We are not all the same: Differentials in Diet Quality and Food Consumption across Canadian Immigrant and Domestic Resident Population

by

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Abstract

Background: The association between diet and immigration is multidimensional; in addition, it varies considerably, depending on the nutrient or food component in question and more importantly, the ethnicities of immigrants to Canada. Current literature identifies dietary patterns in the general Canadian population, yet little is known about dietary heterogeneity among the adult immigrant population. Since the burden of chronic, non-communicable diseases (NCDs) falls disproportionately on immigrants and ethnic minorities, examining the dietary patterns of these populations may offer a framework for health promotion among Canada's most vulnerable groups.

Purpose: This research investigated the association of immigration status and length of residence in Canada with dietary patterns among Canadian adults.

Methods: Data from the 2015 Canadian Community Health Survey (CCHS) Nutrition was used. A Canadian adaptation of Healthy Eating Index (C-HEI) 2015 based on the 2007 Canada's Food Guide (CFG) was used as an indicator of diet quality and adherence to dietary recommendations. Descriptive analyses examined C-HEI mean scores for demographic characteristics by immigration status and length of residence. The association of immigration status and length of residence in Canada with dietary patterns were examined using logistic regression models. The odds of good diet quality and odds of adherence to recommended guidelines for adequacy components (vegetables and fruit, whole fruit, greens and beans, whole grains, dairy, total protein foods, seafood and plant proteins, and fatty acids) and moderation components (refined grains, sodium, added sugars, and saturated fats) were generated from the models, adjusted for covariates of interest in the study.

Results: For the population aged 20 to 79, the average C-HEI 2015 score was 62.99 out of a possible 100 points. We observed heterogeneity in diet quality and food consumption across

immigrants and domestic residents of Canada. Immigrants had significantly higher C-HEI scores compared with Canadian-born (65.06[0.25], 62.19[0.12]; $p<0.001$) and more favourable intakes for many of the score components. Immigrants showed a greater likelihood of achieving a good diet and adherence to recommendations for vegetables and fruit, whole fruit, whole grains, seafood and plant proteins, dairy products, refined grains, sodium, added sugars, and saturated fats. Even so, consumption of greens and beans was low in the immigrant diet. Among immigrant groups, our results suggest that ethnic visible minorities, namely Black, East/Southeast Asian, West Asian/Arab, South Asian, Latin American, and Other have a nutritional health advantage over not only White but their Canadian-born counterparts. Among domestic residents, however, White had a health advantage over most Canadian-born visible minorities. Length of residence strongly affected dietary habits, with both negative and positive effects observed. The main trend after a longer stay in Canada was a substantial increase in the likelihood of fulfilling recommendations for greens and beans, seafood and plant proteins, refined grains and added sugars. On the other hand, we observed a decrease in consumption of dairy, total protein foods, and fatty acids as well as an increasing trend in consumption of saturated fats after a longer stay in Canada. For immigrant men, we observed an acculturation-driven trend in their consumption of vegetables and fruit and refined grains. For immigrant women, our findings suggested an acculturation-driven trend in their consumption of seafood and plant protein, refined grains, and added sugars. Our results also showed that immigrant women are more likely to be rewarded with a good overall diet quality as the length of residence increases. Irrespective of the length of residence, Black, East/Southeast Asian, West Asian/Arab, South Asian, and those identified as Other were more likely to have a good diet quality compared with White immigrant.

Conclusions: The findings of this study postulate heterogeneous nutritional health advantages among Canada's population, as well as an overall “healthy immigrant effect” that is maintained through dietary habits with length of residence in Canada. The results challenge research that portrays immigrants as one broad category when investigating the “healthy immigrant effect” in relation to dietary acculturation. This approach not only undermines the heterogeneity in dietary patterns but also underscores immigrants’ abilities to maintain healthy eating patterns, especially among adult immigrants, with a longer residence in Canada. Results further justify a need for tailoring educational interventions to specific ethnic and racial groups, and adaptation to CFG that is more inclusive.

Preface

This thesis is an original work produced by Adelaide Buadu. No part of this thesis has been previously published. The research project, of which this this is a part, received research ethics approval from the Human Research Ethics Board (REB) of the University of Alberta under the project name “Dietary Patterns of Canadian Ethnic Populations and Associated Risk for Chronic Diseases” No. Pro00102771.

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List of Abbreviations

AMPM	Automated multi-pass method
CCHS	Canadian Community Health Survey
CFG	Canada's Food Guide
C-HEI	Canadian adaptation of Healthy Eating Index
CNF	Canadian Nutrient File
GBD	Global burden of disease report
HEI	Healthy Eating Index
NCDs	Non-communicable diseases
NCI	National Cancer Institute
PHAC	Public Health Agency of Canada
RDC	Research Data Centre
DQI	Diet Quality Index

Chapter 1

Introduction

1.1 Background

Canada's population growth is maintained mostly (82.2%) through immigration (Statistics Canada, 2019a), yet the health of immigrants has not received nearly the attention it deserves in the country. Some research propounds immigrants to Canada tend to be healthier than the host population because of the country's rigorous selection process which favours skilled and healthy immigrants hence the term "healthy immigrant effect" (Statistics Canada, 2019b). In support of this phenomenon, Pérez (2002) posits that compared to non-immigrants, recent immigrants have lower odds of reporting chronic conditions. Immigrants, however, experience deterioration of health and their odds for reporting any chronic condition increase with length of residence in Canada (Pérez, 2002). Some researchers speculate that changes in nutrition and lifestyle patterns illuminate why the risk for chronic conditions tends to be higher for immigrants compared to the Canadian-born population (Satia-Abouta et al., 2002). Thus, there is a loss of the "healthy immigrant effect" through the process of dietary acculturation. It is believed that the observed increase in body mass index (BMI), for instance, might be due to transitions away from cultural eating and lifestyle habits to a more western dietary and sedentary lifestyle during the process of acculturation (Pérez, 2002; Satia-Abouta et al., 2002; Tremblay et al., 2005). Moreover, available data alludes to the possibility of dietary acculturation leading to higher intakes of sodium, fat (Sanou et al., 2014), convenience foods, sugar-sweetened beverages, red meat (Lesser et al., 2014), alcohol consumption, smoking and consuming energy dense diets (Abraído-Lanza et al., 2005).

Notwithstanding the evidence, beneficial nutrition outcomes such as the lessening of nutritional deficiencies in calcium, iron and vitamin D have been noted as effects of dietary

acculturation (Sanou et al., 2014). There is also evidence of increased consumption of vegetables and fruit as well as adopting healthy methods in food preparation with length of residence in Canada (Lesser et al., 2014). Given the significant role of nutrition in many cultures as well as its importance for health, there is a need to understand the nutrition transitions within immigrant groups to guide policies and programs for immigrant-specific interventions to promote healthy eating and prevent nutrition-related chronic conditions.

1.2 Study Rationale

Most previous research finds that diet, and indeed many other health practices, deteriorates with increasing time spend in Canada due to acculturation, hence confirming the "healthy immigrant effect" (Beiser, 2005; Hyman, 2007; Hyman & Jackson, 2010; McDonald & Kennedy, 2004; Sanou et al, 2014). Such findings tend to be interpreted through a homogenous perspective that portrays immigrants as one broad category and draw conclusions on dietary acculturation based on a handful of nutrients or foods. Interestingly, research on nutrition- related chronic diseases offer intriguing insights into heterogeneity within immigrant groups (Anand et al., 2000; Liu et al, 2010; Tremblay et al., 2005). To illustrate, Tremblay and colleagues (2005) reported significant differences across ethnic groups as it pertains to the prevalent rate of overweight and obesity among adults. Tremblay et al (2005) confirm that ethnic differences in overweight and obesity remained even after adjusting for the effects of age, education, household income and physical activity. The study was based on data from the 2000/01 and 2003 CCHS. Likewise, in studies that looked at the correlation of income with both hypertension and diabetes in Canada, even though they noted an association between these variables, income, however, does not seem to explain the differences in these outcomes that were revealed between Blacks and Whites (Gagné

& Veenstra, 2017; Veenstra & Patterson, 2016). As demonstrated, studies in this area of research, although they draw conclusions on minorities or immigrants as a whole, they also offer evidence that shows heterogeneity in health outcomes within this population. By drawing on ideas about how ethnicity appears to be a very important determinant factor as it relates to nutrition-related chronic diseases, we could assume the existence of ethnic differentiation of dietary acculturation and immigrants' nutritional health advantage. Yet, a major limitation of Canadian-based research in the field of public health nutrition is the lack of consideration with regard to heterogeneity within the immigrant population, particularly accounting for ethnic origins (Davison and Gondara, 2019; Hosseini et al., 2021; Nardocci, Leclerc et al., 2019; Pilli and Slater; 2021; Pomerleau et al., 1997). The paucity of research that account for ethnic origin typically do not consider more than one ethnic group (Abou El Hassan & Hekmat, 2012; Delisle, 2010; Kandola et al., 2016; Kwok et al., 2009; Lesser et al., 2014; Rosenmöller et al., 2011; Satia et al., 2001a; Satia et al., 2001b; Subhan & Chan, 2019; Varghese & Moore-Orr, 2002). According to Satia (2010), the process of dietary acculturation, for instance, could be different for each individual, culture or ethnicity. Therefore, the lack of consideration with regard to heterogeneity within the immigrant population in research may prevent us from understanding the true impact of important concepts such as acculturation on immigrants' health.

Furthermore, as opposed to usual intake, studies on nutritional health of immigrants tend to focus typically on daily intakes of nutrients or foods, from which they draw conclusions about dietary habits and acculturation-driven practices (Johnson & Garcia, 2003; Kandola et al., 2016; Kwok et al., 2009; Lesser et al., 2014; Varghese & Moore-Orr, 2002). This approach has limitations considering that 1) dietary guidelines are meant to be met over time and the hypotheses that govern diet-health relationships are based on dietary intakes over the long term (Dodd et al.,

2006; Freedman et al, 2004; Kipnis et al., 2009) 2) dietary acculturation is a time variable and consequently, daily intake is not an adequate representation of an individual's long-term average daily intake.

With the help of Canada's Food Guide (CFG) and the Healthy Eating Index (HEI), current literature identifies dietary patterns based on a comprehensive list of foods or nutrients in the general Canadian population (Garriguet, 2009; Jessri et al., 2017), thus providing us with an understanding on the extent to which Canadians are "eating well with Canada's Food Guide".
Yet this approach of assessing dietary patterns has not been extended towards Canadian-based research on adult immigrants, especially when exploring the association between diet and immigration status and/or length of residence. HEI has both validity and reliability (Garriguet, 2009; Guenther et al., 2014; Guenther et al, 2008; Jessri et al., 2017; Reedy et al., 2018) and as such should be considered when documenting the dietary habits of immigrants and acculturation-driven practices. Since CFG is considered a prominent health promotion tool, this approach could offer insight into its relevancy to Canada's ethnic population.

Dietary intakes and to some extent, dietary acculturation have been reported for South Asians (Kandola et al., 2016; Lesser et al., 2014; Subhan & Chan, 2019; Varghese & Moore-Orr, 2002), Chinese (Kwok et al., 2009; Rosenmöller et al., 2011; Satia et al., 2001a; Satia et al., 2001b), Arab (Abou El Hassan & Hekmat, 2012), African origin (Delisle, 2010), and Haitians (Désilets et al., 2007), howbeit, their findings were not based on national data. Johnson and Garcia (2003), although they reported on the dietary habits for more than one ethnic group, namely Cambodian, Latin-American, Vietnamese and Polish groups, they sampled only 54 participants between the ages of 59 to 81 from London, Ontario. Likewise, Pomerleau, Ostbye, and Bright-See (1998) considered substantial number of immigrants from Europe, Asia, the Caribbean, South

America, and Africa, however, they used data from the Ontario Health Survey for their analysis of micronutrients, which makes the generalizability of their findings to other provinces difficult. None of these studies based their evidence on usual intakes nor used the Healthy Eating Index (HEI) in their analysis.

Most of Canadian literature that deduce their findings from usual intakes or HEI and are based on nationally representative data, do not typically account for immigration status and/or length of residence in Canada or provide analysis of dietary patterns by immigration status and/or length of residence (Garriguet, 2009; Glanville & McIntyre, 2006; Jessri et al., 2017). Davison and Gondara (2019), although considered immigration in their study, they did not account for ethnic differentials. Therefore, at the national level, there is a lack of substantial work that dwells on dietary heterogeneity among the immigrant population in Canada. My thesis would advance beyond prior work by examining diet quality through the analysis of a comprehensive list of food components and its association with immigration status and length of residence, whiles considering ethnic differentials in diet quality.

My work would also bring forth an important conversation on whether our interpretation around the nutritional health of Canadian immigrants through the lens of the negative acculturation perspective, should be reconsidered. The whole notion of the “healthy immigrant effect” in a way has motivated a stream of research as well as narrowed consumers lens towards this perspective. Omariba and peers (2014) provided notable findings which affirms that immigrants' health advantage does not always worsen with the length of residence but rather they maintain better health than the host population as their length of residence increases. Granted, dietary habits are influenced by a great number of factors, the question remains whether Canadian adult immigrants experience a complete loss of “healthy immigrant effect” through the process of dietary

acculturation or whether there is heterogeneity of immigrants' nutritional health advantage when we refrain from a single broad categorization of immigrant population.

In light of the above arguments, the purpose of my thesis research is to provide a better understanding of the role of diet to immigrant differentials in health advantages. Given that Canada has a diverse population, understanding of dietary habits of distinct categories of immigration status is a vital measure in recognizing health disparities. Healthy dietary behaviours are linked with reduced risk of non-communicable diseases (Madden et al., 2008; Mann, 2002; Wiseman, 2008); hence, any observed behaviour could suggest policy and action required at the group and population levels.

There is currently a window of opportunity for this work. The work is timely in that with the current government immigration policy, Canada is expected to receive more than a million new immigrants by this year with new permanent residents accounting for one per cent of the total population (Levitz, 2020). To my knowledge, this will be the first to examine, in dept, dietary patterns of the Canadian adult population by broad categories of immigration status and length of residence, applying the NCI method using national health data and a Canadian adaptation of the Healthy Eating Index (HEI) 2015. The results are expected to aid public health policymakers in forming appropriate dietary strategies that would contribute to a better standard of living for immigrants as well as encourage research in the field of public health nutrition and ethno-epidemiology.

1.3 Objectives

The objective of this thesis is to compare across immigrant groups and residents of Canada, the difference in the distribution of diet quality as well as the consumption of 12 food components to

better our understanding of immigrant health. Specifically, my thesis research questions are formulated as follows: 1A) What are the dietary differences across immigrants and domestic residents of Canada? 1B) How does diet quality change in years since time of immigration?

1.4 Structure of the Thesis

This monograph thesis is divided into four chapters. The first chapter is an introduction which included the general background of the study, the rationale for undertaking this research, as well as the objectives and research questions. Chapter two reviews the literature on nutrition and presents the study design and methodological aspects of the data used in this study. Chapter three presents the results of the study which includes findings from descriptive statistics and logistic regression models. In the fourth and final chapter, the findings of the study are discussed as it pertains to the research questions. I explore some of the strengths and limitations of the study as well as the implications of the findings for public health efforts. The chapter concludes with a summary of the study and make recommendations for future research.

1.5 Statement of Contributions

As the lead author of these four chapters, I was responsible for detailing the research objectives, writing the research proposal, and planning the analytical approach to address each of the research objectives. I was responsible for all the statistical analysis performed in this study, reviewing, and summarizing the literature, and finally writing this thesis. My supervisors provided guidance during each step of the conceptualisation and conduct of the research.

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Chapter 2

Literature Review and Methodology

2.1 Review of the literature on dietary behaviour

2.1.1 Introduction

There are ample ways of assessing the health of a population, however, nutrition offers an unmatched perspective as it is proven to be the modifiable risk factor with the largest burden (Loewen et al., 2018). Lately, dietary pattern analysis has gained support in nutritional epidemiology, as dietary patterns provide a comprehensive representation of the complexity of dietary intake at the population level (Cespedes & Hu, 2015; Ertuglu et al., 2022; Hu, 2002; Jacobs et al., 2011; Tapsell et al., 2016). Since diet is linked with multiple health outcomes, understanding the dietary habits of Canada's populations provide a meaningful framework for reducing the burden of diet-induced chronic diseases. To explore the relationship between diet quality and immigration status along with length of residence, this chapter begins with a brief discussion of the role of nutrition in chronic disease etiology, followed by a discussion of the dietary habits of the general Canadian population. The chapter also draws attention to dietary practices of the immigrant population. Then, it concludes by presenting the empirical methods used for the study.

2.1.2 The importance of nutrition on health

It is well established that the most prevalent chronic health conditions today are due to associations among modifiable risk factors namely physical inactivity, tobacco use, excess alcohol consumption, and unhealthy diet (Bélanger et al., 2014; Mozaffarian et al., 2012; Public Health Agency of Canada [PHAC], 2017). In fact, the Global Burden of Disease study has labelled an unhealthy diet as the leading risk factor for disease, disability and death in Canada and across the

globe for more than two decades (GBD 2017 Diet Collaborators, 2019). Existing literature has also established an association between poor dietary habits and high incidence and prevalence of chronic diseases including cardiovascular disease (Mann, 2002), certain types of cancer (Wiseman et al., 2007), and type 2 diabetes (Madden et al., 2008; Mann, 2002). Madden and colleagues, in their integrative literature review of lifestyle interventions for the prevention of type II diabetes mellitus, found that diet in conjunction with exercise is the most efficacious method for diabetes prevention (Madden et al., 2008). Correspondingly, Mann (2002), in their review, posited that the key to diminishing the epidemic numbers of people with type 2 diabetes and CHD is to limit the intake of saturated fatty acids in conjunction with making lifestyle modifications aimed at lowering the risk of obesity.

Other studies including a prospective cohort study of 44,875 men aged 40 to 75 years in the USA have demonstrated that dietary patterns predict the risk of CHD irrespective of other lifestyle factors (Hu et al., 2000). This perspective is consistent with the findings from another prospective study of 72,113 women aged 30 to 55 years in the US which revealed that greater adherence to the prudent pattern (characterized by higher intake of vegetables, fruit, legumes, whole grains, fish, and poultry), may lower one's risk of cardiovascular and total mortality, whereas greater adherence to the Western pattern (characterized by higher intake of red meat, processed meat, refined grains, sweets and dessert, French fries, and high-fat dairy products) may elevate the risk among initially healthy women (Heidemann et al., 2008). According to the Tracking Nutrition Trends (TNT) survey, in 2018, “6 out of 10 adult Canadians use food and diet to manage health conditions”, thus reiterating the role and importance of nutrition for Canadian adults (Nutrition Solutions, 2020).

2.1.3 Dietary habits of Canada's population

Are Canadians eating healthy? According to the TNT survey, in 2018, 8 out of 10 Canadians rated their eating habits as good to excellent (43% good, 28% very good, 8% excellent). When asked if participants "made any changes over the past year to (improve or) change your eating habits?", 58% of Canadians said they had made changes to their eating habits in the past year. The most reported changes were consumption of more fruit and vegetables, fibre, and protein, as well as reducing sugar, salt/sodium, and fatty foods intakes (Nutrition Solutions, 2020).

Unfortunately, when we examine the evidence, a nationally representative data indicates that the typical diet consumed by most Canadians is characterized by high intakes of saturated fat, trans fats, free sugars, and salt (Moubarac et al., 2013). In other words, an alarming number of the population do not achieve the recommended ranges of servings for most food groups on CFG that are meant to be consumed in large quantities, but rather Canadians exceed the recommended limits for food meant to be eaten in moderation (Garriguet, 2007). A report from the 2004 CCHS Nutrition survey reviewed that among adults, more than 25% of men and women derived more than 35% of their calories from fat. Similarly, almost a quarter of Canadians' calories came from other foods", yet CFG recommends a moderation intake of such foods (Garriguet, 2007). In line with these findings, the most recent CCHS Nutrition survey revealed that Canadian adults derived almost half of their total daily calories (energy intake) from ultra-processed foods and drinks (Nardocci, Polsky et al., 2019). There is evidence that higher consumption of fruit and vegetables reduces the likelihood of mortality from all causes. Notably, there was a reduction in the risk of mortality by 5% for each additional serving a day of fruit and vegetables, by 6% for fruit consumption, and by 5% for vegetable consumption (Wang et al., 2014). Yet, a preponderance of Canadians does not consume the recommended daily minimum of five servings of vegetables and

fruit (Garriguet, 2007; Jessri et al., 2017; Polsky & Garriguet, 2020; PHAC, 2017). In fact, there was a significant decrease in reported daily consumption of fruit and vegetables between 2007 and 2014 (Garriguet, 2007; PHAC, 2017). When we consider sodium intake, however, Canadian adults tend to exceed the recommended amount of 2300 mg per day, putting them at greater risk of high blood pressure, heart disease and stroke (desLibris, 2017). In sum, overall compliance to CFG recommendations is low, hence the observed low diet quality among the adult population (Bélanger et al., 2014; Jessri et al., 2017; Nshimyumukiza et al., 2018).

2.1.4 Dietary profile of Canadian immigrant population

Although my thesis is not solely based on dietary acculturation, that is not to simply compare immigrants to domestic residents, in reviewing the literature on the dietary profile of Canadian immigrants, since current literature on immigrant diet in Canada is heavily based on dietary acculturation, my review would draw heavily from this perspective. Moreover, due to the lack of previous research on immigrant consumption and adherence to Canadian adaptation of HEI, it is difficult to base this review on this standpoint. Having said that, the review presented below should provide a snapshot of the influence of immigration on dietary patterns and practices.

Acculturation is the process by which the minority group adopts the patterns of a dominant/host group. Dietary acculturation, then, refers to the process when the minority group adopt the eating patterns and food choices of their host country (Satia-Abouta et al, 2002). This process, however, does not imply linearity whereby there is a complete adaptation of dietary patterns of the host population. Although this form of adaptation could occur, there is an alternative school of thought that suggests that individuals retain some values while also adopting new ones (Pérez-Escamilla & Putnik, 2007; Ryder et al, 2000). Therefore, there is an integration of diet from

both cultures. Upon review of the literature, although findings were not based on national data, it seems that in Canada, acculturation has resulted in a diet that is characterized by a shift towards increased fat intake, and sodium intake (Lear et al., 2009; Newbold, 2009), energy-dense diets (Satia, 2010), consumption of convenience foods (Laroche et al., 2005), fewer protein intakes, and other deficiencies in vital micronutrients (Bojorquez et al., 2014; Pomerleau et al., 1998). This "western" diet, as it has been termed, has been associated with the surge in obesity and other dietary-related chronic conditions (Kopp, 2019; McDonald & Kennedy, 2005; Pomerleau et al., 1998; Popkin, 2006; Satia, 2010).

The negative acculturation perspective, to some degree, assumes that traditional foods are healthier than "Canadian" foods. Thus, from this perspective, we could deduce that the impact on health due to acculturation is dependent on the extent to which one maintains their previous beliefs or identity or adopts that of their host country (Pérez-Escamilla & Putnik, 2007; Ryder et al., 2000). Immigrants have also been influenced by this perspective as studies suggest that some immigrants to Canada try to maintain their traditional diet as they believe it to be healthier than the Canadian diet (Delisle, 2010; Désilets et al., 2007; Laroche et al., 2005). Contradictorily, in Johnson and Garcia's (2003) cross-sectional study of a convenience sample of older adults, they found that maintaining traditional foods and eating patterns increases some immigrants' risk of sodium intake, alarmingly, as high as 238–474 % of the daily recommended intake. Nevertheless, the influence of the homeland is inevitable and as such some degree of integration is bound to occur (Delisle, 2010; Laroche et al., 2005; Pillarella et al., 2007; Sanou et al., 2014). Dietary acculturation for Canadian immigrants is influenced by multiple factors which impact the degree to which traditional diets are maintained. Studies have reported SES-related factors including education and poverty, access, preference in taste, and other immigration-related stress as influencing the

transition from traditional to Western diet (Delisle, 2010; Désilets et al., 2007; Kwok et al., 2009; Laroche et al., 2005; Patterson et al., 2002; Varghese & Moore-Orr, 2002).

The whole phenomenon of the "healthy immigrant effect" has shifted the interpretation of immigrant nutritional health more towards a negative acculturation perspective. Dietary acculturation, howbeit, has been reported to result in negative and positive practices; hence its effects on overall health are contingent on the specific changes made. For instance, a study on dietary patterns in population groups of African origin living in Canada reported that among Africans in Montreal, dietary acculturation related to fruit and vegetables, fish, whole-grain cereal, and legumes were protective against negative health outcomes, while sweets, processed meats, fried foods, fats and oils, and salty snacks do so on the negative side (Delisle, 2010). Other Canadian studies including one on 244 women of Chinese ethnicity living in Canada (Vancouver) and the US (Satia et al., 2001b) and another on 422 South Asian adults in Vancouver (Kandola et al. 2016), reported that exposure to Canada was associated with increased consumption of fruit and vegetables. South Asians have also been reported to experience a decrease in their intake of high-fat and fried foods upon immigration. Nonetheless, compared to their diet in their country of origin, there appeared to be a rise in intake of convenience foods, sugar-sweetened beverages, and red meat during their stay in Canada (Block et al., 2000). A study based on data from the Ontario Healthy Survey revealed that some immigrants from Asian origins were at an increased risk of inadequate intakes of protein and selected micronutrients compared with non-immigrants. Nonetheless, they reported that some immigrant groups' fat and carbohydrate intakes were more consistent with current Canadian dietary recommendations than those of non-immigrants. In addition, compared to non-immigrants, immigrants, overall, were less likely to exceed the recommended servings for fat or alcohol (Pomerleau et al., 1998).

Although studies presented in this review of the dietary profile of immigrants offer meaningful insight, the majority of the findings were not drawn from national data and as a result, generalizability to the general immigrant population is challenging. It is important to recognize that factors that facilitate the process of dietary acculturation are dynamic and different for each individual or country of origin (Satia, 2010). Henceforth employing general characteristics to define immigrant populations, not only can it be dangerous, but also does not help in understanding the true impact of acculturation on immigrants' health. Moreover, acculturation does not seem to influence foods and nutrients the same way, and as a result, drawing conclusions based on a handful of nutrients or foods may pose some limitations, hence the intent of this thesis. From the reviewed literature, it appears that in studying the associations between dietary patterns and immigration, a number of research gaps exist. Despite the existing evidence, a comprehensive analysis of the diet quality of Canadian immigrants are lacking on the national level.

Comprehensive profile of diet quality, as well as eating habits, based on CFG and usual intakes have been performed for the general population (Garriguet, 2009; Jessri et al., 2017), yet such privilege has not been extended to immigrant nutritional health. Canada's Food Guide presents evidence-based guidelines on nutritional health promotion, however, research on the assessment of immigrant adults' adherence to these guidelines is scarce. Furthermore, the HEI and the application of the NCI method have been proven to provide an unmatched assessment of diet quality at the population level (Tooze et al., 2002; Tooze et al., 2010), yet again, such methodologies are lacking in Canadian research on immigrant adults' nutrition analysis. Dietary analysis in association with immigration status, especially when ethnicity is considered, is very limited. Despite the considerable cultural and ethnic diversity based on nativity in Canada's population, very few studies have investigated the likelihood of achieving an overall good diet

quality among ethnic populations. Most of the Canadian research on dietary patterns is concentrated heavily on South Asians and Chinese individuals and as such, little is known about immigrant nutritional health and immigration-related dietary changes for other ethnic immigrants. Even with their high concentration in the literature, the majority of the data presented for South Asians and Chinese populations are based on local studies, which makes their generalizability questionable.

In an attempt to establish within-immigrant heterogeneity of dietary practices, one must depend primarily on findings from multiple studies since research examining the relationship between immigration and diet quality in Canada typically do not consider more than one ethnicity. This thesis will bridge that gap by simultaneously examining diet quality through the analysis of 12 food components and their association with immigration status and length of residence while considering ethnic differentials in diet quality as it pertains to White, East/Southeast Asian, West Asian/Arab, South Asian, Latin American, Black, Aboriginal and those who identify as "Other". In nutrition epidemiology research and public health efforts, this comprehensive approach may increase the accuracy of characterising dietary patterns, consequently, assisting in the creation of targeted nutrition interventions in the efforts to lessen the burden of poor dietary habits in the multicultural population in Canada.

2.2 Study Methodology

2.2.1 Data Source

The study was conducted using data collected for the 2015 Canadian Community Health Surveys (CCHS) Nutrition. The nationally-representative survey samples Canadians across all provinces on their eating habits and use of nutritional supplements, as well as other health factors.

This survey conducted by Statistics Canada uses a multiclustered, cross-sectional design to randomly select individuals per household to complete the survey. Participation in the study was voluntary. Two questionnaires were administered per household. First, a general health questionnaire to collect general health status, demographic, and lifestyle and anthropometric data. Second, a 24-h dietary recall to assess all food and beverage intake by the selected individual for the past 24-h (Health Canada, 2017). A computerized, Canadian modification of the United States Department of Agriculture (USDA) 5-step Automated Multiple-Pass Method was used for all dietary recalls (Moshfegh et al., 2008). This method has been shown to reduce bias in intakes as well as offer accurate estimation of group total energy and nutrient intakes (Ahmed et al., 2021; National Cancer Institute [NCI], 2019; Moshfegh et al., 2008).

With the help of the 2015 Canadian Nutrient File (CNF), all reported food items were characterized and the nutritional composition was determined. Data were collected between January 2015 and December 2015. An in-depth description pertaining to sampling design and data collection methods have been published elsewhere (Health Canada, 2017). Data analysis was performed at the Research Data Centre (RDC) of Statistics Canada, Toronto Ontario. Statistics Canada provided survey weights with the master files which were used in the present study to ensure all analyses remained nationally representative (Health Canada, 2017).

2.2.2 Study Participants

For the 2015 CCHS Nutrition survey, 20,487 respondents completed the initial 24-h dietary recall and a random subsample of 7,608 were asked to complete a second recall over the phone within 3–10 days after the first recall; response rates were 61.6% and 68.6%, respectively (Health Canada, 2017). The survey covers the population aged one year of age and over living in the ten provinces. Excluded from the survey's coverage are residents of the territories, infants aged less than one year old, persons living on reserves or other Aboriginal settlements, full-time members of the Canadian Forces, and the institutionalized population (Health Canada, 2017). The present analysis concerns respondents aged 20-79 for whom food intake data were available. Other exclusion criteria for this study include women who were pregnant or breastfeeding.

2.2.3 Assessment of diet intake

Diet quality. The outcome variable is diet quality measured by participants' adherence to Canadian adaptation of HEI-2015. The total C-HEI 2015 score is an indication of diet quality, while the component scores when examined together show a pattern of diet quality. From the original 1995 HEI, the United States Department of Agriculture classified scores into diet quality categories: more than 80 points represented a good quality diet; 50 to 80 points, a diet that required improvement; and fewer than 50 points, a poor diet (as cited in Bowman et al., 1998). This concept was applied in the current study to define the binary outcome, Good diet quality. This outcome is defined as having an 80 or greater total C-HEI score; thus, whether you have a "good" diet quality or not. To compare likelihood of consumption of the 12 C-HEI 2015 components among participants, the scores for each component were transformed into

binary outcomes defined as “whether you meet the diet recommendation servings (i.e., achieve maximum score for HEI scoring) or not”.

Other Canadian research has established the reliability and validity of adapting the American Healthy Index for the Canadian population (Garriguet, 2009; Glanville & McIntyre, 2006; Jessri et al., 2017; Woodruff & Hanning, 2010). In accordance with the guidelines presented by Garriguet (2009) and Jessri et al. (2017), the corresponding maximum points and scoring standards for C-HEI 2015 were created for the present study. Nevertheless, there are some differences as their adaptation was based on previous versions of HEI while the C-HEI-2015 for this study is based on the current version of HEI. Similar to previous adaptations, to create C-HEI 2015, HEI-2015 was transformed into CFG 2007 by expressing food intake in accordance with CFG 2007 recommendations based on respondent age and sex. Corresponding to the HEI-2015, the scores for C-HEI 2015 ranges from 0 to 100, with higher scores representing better diet quality. The scoring criteria for the original HEI-2015 and the C-HEI 2015 can be found in Tables 1 and 2, respectively.

The overall HEI-2015 score is made up of 13 components: 9 adequacy components (representing a diet that should be consumed in adequate amounts for optimal health) and 4 moderation components (representing a diet that should be restricted for optimal health). While the HEI-2015 has separate components for total fruit and total vegetables, CFG 2007 combines fruit and vegetables into one food group, as presented on CFG 2007. This makes a total of 8 adequacy components on the C-HEI 2015. All other components are kept the same as HEI-2015.

Scoring criteria for Canadian adaptation of Healthy Eating Index 2015

The scoring for total vegetables and fruit, whole fruit, greens and beans, whole grains, dairy, total protein foods, seafood and plant protein, refined grains, and sodium were formed following the age and sex-specific recommendations found in CFG 2007 as well as Garriguet (2009) and Jessri et al. (2017) criteria. The scoring for fatty acids, added sugars, and saturated fats were maintained from HEI-2015 as CFG 2007 does not offer recommendations for these components.

Briefly, based on CFG recommendations, the standard for maximum scores of the "whole fruit" and "greens and beans" components represent 21% of the "vegetables and fruit"; the standard for maximum score of the "whole grains" component is 50% of the "grain products"; the standard for maximum score of the "seafood and plant protein" component represents 32% of the "total protein foods"; CFG 2007 recommends that half of all grain products should be whole grain and as result, the maximum score standard for the refined grains component is <50% of grain products consumed as refined grain. Based on the Institute of Medicine (IOM) recommendations, maximum score of 10 for those who consume equal to or less than the tolerable upper intake level of sodium, for age and sex. Then the minimum score of 0 would be for those who consume two times the tolerable upper intake level. Garriguet (2009) and Jessri et al. (2017) used AI and UL from IoM in their adaptation approach. "Fatty acids", "added sugars" and "saturated fat" recommendations are taken directly from HEI 2015. In CCHS 2015 nutrition data, sugars were not categorized as either added or naturally occurring and as such, added sugars were calculated using the method developed by Brisbois and peers (Brisbois et al., 2014). Jessri et al. (2017) in creating HEI-C 2010, also used Brisbois et al method in calculating added sugars as part of their empty calorie's component.

One of the significant differences between C-HEI 2015 in this study and previous versions of Canadian HEI is the treatment of legumes in the calculation of amounts of each relevant dietary constituent considered in arriving at HEI scores. Previous adaptations follow the recommendations of HEI-2005 and HEI-2010 for allocation of legumes while I followed the recommendations of HEI-2015 (Garriguet 2009; Jessri et al., 2017). Thus, legumes were allocated to all four components: total protein foods, seafood and plant protein, total vegetables and fruit, and greens and beans, for reasons described in detail elsewhere (Krebs-Smith et al., 2018). In contrast, in earlier versions of the HEI, legumes were counted as protein foods only in the case that the standard was otherwise not met (any legumes counted toward the total protein foods standard were also counted toward the seafood and plant proteins component) and counted toward the two vegetable subgroups only after the protein foods standard had been met.

2.2.4 Assessment of immigration status

Immigration status. In the Canadian Community Health Survey, immigrant status was based on the country of birth given by respondents. Those who specified a country other than Canada were asked if they had been born Canadian citizens. If they said "no," they were determined to be immigrants. Respondents were divided into categories on the basis of their immigration status (versus Canadian-born).

Length of residence in Canada. In the Canadian Community Health Survey, immigrant respondents were asked the year in which they had immigrated to Canada. Comparing that year with the year of the interview made it possible to derive time since immigration. On the basis of responses to these questions, immigrant respondents were categorized by length of residence in Canada (0-4, 5-9, 10-14, 15-19, 20-24, 25-29, 30+ years). The above categories were collapsed

into two groups, (recent [10 years or less] vs long-term immigrants [11 years or more]), for some analysis to avoid restrictive sample sizes.

2.2.5 Assessment of the Covariates

Ethnicity. For this analysis, ethnicity was based on the question in the Canadian Community Health Survey asking respondents to self-identify if they belong to one or more of the following racial or cultural groups: White, Chinese, South Asian (e.g., East Indian, Pakistani, Sri Lankan, etc.), Black, Filipino, Latin American, Southeast Asian (e.g., Cambodian, Indonesian, Laotian, Vietnamese, etc.), Arab, West Asian (e.g., Afghan, Iranian, etc.), Japanese, Korean, Aboriginal Peoples of North America (North American Indian, Métis, Inuit/Eskimo), and Other.

To avoid restrictive sample sizes and increase power, respondents were grouped into eight subgroups: White, East/Southeast Asian (Chinese, Filipino, Southeast Asian, Japanese, Korean), West Asian/Arab, South Asian, Latin American, Black, Aboriginal, and Other.

Age at time of immigration. Immigrants were divided into five categories based on their age at the time of immigration (<13, 13-19, 20-34, 35-49, and 50+ years).

Gender. Respondents were categorized as either male or female.

Age. Age in years was treated as a categorical variable: 20-34, 35-49, 50-64, and 54-79 years.

Physical activity level. Physical activity level was based on the "150 minutes or more of moderate-vigorous physical activity per week" (MVPA) guideline. The two categories of physical activity, sufficient and insufficient, were whether respondent met the minimum physical activity guideline or did not meet the minimum physical activity guideline, respectively.

Smoking. Smokers were identified by asking individuals if they smoked cigarettes daily, occasionally, or not at all. Therefore, the two groups were smokers [those who smoked daily and occasionally] and non-smokers [never smoked].

Education. Respondents were grouped into four categories on the basis of the highest level of education attained as of the completion of the survey: less than high school diploma or its equivalent; high school diploma or a high school equivalency certificate or those with trade certificate or diploma; certificate/diploma or qualifications below the bachelor's level; and bachelor's degree and/or above.

Income. Respondents were grouped into four categories of income: less than $39,999, $40,000 to $59,000, $60,000 to $79,000, and $80,000 and higher.

These variables were considered covariates of interest because of their independent importance on varying levels of dietary habits in adults. Available evidence suggests that dietary patterns might vary by ethnicity (Brenner et al., 2011; Brown et al., 2018; Dubowitz et al., 2008; Kandola et al., 2016; Sharma et al., 2014; Subhan & Chan, 2019). Research also suggests variation in eating habits by gender as females tend to have a healthier eating pattern than males (Garriguet, 2007; McInerney & Ho, 2018; Pérez, 2002a; Subhan & Chan, 2019). A study based on the national representative data, National Health and Nutrition Examination Survey (NHANES), reports that age at time of immigration is associated with eating habits. Specifically, compared with arrival in infancy, adolescence, or adulthood, people who immigrate in middle childhood were associated with less healthy eating in adulthood (Van Hook et al., 2018). A cluster analysis revealed subjects with higher levels of physical activity was more likely to follow a healthy diet (Christofaro et al., 2021). Research has also found effects of cigarette smoking on food cravings and intake. Compared to never smokers, current smokers reported more frequent cravings for high-fat foods

and fast-food fats, after controlling for depression, stress, BMI and demographic factors. Current smokers also reported consuming more high-fat foods and fast-food fats (Chao et al., 2017). Socio-economic factors such as household income and education might also influence eating habits in adults. In particular, lower SES immigrants are at greater risk for unhealthy eating than higher SES immigrants (Van Hook et al., 2018). Differences in food consumption have also been observed across age groups (Garriguet, 2007).

2.2.6 Statistical Analysis

Dietary intake for our sample was measured using 24-hour dietary recalls obtained from the 2015 CCHS Nutrition master data. Since a proportion of participants were surveyed twice, with the availability of more than one day of 24-h dietary recall, we were able to compute usual food intakes using the National Cancer Institute (NCI) method. Estimation of usual intake as opposed to daily intake ensures that our analysis is an accurate representation of participants' long-term average daily intake (Dodd et al., 2006; Freedman et al, 2004; Kipnis et al., 2009). Besides it been recommended for the analysis of the 2015 CCHS–Nutrition survey data (Davis et al., 2019; NCI, 2018), the NCI method considers the correlations between amount consumed and probability of consumption, accounts for covariates, and allows the estimation of usual intakes of episodically consumed foods, which makes it advantageous over previous methods (Tooze et al., 2010; Tooze, Midthune et al., 2006). Training materials on the use of the NCI method to estimate usual intake distribution using the 2015 CCHS-Nutrition data are available from Statistics Canada. The National Cancer Institute has also developed SAS macros for implementation of the NCI method, which is available online.

According to Davis and colleagues, in choosing between stratification and pooling method in nutrient or food estimation, one should consider sample size and research question (Davis et al, 2019). It has been suggested that stratified analysis result in better estimation of normality for each subgroup or stratum of interest and in turn reduce bias (Herrick et al., 2018). Moreover, the number of strata was created based on the NCI's recommendations on the minimum number of people (unweighted) with two non-zero recalls needed for each dietary component per stratum.

With that in mind, since the variable of interest is immigration status, the computation was done for usual intakes for each immigrant status group separately, using a stratified approach. The models were stratified according to immigration status and gender to better reflect random variations in intake. The four strata used were female immigrant, female Canadian-born, male immigrant, and male Canadian-born. Estimated intakes among pseudo-individuals (i.e.,100 simulations per survey respondent) generated in the Monte Carlo simulation step within each stratum were pooled before estimating the distribution of intakes in the overall sample. The *explore* SAS macro outputs a table that identifies whether a one-part (amount) or two-part (uncorrelated or correlated) model should be used in fitting the NCI models for each dietary component within each stratum. The algorithm for choosing the appropriate model was based on Zhang et al. (2011)'s publication, which is also in lined with Krebs-Smith et al. (2010)'s approach. Briefly, if less than 5% of the 24-h recalls (unweighted) within each stratum had zero intake of the dietary component, the amount-only model is used; if greater than 10% of the 24-h recalls (unweighted) within each stratum had zero intake of the dietary component, then the two-part model only model is fitted; if between 5% and 10% of the recalls had zero intake of a food all three models were fitted. Further detailed explanations are published elsewhere (Krebs-Smith et al., 2010; National Cancer Institute, 2021; Zhang et al., 2011).

The covariate included in the models was age. As per the NCI User Guide, an indicator variable for the sequence of 24-hour recalls (first or second when appropriate) and an indicator variable for weekend days (Friday, Saturday, and Sunday) were also included as covariates. The C-HEI-2015 scoring system was applied to the estimated usual intakes among pseudo-individuals to estimate total scores and component scores. The mean of total C-HEI-2015 and component scores were estimated in the overall sample and in specified subgroups. These analyses were weighted with survey weights provided by Statistics Canada as well as Bootstrap balanced repeated replication with 500 repeats was used to estimate standard errors and confidence intervals.

The mean usual C-HEI 2015 scores were estimated according to immigration status and length of residence- gender groupings and additional variables, which included ethnicity, age group, age at immigration, length of residence, physical activity, smoking, education, and income were also assessed. Student's t-test was used to assess mean differences in total C-HEI-2015 and component scores between women and men, immigrants and Canadian-born, as well as recent immigrants and long-term immigrants. For participants' characteristics, descriptive analyses examined prevalence (weighted percentages) for demographic profile and gender in addition to immigration variables. The chi-square test for independence was used to test significant differences between gender, immigration variables, and participant characteristics.

Logistic regression analyses were used to calculate odds ratios for the association between diet quality [Good diet quality and component scores] and immigration status, as well as odds ratios for diet quality and length of residence. The models were adjusted for age at immigration, ethnicity, age, gender, physical activity, smoking, education, and income, except when stratifying the analysis by each of the covariates discussed. All analyses were weighted with survey weights provided by Statistics Canada. The bootstrap method was used to estimate standard errors and

confidence intervals. Results with a two-tailed p-value ≤0.05 were reported as statistically significant. Analyses were completed using Statistical Analysis Software (SAS) version 9.4 (SAS Institute Inc., Cary, NC, USA) and verified with Stata (16.1, StataCorp LLC, College Station, TX).

Table 1: Components of American 2015[1] Healthy Eating Index, range of scores and scoring criteria.

Component	Maximum points	Standard for maximum score	Standard for minimum score of zero
Adequacy:			
Total Fruits[2]	5	≥0.8 cup equivalent per 1,000 kcal	No Fruit
Whole Fruits[3]	5	≥0.4 cup equivalent per 1,000 kcal	No Whole Fruit
Total Vegetables[4]	5	≥1.1 cup equivalent per 1,000 kcal	No Vegetables
Greens and Beans[4]	5	≥0.2 cup equivalent per 1,000 kcal	No Dark-Green Vegetables or Legumes
Whole Grains	10	≥1.5-ounce equivalent per 1,000 kcal	No Whole Grains
Dairy[5]	10	≥1.3 cup equivalent per 1,000 kcal	No Dairy
Total Protein Foods[4]	5	≥2.5-ounce equivalent per 1,000 kcal	No Protein Foods
Seafood and Plant Protein[4,6]	5	≥0.8-ounce equivalent per 1,000 kcal	No Seafood or Plant Proteins
Fatty Acids[7]	10	(PUFAs + MUFAs) / SFAs ≥2.5	(PUFAs + MUFAs)/SFAs ≤1.2
Moderation:			
Refined Grains	10	≤1.8-ounce equivalent per 1,000 kcal	≥4.3-ounce equivalent per 1,000 kcal
Sodium	10	≤1.1 grams per 1,000 kcal	≥2.0 grams per 1,000 kcal
Added Sugars	10	≤6.5% of energy	≥26% of energy
Saturated Fats	10	≤8% of energy	≥16% of energy

[1] Intakes between the minimum and maximum standards are scored proportionately.
[2] Includes 100% fruit juice.
[3] Includes all forms except juice.
[4] Includes legumes (beans and peas).
[5] Includes all milk products, such as fluid milk, yogurt, and cheese, and fortified soy beverages.
[6] Includes seafood; nuts, seeds, soy products (other than beverages), and legumes (beans and peas).
[7] Ratio of poly- and mono-unsaturated fatty acids (PUFAs and MUFAs) to saturated fatty acids (SFAs).

Note. Sourced from Krebs-Smith, S. M., Pannucci, T. E., Subar, A. F., Kirkpatrick, S. I., Lerman, J. L., Tooze, J. A., Wilson, M. M., & Reedy, J. (2018). Update of the Healthy Eating Index: HEI-2015. *Journal of the Academy of Nutrition and Dietetics*, *118*(9), 1591–1602. https://doi.org/10.1016/j.jand.2018.05.021

Table 2: Components of Canadian adaptation of Healthy Eating Index (C-HEI), range of scores and scoring criteria.

Component	Maximum points	Standard for maximum score	Standard for minimum score of zero
Adequacy:			
Total Vegetables and Fruit[2]	10	7-8 servings[1]	0 serving
Whole Fruits[3]	5	1.47-1.68 servings[1]	0 serving
Greens and Beans[4]	5	1.47-1.68 servings[1]	0 serving
Whole Grains[5]	10	3-4 servings[1]	0 serving
Dairy[6]	10	2-3 servings[1]	0 serving
Total Protein Foods[7]	5	2-3 servings[1]	0 serving
Seafood and Plant Protein[8]	5	0.64-0.96 servings[1]	0 serving
Fatty Acids[9]	10	(PUFAs + MUFAs) / SFAs ≥2.5	(PUFAs + MUFAs)/SFAs ≤1.2
Moderation:			
Refined Grains	10	<50% of grains refined	≥50% of grains refined
Sodium (mg/day)	10	≤2300 mg	≥4600 mg
Added Sugars	10	≤6.5% of energy	≥26% of energy
Saturated Fats	10	≤8% of energy	≥16% of energy

[1] Based on the age and sex-specific recommendations [for adults] found in CFG 2007.
[2] Includes dark green vegetables, red and orange vegetables, legumes, starchy vegetables, and other vegetables (fresh, frozen, canned, cooked, raw, juice), and all fresh, frozen, canned, and dried fruit and fruit juices.
[3] Includes all forms of fruit except juice.
[4] Includes dark green vegetables (e.g., broccoli, spinach, romaine, kale) and legumes (e.g., kidney beans, white beans, lentils, chickpeas).
[5] Includes all whole-grain products and whole grains used as ingredients (e.g., whole-wheat bread, oatmeal, quinoa, brown rice).
[6] Includes all milk, including lactose-free and lactose-reduced products and fortified soy beverages (soymilk), yogurt, cheese.
[7] Includes all seafood, meats, poultry, eggs, soy products, nuts, legumes, and seeds.
[8] Includes all seafood, nuts, seeds, legumes, and soy products (except for soy beverages).
[9] Ratio of poly- and mono-unsaturated fatty acids (PUFAs and MUFAs) to saturated fatty acids (SFAs).

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Chapter 3

Results

3.1 Participants Characteristics

Demographic profiles of study participants are presented in Table 3. The majority of respondents were Canadian-born (72.44%), White (73.48%), non-smokers (80.63%), belonged to the 35–49 years age range (31.08%), had attained high school or equivalent level of education (33.82%), and 52% had an annual household income of 80,000 or more. About half of the participants (50.36%) included in the study were male. Although the majority of male met the physical activity requirements (51.28%), there were also more of them who were smokers (22.38%). Most immigrant participants belonged to the 30 or more years length of residence range (31.77%) and 20-34 years of age at the time of immigration range (46.1%).

Demographic profiles of study participants according to immigration status are presented in Table 4. Compared with Canadian-born, a higher percentage of immigrants had attained a higher level of education [at least a bachelor's degree] (38.69%) and had never been a smoker (86.13%). Nonetheless, a higher percentage of immigrants had not met the physical activity requirement (60.34%), and the proportion of Canadian-born (55.15%) in the highest income category was higher than immigrants (43.97%).

Dietary characteristics of the sample

For the adequacy components, increasing levels of intake receive increasingly higher scores, whereas for the moderation components, increasing levels of intake receive decreasingly lower scores. In other words, for all components, higher scores indicate closer conformance with dietary guidance.

Table 5 presents the weighted mean of C-HEI 2015 components and total HEI scores of the total sample as well as by gender. In 2015, the average score on the Canadian adaptation of the Healthy Eating Index was 62.99 (SE: 0.11) for the sampled population aged 20-79. Female (65.74 [0.14] had significantly ($p<0.05$) higher C-HEI score than male (60.27 [0.15]). Apart from fatty acids components where male had a higher mean score than female, 5[0.037] and 4.76 [0.036] respectively, female had significantly ($p<0.05$) higher scores for all other adequacy components. With respect to moderation components, female had significantly higher refined grains and sodium component scores while male had significantly higher added sugars and saturated fats component scores. The lowest scoring component was whole grains even when gender differences were considered.

3.2 Addressing Research Objective 1

C-HEI 2015 scores by immigration status

Table 6 presents the weighted mean of C-HEI 2015 components and total HEI scores by immigration status. The average C-HEI score was significantly higher for immigrant (65.06[0.25] compared to Canadian-born (62.19[0.12]). This difference was observed even when gender was considered. Specifically, female immigrant (67.17[0.31]) and male immigrant (63.02[0.33]) had significantly higher C-HEI scores than their Canadian-born counterparts, (65.21[0.14]) and (59.21[0.15]) respectively. Irrespective of immigration status, female's index scores exceeded those of male. Compared with Canadian-born, immigrant had significantly ($p < .05$) higher scores for the following components: whole fruit, whole grains, seafood and plant protein, fatty acids, refined grains, sodium, added sugars, and saturated fats. In other words, they achieved higher index scores for 8 out of the 12 components.

Socio-demographic differences

Table 7 presents the distribution of diet quality (C-HEI total mean score) among immigrant and Canadian-born with socio-demographic characteristics. Differences in overall diet quality score and immigration status were observed across age groups, physical activity, smoking, education, and income groups. In particular, the average C-HEI score was significantly higher for immigrant across all socio-demographic variables ($p<0.05$). For example, immigrant who belong to the 20-34 years age range (61.99[0.66]) had significantly higher C-HEI scores than their Canadian-born counterpart (60.69[0.25]). This pattern was observed among each age group. Immigrant who are physically active had significantly higher C-HEI mean scores than their Canadian-born counterpart, (65.14[0.41]) and (63.24[0.16]) respectively. A similar pattern was observed among those who did not meet the physical activity guidelines. Immigrants who are non-smokers had significantly higher C-HEI mean scores than Canadian-born smokers, (66.46[0.20]) and (64.08[0.11]) respectively. A similar pattern was observed among smokers. Interestingly, among those who hold a bachelor's or higher degrees, immigrant had significantly lower C-HEI mean scores than Canadian-born, (67[0.36]) and (67.43[0.19]) respectively. Among all other education groups as well as income groups, immigrant had significantly higher scores than Canadian-born.

Ethnic differences in weighted mean scores of diet quality

White immigrant (60.80[0.32]) had significantly lower C-HEI scores than White Canadian-born (62.24[0.13]). For all other ethnicities, immigrant had higher C-HEI mean scores than their Canadian-born counterparts ($p<0.05$). The scores for immigrant compared with Canadian-born are respectively presented as follows: Black (65.78 and 63.29), East/Southeast Asian (65.66 and

64.63), West Asian/Arab (64.30 and 61.73), South Asian (74.37 and 65.85), Latin American (61.38 and 58.08), and Other (66.64 and 62.24).

Among the immigrant group, White had the lowest overall C-HEI score among all other ethnicities. On the other hand, South Asian had the highest overall C-HEI score among the immigrant group. Among the Canadian-born respondents, Aboriginal had the lowest overall C-HEI score (59.39[0.47]) among all other ethnicities, and South Asian had the highest overall C-HEI score among Canadian-born.

Associated odds of diet quality and immigration status

Table 9 presents results obtained from the analyses of many logistic regression models (a separate model per outcome) examining the association between immigration status and diet quality (C-HEI total and components scores) after controlling for length of residence, age at immigration, ethnicity, age, gender, physical activity, smoking, education, and income. Canadian-born was the reference category in these analyses. Immigration status was significantly ($p<0.05$) associated with good diet quality (OR = 1.84 [1.51, 2.26]), vegetables and fruit (OR = 1.16 [0.95, 1.41]), whole fruit (OR = 2.59 [0.64, 2.96]), greens and beans (OR = 0.075 [0.054, 0.10]), whole grains (OR = 2.13 [1.54, 2.93]), dairy (OR = 1.25 [1.03, 1.52]), seafood and plant protein (OR = 1.67 [1.34, 2.09]), refined grains (OR = 2.06 [1.01, 4.21]), sodium (OR = 2.92 [2.44, 3.51]), added sugars (OR = 1.73 [1.11, 2.69]), and saturated fats (OR = 7.86 [5.29, 11.68]).

Among female, immigration status was significantly ($p<0.05$) associated with good diet quality (OR = 1.84 [1.38, 2.44]), whole fruit (OR = 2.87 [2.37, 3.46]), greens and beans (OR = 0.048 [0.030, 0.075]), whole grains (OR = 2.44 [1.58, 3.78]), dairy (OR = 1.51 [1.19, 1.93]), seafood and plant protein (OR = 1.55 [1.16, 2.07]), sodium (OR = 2.05 [1.58, 2.67]), and saturated

fats (OR = 5.43 [3.05, 9.66]). Among male, immigration status was significantly ($p<0.05$) associated with good diet quality (OR = 1.92 [1.47, 2.51]), whole fruit (OR = 2.60 [2.09, 3.23]), greens and beans (OR = 0.10 [0.07, 0.14]), whole grains (OR = 1.77 [1.26, 2.49]), total protein foods (OR = 1.57 [1.27, 1.94]), seafood and plant protein (OR = 2.12 [1.55, 2.90]), sodium (OR = 3.15 [2.46, 4.04]), added sugars (OR = 2.26 [1.34, 3.80]), and saturated fats (OR = 9.37 [2.46, 4.045.63, 15.57]).

Ethnic differences in associated odds

Stratified by immigration status, Table 9.1 presents results from multiple analyses from logistic regression models examining the association between ethnicity and diet quality (C-HEI total scores) after controlling for length of residence, age at immigration, age, gender, physical activity, smoking, education, and income. White was the reference category in these analyses.

Diet quality among immigrants

Among the immigrant subgroup, ethnicity was significantly related to good diet quality. Compared with White, the odds were significantly higher among Black (OR = 3.36 [2.97, 3.81]), East/Southeast Asian (OR = 2.32 [2.07, 2.61]), West Asian/Arab (OR = 1.82 [1.47, 2.25]), South Asian (OR = 12.15 [10.96, 13.46]), and Other (OR = 3.85 [3.28, 4.51]). No significant association was observed between Latin American and White immigrant.

With respect to female immigrant, compared with White, the odds were significantly higher among Black (OR = 3.14 [2.69, 3.66]), East/Southeast Asian (OR = 2.16 [1.89, 2.48]), West Asian/Arab (OR = 1.53 [1.24, 1.88]), South Asian (OR = 11.37 [10.10, 12.80]), and Other (OR =

3.56 [2.92, 4.33]). No significant association was observed between Latin American and White female immigrant.

For immigrant male, the relationship between ethnicity and good diet quality was similar to female immigrant. Compared with White, the odds were significantly higher among Black (OR = 3.60 [3.03, 4.28]), East/Southeast Asian (OR = 2.52 [2.13, 2.98), West Asian/Arab (OR = 1.97 [1.45, 2.66]), South Asian (OR = 12.88 [11.04, 15.04]), and Other (OR = 4.09 [3.38, 4.96]). Again, no significant association was observed between Latin American and White immigrant male.

Diet quality among Canadian-born

Among the Canadian-born subgroup, the likelihood of having a good diet quality was influenced by ethnicity. Compared with Canadian-born White, the odds were significantly higher among East/Southeast Asian (OR = 1.54 [1.25, 1.89]) and Canadian-born who identify as Other (OR = 1.66 [1.47, 1.87]), while Canadian-born South Asian (OR = 0.61 [0.56, 0.66]) and Latin American (OR = 0.0070 [0.0014, 0.034]) had lower odds. However, the odds that Canadian-born who identify as Black, West Asian/Arab, or Aboriginal would have a good diet quality, did not differ significantly from those of Canadian-born White.

With respect to the Canadian-born female, Compared with White, the odds were significantly higher among East/Southeast Asian (OR = 1.32 [1.0079, 1.72]) and Canadian-born female who identify as Other (OR = 1.71 [1.60, 1.82]), while Canadian-born female who identify as West Asian/Arab (OR = 0.51 [0.27, 0.98]), South Asian (OR = 0.55 [0.51, 0.60]), and Latin American (OR = 0.0056 [0.0009, 0.036]) had lower odds. The odds of Canadian-born female who identify as Black or Aboriginal did not differ significantly from those of female who are Canadian-born White.

For Canadian-born male, Compared with White, the odds were significantly higher among East/Southeast Asian (OR = 1.89 [1.33, 2.68]) and Other (OR = 1.76 [1.51, 2.04]), while Latin American male (OR = 0.017 [0.0051, 0.056]) had lower odds. The odds that Canadian-born male who identify as Black, West Asian/Arab, South Asian, and Aboriginal would have good diet quality, did not differ significantly from those of Canadian-born White male.

3.3 Addressing Research Objective 1B

C-HEI 2015 scores by the length of residence

Figure 1 presents the weighted mean C-HEI total scores by the length of residence. There is no clear gradient in the means of C-HEI total scores (diet quality) with increasing length of residence. Nonetheless, we observe a slow increase in mean values from 0 to 4 years until 30+ years when there is a notable decrease in diet quality. The mean C-HEI score decreased from 66.63[0.66] among immigrant who resided in Canada for 25 to 29 years to 64.67[0.39] for those who resided in Canada for 30 or more years.

Socio-demographic differences

Table 8 presents the distribution of diet quality (weighted mean of C-HEI total scores) by the length of residence to participants' socio-demographic characteristics. For recent immigrant [person who immigrated to Canada within the last 10 years], dietary differences were observed across age groups, age at the time of immigration, gender, smoking, education, and income groups. There is a clear gradient of higher C-HEI total scores (diet quality) with increasing age at the time of immigration. Thus, diet quality was significantly higher for those who immigrated at a later age than for early arrivals.

We also observe a significant ($p<0.05$) increase in diet quality with an increase in age. Not surprising, recent immigrant who are female had higher C-HEI scores than their male counterpart, 67.57[0.53] and 62.61[0.6]; $p<0.05$, respectively. Those with a bachelor's degree or higher (66.51[0.58]) and belonged to the $60,000 to $79,000 income range(67.91[2.07]) had the highest C-HEI score among the education and income groups.

When we compare within long-term immigrant group [person who immigrated to Canada 11 or more years], mean scores also increase as age at the time of immigration increases. Thus, diet quality was higher for those who immigrated at a later age compared with earlier ages. Unlike recent immigrant, for long-term immigrant, we observe an increase in diet quality until age 64, where those who belonged to the 64-79 years age range experienced a lower C-HEI score than those in the previous (50-64 years) age range. Similar to recent immigrant, long-term immigrant with a bachelor's degree or higher (67.30[0.44]) and belonged to the $60,000 to $79,000 income range (68.21[0.72]) had the highest C-HEI score among the education and income groups. We also observe similar gender differences where female had higher C-HEI scores than male, 67.05[0.36] and 63.23[0.37]; $p<0.05$, respectively.

Ethnic differences in weighted mean scores of diet quality

Among recent immigrant, Latin American and White had the lowest overall C-HEI score among all other ethnicities. On the other hand, South Asian had the highest overall C-HEI score among this group. Among long-term immigrant, White had the lowest overall C-HEI score among all other ethnicities, and South Asian had the highest overall C-HEI score among this group.

When we compare recent immigrant with long-term immigrant, for ethnic groups whom significant differences were found, recent immigrant had lower mean diet scores than long-term

immigrant. Recent immigrant who identifies as Black (63.72[1.05]) had significantly lower C-HEI mean scores than their long-term immigrant counterpart (66.46[0.53]). Recent immigrant who identifies as West Asian/Arab (63.76[0.98]) had significantly lower C-HEI mean scores than long-term immigrant who identifies as West Asian/Arab (64.79[0.57]). Similarly, recent immigrant who identified as South Asian (72.84[0.73]) had significantly lower C-HEI mean scores than their long-term counterpart (75.29[0.41]). Recent Latin American immigrant (60.26[1.63]) had significantly lower C-HEI mean scores than long-term Latin American immigrant (62.37[0.72]). Recent immigrant who identified as Other (63.14[1.79]) had significantly lower C-HEI mean scores than their long-term immigrant counterpart (67.41[0.72]). Non-significant mean differences were observed between recent immigrant and long-term immigrant from East/Southeast Asian and White ethnicity.

Associated odds of diet quality and length of residence

Table 10 and 10.1 present results from performing many analyses of logistic regressions examining the association between length of residence and good diet quality (C-HEI total score) after controlling for age at immigration, ethnicity, age, gender, physical activity, smoking, education, and income. Canadian-born was the reference category for the analysis in Table 10.

Length of residence was significantly associated with good diet quality. Compared with Canadian-born, the odds were significantly higher for respondents who immigrated in the past 5-9 years (OR = 1.42 [1.15, 1.75]), 10-14 years (OR = 1.36 [1.10, 1.67]), 15-19 years (OR = 1.59 [1.29, 1.95]), 20-24 years (OR = 1.76 [1.40, 2.22]), 25-29 years (OR = 1.82 [1.43, 2.31]), and 30+ years (OR = 1.83 [1.50, 2.24]). The odds of good diet quality for respondents who immigrated in the last 0-4 years were comparable to that of Canadian-born ($p>0.05$).

Participants who immigrated within 0 to 4 years were the reference group for the analysis in Table 10.1. Among the immigrant group, compared with those who immigrated in the last 0-4 years, the odds were significantly higher for respondents in any length of residence category ($p<0.05$). Although we observe an increase in the odds for those who immigrated in the past 10-14 years, it was not statistically different from those who immigrated in the last 0-4 years ($p>0.05$). The observed trend implies that not only do immigrants have better diet quality than Canadian-born, but also their likelihood of good diet quality increases with length of residence. This finding is consistent with our first research question.

Associated odds of food component consumption

Table 11, 11.1, and 11.2 present results from multiples of logistic regression models examining the association between length of residence and diet quality (C-HEI total and components scores) after adjusting for age at immigration, ethnicity, age, gender, physical activity, smoking, education, and income. Canadian-born was the reference category for model *a* and participants who immigrated within 0 to 4 years were the reference group for model *b*.

Model *a*. Compared with Canadian-born, recent immigrant [0-10 years] had significantly greater odds of good diet quality (OR = 1.23 [1.01, 1.49]), as well as meet the recommended servings for whole fruit (OR = 2.06 [1.79, 2.35]), whole grains (OR = 1.51 [1.15, 1.20]), dairy (OR = 1.35 [1.14, 1.61]), sodium (OR = 1.73 [1.47, 2.024]), and saturated fats (OR = 8.85 [5.83, 13.44]). Conversely, recent immigrant was less likely to consume greens and beans (OR = 0.05 [0.038, 0.070]), seafood and plant protein (OR = 0.76 [0.60, 0.96]), fatty acids (OR = 0.46 [0.25, 0.85]), as well as exceed the recommended servings for refined grains (OR =0.30[(0.15, 0.58]) and added sugars (OR = 0.57 [0.39, 0.83]) than Canadian-born; ($p<0.05$). Compared with Canadian-born,

long-term immigrant [≥11 years] had significantly greater odds of good diet quality (OR = 1.51 [1.24, 1.83]), as well as meet the recommended servings for whole fruit (OR = 2.21[1.93, 2.53]), whole grains (OR = 1.75 [1.27, 2.42]), sodium (OR = 2.12 [1.78, 2.51]), and saturated fats (OR = 4.78 [3.17, 7.20]). Consistent with recent immigrant, long-term immigrant had significantly lower odds of consuming greens and beans (OR = 0.071 [0.052, 0.096]), and fatty acids foods (OR = 0.39 [0.19, 0.78]) than Canadian-born.

We discovered both negative and positive habits due to dietary acculturation. While recent immigrant was more likely to meet the recommended servings for dairy and seafood and plant protein, consumption of these components was comparable to Canadian-born as the length of residence increased. Recent immigrant was more likely to exceed the recommended servings for refined grains and added sugars, however, these components were comparable to Canadian-born as the length of residence increased.

Model *b*. When we compare recent immigrant to long-term immigrant to help in examining how food consumption changes with stay in Canada, we observe improvement in the consumption of greens and beans (OR = 1.28 [0.77, 1.21]; $p<0.05$), seafood and plant protein (OR = 1.18 [1.10, 1.27]; $p<0.05$), refined grains (OR = 3.69 [2.32, 5.87]; $p<0.05$), and added sugars (OR = 1.74 [1.33, 2.27]; $p<0.05$) with increase in length of residence. We observe inadequacy in the consumption of dairy (OR = 0.78 [0.71, 0.84]; $p<0.05$), total protein foods (OR = 0.86 [0.81, 0.92]; $p<0.05$), and fatty acids (OR = 0.73 [0.59, 0.91]; $p<0.05$) as length of residence increases. Saturated fat consumption also increased with length of residence (OR = 0.50[0.44, 0.57]) ($p<0.05$).

Differences in diet quality as it relates to the length of residence were also observed by gender. When we examine individual food components, compared with Canadian-born female,

recent immigrant female had significantly higher odds of meeting the recommended servings for whole fruit (OR = 2.45 [2.07, 2.91]), whole grains, (OR = 1.74 [1.19, 2.54]), dairy (OR = 1.52 [1.22, 1.88]), and saturated fats (OR = 6.78[3.53, 13.01]). Compared with Canadian-born female, recent immigrant female had significantly lower odds of meeting the recommended servings for greens and beans (OR = 0.030 [0.020, 0.045]), total protein foods (OR = 0.78 [0.63, 0.96]), seafood and plant protein (OR = 0.76 [0.58, 1.0013]), refined grains (OR = 0.39 [0.16, 0.95]), and added sugars (OR = 0.33 [0.18, 0.60]). Thus, they were more likely to exceed the recommended guidelines for refined grains, added sugars, and saturated fats, resulting in lower odds ratios.

For female, diet quality is comparable to Canadian-born in the early years of immigration, however, we observe an improvement in diet quality with an increase in length of residence. That being so, the odds of good diet quality was significantly higher for long-term immigrant female compared with Canadian-born female (OR = 1.42 [1.09, 1.85]). Consistent with recent immigrant female, long-term immigrant female was also more likely to meet the recommended servings for whole fruit (OR = 2.51 [2.14, 2.94]), whole grains (OR = 1.91 [1.24, 2.96]), dairy (OR = 1.27 [1.018, 1.57]), and saturated fats (OR = 4.016 [2.15, 7.50]) than Canadian-born female. Unlike recent immigrant where sodium consumption was no different from Canadian-born, long-term immigrant female was more likely to meet the recommended servings for sodium intake (OR = 1.54 [1.22, 1.94]; $p<0.05$). Nevertheless, they had significantly lower odds of consuming the recommended greens and beans (OR = 0.045 [0.031, 0.067]), and total protein servings (OR = 0.70 [0.58, 0.85]) than Canadian-born female.

For immigrant female, we observe a shift in the consumption of some foods towards that of their Canadian-born counterpart. Dietary acculturation led to an improvement in the consumption of seafood and plant protein, refined grains, and added sugars. While recent

immigrant female had lower odds of consuming foods with seafood and plant protein and was more likely to exceed the recommended servings for refined grains and added sugars, these differences were comparable to Canadian-born female as the time of residence increases.

Model *b*. When we compare recent immigrant female to long-term immigrant female to help in examining how food consumption changes with stay in Canada, we observe improvement in the consumption of greens and beans (OR = 1.28 [1.05, 1.55]; $p<0.05$), seafood and plant protein (OR = 1.12 [1.025, 1.22]; $p<0.05$), refined grains (OR = 3.86 [2.05, 7.29]; $p<0.05$), and added sugars (OR = 1.55 [1.076, 2.23]; $p<0.05$) with increase in length of residence. We observe inadequacy in the consumption of dairy (OR = 0.77 [0.69, 0.86]; $p<0.05$), total protein foods (OR =0.79 [0.73, 0.87]; $p<0.05$), and fatty acids (OR = 0.74[0.56, 0.99]; $p<0.05$) as length of residence increases. Again, saturated fat consumption also increased with length of residence (OR = 0.54 [0.45, 0.65) ($p<0.05$).

Differences in diet quality as it relates to length of residence were also noted for male. Compared with Canadian-born male, recent immigrant [0-10 years] had significantly greater odds of good diet quality (OR = 1.38 [1.09, 1.74)]), as well as meet the recommended servings for total vegetables and fruit (OR = 1.32 [1.05, 1.66]), whole fruit (OR = 1.83 [1.50, 2.22]), whole grains (OR = 1.37 [1.026, 1.82]), total protein foods (OR = 1.37 [1.15, 1.62]), sodium (OR = 2.89 [2.36, 3.54]), and saturated fats (OR = 10.88 [7.35, 16.094]). Recent immigrant male had significantly lower odds of meeting the recommended servings for greens and beans (OR = 0.092 [0.071, 0.12]), fatty acids (OR = 0.36 [0.16, 0.82]), and refined grains (OR = 0.19 [0.059, 0.58]).

Male who are long-term immigrant were also more likely to have a good diet quality than their Canadian-born counterpart (OR = 1.83 [1.40, 2.39]). Pertaining to individual food components, long-term immigrant male had significantly higher odds of achieving the

recommended servings for whole fruit (OR = 2.12 [1.71, 2.61]), whole grains (OR = 1.63[1.19, 2.25]), total protein foods (OR = 1.27 [1.057, 1.52]), seafood and plant protein (OR = 1.45 [1.098, 1.90]), sodium (OR = 2.86 [2.26, 3.62]), added sugars (OR = 1.80 [1.11, 2.90]), and saturated fats (OR = 5.096 [3.28, 7.92]). Similarly, to recent immigrant male, long-term immigrant was less likely to consume foods with greens and beans (OR = 0.11 [0.079, 0.15]) and fatty acids (OR = 0.23 [0.092, 0.58]) when compared with Canadian-born male ($p<0.05$).

We observe a shift in the consumption of vegetables and fruit, and refined grains towards the Canadian-born population as length of residence increases. Although total vegetables and fruit were significantly higher at the early time of immigration, as length of residence increased, total vegetables and fruit consumption became comparable to that of Canadian-born male. Moreover, the high consumption of refined grains at earlier stages of immigration were diminished, therefore comparable to the Canadian-born male as length of residence increased.

Model *b*. For male, when we compare recent immigrant to long-term immigrant to help in examining how food consumption changes with stay in Canada, we observe improvement in the consumption of whole fruit (OR = 1.11 [1.00, 1.24]), greens and beans (OR = 1.26 [1.074, 1.49]; $p<0.05$), seafood and plant protein (OR = 1.23 [1.10, 1.36]; $p<0.05$), refined grains (OR = 2.86 [1.70, 4.80]; $p<0.05$), and added sugars (OR = 1.98 [1.44, 2.74]; $p<0.05$) with increase in length of residence. Similar to female, we observe inadequacy in the consumption of dairy (OR = 0.82 [0.71, 0.93]; $p<0.05$), and fatty acids (OR = 0.70 [0.50, 0.97]; $p<0.05$) as length of residence increases. Again, saturated fat consumption also increased with length of residence among male (OR = 0.45 [0.38, 0.53]; ($p<0.05$).

Ethnic differences

Stratified by length of residence, Table 12 presents results from the analyses of many logistic regression models examining the association between ethnicity and diet quality (C-HEI total scores) after controlling for age at immigration, age, gender, physical activity, smoking, education, and income. White was the reference category in these analyses.

Diet quality among recent immigrants

Among the recent immigrant subgroup, ethnicity was significantly related to good diet quality. Compared with White, the odds were significantly higher among Black (OR = 5.22 [3.68, 7.40]), East/Southeast Asian (OR = 3.11 [2.20, 4.39]), West Asian/Arab (OR = 2.72 [1.70, 4.34]), South Asian (OR = 15.66 [10.65, 23.01]), and Other (OR = 4.54 [3.06, 6.74]). No significant association was observed between recent immigrant who identified as Latin American and White.

With respect to recent immigrant who are female, compared with White, the odds were significantly higher among Black (OR = 6.39 [4.55, 8.99]), East/Southeast Asian (OR = 3.47 [2.65, 4.55]), West Asian/Arab (OR = 2.53 [1.60, 4.02]), South Asian (OR = 16.01 [11.20, 22.90]), Latin American (OR = 1.55 [1.00, 2.41]), and Other (OR = 5.20 [3.36, 8.05]). For recent immigrant who are male, the relationship between ethnicity and good diet quality was similar to that of their female counterpart. Compared with White, the odds were significantly higher among Black (OR = 4.96 [2.92, 8.43]), East/Southeast Asian (OR = 2.90 [1.64, 5.12), West Asian/Arab (OR = 2.85 [1.48, 5.52]), South Asian (OR = 18.71 [10.87, 32.21]), and Other (OR = 4.94 [2.57, 9.52]). Again, no significant association was observed between recent immigrant male who identify as Latin American and their White counterpart.

Diet quality among long-term immigrants

Among the long-term immigrant subgroup, ethnicity was significantly associated with good diet quality. Compared with White, the odds were significantly higher among Black (OR = 3.16 [2.83, 3.53]), East/Southeast Asian (OR = 2.12 [1.89, 2.37]), West Asian/Arab (OR = 1.61 [1.30, 1.99]), South Asian (OR = 11.43 [10.47, 12.47]), and Other (OR = 3.93 [3.39, 4.55]). No significant association was observed between Latin American and White. With respect to long-term immigrant who are female, compared with White, the odds were significantly higher among Black (OR = 2.93 [2.52, 3.40]), East/Southeast Asian (OR = 1.92 [1.65, 2.24]), West Asian/Arabs (OR = 1.42 [1.15, 1.75]), South Asian (OR = 10.93 [9.71, 12.31]), and Other (OR = 3.76 [3.14, 4.49]). No significant association was observed between Latin American and White.

For long-term immigrant who are male, the relationship between ethnicity and good diet quality was similar to that for their female counterpart. Compared with White, the odds were significantly higher among Black (OR = 3.43 [2.95, 3.99]), East/Southeast Asian (OR = 2.40 [2.09, 2.75), West Asian/Arab (OR = 1.67 [1.22, 2.29]), South Asian (OR = 11.64 [10.28, 13.17]), Other (OR = 4.07 [3.36, 4.93]). Again, no significant association was observed between recent immigrant male who are Latin American and recent immigrant male who identified as White.

3.4 Tables and Figures

Table 3: Demographic profile of Canada's population, aged 20 to 79 years old.

	Total	Female	Male
	Weighted %	**Weighted %**	**Weighted %**
Gender			
Female	49.64		
Male	50.36		
p-value	0.07		
Immigration status			
Canada-born	72.44	72.65	72.23
Immigrant	27.56	27.35	27.77
p-value	<0.001	<0.001	<0.001
Length of residence (years)			
0-4	11.47	11.62	11.32
5-9	14.93	14.73	15.12
10-14	13.43	12.46	14.37
15-19	9.9	11.39	8.45
20-24	10.03	8.63	11.4
25-29	8.47	10.38	6.61
30+	31.77	30.79	32.73
p-value	<0.001	<0.001	<0.001
Age at time of migration (years)			
< 13	16.63	16.03	17.21
13-19	12.42	11.97	12.84
20-34	46.1	48.6	43.74
35-49	21.03	18.89	23.07
50+	3.82	4.51	3.16
p-value	<0.001	<0.001	<0.001
Ethnicity			
Black	3.51	3.81	3.22
East/Southeast Asian	9.16	9.43	8.9
West Asian/Arab	2.7	1.94	3.46
South Asian	4.61	5.32	3.9
Latin American	1.44	1.63	1.27
Aboriginal	2.78	2.32	3.23
Other	2.32	1.64	2.99
White	73.48	73.92	73.05
p-value	<0.001	<0.001	<0.001
Age group (years)			
20-34	22.69	20.61	24.75
35-49	31.08	31.45	30.73
50-64	27.99	28.92	27.06
64-79	18.24	19.02	17.47
p-value	<0.001	<0.001	<0.001

Physical activity level			
Insufficient	54.42	60.21	48.72
Sufficient	45.58	39.79	51.28
p-value	<0.001	<0.001	0.32
Smoking			
Non-smoker	80.63	83.67	77.62
Smoker	19.37	16.33	22.38
p-value	<0.001	<0.001	<0.001
Education			
Less than high school	10.53	9.41	11.63
High school or eq.	33.82	31.4	36.2
Certificate/diploma	26.61	28.81	24.45
Bachelor degree and/or above	29.04	30.38	27.72
p-value	<0.001	<0.001	<0.001
Income			
Less than $39,999	23.72	25.71	21.75
$40,000 to $59,000	16.75	17.3	16.2
$60,000 to $79,000	7.51	8.08	6.95
$80,000 and higher	52.02	48.9	55.1
p-value	<0.001	<0.001	<0.001

Note. Values are weighted percentages and chi-square tests were used to test differences within categories. A *p-value* < 0.05 was considered statistically significant.

Table 4: Demographic characteristics of Canada's population according to immigration status, aged 20 to 79 years old.

	Total Sample		Female		Male	
	Immigrant	**Canadian-born**	**Immigrant**	**Canadian-born**	**Immigrant**	**Canadian-born**
	Weighted %	**Weighted %**	**Weighted %**	**Weighted %**	**Weighted %**	**Weighted %**
Ethnicity						
Black	9.44	1.27	9.73	1.6	9.17	0.95
East/Southeast Asian	32.24	1.96	29.26	1.78	26.53	2.13
West Asian/Arab	7.96	0.71	6.16	0.36	9.7	1.07
South Asian	13.83	1.11	15.49	1.5	12.21	0.72
Latin American	3.99	0.48	4.08	0.71	3.9	0.24
Aboriginal	-	3.82		3.19		4.44
Other	4.67	1.43	4.64	0.52	4.7	2.33
White	32.24	89.23	30.65	90.35	33.79	88.12
p-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Age group (years)						
20-34	17.08	24.88	14.4	23.01	19.68	26.74
35-49	38.07	28.4	39.6	28.4	36.59	28.4
50-64	26.38	28.55	27.44	29.38	25.35	27.73
64-79	18.47	18.17	18.56	19.21	18.38	17.13
p-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Physical activity level						
Insufficient	60.34	52.14	66.32	57.84	54.55	46.5
Sufficient	39.66	47.86	33.68	42.16	45.45	53.5
p-value	<0.001	0.05	<0.001	<0.001	0.1	0.01
Smoking						
Non-smoker	86.13	78.5	91.41	80.71	81.01	76.31
Smoker	13.87	21.5	8.59	19.29	18.99	23.69
p-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Education						
Less than high school	7.77	11.57	8.75	9.63	6.83	13.49
High school or eq.	29.25	35.56	31.71	31.35	26.88	39.72
Certificate/diploma	24.29	27.51	22.64	31.14	25.88	23.91
Bachelor degree and/or above	38.69	25.36	36.9	27.87	40.42	22.87
p-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Income						
Less than $39,999	28.13	22	30.55	23.82	25.79	20.2
$40,000 to $59,000	18.37	16.1	18.05	17.04	18.68	15.17
$60,000 to $79,000	9.52	6.74	11.02	6.96	8.08	6.53
$80,000 and higher	43.97	55.15	40.38	52.18	47.46	58.1
p-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Note. Values are weighted percentages and chi-square tests were used to test differences within categories. A *p-value* < 0.05 was considered statistically significant.

Table 5: Weighted mean[1] component scores on Canadian adaptation of Healthy Eating Index (C-HEI) 2015 among Canadian adults aged 20-79 years old.

	Total		Female		Male		
Components (maximum score possible)	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**	**P-value***
Adequacy:							
Total Vegetables and Fruit (10)	8.43	0.018	8.64	0.021	8.22	0.025	<0.0001
Whole Fruit (5)	3.14	0.014	3.34	0.017	2.93	0.021	<0.0001
Greens and Beans (5)	3.6	0.022	3.69	0.029	3.5	0.029	<0.0001
Whole Grains (10)	2.82	0.02	3.16	0.029	2.48	0.025	<0.0001
Dairy (10)	5.96	0.022	6.18	0.028	5.74	0.03	<0.0001
Total Protein Foods (5)	4.22	0.007	4.48	0.008	3.98	0.01	<0.0001
Seafood and Plant Protein (5)	3.13	0.016	3.46	0.015	2.81	0.024	<0.0001
Fatty Acids, (PUFA + MUFA)/SFA) (10)	4.89	0.028	4.76	0.036	5	0.037	<0.0001
Moderation:							
Refined Grains (10)	4.01	0.022	4.23	0.031	3.77	0.029	<0.0001
Sodium (10)	7.38	0.018	8.72	0.014	6.06	0.032	<0.0001
Added Sugars (10)	8.76	0.006	8.53	0.009	8.97	0.008	<0.0001
Saturated Fats (10)	6.68	0.023	6.55	0.031	6.8	0.029	<0.0001
HEI Total Score (100)	62.99	0.11	65.74	0.14	60.27	0.15	<0.0001

SE: Standard Error.

Note. Standard errors of the mean estimates are weighted and bootstrapped. [1]Due to the application of the NCI method, mean values are based on usual intakes, and adjusted for age, gender, sequence, and weekend.

*Statistically significant difference between female and male based on p-value<0.05 of Student's t-test.

Table 6: Weighted mean[1] component scores on Canadian adaptation of Healthy Eating Index (C-HEI) 2015 by immigration status among Canadian adults aged 20-79 years old.

	Immigrant		Canadian-born		
Components	**Mean**	**SE**	**Mean**	**SE**	**p-value***
Total Vegetables and Fruit	8.36	0.035	8.46	0.02	<0.0001
Whole Fruit	3.5	0.025	3	0.016	<0.0001
Greens and Beans	2.18	0.029	4.14	0.012	<0.0001
Whole Grains	3.27	0.056	2.64	0.016	<0.0001
Dairy	5.49	0.053	6.14	0.019	<0.0001
Total Protein Foods	4.17	0.014	4.24	0.0084	<0.0001
Seafood and Plant Protein	3.48	0.023	3	0.02	<0.0001
Fatty Acids, (PUFA + MUFA)/SFA)	5.94	0.063	4.49	0.019	<0.0001
Refined Grains	4.2	0.067	3.94	0.017	<0.0001
Sodium	8.06	0.041	7.12	0.024	<0.0001
Added Sugars	8.82	0.019	8.73	0.0061	<0.0001
Saturated Fats	7.61	0.048	6.33	0.016	<0.0001
HEI Total Score	65.06	0.25	62.19	0.12	<0.0001
Female					
Total vegetables and Fruit	8.44	0.043	8.71	0.022	<0.0001
Whole Fruit	3.71	0.03	3.2	0.019	<0.0001
Greens and Beans	2.15	0.037	4.28	0.014	<0.0001
Whole Grains	3.68	0.082	2.96	0.022	<0.0001
Dairy	5.88	0.071	6.29	0.026	<0.0001
Total Protein Foods	4.33	0.019	4.53	0.006	<0.0001
Seafood and Plant Protein	3.76	0.025	3.34	0.018	<0.0001
Fatty Acids, (PUFA + MUFA)/SFA)	5.83	0.091	4.37	0.025	<0.0001
Refined Grains	4.47	0.091	4.15	0.026	<0.0001
Sodium	8.84	0.035	8.67	0.013	<0.0001
Added Sugars	8.54	0.025	8.53	0.0087	0.51
Saturated Fats	7.53	0.064	6.19	0.024	<0.0001
HEI Total Score	67.17	0.31	65.21	0.14	<0.0001
Male					
Total Vegetables and Fruit	8.27	0.053	8.21	0.028	<0.0001
Whole Fruit	3.29	0.037	2.8	0.022	<0.0001
Greens and Beans	2.21	0.039	4	0.02	<0.001
Whole Grains	2.87	0.068	2.33	0.021	<0.001
Dairy	5.1	0.072	5.99	0.025	<0.0001
Total Protein Foods	4.02	0.018	3.96	0.013	<0.0001
Seafood and Plant Protein	3.21	0.032	2.65	0.029	<0.0001
Fatty Acids, (PUFA + MUFA)/SFA)	6.05	0.082	4.61	0.028	<0.0001
Refined Grains	3.94	0.088	3.72	0.024	<0.0001
Sodium	7.29	0.052	5.59	0.03	<0.0001
Added Sugars	9.1	0.022	8.93	0.0072	<0.0001
Saturated Fats	7.68	0.062	6.47	0.022	<0.0001
HEI Total Score	63.02	0.33	59.21	0.15	<0.0001

SE: Standard Error.
*Note***.** Standard error of the mean: estimates are weighted and bootstrapped. [1]Due to the application of the NCI method, mean values are based on usual intakes, and adjusted for age, gender, sequence, and weekend.
*Statistically significant difference between immigrant and Canadian-born based on p-value<0.05 of Student's t-test.

Table 7: Distribution of diet quality (weighted average C-HEI total score) to socio-demographic characteristics among immigrants and Canadian-born adults aged 20-79 years old.

	Immigrant		Canadian-born		
C-HEI 2015 score (Diet Quality)	**Mean[1]**	**SE**	**Mean[1]**	**SE**	**p-value***
Ethnicity					
Black	65.78	0.49	63.29	0.84	<0.0001
East/Southeast Asian	65.66	0.36	64.63	1.43	<0.0001
West Asian/Arab	64.3	0.56	61.73	0.87	<0.0001
South Asian	74.37	0.39	65.85	0.66	<0.0001
Latin American	61.38	0.87	58.08	1.34	<0.0001
Aboriginal	-		59.39	0.47	
Other	66.64	0.79	60.88	2.39	<0.0001
White	60.8	0.32	62.24	0.13	<0.0001
Age group (years)					
20-34	61.99	0.66	60.69	0.25	<0.0001
35-49	64.91	0.34	62.48	0.24	<0.0001
50-64	66.88	0.48	62.63	0.21	<0.0001
64-79	65.63	0.42	63.12	0.18	<0.0001
Gender					
Female	67.17	0.31	65.21	0.14	<0.0001
Male	63.02	0.33	59.21	0.15	<0.0001
Physical Activity					
Insufficient	65.01	0.28	61.23	0.16	<0.0001
Sufficient	65.14	0.41	63.24	0.16	<0.0001
Smoking					
Non-smoker	66.46	0.2	64.08	0.11	<0.0001
Smoker	56.42	0.4	55.31	0.19	<0.0001
Education					
Less than high school	62.96	0.68	57.12	0.29	<0.0001
High school or eq.	63.14	0.42	60.45	0.17	<0.0001
Certificate/diploma	65.14	0.42	61.83	0.18	<0.0001
Bach degree or uni. cert/degree	67	0.36	67.43	0.19	<0.0001
Income					
Less than $39,999	65.17	0.44	59.72	0.23	<0.0001
$40,000 to $59,000	64.76	0.5	61.65	0.26	<0.0001
$60,000 to $79,000	68.08	0.75	60.17	0.48	<0.0001
$80,000 and higher	64.47	0.37	63.59	0.15	<0.0001

SE: Standard Error.

Note. Standard error of the mean: estimates are weighted and bootstrapped. [1]Due to the application of the NCI method, mean values are based on usual intakes, and adjusted for age, gender, sequence, and weekend. A value closer to a 100 means better diet quality.

*Statistically significant difference between immigrant and Canadian-born based on p-value<0.05 of Student's t-test.

Table 8: Distribution of diet quality (weighted average C-HEI total score) by length of residence in Canada and socio-demographic characteristics for aged 20-79 years old.

	Recent Immigrant[2]		Long-term Immigrant[3]		
	Mean	**SE**	**Mean**	**SE**	
Age at time of migration (years)					
< 20	58.74	1	62.42	0.46	
20-34	64.76	0.78	66.16	0.34	
35-49	65.14	0.6	67.43	0.72	
50+	68.65	0.88	69.26	1.36	
p-value	<0.0001		<0.0001		
Ethnicity					*p-value**
Black	63.72	1.05	66.46	0.53	*<0.0001*
East/Southeast Asian	65.62	0.74	65.74	0.4	*N.S*
West Asian/Arab	63.76	0.98	64.79	0.57	*0.0079*
South Asian	72.84	0.73	75.29	0.41	*<0.0001*
Latin American	60.26	1.63	62.37	0.72	*<0.0001*
Aboriginal					
Other	63.14	1.79	67.41	0.72	*<0.0001*
White	60.79	0.9	60.84	0.34	*N.S*
p-value	<0.0001		<0.0001		
Age group (years)					
20-34	62.82	0.87	60.94	1.01	*<0.0001*
35-49	65.25	0.62	64.84	0.4	*<0.0001*
50-64	69.33	0.96	66.59	0.53	*<0.0001*
64-79	70.11	0.87	65.35	0.43	*<0.0001*
p-value	<0.0001		<0.0001		
Gender					
Female	67.57	0.53	67.05	0.36	
Male	62.61	0.6	63.23	0.37	
p-value	<0.0001		<0.0001		
Physical activity level					
Insufficient	65.43	0.54	64.9	0.32	
Sufficient	64.37	0.8	65.41	0.49	
p-value	<0.0001		<0.0001		
Smoking					
Non-smoker	66.12	0.46	66.66	0.23	
Smoker	56.79	0.79	56.17	0.41	
p-value	<0.0001		<0.0001		

Table continued on the next page.

Education				
Less than high school	65.43	0.93	62.74	0.73
High school or eq.	61.62	1.04	63.52	0.45
Certificate/diploma	64.76	1.09	65.29	0.46
Bachelor degree and/or above	66.51	0.58	67.3	0.44
p-value	<0.0001		<0.0001	
Income				
Less than $39,999	64.89	0.84	65.36	0.48
$40,000 to $59,000	64.36	1.06	64.91	0.54
$60,000 to $79,000	67.91	2.07	68.21	0.72
$80,000 and higher	64.84	0.61	64.41	0.43
p-value	<0.0001		<0.0001	

SE: Standard Error. N.S: Non-significant.
Note. Standard error of the mean: estimates are weighted and bootstrapped. [1] Due to the application of the NCI method, mean values are based on usual intakes, and adjusted for age, gender, sequence, and weekend. A value closer to a 100 means better diet quality. [2] Recent immigrant: person who immigrated to Canada within the last 10 years.
[3] Long-term immigrant: person who immigrated to Canada 11 or more years.
*p-value<0.05 of Student's t-test.

Table 9: Association between immigration status and diet quality[1] and compliance with recommended component guidelines among Canadian adults aged 20-79 years old.

Component[1]	All respondents		Female		Male	
	Adjusted Odds	95% CI	Adjusted Odds	95% CI	Adjusted Odds	95% CI
Adequacy:						
Total Vegetables and Fruit	1.16*	0.95, 1.41	1.04	0.78, 1.39	1.28	0.99, 1.65
Whole Fruit	2.59*	0.64, 2.96	2.87*	2.37, 3.46	2.60*	2.09, 3.23
Greens and Beans	0.075*	0.054, 0.10	0.048*	0.030, 0.075	0.10*	0.07, 0.14
Whole Grains	2.13*	1.54, 2.93	2.44*	1.58, 3.78	1.77*	1.26, 2.49
Dairy	1.25*	1.03, 1.52	1.51*	1.19, 1.93	1	0.75, 1.33
Total Protein Foods	1.07	0.89, 1.28	0.9	0.73, 1.10	1.57*	1.27, 1.94
Seafood and Plant Protein	1.67*	1.34, 2.09	1.55*	1.16, 2.07	2.12*	1.55, 2.90
Fatty Acids, (PUFA + MUFA)/SFA)	0.56	0.20, 1.57	1.08	0.28, 4.11	0.26	0.06, 1.09
Moderation:						
Refined Grains	2.06*	1.01, 4.21	1.83	0.72, 4.66	1.94	0.78, 4.83
Sodium	2.92*	2.44, 3.51	2.05*	1.58, 2.67	3.15*	2.46, 4.04
Added Sugars	1.73*	1.11, 2.69	1.21	0.58, 2.52	2.26*	1.34, 3.80
Saturated Fats	7.86*	5.29, 11.68	5.43*	3.05, 9.66	9.37*	5.63, 15.57
C-HEI 2015 total score						
Good Diet Quality[1]	1.84*	1.51, 2.26	1.84*	1.38, 2.44	1.92*	1.47, 2.51

CI: Confidence intervals.
Note. Weighted results from multiple analyses of logistic regression models, controlling for length of residence, age at immigration, race, age, gender, physical activity level, smoking, education, and income. Canadian-born was the referent category in these analyses. [1] Good diet quality defined as having a C-HEI 2015 total score of 80 or greater; thus, the likelihood of achieving a good diet quality. Individual food Components are defined as whether participant meet the diet recommendation servings (achieve maximum score for C-HEI scoring) or not. *P<0.05; Confidence intervals (CI) are bootstrapped estimates.

Table 9.1: Association between ethnicity[1] and diet quality[2] according to immigration status among Canadian adults aged 20-79 years old.

	Immigrant		Canadian-born	
C-HEI 2015 (Good diet quality)[1]	**Adjusted Odds**	**95% CI**	**Adjusted Odds**	**95% CI**
Ethnicity				
Total sample				
Black	3.36*	2.97, 3.81	1.01	0.87, 1.18
East/Southeast Asian	2.32*	2.07, 2.61	1.54*	1.25, 1.89
West Asian/Arab	1.82*	1.47, 2.25	0.67	0.39, 1.15
South Asian	12.15*	10.96, 13.46	0.61*	0.56, 0.66
Latin American	1.08	0.91, 1.28	0.0070*	0.0014, 0.034
Aboriginal[2]	-		0.99	0.93, 1.06
Other	3.85*	3.28, 4.51	1.66*	1.47, 1.87
White	1		1	
Female				
Black	3.14*	2.69, 3.66	0.99	0.86, 1.15
East/Southeast Asian	2.16*	1.89, 2.48	1.32*	1.0079, 1.72
West Asian/Arab	1.53*	1.24, 1.88	0.51*	0.27, 0.98
South Asian	11.37*	10.10, 12.80	0.55*	0.51, 0.60
Latin American	1.08	0.91, 1.29	0.0056*	0.0009, 0.036
Aboriginal[3]	-		1.03	0.97, 1.10
Other	3.56*	2.92, 4.33	1.71*	1.60, 1.82
White	1		1	
Male				
Black	3.60*	3.03, 4.28	0.96	0.74, 1.24
East/Southeast Asian	2.52*	2.13, 2.98	1.89*	1.33, 2.68
West Asian/Arab	1.97*	1.45, 2.66	0.92	0.24, 3.43
South Asian	12.88*	11.04, 15.04	0.85	0.64, 1.12
Latin American	1.04	0.68, 1.59	0.017*	0.0051, 0.056
Aboriginal[3]	-		0.9	0.80, 1.0074
Other	4.09*	3.38, 4.96	1.76*	1.51, 2.04
White	1		1	

CI: Confidence intervals.

Note. Weighted results from multiple analyses of logistic regression models, adjusted for age at immigration, gender, age, physical activity, smoking, education, and income. [1] Good diet quality is defined as having a C-HEI 2015 total score of 80 or greater; thus, the likelihood of achieving a good diet quality. [2]Aboriginals were excluded from immigrant group. *P<0.05; CI estimates are bootstrapped.

Figure 1: Weighted C-HEI total scores (diet quality) by length of residence in Canada.

Note. Standard error of the mean: estimates are weighted and bootstrapped. [1]Due to the application of the NCI method, mean values are based on usual intakes, and adjusted for age, gender, sequence, and weekend. A value closer to a 100 means better diet quality.
P<0.0001.

Table 10: Association between length of residence and diet quality[2] among Canadian adults aged 20-79 years old.

	Good diet quality[2]	
	Adjusted Odds	**95% CI**
Length of Residence		
0-4 years	1.15	0.92, 1.43
5-9 years	1.42*	1.15, 1.75
10-14 years	1.36*	1.10, 1.67
15-19 years	1.59*	1.29, 1.95
20-24 years	1.76*	1.40, 2.22
25-29 years	1.82*	1.43, 2.31
30+ years	1.83*	1.50, 2.24
Canadian-born	1	-

CI: Confidence intervals.

Note. Weighted results from multiple analyses of logistic regression models, adjusted for age at immigration, gender, age, physical activity, smoking, education, and income. Canadian-born was the referent category in the analysis. [2] Good diet quality defined as having a C-HEI 2015 total score of 80 or greater; thus, the likelihood of achieving a good diet quality. *P<0.05; CI estimates are bootstrapped.

Table 10.1: Association between length of residence and diet quality[2] among Canadian adults aged 20-79 years old.

	Good diet quality[2]	
	Adjusted Odds	**95% CI**
Length of Residence		
5-9 years	1.27*	1.07, 1.51
10-14 years	1.11	0.94, 1.31
15-19 years	1.31*	1.09, 1.57
20-24 years	1.29*	1.05, 1.58
25-29 years	1.32*	1.06, 1.64
30+ years	1.32*	1.05, 1.67
0-4 years	1	-

CI: Confidence intervals.

Note. Weighted results from multiple analyses of logistic regression models, adjusted for age at immigration, gender, age, physical activity, smoking, education, and income. Recent immigrant whose length of residence is 0 to 4 years was the referent category in the analysis. [2] Good diet quality defined as having a C-HEI 2015 total score of 80 or greater; thus, the likelihood of achieving a good diet quality. *P<0.05; CI estimates are bootstrapped.

Table 11: Association between length of residence and diet quality and compliance with recommended total vegetables and fruit, whole fruit, greens and beans guidelines, among Canadian adults, aged 20-79 years old.

	Model	Good diet quality	Total vegetables &fruit	Whole fruit	Greens and beans
Length of residence		**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**
Total sample					
Recent (0 to 10 yrs.)	a	1.23* (1.01, 1.49)	1.01(0.82, 1.25)	2.06* (1.79, 2.35)	0.05* (0.038, 0.070)
	b	1(-)	1(-)	1(-)	1(-)
Long-term (1 or more yrs.)	a	1.51* (1.24, 1.83)	1.02 (0.84, 1.24)	2.21* (1.93, 2.53)	0.071* (0.052, 0.096)
	b	1.03 (0.92, 1.14)	0.95 (0.86, 1.04)	0.99 (0.92, 1.07)	1.28* (0.77, 1.21)
Canadian-born	a	1(-)	1(-)	1(-)	1(-)
Female					
Recent (0 to 10 yrs.)	a	1.28 (0.97, 1.67)	0.87 (0.66, 1.16)	2.45* (2.07, 2.91)	0.030* (0.020, 0.045)
	b	1(…)	1(-)	1(-)	1(-)
Long-term (11 or more yrs.)	a	1.42* (1.09, 1.85)	0.95 (0.72, 1.26)	2.51* (2.14, 2.94)	0.045* (0.031, 0.067)
	b	0.98 (0.85, 1.14)	0.92 (0.82, 1.03)	0.93 (0.85, 1.00)	1.28* (1.05, 1.55)
Canadian-born	a	1(-)	1(-)	1(-)	1(-)
Male					
Recent (0 to 10 yrs.)	a	1.38* (1.09, 1.74)	1.32* (1.05, 1.66)	1.83* (1.50, 2.22)	0.092* (0.071, 0.12)
	b	1(-)	1(-)	1(-)	1(-)
Long-term (11 or more yrs.)	a	1.83*(1.40, 2.39)	1.17 (0.92, 1.49)	2.12* (1.71, 2.61)	0.11* (0.079, 0.15)
	b	1.12 (0.96, 1.30)	0.97 (0.83, 1.12)	1.11* (1.00, 1.24)	1.26* (1.074, 1.49)
Canadian-born	a	1(-)	1(-)	1(-)	1(-)

CI: Confidence intervals.

Note. Weighted results from multiple analyses of logistic regression models, adjusted for age at immigration, gender, age, physical activity, smoking, education, and income. Model *a* use Canadian-born as referent, and model *b* use recent immigrant whose length of residence is 0 to 10 years as referent. Good diet quality is defined as having a C-HEI 2015 total score of 80 or greater; thus, the likelihood of achieving a good diet quality. Individual food Components are defined as whether participant meet the diet recommendation servings (achieve maximum score for C-HEI scoring) or not.

*P<0.05; CI estimates are bootstrapped.

Table 11.1: Association between length of residence and compliance with recommended whole grains, dairy, total protein foods, seafood and plant protein guidelines, among Canadian adults aged 20-79 years old.

	Model	Whole grains	Dairy	Total protein foods	Seafood &plant protein
Length of residence		**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**
Total Sample					
Recent (0 to 10 yrs.)	a	1.51*(1.15, 1.20)	1.35* (1.14, 1.61)	0.96 (0.79, 1.16)	0.76* (0.60, 0.96)
	b	1(-)	1(-)	1(-)	1(-)
Long-term (11 or more yrs.)	a	1.75* (1.27, 2.42)	1.13 (0.95, 1.35)	0.87 (0.73, 1.033)	1.17 (0.94, 1.46)
	b	1.00 (0.82, 1.22)	0.78* (0.71, 0.84)	0.86* (0.81, 0.92)	1.18* (1.10, 1.27)
Canadian-born	a	1(-)	1(-)	1(-)	1(-)
Female					
Recent (0 to 10 yrs.)	a	1.74* (1.19, 2.54)	1.52* (1.22, 1.88)	0.78* (0.63, 0.96)	0.76* (0.58, 1.0013)
	b	1(-)	1(-)	1(-)	1(-)
Long-term (11 or more yrs.)	a	1.91* (1.24, 2.96)	1.27* (1.018, 1.57)	0.70*(0.58, 0.85)	1.09 (0.83, 1.42)
	b	0.97 (0.75, 1.27)	0.77* (0.69, 0.86)	0.79* (0.73, 0.87)	1.12* (1.025, 1.22)
Canadian-born	a	1(-)	1(-)	1(-)	1(-)
Male					
Recent (0 to 10 yrs.)	a	1.37* (1.026, 1.82)	1.21 (0.93, 1.56)	1.37* (1.15, 1.62)	0.92 (0.70, 1.22)
	b	1(-)	1(-)	1(-)	1(-)
Long-term (11 or more yrs.)	a	1.63* (1.19, 2.25)	0.97 (0.74, 1.27)	1.27* (1.057, 1.52)	1.45*(1.098, 1.90)
	b	1.023 (1.22, 1.49)	0.82* (0.71, 0.93)	0.91 (0.83, 1.0085)	1.23* (1.10, 1.36)
Canadian-born	a	1(-)	1(-)	1(-)	1(-)

CI: Confidence intervals.

Note. Weighted results from multiple analyses of logistic regression models, adjusted for age at immigration, gender, age, physical activity, smoking, education, and income. Model *a* use Canadian-born as referent, and model *b* use recent immigrant whose length of residence is 0 to 10 years as referent. Food Components are defined as whether participant meet the diet recommendation servings (achieve maximum score for C-HEI scoring) or not.

*P<0.05; CI estimates are bootstrapped.

Table 11.2: Association between length of residence and compliance with recommended fatty acids, refined grains, sodium, added sugars, and saturated fats guidelines, among Canadian adults aged 20-79 years old.

	Model	Fatty acids	Refined grains	Sodium	Added sugars	Saturated fats
Length of Stay in Canada		**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**
Total Sample						
Recent (0 to 10 yrs.)	a	0.46* (0.25, 0.85)	0.30* (0.15, 0.58)	1.73* (1.47, 2.024)	0.57* (0.39, 0.83)	8.85* (5.83, 13.44)
	b	1(-)	1(-)	1(-)	1(-)	1(-)
Long-term (11 or more yrs.)	a	0.39* (0.19, 0.78)	1.44 (0.75, 2.79)	2.12* (1.78, 2.51)	1.18 (0.78, 1.78)	4.78* (3.17, 7.20)
	b	0.73* (0.59, 0.91)	3.69* (2.32, 5.87)	1.0013 (0.92, 1.088)	1.74* (1.33, 2.27)	0.50* (0.44, 0.57)
Canadian-born	a	1(-)	1(-)	1(-)	1(-)	1(-)
Female						
Recent (0 to 10 yrs.)	a	0.64 (0.28, 1.47)	0.39* (0.16, 0.95)	1.24 (0.99, 1.57)	0.33* (0.18, 0.60)	6.78* (3.53, 13.01)
	b	1(-)	1(-)	1(-)	1(-)	1(-)
Long-term (11 or more yrs.)	a	0.61 (0.25, 1.51)	1.59 (0.67, 3.76)	1.54* (1.22, 1.94)	0.64 (0.34, 1.21)	4.016* (2.15, 7.50)
	b	0.74* (0.56, 0.99)	3.86* (2.05, 7.29)	1.040 (0.95, 1.14)	1.55* (1.076, 2.23)	0.54* (0.45, 0.65)
Canadian-born	a	1(-)	1(-)	1(-)	1(-)	1(-)
Male						
Recent (0 to 10 yrs.)	a	0.36* (0.16, 0.82)	0.19* (0.059, 0.58)	2.89* (2.36, 3.54)	0.83 (0.53, 1.28)	10.88* (7.35, 16.094)
	b	1(-)	1(-)	1(-)	1(-)	1(-)
Long-term (11 or more yrs.)	a	0.23* (0.092, 0.58)	1.22 (0.54, 2.79)	2.86* (2.26, 3.62)	1.80* (1.11, 2.90)	5.096* (3.28, 7.92)
	b	0.70* (0.50, 0.97)	2.86* (1.70, 4.80)	0.97 (0.84, 1.12)	1.98* (1.44, 2.74)	0.45* (0.38, 0.53)
Canadian-born	a	1(-)	1(-)	1(-)	1(-)	1(-)

CI: Confidence intervals.

Note. Weighted results from multiple analyses of logistic regression models, adjusted for age at immigration, gender, age, physical activity, smoking, education, and income. Model *a* use Canadian-born as referent, and model *b* use recent immigrant whose length of residence is 0 to 10 years as referent. Food Components are defined as whether participant meet the diet recommendation servings (achieve maximum score for C-HEI scoring) or not.

*P<0.05; CI estimates are bootstrapped.

Table 12: Association between ethnicity and diet quality[2] according to length of residence among Canadian adults aged 20-79 years old.

	Recent Immigrant[2]		Long-term Immigrant[3]	
Good diet quality[1]	**Adjusted Odds**	**95% CI**	**Adjusted Odds**	**95% CI**
Ethnicity				
Total sample				
Black	5.22*	3.68, 7.40	3.16*	2.83, 3.53
East/Southeast Asian	3.11*	2.20, 4.39	2.12*	1.89, 2.37
West Asian/Arab	2.72*	1.70, 4.34	1.61*	1.30, 1.99
South Asian	15.66*	10.65, 23.01	11.43*	10.47, 12.47
Latin American	1.18	0.73, 1.91	1.1	0.96, 1.27
Other	4.54*	3.06, 6.74	3.93*	3.39, 4.55
White	1	…	1	…
Female				
Black	6.39*	4.55, 8.99	2.93*	2.52, 3.40
East/Southeast Asian	3.47*	2.65, 4.55	1.92*	1.65, 2.24
West Asian/Arab	2.53*	1.60, 4.02	1.42*	1.15, 1.75
South Asian	16.01*	11.20, 22.90	10.93*	9.71, 12.31
Latin American	1.55*	1.00, 2.41	1.04	0.86, 1.25
Other	5.20*	3.36, 8.05	3.76*	3.14, 4.49
White	1	…	1	…
Male				
Black	4.96*	2.92, 8.43	3.43*	2.95, 3.99
East/Southeast Asian	2.90*	1.64, 5.12	2.40*	2.09, 2.75
West Asian/Arab	2.85*	1.48, 5.52	1.67*	1.22, 2.29
South Asian	18.71*	10.87, 32.21	11.64*	10.28, 13.17
Latin American	1.14	0.39, 3.33	1.14	0.86, 1.51
Other	4.94*	2.57, 9.52	4.07*	3.36, 4.93
White	1	…	1	…

CI: Confidence intervals.

Note. Weighted results from multiple analyses of logistic regression models, adjusted for age at immigration, gender, age, physical activity, smoking, education, and income. [1] Good diet quality defined as having a C-HEI 2015 total score of 80 or greater; thus, the likelihood of achieving a good diet quality. [2] Recent immigrant: person who immigrated to Canada within the last 10 years. [3] Long-term immigrant: person who immigrated to Canada 11 or more years.

*P<0.05; CI estimates are bootstrapped.

Chapter 4

Discussion

4.1 Introduction

Diet and nutrition are important factors in the promotion and maintenance of good health throughout the entire life course. Their role as determinants of chronic diseases is well established and they, therefore, occupy a prominent position in prevention activities (Di Daniele, 2019; Madden et al., 2008; WHO, 2020). Although the purpose of this study is not to make causal inferences between diet and chronic diseases, with existing evidence linking dietary behaviours to diseases, it is of utmost importance to assess the dietary patterns of Canada's population. Moreover, the burden of chronic diseases falls disproportionately on immigrants and racial-ethnic minorities (Agyemang & van den Born, 2019; Beiser, 2005; Bingham et al., 2016; Chiu et al., 2010; Creatore et al., 2010; Di Cesare et al., 2013; Ishmail et al., 2022; Pavli & Maltezou, 2017), therefore, examining the dietary patterns of the population may offer a framework for health promotion among our most vulnerable groups. With this in mind, the questions investigated in this thesis are whether dietary patterns vary across immigrants and domestic residents of Canada and whether diet quality changes in years since the time of immigration.

4.1.1 Canada's adult population

Findings of this thesis research are consistent with previous studies which suggest that overall adherence to the CFG 2007 is low among the Canadian adult population (Garriquet, 2009; Jessri et al., 2017; McInerney et al., 2018). In a nationally representative sample of Canadian adults, this research estimated a mean C-HEI 2015 score of 62.99 out of 100 which implies that the adult Canadian diet requires improvement (Bowman et al., 1998). This estimate is comparable to those

previously reported for the Canadian population. Just to name a few, Garriguet (2009) reported an HEI-C 2005 score of 58.8 out of 100 and McInerney et al (2018) reported a C-HEI score of 64.4 out of 100 in their adult sample. The differences between the C-HEI scores reported in this study population and those reported by others likely reflect differences in the study sample, methodology and dietary analysis strategies (i.e., NCI method). Due to the use of the NCI method in our study, findings are based on the usual intake of food components rather than the daily intakes reported in the other studies. The version of HEI used in adaptation may also affect total scores as the components used in arriving at total scores vary between the previous HEI and the current version employed for this study. Consistent with previous Canadian data revealing pronounced differences between genders in their diet quality, women were more likely to have a good diet quality than men (Garriguet, 2009; Hosseini et al., 2022; Jessri et al.,2017; McInerney et al., 2018). Except for the fatty acids component where men reported higher mean scores, women had higher scores for all other adequacy components. In relation to the moderation components, women were more likely to comply with the guidelines for refined grains and sodium, while men adhered to the guidelines for added sugars and saturated fats better than women. In line with our findings, previous studies have also reported higher intakes of fruit and vegetables (Garriguet, 2006; McInerney et al., 2018; Pérez, 2002a), meat and alternatives as well as a lower frequency of consumption of sodium for women compared with men (McInerney et al., 2018). McInerney et al (2018) study also echo our findings that men's intake of saturated fat is lower than women's, hence the higher C-HEI score. Conversely, Garriguet (2006) reported that irrespective of age, women eat less meat than men do. This finding did not specify whether alternative proteins (i.e., legumes, soy products and eggs) were included, which could explain the differences in our findings.

Among Canada's adult population, we observed the lowest index score, specifically, the lowest consumption of whole grains among the 12 food components even when gender differences were considered. Low whole grain intakes among Canada's population have been noted by McInerney and peers (2018), and Vatanparast and colleagues (2017). Similar patterns have also been found in studies from the USA where there seems to be a national preference for refined grains, and consequently, consumption of whole-grain foods by U.S. adults falls well below the recommended level (Cleveland et al., 2000; Lin & Yen, 2007; Reicks et al., 2014).

4.1.2 Research objective 1A: Diet quality and food consumption across immigrants and domestic residents of Canada

In accordance with the research objectives being investigated, this study revealed that there is substantial heterogeneity in diet quality and food consumption across immigrants and domestic residents of Canada. In particular, immigration status and length of residence in Canada were found to influence diet quality as well as the likelihood of consumption of some food components. Immigrants as a whole had a better diet quality than Canadian-born, however, our findings provide mixed support when we examine components of diet quality (i.e., component scores). In other words, despite the better diet quality among immigrants, the likelihood of adherence to the recommendations of CFG 2007 was not always higher compared with Canadian-born. With reference to components of diet quality (i.e., component scores), we observed that immigrants were more likely to consume vegetables and fruit, whole fruit, whole grains, seafood and plant proteins, and dairy products. They were also more likely to conform to dietary guidance for refined grains, sodium, added sugars, and saturated fats. Even so, consumption of greens and beans was low in the immigrant diet. Moreover, there was no difference in the consumption of protein foods

and fatty acids between immigrants and Canadian-born. Considering that previous immigrant studies on eating habits in Canada have not focused on most of the above food components or otherwise used dietary quality indices, comparisons across studies are limited. Our findings, howbeit are compatible with those of Garriguet (2009) who identified HEI scores and association with immigration status among the Canadian population and reported better diet quality for immigrants compared with non-immigrants. Hosseini et al. (2022), in their studies regarding income and diet quality in Canada, also reported higher diet quality among immigrants compared with non-immigrants. Previous studies have reported more frequent intakes of fruit and vegetables among immigrants in Canada (Kandola et al., 2016; Perez, 2002), Portugal (Costa et al., 2018), and the USA (Gustavsen et al., 2021). A comparison of our results with other studies cannot be made when examining the association between consumption of the other mentioned food components among immigrants as a whole in Canada. Nonetheless, Nardocci, Leclerc and colleagues' (2019) cross-sectional study including 19,363 adults aged 18 years and older from the 2004 CCHS, found that immigrants consume significantly less ultra-processed foods than native-born Canadians. Ultra-processed diets have been associated with unhealthy dietary patterns and are characterized as "energy-dense, high in free and added sugars, saturated and trans fats, and lacking in most micronutrients and other bioactive compounds, fibre, and protein" (Louzada et al., 2018; Martinez Steele et al., 2017; Steele and Monteiro, 2017; Moubarac et al., 2017; Nardocci, Leclerc et al., 2019; Nardocci, Polsky et al., 2019). Although direct comparisons cannot be made, these studies do shed light on why diet quality was found to be higher among immigrants in the current study.

The diet quality and food consumption differed by gender and immigration status. Immigrant women and men had more advantages when we considered diet quality. In addition, immigrant

women and men were more likely to consume whole fruit, whole grains, dairy, seafood and plant proteins, and meet the recommended intake for saturated fats compared with Canadian-born women and men. Immigrant men were also more likely to have higher intakes of total protein foods and lower intakes of sodium and added sugars compared to Canadian-born men. Conversely, both immigrant men and women consume fewer greens and beans compared to their Canadian-born counterparts. Although immigrants consume more vegetables and fruit than the Canadian-born population, this dietary habit was not observed when we compared immigrant women and men to their respective Canadian-born gender. Consequently, the likelihood of vegetables and fruit consumption was comparable between both gender groups of immigrants and Canadian-born.

In addition to gender differences, variations in diet quality score and immigration status were observed across age groups, physical activity, smoking, education, and income groups. In particular, the average C-HEI score was greater for immigrants across all socio-demographic variables. By way of explanation, immigrants achieved a greater average C-HEI score irrespective of age group, physical activity status, smoking status, and income bracket. We observed a slight deviation from this trend when we performed comparisons between those who had obtained a bachelor's degree or higher. Among those who hold a bachelor's or higher degrees, immigrants had lower C-HEI mean scores than Canadian-born in the same education bracket. Nonetheless, among all other education groups, immigrants had higher scores for overall diet quality compared with Canadian-born.

Ethnic differentials in diet quality

Regarding ethnic differences, the results reinforced the notion that immigrants are healthier than their Canadian-born counterparts when it pertains to nutrition. Our findings also establish that

diet quality is not homogenous even within the same ethnic group. Immigrant ethnic minorities experience different dietary advantages from Canadian-born ethnic minorities even when they are from the same ethnic background. This study reveals that among ethnic minorities in Canada, immigrants who identify as Black, East/Southeast Asian, West Asian/Arab, South Asian, Latin American, and Other had more favourable diet quality compared with their Canadian-born Black, East/Southeast Asian, West Asian/Arab, South Asian, Latin American, and Other. These results echo findings from Brown et al (2018) who reported that foreign-born Blacks have better diet quality than their US-born counterparts. Interestingly, White immigrants had lower diet quality compared with White Canadian-born. The findings presented here provide insight into the health of White immigrants by suggesting that, perhaps, White immigrants do not benefit from the immigrant health advantage [as it pertains to nutrition] as do visible minority immigrants. This hypothesis warrants further investigation.

To help in understanding how each ethnicity compares with the predominant ethnic group [White] within the same immigration status, the odds of good diet quality were calculated. Among immigrant groups, this study conveys that Black, East/Southeast Asian, West Asian/Arab, South Asian, and those who identify as Other were more likely to have good diet quality compared with the majority ethnic group [White]. Although we observed a positive direction in the odds of the outcome for those who identify as Latin American, this association was quite weak. These trends remain even after gender stratification. As we might expect, White had the lowest overall C-HEI mean score among ethnic immigrants.

Among domestic residents, this study conveys that the majority group, which is White, has a health advantage over most Canadian-born visible minorities. When compared to Canadian-born White, Canadian-born South Asian and Latin American display lower probabilities of reporting

good diet quality. The same was true for Latin American women and men's diet quality; however, this lower probability of diet quality was observed only among Canadian-born South Asian women and not men. Further, we observe lower probabilities of good diet quality for Canadian-born West Asian/Arab and Aboriginal, but the associations were not statistically significant from that of Canadian-born White. For women, however, this estimate for West Asian/Arab achieved statistical significance. Likewise, Canadian-born Black displayed similar probabilities of good diet quality as White. The same is true for Black women and men's diet quality. On the contrary, Canadian-born East/Southeast Asian and those who identify as Other were more likely to have an overall good diet quality compared to Canadian-born White even when gender differences were considered.

When we examine diet quality based on the frequency of intake, our findings indicate that Aboriginals had the lowest average C-HEI score among Canadian-born ethnic backgrounds. Considering that food insecurity among our indigenous communities remains higher than among non-indigenous Canadians (Batal et al., 2021; Huet et al., 2012), it is not surprising that adherence to nutrition guidelines is low. In fact, previous reports suggest that food security is a protective factor against unhealthy dietary practices for members of this community (Willows, 2005). Adults from food insecure households (particularly Inuits) were reported to have lower HEI scores, lower consumption of vegetables and fruit, grains, and dairy products, and consumed a greater percentage of energy from high-sugar foods compared with adults from food secure households (Huet et al., 2012).

4.1.3 Research objective 1B: Diet quality and food consumption with length residence in Canada

In addressing the study's second research objective, we noted better diet quality among immigrants who have stayed in Canada longer. To investigate within-immigrant heterogeneity in changes in diet quality associated with duration in Canada, length of residence was broken down into five-year intervals and the average C-HEI scores were calculated. Our results even though did not display a clear gradient in the improvement of diet quality, we observed a relatively slow increase in mean values from those who immigrated in the last 0 to 4 years until 30+ years when there is an obvious decrease in diet quality compared to those who resided in Canada for 25 to 29 years. Our findings from within-immigrant probability analysis provide support for our conclusion, which is that the likelihood of good diet quality was greater for immigrants in any length of residence category when compared with respondents who immigrated in the last 0-4 years. For reasons unknown to us, there is a decrease in the average C-HEI score for those who immigrated in the past 10-14 years from their previous counterparts. Moreover, although they displayed a positive direction in their odds ratio, the association was not statistically significant compared with those whose length of residence is from 0 to 4 years.

When immigrants were compared with Canadian-born, our findings still maintain that not only do immigrants have nutritional health advantages, but diet quality improves with length of residence in Canada. Apart from respondents who immigrated in the last 0-4 years whose diet quality was indistinguishable from Canadian-born, in any category of the length of residence, the odds of good diet quality were greater compared with Canadian-born. In contrast with this finding, Davison and Gondara (2019), in their nationally representative cross-sectional study, found that irrespective of length of immigration the proportion of foreign-born immigrants with poor diet quality were greater than that of native-born Canadians. Differences in our findings could be

because of differences in age of our sample populations and the measure of diet quality. The current study is limited to those between the ages of 20 and 79 and diet quality was measured by HEI food components only, while Davison and Gondara (2019) sample consisted of 9 years and older and measured diet quality by food components and nutrient intakes.

Ethnic differentials in diet quality and length of residence in Canada

When ethnicity was considered, although our findings remain that diet quality is higher in later years of immigration, we also noted that this relationship was not the same for each ethnicity. To avoid restrictive sample sizes as well as conform to Statistics Canada's, especially CCHS data's definition of immigration status categories, and length of residence was collapsed into three categories: Recent immigrant [person who immigrated to Canada within the last 10 years], Long-term immigrant [person who immigrated to Canada 11 or more years], and Canadian-born. When we investigated the average C-HEI score (diet quality) within the same racial groups, we found that the average C-HEI scores for East/Southeast Asian and White were not different between recent and long-term immigrants. Nonetheless, the average C-HEI scores improved for Black, West Asian/Arab, South Asian, Latin American, and those who identify as Other with increased length of residence. There were some notable differences when we compare Whites to ethnic minorities within the same length of residence on their odds of achieving good diet quality. Our findings suggest that irrespective of the length of residence, Black, East/Southeast Asian, West Asian/Arab, South Asian, and those who identify as Other were more likely to have a good diet quality compared with White immigrants. However, both recent and long-term immigrants who identify as Latin American were not different from their White counterparts. Results from the stratified analysis reviewed the same associations for men and women.

Acculturation-driven trends in food consumption

In investigating dietary patterns, the findings suggest that, despite the noted nutritional advantages, adherence to some food components recommendations was low compared with Canadian-born. Results from the stratified analysis revealed that compared with Canadian-born, recent immigrants and long-term immigrants were more likely to meet the recommended servings for whole fruit, whole grains, sodium, and saturated fats. Conversely, they were less likely to consume greens and beans and fatty acids foods. Another finding that warrants attention was the evidence of both negative and positive dietary habits due to acculturation. We observed that although the consumption of dairy, seafood and plant protein was more likely to be better in the early years of residence compared with Canadian-born, as stay in Canada increases, the consumption of these foods becomes indistinguishable from a Canadian-born diet. Positively, in the early years of immigration, the likelihood of exceeding the recommended servings for refined grains and added sugars were greater than Canadian-born, yet with the increase in the length of residence, the levels of consumption for these components become indistinguishable from the Canadian-born diet.

For women, recent immigrants and long-term immigrants were both more likely to consume whole fruit, whole grains, dairy, and to achieve the recommended servings for saturated fats. On the other hand, they were less likely to consume greens and beans and total protein foods than Canadian-born. Our results also showed that immigrant women are more likely to be rewarded with a good diet quality as the length of residence increases. We also noted a shift in consumption patterns towards that of Canadian-born women. This shift, however, was positive for immigrant women. By way of explanation, the observed dietary acculturation led to improvements in the

consumption of seafood and plant protein, refined grains, and added sugars. For men, recent immigrants and long-term immigrants were both more likely to adhere to the recommendations for whole fruit, whole grains, total protein foods, sodium, and saturated fats. By contrast, they were both less likely to adhere to the recommendations for greens and beans as well as fatty acids when compared with Canadian-born men. For immigrant men, we observe an acculturation-driven trend in their consumption of vegetables and fruit, and refined grains. Consumption of vegetables and fruit among men was higher at the early years of residence, but unfortunately, intake levels became indistinguishable from Canadian-born men as their time of residence increased. Nevertheless, the higher consumption of refined grains in the early years of immigration was no longer relevant as their stay in Canada increased; hence the likelihood of consumption became comparable to that of Canadian-born men.

In addition to dietary acculturation [comparison between foreign and host population], we investigated differences in dietary patterns among recent immigrants and long-term immigrants to better understand whether immigrants maintain, improve, or experience deterioration in their consumption of key food components. The main trend after a longer stay in Canada was a substantial increase in the likelihood of consumption of greens and beans, seafood and plant proteins, as well as an improvement in compliance with recommended guidelines for refined grains and added sugars. This trend was also observed for immigrant men and women. Moreover, immigrant men were also more likely to consume whole fruit with longer exposure to Canada. On the other hand, we observe a decrease in consumption of dairy, total protein foods, and fatty acids with a longer stay in Canada. This trend was also true for both immigrant men and women. Another trend is the substantial increase in consumption of saturated fats after a long stay in Canada. Thus, the odds of adherence to the recommended lower intakes of saturated fats decrease by half. Both

women and men also experience similar odds of overconsumption of saturated fats. Consistent with our findings, previous research has noted greater consumption of fats with longer duration of years living in Canada (Davison & Gondara, 2019; Kandola et al., 2016; Lear et al., 2009; Newbold, 2009). Also, the alarming increase in saturated fat has been attributed to the use of highly processed foods in placed of traditional ones in attempt to maintain traditional diet in Canada (Johnson and Garcia, 2003). Furthermore, since the typical diet consumed by most Canadians is characterized by high intakes of saturated fat and trans fats, it would make sense that immigrant's consumption would increase with longer duration of residence (Moubarac et al., 2013). Although not a direct comparison, lower consumption of milk has also been linked with long exposure to Canada (Kandola et al., 2016), which could explain the decrease in compliance with dairy observed in this study.

4.1.4 Summary

This is the first study to examine good diet quality among Black, East/Southeast Asian, West Asian/Arab, South Asian, Latin American, and therefore comparison of our results with other Canadian studies cannot be made. Likewise, our application of HEI makes the food components examined in this study unique in the Canadian literature and direct comparisons cannot be made for the association between most food components and immigration status and/or length of residence. The literature is based predominantly on food components such as vegetables and fruit, saturated fats, refined grains, which comparisons has been made; nonetheless, other research tend to focus on energy-dense foods, ultra-processed food, meat, milk, sugar-sweetened beverages, which makes comparison quite challenging.

In comparing the whole phenomenon of dietary acculturation, when we measure nutritional health based on C-HEI total score (diet quality), this study lend support to studies that calls for a positive acculturation perspective in assessing the health of immigrants (Bermúdez et al., 2000; Jackson et al., 2012; Omariba et al., 2014). In line with the positive acculturation perspective, we found that length of residence in Canada has a positive association with diet quality and consumption of certain foods. These findings lend support to research that suggest that not all acculturation-driven dietary changes are detrimental (Bermúdez et al., 2000; Satia-Abouta et al., 2002). When we examine immigrants' nutritional health in relation to diet quality (i.e., C-HEI total score) along with the likelihood of adherence to nutrition guidelines (i.e., component scores), findings support both perspectives of dietary acculturation. Specifically, our findings suggest that the association between diet and immigration is multidimensional, dynamic, and complex; in addition, it varies considerably, depending on the nutrient or food component in question and more importantly, the ethnic origins of immigrants to Canada. This conclusion is in line with research that posited that the process of dietary acculturation is non-linear (Pérez-Escamilla & Putnik, 2007; Ryder et al., 2000; Soo, 2010). Immigrants can experience dietary acculturation both negatively and positively. Our findings also bring forth a comprehensive methodology of assessing immigrant dietary patterns that could potentially avoid over or underestimating immigrants' abilities to maintain healthy eating patterns with exposure to Canada. Thus, by avoiding a single categorization of immigrants we can better make holistic conclusions on immigrant nutritional health.

4.2 Study Strengths and Limitations

This study is novel in that it is the first, to our knowledge, based on comprehensive national data with detailed information on diet quality and food intakes along with immigration status, length of residence, and multiple ethnic groups. Due to our statistical methodologies, our findings concerning diet behaviours remain robust and strong. Research suggests that in comparison with single-day analysis, applying the NCI method produces more robust and accurate results, as well as precise estimates of standard errors as a result of bootstrapping (Black and Billette, 2013; Davis et al., 2019; Herrick et al., 2018; Jessri et al., 2017; McLaren et al., 2014). With our exploration of heterogeneity by immigration status, length of residence, ethnicity, gender, and other potentially relevant within-group variations, our findings call into question assumptions that healthy eating declines with increasing duration of residence in Canada. Our results thus provide a counterpoint to acculturation models that disregards heterogeneity and paint immigrants as one broad category, and by doing so, undermine immigrants' competencies for critically navigating the Canadian food environment.

To our knowledge, this study represents the broadest assessment of dietary patterns across adult immigrant populations, which is a notable strength of this study. Other strengths of this study include the use of national data and the estimation of usual intakes as opposed to daily intakes. This permits the generalizability of our findings as well as provides a comprehensive picture of Canadian adults eating patterns.

Notwithstanding these strengths, this study is subject to some limitations that warrant mention. First, when stratifying the survey sample into a great number of categories appeared problematic with too few observations for example for length of residence (i.e., division of immigrants by 5-year interval of the length of residence), and the number of visible minorities was low among the

Canadian-born adult population, which may have led to relatively unstable odds ratio estimates. Consequently, some estimates of these variables did not achieve meaningful statistical significance due to the smaller sample size and adequacy of its power to detect an effect. Second, CCHS data does not account for participants' most recent place of residence against their country of origin. Canadian-born respondents may have spent extensive time abroad which might influence food choices. For immigrants, the length of residence is measured from the date when a respondent first came to live in Canada, however, an immigrant's country of origin may not be the same as their place of residence which might also influence their food habits. This hypothesis warrants further investigation. Third, although I was interested in the diet outcomes among people who share cultural similarities (i.e., ethnicity) and not necessarily biological traits (i.e., race), since the data does not make distinctions between the terms "race" and "ethnicity" or make clarifications on the ethnicities for some racial groups such as White or Black, for my analyses, I was not able to hold to the true definition of ethnicity as I was limited to the ethnicity breakdown that Health Canada applied in the CCHS.

Fourth, common to all nutrition surveys based on self-reported or proxy reported data, there may be potential underreporting, especially for foods episodically consumed (Garriguet, 2009; Subar et al., 2003). Fifth, the second research question presented in this study is longitudinal in nature, however, due to the lack of nationally representative longitudinal data that would be considered comparable to the 2015 CCHS nutrition data, a cross-sectional study design was employed for the analysis. Since CCHS nutrition is based on cross-sectional data, we are unable to infer causality between diet quality and length of residence in Canada. Therefore, our findings to the second research question that suggest a gradient in the improvement of diet quality over time should be interpreted with caution. Lastly, while Statistics Canada has provided a tutorial on

"how to" implement the NCI SAS macros in CCHS-Nutrition, as of date, there are no training materials for multivariate analyses. They advise researchers to employ their own adaptations in their analysis of multiple nutrients or food. As such, univariate SAS macros were used in generating the means of the distribution of usual intakes for the foods. Multivariate analyses have greater chance of eliminating random day-to-day variations in dietary intake compared with other NCI methods (Jessri, Ng, & L'Abbé, 2017). Moreover, combining the NCI method with Statistics Canada's bootstrapping methodology was computationally intensive.

4.3 Public Health Implications

Findings from this study carry several important substantive implications for the field of public health. The observed negative trend of low adherence to dietary recommendations among Canada's adult population is a concern, hence experts in the field of public health must become proactive in addressing barriers that prevent the population from adhering to Canada's food recommendations guidelines. Given that there is the heterogeneity of dietary patterns among the population, it is vital that any intervention geared towards addressing the barriers to non-adherence be tailored according to immigration status and length of residence in Canada. Findings from this study suggested that ethnicity can influence dietary patterns, accordingly, this evidence should guide and encourage nutritional policies that respect ethnic diversity. Unhealthy dietary habits could have adverse effects on one's health, and as such, the observed negative trend toward low consumption of whole grains is a concern. Evidence suggests that a high intake of whole grains is protective against a higher risk of coronary heart disease, stroke, cardiovascular disease, and all causes of mortality (Aune et al., 2016; Huang et al., 2015; Jacobs et al., 2007; Lillioja et al.,2013;

Steffen et al., 2003; Wu et al., 2015). Consequently, the observed consumption of low intakes of whole grain foods places Canadian adults at risk for these diseases.

Since the burden of chronic diseases falls disproportionately on immigrants and ethnic minorities, any observed negative trends should be an even greater concern. In particular, the adoption of a trend towards a decrease in consumption of greens and beans, dairy, total protein foods, and fatty acids as well as increased intakes of saturated fats because this dietary pattern is a risk factor for several major chronic diseases. There is evidence to suggest that "a higher consumption of dairy products (≥3 servings per day compared with less than once per day) was inversely associated with the presence of hypertension and obesity" (Lago-Sampedro et al., 2019). Other studies have also established an association between dairy consumption and a lower incidence of hypertension and diabetes (Bhavadharini et al., 2020). A high intake of saturated fat has been linked to an increased risk of coronary heart disease (Nettleton et al., 2017; Zong et al, 2016) while a diet adequate in monounsaturated and polyunsaturated fatty acids offer protection against these diseases (Mehta et al, 2021; White, 2009). This implies that there is a need for interventions targeting an increase in consumption of these specific food components to help reduce immigrants' susceptibility to health problems. Perhaps, the low compliance is related to issues of affordability or accessibility among our immigrant population. Incentives such as sugar taxation have been proven to be effective in reducing the consumption of sugary beverages and inversely reducing health disparities across Canada (Kao et al., 2020; Lopez & Fantuzzi, 2012) and abroad (Colchero et al., 2017; Pell et al., 2021; WHO, 2017). Accordingly, I would propose a similar concept, in particular, a lower to no taxation on foods from these components may increase its purchase and in turn more consumption. This hypothesis warrants further investigation.

Besides chronic diseases prevention, diet and nutrition have important implications on overall development as well as on mental health as unhealthy practices have been associated with impaired function and poor mental health (Adan et al., 2019; Marx et al., 2017; Muscaritoli, 2021). Good nutrition has also been linked with good social behaviours (Liu and Raine, 2017). Policymakers have the responsibility of increasing the production, marketing, and sale of healthy foods and beverages known to reduce the risk of chronic disease and offer benefits towards development, mental health, and social behaviours.

Even though the mechanisms to how Canadian adults, especially immigrants, adopt this dietary behaviour is complex and beyond the scope of this study, the evidence introduced in this study accentuates the importance of public policies to support choices that encourage higher compliance with nutritional recommendations. Low adherence could also mean there is a gap in the population's knowledge regarding the nutrition information provided by the Canadian government. Satia-Abouta et al (2002) found that knowledge of nutrition information from the government was associated with increased fruit and vegetable consumption after immigration. This suggests that public health interventions need to focus on making CFG easily accessible and more importantly, relatable to Canada's multicultural population. Thus, there needs to be a modification to CFG that would assist minority populations in the promotion of healthy food choices. Although the most recent version of CFG somewhat considers ethnic differences by offering it in many languages (Government of Canada, 2022), it should be further adapted when we consider findings from this study. For instance, the alarming increase in saturated fat has been attributed to the use of highly processed foods in placed of traditional ones in attempt to maintain traditional diet in Canada (Johnson and Garcia, 2003); therefore, CFG should make specific recommendations on healthier substitute for traditional ingredients for most popular meals among

distinct groups. Similar to the Indigenous approach, CFG should be inclusive of other ethnic backgrounds, namely Black, East/Southeast Asian, West Asian/Arab, South Asian, Latin American, and White.

4.4 Conclusion and Recommendation for Future Research

To conclude, results from this study revealed that there is the heterogeneity of dietary patterns across diverse groups in Canada. Further, it provided evidence that immigrant status and length of residence can influence adherence to recommended guidelines for adequacy components (vegetables and fruit, whole fruit, greens and beans, whole grains, dairy, total protein foods, seafood and plant proteins, and fatty acids) and moderation components (refined grains, sodium, added sugars, and saturated fats) in addition to overall diet quality.

These findings lend support to existing literature that finds evidence of low compliance among the Canadian adult population. Our findings, however, starkly contrast with a large body of research that finds evidence that a greater duration of residence is linked to poorer health behaviours. This study revealed an overall "healthy immigrant effect" that is maintained through dietary habits with duration of residence in Canada.

Immigrants as a whole were more likely to have better diet quality than Canadian-born, nonetheless, when we examine components of diet quality (i.e., component scores) the likelihood of adherence to the recommendations of CFG 2007 was not always higher compared with Canadian-born. Among immigrant groups, our results suggest that ethnic visible minorities, namely Black, East/Southeast Asian, West Asian/Arab, South Asian, Latin American, and "Other" have a nutritional health advantage over not only White but also their Canadian-born counterparts. Among domestic residents, however, the majority race, which is White, has a health advantage

over most Canadian-born visible minorities. Length of residence strongly affected dietary habits, with both negative and positive effects observed. The main trend after a longer stay in Canada was a substantial increase in the likelihood of fulfilling recommendations for greens and beans, seafood and plant proteins, refined grains and added sugars.

On the other hand, we observe a decrease in consumption of dairy, total protein foods, and fatty acids as well as an increasing trend in consumption of saturated fats after a longer stay in Canada. For immigrant men, we observe an acculturation-driven trend in their consumption of vegetables and fruit and refined grains. For immigrant women, our findings suggest an acculturation-driven trend in their consumption of seafood and plant protein, refined grains, and added sugars. Our results also showed that immigrant women are more likely to be rewarded with a good overall diet quality as the length of residence increases. Irrespective of the length of residence, those who identify as Black, East/Southeast Asian, West Asian/Arabs, South Asian, and Other were more likely to have a good diet quality compared with White immigrants.

The results challenge research that identifies immigrants as one broad category when investigating the "healthy immigrant effect" in relation to dietary acculturation. This approach not only undermines the heterogeneity in dietary patterns but also underscores immigrants' abilities to maintain healthy eating patterns, especially among adult immigrants, with a longer stay in Canada. Thus, our findings reinforce the need to investigate potential heterogeneity in food consumption and diet quality within immigrant populations and Canadian-born populations. It also suggests the need for greater specificity in our dietary interventions by acculturation status.

Nevertheless, there are a number of research questions that remain unanswered. Since the length of residence has been identified to be associated with the consumption of food components, with a larger sample size, future research should focus on the impact of length of residence on the

consumption of each food component for each ethnic group. This can provide a more comprehensive perspective on the influence of duration of residence among individual groups. Moreover, since we observed a gradient in the improvement of overall diet quality when measured by 5- year intervals of the length of residence, this underscores the need for future research to consider how consumption of each food component changes over finer divisions of immigrants by the length of residence (i.e., 5-year intervals) with a prospective study design. This would also add to our understanding of immigrant diet practices.

Among the Canadian-born population, our models revealed that White had higher odds of adherence compared to other races, which was not the case for our within-immigrant analysis. Future research should explore the interaction between socioeconomic status and ethnic groups, which may offer better insight as to why Canadian-born visible minorities are at the advantage of poorer diet behaviours. Lastly, future work may benefit from identifying dietary patterns in association with immigration status and length of residence by province. By so doing, it would be possible to locate where Canada's most vulnerable groups reside. Overall, there is an urgent need for public health strategies and educational tools, such as a Canada's Food Guide, that respect the varied diets of Canada's ethnically and racially diverse population, to improve poor dietary practices among immigrant populations and reduce the escalating burden of chronic disease in this population.

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