Examining the diversity of ultra-processed food consumption and associated factors in Canadian adults

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| Novelty bullets: points that summarize the key findings in the work: | Almost all Canadians consume at least one type of ultra-processed food weekly, Nearly half or more Canadians consume chocolate, chips/pretzels, cold breakfast cereal, or fast food at least once weekly, Gender, age, and BMI are consistently associated with ultra-processed food diversity |
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Examining the diversity of ultra-processed food consumption and associated factors in Canadian adults

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Abstract: Ultra-processed food (UPF) consumption is increasing globally at an unprecedented rate. We investigated UPF consumption among Canadian adults and associated socio-demographic and health-related factors. This study was a secondary analysis of the Foodbook study (2014-2015) which collected self-reported data on foods consumed by Canadians during a seven-day period. UPF diversity was assessed by summing the different types of UPFs consumed in the previous week to produce a diversity score. Descriptive statistics summarized UPF diversity among subgroups in Canada. Regression models identified significant associations between UPF diversity, body mass index (BMI), and socio-demographic variables. 6,062 participants, aged 18 years and older, were included, representing 24.7 million Canadian adults. Almost all Canadian adults (99.0%) consumed UPFs at least once weekly. The most common UPFs consumed were chocolate, chips/pretzels, cold breakfast cereal and fast foods. UPF diversity was greatest among men, young respondents, those with high income, and those with obesity. When controlling for potential confounders, UPF diversity for men and women was significantly associated with younger age and higher BMI; it was also associated with region for women. This study suggests UPF consumption in Canada varies across socio-demographic subgroups, but ultimately is pervasive. Further research examining potential health risks associated with UPF consumption is encouraged to inform Canadian interventions.

Novelty:

- Almost all Canadians consume at least one type of ultra-processed food weekly
- Nearly half or more Canadians consume chocolate, chips/pretzels, cold breakfast cereal or fast food at least once weekly
- Gender, age, and BMI are consistently associated with ultra-processed food diversity

Keywords: ultra-processed foods, Canada, obesity, health surveys, food habits, food processing
Introduction

Over the past forty years, industrial food processing techniques have changed rapidly and extensively around the globe (Moubarac et al. 2014a). Processes such as pasteurization have contributed to a safer food supply, while drying and freezing have helped retain nutrients in preserved foods (Moubarac et al. 2014a). However, the “nature, extent, and purpose of food processing” vary greatly, often impacting the dietary quality of transformed food products (Monteiro et al. 2018a). Increasingly, food products are developed using numerous sequences of processes, leading to final products with limited, if any, traces of the original food product (Monteiro et al. 2018a). These more extensive techniques allow for convenient and affordable products that can be safely preserved longer than fresh foods (Monteiro et al. 2013).

The emerging NOVA classification system categorizes foods into four groups based on the type of food processing: Group 1: Unprocessed or minimally processed foods, Group 2: Processed culinary ingredients, Group 3: Processed foods, Group 4: Ultra-processed foods (UPFs) (Monteiro et al. 2016). This system has been widely used by international organizations, including the United Nations’ Food and Agriculture Organization and the World Health Organization’s Pan American Health Organization (Food and Agriculture Organization of the United Nations 2015; Pan American Health Organization 2015). UPFs have been characterized as formulations of ingredients that result from processes such as refining whole foods into substances, some of which are chemically modified. Practically, a UPF can be identified as having at least one ingredient that is never or rarely used in kitchens (e.g. high-fructose corn syrup, hydrogenated oils, hydrolyzed proteins). Or, a UPF may have additives to improve the appeal and palatability of the product (e.g. flavours, colours, thickeners, emulsifiers) (Monteiro...
et al. 2019). Foods that have undergone substantial processing, such as deli meats, sweetened breakfast cereals, and powdered cheese are classified as UPFs (Monteiro et al. 2018a). Ultra-processing helps create products that are hyper-palatable, durable, easy to consume, and ultimately, very profitable (Monteiro et al. 2018a). Through the development of attractive products and aggressive marketing, the presence of UPFs in grocery stores and households continues to increase globally (Global Panel on Agriculture and Food Systems for Nutrition 2016). The percentage of total purchased calories attributed to UPFs in Canada increased from 24% in 1938 to 55% in 2001 and in 2013, Canadians purchased an average of 230 kg of UPFs per person (Moubarac et al. 2014b; Pan American Health Organization 2015). By 2015, UPFs contributed 47% of Canadian adults’ energy intake (Nadocci et al, 2019).

UPFs are characterized by their elevated energy density and glycemic load, as well as high content of dietary fat, free sugar, and sodium (Monteiro et al. 2011). Increased UPF consumption is replacing the consumption of unprocessed or minimally processed foods that typically have higher dietary quality (Moubarac et al. 2014b; Monteiro et al. 2011). Furthermore, many of the UPF processes risk disrupting endogenous satiety mechanisms and may lead to increased consumption (Ludwig 2011). The staggering increase in UPF consumption and associated decline in dietary quality are suggested to contribute to the increased prevalence of excess adiposity and obesity (Canella et al. 2014; Hall et al. 2019; Nardocci et al. 2019a; Nardocci et al. 2019b; Louzada et al. 2015; Monteiro et al. 2018b; Juul et al. 2018; Mendonca et al., 2016). A causal link has not been demonstrated, but increases in UPF production and manufacturing have paralleled the observed increases in obesity and other non-communicable diseases (Monteiro et al. 2013). Recently, in a small randomized control trial study, Hall et al. (2019) demonstrated a
causal link between high UPF diets and excess energy intake and weight gain. Monteiro et al. 2019 summarized the association between UPFs and non-communicable disease such as obesity (Juul et al. 2018), metabolic syndrome (Steele et al, 2019), cardiovascular disease (Srour et al. 2019), dyslipidemia (Rauber et al. 2015), some types of cancer (Fiolet et al. 2018), depression (Gómez-Donoso, 2019) and mortality (Kim et al. 2019,).

There are some nationally-representative studies in Canada on the associations between UPFs, obesity, and socio-demographic factors (Nardocci et al, 2019a,b; Moubarac et al. 2017a,b), but few based on data collected in the past five years (Nardocci et al. 2019a, Moubarac et al. 2017a). To our knowledge, no Canadian studies of UPFs have included people in the territories, though Lavigne-Robichaud et al. 2017 reported on the association of ultra-processed products and metabolic syndrome in the Cree (Eeyouch) in northern Quebec. This study sought to examine the current distribution of UPF consumption among adults in the provinces and territories in Canada and investigate its association with obesity and socio-demographic factors.

Materials and Methods

Data source

This study used the Public Health Agency of Canada’s Foodbook data set, which collected data from 10,942 Canadian respondents in the 10 provinces and three territories, from birth and above from April 2014 to April 2015 (Public Health Agency of Canada 2015). This was a population-based telephone survey on Canadians’ weekly eating patterns. The Foodbook survey was approved by the Health Canada and Public Health Agency of Canada’s Research Ethics Board (REB 2013-0025), as well as the Newfoundland and Labrador Health Research Ethics Authority to fulfill a provincial legal requirement (HREB 13.238).
This study was a secondary analysis of the Foodbook data. The sample was limited to Canadian adults, 18 years and older. The interviews could be completed directly in English, French, Inuktitut or through on-demand verbal translation for other languages including Korean, Mandarin, Russian and Spanish. Adults who could not speak the supported languages, who did not have access to a landline telephone or cellphone, or who had travelled outside their province or territory of residence during the recall period were excluded from the study. As such, a sample size of 6,062 adult respondents was used for analyses. Based on the Marketing Research and Intelligence Association Data Collection Response Rate Calculation, recommended by Statistics Canada, the final response rate of the survey was 19.9% (Public Health Agency of Canada 2015). The data were weighted according to the Foodbook Report protocol to improve the national representativeness of the data set. The weighting accounted for respondent gender, age group, household type, province/territory, number of people in the household, number of land lines and cell phones in the household and most likely census metropolitan area. The sample used for the secondary analyses represented 24.7 million Canadian adults. Further details regarding the Foodbook’s methodology have been previously published (Public Health Agency of Canada 2015).

Ultra-processed foods

The outcome of interest for this study was the diversity of UPFs consumed, based on the NOVA classification system (Monteiro et al. 2018a). As mentioned, this system categorizes foods based on the nature, extent and purpose of processes they undergo (Monteiro et al. 2018a). UPFs usually contain multiple ingredients and additives such as anti-oxidants, stabilisers, or
preservatives in addition to sugars, oils, fats, and/or salt. Typically, little if any intact unprocessed or minimally processed foods are used to produce UPFs. Detailed guidelines on how to categorize the foods according to the NOVA classification system are published elsewhere (Monteiro et al. 2018a). Thirty-three out of over 150 food items in the Foodbook survey could be classified by the four-group NOVA system as UPF (Supplementary Table S1) by closely following the classification of a recently published study (Nardocci et al. 2019b). For most UPFs, the survey only asked whether or not they had been consumed at least once in the past week, not the amount or frequency. For this reason the consumption of UPFs was quantified by measuring the diversity of UPF products consumed, namely, the number of different types of UPF products consumed in the previous seven days. The total number of different types of UPF products (the sum total) that an individual consumed in the previous week constituted that person’s UPF diversity score. For example, if, in the past week, a participant consumed cold breakfast cereal three times and fast food once, the diversity score would be two. This is because two different UPFs were eaten in the previous week.

The UPF diversity score was used as a measurement proxy for UPF consumption, as previous studies have suggested that in general, dietary diversity and food intake are positively related (Hall et al. 2019; Jayawardena et al. 2013; McCrory, Burke, Roberts 2012; Raynor and Epstein 2001).

**Independent variables**

Gender, age, socio-economic status (SES), and geographic region were self-reported and included in the analyses as socio-demographic variables and potential confounders. For
descriptive statistics, gender was included as a dichotomous variable (men, women) and gender-specific regression models were conducted, given their notable differences in eating patterns and obesity distribution (Kanter and Caballero 2012). Age was included as a categorical variable for the descriptive statistics (18-39 years old, 40-64 years old, ≥ 65 years old) and it was included as a continuous variable in the regression model analyses to control for its potential confounding influence on the relationships of interest while minimizing loss of power and precision. To measure respondents’ SES, household income level was used. The measure for household income level was participants’ self-reported annual household income before taxes and deductions, collapsed into three groups (<$30,000, $30,000-$80,000, and > $80,000). Household income was not available as a continuous variable. Province or territory of residence was included as a categorical variable with four groups to minimize the number of dummy variables in the regression models (Atlantic: Newfoundland, New Brunswick, Nova Scotia, and Prince Edward Island; Central: Quebec, Ontario; Western: Manitoba, Saskatchewan, Alberta, British Columbia; Territories: Nunavut, Northwest Territories, Yukon).

Body mass index (BMI) was used to capture overweight and obesity within the population and was calculated as self-reported weight (kg) divided by self-reported height squared (m²). For the descriptive statistics, BMI was included as a categorical variable: normal weight (BMI 18.5 kg/m² - 24.9 kg/m²), overweight (25.0 kg/m² - 29.9 kg/m²), obese (BMI ≥ 30.0 kg/m²). Participants with a BMI less than 18.5 kg/m² were excluded from the analyses. For the linear regression model analyses where BMI was an independent variable, BMI was included as a continuous variable to minimize the loss of power and precision of the estimated coefficients.
Statistical analysis

The data set was cleaned and analyzed quantitatively using Stata IC statistical software, version 15 (StataCorp 2017). The raw data were first analyzed without weighting adjustments. The analyses were then repeated with the weighted data as outlined above. The weighted analyses are presented in this paper. Descriptive statistics were conducted to estimate UPF diversity among Canadians overall and across demographic subgroups. The mean of the UPF diversity score was calculated, stratified by gender, age, income, BMI, and geographic region. Statistically significant differences between subgroups were examined by recasting analysis of variance (ANOVA) and post-hoc pairwise comparisons as single linear regressions, given the weighted data. Bonferroni corrections were used to account for the multiple pairwise comparisons. Subsequently, the proportions of individuals who consumed each of the UPFs were estimated and the proportions were ranked to identify the top ten most commonly consumed UPFs. Gender-specific multivariable linear regression models identified the variables that were significantly associated with UPF diversity. All covariables were included in the models and interactions were tested between the predictor variables. Statistical significance was defined as a p-value < 0.05.

Results

Based on the weighted data, the mean age of respondents was 51.0 years (standard deviation (SD): 16.2 years) and the mean BMI was 26.6 kg/m² (SD: 4.9 kg/m²). Given the small sample size of underweight participants with a BMI less than 18.5 kg/m² (n=108) and the high probability of measurement error, participants identified as underweight were excluded from all analyses. Table 1 presents additional descriptive statistics of the weighted sample. Overall, an
estimated 99.0% (95% CI: 98.6%, 99.3%) of Canadians consumed a UPF product at least once in a week. Out of a total of 33 UPFs in the survey, the overall mean diversity score was 6.4 different types of UPFs (SD 3.1). The greatest diversity of UPFs was observed among men, respondents 18-39 years old, respondents with household incomes over $80,000 compared to the lowest income group, and respondents who were obese compared to those who were normal weight. There were no significant differences in UPF consumption between regions when accounting for the Bonferroni correction.

The ten most commonly reported UPFs consumed, out of 33 possible UPFs during a seven-day period, are found in Table 2. Four UPFs in particular were consumed by approximately half or more of the respondents: 63.3% consumed chocolate (95% CI: 58.2%, 68.1%), 51.9% consumed chips or pretzels (51.9%, 95% CI: 47.1%, 56.7%), 49.7% consumed cold breakfast cereal (95% CI: 44.7%, 54.7%), and 47.5% (95% CI: 39.4%, 55.7%) consumed fast foods.

The diversity of UPFs was also investigated separately by gender (Table 3). Among men the highest UPF diversity score was observed among 18-39 year old respondents. There was significantly more diversity in the highest income group compared to the middle income group. There were no significant differences between BMI groups or regions. Among women, those 18 to 39 year olds had a higher UPF diversity score than those 65 years and older. Among women, there was also a significantly higher diversity score among the respondents in the highest income group compared to the lowest income group, among respondents with obesity and in the Atlantic and Western regions compared to the Central region. Men appeared to report higher UPF
diversity than women if they were 65 years and older, had a household income of $30,000-$80,000, if they were normal weight or if they were overweight, when comparing the same demographic subgroups.

Gender-specific multivariable linear regression models were conducted to investigate whether socio-demographic factors and BMI were significantly associated with the diversity of UPFs consumed in seven days, when all other variables were held constant (Table 4). For both men and women, younger age and higher BMI were consistent predictors of increased UPF diversity. For men, no other variables in the model were related to UPF diversity. For women, living in Atlantic Canada compared to Central Canada was also positively associated with UPF diversity when all other variables were held constant. There were no significant interactions between the predictor variables (data not shown).

Discussion

This study contributes to the scarce literature that is currently available on UPF consumption and associated factors among adults in Canada. The findings suggest that the consumption of UPFs in Canada is pervasive, with almost all Canadian adults consuming at least one UPF product in a week. In particular, chocolate, chips or pretzels, cold breakfast cereal and fast foods were the most commonly reported foods consumed by adults. Likewise, a recently published study using the 2015 Canadian Community Health Survey (CCHS) data also identified fast food, sweetened milk-based products, cookies, cakes, candies and other sweets, among the most commonly consumed UPFs (Nardocci et al. 2019a).
Overall, men consumed the largest variety of UPF products in the past seven days. Compared to younger respondents, older respondents consumed the least. Though this cannot be directly translated to the amount of UPFs consumed, previous studies have highlighted positive association between overall dietary diversity and energy intake (Hall et al. 2019; Jayawardena et al. 2013; McCrory, Burke, Roberts 2012; Raynor and Epstein 2001). A review by McCrory et al (2012) suggested that approximately 22% more energy is consumed when eating a variety of foods compared to a single food item and each additional food can increase the energy intake by an estimated 50-60 kilocalories. Excess energy intake can in turn contribute to diet-related health concerns such as obesity. Greater UPF diversity may reflect increased UPF consumption, and particularly increased energy intake, given that UPFs are typically energy-dense.

Canadian studies using data from the 2004 CCHS and CCHS 2015 reported some consistencies with our study; they similarly reported that men and younger adults consumed more UPFs (Nardocci et al. 2019b, Moubarac 2017a, Moubarac et al. 2017b). We further investigated gender differences by age group. Our study showed no gender differences in UPF diversity for respondents in the youngest age group (18-39 years old) while a recent study conducted in Brazil among young adults aged 21-23 years old reported that women consumed more UPFs (Bielemann et al. 2015). However, the results may not be directly comparable due to the different study settings and the wider age range in our study which was skewed towards older respondents. Interestingly, significant gender differences were observed among the oldest age group in our study, where UPF diversity was significantly greater for men aged 65 years or older compared to women. There did not appear to be any existing literature specifically looking at this older age group stratification. The limited literature regarding gender differences across age
groups highlights the need for additional studies using large, nationally-representative databases to further explore and confirm the associations of UPF consumption with potential predictors, such as gender and age. The area of UPF research is still relatively novel and the most recent operationalized definition of UPF through the NOVA classification system has been validated. It is important to promote a validated, consistent measure of UPF consumption across the literature to ensure comparability between studies as research on this topic continues to emerge (Monteiro et al. 2018a).

In the gender-specific models, decreased age remained strongly associated with higher UPF diversity for both men and women, when controlling for potential confounders. Younger respondents may be driven to consume a greater variety of UPFs due to their increased nutritional requirements, their limited cooking skills, and the greater affordability of common UPFs such as fast foods (Nardocci et al., 2019a; Hartmann, Dohle, Siegrist 2013; Janssen et al. 2018; Kant and Graubard 2004; Luszczynska et al. 2013). Additionally, older respondents may have consumed a more limited diversity of UPFs due to increased unfamiliarity with UPF products (Dwyer et al. 2001).

The gender-specific models also suggested that higher BMI was strongly associated with increased UPF diversity for both men and women. Since 1938, literature has noted a substantial replacement of fresh or minimally processed foods by UPFs, resulting in low fruit and vegetable intake among individuals who frequently consume UPFs (Black and Billette 2015; Moubarac et al. 2014b). The increasing substitution of high quality fresh foods for energy dense UPFs with limited nutrients has been hypothesized to contribute to diet-related morbidities, including the
growing obesity epidemic (Monteiro et al. 2013, Moubarac et al. 2014b). After adjusting for other factors Djupegot et al. 2017 reported higher odds of consumption of UPF dinner products and fast food away from home in overweight/obese participants compared to those who were of normal weight, though not snacks and soft drinks. The positive association between BMI and UPF diversity observed in this study also appears to reflect this hypothesis. Given the cross-sectional nature of the study, it was not possible to investigate the directionality of this potential association. Longitudinal gender-specific research could help elucidate the extent to which an association between UPF consumption and obesity exists.

As UPF consumption continues to increase, emerging studies are beginning to examine the factors associated with UPF consumption, but findings remain limited to specific age groups, geographic locations, or study populations (Louzada et al. 2015; Mendonca et al. 2016). The paucity of literature on this topic highlights the need for further research to better understand the associations between socio-demographic factors and UPF consumption, as well as the extent to which UPF consumption increases the likelihood of obesity. Greater consistency in published findings would help strengthen the evidence base that informs sustainable policies and programs addressing the increasing production and consumption of UPFs. This study offers a first step in presenting recent estimates of UPF diversity among the Canadian population. By highlighting differences between men and women, it suggests that associations with UPF consumption are complex and dependent on a number of factors. More specific studies with qualitative approaches or more recent cohorts, like the ongoing Canada Food Study, may allow for a greater understanding of the determinants of UPF consumption.
This study had many strengths. Firstly, analyses were conducted using a nationally representative sample of 6,062 participants, in all provinces and territories, which allowed for greater power to detect meaningful differences and allowed for findings that are more reflective of the Canadian population. Furthermore, the questionnaire used a seven-day recall period, which better accounted for variations in individuals’ daily food intake compared to a 24-hour recall period (Thompson and Subar 2017). Finally, the NOVA classification system was used to identify UPFs, which is recognized in the literature as a valid tool for research in nutrition and public policy and is used by organizations including the Food and Agriculture Organization of the United Nations and the Pan American Health Organization (Food and Agriculture Organization of the United Nations 2015; Pan American Health Organization 2015). The use of this classification will allow for consistency in the operationalization of the UPF group, in order to more accurately compare findings in future studies in this field.

This study also included limitations. Firstly, the response rate of 19.9% is considered low and may have given rise to non-response bias. However, for most of our analyses, the survey questions pertained to non-sensitive issues, the impact of the possible bias was minimized by focusing the analyses on the variability within groups, and the results were largely consistent with published literature. This allowed for greater confidence in the generalizability of the results. Further research with a greater response rate is encouraged to examine the reproducibility of the findings. The data was also self-reported, which increases the possibility of under-reporting UPFs and resulting measurement bias. Food intake and BMI have previously been shown to be at increased risk of being under-reported in self-reported data collection methods. Under-estimation of intake is more substantial in overweight and obese individuals (Freedman et
al. 2014; Garriguet 2008; Visscher et al. 2006), thereby biasing results toward the null hypothesis. Furthermore, while the survey included 33 different types of UPFs, it was not a comprehensive list, and when faced with foods that could have qualified as processed foods or UPFs (e.g. peanut butter, fruit smoothies, etc.), we chose to err on the side of caution and categorized them as processed foods. Thus, additional commonly consumed UPFs may not have been accounted for. All considered, there was a large overlap of top UPF foods consumed by adults in our study and a representative Canadian study; 7 of the top 10 UPFs in this study overlap with the top 10 UPFs reported by Nardocci et al. 2018. Missing from our study UPFs were industrial packaged breads, soft drinks, sweetened fruit juices and drinks; sauces and spreads; and margarine.

Serving sizes and frequency of intake were also not captured for most of the food items. This did not allow for UPF consumption to be expressed as a percentage of daily energy intake, which is a more commonly used measure of food intake in the literature (Nardocci et al. 2019b). Instead, a proxy measure, using diversity of UPF consumption, was used. This measure has potential for misclassifying scores as low if individuals consume large amounts of few items. Though this UPF diversity score has not yet been validated, the literature supports a positive relationship between diversity score and food intake (Hall et al. 2019; Jayawardena et al. 2013; McCrory, Burke, Roberts 2012; Raynor and Epstein 2001). Additionally, this study was cross-sectional, and despite the covariates, such as age and geographic location, that were included in the model to minimize the effect of confounding on the relationships of interest, residual confounding may have influenced the results from the models, thus making conclusions about causality premature.
Canadians are experiencing substantial changes in the foods they eat due to increasing food processing (Moubarac 2017). This study suggests that the consumption of UPFs in Canada has become ubiquitous, and factors associated with increased consumption of UPFs vary between men and women. Further research in Canada examining the gender-specific relationships between the consumption of UPFs and obesity or other potential chronic health conditions should be considered. Additionally, increased public programs and policies to promote and educate the Canadian population about the benefits of minimally processed, fresh foods should be encouraged.

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Conflict of interest

We declare that we have no conflicts of interest related to this work.

Author contributions

ES was responsible for the design and conceptualization, analysis, interpretation of the data, and drafting and revising of the paper. LGF was responsible for the design,
conceptualization, interpretation of the data, and paper revisions. MdG contributed to the design and analysis and was responsible for the interpretation of the data and paper revisions.

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Tables
Table 1. Descriptive statistics of respondents and ultra-processed food diversity score by demographic variables and BMI groups (Canadian adults, n = 6,062).

|                      | Unweighted Count | Weighted percentage of respondents | Weighted UPF Diversity (number of different UPF/week) |
|----------------------|------------------|------------------------------------|-----------------------------------------------------|
|                      | n                | % (95% CI)                          | Mean (SD) (95% CI)                                  | p-value    |
| **OVERALL**          | 6,062            | --                                 | 6.4 (3.1) (6.1, 6.6)                                | --         |
| **Gender**           |                  |                                    |                                                    |            |
| Men                  | 2,417            | 49.3 (45.7, 52.9)                   | 6.8 (2.9) (6.5, 7.1)                                | 0.000*     |
| Women (Ref)          | 3,644            | 50.7 (47.1, 54.3)                   | 6.0 (3.2) (5.7, 6.2)                                | --         |
| **Age**              |                  |                                    |                                                    |            |
| 18-39 (Ref)          | 951              | 26.2 (14.8, 42.1)                   | 7.5 (2.4) (7.3, 7.6)                                | --         |
| 40-64                | 2,350            | 55.0 (49.9, 60.0)                   | 6.1 (2.6) (5.8, 6.4)                                | 0.002*     |
| 65+                  | 2,758            | 18.8 (10.9, 30.3)                   | 5.7 (4.4) (5.6, 5.7)                                | 0.000*     |
| **Income**           |                  |                                    |                                                    |            |
| <$30,000             | 1,215            | 15.1 (13.6, 16.7)                   | 5.8 (3.3) (5.6, 6.0)                                | 0.013*     |
| $30,000-$80,000      | 2,317            | 37.3 (35.2, 39.4)                   | 6.5 (3.3) (6.0, 6.9)                                | 0.102      |
| >$80,000 (Ref)       | 1,670            | 35.9 (33.5, 38.4)                   | 6.7 (2.7) (6.4, 7.0)                                | --         |
| Not stated           | 860              | 11.7 (9.9, 13.9)                    | 6.0 (3.3) (5.9, 6.0)                                | 0.007*     |
| **BMI**              |                  |                                    |                                                    |            |
| Normal weight (Ref)  | 2,352            | 42.4 (32.6, 52.8)                   | 6.2 (3.0) (5.9, 6.6)                                | --         |
| Overweight           | 2,253            | 37.6 (32.2, 43.3)                   | 6.4 (3.1) (6.2, 6.6)                                | 0.071      |
| Obese                | 1,457            | 20.0 (15.4, 25.6)                   | 6.6 (3.5) (6.3, 7.0)                                | 0.003*     |
| **Region**           |                  |                                    |                                                    |            |
| Atlantic             | 1,229            | 7.1 (5.7, 8.7)                      | 6.8 (6.0) (6.2, 7.5)                                | 0.029      |
| Central (Ref)        | 1,838            | 61.6 (59.7, 63.5)                   | 6.2 (2.2) (5.9, 6.5)                                | --         |
| Western              | 2,336            | 31.0 (28.3, 33.9)                   | 6.6 (3.5) (6.1, 7.1)                                | 0.131      |
| Territories          | 659              | 0.3 (0.1, 0.8)                      | 6.7 (19.6) (6.2, 7.3)                               | 0.031      |

Notes: SD: Standard deviation, BMI: Body Mass Index; 95% CI: 95% Confidence Interval, Ref: Reference group
For Income, 860 respondents did not specify their income group (11.7% of the weighted percentage of respondents). There were no significant differences in sociodemographic characteristics between those who did and did not state their income (data not shown).

Region: Atlantic: NL, NB, NS, PE; Central: ON, QC; West: MB, SK, AB, BC; Territories: NU, NT, YT

Pairwise comparisons using Bonferroni correction for two or more comparisons: significant = * for $p < \frac{0.05}{n}$ where $n$: number of comparisons within category

The 95% CI are presented in the table to demonstrate the uncertainty of the estimates but were not used to establish statistical significance since they do not represent the variability of the observations (Ranstam 2012; Austin and Hux 2002).
Table 2. The 10 most common ultra-processed foods consumed at least once in the past seven days (Canadian adults, n = 6,062).

| Type of UPF food                                      | Proportion who consumed specified type of UPF % (95% CI) |
|------------------------------------------------------|----------------------------------------------------------|
| 1 Chocolate or chocolate-containing candy            | 63.3 (58.2, 68.1)                                        |
| 2 Chips or pretzels                                  | 51.9 (47.1, 56.7)                                        |
| 3 Cold breakfast cereal                              | 49.7 (44.7, 54.7)                                        |
| 4 Fast food                                          | 47.5 (39.4, 55.7)                                        |
| 5 Ice cream/gelato                                   | 39.0 (35.1, 43.0)                                        |
| 6 Processed cheese                                  | 34.5 (34.4, 34.7)                                        |
| 7 Granola bars, power bars or other protein bars     | 33.3 (29.3, 37.6)                                        |
| 8 Sausage                                            | 30.9 (30.2, 31.5)                                        |
| 9 Bacon                                              | 27.6 (22.6, 33.2)                                        |
| 10 Ham deli meat                                     | 27.5 (23.4, 32.0)                                       |

Notes: UPF: ultra-processed food, 95% CI: 95% confidence interval
Based on 33 ultra-processed foods
Table 3. Descriptive statistics of respondents and ultra-processed food diversity score by demographic variables and BMI groups, stratified by gender (Canadian adults, n = 6,062).

| Age          | Range of UPF Diversity values | Mean (SD) | 95% CI     | Category comparisons p-value | Gender comparisons p-value |
|--------------|-------------------------------|-----------|------------|-------------------------------|---------------------------|
| 18-39 (Ref)  | 1-20                          | 7.7 (2.4) | (7.1, 8.4) | --                           | 0.155                     |
| 40-64        | 0-20                          | 6.5 (2.5) | (6.3, 6.8) | 0.021*                       | 0.035                     |
| 65+          | 0-20                          | 6.0 (4.2) | (5.9, 6.1) | 0.009*                       | 0.002*                    |

| Income       | Range of UPF Diversity values | Mean (SD) | 95% CI     | Category comparisons p-value | Gender comparisons p-value |
|--------------|-------------------------------|-----------|------------|-------------------------------|---------------------------|
| <$30,000     | 0-17                          | 6.2 (2.9) | (5.7, 6.6) | 0.040                         | 0.026                     |
| $30,000-$80,000 | 0-20                       | 6.8 (3.1) | (6.3, 7.3) | 0.016*                       | 0.002*                    |
| >$80,000 (Ref) | 0-20                       | 7.1 (2.6) | (6.7, 7.4) | --                           | 0.008                     |
| Not stated   | 0-20                          | 6.6 (3.3) | (6.5, 6.8) | 0.062                         | 0.000*                    |

| BMI          | Range of UPF Diversity values | Mean (SD) | 95% CI     | Category comparisons p-value | Gender comparisons p-value |
|--------------|-------------------------------|-----------|------------|-------------------------------|---------------------------|
| Normal (Ref) | 0-20                          | 6.8 (2.7) | (6.6, 7.1) | --                           | 0.001*                    |
| Overweight   | 0-20                          | 6.7 (2.9) | (6.5, 6.9) | 0.041                         | 0.001*                    |
| Obese        | 0-18                          | 7.0 (3.4) | (6.5, 7.5) | 0.162                         | 0.012                     |

| Region       | Range of UPF Diversity values | Mean (SD) | 95% CI     | Category comparisons p-value | Gender comparisons p-value |
|--------------|-------------------------------|-----------|------------|-------------------------------|---------------------------|
| Atlantic     | 0-19                          | 7.0 (5.1) | (6.2, 7.7) | 0.359                         | 0.275                     |
| Central (Ref)| 0-20                          | 6.7 (2.0) | (6.5, 7.0) | --                           | 0.007                     |
| Western      | 0-20                          | 6.9 (3.2) | (6.4, 7.4) | 0.848                         | 0.033                     |
| Territories  | 0-17                          | 6.9 (20.2)| (4.6, 9.1) | 0.873                         | 0.744                     |

| Age          | Range of UPF Diversity values | Mean (SD) | 95% CI     | Category comparisons p-value | Gender comparisons p-value |
|--------------|-------------------------------|-----------|------------|-------------------------------|---------------------------|
| 18-39 (Ref)  | 0-18                          | 7.1 (2.4) | (6.5, 7.7) | --                           | --                        |
| 40-64        | 0-17                          | 5.7 (2.7) | (5.2, 6.3) | 0.034                         | --                        |
| 65+          | 0-19                          | 5.4 (4.5) | (5.3, 5.4) | 0.007*                       | --                        |

| Income       | Range of UPF Diversity values | Mean (SD) | 95% CI     | Category comparisons p-value | Gender comparisons p-value |
|--------------|-------------------------------|-----------|------------|-------------------------------|---------------------------|
| <$30,000     | 0-15                          | 5.5 (3.5) | (5.5, 5.6) | 0.012*                       | --                        |
| $30,000-$80,000 | 0-19                      | 6.2 (3.4) | (5.7, 6.6) | 0.797                         | --                        |
| >$80,000 (Ref) | 0-16                      | 6.2 (2.7) | (5.9, 6.5) | --                           | --                        |
| Not stated   | 0-16                          | 5.5 (3.1) | (5.3, 5.7) | 0.004*                       | --                        |

| BMI          | Range of UPF Diversity values | Mean (SD) | 95% CI     | Category comparisons p-value | Gender comparisons p-value |
|--------------|-------------------------------|-----------|------------|-------------------------------|---------------------------|
| Normal (Ref) | 0-16                          | 5.8 (3.1) | (5.4, 6.2) | --                           | --                        |
| Overweight   | 0-17                          | 6.0 (3.2) | (5.9, 6.2) | 0.133                         | --                        |
| Obese        | 0-19                          | 6.3 (3.5) | (6.1, 6.5) | 0.009*                       | --                        |

| Region       | Range of UPF Diversity values | Mean (SD) | 95% CI     | Category comparisons p-value | Gender comparisons p-value |
|--------------|-------------------------------|-----------|------------|-------------------------------|---------------------------|
| Atlantic     | 0-18                          | 6.7 (6.8) | (6.0, 7.5) | 0.008*                       | --                        |
| Central (Ref)| 0-17                          | 5.8 (2.2) | (5.4, 6.2) | --                           | --                        |
| Western      | 0-19                          | 6.2 (3.6) | (5.6, 6.9) | 0.008*                       | --                        |
| Territories  | 0-15                          | 6.6 (18.9)| (5.2, 7.9) | 0.239                         | --                        |

Notes: SD: Standard deviation, 95% CI: 95% Confidence Interval, Ref: Reference group
Pairwise comparisons using Bonferroni correction for two or more comparisons: significant = * for $p < \frac{0.05}{n}$, where n: number of comparisons within category.
The 95% CI are presented in the table to demonstrate the uncertainty of the estimates but were not used to establish statistical significance since they do not represent the variability of the observations (Ranstam 2012; Austin and Hux 2002).

Reference groups for “Category comparisons”: Ref; Reference groups for “Gender comparisons”: Women
Table 4. Predictors of ultra-processed food diversity score. Results from multivariate linear regression stratified by gender (Canadian adults, n = 6,062).

| Variables | MEN and WOMEN (n = 5,199) | MEN (n = 2,417) | WOMEN (n = 3,644) |
|-----------|---------------------|-----------------|------------------|
|           | Adjusted (R²=0.05)  | Adjusted (R²=0.04) | Adjusted (R²=0.07) |
|           | β (95% CI)          | p-value         | β (95% CI)       | p-value |
| Age       | -0.039 (-0.05, 0.03) | 0.001           | -0.03 (-0.04, -0.02) | 0.005* |
| BMI       | 0.044 (0.02, 0.07)  | 0.023           | 0.04 (0.01, 0.06) | 0.020* |
| Regions   |                     |                 |                  |         |
| Atlantic  | 0.691 (0.11, 1.28)  | 0.037           | 0.33 (-0.63, 1.29) | 0.274 |
| Western   | 0.376 (-0.23, 0.98) | 0.116           | 0.22 (-0.09, 0.54) | 0.092 |
| Territories | 0.458 (-0.05, 0.97) | 0.061           | 0.24 (-2.36, 2.83) | 0.734 |
| Central (Ref) | --                | ---             | ---               | ---    |
| Income    |                     |                 |                  |         |
| <$30,000  | -0.354 (-0.939, 0.231) | 0.121           | -0.35 (-1.37, 0.67) | 0.277 |
| $30,000-$80,000 | -0.009 (-0.18, 0.16) | 0.836           | -0.12 (-0.37, 0.14) | 0.185 |
| >$80,000 (Ref) | --                | --              | ---               | ---    |

Notes: BMI = body mass index, R² = coefficient of determination, β = beta coefficient, 95% CI: 95% confidence interval
Region: Atlantic: NL, NB, NS, PE; Central: ON, QC; West: MB, SK, AB, BC; Territories: NU, NT, YT
Ref: Reference category (Region: Central, Income: >$80,000)
Significant = * p < 0.05