Research Article

Determinants of Diet Quality in Pregnancy: Sociodemographic, Pregnancy-specific, and Food Environment Influences

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ABSTRACT

Objective: To advance the knowledge of determinants of diet quality in pregnancy by focusing on both personal characteristics and the food environment.

Design: Cross-sectional study in which participants from the Prenatal Health Project were linked to a geographic dataset by home address. Access to fast food, convenience stores, and grocery stores was measured using a geographic information system (ArcGIS9.3).

Setting: Pregnant women (n = 2,282) were recruited between 2002 and 2005 in London, Ontario, Canada.

Main Outcome Measure: Dietary quality was measured using a validated food frequency questionnaire and the Canadian Diet Quality Index for Pregnancy.

Analysis: Univariate and multivariate linear regressions were calculated with the predictor variables on the Canadian Diet Quality Index for Pregnancy.

Results: Pregnant women who were born in Canada, common-law, nulliparous, less physically active, smokers, more anxious, or lacking family support had lower diet quality on average. Presence of fast-food restaurants, convenience stores, and grocery stores within 500 m of participants' homes was not associated with diet quality after controlling for personal variables.

Conclusions and Implications: The food environment does not seem to have a large influence on diet quality in pregnancy. Further research is needed to determine other potential reasons for low diet quality among pregnant women.

Key Words: nutrition, pregnancy, diet, geographic information systems, food environment (*J Nutr Educ Behav*. 2013;45:627-634.)

INTRODUCTION

Maintaining a healthy diet is important for all individuals, but it is crucial during pregnancy. Unfortunately, many pregnant women fail to meet food and nutrient recommendations, especially for fruits, vegetables, grains, folate, and iron.[1-5] In a large cohort of pregnant women in London, Ontario, Canada, researchers found that over 65% of women were not consuming the recommended servings for fruits, vegetables, and grains.[6]

It is important to understand why some pregnant women demonstrate low diet quality. It is unclear how some factors influence diet quality, including marital status, whether the pregnancy was planned, occupation, income, nausea, exercise, and mental health.[3,4,7-12] It is theorized that individuals are more likely to make better health choices when they are motivated and educated to do so, in addition to an environment that supports these decisions.[13] Some studies have previously found that the food environment is associated with diet and obesity among the general population.[14-16] Furthermore, a study by Larsen and Gilliland[17] described the existence of food deserts (ie, socioeconomically deprived areas

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lacking access to affordable, healthy food) in London, Ontario. To the authors' knowledge, only 1 study has assessed the association between access to food stores and diet quality in pregnancy.[18]

Inconsistent relationships between many factors with diet quality in pregnancy, as well as a lack of literature on the influence of the food environment are evident. The objective of this study was to advance the knowledge of determinants of diet quality in pregnancy by focusing on both personal characteristics and the food environment.

METHODS

Participants and Recruitment

The cohort for the present study was originally recruited for the Prenatal Health Project, a prospective cohort study of pregnant women that was developed to investigate the determinants of preterm birth. The University of Western Ethics Review Board for Health Sciences Research Involving Human Subjects approved the Prenatal Health Project. Pregnant women were recruited from 7 high-volume ultrasound clinics across London, Ontario, between January, 2002 and December, 2005. Participants provided written informed consent and were not compensated for their participation. Details of the Prenatal Health Project can be found elsewhere.[19] For this cross-sectional study, participants in the Prenatal Health Project were linked to a geographic database by home address.

Measures

Personal variables, including sociodemographic and pregnancy-specific factors, were extracted from the Prenatal Health Project for use in this study (Table 1 lists definitions and measurements). Food environment variables were based on a comprehensive inventory of every retail food establishment in London, Ontario, which is continually verified and updated through legislated site visits by local health inspectors.[20] Using the geographic information system ArcGIS9.3 (Environmental Systems Research Institute, Redlands, CA, 2009), addresses of all food retailers in London, Ontario were geocoded to an official civic address file to match establishments to their precise geographic location. Locations were previously verified by site visits and alternative directory listings, and the accuracy of the geocoding was confirmed using 30-cm resolution orthophotography.[21] The Network Analyst extension of ArcGIS9.3 was used to create 3 variables that characterize the presence of food establishments within 500 m (or a 5-minute walk) of participants' homes: (1) convenience stores, (2) fast-food restaurants, and (3) grocery stores or local markets with fresh food. A residential area variable was created that defined women's home residences as urban or rural, according to the classification by Statistics Canada.[20]

Dietary intake was assessed during the previous month using a 106-item Food Frequency Questionnaire (FFQ). Previously, the FFQ was validated for use in the Prenatal Health Project in a pilot study of 22 women residing in London, Ontario, who prospectively recorded their food consumption using 3-day food diaries. Correlation coefficients comparing nutrients from the food diaries and the FFQs for these 22 women were as follows: fat, 0.67 ($P < .05$); calcium, 0.42 ($P < .05$); folate, 0.76 ($P < .001$); and iron, 0.19 (not significant). Nutritional intake was quantified from the FFQ using the CANDAT Nutrient Calculation System,[21] which was based on the 2001 Canadian Nutrient File.[22]

The Diet Quality Index for Pregnancy (DQI-P) is a published tool that was created and shown to be an internally consistent measure of diet quality in a population of pregnant American women.[8] For this study, the DQI-P_c was created, modifying the original DQI-P to be consistent with Canadian dietary guidelines. The DQI-P_c is a continuous measure that contains 6 components: recommended servings of grains and fruits and vegetables according to the 2007 Canada's Food Guide; recommended intake of folate, iron, and calcium based on Dietary Reference Intakes; and recommended energy intake from fat according to Health Canada.[23,24] The 2007 Canada's Food Guide was developed based on rigorous scientific evidence that suggests that diets in accordance with recommendations provide adequate nutrition.[25] Each component was assigned a score out of 10.0, except for the fruits and vegetables component, which was scored out of 20.0 (this was 2 components in the original DQI-P). For example, an individual who had 4.0 daily servings of grains would receive a score of 5.7 out of 10.0 for the grain component based on the recommendation of 7.0 daily servings (4.0 / 7.0 × 10.0). The 6 component scores were summed to produce a total score out of 70.0, which was then converted to a percentage.

Data Analysis

All statistical analyses were performed in SAS (version 9.1, SAS Institute, Cary, NC, 2004). Participants were excluded if they had an energy intake value not within 2.0 SD of the mean, which has been used in previous studies to identify implausible energy consumption.[26]

Descriptive statistics were calculated for the predictors. For continuous variables, means were used to describe normally distributed data and medians for skewed data. The frequency counts of women who had sufficient intake were calculated for each DQI-P_c component.

Univariate and multivariate linear regressions were performed with the predictor variables on DQI-P_c. Variables were entered into the multivariate regression if they had $P < .20$ in the univariate analysis, which is a recommended cut point for model building.[27] A stepwise procedure was used in which variables were entered in blocks with automated backward elimination at each step.[28] The third model was trimmed using backward elimination to create a parsimonious model with only variables that were significant at $P < .05$. *A priori* interactions were assessed between presence of fast-food restaurants with marital status and income.

RESULTS

Descriptive Results

The sample size of the complete Prenatal Health Project cohort

Table 1. Measurement and Definitions of Personal Variables Extracted From the Prenatal Health Project (London, Ontario, Canada, 2002–2005)

Variables	Original Questionnaire	Categorization for Current Study
Age	Date of birth Recruitment date	Age = recruitment date – birth date Continuous, rounded down to year
Residency in Canada	What country were you born in? What year did you come to Canada?	Canada, other If other, then years in Canada = study recruitment year – year came to Canada Three categories: born in Canada, > 5 y, ≤ 5 y
Marital status	What is your current marital status?	Three categories: married; common-law; single/never married, separated/divorced
Parity	List of previous pregnancies Outcomes of previous pregnancies: live birth, stillbirth, or miscarriage	Number of previous live births Binary: 0, ≥ 1
Planned pregnancy	Was the current pregnancy planned?	Binary: yes, no
Education	What is the highest level of formal education you have completed?	Binary: college/university, other
Occupation	What best describes your current employment status?	Three categories: not employed voluntarily; employed part-time, student, not employed but looking for job, disability/sick leave; employed full-time
Household income	What is the best estimate of total household income before taxes last year?	Three categories: < $30,000, $30,000–$79,999, ≥ $80,000
Difficulty affording food	Extracted from financial strain index (perceived difficulty level affording food)	Three categories: very/somewhat difficult, not very difficult, not at all difficult
Nausea severity	Have you changed your eating habits owing to nausea? Have you visited a doctor owing to nausea or vomiting?	Three categories: did not change eating habits or visit the doctor owing to nausea; changed eating habits but did not visit the doctor owing to nausea; visited the doctor owing to nausea (regardless of whether changed eating habits)
Exercise	How often do you currently exercise? What is the duration of your exercise?	Three categories: under-exercisers (≤ 2 times/wk for ≤ 60 min, 3–4 times/wk for ≤ 29 min); optimal exercisers (3–4 times/wk for 30–60 min); over-exercisers (≥ 5 times/wk and/or > 1 h each time)
Smoking	Have you ever smoked? How many cigarettes do you typically smoke now?	Binary: smoker (smokes at least 1 cigarette now), nonsmoker (never-smoker or ever-smoker who smokes 0 cigarettes now)
Depression	CES-D[44]	Binary: evidence of depressive symptoms (CES-D ≥ 16), lack of evidence of depressive symptoms (CES-D < 16)
Anxiety	State Trait Anxiety Index[45]–abridged 12-item scale	Continuous, standardized
Social support	Social support scales: perceived social support from partner (7-item scale), family (8-item scale), and friends (8-item scale)[46]	Separate scores for partner, family, and friends Continuous, standardized

CES-D indicates Center for Epidemiological Studies Depression Scale.

was 2,357. After 75 women were excluded owing to implausible energy intake, the sample size for this study was 2,282. The median DQI-P_c score was 79.7%. Table 2 outlines the descriptive statistics for the DQI-P_c and associated recommendations.

Table 3 presents the baseline characteristics of the cohort for the personal variables. Approximately 72% of the women had a college or university education and 89% reported annual income levels above $30,000. Fewer than half of participants resided within 500 m of at least 1 convenience store (47.5%), fast-food restaurant (33.3%), or grocery store or local market with fresh food (10.7%). The majority of the cohort (94.2%) resided within an urban area.

Univariate and Multivariate Regression Results

Occupation was the only personal variable in the univariate analyses predicting DQI-P_c that had $P > .20$. All other personal variables had $P < .20$: age, residency in Canada, marital status, parity, planned pregnancy, education, income, difficulty affording food, nausea severity, exercise,

Table 2. Canadian Diet Quality Index for Pregnancy Components: Descriptive Statistics and Sufficient Intake for Prenatal Health Project Cohort (London, Ontario, Canada, 2002–2005)

Variable	Mean (SD)	Median	Recommendation	Missing	Sufficient Intake, n (%)
Canadian Diet Quality Index for Pregnancy (%)	77.1 (15.7)	79.7	100.0	15	56 (2.5)
Grains, servings/d	4.5 (2.0)	4.2	7.0	6	261 (11.5)
Fruits/vegetables, servings/d	7.4 (3.4)	6.9	8.0	10	860 (37.9)
Fat energy (%)	28.9 (4.2)	28.9	20.0–35.0	0	2,107 (92.3)
Calcium, mg/d	1,087.9 (431.1)	1,122.3	1,000.0	0	1,319 (57.8)
Iron, mg/d	13.1 (4.6)	12.7	22.0	0	108 (4.7)
Dietary Folate Equivalents, μg/d	469.0 (164.0)	447.9	520.0	0	758 (33.2)

smoking, depression, anxiety, and the 3 social support measures from family, friends, and partner. The residential area variable was not significant. Univariate regression coefficients for the association between residing within 500 m of at least 1 food source and DQI-P_c were convenience stores ($\beta = -1.83$; $P = .006$), fast-food restaurants ($\beta = -2.20$; $P = .002$), and grocery stores or local markets ($\beta = -1.52$; $P = .16$).

Table 4 shows the multivariate linear regression of DQI-P_c on predictor variables (models 1 and 2 are not shown). The R^2 for both model 3 and the parsimonious model was 0.05. In the final parsimonious model, variables associated with higher diet quality in pregnancy were immigrants residing in Canada for ≤ 5 years, ≥ 1 previous pregnancies, being married, more exercise, not smoking, lower anxiety levels, and greater social support from family. There were no significant associations for the food environment variables in the final parsimonious model; however, the presence of fast-food restaurants had $P < .20$ in model 3. There were no significant interactions identified between presence of fast-food restaurants and marital status and income.

DISCUSSION

For this study, the median DQI-P_c of 79.7% was 10.0% higher than 2 American studies of diet quality in pregnancy, which used the DQI-P and the Alternative Healthy Eating Index for Pregnancy to measure diet quality.[4,8] The high diet quality is likely driven by the large proportion of university- and college-educated women in this study. The general birthing population of London, Ontario, was similar to this cohort with regard to age, marital status, height, prepregnancy weight, and parity.[29] Although the median DQI-P_c was high, only 2.5% of women met all diet quality recommendations. This is mainly a result of the low proportion of women who met the iron recommendations (4.7%). Pregnant women require more iron, which is usually achieved through dietary supplements[30,31]; however, this was not assessed in this study because the main focus was diet quality through food.

In terms of the personal variables that demonstrated inconsistent relationships with diet quality in pregnancy in the past, in this study planned pregnancy, occupation, income, and nausea during pregnancy were not significantly associated with DQI-P_c; however, significant associations were found for exercise, marital status, and anxiety.[3,4,7-12]

Married women demonstrated better diet quality than single, divorced, separated, or common-law women. Previous studies have found that common-law women are more similar to divorced or separated women than married ones with regard to some health behaviors; specifically, common-law women were more likely to smoke and report feelings of depression.[32,33] Likely, it is not the legal act of being married that drives these differences; rather, common-law women may be systematically different from married women, which could have influenced diet quality scores in this study through uncontrolled confounders.[34]

The higher diet quality demonstrated by recent immigrants (who resided in Canada for ≤ 5 years) compared with women who were born in Canada is consistent with a study that compared diet quality of women of Mexican descent who were born in the United States with immigrants from Mexico who had resided in the United States for ≤ 5 years.[35] These results demonstrate the attenuation of the healthy immigrant effect with longer residency in Canada. This has previously been demonstrated with other aspects of health, including obesity and cardiovascular risk factors.[36-38]

Past literature shows that nulliparous women have better diet quality than women with ≥ 1 previous pregnancies.[4,8,11,12] In this study, a reverse association of parity with diet quality was found. For this cohort, it was previously observed that greater adherence to all of Canada's Food Guide recommendations was associated with higher parity.[6] This finding may be unique to this cohort of pregnant women, because they are generally more educated and have higher income than subjects in previous studies.

Laraia et al[18] found that increased proximity to grocery stores, supermarkets, and convenience stores was associated with better diet quality. They did not investigate the relationship between fast-food restaurants and diet quality. In this study, presence of fast-food restaurants or convenience stores within 500 m of participants' homes was significantly associated with lower diet quality; however, these associations were not sustained in the multivariate analysis. Dean and Sharkey[39] previously found a significant association between fruit and vegetable intake and distance to supermarkets for only rural, not urban, residents among the general population. Because the cohort for this current study was predominately

Table 3. Descriptive Statistics of Personal Variables for the Prenatal Health Project Cohort (London, Ontario, Canada, 2002–2005) (n = 2,282)

Predictor Variables	n	Frequency (%)	Missing
Age			
Continuous	2,282	29.6 (5.0)[a]	0
Residency in Canada			
Lifetime (born in Canada)	2,267	1,931 (85.2)	15
> 5 y		213 (9.4)	
≤ 5 y		123 (5.4)	
Marital status			
Married	2,281	1,759 (77.1)	1
Common-law		349 (15.3)	
Single/separated/divorced		173 (7.6)	
Parity			
0	2,282	1,131 (49.6)	0
≥ 1		1,151 (50.4)	
Planned pregnancy			
No	2,282	626 (27.4)	0
Yes		1,656 (72.6)	
Education level			
Completed university/college	2,279	1,638 (71.9)	3
Other		641 (28.1)	
Occupation			
Employed full-time	2,265	1,425 (62.9)	17
Employed part-time		528 (23.3)	
Not employed voluntarily		312 (13.8)	
Household income			
< $30,000	2,162	246 (11.4)	120
$30,000–$79,999		1,086 (50.2)	
≥ $80,000		830 (38.4)	
Difficulty affording food			
Very/somewhat difficult	2,279	177 (5.1)	3
Not very difficult		596 (26.2)	
Not at all difficult		1,566 (68.7)	
Nausea severity			
No diet change/doctor visit	2,277	898 (39.4)	5
Changed diet/no doctor visit		997 (43.8)	
Visited doctor		382 (16.8)	
Exercise			
Under-exercisers	2,278	1,570 (68.9)	4
Optimal		328 (14.4)	
Over-exercisers		380 (16.7)	
Smoking during pregnancy			
No	2,266	2,040 (90.0)	16
Yes		226 (10.0)	
Depression			
No	2,268	1,851 (81.6)	14
Yes		417 (18.4)	
Anxiety[b]			
Continuous	2,277	0.0 (1.0)[a]	5
Social support from partner[b]			
Continuous	2,281	0.0 (1.0)[a]	1
Social support from family[b]			
Continuous	2,278	0.0 (1.0)[a]	4
Social support from friends[b]			
Continuous	2,274	0.0 (1.0)[a]	8

[a]Mean (SD); [b]Standardized to a mean of 0.0 and an SD of 1.0.

urban (94.2%), this could partially explain the lack of association found between food sources and diet quality.

Strengths and Limitations

A major strength of this study was the large cohort of women who were originally recruited through a prospective study. Furthermore, a geographic information system was used to precisely measure the availability of different types of food retailers in relation to participants' homes,[40] which allowed this study to make an important contribution to knowledge on how local food environments affect health-related behaviors, such as diet quality during pregnancy.[18]

There are strengths and limitations to using FFQs. They cannot capture all food items consumed by participants and may underestimate nutrient values. On the other hand, FFQs are appropriate to use to measure usual consumption.[41] Furthermore, the FFQ used here was validated for use in this cohort; however, the estimate of iron intake from the FFQ was less than that calculated from the food records. It is possible that the diet quality scores in this study may be conservative. In particular, the finding that only 4.7% of participants met the requirements for iron is likely lower than the true value. A major strength of this study is the DQI-P_C, because this measure aimed to capture overall diet quality rather than focusing on minor components of diet. The original DQI-P was shown to be an internally consistent measure of diet quality in a population of pregnant women in the United States.[8]

The low R^2 indicates that the models explain only a small proportion of the variability in diet quality among pregnant women. This study looked at some of the predictors of diet quality during pregnancy, but there are many factors that may contribute to diet quality that were not included in this study (eg, food preference, access to transportation).[42,43]

IMPLICATIONS FOR RESEARCH AND PRACTICE

This study is novel because it incorporated demographic, social, and

Table 4. Multivariate Linear Regression of Canadian Diet Quality Index for Pregnancy on Predictor Variables for the Prenatal Health Project Cohort (London, Ontario, Canada, 2002–2005)

	β (*P*)	
Predictor Variables	**Model 3 (n = 2,086) (R^2 = 0.05)**	**Parsimonious (n = 2,209) (R^2 = 0.05)[a]**
Personal variables		
Residency in Canada		
Lifetime (born in Canada)	Reference	Reference
> 5 y	−0.99 (.40)	−0.89 (.44)
≤5 years	3.79 (.02)	3.31 (.02)
Marital status		
Married	Reference	Reference
Common-law	−2.54 (.01)	−3.07 (.002)
Single/separated/divorced	−1.27 (.38)	−2.42 (.07)
Parity		
0	Reference	Reference
≥ 1	2.61 (< .001)	2.57 (< .001)
Education level		
Completed university/college	Reference	
Other	−1.11 (.18)	
Nausea severity		
No diet change/doctor visit	Reference	
Changed diet/no doctor visit	1.19 (.11)	
Visited doctor	1.40 (.16)	
Exercise		
Under-exercisers	−3.43 (< .001)	−3.66 (< .001)
Optimal	Reference	Reference
Over-exercisers	−0.34 (.78)	−0.79 (.50)
Smoking during pregnancy		
No	Reference	Reference
Yes	−2.22 (.08)	−3.28 (.006)
Anxiety (State-Trait Anxiety Inventory)[b]	−0.84 (.03)	−0.95 (.007)
Social support from family[b]	0.54 (.15)	0.73 (.04)
Social support from friends[b]	0.59 (.11)	
Food environment variable		
Presence of fast food restaurants within 500 m		
0	Reference	
≥ 1	−1.26 (.09)	

[a]Includes only predictor variables significant at $P < .05$; [b]Variables are continuous and standardized to a mean of 0.0 and SD of 1.0.

Note: Models 1 and 2 and variables with $P > .20$ are not shown, for simplicity.

other pregnancy-related variables, as well as food environment factors to predict diet quality in pregnancy. In this cohort, food environment factors did not appear to have an important role after controlling for personal variables. This study identified women who are more likely to demonstrate low diet quality during pregnancy, including women who are born in Canada, those residing with a common-law partner, and those who are smokers, less physically active, nulliparous, and more anxious, and perceive less social support from family.

Further research is needed to determine other potential reasons for low diet quality among pregnant women. Based on the low R^2 of the multivariate models in this study, other important factors that predict diet quality need to be explored. Future research should also focus on developing intervention strategies to promote healthy eating in pregnancy. Based on this research, strategies focusing on the food environment (eg, building more grocery stores in locations defined as food deserts) may not have a large impact on improving diet quality for pregnant women.

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