FACTORS INFLUENCING BODY MASS INDEX AMONG IMMIGRANT AND NON-IMMIGRANT CANADIAN YOUTH: EVIDENCE FROM THE CANADIAN COMMUNITY HEALTH SURVEY

By

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Abstract

Title: Factors influencing body mass index among immigrant and non-immigrant Canadian youth: evidence from the Canadian Community Health Survey

Background: Over the past two decades the prevalence of childhood obesity has reached epidemic proportions. In Canada recent population growth has relied heavily on immigration. In some instances, immigrant youth appear to exhibit better health overall and maybe at less risk for obesity. Unfortunately, there is a paucity of literature on the physical health of immigrant youth in Canada.

Objectives: The objectives of this study are: (i) to examine differences in body mass index and prevalence of overweight/obesity between immigrant versus non-immigrant youth aged 12-19 years and (ii) to identify the extent to which (a) lifestyle factors, specifically sedentary behavior, physical activity, and nutrition, and (b) socio-demographic factors, account for between-group differences.

Methods: Data for this study were collected by Statistics Canada through the Canadian Community Health Survey (CCHS) from 2001 to 2008. Weight, height, fruit and vegetable consumption, sedentary behaviours, and activity were self-reported by participants. Proportion of normal weight, overweight/obese, and zBMI were calculated. Multiple imputation was used to assign values to missing responses. Participants' body composition characteristics, diet and activity and socio-demographic characteristics were reported with descriptive statistics. The associations between standardized BMI scores (zBMI score) and prevalence of overweight/obesity, immigrant status and socio-demographic and lifestyle covariates were analyzed using multilevel linear and logistic regression, respectively.

Results: The CCHS sample included 63509 participants, aged 12 to 19 years. The mean (SD) age of respondents was 15.5 (2.3) years and 6.4% respondents identified themselves as being born outside of Canada. Among immigrant youth the mean (SD) time from immigration was 7.1 years (4.1). 21.8% of non-immigrant youth were overweight/obese compared to 18% of immigrant youth ($p < 0.001$). Immigrant youth had a lower zBMI by 0.441 compared to Canadian-born youth ($p < 0.001$). Furthermore, zBMI increased by 0.02 for every year an immigrant-respondent resided in Canada ($p < 0.001$). The odds of being overweight/obese were 34% lower (OR 0.66, 95% confidence interval (CI) 0.45, 0.86) among immigrant versus non-immigrant respondents. Measures of diet, activity level and sedentary behaviour did not account for the differences in body composition between immigrant and Canadian born youth.

Conclusion: Immigrant youth had a lower rate of overweight/obesity and lower zBMI scores as compared to Canadian-born youth. When examining determinants of obesity, consumption of fruits and vegetables, sedentary behaviour and energy expenditure did not significantly predict overweight/obesity among this sample of Canadian youth.

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Chapter 1: Introduction

Over the past two decades the prevalence of childhood overweight and obesity has steadily risen around the world.(1-3) In Canada, the prevalence of childhood overweight/obesity, derived from measured weight and height of children aged 2 to 17 years has risen from 12%/3% in 1978 to 18%/8% in 2004.(4) The health consequences of this trend includes rising rates of cardiovascular disease, type 2 diabetes and shorter life expectancies.(5)

Immigrants in Canada are the fastest growing segment of the population, contributing to two-thirds of its population growth. There are several reasons why immigrant status needs consideration in the epidemic of childhood obesity. First, there is a scarcity of information on obesity among Canadian immigrant children and youth, despite evidence that suggests that the health of immigrants may differ from the Canadian-born population.(5-7) Furthermore the discrepancies in health outcomes include lower rates of obesity among immigrant versus non-immigrant Canadian adult populations but this has not been previously investigated among Canadian youth.(8, 9) Second, immigrants in Canada are disproportionately exposed to socio-economic adversity, which has been shown to impact health outcomes.(7) For example socio-economic adversity during childhood has been associated with an increased risk of overweight/obesity in adulthood.(10) Third, immigrants may have differing lifestyle routines that alter their risk for developing obesity and related complications, such as lower rates of physical activity.(11, 12)

Embedded in the process of immigration is the period of settlement in a new country with an environment of socio-economic uncertainty and disturbance of previous lifestyle practices which may contribute to the health of an individual and their family and alter their risk profile for conditions and diseases, including obesity. Unfortunately, at present we have little empirical evidence that quantifies differences in overweight/obesity between immigrant versus non-immigrant youth, and the extent to which lifestyle and socio-demographic factors contribute to these differences, if they exist.

Study overview:

The objectives of this study are: (i) to examine differences in body mass index and prevalence of overweight/obesity between immigrant versus non-immigrant youth aged 12-19 years and (ii) to identify the extent to which (a) lifestyle factors, specifically sedentary behavior, physical activity, and nutrition, and (b) socio-demographic factors, account for between-group differences.

Data for analyses come from a series of 4 repeated, cross-sectional surveys of the Canadian Community Health Surveys (CCHS) conducted between 2001-2008. The CCHS aims to collect health-related data on Canadians at the level of the Health Region (HR). It is administered every two years to a representative sample of approximately 130,000 Canadians aged 12 years and older. Key elements of interest for this study are captured in the CCHS including: immigrant status, self-reported height and weight, lifestyle factors such as diet, physical activity, and sedentary behaviour and measures of socio-demographics including income, language, race, and household composition.

Study importance:

As pediatric obesity rates continue to rise, specific sub-populations of children are being identified as more at risk, for example certain ethnic groups including those of South Asian and Aboriginal ancestry (13-15) and children born low birth weight.(16) This study will focus on immigrant youth in Canada, as a sub-population of interest. There is some evidence to suggest that upon arrival new immigrants, both adults and children, may have lower rates of overweight/obesity, however, over time this protection is lost.(8, 17) Although we are not examining longitudinal data and therefore cannot comment on rate of change over time, we hope to make comparisons of immigrant and non-immigrant Canadian youth, which have not been made previously. Furthermore, by examining the contribution of lifestyle and socio-demographic factors to the relationship between immigrant status and overweight/obesity in Canadian youth, this study will be able to better inform future primary prevention initiatives at both the individual and population level.

Overview of Manuscript:

This manuscript includes five chapters. Following this introductory chapter is the Background, which reviews the lifestyle and socio-demographic characteristics that influence childhood obesity. Chapter 3 includes a description of the study methodology, including a description of the CCHS, sample for analyses, concepts and measures, and approach to analyses. Chapter 4 follows with the results of the analysis. The discussion, conclusions, and future directions can be found in Chapter 5.

Chapter 2: Background

Childhood obesity:

In 2010, the World Health Organization deemed childhood obesity as one of the most serious public health issues of this century.(2) Over the past two decades, the prevalence of obesity among children has steadily risen around the world. Globally, in 2010 the number of overweight children under age five was estimated at 42 million, with almost 35 million of these children living in developing countries.(2) Among Canadian children, the prevalence of overweight/obesity rose from 12%/3% in 1978 to 18%/8% in 2004.(4) In 2010, the Canadian Health Measures Survey (CHMS) gave further evidence of this trend by reporting the changing body composition of Canadian children. Comparison data highlighted that in 1981 an average 12-year-old male weighed 41.6 kilograms (kg) and had a BMI of 18.1 kg/m^2; compared to 2007, where an average 12-year-old male weighed 48 kg and had a BMI of 19.2 kg/m^2.(18) The evolution of this epidemic has affected child health including both physical and psychosocial aspects. The far-reaching effects of childhood obesity include poor physical health outcomes, metabolic abnormalities (e.g. elevated fasting glucose, dyslipidemia, non-alcoholic fatty liver disease), elevated blood pressure and disordered sleep; as well as psychosocial consequences, such as bullying and low body image self-esteem, as well as negative effects on mental health.(19-21)

Determinants of childhood obesity

The development of obesity involves a chronic imbalance of excess energy intake and inadequate energy expenditure. By examining the complex interaction between genetics, environment, lifestyle, and socio-demographic factors, one can better understand how this sustained energy imbalance continues. In this study will we focus on the contribution of two key components in this relationship, lifestyle and socio-demographic factors on overweight/obesity among immigrant and non-immigrant Canadian youth.

Lifestyle Factors

Physical activity has shown to be beneficial to overall health as well as contribute to the prevention and treatment of obesity.(22-24) In 2010, Janssen and LeBlanc (24) published a systematic review outlining the positive impact of physical activity on children's health outcomes. With respect to overweight/obesity, they included 25 observational studies and found a median odds ratio for developing overweight/obesity was 1.33 when comparing the least to most physically active groups.(24) Unfortunately, the amount of time that children now spend participating in physical activity has steadily decreased worldwide over the past decade.(25) To obtain optimal health, current Canadian recommendations for youth (aged 12 to 17 years) suggest that they should participate in at least 60 minutes of moderate to vigorous physical activity per day, vigorous activity at least three times per week, as well as muscle and bone strengthening activities three days per week.(26)

Compounding the issue of decreasing amount of time youth spend participating in physical activity is the rise in participation of sedentary activities. A major component in sedentary activities includes time spent in front of a *screen*, which includes watching television, videos/DVD, and playing computer and videogames. Over the past decade, screen time has steadily increased and approximately 25% of children in the United States watch an average of 4 hours of television per day.(3) Recent data from the CHMS showed that Canadian children and youth spend on average 8.6 hours per day participating in sedentary activities.(27) Excess television viewing among children has been associated with adverse health outcomes including delayed language development, aggressive behavior, and cigarette smoking.(28-30) Reducing television viewing has been reported to have benefits including improving nutritional consumption and increasing energy expenditure, with the ultimate goal of improving adiposity.(31, 32) Furthermore, observational studies from the United States (U.S.) survey, the Third National Health and Nutrition Examination Study (NHANES), has shown higher BMI and body fat in children who watched more television.(33, 34) A systematic review by Tremblay and colleagues demonstrated that television viewing > 2 hours per day was associated with a higher risk of overweight/obesity.(32)

The influence of high caloric intake on overall energy balance is often cited as a major contributor to the development of obesity. Among children, the trend in recent years has been towards consuming more processed fast foods, soft drinks, and less fruits and vegetables.(35) Fruit and vegetable consumption has reported health benefits, including an inverse association with risk of coronary heart disease (CHD).(36) A meta-analysis by Dauchet and colleagues synthesized data from nine observational studies that included over 220,000 adults and over 5000 cardiovascular events.(36) They concluded that the risk of coronary heart disease decreased by 4% (RR (95% CI): 0.96 (0.93–0.99), P = 0.0027) for every portion of fruit and vegetable consumed per day.(36) In recent years, the availability of fresh produce in the United States has increased, however there has only been a modest increase in consumption by children and youth.(35) In 2004, only approximately two-thirds of Canadian children and youth consumed the recommended 5 servings of fruits and vegetables per day.(37) Furthermore, Riediger and colleagues noted that fruit and vegetable consumption among Canadian youth was independently correlated with higher household education and income.(38)

Socio-demographic factors

Lifestyle factors discussed previously (physical activity, sedentary behaviour, and diet) appear to have a direct influence on childhood obesity. However, one may argue that the impact of socio-demographic factors must be also equally considered. Socio-economic status has a positive association with health outcomes and a negative association with overweight/obesity trends. Analyses of data from the 2003 National Survey of Children's Health in the United States by Singh and colleagues demonstrated that lower household income was independently associated with obesity, as was a lower level of household education level and non-Caucasian ethnicity.(39) Ethnicity has also shown consistent links to overweight/obesity trends. Hispanic American and Aboriginal children living in the U.S. and Canada have demonstrated higher rates of overweight/obesity compared to Caucasian children.(40-42) Socio-demographic factors may also indirectly contribute to overweight/obesity by impacting key lifestyle factors. Adolescents of lower socio-economic circumstance have been shown to consume fewer fresh fruits and vegetables(38), they also have lower levels of physical activity and higher amounts of sedentary behaviour activities.(43, 44)

Immigrant youth and Obesity

Canada's population increases by approximately 1% each year and immigration accounts for nearly two thirds of that increase.(45) Between 2001 and 2006 the number of children and youth who immigrated to Canada reached almost 400,000.(46) Whereas previously Canadian immigrants came almost exclusively from Europe, the majority now come from countries in Asia and the Middle East.(45, 47) The record number of new immigrants in Canada combined with the epidemic of childhood obesity not only in Canada but globally lends to the motivation for undertaking this study.

Studies contrasting health outcomes among immigrant versus non-immigrant children and adolescents lend support to a general pattern of findings, termed the *healthy immigrant effect (HIE).* The HIE suggests that immigrants arrive in a host country with a favorable state of health, however over time there is evidence of declining health and convergence to that of the native-born population.(6) Key to this experience is a pattern of findings where, over time, immigrants adopt the host populations' habits and lifestyle, termed *acculturation,* putting them at risk for poor health outcomes.(6) The shift in the national composition of recent immigrants to Canada, combined with the deteriorating economic circumstances of recent immigrant families over the past 20 years, calls into question the applicability of the *healthy immigrant effect* to more recent cohorts of immigrant children and adolescents. Foreign-born children are at higher risk for living in lower socioeconomic circumstances and with financial adversity (7), which in turn may place them at higher risk for poor health outcomes. There are, however, examples where immigrant youth in Canada have persistently demonstrated positive health outcomes. In some instances, immigrant children and youth have shown better, sustained health-related outcomes than their Canadian-born peers. This observation has held true in the case of both mental health and tobacco use among Canadian youth. Beiser and colleagues found that immigrant children in Canada have fewer emotional and behavioural problems than their Canadian-born counterparts, despite higher rates of poverty.(7) Another example of better health is in the area of substance use where Georgiades and colleagues found Canadian immigrant youth have lower rates of tobacco use compared to their Canadian-born peers.(48) An important limitation of these studies by Beiser(7) and Georgiades(48) is that they are primarily based on earlier cohorts of immigrant children. The surveys informing these studies were done in the early 1990's, and perhaps not reflective of more recent immigrant youth coming from Asia and the Middle East.

Although Canadian childhood obesity rates have been well described,(1, 4, 49) there are limited data describing the variation in body composition among Canadian immigrant adolescents. In the United States (US), studies have shown that foreign-born adults and children have lower rates of overweight and obesity as compared to US-born adults and children.(50) A study by Singh and colleagues demonstrates the difference in rates of obesity between immigrant and US-born children and youth.(17) Through analysis of data collected in the National Survey of Children's Health (NSCH), they were able to demonstrate that immigrant children and youth in the US, aged 10 to 17 years, had a 26% lower odds (OR 0.74, 95% confidence interval 0.56, 0.98) of obesity than US-born children and youth. These results from the United States may be similar to what is occurring among Canadian immigrant children and youth. However with the differing ethnic and socio-demographic composition of the population in question there may also be differences between immigrant youth in Canada and the US that are important to highlight.

Observations of immigrant adults in Canada demonstrate patterns similar to that described above. A study focused on adult immigrants in Canada by Cairney and colleagues suggests that recency (i.e. years living in Canada) may be an important factor to consider in relation to risk for obesity among immigrants.(8) They demonstrated that among Canadian adults aged 20 to 64 years included in the 1991 National Population Survey, immigrants who had lived in Canada for less than 10 years had lower rates of obesity than immigrants who had lived in Canada for greater than 10 year or Canadian-born adults. Canadian-immigrant adults who had lived for 10 years or more tended to have rates of obesity matching the Canadian-born adult population, as well as higher rates than newly arrived immigrants (i.e. living in Canada less than 10 years).(8)

Immigrant status and lifestyle factors

Currently, there is a limited amount of information about the participation of Canadian immigrant children and youth in physical activity. Physical activity is a well-established determinant in the development of childhood obesity. The current recommendations by experts in this field suggest that Canadian children and youth participate in 60 minutes of moderate to vigorous physical activity (MVPA) per day for ideal health (26, 51), however more than 90% of Canadian children and youth are not meeting this target.(27) Among the general population, participation in physical activity by Canadian children and youth has declined over the past few years. The Canadian Health Measures Survey

(CHMS) objectively measured the physical activity of Canadian youth aged 6-19 years in 2007-2009 by collecting data with accelerometers.(27) Colley and colleagues noted that only 7% of Canadian children (9% of boys and 4% of girls) meet the recommended goal of 60 minutes of MVPA per day.(27) Among adults who have immigrated to Canada, those who have lived in Canada for a longer period of time are less likely to participate in physical activity compared to those immigrant adults that have lived in Canada for shorter periods of time.(11) Similar trends were observed in a study by Dogra and colleagues, as data from the Canadian Community Health Survey (CCHS) showed Canadian immigrant adults were less likely to engage in physical activity and recreational activities than Canadian-born adults.(52) Although a difference in physical activity levels and participation has been shown among immigrant and non-immigrant Canadian adults, it is still unclear if this pattern of physical activity participation is similar for immigrant youth in Canada. In the U.S., a secondary data analysis of the National Survey of Children's Health controlling for socioeconomic and demographic characteristics of participants, showed that immigrant children are more often physically inactive compared to their US-born peers.(12) Immigrant children in this study were also less likely to participate in sports.(12) This observation may be a reflection of a difference in values placed on recreational activities by immigrant families, compared to scholastic pursuits. Patterns of physical activity will be an important factor to assess when examining risk behaviours for obesity and healthy lifestyle strategies.

In recent years, the time spent engaging in sedentary behaviours has gained attention as a key contributing factor in the epidemic of obesity. The current recommendations from the

American Academy of Pediatrics suggest that children older than age 2 years watch no more than 2 hours of television per day.(53) Unfortunately, studies from the U.S., Europe, and Canada have all shown that children watch well over the prescribed amount of television.(3, 53-55) Christakis et al have shown that children who spend more time in front of a screen are also more likely to be obese.(56) Furthermore, a study by Koezuka et al showed with analysis of the 2001 cycle of the CCHS that youth who viewed more than 20 hours/week of television were less likely to participate in physical activity.(57). A study by Singh and colleagues from the U.S., showed that immigrant children were less likely to watch greater than 3 hours of television per day when compared to US-born children, after accounting for socio-demographic factors.(12) This finding suggests that foreign-born children may have a different risk profile that is protective in the development of overweight/obesity, partially through decreased screen time. Unfortunately, there is a scarcity of literature specifically examining the amount of sedentary behavior among immigrant youth in Canada.

The dietary habits of children and youth are essential for optimal health and prevention of chronic disease. In general, children now consume higher quantities of processed fast foods, soft drinks, and less fruits and vegetables.(35) There have been observations to suggest that when newcomers settle in a host country, their diet may change such that over time the diet of newcomers blends towards the host-country inhabitants, a form of acculturation.(58) This process of acculturation, by which immigrants converge towards the norms and behaviors of the dominant culture, may influence the diet of immigrant children and youth. There is conflicting evidence of the diet immigrant youth consume.

In a Canadian study by Dubois and colleagues, evidence from cross-sectional data collection of a cohort of Quebec preschool-age children suggests that children raised by immigrant mothers tended to consume fewer fruits and vegetables.(59) Also, among a sample of school-aged children living within a immigrant-dense suburb of Sweden, a high proportion of participants missed breakfast on a daily basis as well as regularly consumed sweetened drinks.(60) However it has been also shown that children of immigrant parents consume less fats, likely a reflection of *traditional diets*.(59) Lower socio-economic status among immigrant families may also play a role in the access to fresh produce. (59)

Immigrant status and socio-demographic factors

Many unique issues arise when considering the socio-demographic factors that impact newcomers to Canada. It is important to recognize that immigrants in Canada may have a different socio-demographic profile than non-immigrants.(61) Further, there is evidence to suggest that among immigrants within-group heterogeneity may exist, for example with some immigrants having higher income profiles than others.(61, 62) Another consideration is that newcomers may face barriers that limit improvement in their socio-demographic circumstance. For example, the Longitudinal Study of Immigrants in Canada (LSIC) reported that 90% of immigrants to Canada aged 15-24 years intended to pursue educational training upon arrival, however 40% report barriers, most commonly language, which preclude them from achieving their goals.(47) Aside from income and education, immigrants in Canada may face difficulties adjusting to life in a new country and accessing services including healthcare. This may occur for a variety of reasons including: language barriers, assigned gender roles, and being a visible minority.(63) It is therefore important to consider the extent to which socio-demographic factors may impact the outcome of this study by taking into consideration differences between immigrant and non-immigrant respondents.

Consideration of bias in observational research

It is important to consider elements of bias in observational research. Grimes and Schulz outline such an approach that focuses on selection bias, information bias, and confounding.(64)

Selection bias implies that a difference exists in groups being compared, in this case immigrant and non-immigrant Candian youth. Selection bias can occur either as a function of survey design (e.g. sampling strategies) or because of selective participation.(64). The CCHS includes sample weights to ensure the study sample aligns and is representative of Canada's population. However, we will be exploring missing data for differences between survey participants who did and did not have any missing responses. As well, we will document the response rates from the CCHS across the included cycles.

Information bias can also be defined as measurement or observation bias.(64) We will consider data collection methods, as well as the reliability and validity of key variables and how this might affect the interpretation of results.

Another consideration is confounding. A variable is considered confounding if it is associated with the exposure and also affects the outcome, but does not mediate the relationship between exposure and outcome.(64) Confounding needs to be addressed to ensure that observed associations reflect the true magnitude of the association. In this study, confounding must be considered when examining the relationship between overweight/obesity and immigrant status among Canadian youth. This study will control for potential confounders including age, sex, income source and ethnicity by including thee variables as covariates.

Study importance

The prevalence of overweight/obesity among immigrant and non-immigrant adults in Canada has been previously examined.(8) With such high rates of children and youth arriving in Canada from abroad we need to have a better understanding of their physical health outcomes. Furthermore, with the demonstrated global impact of childhood obesity, this study will shed light on the magnitude of this problem among immigrant youth in Canada. Potential mediating lifestyle factors such as physical activity, sedentary behaviour, and diet have also been examined within the Canadian adult immigrant population, and similar to overweight/obesity there has been little attention to Canadian immigrant youth. This study will rely on self-reported data from Canadian youth from an 8-year period (2001 to 2008). With rigorous analytic methods and a robust sample size this study will examine the extent to which differences exist in overweight/obesity among immigrant versus non-immigrant youth, and the lifestyle and socio-demographic factors that may account for group differences.

Study Objectives:

The objectives of this study are: (i) to examine differences in body mass index (BMI) and prevalence of overweight/obesity between immigrant versus non-immigrant youth aged 12-19 years and (ii) to identify the extent to which (a) lifestyle factors, specifically sedentary behavior, physical activity, and nutrition, and (b) socio-demographic factors, account for between-group differences.

Hypothesis:

We hypothesize that youth who have immigrated to Canada will have a lower BMI z score and lower prevalence of overweight and obesity than Canadian-born youth. Also, immigrant youth will have higher levels of physical activity, lower amounts of sedentary behavior, and better nutrition, which may account for the difference seen in levels of overweight and obesity.

Ethical considerations

Data from the Canadian Community Health Survey used for this study were housed in the Research Data Centre (RDC) at McMaster University. The RDC is a university-based extension of Statistics Canada and therefore must comply with the same rules and regulations governing privacy and confidentiality of data. Ethical approval for access to RDC data was obtained through the joint committee operated by the Social Sciences and Humanities Research Council (SSHRC) and Statistics Canada. Controlled access to data is maintained with both physical access controls and also computers without Internet access to outside the RDC. All data management and analyses were conducted at the McMaster University RDC. An RDC analyst, prior to release, vetted all output to ensure that no study participant could potentially be identified.

Chapter 3: Methods

Canadian Community Health Survey – Introduction and objectives

The Canadian Community Health Survey (CCHS) provides the data for this study. CCHS is a cross-sectional study conducted by Statistics Canada every two years. The objective of this survey is to provide information on the health status, health care utilization, and health determinants of a representative sample of Canadian citizens aged 12 years and over. Excluded from the survey are individuals living on Aboriginal Reserves and on Crown Lands, institutional residents, full-time members of the Canadian Forces, and residents of certain remote regions.

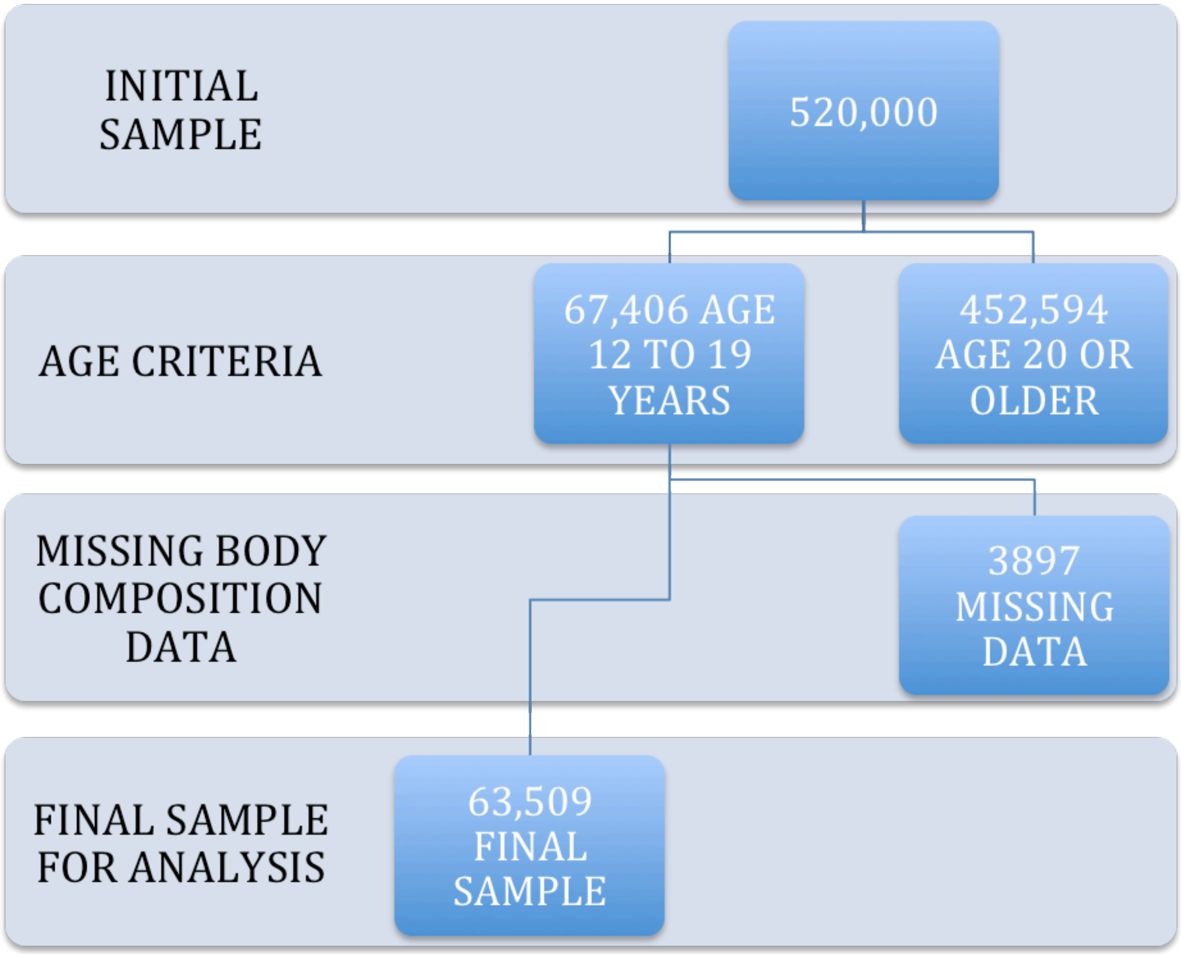
Survey design and Data collection

CCHS provides a representative sample of the Canadian population, with the ability to provide reliable estimates at the Health Region (HR) level. To provide reliable estimates 130,000 respondents per cycle are sampled over a two-year period. The data for this study combined four cycles of CCHS data between 2001 and 2008. The sample allocation occured in two steps, first within province, taking into account population size and number of HRs; and next, within HRs, taking into account the population size of each HR. To select the sample of households, there are three sampling frames: area frame (49% of sample), list frame of telephone numbers (50% of sample) and Random Digit Dialing (1% of sample) telephone number frame. At the time of contacting a household, initially one member of the family is contacted to provide demographic information on household members, i.e. age and sex. Subsequently, one member per household is selected to participate using age and household composition selection probabilities. The response rates for cycles 1.1, 2.1, 3.1, and 2007-2008 were 85%, 81%, 79%, and 76% respectively.(65, 66) The CCHS interview was available in 24 different languages, and participants could select their choice of language. Approximately 75% of participants chose to complete the interview in English.(66)

Sample for analysis

Figure 1 illustrates the selection criteria for the analysis sample. Data from four cycles (cycles 1.1, 2.1, 3.1, 2007-2008) were merged, each cycle having 130,000 respondents. Eligible participants in the present study must be aged 12 to 19 years. This reduced the sample from 520,000 to 67,406 respondents. Next, respondents must have reported their body composition measures, i.e. height and weight. This further reduced the sample size by 3897 (5.7%). The final data set contained 63509 respondents.

FIGURE 1: Final Sample for analysis



<u>Merging CCHS cycles</u>

To combine data from the four cycles of the CCHS, questions of interest to the study objectives were first selected within each cycle. Next, it was confirmed that the stem of each question was asked with the same wording and the response pattern was identical between cycles. A new variable called 'cycle' was created to identify which cycle the data originated. The variable names were standardized across cycles, and the four cycles were subsequently combined into a single master dataset for analysis.

Study measures:

Primary outcome: Measures of overweight/obesity

Survey questions included the respondent self-reporting their height and weight. From this raw data we were able to derive two measures of overweight/obesity, one continuous measure, Body Mass Index (BMI) z score, and one binary outcome, weight category (normal weight versus overweight/obese).

Body mass index (BMI) z score

The BMI for each respondent was calculated by dividing the self-reported weight in kilograms (kg) by the square of height in metres (m^2). Next, the BMI z score (zBMI) was calculated using each respondent's BMI, age, sex and the external reference of the World Health Organization (WHO).(67) The syntax for use with SPSS software was provided by the WHO and based on the WHO Reference 2007 for 5-19 year olds.(67) The WHO Reference 2007 was based on a renewal of the 1977 NCHS/WHO growth reference with supplementation from WHO Child Growth Standards data from 2006.(68)

Overweight/obese versus normal weight

For the purposes of estimating the proportion of respondents classified as overweight/ obese BMI was converted to a dichotomous variable. Using internationally based cut-off points, reference ranges for normal versus overweight/obesity were derived using BMI, sex, and age.(69) Cole et al used an international, multicultural sample from cross-sectional growth surveys of six countries (Brazil, Great Britain, Hong Kong, Netherlands, United States of America, and Singapore) to derive the cut-points.(69) They were developed with the International Obesity Task Force (IOTC) and was created to promote a common definition for reporting and comparing the prevalence of overweight/obesity among international samples.(69, 70) The cut-off points for overweight and obese correspond to adult (aged greater than 18 years) BMI cut-offs of 25 kg/m^2 (overweight) and 30 kg/m^2 (obese). The variable was dummy coded (0, normal weight and 1, overweight or obese).

<u>Socio-demographic covariates:</u>

Immigrant status

Participants were asked if they were born in Canada. The participant was deemed to be an immigrant if they responded 'no'. Follow-up questions were asked with respect to country of birth and year of arrival to Canada. No additional information was collected on parent's country of birth to further classify participants based on immigrant generational status. As such, immigrant status is defined as foreign-born (i.e., 1st generation immigrant) versus Canadian-born (i.e., non-immigrant). The variable was dummy coded (0, non-immigrant and 1, immigrant). Among immigrants, the length of time living in Canada (reported in years) was also collected and reported as a continuous variable.

Age was calculated by taking the difference of the participant's date of birth and date of interview; it is expressed in years.

Sex was reported by asking the participant their gender. This variable was dummy coded (0, male and 1, female).

Race/ethnicity of the participant was determined by asking which racial or ethnic background they belonged to. This variable was dummy coded (0, Caucasian and 1, non-Caucasian).

Language of the participant was determined by asking if they spoke English and/or French or neither. This variable was dummy coded (0, either/both English and French and 1, neither English nor French).

Household size was reported by asking the participant the number of people living in their primary residence.

Income was reported by asking the participants the primary source of their household income. The variable was dummy coded 0, non-assisted (i.e. salary, wages, self-employed, pension), and 1, government assisted (i.e. Employment Insurance, government assistance, no income).

Province of residence was included as a geographic variable. The reference province was Ontario.

<u>Lifestyle covariates</u>

Physical activity was measured by the derived variable, energy expenditure (EE) (kilocalories expended per kilogram of body weight per day). This variable is derived by the CCHS and takes into account the following information: the number of times the survey respondent participated in any activity; the average duration of the activity (in hours); and the *MET*, which is the "metabolic energy cost" of the activity expressed as kilocalories expended per kilogram of body weight per hours of activity (kcal/kg per hour). To further illustrate the interpretation of METs: 2 METS would describe an activity that required twice the amount of energy as compared to a body at rest. Different activities are pre-assigned METs by the Canadian Fitness and Lifestyle Research Institute.(71)

Nutritional intake was measured by the participants' response to questions of consumption of fruits and vegetables. Participants indicated how many times per week they ate any fruit or vegetable. Of note, this question denotes frequency but not amounts of consumption and is not based on Canada's Food guide serving sizes.

Sedentary behaviours The initial proposal for this study included sedentary behaviour as a key explanatory variable. In the CCHS, participants are asked to report the number of hours they spent doing the following activities in a typical week in the past three months: computer, computer games and Internet, video games, television and videos and reading. For all activities, time spent at school or work is excluded.

Questions about sedentary behaviour were only optional content in the surveys and only a subset of participants (50%) were asked these questions based on the needs and preference of the Health Region. Therefore, the analysis was undertaken to account for this sub-sample - once without the sedentary behaviour variable and then a restricted analysis with only the participants that were asked the questions related to sedentary behaviours.

We were unable to find any literature on the validity and reliability of these lifestyle variables in adolescents. It is however important to note that the variables are all self-reported and may be subject to bias as discussed further in the Discussion.

Missing data

Missing data analysis was conducted on all respondents aged 12 to 19 years (n = 67406). The respondents who had missing data for the body composition questions (weight and height) were included in this analysis; however, they were excluded from the final analyses. I first examined the proportion of missing responses for each variable, as presented in Table 1. Next, I conducted univariate logistic regression analysis using SPSS 19.0 to examine the extent to which specific study variables predicted response (i.e., missing vs. non-missing). A dummy variable was created for each respondent where 0 denoted a respondent with no missing data and 1 denotes a respondent with 1 or more missing responses.

Table 1: Proportion of missing data for each variable

Variable	% Missing
Age	0%
Sex	0%
CCHS cycle	0%
Fruit/Vegetable consumption	16.5%
Energy expenditure	5.3%
Sedentary behaviour	0%*
Immigrant status	1.3%
Length of time in Canada	1.3%
Income source	10.3%
Language	1.2%
Household size	0%
Race	5.6%
Height/Weight category	5.8%

*Only asked in a subset of survey participants

There were 44776 (66.4%) respondents with complete data available (dummy coded 0), while 22630 (33.6%) respondents had one or more missed responses (dummy coded 1). The results of the logistic regression models for missing data are shown in Table 2.

Table 2: Results of multiple logistic regression for characteristics of respondents with incomplete data versus respondents with complete data

Variable	B coefficient	SE	Odds Ratio	P value
Immigrant status	-0.308	0.036	0.735	**<0.001**
Immigrant years	-0.030	0.004	0.970	**<0.001**
Age	-0.071	0.004	0.932	**<0.001**
Sex	0.013	0.016	1.013	0.424
Official language	0.377	0.105	1.457	**<0.001**
Household size	0.009	0.007	1.009	0.170
Income source	0.150	0.046	1.162	**0.001**
Race	-0.067	0.026	0.935	**0.009**
Weight category	0.125	0.02	1.133	**<0.001**
Fruit/veg consumption	-0.004	0.003	0.996	0.256
Energy Expend	-0.007	0.002	0.993	**0.004**

The missing data analysis suggests that respondents with an incomplete set of responses have a certain socio-demographic profile. Respondents with an incomplete set of responses were more often: younger age, did not speak either English or French, and Caucasian. Examining the profile lifestyle factors, respondents with an incomplete set of data are more often overweight/obese, and have lower energy expenditure. The odds of respondents having an incomplete set of data were 26.5% lower among immigrants versus non-immigrants.

<u>Addressing missing data</u>

There are a number of factors that must be considered when selecting an approach to addressing missing data. These considerations include, but are not limited to, the type of missing data and the methods by which to handle the data. Types of data missingness include – MCAR (missing completely at random), MAR (missing at random), and MNAR (missing not at random).(72) With data MCAR one assumes data is missing by chance.(73) With MAR one assumes data is missing by chance and provisional on observed values. Finally, when MNAR one assumes the data are provisional on unobserved values. The consideration of these classifications is important when determining how to handle missing data.

There are a variety of methods to address missing data. Strategies include complete case analysis and imputation methods such as mean substitution, single imputation regression, full information maximum likelihood methods and multiple imputation.(72) Allison suggests that when choosing a method to address the issue of missing data one must consider limiting bias, maximizing the available information, and achieving accurate estimates of uncertainty.(73)

Multiple imputation (MI) was used to address missing data in the present study. Multiple imputation assumes data is missing at random (MAR).(73, 74) Advantages of MI include the fact that there is no limitation to the type of dataset it can be used with, as well as addressing the issues of bias while maximizing the use of available information and allowing for accurate estimates of uncertainty. Multiple imputation creates complete data sets with plausible estimates of the missing data.(74) However, the process can be time intensive as multiple datasets must be created and subsequently combined. Single imputation will lead to standard errors that are underestimated. This problem can be addressed by imputing multiple datasets.(73, 74) Once multiple data sets are created with randomly drawn imputed estimates they can be combined into a single dataset.(74) To combine parameter estimates *Rubin rules of estimating a scalar quantity* (74, 75) suggests calculating the average of the estimates over the number of datasets created. To calculate the combined standard error, the variance between and within datasets must be calculated and combined.(75) It is suggested that to achieve accurate estimates one must create at least 5 to 10 data sets using MI.(74):

In this study SPSS software version 19.0 was used for MI. For MI, SPSS uses an algorithm based on linear regression, Markov chain Monte Carlo (MCMC) method. This is the most commonly used method for MI.(73) Five imputed datasets were created and subsequently combined using *Rubin's rules for scalar estimates* as described above. The following variables were imputed and also used as predictor variables: immigrant status, time since immigration, language, race/ethnicity, and income source. Variables that were not imputed and used as predictor variables were basic demographic information such as: age, sex, health region, province, CCHS cycle, as well as the dependent variables, BMI z score and weight category. Variables that were imputed, but not used as predictors in the MI model were: total fruits and vegetable consumption, energy expenditure, and sedentary behaviour.

Statistical analysis

Descriptive statistics:

Participants' characteristics are reported using descriptive statistics: continuous variables will be reported as means and standard deviations, and categorical variables are reported using percentages.

To explore differences in characteristics between non-immigrant and immigrant participants, proportion of sex (male versus female), sedentary behaviour time (<14 hours per week, or >/= to 14 hours per week), race (Caucasian versus non-Caucasian), source of household income (government assisted versus not assisted), language (English and/or French versus neither), and weight category (normal weight versus overweight/obese) will be compared with a chi-square test. Continuous variables including age, energy expenditure, fruit and vegetable consumption, household size, and zBMI will be compared with an independent t test.

Multilevel models:

It is imperative that the model accounts for study design effects and the clustering of respondents within health regions (HR). An ordinary least squares regression model assumes that the units of measure are independent and that the residual terms are uncorrelated. If clustering of respondents within a HR are ignored the risk of under-estimating the standard errors of the regression coefficients increases. Since the design of the CCHS is such that individuals are sampled within HR, multilevel regression models (MLM) will be used for the analysis. Specifically, this study will use a 2-level multilevel random coefficients regression model providing a method for partitioning variability of responses across levels where individuals are subject to the potential influence of groupings. Within Health Regions, respondents are sampled randomly.(76) The fixed classification of this model is the predictor variables as outlined above.

The following equation represents the multilevel model, where i = Level 1 variables (respondent), j = Level 2 variables (HR).

$$y_{ij} = b_0x_0 + b_1x_{1ij} + b_2x_{2ij} \ldots b_mx_{mij} + u_j + e_{ij}.$$

The variation in the dependent variable, y is explained by the fixed parameters of the equation: the intercept term, b_0; the fixed effects (b's) of the independent variables; and the two random effect terms, *e* and *u*. The residual variation is summarized by the variance terms σ^2_e and σ^2_u.

Multilevel Model: continuous outcome, zBMI:

A linear model will be pursued for the continuous dependent variable, zBMI. The analyses were fitted with MLwiN software version 2.24.(77) For multilevel linear modeling in MLwiN, iterative generalized least-squares estimation was used.

Multilevel model: binary response, weight category

A logistic model will be pursued for the binary response dependent variable, weight category. This model will also be fitted with MLwiN software version 2.24.(77) Initially the model is estimated using first order marginal quasi-likelihood (MQL). As first order MQL may under-estimate between-group variation, the final model will be estimated using second order penalised quasi-likelihood (PQL) and iterative generalized least-squares estimation. Also, PQL may have difficultly with convergence, this can be tested by initially running a first order MQL.(76)

Building the model

For both outcome measures (zBMI and weight category), the model is created through a series of steps. The first model is an intercept-only model, the *null model*. The intraclass correlation (ICC) is the ratio of between group variance to within group variance and is calculated from the null model. In this model, adolescents (Level 1) are nested within HR (Level 2).

$$\mathrm{ICC} = \sigma^2_u/(\sigma^2_e + \sigma^2_u)$$

Each model subsequent to the *null model* includes a grouping of related variables. Model 1, includes immigrant status, time since immigration and basic demographics including age, sex, and CCHS cycle. Model 2 includes lifestyle variables of interest for the objectives and hypothesis: activity, diet and sedentary behaviour (for the subgroup analysis only). Model 3 adds socio-demographic covariates including language, source of income, race, and household size. Finally, Model 4 includes province of residence with Ontario being the reference province. The models are outlined in Table 3.

Table 3: Description of models for multilevel modeling

Model	Variables
1	Immigration status, length of time in Canada, CCHS cycle, age, and sex
2	#1 + lifestyle factors: fruit/vegetable consumption, energy expenditure and sedentary behaviour*
3	#2 + socio-demographic factors – income source, ethnicity/race, household size, language
4	#3 + province of residence

*sub-analyses only

<u>Weighting</u>

Each respondent had a sample weight assigned by the CCHS cycle in which they participated. To normalize the sample weights across cycles these sequential steps were performed: (a) the mean of the sample weight for each cycle was calculated, (b) the weight for each participant within a cycle was divided by the mean of the weight, (c) this normalized weight for each respondent was applied as the weighting variable for both descriptive statistics and multilevel modeling.

<u>Sub-sample analysis: Sedentary behaviour</u>

The sample for the sub-analyses, which includes sedentary behaviour, is restricted to those Health Regions who opted into having these questions asked. From the sample of 63,509 respondents in the main analysis, the sample for sub-analyses is further reduced to

29,617 respondents. The data management, including multiple imputation; the statistical analysis for the sub-analyses was identical to the main set of analyses described previously in this section.

Chapter 4: Results

Descriptive data

There were 63,509 participants in the final sample for analysis (i.e. aged 12 to 19 years and available data for weight and height). The distribution of participants from each cycle were similar: from cycle 1 there was 16,645 (26.2%) participants; cycle 2 there was 17,736 (27.9%); cycle 3 there was 15,423 (24.3%) participants; and from cycle 4 there was 13,705 (21.5%). The response rates for each cycle of the CCHS were: 84.7% (cycle 1), 80.6% (cycle 2), 78.9% (cycle 3), and 76% (cycle 4).

The participants were grouped within the 168 Health Regions across the country. The mean (standard deviation) number of participants within a Health Region was 377.89 (285.68). The minimum and maximum number of participants within a Health Region was 41 and 1552. Table 4 outlines the characteristics of the sample population.

Table 4: Characteristics of respondents (weighted)

CHARACTERISTIC	Non-immigrant (n =59457)	Immigrant (n = 4052)	p value
Age, years (mean, sd)	15.51 (0.01)	15.92 (0.03)	<0.001
Sex, female (%)	48.4	46.9	0.022
Race, Caucasian (%)	88.2	26.9	<0.001
Language, English or French (%)	99.5	96.7	<0.001
Daily consumption of fruits and vegetables (mean, sd)	5.22 (0.02)	5.08 (0.04)	0.001
Energy expenditure (mean, sd)	3.91 (0.02)	3.83 (0.05)	0.118
Sedentary behaviour (% >14 hrs/wk) (n=29,617)	69.4	73.6	<0.001
Number living in household (mean, sd)	4.17 (0.01)	4.38 (0.02)	<0.001
Income source (% assisted)	3.5	5	<0.001
Overweight or obese (%)	21.8	18	<0.001
BMI z score (mean, sd)	0.34 (0.004)	0.09 (0.001)	<0.001

The average age of respondents in the sample was 15.5 years with an even distribution between males (51.7%) and females (48.3%) (not shown). In the sample 4052 (6.4%) of respondents identified themselves as born outside of Canada, i.e. immigrant. The majority of respondents could converse in one or both of Canada's national languages. Table 4 presents differences between the non-immigrants and immigrants on key study variables. Immigrants are less likely to be Caucasian, to speak either English or French, to consume fruits and vegetables, and to engage in physical activity. Immigrants have lower z-BMI scores and are less likely to be overweight/obese. Immigrants are more likely to receive government income assistance and to have larger household size. The mean number of years (SD) that immigrant youth lived in Canada was 7.1 (4.1) years (not shown).

Multilevel Modeling (MLM)

Outcome variable: zBMI

A 2-level multilevel linear regression model was used to assess the relationship between immigrant status, lifestyle variables, and socio-demographic characteristics on zBMI.

<u>The null model</u>

Table 5 presents the null model. The purpose of the null model is to address the degree of variance in the dependent variable (zBMI) that is accounted for by variability between groups (HRs) versus within groups (respondents).

Table 5: Results of the null model

	Estimate	Standard Error	P value	ICC
Fixed effect intercept	0.396	0.006		
Random effects variance				
Level 2 (HR)	0.021	0.002	<0.001	1.61
Level 1 (respondent)	1.285	0.007	<0.001	98.39
-2*log likelihood	196908.1			

*ICC = intra-class correlation

The fixed effect intercept indicates the overall sample mean for zBMI is 0.396. The results of the null model show an intra-class correlation of 1.61%. Roughly, 1.6% of the variation in zBMI is attributable to between-HR differences.

Models 1 to 4

Table 6 presents the results for zBMI.

Table 6: Results of multilevel linear modeling on zBMI. Weighted sample from CCHS, n= 63509 after multiple imputation and the combination of 5 datasets

	Model 1		Model 2		Model 3		Model 4	
	B	SE	B	SE	B	SE	B	SE
Fixed effect intercept	1.020	0.032*	1.040	0.034*	1.216	0.040*	1.194	0.041*
Immigrant status	-0.441	0.036*	-0.441	0.036*	-0.419	0.038*	-0.402	0.037*
Time since immigration	0.022	0.004*	0.022	0.004*	0.022	0.004*	0.022	0.004*
Age	-0.031	0.002*	-0.031	0.002*	-0.034	0.002*	-0.034	0.002*
Sex	-0.325	0.009*	-0.322	0.009*	-0.323	0.009*	-0.324	0.009*
CCHS cycle 2	0.039	0.013*	0.041	0.013*	0.034	0.013*	0.036	0.012*
CCHS cycle 3	0.044	0.014*	0.046	0.014*	0.038	0.014*	0.038	0.013*
CCHS cycle 4	0.038	0.014*	0.041	0.014*	0.034	0.014*	0.033	0.014*
Fruit/Veg consumption			-0.006	0.002*	-0.005	0.002*	-0.004	0.002*
Energy expenditure			0.002	0.001*	0.002	0.001*	0.001	0.001
Official language					-0.159	0.063*	-0.163	0.062*
Income source					0.072	0.027*	0.060	0.027*
Race					-0.019	0.017	-0.020	0.017
Household size					-0.032	0.004*	-0.033	0.004*
Newfoundland							0.275	0.028*
Prince Edward Island							0.158	0.037*
Nova Scotia							0.130	0.029*
New Brunswick							0.144	0.028*
Quebec							-0.080	0.016*
Manitoba							0.093	0.024*
Saskatchewan							0.100	0.024*
Alberta							0.015	0.017
British Columbia							-0.072	0.017*
Yukon							0.051	0.087
Northwest Territories							0.232	0.088*
Nunavut							0.437	0.065*
Random effects variance								
Level 2 (HR)	0.018	0.002	0.018	0.002	0.018	0.002	0.008	0.002
Level 1 (respondent)	1.250	0.007	1.250	0.007	1.248	0.007	1.249	0.007
-2*log likelihood	195094.9092		195081.2756		194990.4976		194690.9798	

B = beta coefficient, SE = standard error
*P<0.05

Model 1

Model 1 shows that the association between immigrant status and zBMI is statistically significant and negative; where zBMI decreased by 0.441 if the respondent was born outside of Canada ($p < 0.05$). Also zBMI increased by 0.02 for every year an immigrant-respondent resided in Canada ($p < 0.05$). This model controls for age, sex, and CCHS cycle.

Model 2: Effect of lifestyle factors

Measures of diet (fruit and vegetable consumption) and activity level (energy expenditure) were added to Model 2. This did not effect the association between zBMI and immigrant status. Of note in the final model, activity level was not significantly associated with change in zBMI, but diet shown to be negatively associated with zBMI.

Model 3: Effect of socio-demographic factors

Model 3 included a measure of the respondent's socio-demographic characteristics, including: language spoken in household, income source, race, and household size. The addition of these factors did not affect the strength of association between immigrant status and zBMI. Looking individually at the relationship between each of these covariates and zBMI shows that speaking either English or French and more family members residing in a household were all statistically significantly associated with a decrease in zBMI. Having an income source that was government assisted was associated with a higher zBMI.

Model 4: Effect of province

Model 4 includes the addition of provinces as a variable in Level 2 of the hierarchy. The relationship between zBMI and immigrant status was not changed in this final model. Ontario is considered the reference province in this model. Of note, residing in British Columbia and Quebec is associated with a lower zBMI compared to living in Ontario. However residing in Newfoundland, Prince Edward Island, Nova Scotia, New Brunswick, Manitoba, Saskatchewan, Northwest Territories, and Nunavut was associated with an increase in zBMI compared to living in Ontario.

Sub-sample analysis: Sedentary behaviour and zBMI

The outcome of the sub-analyses with sedentary behaviour shows similarities to the main analysis of the entire sample that does not include sedentary behaviour (see Table 7).

Table 7: Results of sub-sample multilevel linear modeling on zBMI. Weighted sample from CCHS, n= 29,617 after multiple imputation and the combination of 5 datasets

	Model 1		Model 2		Model 3		Model 4	
	B	SE	B	SE	B	SE	B	SE
Fixed effect intercept	0.949	0.055*	0.965	0.055*	1.143	0.064*	1.126	0.065*
Immigrant status	-0.404	0.075*	-0.403	0.070*	-0.368	0.067*	-0.355	0.065*
Time since immigration	0.019	0.007*	0.019	0.007*	0.018	0.006*	0.019	0.006*
Age	-0.027	0.003*	-0.027	0.003*	-0.030	0.003*	-0.030	0.003*
Sex	-0.330	0.013*	-0.326	0.013*	-0.327	0.013*	-0.328	0.013*
CCHS cycle 2	0.031	0.019	0.031	0.019	0.026	0.019	0.036	0.019
CCHS cycle 3	0.058	0.024*	0.060	0.023*	0.053	0.023*	0.037	0.021
CCHS cycle 4	0.059	0.022*	0.062	0.022*	0.055	0.022*	0.050	0.021*
Fruit/Veg consumption			-0.005	0.003	-0.005	0.003	-0.003	0.003
Energy expenditure			0.002	0.002	0.002	0.002	0.001	0.002
Sedentary behaviour			0.004	0.014	0.003	0.000	0.003	0.014
Official language					-0.149	0.102	-0.157	0.101
Income source					0.057	0.040	0.054	0.039
Race					-0.044	0.030	-0.052	0.028
Household size					-0.031	0.006*	-0.033	0.006*
Newfoundland							0.313	0.048*
Prince Edward Island							0.185	0.080*
Nova Scotia							0.171	0.049*
New Brunswick							0.148	0.035*
Quebec							-0.077	0.022*
Manitoba							0.112	0.031*
Saskatchewan							0.110	0.029*
Alberta							0.032	0.026
British Columbia							-0.090	0.030*
Yukon							0.092	0.020*
Northwest Territories							0.299	0.055*
Nunavut							0.577	0.170*
Random effects variance								
Level 2 (HR)	0.014	0.002	0.013	0.002	0.014	0.002	0.006	0.002
Level 1 (respondent)	1.252	0.018	1.252	0.018	1.252	0.018	1.252	0.018
-2*log likelihood	90963.763		90957.6448		90915.357		90785.403	

B = beta coefficient, SE = standard error
*P<0.05

Model 1: Effect immigrant status on zBMI

Results of the sub-analyses multilevel linear model are shown in Table 7. Model 1 shows that the association between immigrant status and zBMI is statistically significant and negative, where zBMI decreased by 0.404 if the respondent was born outside of Canada ($p < 0.001$). Also zBMI increased by 0.019 for every year an immigrant-respondent resided in Canada ($p < 0.001$). This model controls for age, sex and CCHS cycle.

Model 2: Effect of lifestyle factors (diet and activity and sedentary behaviour)

Energy expenditure, consumption of fruits and vegetables, and sedentary behaviour were not significantly associated with change in zBMI. The addition of these variables to the model did not effect the association between zBMI and immigrant status.

Effect of socio-demographic factors

Model 3 included a measure of the respondent's socio-demographic characteristics, including: language spoken in household, income source, race, and household size. The addition of these factors did not affect the strength of association between immigrant status and zBMI. Looking individually at the relationship between each of these covariates and zBMI shows that having more family members residing in a household was statistically significantly associated with a decrease in zBMI.

Model 4: Effect of province

Model 4 includes the addition of provinces as a variable in Level 2 of the hierarchy. This did not effect the association between zBMI and immigrant status. Again, Ontario is considered the reference province in this model. Of note, the pattern of effect by province was similar to the main analysis, with respondents in British Columbia and Quebec having a lower zBMI compared to respondents in Ontario. The other provinces had higher zBMI scores.

<u>Comparison of main and sub-sample analyses</u>

To determine if the sub-sample analyses with sedentary behaviour was similar to the main analyses the results of the two data sets are compared in Table 8.

Table 8: Comparison of Model 2 for main and sub-analyses

	Main analysis model 4		Sub-sample analysis model 4	
	B	SE	B	SE
Fixed effect intercept	1.194	0.041	1.126	0.065
Immigrant status	-0.402	0.037	-0.355	0.065
Time since immigration	0.022	0.004	0.019	0.006
Age	-0.034	0.002	-0.030	0.003
Sex	-0.324	0.009	-0.328	0.013
CCHS cycle 2	0.036	0.012	0.036	0.019
CCHS cycle 3	0.038	0.013	0.037	0.021
CCHS cycle 4	0.033	0.014	0.050	0.021
Fruit/Veg consumption	-0.004	0.002	-0.003	0.003
Energy expenditure	0.001	0.001	0.001	0.002
Sedentary behaviour			0.003	0.014
Official language	-0.163	0.062	-0.157	0.101
Income source	0.060	0.027	0.054	0.039
Race	-0.020	0.017	-0.052	0.028
Household size	-0.033	0.004	-0.033	0.006
Newfoundland	0.275	0.028	0.313	0.048
Prince Edward Island	0.158	0.037	0.185	0.080
Nova Scotia	0.130	0.029	0.171	0.049
New Brunswick	0.144	0.028	0.148	0.035
Quebec	-0.080	0.016	-0.077	0.022
Manitoba	0.093	0.024	0.112	0.031
Saskatchewan	0.100	0.024	0.110	0.029
Alberta	0.015	0.017	0.032	0.026
British Columbia	-0.072	0.017	-0.090	0.030
Yukon	0.051	0.087	0.092	0.020
Northwest Territories	0.232	0.088	0.299	0.055
Nunavut	0.437	0.065	0.577	0.170

Looking at the results of Model 2 for the main and sub-sample analyses shows only minor differences in the estimates and not major difference in the magnitude or direction of the effect. The standard errors are slightly larger for the sub-sample analysis as would be expected with a sample size that is less than half of the main analysis.

Outcome variable: weight category

A 2-level multilevel logistic regression model was used to assess the relationship between immigrant status, lifestyle variables, and socio-demographic characteristics on weight category, where 0 was dummy coded normal weight and 1 was dummy coded overweight/obese.

Null Model:

Table 9 presents the null model. The purpose of the null model is to address the degree of variance in the dependent variable (weight category) that is accounted for by variability between groups (HRs) versus within groups (respondents). In a multilevel regression model the variation at level 1 has a standard logistic distribution with a variance of $\pi^2/3$ (78).

Table 9: Null model

	Estimate	Standard Error	P value	ICC*
Fixed effect intercept	-1.147	0.022		
Random effects variance				
Level 2 (HR)	0.061	0.009	<0.001	1.82
Level 1 (respondent)	3.29			98.18

*ICC = intra-class correlation

The results of the null model show an intra-class correlation of 1.82%. Therefore the differences between HRs accounts for 1.82% of the total variance in the dependent variable, weight category.

Models 1 to 4 with binary outcome weight category

Table 10: Results of multilevel logistic modeling on weight category. Weighted sample from CCHS, n= 63509 after multiple imputation and the combination of 5 datasets

	Model 1		Model 2		Model 3		Model 4	
	B	SE	B	SE	B	SE	B	SE
Fixed effect intercept	-0.891	0.075*	-0.755	0.079*	-0.313	0.098*	-0.343	0.107*
Immigrant status	-0.420	0.104*	-0.425	0.106*	-0.443	0.107*	-0.446	0.106*
Time since immigration	0.023	0.010*	0.023	0.010*	0.024	0.009*	0.024	0.009*
Age	-0.002	0.005	-0.005	0.005	-0.013	0.005*	-0.012	0.005*
Sex	-0.561	0.022*	-0.582	0.022*	-0.586	0.022*	-0.586	0.022*
CCHS cycle 2	0.034	0.026	0.041	0.026	0.024	0.026	0.023	0.027
CCHS cycle 3	0.059	0.027*	0.066	0.027*	0.049	0.027	0.044	0.027
CCHS cycle 4	0.080	0.029*	0.088	0.029*	0.071	0.029*	0.067	0.028*
Fruit/Veg consumption			-0.005	0.004	-0.004	0.004	-0.003	0.004
Energy expenditure			-0.017	0.002*	-0.017	0.002*	-0.016	0.002*
Official language					-0.279	0.159	-0.273	0.159
Income source					0.120	0.050*	0.113	0.050*
Race					0.063	0.048	0.071	0.054
Household size					-0.082	0.010*	-0.082	0.010*
Newfoundland							0.436	0.080*
Prince Edward Island							0.237	0.100*
Nova Scotia							0.180	0.063*
New Brunswick							0.261	0.038*
Quebec							-0.150	0.082
Manitoba							0.142	0.059*
Saskatchewan							0.051	0.045
Alberta							0.029	0.055
British Columbia							-0.203	0.051*
Yukon							0.018	0.029
Northwest Territories							0.402	0.040*
Nunavut							0.533	0.057*
Random effects variance								
Level 2 (HR)	0.057	0.011	0.056	0.011	0.059	0.012	0.026	0.011
Level 1 (respondent)	1	0	1	0	1	0	1	0

B = beta coefficient, SE = standard error
*P<0.05

Model 1

From Table 10, Model 1 shows that the association between immigrant status and weight category is statistically significant and negative ($p < 0.05$). With an odds ratio of 0.66 (ß = -0.420, SE 0.104), the odds of being overweight/obese are 34% lower among immigrant versus non-immigrant respondents. Also the odds of being overweight or obese increased by 2.3% (ß = 0.023, SE 0.01) for every year an immigrant-respondent resided in Canada ($p < 0.05$). This estimate controls for age, sex, and CCHS cycle.

Model 2: Effect of lifestyle factors

Measures of diet (fruit and vegetable consumption) and activity level (energy expenditure) were added to Model 2. This did not affect the relationship of weight category and immigrant status. Of note, energy expenditure demonstrated statistically significant, negative association with weight category. The odds of overweight/obese decreased by 1.7% (ß = -0.017, SE 0.002) for every 1-unit increase in EE.

Model 3: Effect of socio-demographic factors

Model 3 included a measure of the respondent's socio-demographic characteristics, including: language spoken in household, income source, race, and household size. The addition of these factors did not affect the effect estimate of immigrant status and weight category. Looking at the relationship between each of these covariates and weight category shows that having more family members residing in a household is negatively associated with being overweight/obese. Having a government assisted income source was associated with higher odds of being overweight/obese.

Model 4: Effect of province

Model 4 includes the addition of provinces as a variable in Level 2 of the hierarchy. Ontario is considered the reference province in this model. Of note, residing in British Columbia is associated with a lower odds of overweight/obese compared to living in Ontario. However residing in Newfoundland, Prince Edward Island, Nova Scotia, New Brunswick, Manitoba, Northwest Territories, and Nunavut was associated with an increased odds of overweight/obesity compared to living in Ontario. The addition of provinces to the model did not alter the association between immigrant status and weight category.

Sub-sample analysis: Sedentary behaviour and weight category

Table 11: Results of sub-sample multilevel linear modeling on weight category. Weighted sample from CCHS, n= 29,617 after multiple imputation and the combination of 5 datasets

	Model 1		Model 2		Model 3		Model 4	
	B	SE	B	SE	B	SE	B	SE
Fixed effect intercept	-0.962	0.109*	-0.896	0.111*	-0.467	0.133*	-0.488	0.136*
Immigrant status	-0.317	0.146*	-0.323	0.157*	-0.299	0.143*	-0.276	0.147
Time since immigration	-0.083	0.469	-0.084	0.478	-0.083	0.473	-0.084	0.479
Age	-0.001	0.006	-0.003	0.006	-0.011	0.006	-0.012	0.006*
Sex	-0.553	0.030*	-0.568	0.029*	-0.572	0.029*	-0.576	0.029*
CCHS cycle 2	0.023	0.040	0.028	0.041	0.012	0.040	0.035	0.041
CCHS cycle 3	0.077	0.048	0.080	0.047	0.063	0.047	0.034	0.045
CCHS cycle 4	0.088	0.045	0.090	0.044*	0.073	0.044	0.066	0.044
Fruit/Veg consumption			-0.005	0.006	-0.005	0.006	-0.002	0.006
Energy expenditure			-0.014	0.004*	-0.013	0.004*	-0.015	0.004*
Sedentary behaviour			0.082	0.030*	0.079	0.000*	0.080	0.031*
Official language					-0.451	0.225*	-0.458	0.226*
Income source					0.107	0.077	0.100	0.077
Race					-0.003	0.058	-0.003	0.052
Household size					-0.077	0.013*	-0.080	0.013*
Newfoundland							0.589	0.108*
Prince Edward Island							0.245	0.174
Nova Scotia							0.278	0.130*
New Brunswick							0.313	0.069*
Quebec							-0.129	0.050*
Manitoba							0.144	0.058*
Saskatchewan							0.136	0.062*
Alberta							0.045	0.054
British Columbia							-0.204	0.061*
Yukon							0.148	0.108
Northwest Territories							0.473	0.124*
Nunavut							0.393	0.210
Random effects variance								
Level 2 (HR)	0.045	0.01	0.045	0.01	0.046	0.01	0.023	0.009
Level 1 (respondent)	1	0	1	0	1	0	1	0

B = beta coefficient, SE = standard error
*P<0.05

Model 1

Model 1 shows that the association between immigrant status and weight category is statistically significant and negative ($p < 0.05$). With an odds ratio of 0.72 (ß = -0.317, SE 0.146), the odds of being overweight/obese are 28% lower among immigrant versus non-immigrant respondents. Also the odds of being overweight or obese increased by 7.9% (ß

= -0.083, SE 0.469) for every year an immigrant-respondent resided in Canada. This estimate controls for age, sex, and CCHS cycle.

Model 2: Effect of lifestyle factors

Measures of diet (fruit and vegetable consumption), sedentary behaviours, and activity level (energy expenditure) were added to Model 2. This did not affect the relationship of weight category and immigrant status. Of note, energy expenditure demonstrated statistically significant, negative association with weight category. The odds of overweight/obese decreased by 1.4% (ß = -0.014, SE 0.004) for every 1-unit increase in EE. The odds of overweight/obesity was 8.5% (ß = -0.082, SE 0.03) higher among participants who spent >14 hours/week participating in sedentary behaviour.

Model 3: Effect of socio-demographic factors

Model 3 included a measure of the respondent's socio-demographic characteristics, including: language spoken in household, income source, race, and household size. The addition of these factors did not affect the effect estimate of immigrant status and weight category. Looking at the relationship between each of these covariates and weight category shows that more family members residing in a household was negatively associated with being overweight/obese. The odds of overweight/obesity were 36% (ß = -0.451, SE 0.225) less likely among participants who did not speak English or French.

Model 4: Effect of province

Model 4 includes the addition of provinces as a variable in Level 2 of the hierarchy. Ontario is considered the reference province in this model. Of note, residing in British Columbia is associated with a lower odds of being overweight/obese compared to living in Ontario. However residing in Newfoundland, Prince Edward Island, Nova Scotia, New Brunswick, Manitoba, Northwest Territories, and Nunavut was associated with an increased odds of overweight/obesity compared to living in Ontario. The addition of provinces to the model did not alter the association between immigrant status and weight category.

Comparison of main and sub-sample analyses: binary outcome of weight category

To determine if the sub-sample analyses with sedentary behaviour was similar to the main analyses with the binary outcome variable of weight category, the results of the two data sets are compared in Table 12.

Table 12: Comparison of Model 4 for main and sub-analyses, binary outcome variable: weight category

	Main analysis model 4		Sub-sample analysis model 4	
	B	SE	B	SE
Fixed effect intercept	-0.343	0.107	-0.488	0.136
Immigrant status	-0.446	0.106	-0.276	0.147
Time since immigration	0.024	0.009	-0.084	0.479
Age	-0.012	0.005	-0.012	0.006
Sex	-0.586	0.022	-0.576	0.029
CCHS cycle 2	0.023	0.027	0.035	0.041
CCHS cycle 3	0.044	0.027	0.034	0.045
CCHS cycle 4	0.067	0.028	0.066	0.044
Fruit/Veg consumption	-0.003	0.004	-0.002	0.006
Energy expenditure	-0.016	0.002	-0.015	0.004
Sedentary behaviour			0.080	0.031
Official language	-0.273	0.159	-0.458	0.226
Income source	0.113	0.050	0.100	0.077
Race	0.071	0.054	-0.003	0.052
Household size	-0.082	0.010	-0.080	0.013
Newfoundland	0.436	0.080	0.589	0.108
Prince Edward Island	0.237	0.100	0.245	0.174
Nova Scotia	0.180	0.063	0.278	0.130
New Brunswick	0.261	0.038	0.313	0.069
Quebec	-0.150	0.082	-0.129	0.050
Manitoba	0.142	0.059	0.144	0.058
Saskatchewan	0.051	0.045	0.136	0.062
Alberta	0.029	0.055	0.045	0.054
British Columbia	-0.203	0.051	-0.204	0.061
Yukon	0.018	0.029	0.148	0.108
Northwest Territories	0.402	0.040	0.473	0.124
Nunavut	0.533	0.057	0.393	0.210

Looking at the results of Model 4 for the main and sub-sample analyses shows some minor differences in the magnitude of the estimates although the direction of the effects are not different. For example the OR for immigrant status on weight category is 0.63 in the main analysis and 0.76 in the sub-sample analysis. The standard errors are slightly larger for the sub-sample analysis as would be expected with a sample size that is less than half of the main analysis.

Chapter 5: Discussion

Using data from a series of repeated, cross-sectional Canadian Community Health Surveys, the present study examines differences in body mass index and prevalence of overweight/obesity among immigrant and non-immigrant Canadian youth. A secondary goal was to identify the extent to which lifestyle and socio-demographic factors may account for between-group differences.

Statement of findings

We found a significant association between measures of overweight/obesity (i.e. zBMI and proportion of overweight/obese) and immigrant status. Canadian immigrant youth have lower zBMI and a lower prevalence of overweight/obesity, relative to Canadian-born youth. Length of time in Canada (i.e., recency) was associated with higher zBMI scores and increased odds of overweight/obesity.

Previously published work has consistently demonstrated that immigrant adults in Canada are less likely to be overweight/obese relative to Canadian-born adults.(8, 9, 79) Evidence described by Setia and colleagues showed from longitudinal data from the National Population Health Survey (NPHS) that immigrant Canadians had a lower BMI than non-immigrants. They also showed that BMI converged to non-immigrant levels over a 12-year period among Caucasian male immigrants.(9) Cairney et al demonstrated that with a longer time of residence in Canada an adult immigrant will have rates of obesity similar to Canadian-born adults.(8)

The addition of lifestyle factors, including diet, sedentary behaviour, and activity, into the regression models did not impact the association between immigrant status and zBMI or proportion of overweight/obesity. However the association between prevalence of energy expenditure as well as sedentary behaviour with overweight/obesity was statistically significant (see Table 11). We showed that the odds of overweight/obesity decreased by 1.4% (β -0.014, SE 0.004; $p < 0.05$) with each 1-unit increase of energy expenditure. For sedentary behaviour, the odds of being overweight/obesity was 8.5% higher among respondents who spent >14 hours per week participating in sedentary behaviours (β 0.082, SE 0.03; $p < 0.05$). These findings are in line with previously reported literature that reports a negative association between physical activity and rates of overweight/obesity.(22-24)

Furthermore, increased time spent participating in sedentary behaviours has been linked to obesity, diet, physical activity and behavioural problems.(26-29) Albeit statistically significant, the magnitude of these associations with overweight/obesity is small compared to previously reported estimates. It has been shown that compared to less rigorous physical activity, children who are more physically active are 33% less likely to be obese.(24) Further, data from a sample of Canadian adults showed that among men and women spending greater that 14 hours participating in sedentary behaviours per week, the odds of being obese was 1.8 higher (95% confidence interval (CI) 1.6, 2.2) among men and 1.7 higher (95%CI 1.4, 2.1) among women.(80)

Also of note is the negative association between consumption of fruits and vegetables and zBMI score (Table 6). Similar to energy expenditure and sedentary behavior, the size of this effect in the present study is small, however in comparison to other reported studies likely similar in magnitude. For example, in the present study with every 1 unit increase in fruit and vegetable consumption (i.e. 1-unit is equivalent to self-reported consumption of one piece of fruit or vegetable) we observed a corresponding decrease in zBMI score by 0.004 (SE 0.002, $p < 0.05$). In comparison, a large prospective cohort of American children showed that with every 1 serving of vegetable consumption, boys aged 9-14 had a 0.003 decrease in zBMI (95%CI -0.004, -0.001).(81)

Differences between immigrant and non-immigrant Canadian adolescents

By reflecting on the study's main findings it is important to consider differences in the characteristics between the immigrant and non-immigrant Canadian adolescents sampled in the CCHS.

Socio-demographic factors

In this study, there are clear differences between the immigrant and non-immigrant groups in their socio-demographic characteristics. Furthermore, many of the differences between the immigrant and non-immigrant youth in this study are reflective of characteristics already described in the literature and therefore reinforces that our study sample was representative of Canadian youth. These differences included: sex, race, language, income source, and household size. In this sample there are a higher proportion of males versus females in both the immigrant and non-immigrant groups (1.03 males for every 1 female). This is consistent with Canada's demographics which highlights that there are 1.05 males per 1.0 females in Canada.(82) Being a visible minority was more common among the immigrant group ($p < 0.001$). This is not surprising and in line with data published by Statistics Canada, which reports that the majority of immigrants to Canada (children and adults) were born in South Asia, South East Asia and the Middle East.(46) In our sample, 26% of immigrant adolescents self-identified their ethnic group as Asian. With respect to language, a high proportion of both immigrant and non-immigrant respondents spoke English or French (96.7% vs. 99.5%, $p < 0.001$), although the difference between the groups was statistically significant. Previous data from the Canadian Council on Social Development (CCSD) suggest that 63% of Canadian immigrant adolescents aged 15 to 19 years cannot speak either English or French upon arrival to Canada.(83) This would suggest that approximately 30% of immigrant adolescents sampled in this survey have learned to speak an official language since arrival. There is likely minimal differential sample loss since the CCHS incorporates the use of translators for respondents who do not speak either English or French. Income in this study was measured as source of income, defined as non-assisted (salary, wages, dividends, etc.) or assisted (EI, welfare, no income). One could argue that if a family's main source of income were government assisted that they would be at higher risk for low-income or poverty. Immigrant adolescents more often identified their household source of income as assisted (5% vs. 3.5%, $p < 0.001$) compared to non-immigrant adolescents. This estimate of low-income may be an underestimate. Data from Canada's census showed that for immigrant Canadians, although rates of low income decreased with time spent in Canada, despite living in Canada 10 years, 30% of immigrants had low-income.(84) Furthermore, Statistics Canada data from the Longitudinal Administrative Database (LAD) and the Longitudinal Immigration Database showed that between 2002 and 2004 immigrants in Canada had more than 3 times the rate of low income compared to Canadian-born citizens.(61) Unfortunately, other measures of income could not be included in the study. There was >40% nonresponse for the question, what is the total income of your household. With that degree of missing information, the question was excluded.

Lifestyle factors

What we learned about lifestyle factors contradicted our hypothesis. We hypothesized that youth who have immigrated to Canada would have lifestyle habits that were protective against overweight/obesity therefore providing a possible explanation of differences seen between the groups for overweight/obesity. In fact this was not the case. For physical activity, there no was significant difference seen between the groups in regards to energy expenditure, measured in units of kilocalories expended per kilogram of body weight per day (kkd).

However, with respect to diet, the descriptive data showed a statistically significant difference between the immigrant and non-immigrant adolescents. The consumption of fruits and vegetables was greater among the non-immigrant group of adolescents. One hypothesis for this difference is the differential between the groups with respect to financial strain. We see a higher proportion of immigrant families in this study have sources of income that are government assisted. Of note, our final analysis adjusts for government assisted income sources. Azagba and colleagues showed that families with lower socio-economic status consume less fruits and vegetables compared to those of higher socio-economic status.(85)

Differences in the time spent engaging in sedentary behaviours were observed between immigrant and non-immigrant adolescents in this sample. 74% of immigrant youth spent greater than 14 hours per week versus 69% in the non-immigrant group ($p < 0.001$). The only other study we could identify which examines sedentary behaviour activity in immigrant youth is from the U.S.A. Singh and colleagues observed that immigrant children in the US were less likely to watch > 3 hours of television per day compared to US-born children.(12) Our findings are contradictory to this previous work. Although both studies use self-reported measures of sedentary behaviour, Singh et al focused on television viewing and had a younger sample (age 6-18 years).(12) Also of note is the difference in ethnic composition between our Canadian study and the U.S. study. The US study has an immigrant population that is proportionally higher in the number Hispanic American children and our study includes immigrant youth who are more often of Asian or South Asian ancestral origin.

Effect of Health Regions (HRs)

The contextual effects of the environment on health is important to consider.(86) In this study, the sampling of respondents was clustered within HRs. The health regions of the CCHS are geographically distributed within provinces. From Tables 5 and 9 (null models of main sample analyses) the intra-class correlations (ICCs) were 1.61 and 1.82, respectively. This denotes that the differences between HRs accounted for less than 2% of the total variance in the outcome variables, (zBMI and weight category). Since HRs is a construct derived by provinces, an ICC may be difficult to interpret. HRs may overlap physical neighbourhoods or may group neighbourhoods that are very diverse (hence increasing heterogeneity within HR). Also, Boyle and Willms highlighted, with analysis of Ontario Health Survey (OHS) data, that larger areas of aggregation tended to have a smaller amounts of variance.(87) This may be due to greater heterogeneity within larger areas.

Strengths of the study

At present, we have not been able to identify any other studies that address the issue of overweight and obesity among Canadian immigrant adolescents, which makes this study unique in describing a growing segment of the Canadian youth population. The strengths of this study include adequate statistical power, with a robust sample size of over 60,000 adolescents. We also had the opportunity to combine both socio-demographic and lifestyle factors in the models, which allowed for a comprehensive examination of possible contributing factors in the association between overweight/obesity and immigration status. A further strength of the CCHS is that it allows the respondents to have the interview conducted in their preferred language, which lessens the barrier of access.

Limitations of the study

Limitations of the study can be divided into issues of i) study design and data ii) measurement.

Study design and data

As mentioned previously, the data for this secondary data analysis was cross-sectional in nature. Although four cycles of the CCHS were combined for the analysis, there was only one data point per respondent, ruling out a longitudinal analysis and any opportunity to examine temporal associations among the study variables.

Selection bias

There was a relatively large amount of missing information, including ~16% missed responses for fruit and vegetable consumption. This missing data did affect our decisions during analysis, for example our initial choice for an income variable was the answer to the question “what is the your total household income, from all sources”. Unfortunately ~40% of respondents in our sample did not answer this question, leading us to use a variable for income that measured the source of income not quantity. To address loss of data, multiple imputation was used to account for variables that were missing data.

With respect to sampling strategies or selective participation, we note that the CCHS has a sampling strategy that has multiple stages and dual frame design including area, telephone list, and random digit dialing frames.(88) The complex sampling strategy is based on the Labour Force Survey design and allows for precise coverage of Health

Regions.(88) Since the sample is stratified by Health Region the weights are calculated within Health Region and adjusted for non-response and calibrated to match population projection counts.(66)

Information bias (Measurement)

Since this study was done from previously collected Statistics Canada data, there was no control over how variables were collected. A variable central to our study was immigrant status, which was determined by asking respondents if they had been born in Canada or elsewhere. Therefore all respondents who were classified as immigrants are first-generation immigrants. Although we have a measure of recency by asking how long an immigrant adolescent has lived in Canada, being able to differentiate first versus second-generation immigrant status would have enriched the definition.

Also, we note that the dependent variables were reliant on self-reported height and weight, which may contribute to reporting bias. In a previous study, Shields and colleagues compared self-reported height and weight to measured height and weight in a subsample of the 2005 CCHS survey.(89) They demonstrated that, in general, respondents over-estimated their height compared to their actual measured height.(89) Furthermore, respondents generally under-reported their weight, with a larger difference among female respondents than males.(89) Of importance to our study is that immigrant status was not a significant predictor in misreporting height and weight. Also, adolescent males or females did not tend to misreport their height compared to older groups, but younger (aged 12 to 24 years) females tended to under-report their weight.(89) Therefore, although the dependent variable may be affected by self-report it is likely that the two groups, immigrant and non-immigrant adolescents, are affected in similar fashion. The majority of other included variables were also self-reported such as lifestyle factors including fruit and vegetable consumption, energy expenditure, and sedentary activity time. A systematic review of assessments of direct versus self-reported physical activity showed low to moderate correlation between measures.(90) Further a systematic review examining the reliability and validity of sedentary behaviours, found self-reported methods to be reliable but their validity untested.(91)

Confounding

Although as mentioned in the methods section, confounding is addressed by taking into account key variables such as age, sex, income, and ethnicity, we were unable to control for a potentially important variable, education. The CCHS asked participants the highest level of education of any member of the household had achieved, however it does not ask whom that family member is and how this may correlate with employment nor does it ask the level of education achieved by the respondent. We therefore decided not to include education into our model.

Directions for Future Research

Two other variables that may impact the analysis that were not included are i) underweight status and ii) age at time of immigration. How underweight may factor into the relationship between immigrant status and healthy weight could be important. Specifically, if newcomers are consistently shown to have a lower prevalence of overweight/obesity, perhaps the degree of under-nutrition or thinness may account for these differences seen. Another consideration for future analyses is the age at which an immigrant arrives in a host country. There is some evidence to suggest that there are 'sensitive periods' for arrival. For example a study done in Vancouver, Canada suggested those immigrants arriving in Canada from China prior to age 14 were more likely to identify with Canadian culture and lifestyles then those arriving later in life.(92) Therefore age at immigration may impact key lifestyle determinants contributing to healthy weight and should be considered in future research.

Implications of findings

This study adds to the growing body of evidence in North America, that adult and youth immigrants compared to native-born peers have different rates of overweight and obesity(8, 9, 17, 79). We demonstrate that immigrant adolescents in Canada are less often overweight/obese and have lower BMI z scores compared to non-immigrant adolescents. Also important to consider is evidence to suggest that with time spent in Canada, an immigrant adolescent will be at increased risk of becoming overweight and obese. Furthermore, data from our sample also shows Canadian immigrant adolescents have a distinct profile of modifiable risk factors including lower consumption of fruits and vegetables and higher levels of sedentary behaviour.

These findings have important public health implications such that this sub-population of Canadian adolescents should be an important focus for primary obesity prevention interventions. By prospectively studying this sub-group of Canadian youth we will be able to explore facilitators and barriers to healthy lifestyle behaviours and design effective intervention strategies.

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