.

All 15 pregnant women were taking a prenatal vitamin, nine of these women were taking other single vitamin supplements. Four of the 15 non-pregnant women were taking a multivitamin, while four of the non-pregnant women were taking other single vitamin supplements.

Table 1. Nutritional Supplements

	Fish Oil	Calcium	Iron	B Vitamins	Vitamin D	Whey Protein	Multivitamin	Prenatal Vitamin
NP	2	1	-	1	-	-	4	-
P	3	2	1	1	1	1	-	15

Table 1. Nutritional Supplements. Number of non-pregnant (NP) and pregnant (P) women taking supplements at the time of data collection.

Tables 2 and **3** show the physical characteristics and dietary intake values of the two cohorts.

Table 2. Non-Pregnant Women

	Mean	SD	Range
Age (yr.)	26.1	4.1	20-33
Kilocalories	1726	653	945-3559
Protein (g/d)	73	30	46-166
Fat (g/d)	71	24	38-129
Carbohydrates (g/d)	191	93	81-454
BMI (kg/m^2)	23.4	2.1	20-28

Table 2. Non-pregnant Women. Physical characteristics and dietary intake values of the 15 non-pregnant participants.

Table 3. Pregnant Women

	Mean	SD	Range
Age (yr.)	29	4.1	20-33
Kilocalories	1793	362	1049-2320
Protein (g/d)	71	21	39-104
Fat (g/d)	73	17.2	50-114
Carbohydrates (g/d)	220	55	99-337
Pre-Pregnancy BMI (kg/m^2)	23.2	3.9	18-28
Postpartum BMI (kg/m^2)	28.7	4.2	22-36

Table 3. Pregnant Women. Physical characteristics and dietary intake values of the 15 pregnant participants.

There were no significant differences in nutrient intakes of pregnant and non-pregnant women. Further analysis revealed that several nutrient intakes were below DRI values when diet, independent of supplementation, was considered. **Figure 1** shows that both pregnant and non-pregnant women did not meet the DRIs for vitamin E, folate and iron.

Figure 1. Inadequate Micronutrients

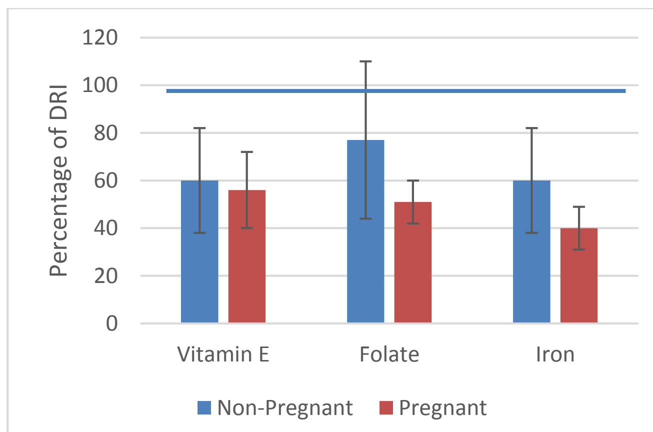

Figure 1. Inadequate Micronutrient Intakes. Both non-pregnant and pregnant participants were deficient in vitamin E, folate and iron when not considering supplementation. Percentage of Dietary Reference Intake (DRI) met for both cohorts is shown. Bars represent means and error bars are standard deviation. Horizontal line shows 100% of DRI.

The average reported intake for vitamin E for pregnant women was 8 mg/d (SD 2.4), while non-pregnant women averaged 9 mg/d (SD 3.2). FFQ data revealed an average of 306 µg/d (SD 51.4) and 11 mg/d (SD 2.3) of folate and iron for pregnant women, respectively. Non-pregnant women's intake averaged 309 µg/d (SD 130.9) of folate and 11 mg/d (SD 3.9) of iron. Intakes for vitamin D, zinc, calcium, and thiamin varied between the two cohorts as seen in **Figure 2**.

Figure 2. Varied Micronutrient Intakes

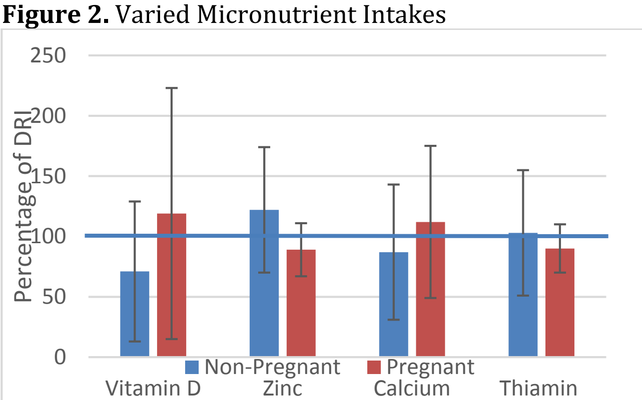

Figure 2. Varied Micronutrient Intakes. Percentage of Dietary Reference Intake (DRI) met for vitamin D, zinc, calcium and thiamin varied among the two cohorts. Bars represent means and error bars are standard deviation. Horizontal line shows 100% of DRI.

FFQ data revealed that pregnant women consumed an average of 6 µg/d (SD 5.2) of vitamin D, 10 mg/d (SD 2.4) of zinc, 1119 mg/d (SD 625.6) of calcium, and 1 mg/d (SD 0.3) of thiamin. Non-pregnant women averaged 4 µg/d (SD 2.9) of vitamin D, 10 mg/d (SD 4.2) for zinc, 874 mg/d (SD 561) for calcium, and 1 mg/d (SD 0.6) for thiamin.

Figure 3 shows that both pregnant and non-pregnant women exceeded the DRIs for vitamins A, B_{12} and C, riboflavin and n-3 PUFAs.

On average, pregnant women reported an intake of 1143 µg/d (SD 359) of vitamin A, 4 µg/d (SD 2.1) of vitamin B_{12}, 110 mg/d (SD 41.2) of vitamin C, 2 mg/d (SD 0.8) of riboflavin, and 1 g (SD 0.4) for n-3 PUFAs. On average, non-pregnant women reported an intake of 1062 µg/d (SD 478.5) of the DRI for vitamin A, 4 µg/d (SD 1.9) for vitamin B_{12}, 96 mg/d (SD 61.6) for vitamin C, 2 mg/d (SD 0.9) for riboflavin, and 2 g/d (SD 0.6) for n-3 PUFAs.

Figure 3. Micronutrients Exceeding DRI

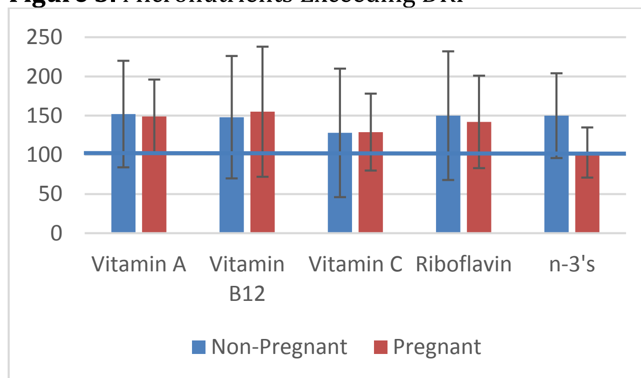

Figure 3. Micronutrients Exceeding Dietary References Intakes (DRIs). Both non-pregnant and pregnant participants exceeded DRIs for vitamin A, vitamin $_{B12}$, vitamin C, riboflavin n-3 polyunsaturated fatty acids (PUFAs) when not considering supplementation. Percentage of DRI met for both cohorts is shown. Bars represent means and error bars are standard deviation. Horizontal line shows 100% of DRI.

DISCUSSION

In our study examining fifteen pregnant and fifteen non-pregnant Caucasian women from the Midwest, there were no significant differences in nutrient intakes between pregnant and non-pregnant women. Both pregnant and non-pregnant women exceeded the DRIs for vitamins A, B_{12}, and C, as well as riboflavin, and n-3 PUFAs. Both cohorts did not meet the DRIs for vitamin E, folate, and iron. Inadequate intake of certain nutrients, such as vitamin E, folate, and iron, can cause complications in fetal development. Therefore, it is crucial that we address these deficiencies and the potential adverse effects that they may have on the fetus. Pregnant women met 56% of the DRI for vitamin E, while non-pregnant met 60%. For folate, pregnant and non-pregnant women met 51% and 77% of the DRI, respectively. Pregnant women met 40% of the DRI for iron and non-pregnant women met 60%. Nutrients that varied between the two cohorts were vitamin D, zinc, calcium, and thiamin. While pregnant women exceeded the DRIs for vitamin D (119%) and calcium (112%), non-pregnant women only met 71% and 87% of the DRIs, respectively. Conversely, non-pregnant women exceeded the DRIs for zinc (122%), thiamin (103%), while pregnant women met 89% and 90% of the DRIs, respectively. The caloric intake levels and intake of macronutrients in our study was similar to those in other studies done with pregnant women (Baer et al. 2005; Mouratidou et al. 2006; Kramer & Kakuma 2010; Piirainen et al. 2006).

In a 2013 study representative of the US population, a positive association was shown between income and diet quality for total vegetables, dark green and orange vegetables and legumes, whole grains, and calories from solid fats, alcoholic beverages, and added sugars for adults. Conversely, as income level increased, sodium intake decreased. A positive association was also shown between adults with a college degree and diet quality for whole fruit, total vegetables, whole grains, and calories from solid fats, alcoholic beverages, and added sugars in comparison to all other education levels. Less than a high school education was associated with higher saturated fat and sodium intake, as well as lower oil intake in comparison to all other education levels. These findings suggest that education may be associated with increased nutrition knowledge, as well as the ability to use this knowledge to make healthy diet choices (Hiza et al. 2013). With all of our participants having completed a high school education and the majority completing at least a bachelor's degree, we believe that our participants would exhibit a positive association with diet quality. Therefore, their education and income levels demonstrate the likelihood of our participants to make high quality choices in terms of diet.

Although vitamin E deficiency is typically seen in individuals with severe malnutrition, genetic defects, and malabsorption syndromes, both cohorts in our study were not consuming adequate vitamin E. While severe vitamin E deficiency is rare, negligible intake of vitamin E is fairly common in the United States. The NHANES III showed that 27% of white participants had blood levels of α-tocopherol less than 20 μmol/L (current recommendation is 15 mg/day). Furthermore, it is estimated that more than 90% of Americans do not meet daily dietary recommendations for vitamin E (Higdon & Drake 2011). This may explain why our participants did not meet their vitamin E requirements. Vitamin E deficiency has not specifically been reported in pregnant women. However, it is hypothesized that this deficiency could cause miscarriage, preterm birth, pre-eclamptic toxemia, and intrauterine growth restriction (McCann & Ames 2005).

Without supplementation, both the non-pregnant and pregnant participants had diets that were below the DRI for folate. Adequate folate is crucial during pregnancy as folate plays an essential role in the prevention of neural tube defects. Inadequate folate intake is associated with abruption placentae, preeclampsia, spontaneous abortion, stillbirth, preterm delivery, and low birthweight. While these effects are severe, they are uncommon when an appropriate supplement is taken in combination with a balanced diet (Molloy et al. 2008). While our participants did not meet the DRI for folate, all 15 pregnant participants took a prenatal vitamin. Therefore, with supplementation, all pregnant participants would be consuming adequate folate.

Iron deficiency affects an estimated 2 billion people worldwide. The prevalence of iron deficiency is higher in females during adolescence because of menstruation. Vegetarian diets also increase this risk as 15-35% of iron is absorbed from meat sources while <10% of iron is absorbed from plant-based sources. Our data revealed that both non-pregnant and pregnant participants were consuming inadequate levels of iron. During the first two trimester of pregnancy, iron deficiency increases the risk for premature birth, low birthweight, infant mortality, and predicts iron deficiency in infants after 4 months of age (Zimmermann and Hurrell 2007). In 2011, NHANES released a study comparing iron deficiency prevalence in non-Hispanic white, non-Hispanic black and Mexican American pregnant women. The results from this study showed that the prevalence of iron deficiency increased with each trimester and the prevalence of iron deficiency was significantly lower for non-Hispanic white pregnant women than in non-Hispanic black and Mexican American pregnant women (Mei et al. 2011). Both cohorts in our study were not consuming an adequate amount of iron. However, supplementation of a prenatal vitamin should address this deficiency.

In our study, both cohorts were exceeding the dietary recommendations for vitamin C. However, according to an NHANES study conducted from 2003-2004, 47% of women ≥20 years reported consuming one of more supplements containing vitamin C. 53% of women who had serum measurements available reported dietary intake of vitamin C less than the Estimated Average Requirement (EAR) (Schleicher et al. 2009). This population's results did not match those of our study as we found that both cohorts had intake levels that exceeded the DRI. This could be due to the fact that the majority of the women in our study had graduate degrees and higher socioeconomic status. Alternatively, this may be partially explained by the tendency for FFQs to overestimate fruit and vegetable intake (Green et al. 1998; Amanatidis et al. 2001). All of the participants in our study had high intake levels of vitamin C, additional supplementation is contraindicated as vitamin C levels continually exceeding the DRI may lead to adverse health effects including hypertension, preeclampsia, gastrointestinal disturbances, kidney stones, and excess iron absorption (Bredbenner 2009). Some studies show that vitamins C and E can help to prevent and treat pre-eclampsia as well as oxidative stress. Other studies have shown that supplementation of both vitamins C and E not only provide no benefit, but actually increase the risk of hypertension in women who are at risk for pre-eclampsia and low birth weight (Hovdenak & Haram 2012). Whatever the case may be, both of our cohorts were not consuming an adequate amount of vitamin E through their diets.

Both non-pregnant and pregnant women in our study were exceeding the DRI for vitamin A. Excess intake of preformed vitamin A can cause teratological effects and liver toxicity (Vitamins 2001). Symptoms of acute toxicity include nausea, vomiting, headache, increased cerebrospinal fluid pressure, vertigo, blurred vision, muscular incoordination, and bulging fontanel in infants. These symptoms are usually temporary and caused by short-term or single doses greater than or equal to 150,000 μg in adults and less in children. Chronic toxicity is caused by large doses over a period of months or years of 30,000 μg/day. Symptoms are varied, but may affect the central nervous system, liver, bone, and skin. The Tolerable Upper Intake Level (UL) was developed in considering the adverse effects of excess vitamin A intake on reduced bone mineral density, teratogenicity, and liver abnormalities (Institute of Medicine 2001). While our cohorts were both exceeding the DRI for vitamin A, the average amounts they were consuming were not large enough to cause any short-term or chronic symptoms.

Both cohorts in our study exceeded the DRIs for vitamin $_{B12}$ and riboflavin. According to the NIH, no adverse effects of excess vitamin B_{12} or riboflavin have been found in humans or animals. However, this does not mean that there is no potential for adverse effects from excess intakes, rather that data on the adverse effects is limited and caution should still be practiced in the intake of these nutrients (Vitamins 2001).

Our study excluded supplements from the nutrient analysis to assess diet quality and therefore demonstrated that supplementation is necessary for both pregnant and non-pregnant women to meet their dietary needs. Our participants had a broad income range, ranging from $25,000 to over $100,000 as well as a diverse educational background, including GEDs, associate's, some college, bachelor's, master's, and doctorate degrees. Conversely, the majority of our participants were Caucasian, therefore limiting the translation of information from our study to other ethnic groups.

The limitations of the NHANES FFQ utilized in our study have been discussed in other studies as well. This tool has been shown to be both valid and reliable in a variety of studies. However, the FFQ has been shown to be more reliable in single-sex studies, like the one we conducted because in general, different genders define portion sizes differently (Marks et al. 2006). It is important to consider that this tool has been utilized with different groups of participants and has been validated for use in pregnant women. FFQs have been fairly accurate in analyzing the nutrient intake of pregnant women, but it is important to note again that this accuracy is dependent on the demographics of these women, as well as the number of items on the questionnaire. One study showed that the FFQ had higher validity with those who had more education and among Caucasians compared to African Americans (Baer et al. 2005). Because our participants were mostly Caucasian, the tool likely provided valid results. However, the range in educational backgrounds may have decreased the validity of this along with our evaluation of non-pregnant women as well as pregnant women. Overall, the majority of studies conducted show that utilizing FFQs can be a useful tool when classifying pregnant women based on nutrient intake (Mouratidou et al. 2006).

Because the nutritional requirements during pregnancy are increased, it may be difficult for women at this stage in their life to meet these requirements without supplementation. However, it is important to monitor the use of supplements as overuse can have detrimental effects equal to, if not worse than, underuse. At the same time, supplementation may have no effect on pregnancy outcomes if adequate amounts are being obtained through the diet (Berti et al. 2011, Hovdenak & Haram 2012). Because supplements can be obtained from a variety of providers, it is in the consumer's best interest to obtain the majority of their nutrients from their diet (Black 2001). However, the majority of pregnant women take prescription vitamins and therefore, do not need to be concerned with the provider.

Future research should include a broader range of ages to include all groups that may become pregnant, as well as an increase in the number of participants. Women from different ethnic backgrounds and geographic regions should also be included in future research.

CONCLUSIONS

Our study indicates that both pregnant and non-pregnant women exceed the DRIs for vitamin A, B_{12}, C, and riboflavin and n-3 PUFAs. Pregnant women's diets do not provide adequate zinc or thiamin to meet the DRI values without supplementation. Non-pregnant women's diets do not provide adequate vitamin D or calcium to meet the DRI values without supplementation. Neither pregnant nor non-pregnant women consume diets adequate in vitamin E, folate, or iron. Therefore, supplementation is required in both non-pregnant and pregnant women's diets in order to ensure that they consume diets that are nutritionally adequate. It is crucial that mothers meet their nutritional requirements during pregnancy because the living environment they create for their child not only affect factors like birth weight and fetal development, but the child's health and development of disease later in life.

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