Comparing Diet Quality Between Online and In-store Grocery Shoppers

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Thesis Preface

Ethical Standards Disclosure

This study was conducted in accordance with the *Tri-Council Policy Statement* (2014). Consent was obtained from each participant prior to beginning the online survey. The University of Ottawa Office of Research Ethics and Integrity granted approval for secondary data analyses (file number H-07-23-9393, Approval Data 05/07/2023).

Author Contributions

With the supervision of Dr. Melissa Fernandez, Andrew Milks (the MSc Candidate) is the principal investigator of this project and was responsible for conceiving and designing the analysis, performing statistical analysis, creating tables and figures, interpreting the results, writing the thesis, communication of the results, and submission of the thesis. Andrew Milks is the first author of the thesis. Dr. Fernandez is the senior author.

Abstract

Online grocery shopping is a popular alternative to in-store grocery shopping. However, it is unclear whether grocery shopping modality is associated with diet quality. The objectives of this study were to compare diet quality and sociodemographic characteristics between online and in-store grocery shoppers and to examine whether the associations between grocery shopping modality and diet quality differed when stratified by specific sociodemographic characteristics. Data was collected from 872 Canadians with an online survey. Pearson's chi-square and one-way ANOVA were used to compare sociodemographic characteristics and linear regression was used to compare the diet quality of online and in-store grocery shoppers. We found significant differences in sociodemographic characteristics, including educational attainment and age, but there were no significant differences in diet quality. Our findings suggest that the use of online grocery shopping is associated with specific sociodemographic characteristics; however, grocery shopping modality is not associated with diet quality.

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1 INTRODUCTION

Poor diet quality is a major modifiable risk factor for non-communicable diseases (NCDs), including cardiovascular diseases, cancers, chronic respiratory diseases, and metabolic diseases.[1] The prevalence of these diseases is rising globally, and Canada is no exception. According to Statistics Canada, approximately 26.8% of Canadian adults are classified as obese, while 36.3% are considered overweight, putting 63.1% of Canadians at a higher risk of NCDs due to excess weight.[2] Besides smoking, unhealthy diets are the second leading risk factor for NCDs in Canada and significantly contribute to the burden of disease and healthcare costs.[3] The economic cost of poor diet quality in Canada is significant. In 2018, it was estimated that failing to meet Canada's healthy eating recommendations carried a yearly financial burden of approximately $26 billion (CAD) in direct and indirect healthcare costs to the Canadian economy.[4]

A growing body of research suggests that the increase in diet-related NCDs corresponds with a significant shift in human dietary and activity patterns over the past several decades, which can be attributed to changes in food systems.[5-8] Food systems, which encompass all the processes involved in producing, processing, packaging, and selling food, have been changing. These changes have been driven by factors such as rising incomes, population growth, globalization and urbanization, technological advancements, and changes in consumer demand.[5] These systems have had to adapt to meet the increasing need to feed a rapidly expanding global population and address growing socioeconomic inequalities regarding food availability and affordability.[7]

The popularity of ultra-processed foods (UPFs) is a notable change in modern food systems.[9] UPFs are energy-dense, nutrient-sparse foods often high in saturated fat, sugars, and

sodium while low in fibre. They are designed to be convenient, highly palatable, and highly profitable. The global supply of UPFs has been growing as they are inexpensive to purchase, have long shelf lives, and are easy to ship and store.[10] The low cost of production and distribution makes UPFs accessible to a wide range of consumers, helping to feed more people at a lower cost.[5] Yet, despite their convenience and affordability, research has indicated that UPFs carry significant health risks. Epidemiological studies have demonstrated a strong correlation between UPF consumption and the prevalence of NCDs, including type 2 diabetes, cardiovascular diseases (CVD), and certain types of cancer.[11] Despite the risks, Canadians are consuming these foods at an increasing rate. In 2015, UPFs contributed 46% of daily caloric intake for Canadian adults and more than 50% for Canadian minors.[12] Contributing to the surge in consumption, UPFs are highly palatable and relatively inexpensive compared to healthier alternatives, such as fresh produce and lean meats, making them an attractive, if not inevitable, choice for many consumers.[7] Compounding on these factors, food retailers have also significantly pushed to promote these processed alternatives.

Food retailers, including grocery stores and supermarkets, have been shown to market and promote these less healthy alternatives aggressively. For example, a 2019 study found that Canadian food retailers allocated an estimated $628.6 million (CAD) to food and beverage advertising. Of that spending, 87.2% was used to promote foods classified as “unhealthy.” In contrast, only 2.1% and 0.8% of the expenditure was dedicated to promoting fruits and vegetables.[13] Additionally, retailers employ in-store strategies to promote these less healthy foods. These tactics include placing products at high-visibility points such as end aisles and near checkouts, strategically arranging stores, and in-store advertisements and promotions.[14]

In response to the increasing burden of poor-quality diets, the Canadian government has implemented new regulations and healthy eating interventions to empower Canadians to eat healthier. For example, new regulations have been implemented to limit traditional media advertising of unhealthy foods (particularly towards children).[15, 16] Additionally, drawing upon decades of research on consumer behaviour in traditional retail environments, the Canadian government, in partnership with various stakeholders, have developed healthy eating programs in traditional food retail settings. These initiatives have included the Western Canadian Healthy Convenience Store Program, the Health Check™ program, and the Grocery Cart Nudging Initiative, among others.[17] Furthermore, Health Canada has updated policies on food and drug regulations, targeting misleading front-of-package labelling.[18] These initiatives are promising strategies for improving diet quality among Canadians by limiting exposure to unhealthy food advertising and supporting consumers in making healthy grocery shopping choices. Yet, the rise of online grocery shopping presents new challenges and opportunities to improve diet quality among Canadians.

As consumers increasingly shift towards online grocery shopping, it remains to be seen whether existing efforts to encourage healthy eating will become redundant in this new digital landscape. Preliminary studies have shown that consumers behave differently in online shopping environments than in-store.[19] For example, a study by Danaher, Wilson, and Davis found that consumers exhibit higher brand loyalty when shopping online than in-store.[20] A study by Chu et al. found that online shoppers exhibit lower price sensitivity than in-store shoppers.[21] Furthermore, in a separate study, Chu et al. found that online shoppers are more size-sensitive than in-store shoppers and elect for options like “variety packs” or “jumbo sizes.”[22] In food retail

environments, these distinct online shopping behaviours may significantly impact diet quality through effects on food selection.

Indeed, preliminary studies have suggested that online grocery shopping platforms affect consumers' food choices.[23-25] For example, one study found that online grocery shoppers made fewer impulse purchases, potentially due to reduced exposure to in-store marketing cues.[26] Reduced impulse purchasing could be a major advantage of online grocery shopping, as impulse purchases tend to be higher-calorie food products.[27] Adding to this, another study found that the delay between order and placement and delivery of groceries can significantly impact food selection. Their results found that as the time between ordering and receiving the groceries increases, customers tend to make healthier choices.[28] Despite the growing number of studies indicating that grocery shopping affects food choice, very little research has considered whether the decision to shop in-store or online affects diet quality.

To our knowledge, only one study has previously compared diet quality between online and in-store grocery shoppers. The study found that online grocery shoppers exhibited slightly better diet quality than in-store shoppers. However, this study was an American study that exclusively recruited individuals from low-income households, with many participating in food assistance programs, thus limiting the generalizability of its findings.[29] Moreover, while numerous studies have compared online and in-store consumer behaviours, there is a noticeable research gap comparing the characteristics of online and in-store shoppers.[19] In light of this, our study sought to investigate these aspects of online grocery shopping. The primary objective of this study was to compare diet quality between online and in-store grocery shoppers. The secondary objectives were to compare sociodemographic and health characteristics between

online and in-store grocery shoppers and to explore whether differences in diet quality between online and in-store grocery shoppers varied between sociodemographic groups.

The following chapter, Chapter 2, critically reviews the existing research on diet quality, its measures and determinants, changes in food systems, online grocery shopping and its impacts on consumer behaviours, and the potential impact of online grocery shopping on diet quality. Chapter 3 presents the study rationale, objectives, and hypotheses. Chapter 4 provides a detailed description of the methodology. Chapter 5 presents the study's findings, while Chapter 6 presents a discussion of said findings. Finally, Chapter 7 provides an overview of the study's contribution to the field of nutrition, the limitations of the study, and offers possible directions for future research.

2 LITERATURE REVIEW

2.1 Diet Quality

2.1.1 Conceptualizing Diet Quality

Early research on the relationship between nutrition and health outcomes often followed a "single nutrient" approach, focusing on the impact of specific nutrients or foods in isolation. While this approach provided valuable insights into the biological mechanisms connecting diet and disease, it also had significant limitations. For example, it overlooked the reality that people consume a variety of foods, not individual nutrients, and these foods can interact in complex ways. As a result, many researchers and governmental agencies have shifted their focus towards studying dietary patterns, which consider the totality of the foods and beverages that make up a person's diet. This approach allows for a more realistic examination of the link between food and health outcomes.

Additionally, research on dietary patterns has informed the development of food-based dietary guidelines in Canada and several other countries, helping to shape recommendations that encourage health-promoting dietary patterns. These dietary guidelines are potent tools in addressing the growing burden on healthcare systems of suboptimal diets and aim to enhance dietary quality, diversity, and balance by emphasizing the consumption of nutrient-rich foods and maintaining a balanced intake of essential nutrients while limiting less healthy dietary components.[30, 31] However, since dietary patterns cannot be measured directly, adherence to these food-based dietary guidelines is often used as a proxy for assessing the overall healthiness of a diet. This measure, known as "diet quality," reflects both the healthfulness and variety of the diet.

2.1.2 Dietary Intake Assessment Tools

Accurate assessment of diet quality requires reliable tools for collecting dietary intake data and evaluating adherence to dietary guidelines. This process typically involves gathering dietary intake information and then applying a diet quality index to measure overall diet quality.

Researchers often depend on self-reported dietary data to calculate diet quality scores. Common tools for collecting this data include food frequency questionnaires (FFQs), 24-hour recalls (24HR), food records, and screening tools. Each method has its own strengths and limitations, with the choice depending on factors such as the scope of the project (e.g., examining the total diet versus specific components), study design, and the reference time frame (e.g., short-term or long-term dietary patterns).[32]

Food frequency questionnaires (FFQs) are widely used to assess dietary intake, particularly in large populations. They are often preferred in such studies because they are self-administered, can capture dietary intake over extended periods, and are generally more cost-effective than other methods like 24-hour recalls.[33] Numerous FFQs have been developed, with substantial variations in the number of items included, the consideration of portion sizes, and the reference periods used (e.g., six months, one year).[32] FFQs are especially useful in studies involving diet quality, as they allow researchers to examine associations between an independent variable and dietary patterns.[34]

A well-known example is the Diet History Questionnaire III (DHQ-III), a web-based FFQ available on the National Cancer Institute's website, which is freely available to researchers and nutrition professionals for assessing food and dietary supplement intake. The DHQ-III uses a nutrient and food group database derived from the National Health and Nutrition Examination Survey (NHANES) data, making it suitable for use among American adults. It includes 135 food

and beverage items and 26 dietary supplement items, with options to collect dietary intake data over one month or year, with or without estimating portion size.[35]

The predecessor to the DHQ-III, the DHQ-II, has been adapted for the Canadian population through the development of the Canadian Diet History Questionnaire II (C-DHQ-II). Due to similarities in lifestyle, food marketing, and food availability between the USA and Canada, the two versions share many similarities, with differences mainly reflecting variations in food availability and fortification practices.[36] The C-DHQ-II was revised using data from the Canadian Community Health Survey, resulting in a final version that includes 153 food and beverage items and 11 supplement questions.[37] While the C-DHQ-II is available online upon request, it retains many limitations, given that it was adapted from the DHQ-II using older dietary data and patterns.

With the release of the DHQ-III, the DHQ-II was phased out as it no longer met current dietary assessment needs and is no longer available online. While the C-DHQ-III is yet to be released, the DHQ-III offers significant updates that make it a more suitable option for dietary assessment today. The DHQ-III includes a broader range of beverages, such as non-dairy milk, green tea, and fruit or vegetable smoothies, which reflects evolving dietary trends. It also includes foods that align with shifting cultural influences, such as sushi, tacos, and burritos. Moreover, the DHQ-III incorporates questions about cooking methods, like grilling or pan-frying, and the level of doneness for meats, poultry, and fish, providing more detailed data on food preparation habits. Additionally, it expands on the range of supplement questions, allowing for more comprehensive dietary intake assessments.[38] Given these changes, it could be suggested that the DHQ-III, while validated for an American population, may better reflect the contemporary dietary intake patterns of Canadians than the C-DHQ-II.

2.1.3 Diet Quality Indexes

Measuring diet quality is essential to nutrition and public health research, as it has been consistently linked to various health outcomes.[39, 40] The basic premise of a diet quality index is that it is an *a priori* approach, using adherence to nutritional guidelines as a proxy measure of the overall diet quality. While earlier concepts of diet quality focused mostly on nutrient adequacy, more contemporary works have incorporated dietary variety as a specific component of diet quality. Furthermore, moderation components have also been incorporated as a principle of diet quality, with certain elements of the diet being scored based on whether a diet contains excessive rather than inadequate intake.[41]

Since dietary indexes are based on specific food-based dietary guidelines, many dietary indexes have been developed to measure adherence to those guidelines. One prominent example is the Healthy Eating Index (HEI), a measure of diet quality that assesses conformance to US dietary guidelines.[42] The HEI has been validated as a reliable measure of diet quality according to the Dietary Guidelines for Americans and provides a comprehensive evaluation of diet quality based on various components such as fruits, vegetables, whole grains, and sodium intake.[43] To calculate the HEI score, dietary intake data is collected typically through food frequency questionnaires (FFQs) or 24-hour diet recalls.[44] The latest version of the HEI, the HEI-2015, assesses various facets of the diet, such as total fruit intake, vegetables, proteins, fats, and other nutrients, to gauge overall diet quality. The scoring system of the HEI-2015 entails assigning points to 13 different components based on consumption levels relative to dietary recommendations. Higher scores are awarded for meeting or surpassing the recommended intake levels, while lower scores are assigned for insufficient consumption. The cumulative points from

all components are then totalled to compute the overall HEI-2015 score, which ranges from 0 to 100, where higher scores indicate better adherence to dietary guidelines and a healthier diet.[45]

Although the HEI has been validated for American adults, it has been adapted to align with Canadian dietary recommendations.[46] In 2009, Garriguet developed the Canadian Healthy Eating Index (C-HEI) by modifying the HEI-2005. The C-HEI was intended to assess adherence to Canada's Food Guide (2007) recommendations and was designed for use with 24-hour recall data.[47] However, in 2019, Health Canada introduced an updated version of Canada's Food Guide with significant changes from the 2007 guidelines. The 2019 guide shifted focus away from age- and sex-specific serving recommendations and instead emphasized dietary variety, encouraging increased consumption of fruits, vegetables, whole grains, and both animal- and plant-based proteins.[48] As a result, the C-HEI no longer aligned with the updated national dietary guidelines.

In response, the Healthy Eating Food Index (HEFI-2019) was developed to measure adherence to the 2019 recommendations. While similar to the HEI, the HEFI-2019 consists of 10 components compared to the HEI's 13, with many shared elements. Both indices allocate 20 points to fruits and vegetables, distinguish between traditional and plant-based proteins (10 points), and include moderation components for sodium (10 points), added/free sugars (10 points), and saturated fats (10 points for HEI and 5 points for HEFI-2019). Despite these similarities, notable differences exist. The HEFI-2019 measures components as total foods, beverages, or energy intake ratios, whereas the HEI typically measures components per 1,000 calories relative to total energy intake. Additionally, the HEFI-2019 assesses beverage intake as a ratio of plain water or unsweetened beverages to total beverage consumption. The total scores also differ: the HEI scores up to 100 points, while the HEFI-2019 scores up to 80 points.[47, 48]

Finally, another difference is that the HEFI-2019 relies on 24-hour recall data rather than FFQ data.

2.1.4 Sociodemographic Variations in Diet Quality

Various factors influence diet quality. Some are individual-specific, like food preferences, but the majority are contextual and beyond personal control.[49] More than simply a matter of choosing to eat healthily, factors such as sex, age, race, income, household composition, and occupation significantly influence an individual's ability to do so.[49-51]

Biological Sex. Females generally exhibit superior diet quality compared to males, attributable to differences in dietary intake and eating behaviours.[52, 53] Canadian males typically adhere to less healthy dietary patterns, consuming fewer recommended food groups like fruits and vegetables.[54, 55] For instance, Azagba and Sharaf, as well as Colapinto et al., found that males consumed fewer servings of fruits and vegetables than females.[51, 56] Baker and Wardle also observed similar findings, findings which they attributed to males' limited nutritional knowledge and awareness of dietary guidelines.[57] Conversely, males tend to consume more non-recommended food groups, with Hack et al. reporting nearly double the alcohol intake in males across all age groups and Jessri et al. noting higher consumption of processed or saturated fat-rich meats.[53, 55]

Differences in eating behaviours between sexes may also influence diet quality.[52, 58] Females, often reported as being more health-conscious, have been shown to avoid foods detrimental to diet quality, like added sugars, red meats, and food additives, due to the perceived health risks associated with these foods.[59] Also, females are often perceived as more susceptible to societal norms surrounding body image, which may promote healthier eating patterns.[60] Other

factors contributing to females' better diet quality include better nutritional knowledge and a higher perceived value on healthy eating.[61, 62]

While often conflated in research, sex and gender are two separate constructs; sex is assigned at birth based on physical attributes such as external genitalia, reproductive organs, chromosomes, and gonads, while gender or gender identity is an individual's internal understanding of themselves and their place in the world concerning gender.[63] In nutrition research, sex is an essential biological variable due to the distinct biological characteristics of male and female subjects. In contrast, incorporating gender identity, while important for health equity, is less common and can pose significant logistical challenges in the design and analysis of nutritional research.[63, 64] The inclusion of gender identity in nutritional research is a topic of continuous discussion; however, current recommendations suggest that, when possible, researchers consider both sex and gender as distinct variables in the design, analysis, and presentation of research.[65]

Race. The relationship between race and diet quality in Canada is complex and not well-defined in the existing literature. Some studies have found that Black and Indigenous Canadians tend to have poorer diet quality compared to Whites. For instance, Doan et al. found that individuals who reported income inadequacy and identified as Black and Indigenous Canadians exhibited poorer diet quality compared to their White counterparts. However, they also found that racial identity was not independently associated with diet quality but a joint effect of racial identity and perceived income adequacy.[66] Similarly, Olstad et al. found that individuals who identified as Indigenous exhibited poorer diet quality than their White counterparts, which was linked to increased dietary intake of UPFs.[67] In contrast to these findings, other research found that, except for Indigenous adults, racialized Canadians exhibited better diet quality than their

White counterparts.[68] Finally, Bodnar et al. found that there were no meaningful differences in diet quality between racialized and non-racialized Canadians.[69]

Socioeconomic Status. Socioeconomic status (SES) is a composite measure determined by indicators that include income, education, and employment status, which can significantly affect an individual's diet quality by shaping their access to healthy foods and their ability to make healthy eating decisions.[67, 70] Dietary inequities between low- and high-SES groups have been observed in epidemiological data, which suggests that diet quality follows a socioeconomic gradient.[71] Individuals of low SES have poorer diet quality than those of high SES, which translates into significant differences in dietary intake patterns. High SES has been associated with greater consumption of fruits and vegetables, lean meats, and a high vitamin and mineral content. In contrast, low SES has been associated with calorie-dense, energy-sparse diets high in refined grains, added sugars, and fats.[67]

Previous studies have revealed disparities in diet quality across income groups in Canada, particularly between lower- and higher-income households. It has been observed that individuals with higher incomes tend to adhere to healthier patterns compared to those with lower incomes.[46, 56, 72] In particular, people from lower-income households have been found to have reduced intakes of energy, protein, and nutritious foods like fruits and vegetables.[51, 73] Instead, their diets tend to be high in processed foods, which are rich in trans fats and refined carbohydrates, which is associated with the lower prices of these foods.[49, 74] The positive relationship between income and diet quality is thought to result from the relative costs of different diets; the most inexpensive diets are often the least nutritious.[75, 76]

Yet the relationship between income levels and diet quality is complex, as some studies have presented opposite findings. It has been reported that an increase in income was related to a

decrease in diet quality. These findings were attributed to the increased likelihood of higher-income individuals consuming meals prepared outside the home, including restaurants and fast-food outlets.[77, 78] Increased consumption of meals prepared outside the home is associated with decreased diet quality, as these foods tend to be energy-dense, low in micronutrients, low in fibre, and served in large portions.[79, 80] The complex relationship between diet quality and income was an issue highlighted by Hosseini and colleagues, who argued that the impact of income on diet quality should not be generalized across all individuals; instead, they emphasized the need to consider each individual's unique circumstances.[78]

Educational attainment is also an essential determinant of diet quality, as it signifies access to materials through its association with occupation and income and embodies cultural and knowledge-based assets.[67, 81-84] International studies have shown that higher education levels are associated with better diet quality through different mechanisms. For example, Barker et al. found that higher educational attainment was related to better self-control, which led to healthier dietary choices.[85] Gibbs et al. found that higher educational attainment led to better nutrition literacy, which resulted in better diet quality.[86] Wilson et al. found that socio-economic mobility, education, and diet quality were interconnected and suggested that higher educational attainment provided individuals with resources and social influences for maintaining a healthier diet.[87] Furthermore, Carlson, Dong, and Lino found that individuals with low educational attainment had significantly poorer diet quality than those with high educational attainment.[88] In a Canadian setting, a study by Olstad et al. found that diet quality increased with educational attainment. They observed that better diet quality among individuals with higher educational attainment was related to higher intakes of fruits and vegetables.[67]

Household Composition. The impact of a household's composition, specifically the number of people residing there, has received limited attention in the literature. This is logically due to the recognition that 'two-person households' or 'single-person households' encompass diverse demographics. Nonetheless, it is reasonable to assume that an increase in household size signifies a notable increase in economic demands, including food and grocery expenditures.[89, 90] Conversely, it could be suggested that larger households could facilitate easier meal preparation or more frequent grocery shopping if responsibilities are shared and that sharing the cost of groceries across several different sources of income could lead to purchasing higher-quality foods. However, these propositions are speculative and require further investigation.

More convincingly, parenthood, particularly motherhood, has been linked to negative dietary outcomes. This phenomenon can be attributed to the time-consuming and often stressful nature of caring for minors, resulting in many parents prioritizing their children's needs over their own dietary habits.[91-93] The shift in priorities becomes clear when observing differences in dietary intake patterns between parents and non-parents. Due to their lack of time, parents tend to favour foods requiring minimal preparation. This preference is illustrated by a study which found that parents consumed more pre-made and snack foods than non-parents. These foods, including salty snacks, pizza, and ice cream, suggest a higher reliance on convenience foods among parents.[92] In addition to their convenience, the high levels of added fats and sugars found in these foods make them highly palatable, which may reflect parents' perceptions that their children are more likely to consume them.[94]

In the Canadian context, the presence of minors in the household has also been shown to influence dietary intake patterns. For example, Nasuti et al. compared dietary intake patterns of first-time parents, second-time parents, and childless couples. They found that compared to

females without children, first-time mothers had higher overall energy, fat, sugar, milk, and fruit intake, and second-time mothers had higher overall energy, fat, sugar, and fruit intake. Although, the observed higher fruit intake among first- and second-time mothers decreased over time. Notably, this study also examined the dietary intake patterns of fathers, a consideration that is relatively absent in most literature. They found that first-time fathers consumed less sugar and more bread than second-time fathers and males without children and that their fibre intake increased longitudinally postpartum.[95] However, the study did not consider the effects of dietary changes on overall diet quality. These results, as well as those found in other studies, indicate that the presence and the number of minors in the household are associated with differences in dietary intake patterns, which could significantly influence diet quality.[93, 96, 97]

Given these findings, it is essential to consider individual-level factors that influence diet quality and societal-level influences. Despite individual characteristics playing a significant role in shaping diet quality, the impact of large-scale changes in food systems cannot be overlooked. These changes have shaped food systems, often setting a precedent for poor-quality diets.

2.1.5 The Nutrition Transition and the Proliferation of UPFs in the Global Food Supply

Beginning around the 1870s, the development of food preservation techniques such as canning and refrigeration, in conjunction with the advent of steam-powered transportation, marked the beginning of the global trade in non-perishable foods.[98] Since then, these technologies have continued to advance, which have been instrumental in meeting the rising global demand for food and ensuring food security for all, in line with the United Nations' Sustainable Development Goals.[99] However, the advent of new food processing technologies, coupled with the globalization of food systems, urbanization, and increasingly sedentary

lifestyles, have led to a global shift in dietary and activity patterns, with significant implications for both dietary and health outcomes.[100, 101]

This shift, known as the 'nutrition transition,' represents changes in dietary and activity patterns and subsequent nutrition-related health outcomes.[6] Today, many developed countries, including Canada and the United States, and many developing countries have shifted away from traditional, high-fibre, minimally processed diets. Instead, they have adopted Westernized diets high in sugars and fats and consume more prepackaged and processed foods.[9, 98] In particular, reliance on ultra-processed foods (UPFs) has increased and has become the primary dietary energy source in many high-income countries, including Canada. Although there is evidence to suggest that increasing consumption of these foods is contributing to a rise in NCDs, their impact on diet and health outcomes is the subject of debate.[11, 98]

Despite conflicting views on the healthfulness of UPFs, respected health authorities, including the World Health Organization, have called for limiting UPF intake.[102] This is due to the growing evidence that links UPF consumption to poor diet quality and the rise of NCDs.

2.1.6 The Association Between UPFs, Diet Quality, and Health Outcomes

The growing presence of UPFs in the global food supply has been accompanied by a rise in obesity and NCDs in many countries, indicating that their consumption might negatively impact human health.[103] The detrimental effects of UPF on human health could be linked to the poorer diet quality of individuals who consume higher amounts of these foods.[104] Diets high in UPFs have been shown to exhibit poorer diet quality compared to diets higher in unprocessed and minimally processed foods. For example, Dinu et al. investigated the consumption of UPFs among a sample of Italian adults, and they found a significant inverse association between adherence to the Mediterranean diet and the proportion of UPF in their diet. They noted that

lower diet quality, as represented by the Medi-Lite score, was associated with more frequent consumption of specific UPFs, including soft drinks, energy drinks, processed meats, cookies, and sweets.[105] Similarly, Nansel and colleagues observed a significant association between poor diet quality and UPF consumption among pregnant women and new mothers, noting that high UPF intake was negatively correlated with overall HEI score and several component scores, including total vegetables, total fruit, total protein, and seafood and plant proteins.[106]

Indeed, UPF consumption has been associated with lower diet quality scores across other diet quality indices, including the Dietary Approaches to Stop Hypertension, the Diet Quality Index-International, and the Alternate Diet Quality Index.[107] Within a Canadian context, a report published by the University of Montreal observed that diet quality was highest among Canadians whose diets contained the least amounts of UPFs. In contrast, those highest in UPFs exhibited the poorest diet quality. The report also found that Canadians with the highest daily intake of UPFs had a significantly higher intake of sodium and nearly double the intake of added sugars compared to Canadians with the lowest daily intake of UPFs.[108] A separate report published by the same team out of Montreal showed similar findings. Their results suggested that diets high in UPFs were associated with poorer overall diet quality in Canada and called for urgent action to limit their consumption.[109]

In addition to the negative implications for diet quality, diets high in UPFs have also been shown to lead to higher energy intake and weight gain. A randomized controlled trial conducted by the National Institutes of Health using ad libitum feeding found that participants consuming a diet high in UPFs ate approximately 500 more calories daily and gained an average of 2 pounds over two weeks. In contrast, those same participants lost weight when following a minimally processed diet.[110] Supporting these findings, a systematic review of 23 studies, comprising ten

cross-sectional and 13 prospective cohort studies, identified a significant association between high UPF intake and increased risk of weight gain and overweight-obesity.[111] Crimarco et al. suggested that the tendency of UPFs to be energy-dense and nutrient-sparse could be a potential mechanism linking increased UPF consumption and weight gain.[112]

Beyond weight gain, high consumption of UPFs has been linked to an increased risk for some NCDs and health conditions, such as metabolic syndrome, CVD, dementia, hypertension, cancer, and all-cause mortality.[103, 113-119] For instance, a meta-analysis by Lian et al. found that individuals with the highest UPF consumption were at increased risk for colorectal cancer, colon cancer, and breast cancer, although no difference in risk was observed for rectal or prostate cancer.[120] Other research has also suggested a particularly strong link between UPF consumption and colorectal cancer. A multi-case control study by Romaguera et al. found that individuals with high UPF consumption had the highest risk of colorectal cancer compared to other types of cancer.[121]

UPF consumption is also linked to an increased risk of certain mental health disorders. Diets high in UPFs are associated with poor mental health outcomes, including anxiety and depression.[122, 123] Coletro et al. found that weekly UPF consumption above the average was associated with a higher prevalence of anxiety and depression symptoms. They argued that this could be due to the high levels of sugar, salt, fat, and stabilizers in these foods, which can lead to inflammation and ultimately increase vulnerability to depression and anxiety.[124]

Moreover, there is increasing interest in CVD risk associated with UPF consumption. Studies have explored this association and have mainly indicated a detrimental relationship. For instance, Li et al. found that higher UPF intake was associated with increased hazards of CVD among individuals with type 2 diabetes, with biomarkers such as renal function, lipid

metabolism, inflammation, and body weight playing a mediating role.[125] Similarly, Chen et al. reported that a higher intake of UPFs was linked to a higher risk of CVD, coronary heart disease, cerebrovascular disease, and all-cause mortality.[126] Jalali demonstrated that participants with the highest UPF intake had a significantly greater incidence of CVD than those with the lowest intake.[127] In terms of a potential mechanism, Henney argued that the link between UPF consumption and NCDs, including CVD, is multifaceted, with factors such as the energy density, macro- and micronutrient composition, and additives in UPFs contributing to adverse health effects.[128]

Despite the growing literature highlighting the potential consequences of high UPF intake, these foods are increasingly being manufactured by transnational food and beverage manufacturers. Evidence suggests that these companies are reshaping food systems by using their market power to influence these foods' availability, price, nutritional quality, and appeal, ultimately driving their consumption.[98]

2.1.7 Technological Advancements and Food System Transformations Associated with Ultra-Processed, Poor-Quality Diets

The nutrition transition (**see section 2.1.4**) towards low-quality and ultra-processed diets is thought to be the result of changes in food system dynamics. These changes include alterations in inputs, stakeholders, and activities involved in food production, processing, distribution, consumption, and disposal.[98, 129]

Faced with limited opportunities for domestic growth, many transnational food and beverage corporations (TFBCs) have ventured into foreign markets. Backed by substantial financial resources and global brand recognition, TFBCs have successfully adapted their global

brands to cater to local preferences in these less saturated foreign markets.[98, 130] Many countries have expedited this process by lowering tariffs and removing trade barriers, thereby facilitating the operations of TFBCs worldwide. These developments have globalized food systems, enabling the transfer of finances, technologies, production processes, raw materials, and finished products across borders. This not only allows TFBCs to penetrate new markets but also links high-income markets with global food supplies and production chains.[98, 131, 132]

Rising incomes, urbanization, and demographic shifts have fueled the demand for UPFs worldwide.[133] Consequently, to meet these demands, TFBCs have set their sights on emerging markets in regions like Central and East Asia, North Africa, and Latin America. By increasing investments, intensifying marketing efforts, and introducing innovative technologies and business practices, these corporations are not just competing with local suppliers but also developing local food and beverage industries that produce home-grown UPFs.[134, 135] The combination of lower manufacturing costs in many low-income countries and advancements in food processing, storage, and shelf-life extension has given rise to a global supply chain of UPFs. This has increased these foods' production and global availability, shifting the focus toward importing UPFs and their common ingredients into high-income countries.[135]

Furthermore, the price of food and ingredients are also key determinants of food affordability and availability. Although the price per calorie of UPFs and minimally processed foods varies by product and region, UPFs and their key ingredients are often less expensive than minimally processed foods, especially in high-income countries.[136] Consequently, the lower production costs of these UPFs have broadened their availability and affordability in high-income countries, leading to a significant increase in their consumption.[98]

Urbanization has also contributed to the growing demand for UPFs. As consumers move closer to retailers, they gain access to a wider variety of affordable foods, including UPFs and beverages.[137] Additionally, urbanization increases consumer's exposure to mass media and unhealthy food advertising.[138] Furthermore, population clustering in urban settings has resulted in occupational patterns that are less compatible with home cooking, leading to a greater reliance on convenience foods. This shift has also led to increased reliance on TFBCs, driven by the limited availability of land for growing one's own food in urban areas.[98, 139]

However, the rise in UPF consumption cannot be attributed solely to increased demand. Changes in supply chains, including the key players who oversee the processes of bringing food from farm to table, have also played a significant role. A handful of companies control a large portion of the global food production market, and their propensity to acquire smaller foreign food producers has led to a homogenization of the food supply. This has largely restricted consumers' food choices to what these companies make available and affordable.[98] Consequently, food producers tend to favour higher-profit, less healthy products, limiting consumers' ability to purchase healthier options.[140]

One of the key actors involved in the changing food systems is the food retailers. In high-income countries, food retail markets are often oligopolistic, dominated by a few grocery retailers. These modern retailers have replaced traditional, small, owner-operated grocery retailers, exerting significant control over the products that are available and accessible to consumers [98, 141]. Together, they have contributed to the rising consumption of UPFs by heavily promoting them through strategies including discounts, print and media advertising, and in-store displays [142]. Retailers have a strong motivation for promoting UPFs, as they often have higher profit margins than minimally processed foods as they are cheaper to produce, have longer shelf

lives, and their convenience and high palatability make them popular among consumers [143]. Retailers employ a variety of strategies to encourage the consumption of UPFs, including discounts, print and media advertising, and in-store displays [142].

While food retailers have long relied on these tactics to influence consumer food choices, online grocery shopping presents a new frontier. Growing evidence suggests that the choice to shop in-store or online influences consumer behaviour and the types of foods they purchase.[25, 144] Some studies suggest that online grocery shopping environments might improve the healthfulness of grocery purchases; compared to in-store environments, which employ a variety of persuasive marketing tactics to encourage impulse buying of less healthy and ultra-processed foods, online grocery shoppers may be less susceptible to these marketing cues, leading to healthier food choices.[24, 25, 145]

2.2 Online Grocery Shopping

2.2.1 Online Grocery Shopping Usage in Canada

The popularity of online grocery shopping in Canada has increased, with the COVID-19 pandemic accelerating its adoption. A report published by the Canadian Internet Registration Authority (CIRA) found that in 2019, only 15% of Canadians had placed an online grocery order from a traditional grocery store, compared to 31% of respondents in 2021.[146] Despite the waning pandemic and the resumption of in-person shopping, online grocery shopping remains a popular alternative, with e-commerce sales remaining above pre-pandemic levels, which might signal a long-term shift in food procurement patterns.[147] Despite the increasing popularity of online grocery shopping, not all consumers are making the switch to digital food retail. Evidence suggests that certain demographic characteristics are associated with a higher propensity for online grocery shopping.[148]

2.2.2 Characteristics of Online Grocery Shoppers

Biological sex may play a role in online grocery shopping habits. Some studies suggest that men are more likely to engage in online grocery shopping than women, which has been attributed to men's higher openness to technology and perceived computer skills.[149, 150] Additionally, women tend to have more negative perceptions of e-commerce and a higher perception of risk associated with online grocery shopping.[151] However, these findings are not universal. Some studies contradict these findings, reporting that women, particularly those with children at home, use online grocery shopping more frequently.[152, 153] Some research suggests that sex does not significantly affect online grocery shopping usage at all.[154] These discrepancies may indicate that other demographic factors influence the relationship between sex and online grocery shopping usage.

The relationship between age and online grocery shopping appears to be more consistent, as it has been reported that younger individuals are more inclined to shop online than older individuals. A study by Hossain et al. found that adults aged 25-34 were the most likely to use online grocery shopping and exhibited the highest frequency of usage. The 35-44 age bracket followed this group, showing the second-highest usage of online grocery shopping. The authors suggested that younger consumers were driven to online grocery shopping due to perceived convenience and lower prices.[155] Conversely, older adults tend to exhibit lower online grocery shopping usage, which might be attributable to a higher perception of risk regarding online shopping, lower perceived value, lower technological proficiency, and a sense of tradition associated with in-store shopping.[156, 157]

Socioeconomic status significantly affects online grocery shopping usage. Studies have shown a positive correlation between yearly household income and online grocery shopping

usage.[158, 159] These findings are to be expected, however, as this holds true for other forms of online shopping, where household income significantly affects the frequency of online buying.[160] Education also affects online grocery shopping usage, as individuals holding a post-secondary degree are more likely to shop online for groceries compared to those with some post-secondary education and a high school education or less.[161] This could be due to higher technological proficiency or because educational attainment is linked to income.[158, 162]

Another factor that has been shown to influence propensity towards online shopping is household composition; more specifically, the household size and the number of minors. Households with more minors tend to use online grocery shopping more frequently, which is potentially attributable to the convenience and the possibility of delivery services that online grocery shopping offers, which can particularly appeal to parents given their busy schedules.[152, 163] Larger households with a greater number of adults also exhibit higher usage of online grocery shopping. However, these households also tend to shop in-store more often, perhaps related to greater food consumption in larger households.[164]

Beyond demographic factors, studies have shown that consumer perceptions and past experiences with online food retail also influence online grocery shopping usage.

2.2.3 Consumer Intentions Towards Online Grocery Shopping

***Motivations for the adoption of online grocery shopping*.** Research indicates that the most frequently recognized advantage of online grocery shopping is the time and effort saved, mainly when delivery services are available.[165-167] This perceived benefit is particularly significant for parents who often grapple with time constraints due to childcare responsibilities, such as assisting with homework or coordinating after-school activities. Online grocery shopping is seen as a solution to the issue of time scarcity, allowing consumers to devote more time to activities they find more meaningful or enjoyable.[168] Parents have reported that the time-saving aspect of online grocery shopping is particularly attractive, and one study found that changing household sizes (e.g., childbirth) was another motivating factor for online grocery shopping usage. Individuals from larger households reported feeling like they had more time for household responsibilities when shopping online.[163]

Comfort is another prominent theme identified in the literature. In the study conducted by Stenius et al., participants provided examples of the comfort associated with online grocery shopping, which included not having to carry heavy grocery bags, the ability to avoid crowds and lineups, and the flexibility to shop within the bounds of their schedule, rather than that of the retailer.[166] Echoing this sentiment, Jilcott Pitts et al. found that parents often face difficulties with in-store grocery shopping when their children accompany them. One participant highlighted the convenience of online ordering and in-store pickup, where a store employee would load her groceries directly into her car. This service eliminated the need to unstrap her children from their car seats and from having to keep an eye on them in the store while shopping.[165]

Health is another significant theme, encompassing a broad spectrum of perceived benefits of online grocery shopping. An example, as perceived by consumers, was the potential for online

platforms to enhance the healthfulness of their diets. Participants believed that online grocery shopping complemented meal planning, as they could research recipes, assess what they already had at home, and then order the necessary items. This process, they believed, would result in a more varied diet.[166, 169] Furthermore, consumers believed online grocery shopping could positively impact their diet because they felt less prone to impulse buying than in-store shopping.[165]

Motivations against the adoption of online grocery shopping. Despite the advantages indicated by online shoppers, many consumers also prefer in-store shopping. Across several studies, consumers' primary concern regarding online grocery shopping was the freshness and quality of food items ordered online.[165, 167, 170] The nature of online shopping prevents consumers from inspecting their selected produce before purchase, which introduces an element of risk.[171] Additionally, consumers have expressed worries about discrepancies between the product chosen online and the actual product delivered, including concerns about the quantity ordered and whether the correct brand was selected.[165, 172]

The cost aspect of online grocery shopping was a significant concern for some consumers, with most participants across the literature perceiving it as costlier than traditional in-store shopping. Participants specifically pointed out additional charges such as picking fees, delivery costs, and tips for delivery personnel as key factors discouraging them from shopping online.[165, 166] Some consumers also expressed their belief that certain products cost more online than in-store. There is evidence that this can be true depending on the specific retailers and their locations.[26, 173, 174] Consumers also reported the lack of mark-down products online as another deterrent.[165]

In some studies, consumers also voiced concerns about the dependability of online grocery services and deliveries, and some expressed frustration toward online retail platforms. Some participants recounted unreliable online grocery shopping experiences, often characterized by unexpected delays, missing items, or other inconveniences during ordering.[175, 176] Additionally, consumers negatively perceived online shopping platforms, primarily due to difficulties navigating them, search functions not working as expected, or the time-consuming nature of locating specific items.[166]

While intentions toward online grocery shopping provide valuable insights into consumer attitudes, examining whether their perceptions of how they act in an online grocery environment align with their actual behaviours is essential. For example, despite the common belief that consumers are more price-sensitive when shopping online due to the ease of comparing prices, some evidence suggests that consumers are less price-sensitive and might be willing to pay more for healthier products.[21]

2.3 Consumer Behaviours in Online Grocery Shopping Environments

With the growth of online shopping, there has been considerable interest in understanding how people shop online and how these behavioural patterns compare to in-store shopping behaviour.[23] Significant differences between online and in-store shopping channels could potentially affect consumer behaviours and, subsequently, the variety and the healthfulness of their purchases.[177] According to the existing literature, online and in-store shopping channels have been shown to elicit different behaviours among consumers, particularly regarding brand loyalty, price sensitivity, time (including the time required for food selection and navigation of shopping channels), and the impact of product displays on consumer behaviours.

2.3.1 Brand Loyalty

Brands significantly influence consumers' product selection process as they convey quality and trigger certain knowledge structures associated with the brand.[178] Consumers form perceptions of a brand based on search attributes, which can be determined before purchase, and experience attributes, which can only be assessed after using or consuming the product.[20] For instance, consumers can ascertain the colour of an apple by inspecting it, but its sweetness or taste can only be evaluated upon consumption. Thus, experience attributes stem from previous encounters with a particular brand, and positive experiences increase the likelihood of repeat purchases.[179]

In traditional grocery shopping environments, consumers can assess a product's search attributes by evaluating the perceived freshness of produce or the quality and integrity of the packaging. However, these attributes are not easily assessed within an online environment, as consumers cannot physically handle the product or evaluate its sensory aspects, such as smell, texture, or sound. In the absence of these attributes, consumers tend to rely more heavily on experience attributes, giving them greater weight in the decision-making process.[20]

Research has shown that brand loyalty is more pronounced in online grocery shopping than traditional in-store shopping. A study by Danaher, Wilson, and Davis used the Dirichlet model for repeat purchases to compare brand loyalty between online and offline environments. Their findings highlighted stronger brand loyalty for online purchases, particularly among brands with higher market share.[20] They also suggested that brand loyalty influences consumers' online food choices more than those made in-store. Research by Pozzi supports these findings, indicating that online shoppers not only demonstrate higher brand loyalty but also show a reluctance to experiment with new brands or try new products.[180]

It is possible that the more pronounced importance of brand loyalty within the online grocery shopping channel could benefit diet quality. Past studies have shown that healthiness is one of the top attributes contributing to building brand loyalty in food retail.[181] For example, one study found that consumers showed higher brand loyalty towards milk and yogurt brands that were low-fat and lower in calories and dairy products enriched with a health-enhancing property.[182] Similarly, Sjostrom et al. found that light brands (i.e., low-fat, low-sugar, or low-calorie foods) showed higher repeat purchase loyalty than regular brands.[183] Finally, a study by Masterson et al. found that consumers showed higher brand loyalty for brands they perceived as "healthy."[184] Therefore, increased brand loyalty, where healthiness is often a major attribute in building brand loyalty, could potentially improve diet quality by encouraging consumers to repeatedly choose healthier options, such as products that are lower in fat or reduced sugar.

2.3.2 Price Sensitivity

Research has indicated that online shoppers exhibit different behaviours than in-store shoppers regarding price sensitivity. It has been suggested that consumers are generally less sensitive to price when shopping online than in-store.[185]

A possible explanation for the observed difference in price sensitivity between online and in-store shoppers is the potential ineffectiveness of promotional activities and discounts in online environments. In a study by Degeratu et al., the impact of online and in-store shopping environments on consumer price sensitivity showed that online shoppers were less sensitive to price changes than those shopping in-store. The authors suggest that their results might indicate that traditional grocery stores have a more significant influence on consumers through discounts and promotional activities, leading to a higher likelihood of brand switching. They also found that in-store shoppers were more responsive to point-of-purchase activities, such as in-store

signage or special placements, irrespective of whether these activities involved a price reduction.[177] It is possible that reduced sensitivity to product promotions and discounting could positively impact diet quality. As promotions are mostly applied to unhealthy products, online shoppers might be less susceptible to these marketing tactics and avoid making unplanned purchases.[186] Additionally, a study involving Brazilian grocery shoppers found online consumers were more willing to pay a premium for groceries if it allowed them to adhere to their intended purchases. While online shoppers spent more on individual items, this increased spending was offset by in-store shoppers who spent more on unplanned purchases.[187] These findings suggest that online shopping may promote better adherence to meal plans and dietary goals, as shoppers are less likely to deviate from their planned purchases.

Furthermore, research has shown a link between higher price sensitivity and an increased likelihood of obesity – a condition closely associated with poor diet quality.[188] Individuals and households that prioritize price in their food purchasing decisions are more likely to make unhealthy food choices, leading to a higher risk of obesity.[189] A study by Okrent and Sweitzer revealed that households with obese members displayed higher price sensitivity than overweight and normal-weight households.[190] While Wang et al. found that price promotions applied to soft drinks resulted in more stockpiling behaviours in countries with higher obesity rates. Their results suggested that obese individuals were more susceptible to price promotions, particularly towards unhealthy foods.[191] In light of these findings, it is possible that the reduced price sensitivity associated with online shopping channels could potentially benefit diet quality, especially for obese individuals who appear to be more vulnerable to the influence of price promotions on unhealthy foods. By decreasing the reliance on price as the primary factor in food purchasing decisions, online shopping may encourage healthier food choices.

2.3.3 Time

Although limited literature exists, time, including the duration of selecting or comparing products and the time required to complete a grocery shopping trip, is another factor highlighting behavioural differences associated with online grocery shopping.[23]

Evidence suggests that online grocery shopping saves time for consumers and that online shopping trips are considerably faster than in-store trips.[192, 193] Prior studies indicate that an average in-store trip to the supermarket takes between 13 to 40 minutes when tracked using radio frequency identification and between 14 to 31 minutes using observational methods.[194, 195] However, these studies noted that the duration of a shopping trip highly depends on factors such as the number of items being purchased, the location and size of the store, and the data collection method. In comparison, online shopping trips are considered to be significantly quicker. For example, one study estimated that for a 12-item grocery list, an in-store trip would take a mean of 30 minutes to complete, with 10 minutes which could be spent at the cash register. In contrast, they found that the same list would take only 11.3 minutes to complete online.[23]

Reduced time online shoppers spend per trip could lead to better diet quality. Research indicates that the longer consumers spend shopping, the more likely they are to make unplanned purchases.[196] Retailers often exploit this tendency by employing in-store strategies designed to extend shopping trips, thereby increasing the chances of unplanned purchases.[197] This is partially because in-store shoppers are exposed to numerous signs, displays, and other marketing tactics to attract their attention. The longer shoppers remain in a retail environment, the more they encounter these tactics, which can lead to unplanned purchases that may negatively impact their diet quality.[198] Furthermore, while online shoppers tend to have shorter overall shopping trips, they appear to spend more time selecting a product than in-store shoppers. Anesbury et al. found

that online shoppers took an average of 19 seconds to select a product, while in-store shoppers took 9-17 seconds. Although the authors argued that this could result from unfamiliarity with online shopping platforms' format, it could also indicate that online shoppers are more mindful and deliberate in their product selection.[23] This additional time spent could potentially reflect a more thoughtful and less impulsive decision-making process, potentially leading to better dietary choices.

2.3.4 Product Displays and Website-Specific Innovations

How products are displayed and advertised in a food retail setting can significantly impact consumer behaviour.[14, 199] This is particularly evident when comparing online and in-store grocery shopping channels. Retailers often use in-store displays (ISDs) to highlight specific brands or products in traditional grocery stores. The main objective of these displays is to capture and enhance consumers' visual attention, thereby making the featured products more noticeable and appealing.[199] Retailers achieve this by manipulating product presentation through shelf signage, strategic shelf positioning, and end-of-aisle placements. Drawing attention to these products is vital for retailers, as it greatly increases the probability of purchase.[199, 200] Given their effectiveness in boosting store revenues, American retailers spend approximately $60 billion on ISDs annually.[201]

ISDs have been proven to be particularly effective in boosting sales of specific products. For example, a study by Bemmaor et al. revealed that introducing ISDs for price-promoted products resulted in nearly a three-fold increase in sales.[202] Another study by Han, Chandukala, and Shibo found that different types of ISDs led to varying levels of sales increase. They discovered that for each week a specific product was featured in an ISD, the revenue for that product rose by an average of 11.15%.[201]

Yet, while ISDs contribute positively to retailer profits, they often negatively impact diet quality as unhealthy products frequently dominate these displays. One study found that 66% of end-of-aisle displays, 53% of island bin displays, and 88% of checkout displays were dedicated to unhealthy products.[203] These findings suggest that in-store grocery shopping channels may prioritize store profits at the cost of promoting poor-quality diets. However, these strategies may not be as effective in online shopping channels.

Directly translating in-store ISDs to an online grocery shopping platform presents significant logistical challenges, but retailers have adapted some of these strategies into a digital format. For example, while traditional grocery stores use end-of-aisle and shelf displays, their digital counterparts are represented by first-page results and screen position (i.e., the order in which products are listed on-screen). Even though these strategies have become more advanced alongside technological advancements, evidence suggests that these digital adaptations may not be as effective as their in-store equivalents.[24]

Several possible explanations have been proposed for why ISDs might be less effective in online shopping channels. Firstly, online shoppers tend to be driven by more utilitarian motives, focusing on practicality and efficiency, compared to in-store shoppers, who are more likely to be driven by hedonistic motives. To, Liao, and Lin found that online grocery shoppers are primarily motivated by convenience, time savings, and the ability to compare products, rather than the hedonistic pleasures of shopping, such as exploration, adventure, and social interaction. Their findings indicated that online shoppers are more likely to purchase only what they need and that product suggestions or ISDs are less influential since they are goal-oriented and less interested in discovering or trying new products.[204]

Secondly, unlike in-store shopping channels, which are expansive and not confined to a single screen, online shopping channels have limited space to display products. Research by Ghani and Kamal found that the size of ISDs correlated with their effectiveness in prompting unplanned purchases, where larger displays attracted more attention.[205] Online platforms, however, cannot allocate as much space due to screen size constraints. These smaller screen sizes limit the size and number of ISDs that retailers can advertise to online shoppers, thus limiting their exposure.[206]

Thirdly, the ability to use search functions in online shopping channels can prevent consumers from having to browse through many products and be exposed to more ISDs. A study by Benn et al. found that nearly 80% of online shoppers utilized search bars, and in their study, participants felt that they avoided many of the in-store marketing strategies to encourage unplanned purchasing by being able to search for the products they wanted. This ability to search for products online may further reduce the effectiveness of ISDs by bypassing the browsing experience typical of in-store shopping channels.[207]

In summary, studies of consumer behaviours have shown that online and in-store shopping channels elicit different behaviours among consumers. Research suggests that online shoppers might be prone to healthier shopping habits, including reduced impulse buying, reduced price sensitivity for healthier options, and a more utilitarian approach to shopping, resulting in better adherence to grocery shopping lists. These differences in behaviours could imply that online grocery shopping may result in healthier food selection and better diet quality.

2.4 The Potential Impact of Grocery Shopping Modality on Diet Quality

The literature surrounding diet quality and online grocery shopping is sparse, and even more so regarding whether there is a significant difference based on the decision to shop in-store

or online. While there is ample research looking at in-store grocery shopping and diet quality, most of the existing literature surrounding online grocery shopping has focused on factors such as food selection, nutrient content, and food access rather than diet quality.

To our knowledge, only one study has compared diet quality between online and in-store grocery shoppers. In their study, Avelino et al. examined the relationships between online grocery shopping, food environments, and diet quality among low-income adults in Connecticut who were mostly enrolled in a food assistance program and were at risk of experiencing food insecurity. Their study found that adults who did not order groceries online had the poorest diet quality, particularly if they perceived their local food environment as less healthy. Conversely, adults who perceived their local food environments as healthy, were enrolled in food assistance programs, and shopped online for groceries exhibited better diet quality. Their results suggest that online grocery shopping can improve diet quality, particularly for those who perceive their local food environment as less healthy. Furthermore, the findings indicated that when individuals enrolled in supplemental nutrition assistance programs can use those benefits on online grocery shopping platforms, it becomes a promising tool for improving access to fresh produce for individuals living in food deserts.[29]

In addition to the findings by Avelino et al., our literature review suggests that online grocery shopping may offer an advantage for diet quality over in-store grocery shopping. This is particularly supported by extensive research indicating that online grocery shopping might reduce impulse buying of unplanned purchases. Impulse buying is “the sudden, often powerful and persistent urge to buy something immediately” and tends to be made without consideration for any potential consequences.[208] Numerous studies, including interviews, experimental designs,

and grocery receipt analyses, have corroborated that online shoppers make fewer impulse purchases than in-store shoppers.[24, 28, 165, 209]

The potential mechanisms through which online grocery shopping might reduce impulse buying and promote adherence to healthy dietary patterns are primarily related to the effects of online and in-store shopping channels on shoppers' psychological patterns during food choice decisions and the subsequent behavioural outcomes. Our literature review identified four key themes when examining these behavioural differences.

Firstly, online grocery shopping encourages higher brand loyalty among consumers. This can be advantageous for diet quality, as consumers may adhere to healthier brands and be more resistant to trying new products, including price-promoted, often less healthy items.[182] Secondly, online grocery shopping has been shown to reduce consumers' price sensitivity, particularly regarding healthier foods.[21, 186] As a result, higher prices for healthier foods may be less of a deterrent for online shoppers, supporting a healthier diet. Thirdly, online grocery shoppers spend less time browsing but more time selecting products. This can benefit diet quality, as shorter shopping trips are associated with fewer unplanned purchases, and more time spent selecting products could potentially lead to more thoughtful and less impulsive choices.[23] Finally, evidence suggests that ISDs are less effective in online shopping channels than in-store. Since a higher proportion of ISDs promote unhealthy foods, reduced exposure to ISDs in online shopping may decrease impulse buying and its negative dietary consequences.[204, 210]

Despite the results of Avelino et al.'s study and empirical evidence suggesting that online grocery shopping reduces impulse buying, which may subsequently lead online grocery shoppers to exhibit better diet quality than in-store grocery shoppers, there are noticeable gaps in the literature. Therefore, the impact of grocery shopping modality on diet quality is unclear.

2.5 Conclusions and Gaps in the Literature

In this chapter, we present evidence of the growing burden of disease associated with diet-related NCDs. Modern diets, primarily consisting of UPFs, are associated with poor diet quality and have been linked to the rising prevalence of NCDs. We discuss how changes to food systems, such as technological advancements in food storage, food safety, and the globalization of food systems, have contributed to the global supply chain of UPFs. In addition, we discuss how digital food retailers, including online grocery shopping, are further contributing to the changing food systems. We also discuss how online shopping channels influence consumer behaviours and the potential benefits of online grocery shopping platforms for diet quality.

Despite our literature review's findings suggesting that online grocery shoppers might exhibit better diet quality than in-store grocery shoppers, the relative lack of evidence leads us to recognize that the impact of grocery shopping modality on diet quality is unclear.

3 RATIONALE, OBJECTIVES, AND HYPOTHESES

3.1 Rationale

The rationale for this study is to expand the field of knowledge surrounding the online grocery shopping landscape in Canada and to help fill in some of the knowledge gaps that were identified during our literature review. The following gaps were identified while conducting the literature review:

Firstly, while market research has provided insight into differences in sociodemographic characteristics of online and in-store grocery shoppers, there is a shortage of studies examining whether these differences are statistically significant.[19, 152] This information is important to nutrition researchers as it can help identify issues surrounding access inequities and barriers to use among certain populations and inform targeted interventions.

Secondly, despite the growing need to address the global state of poor diet quality and the increasing burden of NCDs, little research has considered whether the proliferation of online grocery platforms contributes to this issue. Some studies have proposed certain advantages and disadvantages of online grocery shopping for diet. However, these studies did not directly examine diet quality.[24, 165, 170] Two studies compared the healthfulness of online and in-store purchases but did not directly measure diet quality quantitatively.[25, 145] Furthermore, the sole study we found that compared diet quality between online and in-store grocery shoppers only assessed low-income individuals in the United States, most of whom received supplemental nutrition assistance. As a result, their findings may have limited applicability to the general population and other countries.[29]

Thirdly, during the literature review, research indicated that while there are distinct behavioural patterns exhibited by online grocery shoppers, sociodemographic factors mediate these behaviours. For example, younger individuals have been shown to have greater proficiency in navigating online shopping platforms. Despite evidence suggesting that online grocery shopping could particularly benefit older individuals, difficulty navigating online shopping platforms might hinder their ability to purchase their desired products.[211, 212]

Examining the relationships between grocery sociodemographic characteristics, diet quality, and grocery shopping modality could provide several benefits: 1) help to identify barriers to usage among certain sociodemographic groups, 2) provide baseline information regarding online grocery shopping users and diet quality in Canada, 3) help to identify existing issues related to diet quality in Canada, and 4) help inform the development of healthy eating interventions or future research regarding online grocery shopping.

3.2 Objectives

Therefore, this thesis is meant to contribute to filling these knowledge gaps. The specific objectives are:

1) To compare sociodemographic characteristics between online and in-store grocery shoppers.

2) To compare diet quality between online and in-store grocery shoppers.

3) To examine whether diet quality differs between online and in-store shoppers based on sociodemographic characteristics.

3.3 Hypotheses

Based on the literature review findings, we hypothesize that there will be significant differences in participant characteristics between online and in-store grocery shoppers. Furthermore, based on research indicating that online grocery shoppers are less prone to impulse buying behaviours, we hypothesize that there will be a difference in diet quality between online and in-store grocery shoppers. Specifically, online grocery shoppers will exhibit better diet quality than in-store shoppers. Finally, we hypothesize that the relationship between grocery shopping modality and diet quality will differ based on sociodemographic characteristics.

4 METHODOLOGY

4.1 Study Design

This Master's project was part of the larger "Canadian Food Purchasing and Consumption Study," an exploratory web-based study that seeks to understand the relationship between food purchasing methods (online or in-store) and Canadians' eating practices.

4.2 Participants and Sampling

The target population for this study was Canadian adults who use the Internet. Convenience non-probability sampling was used to obtain a large sample of eligible participants. The inclusion criteria for the study were that participants had to live in Canada, could read and understand English, had access to the Internet, possessed a valid email address, and were at least 18 years of age. As the DHQ-III is only available in English, only participants who understood written English could participate.

Prior to data collection, sample size estimates were calculated using PASS 12 (2013), NCSS, LLC. Kaysville, UT. www.ncss.com. Based on the primary outcome diet quality (HEI), a sample size of 701 participants was determined to achieve 80% power to detect an R-squared increase from 10% to 11%. This means that an R-squared increase of 1% could be attributed to one independent variable of online food purchasing using multiple linear regression with a significance level (alpha) of 5%. To account for the expected sample loss from incomplete questionnaires and implausible data, a total of 2400 participants were recruited. The initial R-squared of 10% was selected based on existing research, which suggested that 18-19% of the variation in HEI could be explained by a combination of sociodemographic and food environment factors (e.g., the presence of a grocery store, convenience store, or restaurant) in a Canadian population.[213] In the absence of information about digital food environments, a

conservative approach was taken using an R-squared of 10% - lower than what was reported in previous research. Using a conservative approach, it was estimated that online food purchasing would explain a minor increase of only 1% in the R-squared of HEI. Thus, the sample size of 701 participants was calculated to detect an increase of at least 1% in HEI from an initial R-squared of 10% attributed to online food purchasing.

4.2.1 Recruitment

Participants were recruited through paid and unpaid social media advertising on Facebook, Instagram, X (formerly Twitter), LinkedIn, and Kijiji. Advertisements were also shared by the study team in posts on their social media. Participants were incentivized to complete the study by being entered into a draw to win one of 6 $250 Amazon gift cards. Participants were entered into the draw up to two times, once after completing the REDCap survey and once after completing the DHQ-III. Gift cards were issued electronically and sent to winning participants via email.

Participants were directed to the consent form and Section 1 of the survey via a link within the study advertisements. The link led to the REDCap platform, where participants were required to read and agree to the consent form before proceeding with the study. Following reports of false advertising on Facebook, an ethics amendment was made to direct participants who clicked on social media advertisements to the team's official website, digitalfoodenvironments.com, rather than directly to the survey. On the team's webpage, they could read about the study and access the survey and consent form link. After participants completed the survey on REDCap, they were automatically emailed a personalized link and identifier to begin the DHQ-III, which was housed on another website run by the National

Institutes of Health (NIH) and is managed and developed by the National Cancer Institute (NCI) (https://epi.grants.cancer.gov/dhq3/).

4.3 Data Collection Tools

This study used a web-based survey that consisted of three sections: 1) participant and household characteristics, 2) a questionnaire on eating practices, and 3) a food frequency questionnaire (FFQ).

Section 1 of the survey (participant and household characteristics) was adapted from the Canadian Community Health Survey (CCHS) – Nutrition, 2015. It was a 19-item questionnaire that contained questions related to demographic (age, gender, sex, marital and immigration status, number of children, and household size), socioeconomic (income and education), and health (body weight and height, food allergies, and special diets) characteristics. Section 2 (eating practices) consisted of a 52-item questionnaire collecting information on online and offline food purchasing practices, consumption of meals made at home, and food literacy attributes. The research team designed questions regarding food purchasing practices. Section 3 (the FFQ) consisted of the Diet History Questionnaire III (DHQ-III), a validated web-based FFQ. Data was collected over 12 months to account for seasonal variations in food ordering and dietary intakes. Data collection began in January 2022 and ended in January 2023.

4.3.1 Quality Assurance

To ensure data quality and minimize the risk of bots and duplicate responses, the research team implemented quality control measures throughout each stage of the data collection process. The team monitored the data daily for unusual activity. When participants clicked the survey link in the social media ads, they were directed to the Digital Food Environments website, where they could read about the study and team and access the consent form and survey on REDCap. To

begin the survey, participants had to complete a CAPTCHA to prevent automated responses. After finishing the first section, participants were prompted to check their email for credentials needed to continue to section two to complete the DHQ-III, which was hosted on another website. Post-data collection, the team reviewed responses for duplicates, including only the initial submission if multiple entries were detected. Participants with undeliverable emails were excluded from the study. Finally, the team checked for inattentive responses within the remaining data for one section of the survey, but none were found.

4.3.2 Measures

The primary outcome variable for this study was diet quality. Using data collected with the DHQ-III, a diet quality score, as represented by the Healthy Eating Index (HEI) score, was automatically calculated for all participants who completed the DHQ-III. The HEI measures diet quality based on compliance with the U.S. Dietary Guidelines for Americans (DGAs).[214] It is a continuous variable with a range of 0 to 100, with a score of 100 representing a diet that aligns with the DGAs.[42] The primary outcome variable for this study was diet quality. Using data collected with the DHQ-III, a diet quality score, as represented by the Healthy Eating Index (HEI) score, was automatically calculated for all participants who completed the DHQ-III. The HEI measures diet quality based on compliance with the U.S. Dietary Guidelines for Americans (DGAs).[214] It is a continuous variable with a range of 0 to 100, with a score of 100 representing a diet that aligns with the DGAs.[42]

The primary independent variable for this study was food purchasing mode, derived from question 26 of the REDCap survey: “Over the last 12 months, how many times did you buy groceries online?”. Participants were categorized according to their online grocery shopping frequency. Individuals with zero instances of online shopping within the last year fell into the ‘no

usage' category. Participants within the lowest 33% of the frequency distribution were designated as 'low usage.' Participants whose frequency was between the 34th and 66th percentiles were designated as 'moderate usage.' Finally, those in the 67th percentile and above were designated as 'high usage.' The decision to convert the frequency of online grocery shopping from a continuous variable to a categorical variable was made due to the highly skewed distribution of online grocery shopping usage. Furthermore, the decision not to apply transformations to the independent variable was driven by the analytical focus on comparing the impact of distinct, non-ordinal categories on the dependent variable.

The covariates of this study were sociodemographic characteristics obtained from Section 1 of the cross-sectional survey. These characteristics included sex, gender, age, race, BMI, educational attainment, country of birth, household size, marital status, number of minors in the household, and employment status. Certain categorical variables that had levels with low frequencies ($n<5$) were grouped to avoid violating the assumptions of the Chi-Square analysis.

Educational attainment was categorized into the following groups: 1) High school or less, containing primary school and high school; 2) College diploma, technical degree, or other, containing College diploma or technical degree, Trade school, and other; and 3) University degree, containing bachelor's degree and graduate degree (master's or doctorate). The categorization of educational attainment was guided by research indicating a dichotomy in diet quality between those with and without a university degree.[78]

Employment status was categorized into the following groups: 1) Employed, containing full-time employment and part-time employment; 2) Not currently employed, containing not currently employed and retired; 3) Other, which contained disability and other; and 4) Full-time parent or caregiver. These groupings were informed by literature which suggested that

individuals with traditional employment statuses (i.e., full-time, part-time employment) typically have less time available for cooking compared to those in other employment statuses.[215]

Participants were asked whether they identified as belonging to a racialized group. Race was categorized into the following groups: 1) Yes or prefer not to say, which contained Yes and Prefer not to say, and 2) No. The grouping of 'Yes' and 'Prefer not to say' was necessary due to the low frequency of responses for the latter group. Participants within these groups exhibited similar diet quality and online grocery shopping habits.

The number of minors in the household was categorized into the following groups: 1) zero minors, 2) one minor, and 3) two or more minors, which contained 'three minors,' 'four minors,' and 'five or more minors.' Households with two, three, four, and five or more minors exhibited similar behaviours in terms of online grocery shopping usage and HEI score.

Marital status was re-coded to combine 'Married' and 'Common-law' because the presence of a partner, whether married or not, has been shown to influence dietary habits significantly.[216]

Yearly household income was categorized into the following groups: 1) lower-income, which contained the income groupings of '$0-24,999' and '$25,000-49,999'; 2) middle-income, which contained the income groupings of '$50,000-74,999' and '$75,000-99,999'; 3) higher-income, which contained the income groupings of '$100,000-124,999' and '$125,000 or more'; and 4) Prefer not to say. Lower, middle, and higher-income brackets are commonly used in research for their natural segmentation. The combined income groupings exhibited similar behaviours in online grocery shopping usage and HEI scores within our study sample.

While conducting our statistical analyses, we initially considered both sex and gender as we did not want to exclude the small proportion of our sample who did not identify as cisgender

(2.61%). However, our analyses demonstrated no significant differences in diet quality or online grocery shopping usage when considering participants' biological sex or gender identity. Therefore, we incorporated only biological sex into our analyses.

4.4 Statistical Analysis

Data was analyzed using Stata 18 software (College Station, TX).

4.4.1 Summary Statistics

Continuous and discrete variables were described using means and standard deviations, while categorical variables were described using frequencies and percentages. To compare sociodemographic characteristics between online and in-store grocery shoppers, participants' characteristics were compared across online grocery shopping usage categories using Pearson's chi-square tests for categorical variables and one-way ANOVA for continuous variables at a significance level of $p < .05$.

4.4.2 Multivariable Linear Regression Analysis

A multivariable linear regression analysis was conducted to assess the relationship between grocery shopping modality and diet quality. HEI score was treated as a continuous dependent variable, while online grocery shopping usage categories were categorical. These categories included "low usage," "moderate usage," "high usage," and "no usage," the last of which served as the reference group.

The covariables included in the model building were selected based on *a priori* evidence, which suggests a correlation between the covariate and diet quality (**see section 2.1.3**). Variables with a p-value of $p < 0.05$ were considered statistically significant and were included in Model 2 and Model 3. Sex, age, educational attainment, yearly household income, and the number of

minors in the household were retained due to their statistical significance. Despite only nearing significance, BMI was also included in Model 3, as previous research has shown a significant correlation between BMI and HEI score.[217]

Three models were constructed, with Model 1 consisting of the dependent variable (HEI score) and the primary independent variable (online grocery shopping usage). Model 2 added sex, age, educational attainment, yearly household income, and the number of minors in the household as independent variables. Model 3 controlled for the same variables as Model 2, adding BMI as a continuous covariable.

4.4.3 Stratified Multivariable Linear Regression Analyses

Models 1, 2, and 3 were stratified by demographic groups identified as significantly associated with online grocery shopping usage and HEI score. Regression models were stratified by sex (male and female), the number of minors in the household (zero, one, or two or more minors), educational attainment (high school or less, college diploma, technical degree, trade school, or other, and university degree), and yearly household income (lower-income, middle-income, higher-income and prefer not to say). The decision to stratify these variables using these particular groupings was made for simplicity and to maintain greater power. The decision to group these variables was informed by Chi-square and one-way ANOVA analyses, which revealed no significant differences among the categories regarding the primary independent variable (online grocery shopping usage frequency) and the dependent variable (diet quality).

We used stratified analyses rather than interaction terms in our linear regression models to ensure the study results were simple and easily interpretable. We believed that stratified models would make it easier for researchers and nutrition professionals to understand our

findings. To ensure thoroughness, we also conducted additional statistical analyses to test for potential interaction effects within our models; however, no meaningful interactions were found.

5 RESULTS

5.1 Respondents

Table 1 describes participant characteristics. A total of 2400 people were initially recruited for the survey. Of these, 1267 participants completed all three sections. After excluding participants with incomplete data, 872 responses were deemed valid for analysis.

Regarding online grocery shopping usage, 50.1% of respondents reported no online grocery shopping over the past twelve months. A majority of respondents were female and identified as non-racialized persons (79.8% and 80.3%, respectively). In addition, 60.1% of participants were married or common-law, and 74.0% had zero minors living in the household.

In terms of socioeconomic status indicators, over half of the participants had a university degree (51.6%) and held traditional part- or full-time employment (56.9%). Individuals from lower-income households constituted 26.5% of participants, while participants from middle-income and higher-income households comprised 32.9% and 26.4%, respectively. A further 14.2% of participants chose not to disclose their annual household income. The mean HEI score for the total sample was 65.9.

5.1.2 Comparison of Baseline Characteristics Across Online Grocery Shopping Usage Categories

Table 1 presents the results of Pearson's chi-square analyses exploring differences in sociodemographic characteristics between online shopping categories. Significant differences were observed in several baseline characteristics across online grocery shopping categories.

Pearson's chi-square tests found significant differences in employment status ($p< 0.001$), yearly household income ($p= 0.05$), and educational attainment ($p= 0.02$) across online grocery shopping usage categories. Additionally, significant differences in the number of minors in the household ($p< 0.001$) and household size ($p< 0.001$) were also observed. One-way analysis of variance showed significant differences in age and BMI ($p< 0.001$ and $p= 0.01$, respectively) across online grocery shopping categories.

No statistically significant differences were found according to sex ($p= 0.15$), race ($p= 0.75$), marital status ($p= 0.30$), or HEI score ($p= 0.37$) across online grocery shopping categories.

5.2 Simple and Multivariable Linear Regression Analyses

Table 2 presents the results of the simple linear regression and multiple linear regression analyses. Model 1 (null model) was not statistically significant ($p= 0.37$) and explained minimal variance in HEI score. It found no statistically significant differences in diet quality between the no-usage group and the low-, moderate-, and high-usage groups.

Model 2 (null model + sex, age, educational attainment, yearly household income, and the number of minors in the household) was statistically significant ($p< 0.001$) and explained approximately 7.8% of the variance in the independent variable. However, there were no significant differences in diet quality between the no-usage and the low-, moderate-, and high-usage groups.

Model 3 (Model 2 + BMI) was statistically significant ($p< 0.001$), and it explained approximately 9.82% of the variance in HEI score. There were no significant differences in diet quality between the no-usage and the low-, moderate-, and high-usage groups.

5.3 Stratified Simple and Multivariable Linear Regression Models

For Models 1, 2, and 3, no significant differences in diet quality between the no-usage group and the low-, moderate-, and high-usage groups were found when stratified according to sex (**Table 3**), educational attainment (**Table 5**), and yearly household income (**Table 6**).

When stratified by the household number of minors, a significant difference in diet quality was observed for participants with two or more minors in the household. Compared to the no-usage group, diet quality was significantly poorer among participants in the high-usage group, ß= -7.52 (2.44), p= 0.003 (**Table 4**). However, no significant differences in diet quality were found for participants with zero or one minor in the household (**Table 4**).

6 DISCUSSION

In the present study, our objectives were to explore whether there were differences in sociodemographic characteristics and diet quality between online and in-store grocery shoppers. We also examined whether diet quality differed between online and in-store shoppers based on sociodemographic characteristics. To meet these objectives, we analyzed survey responses from 872 Canadian consumers, focusing on their use of online grocery shopping and their diet quality. Our results found that while there are significant differences in the sociodemographic characteristics of online and in-store shoppers, there was no difference in diet quality. The one significant finding was that Canadians with two or more minors in the household with high online grocery shopping usage had significantly poorer diet quality than those who shopped exclusively in-store. However, as this was the only significant finding, we cannot rule out the possibility of a spurious relationship. Our findings suggest that grocery shopping modality, as a single variable, is not associated with diet quality.

6.1 Sociodemographic and Household Differences between Online and In-store Grocery Shoppers

For our primary objective, this study's results suggest significant differences in sociodemographic and household factors between online and in-store grocery shoppers. Our research identified a significant correlation between age and the frequency of online grocery shopping. Specifically, individuals with low, moderate, and high usage of online grocery shopping services had a lower average age than the no-usage group. This suggests that online grocery shoppers are generally younger than those who shop exclusively in-store. This observation aligns with previous research, which found that millennials were Canada's most frequent users of online grocery shopping services. At the same time, individuals over the age of

65 used these services the least.[218] Age is an established factor influencing participation in e-commerce. Younger individuals are more likely to shop online due to their innovative nature, familiarity with technology, and lower frustration and anxiety levels when using the Internet. On the other hand, older consumers often prefer in-store shopping as they appreciate its hedonic benefits, including the social and recreational aspects of the shopping experience.[219]

In addition, we observed a significant difference in educational attainment and employment across the online grocery shopping usage groups. The high-usage group had the highest proportion of university-educated individuals, while the no-usage group had the lowest proportion. This observation aligns with previous research indicating a correlation between higher educational attainment and preference for online shopping. Burroughs and Sabherwal have argued that individuals with higher levels of education might have greater self-efficacy in navigating new or unfamiliar environments and greater computer self-efficacy, which would increase the likelihood of online shopping.[220] Regarding income, the high-usage group had the highest proportion of employed individuals and the lowest proportion of unemployed individuals. This result is unsurprising as employment status is closely linked to financial capacity. Employed individuals generally have higher disposable income, which affords them the convenience of online grocery shopping and potentially higher prices, which may include extra fees or higher prices for items ordered online.[221] Moreover, Van Droogenbroeck and Van Hove found that households where all adults were employed full-time were more likely to adopt online grocery shopping than those where one or more adults were not. They argue that because adults employed full-time experience greater time scarcity, they have a stronger motivation to save time through online grocery shopping.[163]

We also observed a significant difference in the number of minors per household. The no-usage group predominantly consisted of households with no minors, whereas the high-usage group had a higher proportion of households with two or more minors. These findings align with previous research, which has indicated a positive correlation between the number of children in a household and the propensity for online grocery shopping. For instance, a study in Spain revealed that households with preschool children (0-5 years of age) and young people (6-18 years of age) exhibited a stronger preference for online grocery shopping after controlling for other factors that predict online grocery shopping usage.[222]

6.2 Diet Quality and Grocery Shopping Modality

For our second objective, we explored whether there was a significant difference in diet quality between the no-usage and online shopping groups (low-, moderate-, and high-usage categories). Based on pre-existing literature suggesting that online grocery platforms reduce impulse buying behaviours, we hypothesized that online shoppers would exhibit better diet quality than in-store grocery shoppers. However, we found no significant differences in diet quality. Instead, our findings suggest that the grocery shopping modality does not affect diet quality and that grocery shoppers behave the same way online as they do in-store.

Throughout our literature review, several studies promoted online grocery shopping as an effective tool in preventing unplanned purchases associated with impulse buying behaviours.[24-26] Impulse buying behaviour has been associated with less healthy food choices, and therefore, we believed that this would translate to better diet quality among online grocery shoppers.[27, 223] The lack of significant differences in diet quality between online and in-store grocery shoppers reflected in our study could imply that the relationship between impulse buying, grocery shopping modality, and diet quality is as impactful as previously believed.

One theory that could explain our findings is that while online grocery shopping may reduce the number of unplanned purchases of less healthy foods, this potential benefit could be counterbalanced by an increase in planned unhealthy food purchases or a decrease in planned purchases of healthy foods. Studies, such as the one conducted by Zatz et al., support this theory. They found that while impulse buying decreased for items like candy and frozen desserts, online shoppers made more planned purchases of unhealthy products like sugar-sweetened beverages and sweet and salty snacks.[25] Their results revealed that although certain unhealthy foods are more prone to impulse buying and subsequently decrease with online ordering, other unhealthy products are not considered impulse purchases. Chintala, Liaukontye, and Yang's study found that while online shoppers purchased 5-7% fewer impulse purchases, such as candy, bakery products, and savoury snacks, they also purchased 13% fewer fresh vegetables.[224] Lacko, Ng, and Popkin found that online shoppers purchased fewer overall calories and snack foods, but they also purchased fewer non-starchy vegetables and had a higher daily sugar intake.[225] The decreased buying of vegetables observed in these studies could be attributed to concerns regarding the quality of fresh produce purchased online that have been noted in other studies.[165, 224] These findings suggest that while online grocery shopping may reduce impulsive buying of unhealthy items, it does not necessarily lead to healthier overall purchasing behaviours. The decrease in the purchase of vegetables, combined with a higher intake of sugary foods, indicates that other factors, such as pre-existing dietary habits and concerns about the freshness of produce, could offset the benefits of reduced impulse buying. Thus, even though online grocery shopping has the potential to reduce the likelihood of purchasing certain unhealthy foods, our results suggest that its overall impact on diet quality may be limited by the persistence of unhealthy planned purchases and the reduced purchase of healthier foods.

Furthermore, although a growing body of research has focused on online impulse buying, notable limitations in the existing literature may have contributed to the assumption that online grocery shopping channels reduce impulse purchasing and subsequently promote healthier food choices and better diet quality. These assumptions may partly explain our study's lack of significant results.

One notable limitation in online impulse buying literature is the inconsistency in researchers' theoretical models in understanding this behaviour. According to Chan, Cheung, and Lee, one of the major difficulties in synthesizing and interpreting the results from online impulse buying studies is the lack of a unified theoretical framework.[226] Early models of impulse buying were primarily focused on exposure to in-store stimuli, such as displays, smells, and store layout, and suggested that impulse buying was driven by external factors leading to unplanned purchases.[226-228] In contrast, more contemporary models shifted towards viewing impulse buying as an internal process. In this process, individuals experience a strong, often emotionally complex, urge to make immediate purchases. This psychological mechanism can sometimes lead to internal conflict and is driven by complex decision-making processes.[229] Studies of in-store impulse buying have often employed the “stimulus-organism-response” (S-O-R) framework to bridge these perspectives. This psychological model conceptualizes impulse buying behaviour as a multi-step process that begins with a hedonistic impulse triggered by an external cue and is mediated by cognitive processing. The S-O-R model effectively integrates both early and contemporary models by emphasizing the role of both internal and external cues.[226]

However, this nuanced understanding has not fully carried over to the study of online impulse buying. The literature remains largely divided: some studies conceptualize online impulse buying as a hedonistic and spontaneous reaction to stimuli, similar to early models.[230] In

contrast, others have considered the mediating role of cognitive processes between stimulus and purchasing decisions.[231] This division in theoretical perspectives makes it difficult to consolidate findings across studies, as the differing conceptualizations lead to inconsistent methodologies and conclusions.[226]

Another potential limitation in the online impulse buying literature is the difficulty of accurately measuring impulse buying behaviours. This challenge is compounded by an over-reliance on self-reported data, where a high risk or social desirability bias can lead to underreporting impulse buying behaviours.[232, 233] As a result, participants are often asked about their "urge to buy" as a surrogate for their actual impulse buying behaviours. These studies often ask participants to reflect on their shopping experience using questions like "I felt compelled to make purchases outside of my original shopping intentions."[234] While these questions are designed to minimize biased responses, they also introduce vagueness and subjectivity, leading to several challenges.[226] For example, if a consumer has a pre-made shopping list that does not contain butter, but after seeing a promotion on butter, they recall that they are running low and may decide to purchase it. Technically, this is considered an impulse purchase triggered by an external cue, but the consumer may not perceive it as being impulsive as it aligns with their broader shopping goals.

Finally, another important limitation in the existing research relates to the generalizability of the existing literature. Many studies that have shaped our modern understanding of the impact of internal and external cues on impulse buying predominantly sampled university students.[226, 230, 235-238] This approach was considered reasonable at the time, as the studies were often conducted before the widespread adoption of the internet across diverse populations, and university students were among the primary users of online platforms. However, Chan, Cheung,

and Lee argued that with increasing internet use by people from a wide range of demographic backgrounds, there might be a need to reassess whether the generalizability of earlier studies still accurately represents the growing diversity of online shoppers.[226]

Given these potential limitations in the impulse buying literature, specifically, the deviations in theoretical understandings of impulse buying, the over-reliance on self-reported data, and the limited generalizability of studies based on non-representative samples, it's possible that these issues have led to the inaccurate assumption that online grocery shopping inherently reduces impulse buying. These assumptions may have influenced our hypothesis, leading us to expect healthier food choices and better diet quality among online shoppers. However, the lack of significant results in our study suggests that shoppers behave the same way online as they do in-store and that the actual impact of online shopping on impulse buying may be more complex and less straightforward than previously believed.

Furthermore, our literature review identified several key themes related to behavioural differences between consumers using online versus in-store shopping channels. These themes include brand loyalty, price sensitivity, time, and finally, product displays and website innovations. We believed these factors suggested that online shoppers exhibited behaviours more conducive to healthier food choices and improved diet quality. However, given the shallow pool of research surrounding the healthfulness of online grocery shopping to draw from, we acknowledge that these themes could also be interpreted differently.

Firstly, online grocery shoppers have been shown to exhibit higher brand loyalty than in-store shoppers. We hypothesized that this heightened loyalty could contribute to better diet quality, as shoppers may be less inclined to browse other products. Moreover, consumers tend to show greater brand loyalty towards brands they perceive as healthy. However, this increased

brand loyalty among online shoppers could also indicate a reluctance to compare products, driven by a desire to save time and a greater emphasis on convenience.

Search cost refers to the time, effort, and resources consumers expend to obtain price or product information.[239] In retail environments, the level of search cost significantly influences consumer behaviours; high search costs can discourage thorough searches and promote less thoughtful purchasing decisions based on limited information or options.[240] This behaviour becomes more pronounced in online environments, where consumers face a broader range of products and must navigate multiple pages and menus. For some individuals, particularly those less familiar with online shopping platforms, the cognitive effort required to locate specific products in an online grocery shopping environment may substantially increase search costs.[23] As a result, higher brand loyalty in online grocery shopping may reflect an unwillingness to invest significant energy or effort into the search process. Consequently, online shoppers may be likelier to choose products based on brand recognition rather than healthfulness or ingredient quality.

Secondly, although our hypothesis suggested that online shoppers, with their lower price sensitivity, would make healthier food choices by being less deterred by the higher costs of healthier options, our results did not find significant support for this. This may reflect the findings of Middaugh et al., which suggest that price alone is not the primary driver of healthy food consumption. Instead, factors like nutrition knowledge and education level play a crucial role.[241] This could imply that even if online shoppers are less influenced by price, without adequate nutrition knowledge or an educational level that supports healthy food choices, the potential benefits of online grocery shopping on diet quality may be limited.

Thirdly, we hypothesized that the increased time online shoppers spend selecting products might be associated with making more thoughtful and less impulsive decisions. However, this extended time could also be attributed to consumers' unfamiliarity with online shopping platforms, leading to longer search times to locate products on the screen.[23]

Fourthly, evidence suggests that ISDs may not be as effective in promoting impulse buying behaviours in online grocery shopping channels due to factors such as limited screen size. We hypothesized that the reduced effectiveness of ISDs in online shopping environments could lead to fewer unplanned purchases and, consequently, better diet quality. However, as Chan, Cheung, and Lee point out, most studies on online impulse buying have primarily focused on applying theoretical models of ISDs from traditional brick-and-mortar grocery stores to online platforms. Fewer studies have considered online-exclusive ISDs, such as repeat purchase suggestions and product recommendation algorithms, as cues for impulse buying.[226] This gap in the literature may help explain our study's lack of significant findings. It is possible that these online-exclusive ISDs, rather than traditional ones, play a more crucial role in influencing online shopping behaviours and diet outcomes.

6.3 Stratified Models of Diet Quality Among Online Shoppers

For our secondary study objective, we observed that in households with two or more children, individuals with high online grocery shopping usage exhibited significantly worse diet quality than those who shopped exclusively in-store. Online grocery shopping, while appealing for its time-saving benefits – particularly valuable in larger families – appears to have unintended negative consequences on diet quality. The online shopping modality often caters to the need for convenience, leading to increased purchases of pre-packaged and non-perishable foods.[24] These foods, which are readily accessible and heavily promoted through online platforms, typically

contain high sugar, fat, and sodium levels.[242] Their broad palatability, especially to children, helps ensure easier mealtimes but at the cost of nutritional value. Furthermore, home cooking is linked to improved diet quality, a benefit that tends to be passed on to children. This association is characterized by increased consumption of fruits and vegetables alongside reduced intake of sugar-sweetened beverages and fast foods.[243-245]

Concerns about the freshness of produce available online may further deter parents from making healthier choices. Horning et al. found that parents who reported lacking time for cooking tended to have a lower household availability of fruits and vegetables.[246] The increased ease in bulk-purchasing associated with online grocery shopping may also compound these factors, leading busy parents to purchase larger quantities of less nutritious food options than those who shop in-store.[24]

7 CONCLUSION

7.1 Contributions to the Field of Nutrition

This thesis offers significant contributions to the field of nutrition research. With the rising prevalence of NCDs and obesity alongside technological advancements and the digitalization of food retail, our study findings suggest that the modality of grocery shopping, whether online or in-store, does not significantly impact diet quality. The insights provided by our study indicate that public health efforts and future research should focus on other factors that influence diet quality. By directing attention to areas such as nutrition education, socioeconomic disparities, and lifestyle interventions, nutrition researchers and public health professionals can better address the underlying causes of poor diet quality and work towards reducing the burden of diet-related health issues.

7.2 Strengths and Limitations

To our knowledge, our study represents the first investigation of differences in diet quality between online and in-store grocery shoppers in Canada. However, these findings should be interpreted in line with the limitations of the study.

First, we used convenience sampling to recruit participants, which may limit the representativeness of our sample compared to the Canadian population. As a result, certain demographics, including online grocery shoppers, women, and individuals with a university education, were overrepresented. However, our large sample size allowed us to control for covariables in our regression models to mitigate potential sampling bias.

Our decision to use the DHQ III, an FFQ validated for use in the United States but not in Canada, was driven by the online nature of this study, which made the use of 24-hour recalls impractical. We required a food intake assessment tool that could be self-administered online and

provided an estimate of usual dietary intake. While a Canadian equivalent, the C-DHQ-III, was planned, it was unavailable. The C-DHQ-II was unsuitable for our study as it dated back to 2010, and the updated DHQ-III provided options that better reflected Canadians' diet in 2022. Despite this limitation, the dietary patterns in Canada and the U.S. are highly similar, largely due to the influence of major multinational food producers like PepsiCo, General Mills, and Nestlé, which dominate the food markets in both countries.[7] Similarities in product availability likely result in similar dietary patterns across the U.S. and Canada.[37] Similarly, diet quality was represented by the Healthy Eating Index rather than the Canadian Healthy Eating Index (C-HEI) or the HEFI-2019. Our reasons for selecting the HEI are that the C-HEI is outdated and no longer reflects Canadian dietary guidelines, and the HEFI-2019 had not yet been developed at the time of data collection.[47] However, given the similarities between American and Canadian healthy eating guidelines, the Healthy Eating Index provides a good estimation of the overall diet quality of Canadians.[46]

Despite its limitations, this study provides an important contribution to the existing knowledge of online grocery shopping. Firstly, a significant portion of studies on online grocery shopping do not directly measure diet quality; instead, they analyze the types of food that consumers purchase.[25, 224, 225, 247, 248] Household food purchases only offer a moderate estimate of a person's overall diet quality, as research has shown a discrepancy between food purchases and actual dietary intake. This discrepancy can be attributed to the fact that the food consumers buy does not always equate to what they consume. Food items may be wasted, shared, or used for non-dietary purposes. In addition, the way food is prepared or combined, which significantly affects its nutritional value, is not reflected in purchases.[249] This aspect is often overlooked in studies, further complicating the understanding of online grocery shopping's impact on diet

quality. By directly measuring diet quality, our data provides a more accurate understanding of the impact of online grocery shopping on diet quality. Secondly, the only study we identified that directly measured diet quality classified participants as “online” or “in-store” shoppers based on whether they had ever used online grocery shopping.[29] In contrast, our study considers the frequency of online grocery shopping, providing a more nuanced categorization into low-, moderate-, and high-usage groups. This approach offers insight into a potential dose-response relationship, highlighting the varying impacts of online grocery shopping frequency on diet quality.

7.3 Areas for Future Research

While our study found no association between grocery shopping modality and diet quality, online grocery shopping may offer advantages beyond the scope of our study.

Online grocery platforms could potentially benefit those who, for various reasons, find it challenging to access healthier food options. In Canada, the aging population faces numerous obstacles, such as declining mobility, lack of transportation, and increased social isolation. These factors can severely limit seniors’ ability to perform everyday tasks, including visiting grocery stores.[250] E-commerce could serve as a promising tool in preserving this demographic's independence and nutritional health.[251] By facilitating access to online grocery shopping and delivery services, seniors can obtain their dietary essentials more easily. Supporting this notion, research from Montreal, Québec, suggests that decreased physical mobility in older adults is a strong motivating factor for the adoption of online grocery services, and these platforms have been touted as potentially effective means to enhance access to nutritious foods among older adults.[212] A pilot program from New Jersey, USA that introduced seniors to an online grocery platform found that participants expressed a positive opinion on the initiative and noted an

increased availability of healthier food choices and a decreased reliance on transportation for their grocery needs.[252]

Online grocery shopping could also positively influence other health-related aspects, such as stress reduction. Chronic stress, much like suboptimal diet quality, is a risk factor for numerous prevalent NCDs, including coronary artery disease, diabetes, and various psychiatric disorders.[253] Studies conducted by Jilcott Pitts et al. and Trude et al. revealed that among their participants, one of the most frequently cited benefits of online grocery shopping was a perceived reduction in stress.[165, 173]

Another possible area for future research is tailored nutritional interventions via online grocery platforms. Exploring the effects of personalized recommendations or dietary guidance could uncover effective strategies for enhancing diet quality among online shoppers. These interventions could be uniquely designed to address specific nutrient deficiencies, improve consumption of particular food groups, or specific health conditions, such as type 2 diabetes or heart disease.[254, 255]

Finally, online grocery shopping may also positively affect meal planning behaviours. A pilot study associated with the University of Kentucky found that online shoppers exposed to healthy eating nudges significantly improved meal planning and healthier food purchases.[256]

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Tables and Figures

Table 1. Sample characteristics of Canadian grocery shoppers (n = 872).

Characteristic	No Usage	Low Usage	Moderate Usage	High Usage	Total	p-value[a]
N =	437 (50.1%)	126 (14.4%)	206 (23.6%)	103 (11.8%)	872 (100.0%)	
Sex						.15
Female	338 (77.3%)	107 (84.9%)	171 (83.0%)	80 (77.7%)	696 (79.8%)	
Male	99 (22.7%)	19 (15.1%)	35 (17.0%)	23 (22.3%)	176 (20.2%)	
Age *	48.1 (17.0)	47.4 (16.7)	44.8 (14.8)	41.6 (12.9)	46.5 (16.2)	<.001
BMI *	27.1 (5.83)	28.4 (6.27)	27.7 (6.40)	26.0 (6.20)	27.3 (6.10)	.02
Racial person [b]						.75
Non-racialized person	354 (81.0%)	103 (81.7%)	164 (79.6%)	79 (76.7%)	700 (80.3%)	
Racialized person or prefer not to say	83 (19.0%)	23 (18.3%)	42 (20.4%)	24 (23.3%)	172 (19.7%)	
Marital status [b]						.30
Married or common-law	249 (57.0%)	76 (60.3%)	128 (62.1%)	71 (68.9%)	524 (60.1%)	
Single	133 (30.4%)	39 (31.0%)	58 (28.2%)	21 (20.4%)	251 (28.8%)	
Divorced, widowed, or separated	55 (12.6%)	11 (8.7%)	20 (9.7%)	11 (10.7%)	97 (11.1%)	
Employment status [b]						<.001
Employed	233 (53.3%)	63 (50.0%)	127 (61.7%)	73 (70.9%)	496 (56.9%)	
Unemployed	104 (23.8%)	31 (24.6%)	50 (24.3%)	10 (9.7%)	195 (22.4%)	
Full-time parent or caregiver	19 (4.30%)	8 (6.3%)	7 (3.4%)	9 (8.7%)	43 (4.9%)	
Other	81 (18.5%)	24 (19.0%)	22 (10.7%)	11 (10.7%)	138 (15.8%)	
Educational attainment [b]						.02
University Degree	209 (47.8%)	64 (50.8%)	111 (53.9%)	66 (64.1%)	450 (51.6%)	
High school or less	93 (21.3%)	28 (22.2%)	28 (13.6%)	12 (11.7%)	161 (18.5%)	
College, trade school, other	135 (30.9%)	34 (27.0%)	67 (32.5%)	25 (24.3%)	261 (29.9%)	
Yearly household income [b]						.05
Lower-income	121 (27.7%)	30 (23.8%)	62 (30.1%)	18 (17.5%)	231 (26.5%)	
Middle-income	144 (33.0%)	43 (34.1%)	63 (30.6%)	37 (35.9%)	287 (32.9%)	
Higher-income	108 (24.7%)	28 (22.2%)	55 (26.7%)	39 (37.9%)	230 (26.4%)	
Prefer not to say	64 (14.6%)	25 (19.8%)	26 (12.6%)	9 (8.7%)	124 (14.2%)	
Household size						<.001
One person	84 (19.2%)	26 (20.6%)	47 (22.8%)	8 (7.8%)	165 (18.9%)	
Two people	197 (45.1%)	52 (41.3%)	72 (35.0%)	26 (25.2%)	347 (39.8%)	
Three people	71 (16.2%)	21 (16.7%)	33 (16.0%)	25 (24.3%)	150 (17.2%)	
Four people	50 (11.4%)	17 (13.5%)	36 (17.5%)	28 (27.2%)	131 (15.0%)	
Five or more people	35 (8.00%)	10 (7.9%)	18 (8.7%)	16 (15.5%)	79 (9.1%)	
Household minors [b]						<.001
Zero minors	352 (80.5%)	97 (77.0%)	152 (73.8%)	44 (42.7%)	645 (74.0%)	
One minor	42 (9.6%)	13 (10.3%)	25 (12.1%)	28 (27.2%)	108 (12.4%)	
Two or more minors	43 (9.8%)	16 (12.7%)	29 (14.1%)	31 (30.1%)	119 (13.6%)	
HEI Score*	66.1 (10.9)	66.6 (9.91)	65.8 (9.96)	64.3 (10.9)	65.9 (10.5)	.37

** Mean (Standard deviation). Sample size and percentage (%) of survey participants, split by online grocery shopping usage categories. [a] p-values represent the significance (p< .05) of chi-square tests for categorical variables and one-way ANOVA comparing only grocery shopping usage across sociodemographic variables. [b] Certain categorical variables were grouped due to small cell size (n< 5) to avoid violating the assumptions of the Chi-square test (see methods section for details).*

Table 2. Regression Analysis of Diet Quality Among Online and In-store Grocery Shoppers (n = 872).

	No usage	Low usage		Moderate usage		High usage	
		ß (SE)	*P*	ß (SE)	*P*	ß (SE)	*P*
Model 1	ref	0.46 (1.07)	.66	-0.32 (0.89)	.82	-1.83 (1.15)	.11
Model 2	ref	0.30 (1.03)	.77	-0.46 (0.87)	.60	-1.36 (1.16)	.24
Model 3	ref	0.64 (1.03)	.63	-0.24 (0.86)	.78	-1.56 (1.15)	.18

ß, Beta coefficient. SE, Standard error. P, p-value. Model 1: crude model (HEI score and online grocery shopping usage). Model 2: Model 1 with the addition of sex, age, number of minors, yearly household income, and educational attainment. Model 3: Model 2 with the addition of BMI. A p-value of < .05 was considered significant.

Table 3. Regression Analysis of Diet Quality Among Online and In-store Grocery Shoppers Stratified by Sex (n = 872).

	No usage	Low usage		Moderate usage		High usage	
Males		ß (SE)	*P*	ß (SE)	*P*	ß (SE)	*P*
Model 1	ref	0.99 (2.87)	.66	-1.84 (2.25)	.72	-0.95 (2.65)	.11
Model 2	ref	0.97 (2.86)	.73	-2.33 (2.31)	.32	1.79 (2.92)	.54
Model 3	ref	1.53 (2.87)	.59	-1.75 (2.33)	.45	1.56 (2.90)	.59
Females							
Model 1	ref	0.06 (1.13)	.96	-0.24 (0.96)	.80	-2.10 (1.27)	.10
Model 2	ref	0.29 (1.10)	.79	-0.10 (0.93)	.91	-2.02 (1.28)	.12
Model 3	ref	0.56 (1.10)	.61	0.05 (0.93)	.96	-2.21 (1.27)	.08

ß, Beta coefficient. SE, Standard error. P, p-value. Model 1: crude model (HEI score and online grocery shopping usage). Model 2: Model 1 with the addition of age, the number of minors, yearly household income, and educational attainment. Model 3: Model 2 with the addition of BMI.

Table 4. Regression Analysis of Diet Quality Among Online and In-store Grocery Shoppers Stratified by the Number of Minors in the Household (n = 872).

	No usage	Low usage		Moderate usage		High usage	
Zero minors		ß (SE)	*P*	ß (SE)	*P*	ß (SE)	*P*
Model 1	ref	0.76 (1.22)	.53	-0.31 (1.03)	.76	1.10 (1.70)	.52
Model 2	ref	0.65 (1.19)	.58	-0.52 (1.01)	.61	0.41 (1.66)	.81
Model 3	ref	0.92 (1.18)	.43	-0.28 (1.00)	.78	0.60 (1.64)	.72
One minor		ß (SE)	*P*	ß (SE)	*P*	ß (SE)	*P*
Model 1	ref	4.08 (2.92)	.17	0.70 (2.33)	.77	0.15 (2.25)	.95
Model 2	ref	4.40 (2.98)	.14	0.63 (2.28)	.78	2.24 (2.31)	.34
Model 3	ref	4.51 (2.99)	.14	0.58 (2.38)	.80	1.93 (2.36)	.42
Two or more minors [a]		ß (SE)	*P*	ß (SE)	*P*	ß (SE)	*P*
Model 1	ref	-4.10 (3.10)	.19	-0.52 (2.55)	.84	-5.51 (2.50)	.03
Model 2	ref	-5.45 (3.07)	.08	-1.29 (2.49)	.61	-7.09 (2.49)	.005
Model 3	ref	-4.29 (3.11)	.17	-0.57 (2.50)	.82	-7.52 (2.44)	.003

ß, Beta coefficient. SE, Standard error. P, p-value. Model 1: crude model (HEI score and online grocery shopping usage). Model 2: Model 1 with the addition of sex, age, yearly household income, and educational attainment. Model 3: Model 2 with the addition of BMI.

[a] To maintain statistical power, 'Two,' 'Three,' 'Four,' and 'Five or more minors' were grouped due to small cell sizes (n<5). The categories above exhibited similar behaviours regarding trends in HEI scores.

Table 5. Regression Analysis of Diet Quality Among Online and In-store Grocery Shoppers Stratified by Educational Attainment (n = 872).

	No usage	Low usage		Moderate usage		High usage	
High school or less		ß (SE)	*P*	ß (SE)	*P*	ß (SE)	*P*
Model 1	ref	-0.09 (2.26)	.97	2.45 (2.26)	.28	0.57 (3.21)	.86
Model 2	ref	-0.59 (2.27)	.80	1.33 (2.30)	.56	1.10 (3.35)	.56
Model 3	ref	0.43 (2.26)	.85	1.10 (2.26)	.63	1.77 (3.30)	.59
College, trade school, or other		ß (SE)	*P*	ß (SE)	*P*	ß (SE)	*P*
Model 1	ref	0.56 (2.04)	.79	-1.43 (1.59)	.37	-2.62 (2.31)	.26
Model 2	ref	-0.13 (2.06)	.95	-1.13 (1.62)	.49	-2.34 (2.37)	.32
Model 3	ref	0.09 (2.03)	.96	-0.91 (1.60)	.57	-2.31 (2.34)	.33
University degree		ß (SE)	*P*	ß (SE)	*P*	ß (SE)	*P*
Model 1	ref	0.51 (1.47)	.73	-0.98 (1.20)	.41	-3.07 (1.44)	.04
Model 2	ref	1.15 (1.42)	.42	-0.34 (1.17)	.77	-1.06 (1.47)	.47
Model 3	ref	1.36 (1.42)	.34	-0.08 (1.17)	.95	-1.40 (1.47)	.34

ß, Beta coefficient. SE, Standard error. P, p-value. Model 1: crude model (HEI score and online grocery shopping usage). Model 2: Model 1 with the addition of sex, age, yearly household income, and number of minors. Model 3: Model 2 with the addition of BMI.

Table 6. Regression Analysis of Diet Quality Among Online and In-store Grocery Shoppers Stratified by Yearly Household Income Bracket (n = 872).

	No usage	Low usage		Moderate usage		High usage	
Low income		ß (SE)	*P*	ß (SE)	*P*	ß (SE)	*P*
Model 1	ref	0.70 (2.13)	.74	-1.45 (1.63)	.37	-0.20 (2.64)	.94
Model 2	ref	1.07 (2.12)	.62	-1.16 (1.65)	.48	-0.19 (2.72)	.95
Model 3	ref	0.99 (2.11)	.64	-1.02 (1.64)	.53	-0.13 (2.70)	.96
Middle income							
Model 1	ref	1.25 (1.88)	.66	0.37 (1.64)	.82	-4.06 (2.00)	.04
Model 2	ref	0.73 (1.88)	.70	-0.32 (1.63)	.84	-2.60 (2.08)	.21
Model 3	ref	1.62 (1.88)	.39	0.44 (1.62)	.79	-2.42 (2.06)	.24
High income							
Model 1	ref	-1.40 (2.09)	.50	-0.38 (1.63)	.81	-1.72 (1.84)	.35
Model 2	ref	-0.80 (2.03)	.70	0.07 (1.58)	.97	-0.76 (1.58)	.68
Model 3	ref	-0.54 (2.01)	.79	-0.03 (1.56)	.99	-1.58 (1.87)	.40
Prefer not to say							
Model 1	ref	1.36 (2.61)	.60	0.41 (2.57)	.87	-1.46 (3.94)	.71
Model 2	ref	0.68 (2.60)	.80	0.24 (2.51)	.93	-1.54 (3.85)	.69
Model 3	ref	0.89 (2.60)	.73	0.53 (2.52)	.83	-1.22 (3.85)	.75

ß, Beta coefficient. SE, Standard error. P, p-value. Model 1: crude model (HEI score and online grocery shopping usage). Model 2: Model 1 with the addition of sex, age, number of minors, and educational attainment. Model 3: Model 2 with the addition of BMI. A p-value of < .05 was considered significant.

To maintain statistical power due to small cell sizes (n<5), income categories were reclassified into "lower income," "middle income," and "high income." The categories '$0-24,999' and '$25,000-49,999' were combined to form lower income; '$50,000-74,999' and '$75,000-99,999' were combined to form middle income; and '$100,000-124,999' and '$125,000 or more' were combined to form high income. This reclassification was necessary as smaller groups had small cell sizes, compromising statistical power. Lower, middle, and high-income brackets are commonly used for their natural segmentation and exhibit similar behaviours in HEI score trends within our study sample.