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Diet quality during pregnancy and its association with social factors: 3D Cohort Study (Design, Develop, Discover)

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Abstract

Good diet quality during pregnancy provides adequate nutrition to support both the mothers and the fetus. The objective of this study is to describe the distribution of diet quality during pregnancy and to study the association between social factors and diet quality during pregnancy in a Canadian population. This study was based on 1535 pregnant women who provided dietary information in the 3D Cohort Study in Quebec, Canada. A 3-day food record was used to collect dietary intake in the second trimester of pregnancy. A Canadian adaption of the Healthy Eating Index (HEI-C) 2010 was used to quantify diet quality. Univariate and multiple linear regression models were used to calculate unadjusted and adjusted effect estimates and confidence intervals for the association between social factors and HEI-C. The mean HEI-C 2010 score in this study was 62.9 (SD: 11.2). Only 4.5% and 8.3% of the pregnant women consumed the recommended amounts of whole grains and 'greens and beans', respectively. Diet quality was lower in some subgroups of pregnant women. After multivariable adjustment, lower diet quality was observed in participants who were less educated, younger, overweight or obese before pregnancy, or parous. There was an interaction between ethnicity and immigration status on diet quality in pregnancy. These findings could be useful for health practitioners and policymakers in developing strategies to improve the diet quality of pregnant women.

KEYWORDS

Cohort Studies, diet, educational status, healthy, maternal, obesity, parity, pregnancy

William Fraser and Lise Dubois contributed equally to this study.

1 | INTRODUCTION

The first 1000 days, including the prenatal period, is a unique period for children to develop their ability to grow and prosper in society (Koletzko et al., 2017; Schwarzenberg et al., 2018). Malnutrition during pregnancy represents a major public health issue that affects maternal health and offspring development and contributes substantially to the global burden of disease and disability (Hanson et al., 2015; Lim et al., 2013). Good diet quality during pregnancy provides adequate nutrition to support both the mothers and the fetus and is an important contributor to the children's physical and intellectual development (Fleming et al., 2018; Hanson et al., 2015; Stephenson et al., 2018).

A diet of good quality includes a variety of vegetables, fruits, whole grains, protein, low-fat dairy, healthy oils and a limited intake of saturated and trans fats, added sugars and sodium (Krebs-Smith et al., 2018). Individuals may be considered as having good overall diet quality when they follow the recommendations from dietary guidelines (Krebs-Smith et al., 2018). However, the proportion of pregnant women following the recommendations remains low in high-income countries (Bodnar & Siega-Riz, 2002; Crozier et al., 2009; Fowler et al., 2012; Malek et al., 2016; Morton et al., 2014; Pick et al., 2005). For example, only 35% of pregnant women in a Canadian cohort met the recommendations for vegetables and fruits in 2002–2005 (Fowler et al., 2012), and only 10% of pregnant women in an Australia study met the recommendations for vegetables in 2013 (Malek et al., 2016). What people habitually eat and avoid eating is not simply a matter of personal choices. Changes in diet quality may be difficult due to barriers at the individual, social–cultural and environmental levels (Mozaffarian et al., 2018; Sugiyama & Shapiro, 2014). However, pregnancy offers a window of opportunity for intervention, because pregnant women may be more willing to adopt healthier dietary habits during this period of life due to perceived benefits to the babies and themselves (Gardner et al., 2012; Vanstone et al., 2017).

Starting from before pregnancy, social inequalities exert their influence on different aspects of the women's experience. Even in high-income countries such as the United States and Canada, some subgroups of the population still have limited access to high-quality foods to provide adequate nutrition (Ivers & Cullen, 2011). It is thus vital to study social factors associated with diet quality to develop effective public health interventions. A systematic review (Doyle et al., 2017) found that women who were older, more educated, with higher income or other markers of affluence were more likely to follow a healthier dietary pattern or have a better diet quality. The finding was consistent across different populations and settings. However, not all studies used multivariable models, so it was not clear how these factors were confounded by each other. Findings regarding ethnicity and parity were less consistent and they could be acting as markers of age, education status and other sociodemographic factors.

Thus, the objective of this paper is to characterize diet quality during pregnancy and identify social factors associated with the diet quality of pregnant women that could inform the targeting of interventions designed to reduce the inequities in diet quality.

Key message

- The diet of the women in Canada still needs improvement, especially regarding whole grains and 'greens and beans', where the majority of the women did not meet the recommendations.
- Pregnant women who were less educated, younger, overweight or obese before pregnancy, or parous should be targeted for improving diet quality in Canada.
- There was an interaction between ethnicity and immigration status on diet quality during pregnancy.

2 | METHODS

2.1 | The 3D Cohort Study

The 3D Cohort Study is a pregnancy and birth cohort that recruited 2366 pregnant women who were at 8–14 weeks of gestation and planning to deliver in urban clinical centres in three of the four largest metropolitan areas in Quebec, Canada from 2010 to 2012. Detailed information on the cohort has been described elsewhere (Fraser et al., 2016). Briefly, inclusion criteria included age 18 and 47 years at recruitment and ability to communicate in French or English. Exclusion criteria included current intravenous drug use, severe illnesses or life-threatening conditions, and multiple gestations. Structured interviews were conducted at recruitment, mid, late pregnancy and post-partum by research nurses and research assistants. Written informed consents were obtained from each participant. Ethical approvals were obtained from the Health Sciences and Science Research Ethics Board of the University of Ottawa, the research ethics committee at Sainte-Justine's Hospital in Montreal and all other participating study cites.

2.2 | Exposures

Information about maternal characteristics was collected by interviewers at recruitment (8–14 weeks of gestation). Characteristics used in this study included maternal age (<25, 25–<35, ≥35), ethnicity (White, non-White), marital status (married, live with common law/partner, single), education (secondary school diploma or less, college, undergraduate degree, graduate degree), household income in Canadian dollars (<30,000, 30,000–59,999, 60,000–79,999, 80,000–99,999, ≥100,000), parity (0, ≥1) and self-reported prepregnancy weight. Height was measured by trained research nurses. Prepregnancy body mass index (BMI) (kg/m^2) was calculated using self-reported prepregnancy weight in kilograms divided by height in metres squared. Social support was considered but not included in the model due to a lack of information.

2.3 | Outcome: Diet quality in pregnancy

2.3.1 | Generating energy and nutrients from a 3-day food record

Details of dietary data collection and processing have been described elsewhere (Dubois et al., 2018; Morisset et al., 2017). Briefly, a 3-day food record was provided to the participants at the second prenatal visit (20–24 weeks) to record dietary intakes on 2 weekdays and 1 weekend day. Pregnant women were trained by the research nurses on how to complete the 3-day food record. They completed the food record at home and returned the food records by mail. The food items in the food records were coded by trained nutritionists into Food Processor software (ESHA Research, Inc.), which was linked to the Canadian Nutrient File, to generate a complete database of energy and macronutrient and micronutrient intakes. As the content of added sugars was not readily available in the Canadian Nutrient File, it was calculated following a published method (Brisbois et al., 2014).

2.3.2 | Assigning food to a number of food group servings

The food items were assigned to four major Canada's Food Guide (CFG) food groups, 30 subgroups and to Tiers 1–4 using the food classification system developed by Health Canada (Elvidge Munene et al., 2015). CFG encourages people to choose foods lower in fat, sugar and salt. Foods that exceed at least two upper thresholds (total fat: >10 g/reference amount (RA); sugars: >19 g/RA; sodium: >360 mg/RA; saturated fat: >2 g/RA) will be classified into Tier 4. For 'milk and alternatives' and 'meat and alternatives' group, the upper threshold for saturated fat was not counted due to the fact that these food groups contain more inherent saturated fats than other food groups. Foods allocated to Tier 4 were excluded when counting the number of CFG servings of food in the four major food groups because they were classified as 'not in line with the guidance in CFG' (Elvidge Munene et al., 2015).

In CFG classifying system, mixed dishes (e.g., spaghetti with meat sauce) were classified into a subgroup called 'recipes' without breaking down into the four main food groups. The energy intake from foods in the subgroup 'recipes' accounted for 8% of the total energy intake of this study population. Thus, an omission of the mixed dishes in counting the number of servings of the four main groups would lead to an underestimation of the number of servings. For a more concise estimate, mixed dishes in the food records were decomposed into food group and subgroup servings by linking to standard recipes in the Food Patterns Equivalents Database (FPED) developed by the US Department of Agriculture (USDA), which converts the foods and beverages to USDA Food Patterns components (USDA). The matching was performed manually according to name and description, with a secondary aim of minimizing the energy density gap. When there were multiple possible matches, the one with the smallest gap in energy density per 100 g was chosen. When an exact match was not found in FPED, the most similar item regarding components of the food groups was chosen. This process was performed by a student with a background in nutrition and reviewed by a nutritionist who was familiar with the foods consumed locally. USDA Food Patterns components were then converted to the number of servings in the CFG.

2.3.3 | Generating diet quality

Overall diet quality in pregnancy was calculated according to the Canadian adaption of Healthy Eating Index (HEI-C) 2010 developed in 2017 (Jessri et al., 2017). HEI-C contains eight components for foods that should be consumed in adequate amounts (total fruits and vegetables, whole fruit, greens and beans, whole grains, dairy, total protein foods, seafood and plant proteins, fatty acids) and three that should be consumed in moderate amounts (refined grains, sodium, empty calories), resulting in a total score of 100 (see Supporting Information: Table 1). At the time of data collection, people's diet was guided by age- and sex-specific recommendations from CFG 2007, which were designed scientifically for the food intake pattern to meet the nutrient requirements and to avoid nutrient excess. Thus, the number of servings for 19–50-year-old women in CFG 2007 were used in this study: that is, eight servings of vegetables and fruits, six to seven servings of grain products, two servings of 'milk and alternatives' and two servings of 'meat and alternatives' per day (Health Canada, 2007, 2009, 2010, 2019;). Because pregnant women were advised to include an additional two to three servings per day from any of the four food groups (Health Canada, 2009), the cut-offs for 'total vegetables and fruits', grain products and 'milk and alternatives' were set at eight, seven, and three, respectively, to align with the examples given by Health Canada (Fowler et al., 2012). The cut-offs for whole fruit and 'greens and beans' component were set at 21% of that for 'total vegetables and fruits', which are 1.68 servings (Garriguet, 2009; Jessri et al., 2017). The cut-offs for whole grains were set at 50% of that for total grain products, which are 3.5 servings, according to CFG 2007 recommendations. Empty calories were defined as calories from saturated fats, alcohol and added sugars (Brisbois et al., 2014; Jessri et al., 2017). The detailed scoring standards for min and max of each of the HEI-C components used in this study were listed in Supporting Information: Table 1. Intermediate intakes were scored proportionately between min and max. Total HEI-C score, adequacy subscore and moderation subscore were sums of specific individual components.

2.4 | Statistical analyses

A flowchart for the study samples was presented in Figure 1. Proportions were used to display the characteristics of the 3D study sample, a sample with reliable diet information and a complete case sample (participants with no missing values on any of the variables included in the multiple linear regression model). The mean and SD of the intakes for each component of the HEI-C were calculated in the sample with reliable diet information. Mean, SD, range and the proportion reaching the maximum scores were calculated for the total HEI-C score and the components. To validate that higher HEI-C was associated with higher beneficial nutrient supply, HEI-C scores were divided into quartiles, to present the mean and SD of selected nutrients in each HEI-C quartile (Jessri et al., 2017). Univariate and multiple linear regression models were used to calculate unadjusted and adjusted effect estimates and confidence intervals (CIs) for the association between maternal characteristics and HEI-C. Multiple linear regression was performed on the complete case sample. Residual plots were used to visually check for homoscedasticity and normality assumptions of the multiple linear regression models. As the assumptions of the models were roughly met, no transformations of the variables were performed. Interactions between pairs of the social factors were tested by adding the product interaction term to the multiple regression model. All statistical analyses were performed using Statistical Analysis System software version 9.4 (SAS v9.4; SAS Institute Inc.). A two-sided $p < 0.05$ was set as the level of statistical significance.

3 | RESULTS

A total of 1535 pregnant women (65% of the 3D Cohort Study sample) who provided complete and reliable information for the 3-day food record were included in this study (Figure 1). The mean age at enrolment was 31.5 (SD: 4.3) years. Mean prepregnancy BMI was 23.8 kg/m^2 (SD: 5.1). The mean gestational age at food record completion was 23.0 weeks (SD: 2.9). As shown in Table 1, only a small proportion had less than or equal to secondary school education (6.2%) or had annual household incomes below 30,000 Canadian dollars (7.8%); 30.6% were overweight or obese before pregnancy. More than half (58.0%) were nulliparous. Most were born in Canada (71.7%), classified themselves as White (80.1%), and were married or living with a partner (95.8%). Compared with the total 3D study sample, participants included in this study were on average older, with higher income and education level, more likely to be White and born in Canada and less likely to be overweight or obese before pregnancy.

As shown in Table 2, the mean HEI-C 2010 score was 62.9 (SD: 11.2). The proportion of women reaching the recommended

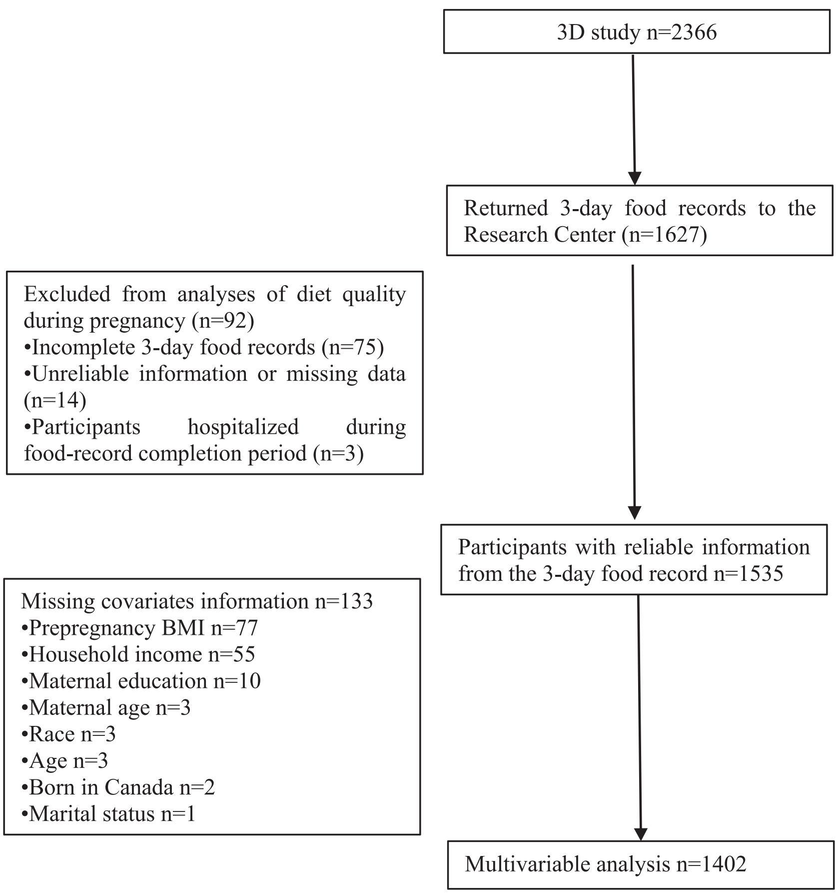

FIGURE 1 Flow diagram for the study samples

TABLE 1 Characteristics of the study samples

Characteristics	3D sample	Sample with reliable diet information	Complete case sample[a]
n	2366	1535	1402
Mother's age (%)			
<25	7.3	5.5	5.4
25–<35	70.7	73.7	74.0
≥35	22.0	20.8	20.7
Maternal education (%)			
Secondary school or less	9.5	6.2	5.7
College	28.2	25.6	25.2
Undergraduate degree or above	62.3	68.2	69.1
Household income (CAD) (%)			
<30,000	10.8	7.8	7.4
30,000–59,999	19.1	17.2	17.1
60,000–79,999	17.2	17.8	18.1
80,000–99,999	18.9	22.4	22.4
≥100,000	29.1	34.8	35.0
Married/common law/ partner (%)	94.5	95.8	95.9
Prepregnancy BMI (%)			
Underweight < 18.5	6.0	6.2	6.2
Normal weight 18.5–24.9	63.3	65.4	65.6
Overweight 25–29.9	18.4	16.8	16.4
Obese > 30	12.3	11.7	11.8
Nulliparous (%)	54.2	58.0	58.2
Mother born in Canada (%)	65.1	71.7	73.0
Mother White (%)	72.2	80.1	81.1

Abbreviations: BMI, body mass index; CAD, Canadian dollars.
[a]Sample with no missing value in diet and covariates in multivariate analysis.

servings for whole grains was 4.5%. Similarly, only 8.3% reached the recommended servings of 'greens and beans'. About half consumed the recommended servings of protein foods (49.4%) and 'seafood and plant proteins' (52.1%). The majority (62.5%) of the participants consumed the recommended servings of whole fruits.

A higher density of beneficial micronutrients from food including calcium, vitamin A, folate, vitamin C, vitamin D, calcium, magnesium, iron, and zinc was found in higher quartiles of HEI-C (Supporting Information: Table 2). The density of protein, fibre, polyunsaturated fatty acids and monounsaturated fatty acids increased in higher quartiles of HEI-C, whereas the density of total fat, saturated fat, added sugars and sodium decreased. There was no significant trend for carbohydrates.

Table 3 showed unadjusted and multivariable-adjusted analyses for the social factors in association with the HEI-C score. In univariate analysis, women who were <25 years of age, single, overweight or obese before pregnancy, or parous had lower HEI-C scores than the reference group. Women who had an undergraduate degree, attended graduate studies or with household income above 100,000 Canadian dollars had higher HEI-C scores than the reference group. In multivariable analysis, participants who attended graduate studies (mean difference: 4.0 [95% CI: 1.2–6.9]) had higher HEI-C scores compared with secondary school or less. Participants who were <25 years of age (mean difference: −4.9 [95% CI: −7.6 to −2.2] compared with 25–35 years of age), overweight (mean difference: −2.8 [95% CI: −4.4 to −1.3] compared with normal BMI), obese (mean difference: −3.1 [95% CI: −4.9 to −1.3] compared with normal BMI), parous (mean difference: −2.7 [95% CI: −3.9 to −1.5] compared with nulliparous) had lower HEI-C scores. Household income and marital status no longer had a statistically significant association with HEI-C after adjustment.

There was an interaction between ethnicity and immigration status on HEI-C. As shown in Table 4, for women who were born in Canada, visible minority women had lower HEI-C scores than White women (mean difference: −5.9 [95% CI: −9.5 to −2.3], $p = 0.001$). On the contrary, for women who were not born in Canada, visible minority women had higher HEI-C scores than White women (mean difference: 3.9 [95% CI: 1.6–6.2], $p = 0.001$). For White women, those who were not born in Canada had lower HEI-C than those who were born in Canada (mean difference: −3.6 [95% CI: −5.5 to −1.6], $p < 0.001$). However, for non-White women, those who were not born in Canada had higher HEI-C than those who were born in Canada (mean difference: 6.2 [95% CI: 2.4–10.0], $p = 0.001$).

4 | DISCUSSION

This study demonstrated that the diet quality of pregnant women still needs improvement, especially with respect to the intake of whole grains and 'greens and beans'. Diet quality among pregnant women was associated with social factors. After multivariable adjustment, diet quality was lower in some subgroups of pregnant women, including those who were less educated, younger, overweight or obese before pregnancy, or parous.

Pregnant women in this study were having better diet quality than that reported in the general population (Jessri et al., 2017) (mean HEI-C: 62.9 vs. 50.9). However, a cautious interpretation of this comparison is needed because pregnant women in this study have higher socioeconomic status than the general pregnant women and general population in Canada. Still, the compliance in specific subgroups of food was low. In this study, only 4.5% of the pregnant women met the recommended number of servings for whole grains, only 8.3% for greens and beans and only about 1 in 3 for 'milk and

TABLE 2 Mean food and nutrient intakes and scores of components of HEI-C for 1535 women participating in the 3D Cohort Study

Component	Intake Mean ± SD	Scores Mean ± SD	Range	Proportion reaching max score (%)
Total fruits and vegetables, servings/day	7.4 ± 2.8	8.1 ± 2.1	0.4–10	36.5
Whole fruit, servings/day	2.4 ± 1.6	4.2 ± 1.3	0–10	62.5
Greens and beans, servings/day	0.7 ± 0.7	2.0 ± 1.6	7.7–20	8.3
Whole grains, servings/day	1.0 ± 1.1	2.8 ± 2.9	0–5	4.5
Milk and alternatives (servings/day)	2.6 ± 1.3	7.6 ± 2.6	0–5	33.6
Total protein foods (servings/day)	2.1 ± 0.9	4.3 ± 1.0	0–10	49.4
Seafood and plant proteins (servings/day)	0.8 ± 0.7	3.6 ± 1.8	0–10	52.1
(PUFA + MUFA)/SFA (no unit)	1.6 ± 0.5	3.2 ± 2.9	0.1–5	4.5
Refined grains (% of total grains)	82.6 ± 18.8	3.3 ± 3.3	0–5	7.6
Sodium (mg)	2841 ± 848	6.0 ± 2.6	0–10	3.5
Empty calories (% of energy)	21.3 ± 4.7	17.9 ± 2.4	0–10	33.1
Total adequacy score		35.7 ± 8.0	10.7–57.4	0.0
Total moderation score		27.2 ± 5.2	11.4–40	0.4
Total HEI-C score		62.9 ± 11.2	28.8–95.6	0.0

Abbreviations: HEI-C, Canadian Healthy Eating Index; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids.

alternatives'. The results were consistent with findings from other high-income countries, indicating that a large portion of pregnant women was not meeting the dietary guidelines (Bodnar & Siega-Riz, 2002; Crozier et al., 2009; Malek et al., 2016; Morton et al., 2014; Pick et al., 2005). Because CFG 2007 was designed for meeting nutritional requirements, the results in this study indicated that women might have some difficulties meeting the dietary guidelines, and thus could have inadequate nutrition supplies. Indeed, previous research from our group found that intake of iron, folate and vitamin D from food sources was below recommended values for a vast majority of pregnant women (Dubois et al., 2017). For women having difficulties meeting the guidelines, other sources of nutrients, such as nutritional supplements and exposure to sunshine, could be recommended as appropriate to meet the needs for adequacy of nutrients supply.

Consistent with our findings, higher education, older age, and lower prepregnancy BMI were found to be associated with higher diet quality (Bodnar & Siega-Riz, 2002; Kritsotakis et al., 2015; Rifas-Shiman et al., 2009; Savard et al., 2019; Shin et al., 2016), including in low-income settings (Fowles et al., 2011). The interpretation of the lower diet quality in women with overweight and obesity before pregnancy requires comment. In addition to interpreting prepregnancy BMI as a determinant of diet quality during pregnancy, it could also be interpreted that diet tracking back to prepregnancy was a determinant of prepregnancy BMI. The finding from previous studies that diet quality changed little (Savard et al., 2019) from prepregnancy to pregnancy supports this hypothesis.

Interestingly, in our study, although income was positively associated with diet quality in univariable analysis, the association was no longer statistically significant after multivariable adjustment, mainly due to the confounding effect of age and education. This result was in line with an urban pregnancy cohort in the United States (Deierlein et al., 2021). Similar to our findings, parity has been found to be inversely associated with diet quality in two US cohorts, and inversely associated with a 'health conscious' dietary pattern in a population-based cohort study in the United Kingdom (Bodnar & Siega-Riz, 2002; Northstone et al., 2008; Rifas-Shiman et al., 2009). Some possible mechanisms for this association could be that parous women are more likely to rely on their own past knowledge or assumptions for healthy behaviours during pregnancy, rather than seeking out information, compared with nulliparous women (Declercq et al., 2007; Grenier et al., 2021). Parous women also reported a larger number of 'very stressful' days 1 year before birth than nulliparous women, which might influence their ability to maintain a healthy diet (Public Health Agency of Canada, 2009). Our results indicate that parous women need more attention from care providers or social support to improve diet quality compared with nulliparous women. Only one previous study found the opposite direction of this association that parity was positively associated with diet quality (Nash et al., 2013), possibly because age was not adjusted in the analysis. It has been shown from previous studies that higher parity was associated with older age, and age has been consistently reported to be positively associated with diet quality (Bodnar & Siega-Riz, 2002; Kritsotakis et al., 2015; Rifas-Shiman et al., 2009; Savard et al., 2019).

To our knowledge, our study is the first to report the interaction between ethnicity and immigration status (born in Canada) on diet quality during pregnancy. Validation of this finding in other studies is needed due to the limitation that this study sample was not a representative sample of the Canadian pregnancy population. While

TABLE 3 Unadjusted and multivariable-adjusted analyses for the social factors in association with HEI-C

Characteristics	*n*	HEI-C scores, mean ± SD	Regression estimates (95% CI)[b]	
			Unadjusted	Multivariable[a]
Total	1535	62.9 ± 11.2		
Age (years)				
<25	85	56.3 ± 10.5	**−6.2 (−8.8,−3.6)**	**−4.9 (−7.6,−2.2)**
25–<35	1129	63.1 ± 11.3	Reference	Reference
≥35	318	64.2 ± 10.5	0.9 (−0.6,2.3)	1.2 (−0.2,2.6)
Missing	3	59.9 ± 8.1		
Education				
Secondary school or less	94	57.5 ± 11	Reference	Reference
College	391	60.3 ± 11.2	2.1 (−0.6,4.7)	0.3 (−2.4,2.9)
Undergraduate degree	628	63.9 ± 11.3	**5.6 (3.0,8.1)**	2.7 (0,5.4)
Graduate degree	412	65.2 ± 10.2	**6.8 (4.1,9.4)**	**4.0 (1.2,6.9)**
Missing	10	59.9 ± 8.6		
Household income (CAD)				
<30,000	116	60.3 ± 11.1	Reference	Reference
30,000–59,999	254	61.9 ± 11.5	1.5 (−1.1,4.0)	1.4 (−1.2,3.9)
60,000–79,999	263	61.6 ± 10.7	1.2 (−1.3,3.7)	0.3 (−2.4,2.9)
80,000–99,999	332	62.6 ± 10.7	1.9 (−0.6,4.4)	0.2 (−2.5,2.8)
≥100,000	515	65 ± 11.2	**4.5 (2.1,6.8)**	1.9 (−0.7,4.5)
Missing	55	62.3 ± 11.4		
Marital status				
Married	614	63.1 ± 10.7	Reference	Reference
Common law/partner	856	63.1 ± 11.4	0.3 (−1.0,1.5)	0.1 (−1.3,1.4)
Single	64	58.7 ± 12.7	**−4.3 (−7.4,−1.3)**	−3.1 (−6.3,0)
Missing	1	57.1 ± 0		
Prepregnancy BMI				
Underweight (BMI < 18.5)	90	64.8 ± 11.6	1.2 (−1.2,3.6)	1.7 (−0.6,4.1)
Normal weight (BMI: 18.5–24.9)	953	64 ± 11.1	Reference	Reference
Overweight (BMI: 25.0–29.9)	245	60.8 ± 10.8	**−3.1 (−4.7,−1.5)**	**−2.8 (−4.4,−1.3)**
Obese (BMI ≥ 30.0)	170	59.4 ± 10.7	**−4.5 (−6.3,−2.7)**	**−3.1 (−4.9,−1.3)**
Missing	77	62.8 ± 11.5		
Parity				
0	891	64 ± 10.9	Reference	Reference
≥1	644	61.4 ± 11.4	**−2.5 (−3.7,−1.4)**	**−2.7 (−3.9,−1.5)**
Born in Canada				
No	434	62.8 ± 10.9	−0.2 (−1.5,1.1)	**−5.9 (−9.5,−2.3)**
Yes	1099	63 ± 11.3	Reference	Reference
Missing	2	55.6 ± 2.2		

(Continues)

TABLE 3 (Continued)

Characteristics	n	HEI-C scores, mean ± SD	Regression estimates (95% CI)[b]	
			Unadjusted	Multivariable[a]
White				
No	305	63.1 ± 10.8	0 (−1.5,1.5)	**−3.6 (−5.5,−1.6)**
Yes	1227	62.9 ± 11.3	Reference	Reference
Missing	3	59.7 ± 5.3		
Born in Canada × White (*p* for interaction)				$p < 0.001$

Abbreviations: BMI, body mass index; CAD, Canadian dollars; CI, confidence interval; HEI-C, Canadian Healthy Eating Index; SD, standard deviation.
[a]Adjusted for all characteristics simultaneously using a complete case sample ($n = 1402$).
[b]Stastistical significant values ($p < 0.05$) were highlighted in bold.

TABLE 4 Interaction between ethnicity and immigration status on Canadian Healthy Eating Index (HEI-C)[a]

	Ethnicity White, β (95% CI), *p*	Ethnicity non-White, β (95% CI), *p*	β (95% CI) for ethnicity within strata of immigration status	*p* for interaction
Born in Canada				<0.001
Yes	Reference	**−5.9 (−9.5,−2.3), *p* = 0.001**	**−5.9 (−9.5,−2.3), *p* = 0.001**	
No	**−3.6 (−5.5,−1.6), *p* < 0.001**	0.3 (−1.6,2.2), *p* = 0.75	**3.9 (1.6,6.2), *p* = 0.001**	
β (95% CI) for immigration status within strata of ethnicity	**−3.6 (−5.5,−1.6), *p* < 0.001**	**6.2 (2.4,10.0), *p* = 0.001**		

[a]Adjusted for age, education, household income, marital status, prepregnancy BMI and parity.

'the healthy immigrant effect' indicates that immigrants are generally healthier than the native-born population (Vang et al., 2017), this result indicates that ethnicity needs to be considered when studying the association between immigration and diet, or other diet-related health outcomes.

Our study has some limitations. The distributions of the 3D study sample and our study sample that have reliable dietary information were towards that of a high socioeconomic status, and thus not a representative sample of the population of Canadian pregnant women. Because higher education is associated with higher diet quality, the true estimates of HEI-C in the general population could be lower than the estimates in this study. The results of the study might not be generalized to a population with a lower socioeconomic status. Additionally, causality could not be concluded due to the nature of the study design. Furthermore, our study only captures diet in the second/third trimester of pregnancy. However, although diet quality might change in the first trimester due to nausea or food aversions, studies have shown that diet quality changes little across trimesters (Lebrun et al., 2019; Savard et al., 2019). Our study also had several strengths, including a large sample size, a large set of covariates and the 3D food records dietary assessment method used, which is less prone to memory biases and is recognized as one of the most accurate tools for dietary assessment (Bingham et al., 1995; Kolar et al., 2005).

5 | CONCLUSION

Social factors are associated with diet quality during pregnancy in Canada. Women who were less educated, younger, parous or with a higher BMI had lower diet quality in pregnancy. These findings could be useful for health practitioners and policymakers in developing strategies to improve the diet quality of pregnant women.

AUTHOR CONTRIBUTIONS

Yamei Yu is the guarantor of the paper. Yamei Yu, William Fraser and Lise Dubois contributed to the conception of the research question. Yamei Yu and Cindy Feng contributed to the statistical analyses. Yamei Yu, Brigitte Bédard and Lise Dubois contributed to the dietary data coding. Yamei Yu, Cindy Feng, Brigitte Bédard, Lise Dubois and William Fraser contributed to the drafting and reviewing of the paper and provided approval for the version submitted for publishing.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

Data are available on request due to privacy/ethical restrictions.

ETHICS STATEMENT

This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving research study participants were approved by the Health Sciences and Science Research Ethics Board of the University of Ottawa, the research ethics committee at Sainte-Justine's Hospital in Montreal, and all other participating study cites. Written informed consent was obtained from all subjects/patients.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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