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Determinants of Diet Quality in Pregnancy: Does Geography Play a Role?

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Abstract & Keywords

The objective of this study was to identify the individual- and community-level determinants of diet quality during pregnancy. Subjects included 2282 pregnant women in London, Ontario who participated in the Prenatal Health Project (PHP). Dietary intake was measured using a validated food frequency questionnaire and diet quality was assessed using the Diet Quality Index for Pregnancy. Participants of the PHP were linked to a geographic dataset by home address to determine the community-level variables using a geographic information system. Insignificant variability at the community-level resulted in an individual-level multivariable regression analysis instead of a multi-level. Our findings indicated that pregnant women who were born in Canada, unmarried, nulliparous, less physically active, smokers, more anxious, and lacking family support had lower diet quality on average. Presence of fast food restaurants, convenience stores, and supermarkets in relation to participants' homes did not appear to be major contributors to diet quality in our cohort.

Keywords: Prenatal Health Project, diet quality, diet quality index for pregnancy, pregnancy, maternal health, geographic information system, food geography, fast food restaurants

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List of Abbreviations

PHP	Prenatal Health Project
DQI-P	Diet Quality Index for Pregnancy
RDA	Recommended Dietary Allowances
FFQ	Food Frequency Questionnaire
DRI	Dietary Reference Intakes
EAR	Estimated Average Requirement
AI	Adequate Intake
UL	Tolerable Upper Intake Level
PCA	Principal Component Analysis
HEI	Healthy Eating Index
ARFS	Australian Recommended Food Score
AHEI-P	Alternative Healthy Eating Index
NHANES	National Health and Nutrition Examination Survey
BMI	Body Mass Index
CIHR	Canadian Institutes of Health Research
DA	Dissemination Area
$DQI\text{-}P_m$	Modified Diet Quality Index for Pregnancy
DFE	Dietary Folate Equivalents
CES-D	Centre for Epidemiological Studies Depression Scale
STAI	Speilberger State Trait Anxiety Index
ICC	Intraclass Correlation Coefficient
DF	Degrees of Freedom
SD	Standard Deviation
GIS	Geographic Information System
VIF	Variance Inflation Factor

Chapter 1: Background & Significance

Maintaining a healthy diet is important for all individuals, but it is especially crucial for pregnant women since food and nutrient demands are increased to support a healthy pregnancy. Unfortunately, pregnant women are consistently failing to meet the food and nutrient recommendations for pregnancy. A prospective American study of diet quality in pregnancy found that the mean score on a dietary index was 61, where the maximum score of 90 was not achieved by any participants(1). In New Zealand, it was found that fibre intake was below adequate levels in 81% of the pregnant women studied(2). Women in Portugal increased nutrient intake during pregnancy but were still not receiving adequate folate, iron, and vitamin E(3). In London, Ontario, 65% and 90% of pregnant women in our cohort were not consuming the recommended servings for the fruit and vegetable food group and grain food group, respectively, according to recommendations of the 2007 Canada Food Guide(4). Nutrient intakes consumed through food and supplements in our cohort were also found to be low, where 31%, 18%, and 16% of pregnant women were below the Recommend Dietary Allowances (RDA) for iron, zinc, and folate, respectively(5).

It is apparent from the above findings that pregnant women are not consuming adequate nutrition; this is concerning and it is important to determine why diet quality is inadequate by assessing both individual- and community-level factors that may be involved. The majority of studies that have assessed diet quality in pregnancy focused primarily on individual-level determinants. There is a lack of literature regarding community-level determinants of pregnant women's diet quality, especially with studies combining community- and individual-level determinants. Furthermore, to our knowledge there have been no Canadian studies that assess determinants of diet quality during pregnancy by using a diet quality index; rather many studies only address micronutrient deficiencies or food group consumption. This thesis aimed to advance the knowledge of determinants of diet quality in pregnancy by focusing on both individual- and community-level determinants and assessing overall diet quality using the Diet

Quality Index for Pregnancy (DQI-P) of a cohort of Canadian women. This research has the potential to impact policy regarding the targeting of interventions to improve diet quality. If individual-level factors dominate the findings, this will identify specific at-risk groups of women who may benefit from educational programs regarding the importance of nutrition in pregnancy. If diet quality is found to be strongly associated with access to food stores, future restructuring of the food landscape may be implemented; specifically, through evidence-based urban planning, the number of fast food restaurants could be reduced in certain areas and grocery stores could be built in areas with poor access to fresh food.

The following literature review describes the specific food and nutrient recommendations for pregnancy, the tools that are commonly used in research to assess food intake and diet quality, whether or not pregnant women are meeting the food and nutrient recommendations, and summarizes the available research on both individual- and community-level determinants of diet quality in pregnancy.

Chapter 2: Literature Review

2.1 Recommendations for Healthy Eating during Pregnancy

2.1.1 Canada's Food Guide to Healthy Eating

The 2007 Eating Well with Canada's Food Guide is an important nutrition policy document that is available to the public. It has been revised since the 1992 version to include diet recommendations based on age and sex. The food guide includes specific examples to demonstrate serving sizes for various products within each food group. The food guide also provides extra guidance concerning food quality rather than just quantity; for example, it advises eating dark green and orange vegetables and to choose whole grain products. It is recommended that females between the ages of 19 and 50 should consume 7-8 servings of fruits and vegetables, 6-7 servings of grain products, 2 servings of milk and alternatives, and 2 servings of meat and alternatives daily. There are further recommendations for women of child bearing age and pregnant women; specifically, it advises pregnant women to take a multivitamin containing folic acid and iron. Women who are pregnant or breastfeeding require more calories in their diet and therefore the food guide recommends including 2 to 3 extra food guide servings daily. The food guide provides specific examples of extra food items that could be consumed from the fruits and vegetables, grain products, and milk food groups(6).

The new food guide recommendations were developed based on rigorous scientific evidence, which involved a two-step modeling procedure where diets were simulated that were in accordance with the food guide recommendations. These simulated diets followed food intake patterns, including specific recommendation statements concerning the quality of food choices, for example to eat whole grain foods. It was found that these simulated diets provided satisfactory results for all nutrients and energy assessed. Furthermore, consumption of fruits, vegetables, fish, and whole grain foods were found to reduce the risk of cardiovascular disease where consumption of fruits and vegetables were found to reduce the risk of cancer. Therefore, the evidence suggested that following the recommendations of the new food guide resulted in consumption of necessary amounts of nutrients and energy, and subsequently may reduce the risk of acquiring certain chronic diseases(7).

2.1.2 Nutrient Recommendations for Pregnancy: Folate, Iron, and Calcium

Proper nutrition in pregnancy is essential for the health of the mother and the fetus. With the emerging, and rapidly growing, body of literature in the area of epigenetics, it is recognized that the fetal environment may influence the lifetime health of the individual, and perhaps even the offspring(8, 9).Three nutrients especially important in pregnancy are folate, iron, and calcium. Low folate intake during the periconceptional period, which is approximately one month prior to conception through to one month following conception, is associated with increased risk of the fetus developing neural tube deficits(10). A deficiency in iron can cause anemia. Maternal anemia has been shown to be associated with other adverse outcomes such as premature birth, low birth weight, and even infant mortality(11). Calcium supplements during pregnancy may be responsible for decreased risk of pregnancy-induced hypertension. During pregnancy, especially the third trimester, 25-30 grams of calcium are transferred to the fetus; physiologically, the maternal intestinal absorption of calcium is increased to meet these demands, rather than the mother requiring a greater intake of calcium(12).

It is difficult to accurately assess adequacy of nutrient intake within individuals or groups of individuals but there are dietary reference standards called Dietary Reference Intakes (DRIs) that can be used to estimate adequacy of nutrient intake. One such DRI is the RDA, which is defined as "the average daily nutrient intake level sufficient to meet the nutrient requirement of nearly all (97 to 98 percent) healthy individuals in a particular life stage or gender group"(13). A limitation of the RDA is that it is only appropriate to assess intake at the individual-level and not at the group-level(13). The Estimated Average Requirement (EAR), which is defined as "the average daily nutrient intake level estimated to meet the requirement of half the healthy individuals in a particular life stage and gender group", is appropriate to use not only to assess intake adequacy at the individual level but also, to estimate the prevalence of inadequate nutrient intake within a specific group of people(13). EARs have not been established for all nutrients, such as for calcium, and so in this case an Adequate Intake (AI) can be used and is defined as "a recommended average daily nutrient intake level based on observed or experimentally determined approximations or estimates of nutrient intake by a group (or groups) of apparently healthy people that are assumed to be adequate"(13). A Tolerable Upper Intake Level (UL) has also been established for some nutrients and is defined as "the highest average daily nutrient intake level likely to pose no risk of adverse health effects to almost all individuals in the general population. As intake increases above the UL, the potential risk of adverse effects increases"(13).

EARs have been established for folate and iron where an AI has been established for calcium. The EAR for folate for females aged 14 and older is 320 µg/day and it is also recommended that any woman that could possibly become pregnant should take a daily supplement containing 400 µg of folate in addition to the amount of folate found in a healthy diet. The EAR for folate for pregnant women is 520 µg/day and is 500 µg/day for lactating women. The EAR for iron for menstruating females between the ages of 19 and 50 is 8.1 mg/day, where the EAR for pregnant women is increased to 22 mg/day. The AIs for calcium are the same for pregnant and non-pregnant women. It is recommended that females 18 years of age or younger should consume 1300 mg/day and females aged 19-50 years of age should consume 1000 mg of calcium per day(14).

2.2 Measurements of Dietary Intake

There are many options to consider when deciding on the best tool to use to assess food intake in a research study. Three main measurement tools found in the literature are food records, dietary recalls, and food frequency questionnaires (FFQs) where each of these methods has specific strengths and limitations(15). Table A.1 in Appendix A summarizes the main strengths and limitations of these measurements.

2.2.1 Food Records

Food records, also called food diaries, are used to collect diet information where an individual is asked to keep a detailed list of all the food that they consumed during a specific day(s). The use of a food record is advantageous to determine accurate consumption during the period of the record because it is not dependent on memory since the subject directly measures the food quantity consumed. On the contrary, subjects may lack motivation to keep a detailed log of the type and quantity of all food consumed, not to mention that participants may consciously alter their regular diet since they are aware that they are participating in a study. Food records are expensive and can only capture diet on the day(s) that the record takes place and thus does not specifically capture usual diet. Usual intake can be estimated if food records are conducted at multiple time points, such as six days, spaced out over a long period of time but this is usually not feasible in most epidemiological studies(15).

2.2.2 Dietary Recall

A 24-hour dietary recall is a detailed interview that is conducted by a trained dietary expert to collect information on every item that the participant recalls consuming during a recent 24-hour period. The position of the skilled interviewer is essential since they can probe the participant for additional food items and specific cooking techniques, as well as phrasing the questions in a way that encourages the participant to recall the food that they ate more accurately. The main advantages to using a dietary recall over food records are the minimal response burden, the participant does not need to be literate, and the participant is less likely to alter their diet if they are unaware of the study when they are making diet choices. However, the main disadvantage of this method compared to food records is that it is dependent on memory since the subject is required to remember the type of food they consumed and especially the quantity(15).

2.2.3 Food Frequency Questionnaires (FFQ)

An FFQ is a survey that is used to determine individuals' usual intake of food over a specified period of time. It generally contains a list of food items and an accompanying frequency response key. The food items that are chosen to be in a specific FFQ are determined based on the research objectives. It may be counter-productive to include too many food items because the participants may be unwilling to complete a long survey and lose motivation. The food list should include foods that are consumed fairly often by the majority of participants, contain a high percentage of the nutrient(s) of interest to the study objectives, and also have variability of intake between the population under study. The frequency response key will also vary depending on the study, where some FFQs may opt to use an open-ended response option rather than specific frequency categories. The main advantage to using an FFQ to assess diet quality compared to the other food collection methods is its ability to capture diet intake over a long period of time, especially if the time frame of interest is in the past. Food records and dietary recalls are generally only conducted based on a few days of food intake and thus it is difficult to assess usual intake. Other advantages include its fairly low respondent burden, it is inexpensive, and it is generally easier for people to remember their usual food intake than to remember specific foods eaten on one occasion thereby limiting error due to memory. A disadvantage of the FFQ is that it is restricted to certain food items, which may be an issue in culturally diverse populations. Also, some similar food items may be grouped together in one question, such as bread; bagels; and English muffins, so it may not capture some specificity of the diet. The FFQ is also limited by the frequency categories provided and may not determine the exact frequency of intake. For this reason and because the FFQ measures usual intake and not actual intake, it is generally not the best method to use to obtain accurate nutrient intakes; however it is appropriate to use when the study requires individuals to be ranked according to diet(15).

2.3 Measures of Diet Quality

In order to assess diet quality, the dietary intake measures mentioned above must be used in combination with a diet quality tool. Two of the most popular measures of diet quality include principal component analyses (PCA) and diet indices. PCA is used to describe specific patterns of diet observed in a population; it is a data-driven approach(16). Diet indices, including the Healthy Eating Index (HEI) and the Diet Quality Index for Pregnancy (DQI-P), are generally calculated from various food and nutrient components where an overall score is then assigned for each participant. Table B.1 in Appendix B illustrates the diversity of tools used to quantify diet quality in various studies, where these tools are described in more detail below.

2.3.1 Principal Component Analysis (PCA)

PCA is an exploratory statistical procedure used to reduce the dimensionality of a dataset(16). It aims to uncover trends in the data and thus, is useful with datasets involving food variables to determine the most common diet patterns(16). When PCA is used to determine groups based on diet, these groups will depend on the study and the diet composition of the participants, therefore, because it is data-driven, the same diet patterns are not reproducible between studies(17).

Three different studies conducted in New Zealand, United Kingdom, and Finland all assessed diet quality in pregnancy using PCA but found 3, 5 and, 7 different dietary patterns respectively. The New Zealand study, conducted by Thompson and colleagues, discovered three dietary patterns in which they appropriately named junk, traditional, and fusion. The 'junk' pattern was characterized by ice cream, sweet biscuits, cakes, scones, pies, and chocolate. 'Traditional' was characterized by fruits (apples, bananas, citrus, etc.), green and root vegetables, dairy, and water. 'Fusion' was a mixture of healthy and unhealthy food choices, specifically it was characterized by fruits, fried rice and noodles, fish, milk, coffee and tea, and cheese(18). In the UK, Northstone and colleagues identified five unique dietary patterns among pregnant women, which they called health conscious, traditional, processed, confectionary, and vegetarian(19). Lastly, Arkkola and team characterized seven dietary patterns among pregnant Finnish women where these patterns were named healthy, fast food, traditional bread, traditional meat, low-fat foods, coffee, and alcohol and butter.

2.3.2 Australian Recommended Food Score (ARFS)

ARFS is a diet quality index that is quantified based on the regular intake of food items from the Dietary Questionnaire for Epidemiological Studies FFQ that complies with both the Dietary Guidelines for Australian Adults and the Australian Guide to Healthy Eating. The index consists of eight components: vegetables; fruits; grains; dairy; nuts, beans, and soya; meat; fish; and fat. There is a maximum possible score of 72. Each component score is weighted differently with vegetables having the greatest weight of 22 followed by fruits and grains each out of 14(20).

2.3.3 Healthy Eating Index (HEI)

The HEI is a diet quality index that is generally the gold standard to measure diet quality(21). The HEI is composed of 5 food groups, 4 nutrients, and a food variety measure. It has a total score out of 100, where each of the following 10 components contributes 10 points: grains, vegetables, fruit, dairy, meat, total fat, saturated fat, cholesterol, sodium, and variety of foods in diet(21). Since the original version of the HEI was developed, modifications to the measure have been produced. One modified version of the HEI was name the HEI_n where the components included total fruit (including juice); whole fruit (not including juice); total vegetables; dark green or orange vegetables and legumes; total grains; whole grains; milk; meat and beans; oils; saturated fat; sodium; calories from solid fat, alcohol, and added sugar(22).

A prospective pilot study was conducted in the United States in 2005 by Pick and colleagues to compare diet quality of non-pregnant women with pregnant women based on the HEI and these authors concluded that the HEI is not an appropriate measure for diet quality in pregnancy. The researchers found that macronutrient intakes were similar for both pregnant and non-pregnant women except pregnant women consumed more calories overall. Subjects with an HEI score greater than 80 were still not meeting the recommendations for iron and folate intake especially among the pregnant group where the recommendations for iron and folate are increased. The authors concluded that the HEI does not take into consideration the increased vitamin and mineral recommendations during pregnancy and is therefore, not an appropriate measure to use to assess diet quality of pregnant women(23).

In 2002, the Alternative Healthy Eating Index (AHEI) was developed based on the HEI to include food and nutrient components that may better predict chronic diseases(24). The components of the AHEI includes: fruits; vegetables; nuts and soy protein; ratio of white to red meat; cereal fibre; trans fat; ratio of polyunsaturated to saturated fatty acids; duration of multivitamin use; and alcohol consumption(24). Based on the AHEI, the AHEI-P was developed for assessment of diet quality specifically for pregnant women. The AHEI-P consists of nine components each worth ten points: vegetables, fruits, ratio of white to red meat, fibre, trans fat, ratio of polyunsaturated to unsaturated fatty acids, folate, calcium, and iron(1). The AHEI-P is a relatively new diet quality index and has not yet been shown to be an accurate measure of diet quality in pregnancy, as it was just constructed for the use in one American population(1).

2.3.4 Diet Quality Index for Pregnancy (DQI-P)

The Diet Quality Index for Pregnancy (DQI-P) was developed by the researchers from the Pregnancy, Infection, and Nutrition (PIN) study in the United States to assess diet quality of pregnant women specifically(25). The DQI-P has eight components each out of ten points: recommended servings of grains, vegetables, and fruit based on the Dietary Guidelines for Americans and the Food Guide Pyramid; recommended folate, iron, and calcium based on the Recommended Dietary Allowance (RDA); percentage of energy from fat based on the Dietary Guidelines for Americans; and a meal pattern score(25).

The DQI-P has been shown to be an accurate measure of diet quality in a group of pregnant American women. Specifically, it was found that with increasing overall DQI-P score, there was a statistically significant increasing trend for each of the ten components(25). The DQI-P was the first diet quality index composed of both food groups and nutrients to accurately assess diet quality in pregnancy(25). Furthermore, the DQI-P components are fairly easy to calculate using Canadian food and nutrient recommendations. The DQI-P has been used frequently in the literature to summarize pregnant women's diet quality in the United States, where the AHEI-P appears to be used less frequently(25-30). The authors of the PIN study have used the DQI-P to show that pre-pregnancy BMI is associated with diet quality in pregnancy and also that proximity to supermarkets is associated with diet quality(28, 29). The DQI-P has also been used by Harley and Eskenazi to show that social support is associated with diet quality among Pregnant Mexican American women(27). Finally, Watts and colleagues assessed diet quality in a group of low income Native American and Caucasian pregnant women using the DQI-P, where diet quality was found to be low in both groups(30).

2.4 Women's Dietary Intake during Pregnancy

Past studies have consistently demonstrated that women are not maintaining healthy diets throughout the duration of their pregnancies. This observation has been noted in various studies that have used different methods to assess diet quality and also, conducted in various developed countries across the world, including the United States and Canada(1, 3, 20, 30, 31).

2.4.1 Dietary Intake Research from Non-Canadian Studies

Two American studies used dietary indices to quantify diet quality in pregnancy and both studies found that diet quality was low on average. The one study used the AHEI-P to quantify diet and found that the participants in their study had a mean AHEI-P score of 61 out of a maximum possible score of 90(1). The other study used the DQI-P to compare diet quality of pregnant Caucasian and Native American women. These authors concluded that overall mean DQI-P scores for both pregnant Native American and Caucasian women were low, which indicated that they needed improvement(30).

Other research has shown that nutrient intakes, especially iron and folate, are below the recommended intakes for the majority of pregnant women studied. Data from the Third National Health and Nutrition Examination Survey (NHANES III; 1988-1994) assessed the diet quality of pregnant American women with 24-hour dietary recalls. It was found that the mean intake of dietary folate for pregnant women was well below the 520 μg/day recommendation at 288 μg/day. The mean intake of iron in pregnant women was 15.34 mg/day consumed through diet only, which is below the 22 mg/day recommendation for pregnancy(11). Furthermore, another study using NHANES data to assess adequacy of iron in pregnant American women by measuring actual serum levels of iron indicated that overall prevalence of iron deficiency of these women was 18 +/- 1.4%. Iron deficiency increased to approximately 30% when focusing on only women in their third trimester of pregnancy(31).

A prospective study of pregnant women in Portugal investigated diet quality prior to conception and throughout the duration of pregnancy and found that pregnant women were not consuming the recommended amounts of folate (90.8%) and iron (88%)(3). A large study conducted in Australia measured diet quality in women who gave birth within the past 12 months, who are currently pregnant, who are trying to conceive, and other women. In this study cohort, overall intakes of nutrients were higher for pregnant women but they were still not consuming recommended levels of iron(20). A cross-sectional study conducted in Brazil investigated iron consumption in pregnant and non-pregnant women and found that the pregnant women were less likely to have adequate intake of iron, which was observed mainly because of the increased recommendations for pregnancy(32).

2.4.2 Dietary Intake Research from Canada

Overall adequacy of diet quality in pregnancy for Canadian populations has been understudied, since population based surveys in Canada on diet quality generally exclude pregnant women; however, Canadian research of the general population can still be informative regarding diet quality of women during their reproductive years. Overall, non-pregnant and pregnant women in Canada appear to have low diet quality and are generally deficient in iron and folate(33-36).

A 2009 report by Health Canada has identified diet qualities of Canadian men and non-pregnant women based on data from the Canadian Community Health Survey. The mean HEI score was 58.8 out of a maximum score of 100; however, women's diet quality scores were generally higher than the men's scores(33). A population weighted Canadian study was conducted to describe the nutrient and energy intake of Canadians and it was found that women consumed low levels of folate, iron, and calcium in their reproductive years(34).

A few smaller Canadian studies have focused on pregnancy but, specifically addressed nutrient adequacy rather than overall diet quality. A sub-sample of pregnant women from the Canadian Community Health Survey was studied using a 24-hour food recall measure. This study used the EAR for iron during pregnancy (22 mg/day) to estimate adequate intake of iron and found that 85% of women did not meet the EAR from food sources alone(35). In another study, a sub-sample of pregnant Canadian women was recruited as part of a prospective randomized trial. The researchers estimated dietary folate intake from 3-day weighted food records and found that a substantial portion of the pregnant women (36%) had dietary folate intakes below the EAR and none of the women had intakes above the UL(36).

2.4.3 Dietary Intake Research from the Prenatal Health Project

Jennifer Fowler's Masters thesis examined dietary intakes for the first 1300 women in our study. Fowler compared the women's diets to the 1992 food guide to determine nutritional adequacy. She found that more than 75% of the women met the recommendations for milk and alternatives, and meat and alternatives; however, 65% and 90% of the women were not consuming the recommended servings for fruits/vegetables and grains respectively. Almost 5% of the women did not meet recommendations for any of the four food groups. Furthermore, only 19% of the pregnant women in this study met the recommendations for all four food groups. Women were more likely to meet the recommendations for all four of the food groups if this was not their first pregnancy(4). Since this analysis was completed, Health Canada published a new food guide which includes increases in the recommended number of servings for fruits and vegetables, and grain products(6).

Amrita Roy's Masters thesis studied a few aspects of nutritional intake, including both dietary intakes and supplement use. It was found that 31%, 18%, and 16% of pregnant women were below the RDA for iron, zinc, and folate respectively even when considering nutrients received from supplements as well as food(5). Roy and colleagues also investigated the relationship between zinc intake, stress, and depression and found that participants who consumed higher daily levels of zinc were less likely to exhibit symptoms of depression and participants who experienced more stress were more likely to show symptoms. Furthermore, a high average daily intake of zinc decreased the association between stress and symptoms of depression; therefore, zinc appeared to buffer the association between stress and symptoms(37).

2.5 Individual-level Determinants of Diet Quality in Pregnancy

Many individual-level factors have been identified in the literature that can have an influence on diet quality during pregnancy (please see table C.1 in Appendix C). These factors and their associations with diet quality during pregnancy are summarized below.

2.5.1 Age

There is general consensus found in the literature that age is positively associated with diet quality in developed countries, independent of the methods used to assess diet quality.

A large prospective cohort study conducted by Rifas-Shiman and colleagues in the United States found that pregnant women who were younger generally had lower AHEI-P scores, in other words, women who were older generally had better diet quality(1). Another large prospective cohort study assessed diet quality in pregnant American women using the DQI-P. This study also found that women who were older had significantly higher DQI-P scores overall(25). A New Zealand study conducted by Watson and McDonald used nutritional adequacy, food weight, and energy intake to determine diet quality. Watson and McDonald found that older women generally had better diet quality, particularly, women less than 30 years of age consumed less energy and a smaller median weight of food, therefore less protein and fibre, among other nutrients were consumed(2). Northstone and colleagues conducted a large population-based prospective study in the United Kingdom where they used PCA to determine various diet types among pregnant women and the association between diet and sociodemographic variables. These researchers discovered that age tended to be positively associated with a more healthy diet and negatively associated with an unhealthy diet, such as one characterized by sugars or high-fat foods(19). A large Finnish study conducted by Arkkola and team also used PCA to determine characteristics that would be associated with diet quality in pregnancy. The researchers found that diets characterized as 'Healthy' and 'Low-Fat Food' diets were positively associated with age, where unhealthier diets such as a 'Fast Food' diet were negatively associated with age(38).

2.5.2 Ethnicity

There are mixed results regarding the association between ethnicity and diet quality in pregnancy. This stems partly from the heterogeneity of studies on ethnicity, where studies choose different comparison groups that focus on specific ethnicities, or more broadly look at immigrants. Furthermore, ethnicity is such a difficult construct to accurately measure for research studies(39).

A large American study compared DQI-P scores for pregnant Caucasian and Native American women and found that both Caucasians and Native Americans had low DQI-P scores and were not significantly different from one another(30). There is some evidence that African Americans may have better diet quality overall compared to Caucasians. An American study conducted by Rifas-Shiman and colleagues did not discover a significant association between Caucasians and African Americans in regards to overall diet quality during pregnancy after adjusting for education and age; however, African American women tended to have some healthier dietary behaviours compared to Caucasian women, such as a greater intake of fruit, higher ratio of white to red meat, and less trans fat consumption(1). Another American study did find statistically significant results where African American women had higher intakes of grain and fruit servings compared to Caucasian women(25). In contrast, a study using NHANES data found Caucasian women to have higher total body iron than African American women(31).

A prospective cohort study of pregnant Mexican women who resided in the United States found that women who had spent their childhoods in Mexico rather than the United States were twice as likely to have a high diet quality(27). A study by Northstone and colleagues compared the diets of Caucasian women to non-Caucasian women and found that the "Health Conscious" diet type was negatively associated with non-Caucasian women and "Confectionary" diet type was negatively associated with Caucasian ethnicity, which indicated that in this case Caucasian women generally had better diet quality(19).

2.5.3 Marital Status

Most studies have not found an association between marital status and diet quality; however, these studies did not include a separate category for common-law women or women residing with a partner.

Two recent European studies found no association between marital status and diet quality during pregnancy; however, they both used nutrient intakes or food items consumed rather than a diet quality index(3, 19). An American study that used the DQI-P to assess diet quality in pregnancy found that women who were married had a significantly higher DQI-P than women who were single, separated, divorced, or widowed(28).

2.5.4 Parity

There is a fairly consistent finding in the literature that lower parity, or nulliparity, is associated with higher diet quality. Parity refers to the number of times a woman has given birth; nulliparous, refers to a woman who has never given birth.

Two large prospective cohort studies conducted in the United States came to similar conclusions in regards to diet quality and parity but used different diet quality indices to assess diet. Bodnar and Siega-Riz found that women who were nulliparous had significantly higher DQI-P scores overall(25). More recently, Rifas-Shiman and team found that women with lower parity had higher AHEI-P scores(1). Watson and McDonald found that women with a parity count of 2 or more consumed less energy and a smaller median weight of food(2). It has also been found using NHANES data that a parity of 2 or more is associated with less total body iron compared to pregnant women with a parity of 1 or 0(31). The research conducted by Northstone and colleagues found that a 'Health Conscious' diet type was negatively associated with parity(19). Similarly, Arkkola and team found that healthy diet patterns such as 'Healthy' diet and 'Low Fat Food' diet were negatively associated with parity; however, unhealthier diet types such as 'Fast Food' diet was also negatively associated with parity(38).

2.5.5 Planned Pregnancy

There is some evidence in the literature that planned pregnancy may be positively associated with diet quality in pregnancy. The evidence also indicates that women who plan their pregnancies may increase their supplementation, specifically of folic acid.

A prospective cohort study conducted in Portugal found that women who planned their pregnancies generally had more adequate vitamin E intake(3). A retrospective study conducted in Turkey found that 37% of mothers with unwanted pregnancies, 29.1% of mothers with unplanned pregnancies and 17.2% of mothers with planned pregnancies did not achieve the nutrient recommendations for pregnancy. These researchers also discovered that 24% of women with unwanted pregnancies reported that they changed their diet to meet pregnancy requirements compared to 75% of women with planned pregnancies(40).

An American, prospective study assessed the association of intended pregnancy within the next year with positive or negative changes in health behaviours. The authors reported that women who were considering pregnancy within the next year were more likely to report folic acid supplementation than women not considering pregnancy within the next year. However, pregnancy intention did not attain statistical significance in the multivariable logistic regression models for each of the health behaviour outcomes(41). A study conducted in England assessed the self-reported perceived barriers to healthy eating during pregnancy. The researchers found that women were more likely to take a folate supplement if the pregnancy was planned(42).

2.5.6 Education

A consistent relationship between greater educational attainment and better diet quality in pregnancy is generally found in the literature.

Bodnar and Siega-Riz found that women who were more educated had significantly greater DQI-P scores(25). More recently, Rifas-Shiman and colleagues used the AHEI-P index and also noted that pregnant women in the United States who were less educated had lower diet quality(1). Northstone and fellow researchers used PCA and found that women who had healthier diets were more educated(19). Arkkola and team reached the same conclusion as Northstone and colleagues using PCA where they concluded that 'Healthy' and 'Low-Fat Food' diet types were positively associated with education, where the 'Fast Food' diet type was negatively associated with education(38). The association between diet and education is less consistent when studies focus on specific nutrients. In a New Zealand study, Watson and McDonald found that education was associated with diet and accounted for the greatest amount of variance out of all the predictors studied. In particular, among women with the same energy intakes, more educated (≥5 years of high school or further education) women had higher intakes of important micronutrients for pregnancy such as folate and zinc(2). Pinto and team found that women with a greater education level were more likely to have adequate iron intake during pregnancy(3). Conversely, an American study conducted using data from NHANES did not find a significant association between education level and total body iron(31).

2.5.7 Occupation

There have only been a few studies in the literature that have focused on the association between occupation and diet quality in pregnancy; of these only one, to our knowledge, found a significant association.

Watson and McDonald found that occupation was associated with diet quality in pregnancy independent of the education status; however, few women in the study were employed so the occupation of the partner was used instead of the women. High occupation status, defined as higher professional/administrative, lower professional/technical, or clerical/highly skilled, was significantly associated with higher intakes of beta carotene, magnesium and vitamin E compared to the low occupation group (skilled, semi-skilled, or unskilled)(2). A study conducted by Pinto and colleagues measured occupation based on whether the women was employed, unemployed or a student and concluded that there was no statistically significant association between occupational status and diet quality during pregnancy(3).

2.5.8 Income

Similarly to occupation, to our knowledge, there is only one study in the literature that has found a significant association between income and diet quality in pregnancy, where other studies did not come to this conclusion.

Two different prospective cohort studies did not find a statistically significant association between income and diet quality during pregnancy(1, 3). Furthermore, a study focusing on total body iron of pregnant women who participated in NHANES did not find a statistically significant association between iron levels and income(31). One study conducted by Bodnar and Siega-Riz did find that women who had income levels that were greater than 350% of the poverty level had significantly greater DQI-P scores(25).

2.5.9 Nausea

There is no consistent relationship found for morning sickness and nausea in relation to diet quality during pregnancy in the literature. There is some evidence that an association may exist but the direction of this association is still questionable.

Research conducted by Watson and McDonald found that morning sickness was associated with diet, where women who experienced emesis during pregnancy had significantly lower intakes of energy, protein, carbohydrates, and fibre(2). Contrarily, Pinto and colleagues found that women who experienced nausea and vomiting during their first trimester were more likely to have sufficient iron intake than women who did not experience these symptoms(3). Rifas-Shiman and team found no association between morning sickness or nausea and diet quality within their prospective cohort study(1).

2.5.10 Physical Activity

A few studies in the literature have focused on physical activity and its association with diet quality in pregnancy and noted that there appears to be an association.

Laraia and colleagues found that women who engaged in vigorous leisure activity before pregnancy had significantly higher DQI-P scores than women who did not engage in vigorous leisure activity prior to pregnancy(28). Watson and McDonald found that activity level was only minimally associated with diet quality and explained these findings given that energy expenditure is only weakly associated with energy intake except for high levels of energy expenditure and in this study energy expenditure among the pregnant woman was not very high(2).

2.5.11 Smoking

There is mostly a consistent finding in the literature that non-smoking pregnant women generally have better diet quality compared to pregnant women who smoke.

In the study by Watson and McDonald, smoking during pregnancy was found to be significantly associated with a lower energy intake and lower intakes of carbohydrates, fat, and fibre(2). Northstone and colleagues found that a dietary pattern characterized by the 'Health Conscious' diet was negatively associated with smoking among pregnant women(19). Arkkola and team reached a similar conclusion where healthier diet patterns such as 'Healthy' and 'Low-Fat Food' diets were negatively associated with smoking and unhealthy diets such as, 'Fast Food' and 'Coffee' diet types were positively associated with smoking during pregnancy(38). However, Pinto and colleagues found no significant association between smoking during pregnancy and diet quality(3).

2.5.12 Mental Health: Depression, Stress, and Anxiety

Many of the studies that have focused on mental health and diet quality in pregnancy were interested in the effect that diet has on mental health, specifically depression, rather than if mental health predicts diet; regardless of the direction of the association, some of these studies still suggest that an association exists. Furthermore, the majority of these studies are interested in post-partum depression rather than depression status during pregnancy.

A Japanese study assessed the effect that overall diet may have on preventing the risk of post-partum depression. This study used PCA to describe diet patterns observed in the population of women studied and found that of the three patterns observed – Healthy, Japanese, and Western diets – a negative association with postpartum depression was observed between the second quartile of the Western diet compared to the first quartile; however, these authors concluded that diet did not appear to be a major factor for preventing post-partum depression(43).

Other studies have focused on specific nutrients and their potential to impact mental health. Another study on preventing post-partum depression conducted a clinical trial where pregnant women were randomized to receive either a calcium supplement or a placebo. This study found that at 12 weeks post-partum, the calcium treated group had significantly less evidence of depression(44).

One American study investigated the effects of anxiety, stress, and fatigue on diet quality in pregnancy; however, they used a convenience sample of women who were generally well-educated, non-smokers, married, and Caucasian. The researchers found evidence to suggest that fatigue, stress, and anxiety were associated with unhealthy diets among their sample. Women who were more fatigued had higher energy, carbohydrate, fat, protein, and zinc intakes. Stress was positively associated with greater intakes of energy; fat; protein; iron; zinc; bread; and the fats, oils, sweets, and snacks food group. Similarly, anxiety was positively associated with greater intakes of fats, oils, sweets, and snacks food group(45).

2.5.13 Social Support

Studies found in the literature tend to agree that greater social support is associated with better diet quality in pregnancy.

A small cross-sectional study conducted in the United States found that social support positively affected nutrition among low-income pregnant women. Specifically, social support received from everyone except from the partner increased health behaviours including nutrition(46). A small American nursing study found a positive association between social support and positive health practices, including diet quality among pregnant women(47). Harley and Eskenazi noted that social support may interact with immigrant status to influence diet quality. The researchers found that perceived social support increased diet quality among women who had spent their childhoods in Mexico but this was not observed from women who spent their childhoods in the United States(27).

2.6 Community-level Determinants

2.6.1 Access to Food Sources for the General Population

2.6.1.1 Food Deserts

Food deserts have been defined as socioeconomically deprived areas where healthy, affordable food is not readily accessible(48). A recent ecological study conducted by Larsen and Gilliland compared accessibility of supermarkets in 1961 to accessibility in 2005 in London, Ontario. These researchers found that large geographic areas were not within walking distance to supermarkets and that food deserts appeared to exist in Central and East London. Furthermore, the average proportion of the census tract population with easy supermarket access had decreased overtime from 45% in 1961 to 18.3% in 2005, where Central London was much better served in 1961 than in 2005(49).

Food deserts may have developed in London, Ontario partly due to the distribution shift of fresh food sources over time where small grocery stores throughout the city were forced to close because large superstores located in the suburbs had proliferated and attracted customers. Many wealthier residents had moved out of the city to the suburbs where many poorer residents remained in the city, where there is less availability of fresh food. This distribution shift of fresh food sources is especially problematic for the less wealthy residents of urban London who may not have access to a vehicle(49). It has also been theorized that food deserts may exist in some cities as a result of zoning laws. Zoning laws have also allowed fast food establishments to proliferate without limiting the quantity in a particular area, which has led to certain areas with a dense population of fast food restaurants(50).

2.6.1.2 Food Environment versus Built Environment

Researchers conducted a study in Erie County, New York to assess whether the food environment or the built environment had a greater impact on women's Body Mass Index (BMI). In terms of the food environment, they found that the number of restaurants available within a five minute walk of participants' homes was positively related to BMI. Furthermore, a greater distance from an unhealthy food source, such as a convenience store, relative to a healthy one was negatively related to BMI. There was a significant interaction between land use mix and the availability of restaurants within a five minute walking distance; although land use mix increases walkability, or physical activity, it may allow women to walk to restaurants more easily and result in an increased BMI(51).This study found that the food environment can influence the BMI of women, even women who reside in environments that promote physical activity. This alludes to the mechanism of increased BMI through unhealthy diet rather than lack of physical activity.

2.6.1.3 Determinants of Grocery Store Access

Associations between grocery store or supermarket access and neighbourhood-level variables were found to vary depending on the area studied. In Detroit, Michigan high residency African American communities were found to have poorer access to supermarkets(52). A study in the United Kingdom found that the most deprived communities only had poorer access in rural areas but actually had better access in urban areas(53). One study considered supermarket access throughout the United States and noted that urban areas in general had better access(54).

An ecological study conducted by Zenk and colleagues in Detroit, Michigan assessed which neighbourhood characteristics were associated with access to supermarkets and found that in general, the impoverished communities with higher proportions of African American residents had greater distances to the nearest supermarket. Neighbourhoods with medium and high African American residency had longer distances to travel to the supermarket than low residency African American neighbourhoods even when neighbourhood poverty levels were high. About a quarter of the residents in the neighbourhoods with medium and high African American density did not own a car; this fact combined with the further distances to supermarkets exacerbates the issue of poor supermarket access(52).

Different results were obtained in a similar ecological study that was conducted in the United Kingdom where it was found that poorer communities had shorter distances to supermarkets except in rural neighbourhoods. In general, median travel times to the nearest grocery store were shorter for the most deprived compared to the least deprived neighbourhoods. When stratified by type of neighbourhood, the same relationship above was found to be significant only for urban neighbourhoods; however, the opposite association was observed for rural neighbourhoods where the most deprived neighbourhoods were found to have longer travel times to stores with fresh produce. Therefore, the researchers concluded that it is not necessarily true that the most deprived neighbourhoods in the UK have greater travel times to grocery stores; rather, it seems to depend on the type of neighbourhood(53).

Recently, a large study of the conterminous United States was conducted that assessed supermarket proximity compared to fruit and vegetable consumption and obesity. Metropolitan areas were found to have shorter distances to small, medium, and large superstores than non-metropolitan areas. In metropolitan areas, obesity was positively associated with distance to supermarkets and fruit and vegetable consumption was negatively associated with proximity to supermarkets. No significant association was found in non-metropolitan areas between distance to supermarket with obesity or fruit and vegetable consumption(54).

2.6.2 Community-level Determinants of Diet Quality in Pregnancy

There appears to be a lack of literature regarding community-level determinants of the diet quality of pregnant women. There is one study that was conducted in the United States that used the DQI-P to assess diet quality in pregnancy and any significant associations there may be with some community-level variables(29). This study assessed the association between access to food sources and diet quality in pregnancy. On average, participants lived within two miles of supermarkets, grocery stores, and convenience stores. Density of food sources was not found to be associated with DQI-P; however, increased distances from supermarkets and convenience stores were found to be significantly associated with lower average DQI-P scores, where there was no association found for grocery stores. Women residing more than four miles from a supermarket were more likely to be in the lowest compared to the highest quartile for DQI-P even after controlling for grocery store and convenience store proximity(29).

2.7 Summary

Canada has specific nutrient and food recommendations for pregnancy, but it appears that many pregnant women, including London, Ontario women from the PHP cohort, are not meeting these criteria. Diet can be quantified in studies using different measures, such as food records, dietary recall, or FFQ, where diet quality is generally assessed in studies by using PCA or dietary indices. Diet quality in pregnancy appears to be consistently associated with the following individual-level variables: age, parity, education, social support, smoking, and physical activity. Inconsistent relationships between diet quality in pregnancy and ethnicity, marital status, planned pregnancy, income, occupation, nausea, and mental health (stress, anxiety, and depression) are observed in the literature. Furthermore, there is a lack of literature regarding the effects of community-level variables on diet quality in pregnancy but one study found that proximity to, but not density of, supermarkets and convenience stores was significantly associated with diet quality in pregnancy.

Chapter 3: Objectives & Hypotheses

3.1 Objectives

The objective was to identify the individual- and community-level determinants of diet quality during pregnancy, as measured by the DQI-P, in a Canadian cohort, and to assess the relative contributions of determinants.

Based on the literature, some relationships are still inconsistent. The gap addressed by this study is the lack of knowledge of the relative contributions of individual- and community-level determinants of diet quality in pregnancy.

Individual-level determinants investigated include age, immigrant status, marital status, parity, planned pregnancy, education level, workforce participation, household income level, financial difficulties affording food, nausea severity during pregnancy, exercise frequency/duration, smoking status during pregnancy, evidence of depression symptoms, state-trait anxiety levels, stress levels, and social support received from the family, friends, and partner.

The original community-level determinants to be investigated included proximity and density of grocery stores, convenience stores, and fast food restaurants within 500 metres and 1000 metres of participants' residences; and geographical residence, specifically, urban or rural location of participants' homes.

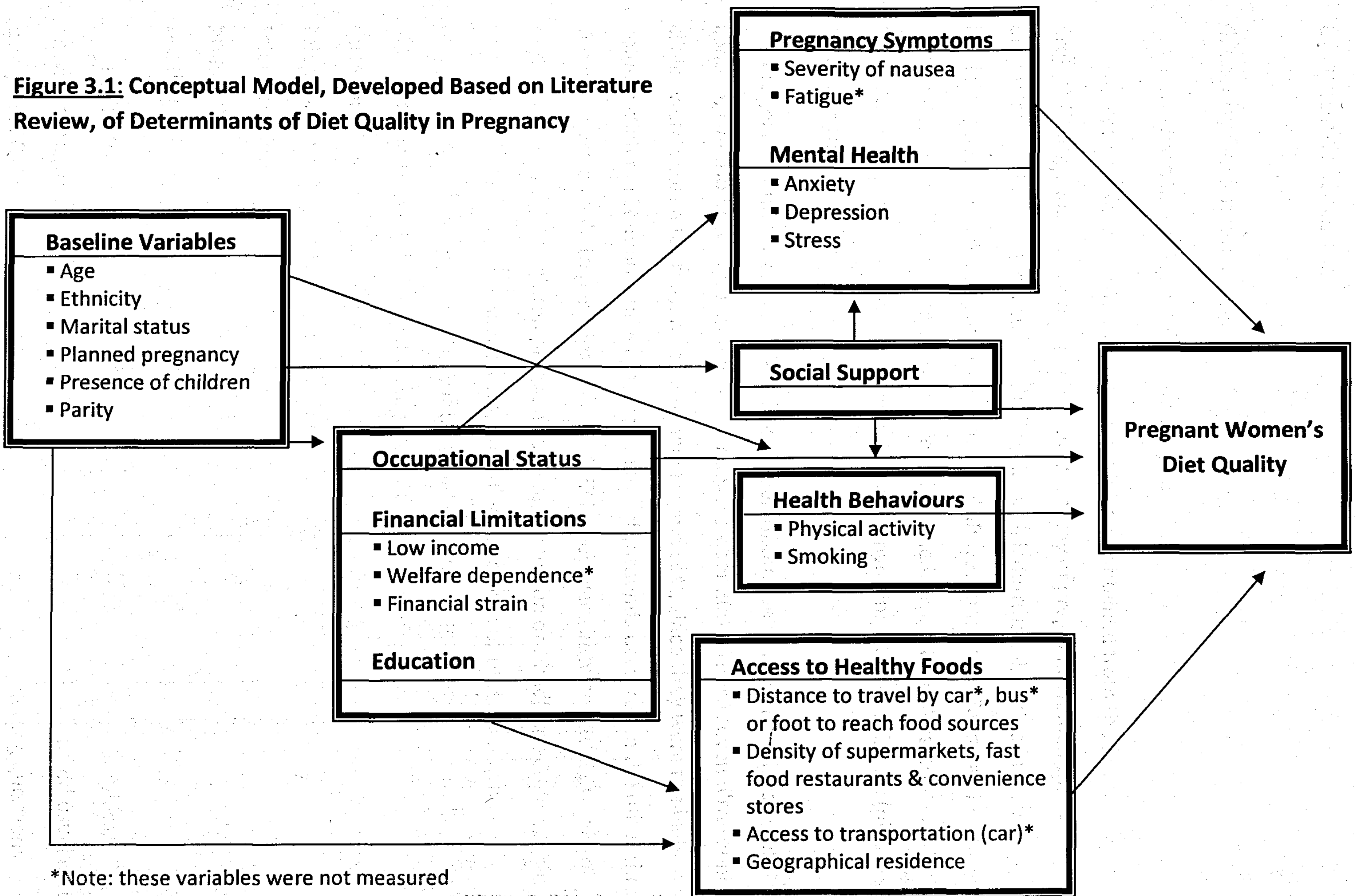
3.2 Hypotheses

These potential determinants of diet quality were selected from a literature review. From this literature review we hypothesized a conceptual model (figure 3.1), which underpinned the analyses in the study.

Further, we hypothesized that pregnant women would be at a greater risk of lower diet quality if they were: Canadian-born, younger in age, unmarried, less educated, employed full-time, a smoker, less physically active, had higher parity, an unplanned pregnancy, lower income, more financial difficulties affording food, severe morning sickness, less social support, and greater evidence of anxiety, stress, and depression.

In regards to the community-level variables, we hypothesized that lower diet quality would be associated with poor accessibility to grocery stores, greater accessibility to fast food restaurants, and greater accessibility to convenience stores.

Figure 3.1: **Conceptual Model, Developed Based on Literature Review, of Determinants of Diet Quality in Pregnancy**



*Note: these variables were not measured

Chapter 4: Methods

4.1 Study Design and Sample

4.1.1 Overview of Prenatal Health Project

The cohort of women in the present study were obtained from the Prenatal Health Project (PHP), which was a prospective cohort study of pregnant women that was originally developed to investigate the psychosocial, nutritional, endocrine, and infectious determinants of preterm birth. The PHP was funded by Canadian Institutes of Health Research (CIHR) in 2001 and approved by The University of Western Ontario Ethics Review Board for Health Sciences Research Involving Human Subjects (please see Appendix D).

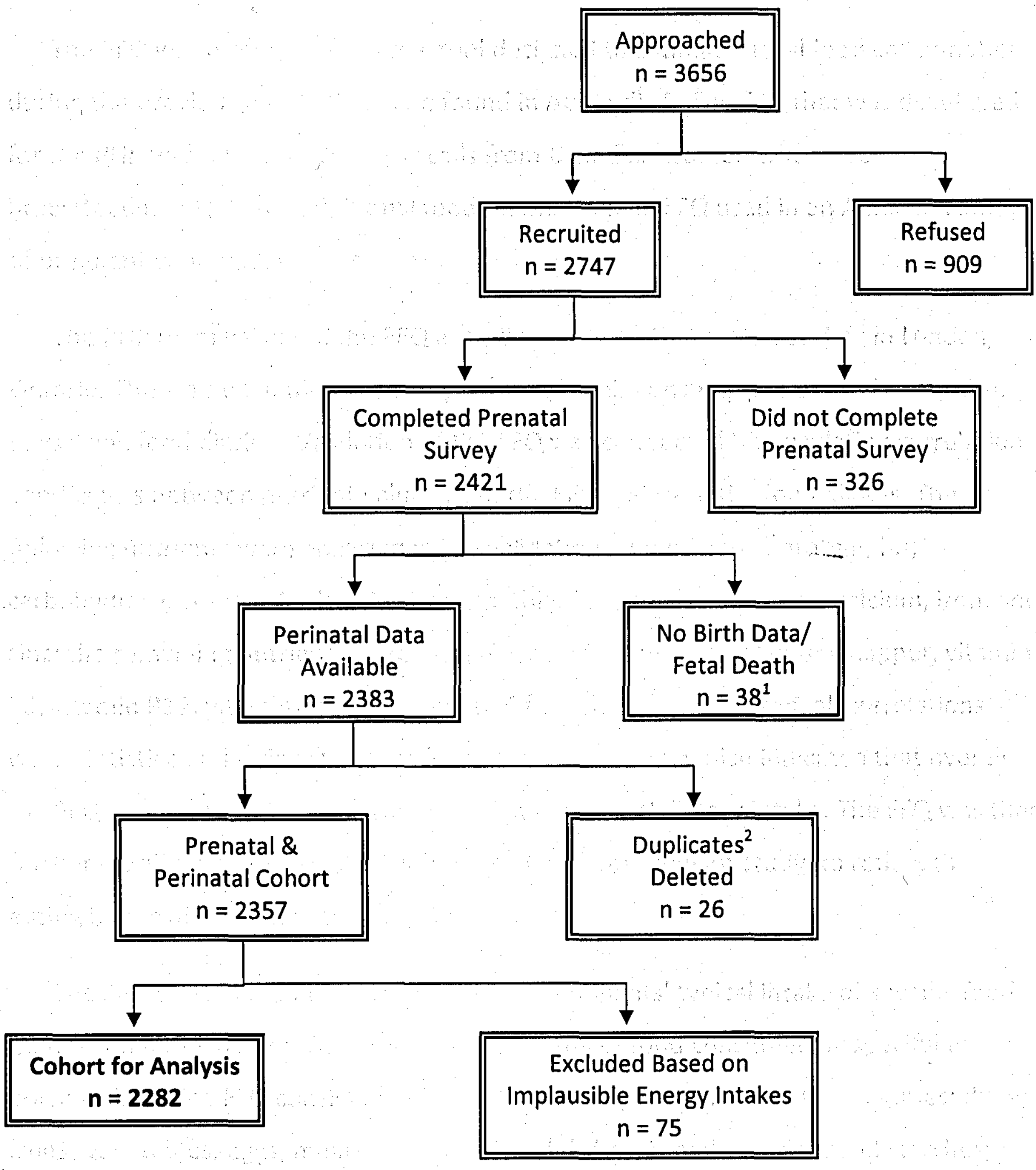
Pregnant women were recruited from seven of the ten ultrasound clinics across London, Ontario between January 2002 and December 2005. These seven ultrasound clinics were chosen for reasons of convenience and cost, since they were the highest volume clinics in London and very few prenatal ultrasounds occurred in the other three. Women were eligible to participate in the PHP if they were between 10-21 weeks of gestation, carrying a singleton pregnancy, living in London or Middlesex County, able to understand and sign the consent form, and 16 years of age or older; women were ineligible to participate in the study if they had any known fetal anomalies. Women who agreed to participate in the PHP were provided with a document that included questionnaire response keys and a copy of the FFQ, which were used to supplement the telephone interview. During recruitment an appointment was scheduled to conduct the telephone interview approximately one week after recruitment. A cohort of 2357 pregnant women completed the prenatal study and also had available birth data (please see figure 4.1).

The PHP questionnaire collected information on participants' demographics, previous pregnancies, health behaviours, social support, mental health, and usual diet using an FFQ. Some extracted pages of the PHP questionnaire, including questions regarding income and the FFQ, can be found in Appendix E. The participants' responses were recorded on scantron sheets, which were later scanned onto the computer and imported into the data management program, Microsoft Access, in an ASCII file type.

4.1.2 Linkage to Geographic Database

Participants of the PHP were linked to a geographic database by street address to assess proximity to different food retailers listed in a comprehensive food inventory database for the City of London and surrounding Middlesex County(55, 56). Communities were determined based on dissemination area (DA), which is a small and generally stable geographic unit composed of approximately one or two neighbouring blocks containing approximately 400 to 700 individuals(57).

Figure 4.1: Sample Flow Diagram of PHP



[1]21 participants had no birth data available and 17 participants experienced a fetal death
[2]Duplicates refer to women who were enrolled in the study twice for two different pregnancies; there were actually 27 duplicates but one participant had no birth data available anyway and was excluded for this purpose

4.2 Data Collection/Coding

4.2.1 Food Frequency Questionnaire

The FFQ was a semi-quantitative tool designed to estimate usual food consumption during the previous month; it can be found in Appendix E. The FFQ that was developed for the PHP was based on dietary recalls from Canadian women who were breastfeeding(58). Some additional foods came from an FFQ used in an American study of pregnant women(59).

The PHP team validated the FFQ in a pilot study of 22 women residing in London, Ontario. The women in the pilot study recorded their consumption of food over three days using food diaries. Validation of the FFQ was conducted by calculating correlation coefficients between nutrient values from the FFQ and from the food diaries. The following nutrients were analyzed in the validation study: energy, protein, fat, carbohydrate, vitamin A, vitamin C, niacin, thiamine, riboflavin, folate, calcium, iron, and zinc; the remaining nutrients were not analyzed: magnesium, selenium, copper, vitamin B6, vitamin B12, vitamin E, and vitamin D. Of the nutrients analyzed, all correlations were statistically significant except for thiamine and iron, which indicated that overall the FFQ was found to be an adequate measure of usual dietary intake. The FFQ was then further modified, in accordance with the results from the pilot study, to reflect the eating habits of women in London, Ontario.

The FFQ used in the PHP inquired about participants' typical intake of specific food items during the previous month and the quantity of food consumed by specifying portion sizes. The FFQ consisted of 106 food items divided into 7 food categories: dairy; fruits; vegetables; eggs, meats, fish, and mixed dishes; breads, cereals, and starches; beverages; and sweets, baked goods, and miscellaneous.

The participants described their frequency of consumption for each food item by choosing one of the following responses: never, 1-3 times/month, once/week, 2-4 times/week, 5-6 times/week, once/day, 2-3 times/day, or 4 or more times/day.

Nutritional intake, such as kilocalories, macronutrients, and micronutrients, were quantified from the FFQ using the CANDAT Nutrient Calculation System(60), which was based on the 2001 Canadian Nutrient File(61). Conversion into nutrient and energy values involved multiplying the weight of the portion size for each food item assigned in the FFQ by the food item's nutritional content.

4.2.2 Outcome Variable: Modified Diet Quality Index for Pregnancy

The Modified Diet Quality Index for Pregnancy (DQI-P_m) is an index that is intended to assess overall diet quality of pregnant women. We constructed the DQI-P_m, which is a modified version of the original DQI-P that was created and shown to be an accurate measure of diet quality in a population of pregnant women in the United States(25). Specifically, each component of the DQI-P showed a statistically significant trend with the overall DQI-P score; for example, an increasing grain component score was associated with an increase in overall DQI-P score. The DQI-P could also detect variations in diet quality by different maternal sociodemographic factors: income levels greater than 350% of the poverty line, older, nulliparous, and more educated women had statistically significant higher DQI-P scores(25).

The DQI-P_m is a continuous measure that contains six food, nutrient, and energy components that are important for pregnancy: recommended servings of grains and fruit/vegetables according to the 2007 Canada's Food Guide; recommended intake of folate, iron, and calcium based on DRIs; and recommended energy intake from fat according to Health Canada(6, 14).

The DQI-P_m was modified from the original index to be used in our cohort of Canadian women. The original DQI-P index included another component, 'the meal pattern score', which was not measured in our population and consequently was not included in the DQI-P_m. The American DQI-P had two separate components for fruit and vegetable food groups where they were considered one component for the DQI-P_m following the guidelines for Canada's Food Guide. The components of the original DQI-P were created based on the recommendations by the Food Guide Pyramid and the Dietary Guidelines for Americans where the DQI-P_m was based on recommendations in the 2007 Canada's Food Guide and by Health Canada. The DQI-P_m components along with food and nutrient recommendations for pregnancy are summarized in table 4.1.

Participants were included in the DQI-P_m creation only if they had all values for the 'fruit', 'vegetable' or 'grain' items in the FFQ. The different food items consumed by the participants assessed by the FFQ were grouped into their respective food groups: fruit/vegetables or grains according to Canada's Food Guide. All the items of the 'fruit' and 'vegetable' categories in the FFQ were included in the fruit/vegetables food group for the DQI-P_m except for red chili sauce, which is a condiment and tofu, which belongs to the meat and alternatives food group according to Canada's Food Guide. Potatoes, which were in the 'breads, cereals and starches' category in the FFQ, were included in the creation of the fruit/vegetables food group, also in agreement with Canada's Food Guide. All food items in the 'bread, cereals and starches' category in the FFQ represented the grain food group except for potatoes, French fried potatoes, and potato chips/corn chips.

Serving sizes used in the FFQ were adjusted to be in accordance with one serving size in Canada's Food Guide. FFQ serving sizes and Canada's Food Guide serving sizes for grains and fruit/vegetables are shown in table 4.2 and 4.3, respectively, along with the conversion factors. The frequency of consumption of food items in the FFQ, which included monthly and weekly intakes, were converted to daily intakes. The average intake frequency was chosen for the intake frequencies in the FFQ that included a range of values (table 4.4).

Daily intakes of Dietary Folate Equivalents (DFE), iron, and calcium ingested from food only (not supplements) were used to create the three nutrient components. The daily percentage of energy intake from fat was calculated using the daily energy consumption and the daily intake of fat values. One gram of fat provides nine kilocalories of energy, so fat consumption (in grams) was multiplied by nine to obtain the amount of energy provided from fat and then this value was divided by total energy consumed per day and then multiplied by 100%.

Component scores were created by using the daily intakes of each food or nutrient and applying the necessary component score calculation, which are provided in table 4.1. It is recommended that pregnant women consume two to three extra food guide servings per day, so the high end of the recommended servings for grains and fruit/vegetables food groups were chosen(6). The fruit/vegetables component was weighted more heavily than the other components because it is considering two important types of food, where each had a score out of 10 in the original DQI-P. In a recent study, a revised Canadian healthy eating index also scored their fruit/vegetables component out of 20 where the remaining components were scored out of 10(62). The component scores represented optimal consumption for each food group or nutrient with 10 being a perfect score for each item (or 20 for fruit/vegetables component); In other words, women who consumed at or above the recommended level for a food group/nutrient received the maximum score of 10 or 20 for that component.

The participants received a score for each of the six components, which were then summed to produce a total score out of 70. This score was then transformed to a percentage score to produce a final DQI-P_m score out of 100 (please see table 4.1 for scoring calculations).

Table 4.1: The 6 DQI-P_m Components: Recommended Daily Intakes & Score Calculations

Component	Recommendation	Score Calculation	Max Score	Max % Score
Grains	7 servings/day	(# daily servings of grains/7)*10	10	10/70*100%
Fruit/Vegetables	8 servings/day	(# daily servings of vegetables & fruit/8)*20	20	20/70*100%
Dietary Folate Equivalents	520 µg/day (EAR)	(µg/day of folate/520)*10	10	10/70*100%
Calcium	1000 mg/day ages ≥ 19 (AI) 1300 mg/day ages < 19 (AI)	(mg/day of calcium/1000)*10 (mg/day of calcium/1300)*10	10	10/70*100%
Iron	22 mg/day (EAR)	(mg/day of iron/22)*10	10	10/70*100%
% Energy from Total Fat	20-35%	≥19.5 and <35.5 = 10 <19.5 and ≥35.5 = 0	10	10/70*100%
Overall Diet	All the above	Sum of components	70	100%

Table 4.2: Food items included in Grains Component of DQI-P_m

Food Item in FFQ	FFQ Category	One Food Guide Serving	FFQ Serving	Conversion Factor
Bagel/English muffin	Grains	½	1	X2
Hot cereal	Grains	¾ cup	1 cup	X4/3
Cold cereal/bran flakes	Grains	30 g	1 cup	X1
Pancakes/waffles	Grains	1	2	X2
Muffin/biscuits	Grains	½	1	X2
Crackers	Grains	30 g (10 crackers)	1 cracker	X1/10
White/brown rice	Grains	½ cup	1 cup	X2
Pasta	Grains	½ cup	1 cup	X2
Other grains (couscous)	Grains	½ cup	1 cup	X2
White/whole wheat bread	Grains	1 slice	1 slice	X1

Table 4.3: Food Items included in Fruit/Vegetables Component of DQI-P_m

Food Item in FFQ	FFQ Category	One Food Guide Serving	FFQ Serving	Conversion Factor
Spinach	Vegetable	1 cup raw	½ cup cooked	X1
Tomatoes	Vegetable	½ cup	1 whole	X1
Romaine lettuce	Vegetable	1 cup	1 serving	X1
Celery	Vegetable	1 medium stalk	4 inch stick	X1
Mushrooms	Vegetable	½ cup	1	X 1/3
All other vegetables	Vegetable	½ cup	½ cup	X1
Potatoes	Grains	½ cup	1 cup	X2
Raisins	Fruit	2 oz (¼ cup)	1 oz (small pack)	X1/2
Cantaloupe	Fruit	½ cup	¼ melon	X1
Watermelon	Fruit	½ cup	1 slice	X1
Grapefruit	Fruit	½	½	X1
Berries	Fruit	½ cup	½ cup	X1
All juices	Fruit	½ cup	Small cup	X1
All other fruit	Fruit	1	1	X1

Table 4.4: Consumption Frequency in FFQ Converted to Daily Serving Sizes

Frequency in FFQ	Daily Serving Size
Never	0
1-3 times per month	0.0667
Once per week	0.1429
2-4 times per week	0.4286
5-6 times per week	0.7857
Once per day	1
2-3 times per day	2.5
4 or more times per day	4

4.2.3 Predictor Variables: Prenatal Health Project Variables

The following variables were chosen to be extracted from the prenatal survey, according to the conceptual model, to be considered as predictors of the DQI-P_m. The categorization process is described below for each of the predictor variables, where this process is summarized more succinctly in table 4.5.

Age

Mother's age at time of recruitment was calculated by subtracting the date of the mother's birthday from the PHP study recruitment date. Age remained as a continuous variable for the analyses.

Residency in Canada

Participants who reported having been born outside of Canada were asked what year they moved to Canada. Time residing in Canada for immigrants was determined by subtracting the year that the subject moved to Canada from the PHP study recruitment year. One variable was created and categorized into three groups that represented time in Canada: born in Canada, resided in Canada greater than 5 years, or resided in Canada 5 years or less. Five year time intervals were chosen because an American study conducted based on pregnant women who were born in Mexico found differences in health behaviours between women who were residing in the United States for 5 years or less compared to women who were living in the United States for more than 5 years(63).

Marital Status

Current marital status in the PHP was captured from a question with the following response categories: married; common law (or living as married); single or never married; separated or divorced; or widowed. None of the participants reported being widowed. Marital status was collapsed for the analyses into three categories: married; common law; single, never married, separated, or divorced. There is evidence in the literature to support the decision to categorize marital status into the aforementioned categories. Generally, the health status of adults residing with a partner more closely resembled the health status of divorced or separated adults than married adults, which supported our decision to group common-law women independently of married women(64). It has been found that women in these three categories differ in respect to health behaviours during pregnancy as well; specifically, common-law women were more likely to smoke and report feelings of depression and less likely to breastfeed during pregnancy than married women(65). Although the literature has demonstrated that never married/single women differ from divorced/separated women in terms of health status and health behaviour, these two groups of women were categorized together for the analyses because of the small sample size of women who classified themselves as divorced or separated.

Parity

Participants' self-reported their previous pregnancies (not including their current one), where this involved listing each year of pregnancy and whether this pregnancy resulted in a live birth, a stillbirth, or a miscarriage. The number of live births (counting twins and triplets as 2 and 3 births, respectively) were used for the parity count(66). Parity was dichotomized for the analysis into nulliparous versus parity of one or more.

Planned Pregnancy

Planned pregnancy was measured from participants' responses to a question asking whether their current pregnancy was planned. Respondents gave a binary yes or no response.

Education

The prenatal survey solicited the highest level of completed formal education in categories: elementary school, some high school, completed high school, some college or university, college diploma, university degree, trade school, or other. For the analysis, education was categorized into college or university; or other. The variable was categorized into a binary variable based on sample size since a high proportion of our population was college or university educated.

Work Force Participation

Participants were asked what best describes their current employment status where responses included: employed full-time; employed part-time; temporarily laid off or leave of absence; looking for work; homemaker; or other (student, self-employed, etc.). The responses, including 'other' responses, were re-categorized into the following three categories: not employed voluntarily; student, employed part-time, looking for work, on disability or sick leave; or employed full time. These categories were believed to reflect amount of free time, for example, women who were employed full-time might have had less time available to prepare healthy meals compared to women who chose not to be employed. Women who were occupied with school or looking for a job may have also had less time available to prepare nutritious meals than women who chose not to work.

Household Income

Participants were asked to report their best estimate of total household income before taxes last year from all members of their household and from all sources. The household income question can be found in Appendix E. Participants were asked if their income level was less than $30k or greater than or equal to $30k and then the question became more specific to narrow down the income range. Income levels were determined in this manner to minimize missing responses because some participants may have felt more comfortable disclosing a broad income range rather than a specific income. The income ranges were narrowed down to the following responses: less than 10k, 10k-14999, 15k-19999, 20k-29999, 30k-39999, 40k-59999, 60k-79999, 80k or greater, no income, don't know, refuse to answer. For the analysis, responses were categorized into three categories: less than 30k, 30k-79999, or ≥80k, where women who responded no income, don't know, or refuse to answer were coded as missing. The lower income cut-off was chosen because $30k is around the poverty line for an average Canadian family during the time of the survey(67). A higher income category of $80k or more was chosen because Canadian adults within this income category have been shown to differ from Canadian adults belonging to all other income levels in regards to physical health and self-reported health(68).

Difficulty Affording Food

Within a financial strain index, participants were asked "when you think of your financial situation overall, how difficult would you say it is to meet each of the following commitments?". Ten financial situations were included in the index but the only one that was included in this analysis was food. Participants' responses included: very difficult, somewhat difficult, not very difficult, or not at all difficult. The very difficult and somewhat difficult categories were collapsed for the analysis and this decision was based on sample size since few participants chose 'very difficult' and 'somewhat difficult' responses.

Nausea Severity

Severity of nausea was assessed by combining participants' binary responses for two questions: if they had changed their eating habits due to nausea or if they had visited a doctor due to nausea or vomiting. Participants were categorized into three categories based on nausea severity: did not change eating habits or visit the doctor due to nausea; changed eating habits but did not visit the doctor due to nausea; and visited the doctor due to nausea, regardless of whether or not they changed their eating habits.

Physical Activity

Participants self-reported their exercise frequency and duration. Responses for exercise frequency included: never, once or twice a month, once or twice a week, 3-4 times a week, or 5 or more times a week. Responses for duration included: less than 15 minutes, 15-29 minutes, 30-60 minutes, or more than 1 hour. Frequency and duration of exercise were combined to create a variable that estimated whether the participants were within the recommended exercise guidelines. The Public Health Agency of Canada recommends 30 minutes of moderate exercise for four days per week(69). Participants were categorized as under-exercisers, optimal exercisers or over-exercisers based on the following: under-exercisers exercised twice a week or less for 60 minutes or less (also includes never exercisers) or 3-4 times per week for 29 minutes or less; optimal exercisers exercised 3-4 times a week for 30-60 minutes each time and; over-exercisers exercised for over an hour each time and/or 5 or more times a week. Our decision to categorize exercise in this manner was based on two studies from the United States that also categorized physical activity based on whether or not pregnant women met the recommendations for physical activity(70, 71).

Smoking Status during Pregnancy

Participants provided data on whether they have ever smoked. If they responded no then they were coded as a non-smoker. If the participant responded yes then they were asked how many cigarettes they typically smoked per day now (during their pregnancy). Participants who responded that they were not currently smoking any cigarettes were also coded as non-smokers and participants who responded that they were currently smoking one or more cigarettes per day were classified as smokers. For the statistical analysis smoking status during pregnancy was a binary variable.

Depression

The Centre for Epidemiological Studies Depression Scale (CES-D) is a 20-item index used to assess depression symptoms(72). Participants were asked how often they felt a certain way over the past seven days, where most of the statements were feelings or symptoms associated with depression and only 4 of the 16 statements referred to positive feelings. Responses to statements included: rarely or none of the time (less than 1 day), some or a little of the time (1-2 days), occasionally or a more moderate amount of time (3-4 days), or most or all the time (5-7 days). Points were assigned to each of the responses from 0 for rarely or none of the time to 3 points for most or all of the time. The following 4 positive statements were reverse scored: 'I felt that I was just as good as other people', 'I felt hopeful about the future', 'I was happy', and 'I enjoyed life'. The CES-D score totals were produced by summing the points received for each of the 20 items. This variable was coded as binary in the analysis where participants with scores greater than or equal to 16 were classified as having evidence of depressive symptoms(72).

Stress

Chronic Strain

There were six indices in the prenatal survey that assessed chronic strain: family strain, general strain, relationship strain, caregiver strain, economic strain, and occupational strain. There were 29 items used to assess family, relationship, general, and occupational strain, which were extracted from Wheaton's original scale consisting of 51 items(73). For each item, respondents were asked how true the following statements were and to respond with either not true, somewhat true, or very true. Responses were scored as follows: not true = 0, somewhat true = 1, and very true = 2. Participants who were not in a relationship or who were not employed at the time of the survey were assigned a score of 0 for the relationship strain scale or the occupational strain scale, respectively. A 7-item scale was used to assess caregiver strain(74). Respondents were asked how well each statement described them and were given the choices: completely, quite a bit, somewhat, or not at all. Responses were reverse scored where completely = 3 points, quite a bit = 2, somewhat = 1, and not at all = 0. Five of the questions referred to being in a caregiver role in general where the other two questions referred directly to the participants' own children, thus participants without children were assigned a score of 0 for those two items. Economic strain was assessed with a 10-item scale(75). Participants were asked what they thought of their financial situation, how difficult it was for them to meet specific commitments. Responses included: very difficult, somewhat difficult, not very difficult, or not at all difficult. Responses to economic strain were reverse scored where very difficult = 3 points, somewhat difficult = 2, not very difficult = 1, and not at all difficult = 0. Scores for the responses for each of the 6 scales were summed.

Stressful Life Events

Stressful life events that affected the participants within the previous 12 months were assessed using a 40-item index. Stressful life events also occurring to their partner or children were included for 19 of the items and 9 items assessed stressful life events involving relatives or close friends as well(76-79). A number was assigned for each stressful life event statement according to the number of people affected by such event, for example, if both the participant and her partner were affected by an event then the participant would receive a point of 2 for that item. All the points for the 40 items were summed to produce a total score for stressful life events.

Total Stress Score

The scores for the chronic strain and the stressful life events were standardized then these two variables were summed and the total was standardized to produce a total composite stress score with a mean of 0 and a standard deviation of 1. This total standardized, continuous variable was used in the analyses. Higher scores indicated greater levels of perceived stress.

Anxiety

Anxiety was assessed using an abridged 12-item scale of the Speilberger State Trait Anxiety Index (STAI)(80, 81). Participants were asked how often they felt a certain way over the past week where responses included: not at all, somewhat, moderately so, or very much so. Negative statements were coded from 1 for not at all to 4 for very much so, where positive statements were reverse coded. Scores for each item were summed to produce an overall STAI score where higher scores indicated greater levels of anxiety. This index remained as a continuous variable for the analysis and was standardized to a mean of 0 and a standard deviation of 1.

Social Support

Social support was measured using three scales that assessed social support received from the partner, family (other than the partner), and friends. Social support from the partner was assessed with a seven-item scale; social support from family and social support from friends were each assessed using an eight-item scale. Participants responses to each item included: strongly agree, agree, neither agree nor disagree, disagree, or strongly disagree. Participants' responses were assigned points in decreasing order from 4 points for strongly agree to 0 points for strongly disagree. The points for all the items in each scale were summed to produce the three total social support scores for the partner, family, and friends. Individuals without a partner were assigned a score of 0 for the partner social support scale. A higher score indicated greater social support. Each social support variable was standardized to a mean of 0 and a standard deviation of 1 and these standardized, continuous variables were used for the analysis(79).

Table 4.5: Prenatal Health Project Predictor Variables Creation and Coding

Variables	Questions Available in Dataset	Original Coding in Dataset	Re-Coding for Analysis
Age	Date of birth	Recruitment date, birth date	Age = recruitment date – birth date Continuous, rounded down to the year
Residency in Canada	What country were you born in?	Canada, list of other countries	Canada, other Years in Canada = recruitment year – year came to Canada Three categories: born in Canada, > 5 years, ≤ 5 years
	What year did you come to Canada?	Numeric lists of years	
Marital Status	What is your current marital status?	Married, common-law, single/never married, separated/divorced, or widowed	Three categories: Married; common-law; single/never married, separated/divorced
Parity	List of previous pregnancies	Count variable	Number of previous live births Binary: 0, ≥1
	Outcomes of previous pregnancies	Live birth, stillbirth, or miscarriage	
Planned Pregnancy	Was the current pregnancy planned?	Yes or no	Binary: yes, no
Education	What is the highest level of formal education you have completed?	Elementary school, some high school, high school, some college/university, college, university, trade school, or other	Binary: college/university, other
Workforce Participation	What best describes your current employment status?	Employed full-time, employed part-time, temporarily laid off/leave of absence, looking for work, homemaker, or other (students, self-employed, etc.)	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?	< 10k, 10k-14999, 15k-19999, 20k-29999, 30k-39999, 40k-59999, 60k-79999, or ≥ 80k	Three categories: < 30k, 30k-79999, ≥80k

Difficulty Affording Food	Extracted from a financial strain index: perceived difficulty level affording food	Very difficult, somewhat difficult, not very difficult, or not at all difficult	Three categories: very/somewhat difficult, not very difficult, not at all difficult
Nausea Severity	Have you changed your eating habits due to nausea…?	Yes or no	Three categories: did not change eating habits or visit the doctor due to nausea; changed eating habits but did not visit the doctor due to nausea; visited the doctor due to nausea (regardless of whether or not they changed their eating habits)
	Have you visited a doctor due to nausea or vomiting?	Yes or no	
Physical Activity	How often do you currently exercise?	Never, once or twice a month, once or twice a week, 3-4 times a week, or 5 or more times a week	Three categories: under-exercisers (twice a week or less for 60 minutes or less, 3-4 times/week for 29 min or less); optimal exercisers (3-4 times/week for 30-60 minutes); over-exercisers (5 or more times a week and/or more than an hour each time)
	What is the duration of your exercise?	Less than 15 min, 15-29 min, 30-60 min, or more than 1 hour	
Smoking	Have you ever smoked?	Yes or no	Binary: smoker (ever smoker who smokes at least 1 cigarette now), non-smoker (never smoker or ever smoker who smokes 0 cigarettes now)
	How many cigarettes do you typically smoke now?	Numeric response	
Depression	The Center for Epidemiological Studies Depression Scale (CES-D)	Index with continuous data	Binary: evidence of depressive symptoms (CES-D ≥ 16), lack of evidence of depressive symptoms (CES-D < 16)
Stress	Stress scales: chronic strain scales (family strain, general strain, relationship strain, caregiver strain, economic strain, and occupational strain) and stressful life events scales	Indices with continuous data	Sum of chronic strain and stressful life event scales Continuous, standardized
Anxiety	State Trait Anxiety Index (STAI)	Index with continuous data	Continuous, standardized
Social Support	Social support scales: perceived social support from partner, family, and friends	Indices with continuous data	Separate scores for partner, family, and friends Continuous, standardized

4.2.4 Predictor Variables: Geographic Variables

Food stores used in this study included convenience stores, fast food restaurants, grocery stores, and grocery stores or local markets with fresh food. Food venues in London and Middlesex were classified into these four categories based on a food inventory database(55, 56).

Proximity Variables

There were four variables that described proximity of food sources in relation to participants' residences: distance to nearest convenience store, distance to nearest fast food restaurant, distance to nearest grocery store, and distance to nearest grocery store or local market with fresh food. These proximity variables were determined using the street network file and the Network Analyst extension in the software, ArcGIS 9.3. These variables represented the shortest pathway along the street network from the participants' residences to the specific food venue. They were measured in metres but converted to kilometres and retained as continuous variables for the analysis.

Density/Presence Variables

There were eight density variables that described food establishments surrounding participants' homes: number of convenience stores, number of fast food restaurants, number of grocery stores, and number of grocery stores or local markets with fresh food. Each of these variables was assessed within 500 metres (approximately a five minute walk) and 1000 metres (approximately a ten minute walk) of participants' residences. The density variables were created using the Network Analyst extension of ArcGIS 9.3 to determine the number of food establishments within 500 metres and 1000 metres from participants' residences. The density variables were measured as count variables but were coded as binary variables for the analysis, where participants had either no food establishments or any food establishments within 500 or 1000 metres from their residences. These binary variables represented presence of food sources, in contrast to the density variables, which measured number of food sources.

Geographic Residence

Women were categorized as urban or rural where women residing in the suburban areas were classified as rural, according to the classification by Statistics Canada(82).

4.3 Data Analysis

All statistical analyses were conducted in SAS 9.2. Participants were excluded from the analyses if they had an energy intake value not within two standard deviations of the sample mean, which would indicate implausible energy consumption (please see Appendix F for calculation). Missing values for variables were dealt with using pairwise deletion, where participants were excluded from certain analyses if they had missing data for the particular variable used in that analysis.

4.3.1 Descriptive

For the binary and categorical predictor variables, the proportion of women within each category was calculated. The means, medians, and standard deviations were calculated for the continuous predictor variables. The means, medians, and standard deviations were also calculated for the overall DQI-P_m scores and for each DQI-P_m component. The frequency and percent of women who had sufficient intake for overall DQI-P_m and for each component, with and without considering nutrients consumed through supplements, were noted. Criteria used to determine sufficiency for each component and overall DQI-P_m score can be found in table 4.1.

4.3.2 Univariable Regression

Univariable linear regression was conducted for all the variables on DQI-P_m and regression coefficients, p-values, and confidence intervals were obtained.

4.3.3 Consideration of a Multi-Level Analysis

An Intraclass Correlation coefficient (ICC) was calculated to determine the proportion of the variance in DQI-P_m that may exist at the community-level using DA as a proxy for community (see Appendix G). This analysis suggested that the proportion of the variation found at the community-level was not significant and that a multi-level analysis may be unnecessary, since there would only be a small proportion of the variance to explain. It was decided that the geographic variables would be retained as individual-level variables and that all analyses would be conducted at the individual-level.

4.3.4 Multivariable Regression

Multivariable linear regression was conducted with the predictor variables on DQI-P_m. Modeling was conducted as a stepwise procedure where variables were entered in blocks according to the conceptual model (figure 3.1) with automated backwards elimination at each step. Variables were entered into the multivariable regression if they were significant (p-value less than 0.2) in the univariable analysis. The first block of variables was entered into the analysis and the variable with the largest p-value (greater than 0.2) was backward eliminated. Variables were eliminated one by one until all variables in the model had p-values less than 0.2. Subsequently, the next block of variables was entered and the process was repeated until all variables were entered and all p-values were less than 0.2. Three models were conducted from the three accompanying blocks. The third model was trimmed using backward elimination to create a parsimonious model with only variables that were significant at a p-value less than 0.05. Beta coefficients, p-values, and confidence intervals were calculated.

Two of the presence variables were found to be quite similar after re-coding from ordinal to binary: presence of grocery stores and presence of grocery stores or local markets. Thus, only one of these two variables could be used in the analysis, so the presence of grocery stores or local markets with fresh food variable was chosen to be used in the analysis because it provided more detail regarding availability of fresh food compared to only grocery stores.

A decision was reached to only include the number of food sources within 500 metres variables in the multivariable analysis and not include number of food sources within 1000 metres or distances to food sources variables since these three variable categories measured similar constructs and were thus highly correlated.

Interactions between fast food restaurants within 500 metres of participants' homes and specific social determinants (income level and marital status) were investigated. A two degree of freedom (DF) test for interaction was conducted for each interaction separately within the parsimonious model. Interactions were considered statistically significant at a p-value less than 0.05.

A sensitivity analysis was conducted using backwards elimination, rather than stepwise entry of variables with backwards elimination at each step, to determine if similar results would have been achieved regardless of the model building procedure used.

Chapter 5: Results

5.1 Descriptive Results

After exclusion of women outside of 2 SD for energy intake, the total sample size was 2282 women. The 2282 women of the PHP resided in 555 different communities or DAs. The average number of women per DA was 4 with a mode of 2 women per DA. Number of women per community ranged from 1 to 40 women; however, 105 communities only had one resident of the PHP where only one community had 40 residents (please see table 5.1).

The characteristics of the sample are described in table 5.2 for categorical and binary variables and table 5.3 for continuous variables. The variables with the most missing values were stress with 131 women missing and household income with 120 women missing. The median age of the women in our cohort was 30 years old. A high proportion of the sample was married (77%), college or university educated (72%), and employed full-time (63%). Half of the women in the sample were nulliparous and 73% planned their pregnancies. Forty-seven percent of the women lived within 500 metres of at least one convenience store, 33% lived within 500 metres of at least one fast food restaurant, and only 11% lived within 500 metres of at least one grocery store or local market with fresh food. Furthermore, the median distances to the nearest fast food restaurant and grocery store were 477 metres and 931 metres, respectively.

The descriptive statistics for the DQI-P_m score and each component are displayed in table 5.4. The median DQI-P_m score for our cohort was just below 80% where only 2.45% of women were found to be sufficient for all the components and thus achieved the maximum DQI-P_m score of 100%. On average, women were not consuming the recommended servings for grains and fruit/vegetables with median servings of 4.21 and 6.93, respectively. Also, only 4.73% of women in our cohort were found to have sufficient iron intake through diet alone.

5.2 Univariable and Multivariable Regression Results

Results for the univariable and multivariable regressions of DQI-P_m on predictor variables are displayed in table 5.5. Please note that dashed lines in the table represent variables that were entered and subsequently backward eliminated; or in the case of variables that were insignificant in the univariable analysis, were not entered into model 1. The shaded cells in the table represent variable blocks that have not yet been entered into the model.

Among the geographic variables that were not included in the multivariable analysis, only the variable measuring presence of convenience stores within 1000 metres was significant; specifically, women residing within 1000 metres of at least one convenience store had 1.7% (95% CI = -3.26%, -0.15%) lower DQI-P_m scores than women not residing within 1000 metres of any convenience stores. Fast food restaurants and grocery stores or local markets within 1000 metres, and distances to nearest convenience stores, fast food restaurants, and grocery stores were not found to be significant in the univariable analyses.

All three variables assessing presence of food sources within 500 metres of participants' residences were significant in the univariable analyses at a p-value less than 0.2. Specifically, all three variables indicated that residing within 500 metres of at least one compared to none of the particular food venues resulted in lower diet quality.

Workforce participation and geographical residence were both insignificant ($p \geq 0.2$) in the univariable analyses and subsequently, were not included in the multivariable analysis.

The following variables were significant at a p-value less than 0.2 in the univariable analyses but did not retain significance after all the blocks were entered. Planned pregnancy was backward eliminated from the multivariable analysis when added in model one. Age retained statistical significance in model one but was no longer significant in model two. Difficulty affording food did not retain significance in the multivariable model when added in model two. Household income level was significant in model 2 but was backward eliminated in model 3. Depression, social support from the partner, presence of convenience stores within 500 metres, and presence of grocery stores or local markets within 500 metres were all entered into model three but did not retain significance and were subsequently backward eliminated.

Stress was significant in the univariable analysis and was entered in the multivariable model but there were concerns with multicollinearity so stress was selectively removed from the multivariable analysis; this is discussed in further detail in Appendix H.

The following variables were significant in model three at a p-value of 0.2 but were not at a significance level of 0.05 and as a result, were not included in the parsimonious model: education level, nausea severity, friend social support score, and presence of fast food restaurants within 500 metres of participants' homes.

Residency in Canada, marital status, parity, physical activity, smoking, anxiety levels, and social support from the family were the only variables that remained significant at a p-value less than 0.05 in the final parsimonious model. Recent immigrants who had resided in Canada for five years or less were found to have a 3.31% (95% CI=0.44%, 6.19%) increase in DQI-P_m score compared to women who were born in Canada. Compared to married women, common-law women had a 3.07% (95% CI=-4.97%, -1.16%) decrease in DQI-P_m score. Women with a parity of one or more were found to have a 2.57% (95% CI=1.27%, 3.88%) increase in DQI-P_m score compared to nulliparous women. Women who were classified as under-exercisers had a significantly lower DQI-P_m score than women classified as optimal exercisers; specifically, on average scores were 3.66% lower (95% CI=-5.54%, -1.79%). Smokers compared to non-smokers had a 3.28% lower DQI-P_m score (95% CI=-5.61%, -0.94%). For the relationship between anxiety levels and diet quality, with each standard deviation increase in the STAI score, DQI-P_m decreased by 0.95% (95% CI=-1.64%, -0.26%). Greater perceived social support from the family was found to be associated with an increase in DQI-P_m scores;

specifically, one standard deviation increase in the family social support score was associated with a 0.73% (95% CI=0.05%, 1.42%) increase in DQI-P_m score.

The interactions investigated of presence of fast food restaurants within 500 metres with marital status and with income were both found to be insignificant a p-value of 0.05. Please refer to table 5.6.

The same results were obtained for the sensitivity analysis using backwards elimination, where model 3 and the parsimonious model remained unchanged.

Table 5.1: Frequency of DAs with Specified Number of Women per DA

# of Women per DA	Frequency of DAs	% of DAs
1	105	18.92
2	113	20.36
3	84	15.14
4	72	12.97
5	59	10.63
6	42	7.57
7	19	3.42
8	18	3.24
9	6	1.08
10	9	1.62
11	8	1.44
12	6	1.08
13	1	0.18
14	2	0.36
16	3	0.54
17	3	0.54
20	1	0.18
22	2	0.36
39	1	0.18
40	1	0.18
TOTAL	555	100

Table 5.2: Descriptive Statistics for Sample: Binary & Categorical Variables (N = 2282)

Predictor Variables (Binary/Categorical)		N	Frequency (%)	Missing
Residency in Canada	Lifetime (born in Canada) >5 years ≤5 years	2267	1931(85.18) 213(9.40) 123(5.43)	15
Marital Status	Married Common-law Single/separated/divorced	2281	1759(77.12) 349(15.30) 173(7.58)	1
Parity	0 ≥1	2282	1131(49.56) 1151(50.44)	0
Planned Pregnancy	No Yes	2282	626(27.43) 1656(72.57)	0
Education Level	Completed university/college Other	2279	1638 (71.87) 641(28.13)	3
Work Force Participation	Employed full-time Employed part-time[1] Not employed voluntarily	2265	1425(62.91) 528(23.31) 312(13.77)	17
Household Income	< 30k 30k-79,999 ≥80k	2162	246(11. 38) 1086(50.23) 830 (38.39)	120
Difficulty Affording Food	Very/somewhat difficult Not very difficult Not at all difficult	2279	177(5.13) 596(26.15) 1566(68.71)	3
Nausea Severity	No diet change/doctor visit Changed diet/no doctor visit Visited doctor[2]	2277	898(39.44) 997(43.79) 382(16.78)	5
Exercise	Under-exercisers Optimal Over-exercisers	2278	1570(68.92) 328(14.40) 380(16.68)	4
Smoking during Pregnancy	No Yes	2266	2040(90.03) 226(9.97)	16
Depression (CES-D)	No Yes	2268	1851(81.61) 417(18.39)	14
Geographical Residence	Rural Urban	2275	132(5.80) 2143(94.20)	7
Presence of Convenience Stores within 500 m	0 ≥1	2272	1192(52.46) 1080(47.54)	10
Presence of Fast Food Restaurants within 500 m	0 ≥1	2273	1517(66.74) 756 (33.26)	9
Presence of Grocery Stores or Local Markets within 500 m	0 ≥1	2275	2032(89.32) 243(10.68)	7
Presence of Convenience Stores within 1000 m	0 ≥1	2272	510(22.45) 1762(77.55)	10
Presence of Fast Food Restaurants within 1000 m	0 ≥1	2273	674(29.65) 1599(70.35)	9
Presence of Grocery Stores or Local Markets within 1000 m	0 ≥1	2275	1547(68.00) 728(32.00)	7

[1]Also includes students, unemployed but looking for job, and on disability/sick leave

[2]Subjects visited the doctor but may or may not have changed their diet due to nausea

Table 5.3: Descriptive Statistics for Sample: Continuous Variables (N = 2282)

Predictor Variables (Continuous)	N	Mean	Median	SD	Missing
Age (years)	2282	29.61	30.00	4.98	0
Stress (standardized)	2151	0.00	-0.16	1.00	131
Anxiety (STAI; standardized)	2277	0.00	-0.16	1.00	5
Social Support from Partner (standardized)	2281	0.00	0.37	1.00	1
Social Support from Family (standardized)	2278	0.00	0.44	1.00	4
Social Support from Friends (standardized)	2274	0.00	-0.12	1.00	8
Proximity of Nearest Convenience Store (Km)	2275	0.58	0.36	0.99	7
Proximity of Nearest Fast Food Restaurant (Km)	2275	0.71	0.48	1.25	7
Proximity of Nearest Grocery Store (Km)	2275	1.24	0.93	1.68	7
Proximity of Nearest Grocery Store or Local Market (Km)	2275	1.05	0.89	0.92	7

Table 5.4: DQI-P_m Components: Descriptive Statistics & Sufficient Intake (food only and food + supplements)

Variable	Mean	Median	SD	Missing	# with Sufficient Intake: food only	# with Sufficient Intake: food + supplements (%)
DQI-P_m (%)	77.07	79.65	15.73	15	56(2.47)	107(4.85)
Grains (servings/day)	4.51	4.21	1.99	6	261(11.47)	N/A
Fruit/Vegetables (servings/day)	7.43	6.93	3.38	10	860(37.85)	N/A
Fat Energy (%)	28.92	28.87	4.23	0	2107(92.33)	N/A
Calcium (mg/day)	1087.90	1122.27	431.09	0	1319(57.80)	N/A*
Iron (mg/day)	13.13	12.65	4.61	0	108(4.73)	1575(69.02)
Dietary Folate Equivalents (µg/day)	468.97	447.85	164.00	0	758(33.22)	1913(83.83)

*No quantitative variable for calcium supplement

Table 5.5: Univariable & Multivariable Linear Regression of Diet Quality (DQI-P_m) on Predictor Variables

Predictor Variables		Beta (p-value)				
		Univariable[1]	Model 1 N=2252 R^2=0.024	Model 2 N=2134 R^2=0.026	Model 3 N=2086 R^2=0.048	Parsimonious[2] N=2209 R^2=0.046
Age[3]		0.27(<.0001)	0.11(0.1164)	----------------	----------------	----------------
Residency in Canada	Lifetime (born in Canada)	Reference	Reference	Reference	Reference	Reference
	> 5 years	-0.52(0.6489)	-0.88(0.4377)	-0.80(0.4960)	-0.99(0.4046)	-0.89(0.4355)
	≤ 5 years	3.56(0.0153)	2.98(0.0420)	3.71(0.0194)	3.79(0.0160)	3.31(0.0239)
Marital Status	Married	Reference	Reference	Reference	Reference	Reference
	Common-law	-4.73(<.0001)	-4.09(<.0001)	-2.98(0.0034)	-2.54(0.0142)	-3.07(0.0016)
	Single/separated/divorced	-5.16(<.0001)	-4.29(0.0009)	-2.26(0.1259)	-1.27(0.3833)	-2.42(0.0666)
Parity	0	Reference	Reference	Reference	Reference	Reference
	≥1	2.16(0.0011)	1.56(0.0237)	2.17(0.0012)	2.61(0.0001)	2.57(0.0001)
Planned Pregnancy	No	-2.49(0.0008)	----------------	----------------	----------------	----------------
	Yes	Reference				
Education Level	Completed university/college	Reference		Reference	Reference	----------------
	Other	-3.61(<.0001)		-1.62(0.0542)	-1.11(0.1844)	
Work Force Participation	Employed full-time	-1.22(0.2175)		----------------	----------------	----------------
	Employed part-time	-0.37(0.7420)				
	Not employed voluntarily	Reference				
Household Income	< 30k	-4.45(<.0001)		-2.51(0.0514)	----------------	----------------
	30k-79,999	-2.21(0.0021)		-1.61(0.0294)		
	≥80k	Reference		Reference		
Difficulty Affording Food	Very/somewhat difficult	-3.42(0.0234)		----------------	----------------	----------------
	Not very difficult	-1.48(0.0504)				
	Not at all difficult	Reference				
Nausea Severity	No diet change/doctor visit	Reference			Reference	----------------
	Changed diet/no doctor visit	1.10(0.1294)			1.19(0.1072)	
	Visited doctor	0.91(0.3434)			1.40(0.1582)	

Exercise	Under-exercisers Optimal Over-exercisers	-3.88(<.0001) Reference -1.19(0.3131)			-3.43(0.0005) Reference -0.34(0.7803)	-3.66(0.0001) Reference -0.79(0.5042)
Smoking during Pregnancy	No Yes	Reference -5.79(<.0001)			Reference -2.22(0.0780)	Reference -3.28(0.0060)
Depression (CES-D)	No Yes	Reference -2.90(0.0007)			------------------	--------------------
Stress[3]		-0.63(0.0085)			4	--------------------
Anxiety (STAI)[3]		-1.73(<.0001)			-0.84(0.0249)	-0.95(0.0072)
Social Support from Partner[3]		1.23(0.0002)			------------------	--------------------
Social Support from Family[3]		1.28(0.0001)			0.54(0.1492)	0.73(0.0357)
Social Support from Friends[3]		1.19(0.0003)			0.59(0.1090)	--------------------
Geographical Residence	Rural Urban	Reference 0.046(0.9740)			------------------	--------------------
Presence of Convenience Stores within 500 m	0 ≥1	Reference -1.83(0.0059)			------------------	--------------------
Presence of Fast Food Restaurants within 500 m	0 ≥1	Reference -2.20(0.0018)			Reference -1.26(0.0847)	--------------------
Presence of Grocery Stores or Local Markets within 500 m	0 ≥1	Reference -1.52(0.1570)			------------------	--------------------
Presence of Convenience Stores within 1000 m	0 ≥1	Reference -1.70(0.0317)				
Presence of Fast Food Restaurants within 1000 m	0 ≥1	Reference -0.89(0.2217)				
Presence of Grocery Stores or Local Markets within 1000 m	0 ≥1	Reference -0.57(0.4196)				
Proximity of Nearest Convenience Store (Km)[3]		-0.049(0.8838)				
Proximity of Nearest Fast Food Restaurant (Km)[3]		-0.051(0.8473)				
Proximity of Nearest Grocery Store (Km)[3]		-0.005(0.9793)				
Proximity of Nearest Grocery Store or Local Market (Km)[3]		0.46(0.1961)				

[1] All predictor variables significant at $p < 0.2$ in univariable were included in multivariable analyses
[2] Includes only predictor variables significant at $p < 0.05$
[3] Variables are continuous
[4] Stress was excluded from the analysis because there were concerns with multicollinearity (please see Appendix H)

Note: dashed lines represent variables that were entered and subsequently backward eliminated; or in the case of variables that were insignificant in the univariable analysis, were not entered into model 1. The shaded cells in the table represent variable blocks that have not yet been entered into the model.

Table 5.6: Two Degree of Freedom F-Tests for Interaction Assessed within the Parsimonious Model

Interaction	F-value	P-value
Marital status*Presence of fast food within 500 m	0.59	0.5535
Income*Presence of fast food within 500 m	1.28	0.2781

Chapter 6: Discussion

6.1 Main Findings

The main objective of this study was to determine the individual-level and community-level determinants of diet quality in pregnancy. The intuition was to construct a multi-level model. A decision was made to not proceed with a multi-level analysis since an insignificant ICC was calculated, which indicated that a small proportion of the variability in diet quality existed between communities. It would be unnecessary to conduct a study to explain such a small proportion of the variance. A Canadian study conducted in Hamilton also found that for health indicator variables, such as health problems and health related quality of life, a small proportion of the variance was explained based on the enumeration area or the community-level studied(83).

6.1.1 PHP Factors

In our study, the following variables retained significance in the multivariable parsimonious model and were considered to be the most important determinants of diet quality in pregnancy: residency in Canada, parity, marital status, physical activity, smoking, anxiety levels, and social support from the family.

For the multivariable results, recent immigrants who resided in Canada for 5 years or less were found to have a significant increase in DQI-P_m score compared to women who were born in Canada. Similar results were found in an American study that assessed diet quality of Mexican women who were born in the United States compared to immigrant women who had spent 5 years or less, 6-10 years, or 11 years or greater in America. These authors also found that the most recent immigrants who had resided in the United States for 5 years or less had significantly better diet quality than all other women(27). These results from our cohort are interesting considering that the 'recent immigrant' category consisted of a heterogeneous group of women who had immigrated to Canada from all over the world and yet diet quality on average was still found to be better than Canadian-born women.

The literature is generally consistent in the finding that nulliparous women have better diet quality than women with greater parity and this finding has been replicated in many populations using different measures of diet quality(1, 2, 19, 25, 38). In our study, the effect of parity on diet quality was found to be the opposite of what has been found previously in the literature, where a parity count of one or more was associated with better diet quality. It has also been observed in a past study that women in our cohort were more likely to meet Canada's Food Guide recommendations for all four food groups if they had a parity of 1 or more compared to nulliparous women(4). Perhaps these results were observed because the women in our cohort are unique in the fact that the majority were highly educated, employed full-time, and married. Based on 2006 Census data, 55% of Canadian women aged 15-44 had post-secondary education compared to about 72% of the women in our study(84). Perhaps these results are biased as a result of our highly educated cohort. Another explanation is that these women may be more likely to consume meals as a family, resulting in the observed association between parity and diet quality. A small study of employed parents used cluster analysis to identify a select group of participants who were consuming the majority of their meals as a family. Of all the clusters identified, this 'family meal' cluster most resembled the PHP cohort in regards to the high proportion of women who were married and highly educated. These researchers found that individuals belonging to this cluster had more children than the other two clusters and also had the highest HEI scores, which is consistent with our findings regarding parity(85). Based on these results, our cohort may have consisted of a greater proportion of women who prepared home cooked meals, where other studies that observed the opposite association between parity and diet quality, may have had a lower proportion of this specific 'meal pattern' type; however, we would require more information to substantiate this claim.

There is no consensus in the literature on the association between marital status and diet quality. One study that also used the DQI-P to assess diet quality found that diet quality was significantly lower in separated, divorced, or widowed pregnant women compared to married women in a univariable analysis(28). We also observed this association in our univariable analysis but this association was not significant in the parsimonious model. Furthermore, a consistent significant difference was observed between common-law women and married women in regards to DQI-P_m score, where married women had better diet quality. Past studies of marital status and diet quality in pregnancy generally have not included a separate common-law category for the marital status variable; however, recent studies have shown that common-law women are more similar to divorced or separated women than married women in regards to some health behaviours(64, 65).

A previous study has found that vigorous leisure activity prior to pregnancy was significantly associated with better diet quality in pregnancy, which is consistent with our findings that following the recommendations regarding exercise is associated with better diet quality compared to women who exercise below the recommendations(28). Smoking during pregnancy was found to be significantly related to DQI-P_m scores in our study where this finding is generally consistent with past studies(2, 19, 38). It is not surprising that both under-exercisers and smokers tended to exhibit lower diet quality since individuals who demonstrate an unhealthy behaviour in one aspect of their lives generally behave similarly for other aspects(86).

In our study, STAI scores were found to be significantly associated with diet quality in pregnancy. Anxiety in pregnancy is generally an understudied area, but one study did find similar results to ours where anxiety was positively associated with some unhealthy dietary intakes, such as greater consumption of fats, oils, sweets, and snacks(45).

The literature is generally in agreement with our findings that greater social support is associated with better diet quality(27, 46, 47). The majority of studies have only focused on social support overall and not specific sources of social support. One small study of low income pregnant women assessed perceived social support from the partner and from 'others', which included family and close friends. These researchers found that social support from family and friends was significantly correlated with health behaviours, such as adequate diet, where partner social support did not appear to be correlated with diet quality(46). This is consistent with our results where social support from the family was found to be the most influential social support variable and social support from the partner the least influential, since it was the first of the three to be eliminated from the parsimonious model.

Workforce participation was not found to be significant in the univariable analysis and this could have been a result of the categorization of the variable; the 'employed part-time' workforce participation category included a heterogeneous group of women who classified themselves as students, working part-time, looking for work or on a leave of absence. Furthermore, many of the women in our cohort were employed full-time, which reduces the variability of the workforce participation variable. On the other hand, there may not have been a true association between workforce participation and diet quality in pregnancy. Another study also failed to find a significant association between women who were employed compared to women who were not employed during pregnancy and nutrient inadequacy(3). Furthermore, the only study that did find an association between occupation and diet quality in pregnancy assessed the occupation of the women's partners rather than the women themselves(2).

Past studies in the literature have generally found that the most important predictors of diet quality in pregnancy were age and education, yet these variables did not retain significance in our final multivariable model(1-3, 19, 25, 38). This was most likely observed because variables in the conceptual model which are more proximal to the outcome may have attenuated the effects of age and education since these variables are considered to be pathway variables leading to some of the variables more proximal to the outcome. Furthermore, the other studies that found significant associations between age and/or education and diet quality in pregnancy employed different methods and used different predictors than this study. Two of the studies used PCA and two other studies looked at specific nutrients rather than a diet quality index as their outcome(2, 3, 19, 38). The study by Bodnar and Siega-Riz only reported a univariable instead of a multivariable analysis. They found similar findings to ours where age and education were both significantly associated with diet quality in pregnancy at the univariable level(25). Finally, Rifas-Shiman and colleagues did conduct a multivariable analysis using a diet quality index and found age and education to still be significantly associated with diet quality, albeit attenuated compared to the univariable analyses; however, these authors used fewer predictors than this current study(1).

6.1.2 Geographic Factors

To our knowledge, only one other study has focused on the effect of geography on diet quality in pregnancy and this study found that increased proximity to grocery stores, supermarkets, and convenience stores all increased diet quality(25). In this past study, the finding that convenience store proximity increased diet quality seems counter-intuitive since convenience stores generally have minimal healthy fresh food choices(87). Also, this study did not investigate the relationship between fast food restaurants and diet quality, where our study did focus on fast food restaurants, convenience stores, and grocery stores. In our study, the presence of at least one grocery store or local market with fresh fruits and vegetables was found to decrease diet quality in pregnancy (at a p-value < 0.2), even though this finding was not consistent with our hypothesis it is explainable since grocery stores and markets also provide access to a wide variety of unhealthy food choices. Moreover, having at least one fast food restaurant or convenience store within 500 metres of the participants' homes significantly decreased diet quality compared to not residing within 500 metres; however, these associations were only significant at a p-value less than 0.05 in the univariable analyses. When included in the multivariable analysis, the effect of fast food restaurants within 500 metres on diet quality attenuated and only showed a trend toward significance. It is possible that this attenuation of geographic variables in the multivariable analysis was a result of directed pathways between earlier variables in the conceptual model and geographic variables. A post-hoc analysis conducted showed that a parsimonious model including only the block three variables and not any earlier variables resulted in a statistically significant association between presence of fast food restaurants within 500 metres and diet quality (please see Appendix I). Another possible explanation is that the univariable analyses with geographic variables may have been confounded by various factors such as marital status and parity, which could determine where an individual resides and thus the availability of food sources, which would indicate that access to food sources may not play a major role in diet quality in pregnancy.

Other studies have investigated the associations between access to food outlets and diet quality in the general population, rather than pregnant women specifically. Among these studies there have been inconsistent results. A national multi-level study was conducted in New Zealand to determine the associations between fruit and vegetable consumption and distance to fast food outlets. Vegetable intake was found to be significantly lower for individuals who resided in communities with better access to fast food restaurants; however, no significant associations were observed for fruit intake(88). These same authors also assessed neighbourhood access to supermarkets and convenience stores and the relationship with fruit and vegetable intake and found a significant negative association between vegetable intake and access to convenience stores; similarly, no significant associations were observed with fruit intake. Also, no significant associations were found between fruit or vegetable intake and accessibility of supermarkets(89). The authors concluded that neighbourhood access to food sources may not be a major determinant of diet-related health outcomes, which is consistent with our findings of pregnant women in London, Ontario.

In the United States, there is some evidence that neighbourhood access to supermarkets may have an impact on diet quality for the general population of Americans. Findings from the Atherosclerosis Risk in Communities Study indicated that among African Americans, number of supermarkets within the census tract was significantly associated with increased fruit and vegetable consumption, where this association was not significant for Caucasian residents(90). Another American study focused on grocery store access and the in-store shelf space devoted to fruits and vegetables. This study also indicated that vegetable intake was significantly associated with access to a grocery store; furthermore, there was a significant dose-response relationship observed between fresh vegetable shelf space and servings of vegetables consumed(91). Access to food sources may play a role in diet quality in some populations, such as these American populations studied but it does not appear to be an important factor in our population of London, Ontario pregnant women.

Contrary to the findings in the United States, a quasi-experimental study conducted in the United Kingdom showed that fruit and vegetable consumption did not improve after a new superstore was built in an economically deprived area compared to a control town where there was no intervention. Rather, both the intervention and non-intervention communities showed an increase in fruit and vegetable consumption after the new superstore opened. The authors concluded that the introduction of the new superstore in an area where fresh food sources were previously scarce, did not seem to improve fruit and vegetable consumption(92). Another UK study was conducted with the purpose of assessing attitudes and behaviours of low income men and women in regards to availability and accessibility of fruits and vegetables. In the opinions of the participants, accessibility was not a major issue preventing them from consuming the recommended amounts of fruits and vegetables. Of the individuals who did not own a vehicle, 71% did not find it difficult to visit a supermarket where only 10% of all the participants did report difficulty accessing a supermarket(93).

We did not find an association between urban and rural London areas and DQI-P_m. There is a lack of evidence in the literature linking geographic area with diet quality in pregnancy. A study in Finland compared diet patterns of pregnant women who resided in the city of Tampere compared to the city of Oulu. Tampere is the larger of the two and it is located in the South of Finland whereas Oulu is located in the North. When comparing women's diet patterns between cities, the authors found that women in the larger Southern city, Tampere, were significantly more likely to have a 'Healthy' diet pattern than women residing in Oulu(38). In the United States, diet quality was compared between the general population of individuals residing in Maryland, North Carolina, and New York, where New York residents were found to have healthier diets than the other two regions(94). Perhaps women residing in London, Ontario are fairly homogenous in regards to diet quality and we may have observed a difference in diet quality if we compared women in London to women residing in another city in Ontario. Furthermore, there is not a lot of variability in the geographical residence variable in our cohort, where the majority of the women resided in urban London.

6.2 Strengths and Limitations

One of the major strengths of this study was the cohort of women used for analysis since these women were recruited through the Prenatal Health Project, which was a large prospective cohort study. The data for the PHP were carefully inputted into the database and cross-checked for errors, where missing values were minimized. A limitation of the PHP is that the sample was a convenience sample, which may limit the generalizability of the study to some extent. It has been noted that the participants of the PHP are more educated than the general Canadian population; however, the general birthing population of London has been found to be similar to the PHP in regards to age distribution, marital status, height, pre-pregnant weight, and parity(84, 95). Furthermore, women who did not receive an ultrasound within 10-21 weeks of gestation would not have been sampled in this cohort; however, most women do receive an ultrasound within this timeframe so the women excluded due to this would be negligible(96).

Since the data collection for the PHP had already been completed prior to the analysis for this study, there were some variables that could not be measured in the conceptual model. These included fatigue during pregnancy and access to transportation; however, fatigue was not frequently found in the literature to be a major contributor to diet quality in pregnancy and since access to food sources were assessed using walking distance and not by driving distances, access to transportation was not an important factor(45).

There are strengths and limitations to using FFQs. FFQs have been criticized for not producing valid estimates of food and nutrient intake. FFQs cannot possibly capture all food items consumed by participants and may underestimate number of servings. Nutrient values calculated from an FFQ may also be inaccurate since actual food consumption is not quantified. On the other hand, FFQs are appropriate to use in studies for the purpose of ranking individuals according to intake and to capture usual consumption, where this was the purpose of this study to be able to contrast sufficiency of diet in the participants based on various determinants(15). Furthermore, the FFQ used in our study has been validated for use in our cohort. Usage of the DQI-P_m is a major strength of the study, since this measure aims to capture overall diet quality rather than focusing on minor components of diet or nutrition, which has been done in previous studies. As mentioned above, the inherent errors that may exist by using the FFQ could result in measurement error in the DQI-P_m but this will most likely not sufficiently affect the results since any error in the DQI-P_m will be expected to be approximately the same among participants(15). The original DQI-P was developed and shown to be an accurate measure of diet quality in a comparable population of pregnant women residing in the United States(25).

A further strength of this study was that a Geographic Information System (GIS) was used to precisely measure the distance and number of food sources in relation to participants' homes(97).

6.3 Conclusions and Future Directions

This research was novel since it incorporated the effects of geographic as well as sociodemographic factors, mental health, and other pregnancy-related variables to predict diet quality in pregnancy. Overall, our findings indicated that pregnant women who were born in Canada, common-law, nulliparous, less physically active, smokers, more anxious, and perceiving less social support from their family were more likely to have lower diet quality in relation to respective comparison groups. In our cohort, presence of fast food restaurants, convenience stores, and grocery stores do not appear to be major contributors of diet quality in pregnancy after controlling for other variables. Our cohort is unique since the majority of the women are highly educated; food access could still play a role in diet quality in other populations. Perhaps a future population-based study could investigate the impact that food access may have on the diet quality of the more general Canadian population, rather than our cohort of highly educated pregnant women.

Dissemination of the study results will proceed through publication in a peer reviewed journal and through presentations at relevant epidemiology and health conferences. Our results may have implications for public health intervention. Subgroups of pregnant women who may be at greater risk of low diet quality, such as women who are Canadian-born, nulliparous, unmarried, more anxious, and lacking support from the family, could be targeted to receive more information on the importance of healthy eating during pregnancy and how to establish a healthy diet. Furthermore, promotion of health initiatives such as increasing physical activity and quitting smoking may be important since these behaviours were found to be significantly related to low diet quality and indicative of clustering of unhealthy behaviours among some pregnant women. It is important for women to eat well, exercise, and to avoid smoking during pregnancy for their own benefit and especially for the well-being of their infant.

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Appendix A: Comparisons of Dietary Intake Measures

Table A.1: Strengths and Limitations of Dietary Intake Measures(15)

<table>
<tr><th></th><th>Food Frequency Questionnaire</th><th>Dietary Recall</th><th>Food Record/Diary</th></tr>
<tr><td rowspan="2">Strengths</td><td rowspan="2">-Can capture diet intake over a long period of time: generally studies of reproducibility are fairly good
-Appropriate when study requires individuals to be ranked on diet
-Generally easier for people to remember their usual food intake than to remember specific food eaten on one occasion
-Generally inexpensive
-Fairly low respondent burden</td><td colspan="2">-Based on actual data: can be used to measure absolute intake rather than an estimate
-Open ended: not limited by categories, allows specificity of food type and quantity
-Sensitive to cultural differences in food: not limited to certain food</td></tr>
<tr><td>-Minimal response burden
-Respondent does not need to be literate
-Less likely to alter diet if unaware of study at the time of eating</td><td>-Is not dependent on memory: subject can measure food quantity consumed
-Accurate portion sizes can be obtained</td></tr>
<tr><td rowspan="2">Limitations</td><td rowspan="2">-Restricted to certain food items: may not be able to capture entire diet, especially in culturally diverse populations
-Specific food items are usually grouped together in one question
-Portion sizes may be perceived differently from person-to-person
-Limited by frequency categories: exact frequency of intake is not observed
-Generally not the best method to use to obtain accurate nutrient intakes: not based on actual data so respondents may not remember exactly how often they usually eat specific food</td><td colspan="2">-One/a few days of food intake is not going to be representative of entire diet over a period of time
-Participants are more likely to become less motivated as the number of days required are increased
-Inappropriate for assessing past diets: especially an issue for retrospective studies
-Expensive</td></tr>
<tr><td>-Dependent on memory: subject is required to remember type of food consumed and especially the quantity</td><td>-Requires a great deal of motivation for subjects: could lead to low response rates
-Dependent on literacy
-Subjects may consciously alter diet if they are aware that they are recording food intake for a study</td></tr>
</table>

Appendix B: Diet Quality Measures used in the Literature

Table B.1: Diet Quality Measures used in the Literature: Components of Measures and Population Studied

Reference	Diet Measure and Components	Population
Knol, 2005	Cluster analysis & principal components analysis (PCA) to find eating patterns; validated using Healthy Eating Index (HEI)(98)	Children aged 2-8
Kourlaba, 2009	HEI: recommendations for grains, vegetables, fruit, dairy, meat, total fat, saturated fat, cholesterol & sodium intakes, variety of foods in diet(99)	Children aged 2-5
Beydoun, 2009	HEI_n: total fruit (includes juice); whole fruit (not juice); total vegetables; dark green & orange vegetables & legumes; total grains; whole grains; milk; meat & beans; oils; saturated fat; sodium; calories from solid fat, alcohol & added sugar(22)	Parents aged 20-65 and children aged 2-18
Bodnar, 2002	Diet Quality Index for Pregnancy (DQI-P): recommendations for grains, vegetables, fruits, folate, iron, calcium, percentage of calories from fat, and meal pattern score(25)	Pregnant women
Laraia, 2004	DQI-P(29)	Pregnant women
Laraia, 2007	DQI-P(28)	Pregnant women
Harley, 2006	DQI-P: without meal pattern component(27)	Pregnant women
Watts, 2007	DQI-P (modified): saturated fat and cholesterol components were added and diet variety was assessed rather than the meal pattern score(30)	Pregnant women
Rifas-Shiman, 2009	Alternative Healthy Eating Index for Pregnancy (AHEI-P): vegetable, fruit, ratio of white to red meat, fibre, trans fat, ratio of polyunsaturated to unsaturated fatty acids, folate, calcium, and iron(1)	Pregnant women
Hure, 2009	Australian Recommended Food Score (ARFS): vegetables, fruit, grain, dairy, nut & beans & soya, meat, fish, fat(20)	Women (pregnant & non-pregnant)
Thompson, 2010	PCA(18)	Pregnant women
Arkkola, 2008	PCA(38)	Pregnant women
Northstone, 2008	PCA(19)	Pregnant women

Appendix C: Determinants of Pregnant Women's Diet Quality Identified in the Literature

<u>Table C.1</u>: Determinants of Pregnant Women's Diet Quality Identified in the Literature

Determinants	Study	Significant Association Found	Comparison Groups for Nominal Variables
Age	Arkkola, 2008	Positive(38)	
	Bodnar, 2002	Positive (25)	
	Northstone, 2008	Positive (19)	
	Rifas-Shiman, 2009	Positive (1)	
	Watson, 2009	Positive (2)	
Ethnicity	Bodnar, 2002	Black(25)	White; Black
	Harley, 2006	Mexican immigrants(27)	Mexican immigrants; American Mexicans
	Northstone, 2008		White; non-White
	Watts, 2007	White(19)	White; Native
	Rifas-Shiman, 2009	White(30) Null(1)	White; Black
Marital Status	Laraia, 2007	Married(28)	Married; single; divorced/separated/ widowed
	Northstone, 2008	Null(19)	Currently has partner; no partner
	Pinto, 2009	Null(3)	Married; not married
Parity	Arkkola , 2008	Negative(38)	
	Bodnar, 2002	Negative (25)	
	Northstone, 2008	Negative (19)	
Planned Pregnancy	Pinto, 2009	Positive(3)	
	Arslan Ozkan, 2010	Positive (40)	
Education	Arkkola , 2008	Positive(38)	
	Bodnar, 2002	Positive (25)	
	Northstone, 2008	Positive (19)	
	Pinto, 2009	Positive (3)	
	Rifas-Shiman, 2009	Positive (1)	
	Watson, 2009	Positive (2)	
Occupational Status	Watson, 2009	Positive(2)	
	Pinto, 2009	Null(3)	
Income	Bodnar, 2002	Positive(25)	
	Pinto, 2009	Null(3)	
	Rifas-Shiman, 2009	Null(1)	
Severity of Morning Sickness	Pinto, 2009	Positive(3)	
	Watson, 2009	Negative(2)	
	Rifas-Shiman, 2009	Null(1)	

Physical Activity Level	Laraia, 2007 Watson, 2009	Positive(28) Positive(2)	
Smoking	Arkkola , 2008 Laraia, 2007 Northstone, 2008 Watson, 2009 Pinto, 2009	Negative(38) Negative(28) Negative(19) Negative(2) Null(3)	
Depression	Harrison-Hohner, 2001 Okubo, 2011	Negative(44) Negative(43)	
Stress	Hurley, 2005	Negative(45)	
Anxiety	Hurley, 2005 Northstone, 2008	Negative(45) Negative(19)	
Social Support	Harley, 2006 Schaffer, 1997 Canella, 2006	Positive(27) Positive (46) Positive (47)	
Geographical Residence	Arkkola , 2008	Tampere(38)	Tampere; Oulu (Two cities)
Proximity of Convenience Stores	Laraia, 2004	Positive(29)	
Proximity of Supermarkets	Laraia, 2004	Positive(29)	

Appendix D: Ethics Approval

The UNIVERSITY *of* WESTERN ONTARIO

Research Ethics Office • Dental Sciences Building, London, ON, Canada N6A 5C1
Telephone: (519) 661-3036 Fax: (519) 850-2466 E-mail: ethics@uwo.ca

REVIEW BOARD FOR HEALTH SCIENCES RESEARCH INVOLVING HUMAN SUBJECTS (FULL BOARD)
CERTIFICATION OF APPROVAL OF HUMAN RESEARCH

ALL HEALTH SCIENCES RESEARCH INVOLVING HUMAN SUBJECTS AT THE UNIVERSITY OF WESTERN ONTARIO
OPERATES IN ACCORDANCE WITH AND CONFORMS TO THE TRI-COUNCIL POLICY STATEMENT
(ETHICAL CONDUCT FOR RESEARCH INVOLVING HUMANS)

2000-2001 REVIEW BOARD MEMBERSHIP

1) Dr. P.G.R. Harding, (Chair) (Obstetrics .Gynaecology)
2) Ms. S. Hoddinott, Director of Research Services (Epidemiology)
3) St. Joseph's Health Centre Representative ()
4) Dr. R. McManus, London Health Sciences Centre - Victoria Campus Representative (Endocrinology Metabolism)
5) London Health Sciences Centre - University Campus Representative
6) Dr. L. Heller, Office of the President Representative (French)
7) Ms. S. Agranove, Office of the President Representative (Community)
8) Ms. S. Fincher-Stoll, Office of the President Representative (Legal)
9) Dr. D. Freeman, Faculty of Medicine Dentistry Representative (Clinical)
10) Dr. G. Woodbury, Faculty of Medicine Dentistry Representative (Basic)(Epidemiology)
11) Dr. G. McCarthy, School of Dentistry Representative (Oral Biology)
12) Ms. D. Travis, Faculty of Health Sciences Representative, (Nursing)
13) Dr. D. Jonker, London Regional Cancer Centre Representative, (Oncology)
14) Ms. N. Pus, London Clinical Research Association Representative (Nursing)
15) Dr. M. Gibson, Research Institutes Representative (Psychology)

Alternates are appointed for each member.

THE REVIEW BOARD HAS EXAMINED THE RESEARCH PROJECT ENTITLED:

Prediction of Preterm Birth

REVIEW NO: 08253E

AS SUBMITTED BY: Dr. M.K. Campbell • Epidemiology & Biostatistics, University of Western Ontario

AND CONSIDERS IT TO BE ACCEPTABLE ON ETHICAL GROUNDS FOR RESEARCH INVOLVING HUMAN SUBJECTS UNDER CONDITIONS OF THE UNIVERSITY'S POLICY ON RESEARCH INVOLVING HUMAN SUBJECTS.

APPROVAL DATE: April 26, 2001 (UWO Protocol, Letter of Information & Consent)

AGENCY CIHR

AGENCY TITLE:

P. Harding, Chair

c.c. Hospital Administration

Appendix E: Extracted Pages of Prenatal Health Project Questionnaire

Thank you for providing us with some information about your lifestyle. It is important for us to know something about your financial situation. I realize these are extremely personal matters and I wish to assure you again that your responses will be kept strictly confidential.

PARTICIPANTS MAY DECLINE TO RESPOND TO THIS QUESTION AS THEY FEEL IT IS TOO INVASIVE. YOU MAY NEED TO PROMPT SOME RESPONDENTS AS TO SOURCES OF INCOME. WE ARE INTERESTED IN ALL SOURCES INCLUDING MOTHER'S ALLOWANCE, WELFARE, DISABILITY, UNEMPLOYMENT INSURANCE, PENSION, STUDENT LOANS, LOTTERY WINNINGS, INHERITANCE.

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29. What is your best estimate of the total income of all members of your household from all sources before taxes and deductions for the past year. By total income I mean total gross income from paid employment, government assistance, student loans or inheritance. Was the total household income:

- ○ Less than $30,000
  - ○ Less than $15,000
    - ○ Less than $10,000
    - ○ $10,000 to $14,999
  - ○ Greater than or equal to $15,000
    - ○ $15,000 to $19,999
    - ○ $20,000 to $29,999
- ○ Greater than or equal to $30,000
  - ○ Less than $60,000
    - ○ $30,000 to $39,999
    - ○ $40,000 to $59,999
  - ○ Greater than or equal to $60,000
    - ○ $60,000 to $79,999
    - ○ $80,000 or more

○ *NO INCOME*
○ *DON'T KNOW*
○ *REFUSE TO ANSWER*

30. When you think of your financial situation overall, how difficult would you say it is to meet each of the following commitments? (Please refer to the column labelled A from your response option table.)
Would you say that ______ tend(s) to be very difficult, somewhat difficult, not very difficult, or not at all difficult.

	Very difficult	Somewhat difficult	Not very difficult	Not at all difficult	Not applicable
Housing	①	②	③	④	
Food	①	②	③	④	
Children's clothing	①	②	③	④	NA
Personal expenses	①	②	③	④	
Transportation	①	②	③	④	
Child care or babysitting	①	②	③	④	NA
Child's recreational activities	①	②	③	④	NA
Medical expenses	①	②	③	④	
Dental expenses	①	②	③	④	
Optical expenses	①	②	③	④	

Is there any other commitment that is difficult to meet financially? ○ Yes ○ No

____
(Please specify)

Thank you for telling me about your financial commitments. Now I would like to know a little bit about your energy level and the time it takes to do things on most days. (Please refer to column B in your response option table.)

13

Food Frequency Questionnaire

DAIRY

	0	1-3 Mo	1 wk	2-4 wk	5-6 wk	1 d	2-3 d	4+ d
Skim or 1% or 2% Milk (8 oz glass)								
Whole Milk (8 oz glass)								
Cream e.g. Coffee, Whipped (1 Tbsp)								
Sour Cream (1 Tbsp)								
Sherbet or Ice Milk (1/2 cup)								
Ice Cream (1/2 cup)								
Yogurt (1/2 cup)								
Cottage or Ricotta Cheese (1/2 cup)								
Cream Cheese (1 oz)								
Other cheese e.g. Processed cheddar, etc. Plain or as part of a dish (1 slice or 1 oz)								
Margarine (pat), added to food or bread; exclude use in cooking								
Butter (pat), added to food or bread; exclude use in cooking								
Custard or pudding (1/2 cup)								
Chowder or Cream soup (1 cup)								

FRUITS

	0	1-3 Mo	1 wk	2-4 wk	5-6 wk	1 d	2-3 d	4+ d
Raisins (1 oz or small pack) or grapes (1/2 cup)								
Bananas (1)								
Cantaloupe (1/4 melon)								
Watermelon (1 slice)								
Fresh apples or pears (1)								
Apple juice or other fruit juice (small glass)								
Oranges (1)								
Orange juice (small glass)								
Grapefruit (1/2)								
Grapefruit juice (small glass)								
Strawberries, fresh, frozen or canned (1/2 cup)								
Peaches, apricots or plums (1 fresh or 1/2 cup canned)								
Blueberries, fresh, frozen or canned (1/2 cup)								

VEGETABLES

	0	1-3 Mo	1 wk	2-4 wk	5-6 wk	1 d	2-3 d	4+ d
Tomatoes (1)								
Tomato juice (small glass)								
Tomato sauce e.g. Spaghetti sauce (1/2 cup)								
Red Chili sauce (1 Tbsp)								
Tofu or soybeans (3-4 oz)								
Green or yellow beans (1/2 cup)								
Broccoli (1/2 cup)								
Cabbage or cole slaw (1/2 cup)								
Cauliflower (1/2 cup)								
Brussel Sprouts (1/2 cup)								
Carrots (1 whole or 1/2 cup cooked)								
Corn (1 ear or 1/2 cup frozen or canned)								
Peas or Lima beans (1/2 cup fresh, frozen or canned)								
Mixed vegetables (1/2 cup)								
Baked beans or lentils: baked or boiled (1/2 cup)								
Yellow (winter) squash (1/2 cup)								
Eggplant, Zucchini or other summer squash (1/2 cup)								
Yams or sweet potatoes (1/2 cup)								
Spinach, cooked (1/2 cup)								
Romaine or leaf lettuce (1 serving)								
Celery (4" stick)								
Mushrooms: fresh, frozen or canned (1)								
Beets (1/2 cup)								

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EGGS, MEATS, FISH, MIXED DISHES

0 | 1-3 Mo | 1 wk | 2-4 wk | 5-6 wk | 1 d | 2-3 d | 4+ d

Eggs (1)
Chicken or Turkey (4-6 oz)
Bacon (2 slices)
Hot Dogs (1)
Processed meats: sausage, salami, bologna, etc. (pc or slice)
Liver (3-4 oz)
Hamburger (1 patty)
Main dish: Beef, pork, lamb e.g. Steak, roast, ham, etc. (4-6 oz)
Canned tuna fish (3-4 oz)
Dark meat fish e.g. Mackerel, salmon, sardines, bluefish (3-5 oz)
Other fish (3-5 oz)
Shrimp (3 med), lobster (1/4 cup cooked), scallops (3 med) as main dish
Beef, pork or lamb stew (1 serving)
Beef, pork or lamb in casserole (1 serving)
Pizza (1 slice)

BREADS, CEREALS, STARCHES

0 | 1-3 Mo | 1 wk | 2-4 wk | 5-6 wk | 1 d | 2-3 d | 4+ d

Cold Breakfast Cereal e.g. Cheerios, Corn Flakes (1 cup)
Cooked oatmeal or other hot cereal (1 cup)
Bran Flakes, All Bran or other high fibre cereal (1 cup)
White Bread including Pita or Tortillas (1 slice)
Whole wheat or rye bread (1 slice)
English muffins, bagels or rolls (1)
Muffins or biscuits (1)
Brown rice (1 cup)
White rice (1 cup)
Pasta e.g. Spaghetti, noodles, macaroni (1 cup)
Other grains e.g. bulgur, kasha, couscous (1 cup)
Pancakes or waffles (2)
French fried potatoes (4 oz)
Potatoes, baked, boiled (1) or mashed (1 cup)
Potato chips or Corn chips (small bag or 1 oz)
Crackers e.g. Triscuits, Wheat Thins, Saltines (1)

BEVERAGES

0 | 1-3 Mo | 1 wk | 2-4 wk | 5-6 wk | 1 d | 2-3 d | 4+ d

Coffee (1 cup)
Tea (1 cup)
Herbal tea (no caffeine), iced or hot (1 cup)
Sparkling or mineral water (1 cup)
Beer (1 glass, can or bottle)
Red wine (4 oz)
White wine (4 oz)
Liquor e.g. Whiskey, gin (1 drink/shot)
Hawaiian Punch, lemonade or other non-carbonated fruit drink (1 glass, can or bottle)
Broth type soups (1 cup)
Cola with sugar e.g. Coke or Pepsi (1 glass or can)
Other carbonated beverage with sugar e.g. 7 Up, Ginger Ale (1 glass or can)

SWEETS, BAKED GOODS, MISCELLANEOUS

0 | 1-3 Mo | 1 wk | 2-4 wk | 5-6 wk | 1 d | 2-3 d | 4+ d

Chocolate bars or pieces e.g. Hershey's (1 reg bar) or M&Ms (1 small pkg)
Cookies (1)
Brownies (1)
Doughnuts (1)
Cake (1 slice)
Sweet roll, coffee cake or other pastry (1)
Pie (1 slice)
Jams, jellies, preserves, syrup or honey (1 Tbsp)
Peanut butter (1 Tbsp)
Popcorn (1 cup)
Nuts (small packet or 1 oz)
Oil and vinegar dressing e.g. Italian (1 Tbsp)
Mayonnaise or other creamy salad dressing (1 Tbsp)

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Appendix F: Implausible Energy Intake Calculation

Calculation of cut-points to determine women who are outside of 2 standard deviations (SD) for energy intake:

Mean of energy intake = 2022.225 kcal/day

SD of energy intake = 753.89423 kcal/day

2*SD = 2(753.89423) = 1507.78846 kcal/day

Cut-point of women greater than 2 SD of energy intake = 2022.225 + 1507.78846 = 3530.01346 kcal/day

Cut-point of women less than 2 SD of energy intake = 2022.25 – 1507.78846 = 514.43654 kcal/day

Appendix G: Intraclass Correlation Coefficient Calculation

Intraclass Correlation Coefficient (ICC) for my outcome variable, DQI-P_m, based on DA-level:

Covariate Parameter: DA = 3.4392; p = 0.1429

Covariate Parameter: Residual = 244.43; p < 0.0001

ICC = Covariate Parameter: DA / (Covariate Parameter: DA + Covariate Parameter: Residual)

ICC = 3.4392 / (3.4392 + 244.43)

ICC = 0.0139

The 'covariate parameter DA' explains the amount of variance at the community-level. The variance is found to be statistically insignificant; in other words, there is no significant variation between communities. The ICC explains the proportion of variation at the community-level and at a value of 0.0139, it is not substantively large(100, 101).

Average number of women per DA

There were approximately 4 women per DA on average and about 19% of the DAs only had one resident. The small group size combined with an insignificant ICC justifies the decision to do an individual-level analysis rather than a multi-level analysis(100, 101).

Appendix H: Multicollinearity Issues with Stress Variable

The stress variable, which had a significant negative association with DQI-P_m in the univariable analysis, was found to be positively associated with DQI-P_m when included in the multivariable analysis. One explanation for the observation of variables in the multivariable analysis with signs in the opposite direction of expected is multicollinearity within the model(102, 103). The potential for multicollinearity of the stress variable with other similar variables in the model was further inspected. First, the betas and p-values of the model 3 variables where compared to each other in two different models: when stress is included and when stress is excluded from the model. The presence of the stress variable appeared to affect the income, anxiety, and social support from the partner variables specifically (Table H.1). The relationships/correlations between these three variables with the stress variable were explored. The stress variable appeared to be highly correlated with both anxiety and social support from the partner (Table H.2). Stress also appeared to be significantly associated with income level in a generalized linear model (Table H.3). Furthermore, a multivariable model was constructed using all the variables from model 3 (including stress) but excluding the anxiety, income and, social support from the partner variables. When comparing the beta and p-values of this model to the model 3 with stress in table H.1, it appears that the beta value attenuates and the p-value becomes less significant to the point where stress is no longer significant at a p-value of 0.2 when these three variables are not included in the same model as the stress variable (Table H.4). Finally, the Variance Inflation Factors (VIFs) were calculated for all model 3 variables including and excluding stress (Table H.5). According to Freund et al, an appropriate cut-off for the VIFs to determine if multicollinearity is affecting the estimates is $1/(1-R^2)$(102). Since the R^2 for both of the model threes is quite low (approximately 0.05 for both), the appropriate cut-off for the VIFs would be only 1.05. The majority of the variables are over this cut-off but one of highest VIFs is observed for the stress variable. The high VIFs observed for the exercise variables are a result of the reference category chosen and thus in this case, the multicollinearity of the exercise variables does not affect the model estimates(104). The majority of VIFs, and all of the higher VIFs, attenuate when *model 3 does not include stress.*

Based on all the evidence illustrated above, it was decided that there was most likely an issue of collinearity with the stress variable, so stress was selectively removed from the final multivariable model.

Table H.1: Comparing Effects of Stress Variable on Model 3 Variables

Predictor Variables		Beta (p-value) Model 3 No Stress	Beta (p-value) Model 3 With Stress
Residency in Canada	Lifetime (born in Canada)	Reference	Reference
	> 5 years	-0.89(0.4536)	-0.49(0.6850)
	≤ 5 years	4.05(0.0107)	4.19(0.0101)
Marital Status	Married	Reference	Reference
	Common-law	-2.59(0.0112)	-2.77(0.0099)
	Single/separated/divorced	-1.15(0.4407)	0.13(0.9432)
Parity	0	Reference	Reference
	≥1	2.62(0.0001)	2.50(0.0006)
Education	Completed university/college	----------------	Reference
	Other		-1.34(0.1298)
Household Income	< 30k	-1.61(0.2131)	-1.76(0.2058)
	30k-79,999	-1.28(0.0831)	-1.24(0.1078)
	≥80k	Reference	Reference
Nausea Severity	No diet change/doctor visit	Reference	----------------
	Changed diet/no doctor visit	1.20(0.1042)	
	Visited doctor	1.40(0.1592)	
Exercise	Under-exercisers	-3.33(0.0006)	-3.19(0.0015)
	Optimal	Reference	Reference
	Over-exercisers	-0.31(0.7962)	-0.26(0.8349)
Smoking during Pregnancy	No	Reference	Reference
	Yes	-2.24(0.0755)	-2.63(0.0419)
Stress (Continuous)		**Removed**	**0.82(0.0797)**
Anxiety (STAI) (Continuous)		-0.80(0.0334)	-0.95(0.0276)
Social Support from Partner (Continuous)		----------------	0.95(0.0428)
Social Support from Family (Continuous)		0.56(0.1346)	----------------
Social Support from Friends (Continuous)		0.53(0.1506)	0.70(0.0624)
Presence of Fast Food Restaurants within 500 m	0	Reference	----------------
	≥1	-1.17(0.1103)	

Table H.2: Correlations of Stress with Anxiety and Social Support from the Partner

Variable Compared to Stress	Correlation Coefficient (p-value)
Anxiety	0.538(<0.0001)
Social Support Partner	-0.402(<0.0001)

Table H.3: Standardized Stress Score Based on Household Income Level

Level of Income	N	Mean (SD)
<30K	222	0.89(1.24)
30K-79999K	1028	0.006(0.96)
≥80K	793	-0.37(0.76)

Generalized Linear Model: stress = household income level

F-value (p-value): 169.18 (<0.0001)

Table H.4: Beta Value (p-value) of Stress Variable in Model 3 with and without Anxiety, Social Support from Partner and Income Variables

With Variables	Without Variables
0.89(0.0584)	0.14(0.7234)

Table H.5: Variance Inflation Factors (VIFs) for Models with/without Stress

Predictor Variables		VIFs	
		Model 3 No Stress	**Model 3 With Stress**
Residency in Canada	Lifetime (born in Canada)		
	> 5 years	1.02	1.02
	≤ 5 years	1.06	1.06
Marital Status	Married		
	Common-law	1.19	1.25
	Single/separated/divorced	1.26	1.68
Parity	0		
	≥1	1.05	1.12
Household Income	< 30k	1.52	1.61
	30k-79,999	1.22	1.27
	≥80k		
Nausea Severity	No diet change/doctor visit		
	Changed diet/no doctor visit	1.21	---------------
	Visited doctor	1.21	
Exercise	Under-exercisers	1.84	1.85
	Optimal		
	Over-exercisers	1.80	1.82
Smoking during Pregnancy	No		
	Yes	1.23	1.24
Stress (Continuous)		**Removed**	**1.85**
Anxiety (STAI) (Continuous)		1.24	1.54
Social Support from Partner (Continuous)		-----------------	1.69
Social Support from Family (Continuous)		1.20	----------------
Social Support from Friends (Continuous)		1.19	1.15
Presence of Fast Food	0		
Restaurants within 500 m	≥1	1.07	----------------

Appendix I: Post-Hoc Analysis with only Block 3 Variables

Table I.1: Parsimonious Multivariable Linear Regression of Diet Quality (DQI-P_m) with only Block 3 Predictor Variables

Predictor Variables		Beta (p-value)
Exercise	Under-exercisers	-3.50(0.0002)
	Optimal	Reference
	Over-exercisers	-0.88(0.4583)
Smoking during Pregnancy	No	Reference
	Yes	-4.54(<.0001)
Anxiety (STAI) (Continuous)		-1.25(0.0002)
Presence of Fast Food Restaurants within 500 m	0	Reference
	≥1	-1.67(0.0172)

Theory: Geographic variables are pathway variables between earlier predictors and outcome

When earlier variables are not included in the analysis, the number of fast food restaurants within 500 metres of participants' homes becomes statistically significant at a p-value less than 0.05, where it was not in the final parsimonious model of the main analysis. This may be evidence that it is a pathway variable and that the effect was attenuated in the main analysis because earlier variables in the pathway were controlled.