Cardiovascular Disease Risk factors in Canadian-born and Immigrant Children and Youth in the Canadian Health Measures Survey

by

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Abstract

Immigrants make up almost 20% of Canada's population. Recent adult immigrants to Canada are generally in better health than those born in Canada. However, we know little about whether this is also the case in children. We compared mean levels and prevalence of adverse levels of CVD risk factors between immigrant (foreign-born) and Canadian-born children and youth using data from 4211 children and youth aged 6 to 19 years in the Canadian Health Measures Survey cycles 1 and 2 (2007-2009, 2009-2011). Levels of obesity, high waist circumference, elevated blood pressure, and dyslipidaemia were lower in immigrant than in Canadian-born children and youth. However, Canadian-born children and youth reported better health behaviours. Overall, results indicated a trend toward a more favourable CVD risk factor profile among immigrant children and youth in Canada. This study suggests a health advantage in immigrant children and youth over Canadian-born children and youth.

Dedicated to my mother Ursula Ata (1937 - 2013)

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Abbreviations

AAP	American Academy of Pediatrics
AHA	American Heart Association
ATP	Adult Treatment Panel
BMI	Body Mass Index
CCHS	Canadian Community Health Survey
CDC	Centers for Disease Control and Prevention
CHASE	Child Heart and Health Study in England
CHMS	Canadian Health Measures Survey
CI	Confidence Interval
CPAFLA	Canadian Physical Activity, Fitness, and Lifestyle Approach
CRP	C-reactive Protein
CVD	Cardiovascular Disease
DASH	Determinants of Adolescent Social Well-Being and Health Study
HDL	High-density Lipoprotein
IDF	International Diabetes Federation
IOTF	International Obesity Task Force
LDL	Low-density Lipoprotein
LFS	Labour Force Survey
LSIC	Longitudinal Survey of Immigrants to Canada
NCEP	National Cholesterol Education Program
NHANES	National Health and Nutrition Examination Survey
NHIS	National Health Interview Survey
NPHS	National Population Health Survey
NSCH	National Survey of Children's Health
QCAHS	Quebec Child and Adolescent Health and Social Survey
SD	Standard Deviation
SHARE	Study of Health Assessment and Risk in Ethnic groups
UK	United Kingdom
US	United States
WHO	World Health Organization

1 INTRODUCTION

1.1 CVD burden and the epidemiologic transition

Cardiovascular disease (CVD) is a major cause of mortality worldwide accounting for about 30% of all global deaths.[1] Ischemic heart disease, stroke and congestive heart failure contribute most to the global burden of CVD. In Canada, 27% of all deaths were due to CVD in 2009[2] and heart disease and stroke presents an economic burden of $20.9 billion every year in health care costs and decreased productivity.[3] Global differences in CVD mortality rates can partly be explained by the epidemiologic transition, which refers to the gradual transition in health burden from infectious diseases to noncommunicable diseases with the development of a country. As the transition progresses, CVD becomes the major cause of morbidity and mortality.[4] At the same time, higher income is associated with improvements in health care and life expectancy increases. CVD incidence and mortality rates eventually decline in the last stage, due to preventive risk factor reduction strategies and secondary prevention treatment strategies.[5] Globally, Sub-Saharan Africa is in the earliest stage of the epidemiologic transition and has the lowest proportion of deaths due to CVD with 5-10%; South and East Asia, the Pacific, Latin America and the Caribbean are in the second stage with deaths due to CVD accounting for 15-35% of all deaths, while the Middle East has transitioned to the third stage which includes Europe and Central Asia representing the highest CVD mortality rates with deaths due to CVD at 60% of all deaths. In Europe and Central Asia, the CVD mortality rate is more than two times higher than in other high income countries including Canada, which are in the fourth stage with deaths from CVD constituting about 30% of all deaths.[6]

Economic changes are linked to and cannot be disassociated from social and behavioural changes occurring in countries undergoing the epidemiologic transition. A country's gross national per capita income appears to be related to the CVD risk of its population, in keeping with the epidemiologic transition. Worldwide, lowest mean body mass index (BMI) levels (22-23 kg/m^2) are reported for Africa and Asia, and highest mean BMI levels (25-27 kg/m^2) are reported for North America, Europe, and some Latin American, North African and Pacific Island countries.[7,8] Low income and rural location have been associated with a higher prevalence of obesity in high income countries and with a lower prevalence of obesity in low and middle income countries.[9,10] Low and middle income countries now face a "double burden" of undernutrition and rising obesity, with urban areas being more affected with rising levels of obesity as exposure to energy dense foods increases.[11] The United States (US) population has the highest mean BMI among high income countries.[8] In contrast, elevated blood pressure has lower prevalence in high income countries compared to low and middle income countries.[12] This is likely due to risk reduction and treatment strategies in place in high income countries.[13] Observed blood pressure patterns could also partly reflect ethnic predisposition and differences in dietary salt intake.[14,15] Dyslipidaemia has been decreasing in high income countries, but prevalence remains highest in high income countries and lowest in low and low middle income regions.[16] Of the high income countries, Western Europe has higher mean cholesterol than North America. East and Southeast Asia and the Pacific region are experiencing an increase in the prevalence of dyslipidaemia.[16] Table 1.1 provides an overview of the varying prevalence of CVD risk factors globally.

	Obesity† [%] Ages ≥ 20 years		**Elevated BP**† [%] Ages ≥ 25 years		**Elevated cholesterol**‡ [%] Ages ≥ 25 years	**CVD Mortality**‡ [per 100,000] Ages 30-70 years
	Male	Female	Male	Female	Male & Female	Male & Female
Africa	5.3	11.1	38.1	35.5	22.6	382
Americas	23.5	29.7	26.3	19.7	48.0	169
South East Asia	1.7	3.7	25.4	24.2	29.0	322
Europe	20.4	23.1	33.1	25.6	54.0	238
Eastern Mediterranean	13.0	24.5	30.7	29.1	38.0	344
Western Pacific	5.1	6.8	28.7	23.7	36.0	184

Table 1.1: Adult prevalence of CVD risk factors and mortality rates by WHO (World Health Organization) region.

† World Health Statistics 2012 [12]

‡ Global Status Report on Noncommunicable Diseases 2010 [5]

Abbreviations: *BP* Blood pressure; *CVD* Cardiovascular disease.

1.2 Prevalence of CVD risk factors in adults in North America

Even though awareness, knowledge, and treatment of CVD risk factors has improved, lifestyle behaviours have become more unhealthy and obesity and hypertension prevalence has been increasing in the last 20 years in North America. Obesity prevalence increased by 10% between 1992 and 2009 in Canada and was as high as 24.1% in 2009.[17] In the US, the prevalence of obesity increased from 22.9% to 30.5% between 1988 and 2000 and was as high as 35.5% in 2010.[18,19] Hypertension has also increased in the last 20 years, but not quite in the same magnitude as obesity. Hypertension prevalence increased from 23.9% in 1994 to 28.5% in 2000, but stayed at that level in 2008 in the US.[20] About 77% of those 28.5% (approximately 70 million people) are being treated for hypertension.[21–23]. Similar to obesity, the prevalence of hypertension is lower in Canada than in the US. The proportion of Canadians with hypertension decreased from

21% in 1985/1992 to 19% between 2007 and 2009.[24,25] Similarly, mean serum cholesterol levels decreased by 10mg/dl between 1988/1994 and 2007/2010, likely due to the fact that lipid-lowering medication use has increased from 3.4% in 1994 to 15.5% in 2010.[26] However, a high proportion of Canadians had dyslipidaemia (45%) between 2007 and 2009, despite the fact that it was about 6% lower than in the US.[27–29] This pattern appears relatively consistent, wherein CVD risk factor prevalence is high in North America, however, Canada has lower prevalence of CVD risk factors compared to the US.[30]

1.3 Migration and ethnic predisposition

Migration itself has been associated with a change in CVD risk, whereby an immigrant CVD risk changes over time to that of the residents of the host country. Thus immigrants from less affluent countries increase their risk of CVD by moving to high income North American countries.[31–33] Recent immigrants to these countries have lower levels of CVD risk factors such as obesity, when compared to long-time residents.[32–35] They are also in better health, have better health behaviours, and have lower prevalences of chronic conditions.[36–39] This phenomenon has often been referred to as the "healthy immigrant effect". However, the protective effect of immigrant status on health is lost over time.[40,41] The new physical, social, and cultural environment of the host country gradually influences patterns of morbidity and mortality in the immigrant population until they resemble or converge to those of the host population.[42] As the majority of Northamerican immigrants come from low and middle income countries with a lower prevalence for most CVD risk factors, convergence eventually results in an increase in CVD risk factors.[34,39] Migration and length of settlement in North America have been associated with a rise in prevalence of CVD risk factors such as obesity, blood pressure, and dyslipidaemia in immigrants,[33,43–46] to the level of the host population or higher.

Some ethnic groups also have an additional genetic predisposition to CVD. These genetic traits or susceptibilities may once have been protective (e.g. during famine or in a low salt environment) but when exposed to the urban lifestyle and Western diet they put affected individuals at higher risk of CVD.[47] For example, South Asian ethnicity is associated with a predisposition for abdominal obesity and dyslipidaemia;[48,49] African ethnicity is associated with a predisposition to elevated blood pressure.[50,51] When South Asians and Africans migrate to Western countries, the change in lifestyle in combination with their predisposition for CVD risk leads to increases in risk factor prevalence which can become even higher than those of the host populations.[52] For example, migrant Asian Indian women were twice as likely to have general and abdominal obesity compared to Asian Indian women living in high income Western countries.[53] Similarly, in a comparison of CVD risk profiles among ethnic groups using population health surveys between 1991 and 1996, the prevalence of high blood pressure was shown to almost double that of the White populations in adult Black and South Asian men living in England.[54] This genetic susceptibility appears to manifest most profoundly in environments that promote weight gain and obesity.

1.4 Health status of Canadian immigrants

Canada has a growing immigrant population of diverse ethnic background, which currently makes up almost 20% of the whole population.[40] Chinese immigrants make up the largest minority group, followed by South Asians and Africans.[55] Immigrant health status, either for the whole immigrant population or stratified by country of birth, is commonly assessed by comparing it to that of the Canadian-born population. Adult immigrants to Canada are generally in better health on arrival when compared to Canadian-born individuals in terms of chronic illness and CVD health.[38,56] This is again an example of the aforementioned "healthy immigrant effect". New immigrants might enjoy better health because of self-selection, immigration admission requirements and screening, and healthier lifestyle behaviours in the former country of residence.[57] Immigrants to Canada are often be part of an elite group in their countries of origin as they are required to be educated and have financial stability to meet the demands of admission screening. This health advantage is most obvious in recent immigrants[37] but tends to deteriorate, on average, in about 10 years.[58] Data from Statistics Canada's 2000/2001 Canadian Community Health Survey (CCHS) showed that new immigrants to Canada had about 25% lower prevalence of the chronic conditions heart disease, diabetes, high blood pressure and cancer than Canadian-born, but the difference diminished after 20 years spent in Canada.[59] A general process of adaptation to the new society appears to be shared by all immigrants.[60] Immigrant health status changes with exposure to the social, cultural, and physical environment. The process of adaptation to the new society that involves changes in norms, attitudes, and health behaviours is known as acculturation.[60] The deterioration in health is thought to be due to the process of acculturation to the host society,[61] which involves behavioural changes toward the Western lifestyle and diet.[62,63] Challenges with regard to employment and access to services as a result of the resettlement may also contribute to the deterioration in health.[64] Indeed, acculturation to Canada has been shown to be associated with increases in CVD risk factors such as obesity and high blood pressure.[46] The acculturation process is said to be more swift in individuals with higher education, those with previous exposure to Western culture, and in children and young adults.[62]

1.5 CVD risk in children and youth

Patterns of CVD risk factors seen in adults are also evident in children and youth. Since 1970, the prevalence of obesity has more than doubled in Canada, and 31.5% of Canadian children and youth were overweight or obese in 2011.[65] In the US, the proportion of overweight or obese children and youth is even higher and reached 34.7% in 2008.[66] Obesity is associated with elevated blood pressure and high cholesterol, and children and youth are now being diagnosed with health conditions that were previously seen almost exclusively in adults.[67,68] The prevalence of youth with high serum cholesterol in Ontario increased from 2% to 5% between 2002 and 2008.[69] In the US, it had already reached 10% in 2006.[70] 3% of Canadian children and youth had borderline or elevated blood pressure in 2009 and 7% of US children and youth were found to have borderline or elevated blood pressure in 2006.[71,72] The rise in CVD risk factors in children and youth is thought to be associated with physical inactivity, increased meal portion sizes, and diets that are high in fat, sugar and salt but low in fruits and vegetables.[73,74]

It may be hypothesized that the "healthy immigrant effect" also applies to children and youth: Like their adult counterparts, they may be healther than children born in Western countries owing to self-selection, immigration admission screening, and healthier pre-immigration lifestyle behaviours. Similarly, children and youth immigrants to Canada may also be at risk of adopting unhealthy lifestyle habits due to their exposure to Western culture. Immigrant children and youth to Canada may feel more pressure than adults to adopt to Western lifestyle habits in order to fit in to the Canadian culture and establish relationships with their peers. Even though children due to their young age may be considered recent immigrants, the accelerated acculturation process observed in younger adults is likely to also apply to children and youth, and as a result, immigrant children and youth in North America may be at a higher risk for developing adverse levels of CVD risk factors following migration, and may lose their health advantage faster than adults.

To date, there is little high quality data available on CVD risk factors such as general and abdominal obesity, high blood pressure and elevated blood lipids in immigrant children in North America. Existing studies have focused on the relationship of acculturation with health behaviours such as fruit and vegetable consumption, physical activity[75–77] and obesity in young children, older children and youth.[76–78] While CVD risk factors (blood lipids, insulin, inflammation marker C-reactive protein (CRP)) have been reported for children of different ethnicities living in high income countries,[79–81] there are no published reports on the relationship for immigrants to Western countries that have assessed a broad range of CVD risk factors such as obesity, blood pressure, blood lipids, and CRP.

1.6 Conceptual models

Figure 1.1 shows the relationship between immigrant status and CVD risk factors. Immigrant health status depends on genetics, country of birth, level of education, and income. Level of acculturation to the new society is dependent on age at immigration, time since immigration, and the retention of the culture of origin, with language spoken at home being an indicator of the latter. Migration to Canada is followed by acculturation, which leads to changes in health behaviours and eventually, development of CVD risk factors such as obesity, high blood pressure, and dyslipidaemia.

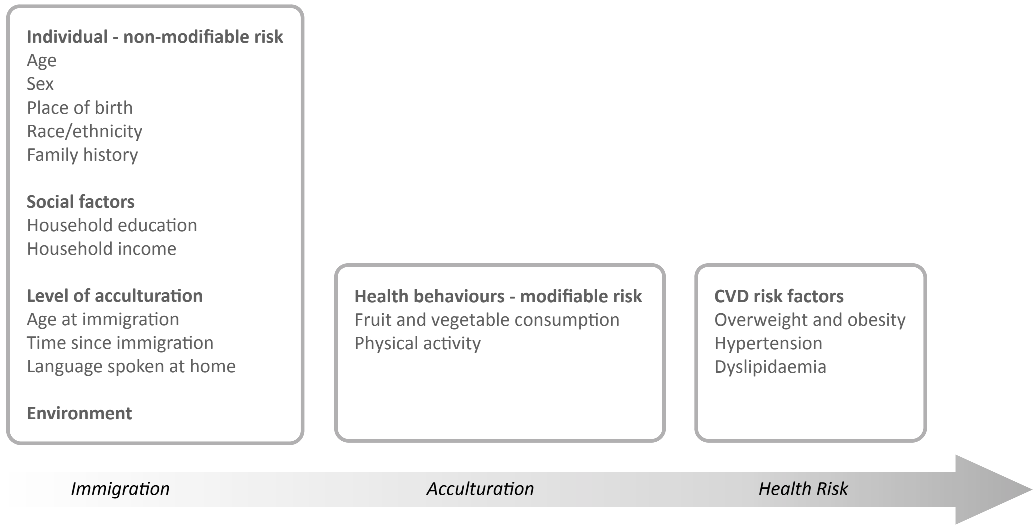

Figure 1.1: Conceptual diagram of the relationship between immigrant status and CVD risk factors. Acculturation is associated with changes in health behaviours and ultimately with increases in CVD risk factors obesity, high blood pressure, and dyslipidaemia.

Figure 1.2 shows how individual, social, and environmental factors influence CVD risk factors in immigrants. Socio-economic factors determine the surrounding environment, which then influences an individual's health behaviours. Non-modifiable individual factors are determined by ethnic origin and genetics, which in turn determine differences in CVD risk. The environment influences health behaviours in many different ways associated with infrastructure, social norms, and surrounding living conditions. As a results, immigrant health status is dependent on ethnicity, socio-economic factors, and the stage of the process of adaptation to the host society, culture, and physical environment.

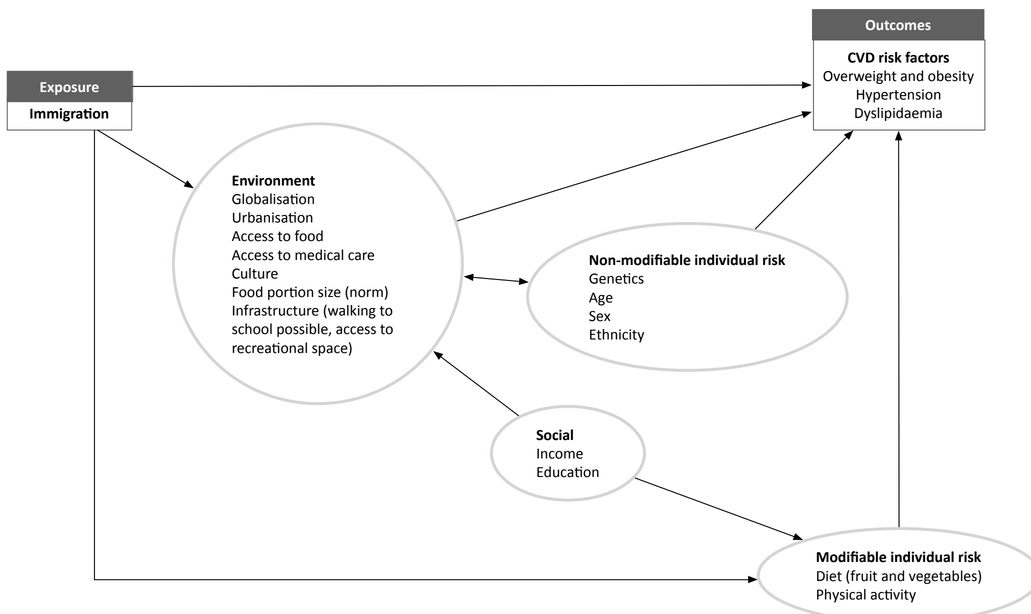

Figure 1.2: Conceptual diagram of the interplay between individual, social, and environmental factors, which influence CVD risk factors.

2 BACKGROUND AND LITERATURE REVIEW

This section begins with a brief explanation of how unhealthy lifestyle behaviours are associated with CVD risk factors in children. Next, the measurement of immigrant health status will be discussed. This is followed by an overview of the literature on the association of immigrant status and acculturation with health behaviours and CVD risk factors (obesity, elevated blood pressure, dyslipidaemia) in adults and children. The section concludes with a summary of the literature review findings, and the contribution of the proposed study to the current state of knowledge.

2.1 Healthy lifestyle behaviours in children are key to reduction of CVD burden in adults

Although CVD commonly manifests itself clinically only in adulthood, the etiology of CVD begins early in life, with CVD risk factors already present and detectable in childhood.[82–86] CVD risk factors often persist from childhood into adulthood, eventually leading to CVD.[87–92] For example, overweight children are twice as likely to become overweight adults, and those who are overweight in late adolescence are most likely to be overweight as adults.[90]

Behavioural risk factors may be responsible for about 80% of CVD.[5] Two of the most important behavioural risk factors for CVD, unhealthy diet and physical inactivity, are the result of habits and preferences developed in childhood.[93] Low levels of physical activity and increased time spent in sedentary activities are associated with increased risk of obesity, adverse lipid profiles, and elevated blood pressure in children and adolescents.[93,94] In a study by Friedemann et al., systolic blood pressure was 4.5 mmHg (99%CI 2.4;6.6) higher in overweight and 7.5 mmHg (99%CI 3.4;11.6) higher in obese children when compared to normal weight children.[67] Total cholesterol and triglycerides were 0.15 mmol/L (99%CI 0.04;0.25) and 0.26 mmol/L (99%CI 0.13;0.39) higher in obese children when compared to normal weight children.[67] Through these associations, obesity in later adolescence is associated with increased risk of CVD in adulthood.[92] Prevention of obesity in childhood and adolescence through retention or adoption of healthy lifestyle behaviours is therefore key to CVD risk factor reduction.[95,96]

2.2 The measurement of immigrant health status

Country of birth can be used as indicator of immigrant status by considering anyone born outside Canada (foreign-born) as an immigrant and comparing them to those whose country of birth is Canada (Canadian-born). Country of birth may also be used as a proxy for ethnicity when examining ethnic differences in health status and health behaviours between immigrants. If information on the parents' birthplace is available, country of birth can also be used to define generational immigrant status (e.g. 1st or 2nd generation immigrant).[97]

However, country of birth is a static measure and cannot assess the dynamic nature of the adoption of beliefs, attitudes and health behaviours of the host country, a process known as acculturation.[60] The concept and measurement of acculturation is complex. Aspects of acculturation such as years since immigration, generational immigrant status, or language spoken at home can be used to assess the level of acculturation. Younger individuals and those with higher education are believed to acculturate more quickly.[62] The level of acculturation increases with time spent in the host country and is associated with lower use of the native language at home. Years since immigration may be used to compare health behaviours of recent and longer-term (fully acculturated) immigrants.[52] Generational status may be used to compare immigrants with different levels of acculturation within the same ethnic group. For example, generational status has been used to look at differences in obesity prevalence between first and second generation immigrant youth in the US.[78]

However, these single item measures cannot do justice to the complexity of the acculturation process.[98,99] Acculturation is a complex multidimensional process that is difficult to quantify and single item measures can only give information on parts of this complex process.[100] On the other hand, while single indicators are not ideal, they are often the only practically feasible way to estimate the level of acculturation in larger studies.

2.3 Factors influencing health status and health behaviours

Besides the adoption of beliefs, attitudes, and behaviours, which is driven by the new social and cultural environment, the physical environment also influences the health behaviors and health status of new immigrants. Factors such as access to healthy food, recreational spaces, facilities, and services all influence health behaviours. The new physical, social and cultural environment of the host country is believed to gradually influence morbidity and mortality in the immigrant population until they eventually resemble or converge to those of the host population.[42,56,64,101]

2.4 General health status in immigrants to Canada

Before looking more specifically at CVD risk factors and changes thereof that occur with increasing exposure to the host society, it is important to first look at the general health status of immigrants to Canada. New adult immigrants seem to have an advantage in health compared to adults who are Canadian-born. New adult immigrants to Canada are less likely to have a chronic illness, and are in better CVD health compared to Canadian-born individuals.[38,39,56,59] The finding that recent adult immigrants are in better health than their Canadian-born counterparts still remains consistent in more recent studies.[36] In the 2009/2010 CCHS, immigrants had higher odds of reporting better health compared to those of the 2000/2001 CCHS cycle.[36] However, adult immigrants tend to not maintain their advantage in health. Data from the National Population Health Survey (NPHS) describes an almost continuous decline in self-reported health status for adult immigrants over time since immigration.[61] This is supported further by data from the Longitudinal Survey of Immigrants to Canada (LSIC) from 2001-2005.[102] For immigrant health status to reach the level of the Canadian population, the decline in health status with time and age has to be greater than in Canadian-born individuals.[103] The advantage in health tends to be lost in about 10 years.[58] Lastly, it is important to point out that economic, family class, and humanitarian immigrants are commonly treated as one group. However, when looked at separately, the small subgroup of humanitarian migrants, which constitutes 6% of immigrants,[104] have also been shown to experience a loss of physical health status with time spent in Canada.[105]

2.5 Composition of the Canadian immigrant population

The Canadian immigrant population is growing. In 1991, immigrants made up 16.1% of the Canadian population; this number rose to 19.8% in the 2006 Census. The proportion of immigrants is projected to rise to around 22% by 2017.[106] Much has changed in the composition of the immigrant population due to changes in the federal immigration policy. Thirty years ago, Europeans were the largest group of newcomers to Canada (61.6%). Today, people born in Asia (including the Middle East) form the largest group (58.3%), followed by those born in Europe (16.1%), Central, South America, the Caribbean (10.8%), and Africa (10.6%).[107]

2.6 Ethnic differences in CVD risk in immigrants to Canada

Immigrants are a diverse population with an uneven distribution of CVD risk (genetic, behavioural, environmental) across different ethnic groups migrating from environments with differing risk factor prevalence. Acculturation to Canada has been associated with increases in CVD risk factors in various ethnic groups with differing pre-migration histories. Indeed, ethnic predisposition is believed to explain in part differences in CVD risk factor levels between the groups.[46]

Most of Canada's immigrants now come from low and middle income countries. Immigrants from middle income and low income countries are at an increased risk of CVD after they settle in North America.[31–33] However, within this group, distinct differences in CVD risk between ethnic groups have also been reported. The prevalence of CVD in some ethnic groups following immigration not only increases to resemble that of the host population, but becomes higher than that of the host population after convergence. For example, South Asians have been reported to have a predisposition to abdominal obesity, glucose intolerance, high triglycerides and low levels of high-density lipoprotein (HDL) and African ethnicity has been associated with a higher prevalence of elevated blood pressure.[50,51,108,109]

Differences in CVD risk between ethnic groups have been observed in Canadian immigrants. Generally, non-European immigrants seem to lose their health advantage faster than European immigrants to Canada.[110] Non-European immigrants, who had lived in Canada less than 10 years were twice as likely as Canadian-born individuals to experience a transition from good, very good, or excellent health to fair or poor health. Canadian-born individuals in turn were twice as likely as European immigrants to experience this transition.[110] Combined data from the NPHS,[111] and the CCHS 2001, 2003, 2005, and 2007[112] among individuals from Ontario 12 years or older of White, South Asian, Chinese or Black ethnicity, showed differences in the prevalence of heart disease ranging from 3.2% in Chinese, followed by 3.4% in Blacks to highest levels of 5.2% in South Asians.[52] The prevalence of hypertension was the highest in Black people (19.8%), followed by South Asians (17%) and Chinese (15.1%), and lowest among White (13.7%). Mean BMI was highest among White (25.3 kg/m^2) and Black people (25.5 kg/m^2), followed by South Asians (24.2 kg/m^2), and lowest among Chinese (22.3 kg/m^2). The prevalence of obesity was lowest for Chinese (2.5%), higher for South Asians (8.1%), and highest for Black (14.1%) and White people (14.8%).[52] Non-European immigrants appear to be at a higher risk of gaining weight. Based on data from the NPHS 1994/1995 to 2002/2003, recent non-European immigrants were more likely to experience a 10% or greater increase in their BMI than recent European immigrants over the 8-year period.[110]

Predisposition of South Asians to abdominal obesity, glucose intolerance, high triglycerides, and low levels of HDL seems to put this immigrant group at an increased risk of CVD compared to other ethnic groups.[108,109] The Study of Health Assessment and Risk in Ethnic groups (SHARE) investigated CVD factors and their determinants in South Asian, Chinese and European Canadians between 35 and 75 years of age, who had lived in Canada for at least 5 years. They found that Canadian residents of South Asian origin who have spent at least five years in Canada have the highest mean levels of cholesterol, low-density lipoprotein (LDL), and triglycerides compared to Canadian residents of Chinese and European origin.[109]

CRP is a marker of systemic inflammation and has been associated with the development of CVD.[113–115] However, the degree to which CRP levels translate into an increased risk of CVD in different ethnic sub-populations has not been fully understood yet.[116,117] In a random sample of four Canadian communities, the age- and sex-adjusted mean CRP levels were 2.59 mg/L among South Asians, 2.06 mg/L among those of European ancestry, and 1.18 mg/L among Chinese.[118]

In summary, among different immigrant groups in Canada, Chinese immigrants appear to be at the lowest risk of CVD as they have the lowest prevalence of heart disease, obesity, and high blood pressure compared with other ethnic groups. South Asians seem to have the highest risk of CVD, which may in part due to their tendency to have a more unfavourable lipid profile. The high prevalence of obesity and high blood pressure in Black immigrants does not seem to translate to a higher CVD risk.[13]

2.7 Changes in health behaviours with time since immigration

2.7.1 Diet

Immigrants moving from low and middle-income countries tend to increase their intake of grains, meat, dairy products, sugar, and fat[119,120] and to gradually decrease their fruit and vegetable consumption[52] after they move to Western countries. In a study on dietary intake, Chinese living in North America were found to consume 35% calories from fat compared to 22% in Chinese living in China.[32] The relationship between acculturation to the US and diet in Latin American adults was investigated using four consecutive NHANES (National Health and Nutrition Examination Survey) cycles from 1999-2004. The study revealed that time spent in the US was associated with a higher consumption of sugar, fast food, and fatty snacks, and a lower consumption of fruits and vegetables.[121] A systematic review further corroborated this evidence.[122] An increase in portion size and a higher frequency of eating out has also been reported in Chinese immigrants to Canada.[123] Decreased availability of traditional foods, increased cost as well as environmental and social barriers have been proposed as explanations for the shift in diet away from traditional foods.[124] Maintaining a traditional diet can be protective against CVD risk.[125] Meat consumption increases with acculturation to North America, and non-vegetarians tend to have higher levels of cholesterol, triglycerides and LDL than vegetarians.[126] However, even if conversion to non-vegetarianism following migration is part of the shift in health behaviours,[125] so is the absolute amount of fat intake. In contrast to what has been mostly reported in North American studies, migration and acculturation to France has been observed to have a protective effect in North African immigrants with regard to their CVD risk. They tend to preserve their healthy diet as long-term immigrants and have lower CVD morbidity and mortality compared to the French population.[127–129] North Africans are the largest non-Caucasian ethnic group living in France, so they may find it easier to retain their culture and traditional diet than immigrants to North America.

2.7.2 Physical activity

Besides diet, the energy balance is further modified by physical activity. Recent immigrants to Canada are less physically active in terms of walking, sports, endurance, and recreation activities than Canadian-born residents.[37,130,131] Data from 20-64 year-old immigrants in the CCHS showed that recent immigrants ($\leq$ 10 years) engaged in moderate to vigorous daily physical activity (16%) less frequently than long-term ($>$ 10 years) immigrants (20%) or Canadian-born residents (24%).[132] However, immigrants (recent and long-term) are more likely to walk or cycle to work or school compared and non-immigrants.[131] Tremblay et al. found immigrants to have higher levels of physical activity with time spent in Canada, but at the same time the prevalence of overweight and obesity also increased over time since immigration[133], a pattern was also observed in immigrants to Australia.[134] This finding may be explained by an increase in the intake of energy-dense foods and portion size after settlement, which cannot be compensated for by moderate physical activity to maintain a healthy weight. Similar to the weight gain that occurs after immigration, the increase in physical activity is due to the process of acculturation to the host society. One can speculate that awareness about CVD and its risk factors may increase with acculturation and may lead to improvements in physical activity levels. There may also be fewer financial barriers as immigrants may move to better jobs with time, which would allow for more flexibility in terms of financial resources and time needed to engage in organized physical activities. The adoption of beliefs and behaviours relating to diet may not necessarily show the same pattern as those relating to physical activity.

2.8 Changes in health behaviours with adoption of the official language

Some studies have used the adoption of official languages as a proxy measure of acculturation, while speaking the language of cultural origin at home can be seen as a measure of cultural retention. Immigrants who retain more of their original culture might also retain healthier lifestyle behaviours, especially with respect to diet. Speaking mainly the language of cultural origin at home has been associated with consumption of foods most commonly consumed among less-acculturated individuals such as higher amounts of fruits and vegetables and more traditional, non-processed foods.[121] Speaking English at home has been associated with a more Western diet that high in sugar content, fast food consumption, and fatty snack intake.[122] Norman et al. found that the single item acculturation measures used to assess diet in low-income Hispanic women contributed different information on dietary fat intake: Speaking English at home was associated with a lower consumption of traditional foods such as beans and peas. The combination of the two single item measures country of birth (US-born vs. foreign-born) and language spoken at home yielded more information on dietary practices than the use of one single item measure alone. Those born in the US who preferred speaking English at home had a greater consumption of processed foods, salty snacks, and higher fat foods.[135] A lower level of acculturation or cultural retention of the culture of origin seems to be associated with more healthy dietary behaviours. No data are available on the association between acculturation and physical activity.

2.9 CVD risk factors with time since immigration

2.9.1 Overweight and obesity

A diet higher in fat, sugar, and processed foods, and lower in fruit and vegetables can explain in part the increase in overweight and obesity observed in adult immigrants to Western countries. Using pooled data from the Statistics Canada's NPHS and CCHS 1996-2007, Chiu et al. found an increase in obesity and hypertension among recent vs. long-term immigrants ($<$15 years vs. 15+ years in Canada).[46] Long-term immigrants of White, South Asian, and Chinese ethnicity (aged 12 years and older) all experienced an increase in obesity and hypertension; Black people experienced an increase in hypertension only.[46] Goel et al. reported similar trends observed using data from the US National Health Interview Survey (NHIS 2000) where 10 years or longer spent in the US was associated with a significant increase in BMI for all foreign-born ethnic groups except for Black people.[44] Immigrants living in the US for at least 15 years had a prevalence of obesity of 19%, very close to the 22% seen among US-born individuals.[44] However, Lauderdale et al. found an increase in the risk of overweight and obesity among all foreign-born individuals in NHIS with length of time spent in the US.[33] Data from the 2002 NHIS showed a 31% increased risk of overweight and obesity in immigrants who lived $\geq$ 15 years in the US compared to immigrants who lived in the US $<$ 10 years.[45] Immigrants who moved to the US in the past year, 1-5 years ago, 5-10 years ago, $\geq$ 15 years were 61%, 38%, 35%, 28%, and 13%, respectively, less likely to be overweight than US-born individuals. Female immigrants in the NHIS were faster to converge to BMI levels of US-born individuals than male immigrants.[34] Fourteen of fifteen studies reported a positive significant relationship between BMI and time since immigration in the US.[136] In sum, these studies underscore that immigrants to Canada and the US are at an increased risk of overweight and obesity after having spent at least 10 years in the host country.

2.9.2 Hypertension and hyperlipidaemia

Data from the 1993-1994 NHIS in the US showed that blood pressure increased with time spent in the US among adults 25 years and older.[43] Immigrants who moved to the US in the past year, 1-5 years ago, 5-10 years ago, $\geq$ 15 years were 66%, 33%, 35%, 25% and 19%, respectively, less likely to report high blood pressure than US-born individuals.[43]

Using data from the 2002 NHIS, Koya et al. found 59% higher odds of hyperlipidaemia for immigrants who had lived in the US for more than 15 years compared to those who had lived in the US for less than 10 years.[45] These studies highlight that immigrants are at an increasing risk of high blood pressure and dyslipidaemia with more time spent in the US.

2.9.3 Increased CRP levels

The association between time since immigration and increased levels of CRP has not been examined yet. There is only one study that has reported increased levels of CRP in Hispanics with a higher level of acculturation as measured by a language use acculturation scale in the NHANES 1999/2008 population.[137] Higher levels of acculturation were associated with high CRP levels of above 3.0 mg/L. Median CRP levels were 2.0 (interquartile range 3.8) and 2.0 (interquartile range 3.1) in those with a higher and lower levels of acculturation, respectively.

2.10 Health behaviour changes in children and youth with acculturation to North America

Acculturation to North America has been associated with changes in diet in immigrant children and youth. Unger et al. found that acculturation to the US was associated with increased fast food consumption and lower levels of physical activity among Asian American and Hispanic 6th grade youth in Southern California.[75] Second generation adolescent Chinese immigrants in Canada and those with a higher level of acculturation as measured by official language use, were more likely to be interested in consuming dessert, snack, and fast foods than first generation Chinese immigrants despite being more informed on nutrient content.[138]

In keeping with the hypothesis that immigrants might have better lifestyle behaviours pre-immigration, which are gradually changed with acculturation to the host country, first generation 11 to 13 year-old migrant children to the United Kingdom (UK) were more likely to consume the recommended daily servings of fruit and vegetables compared to UK-born children participating in the Determinants of Adolescent Social well-being and Health (DASH) study (OR for < 1 vs. $\geq$ 5 servings per day: girls 0.72 (95%CI 0.55;0.94), boys 0.61 (95%CI 0.48;0.79).[76] Similar to adult immigrants, lower levels of acculturation were associated with lower levels of physical activity ($\beta =$ -46.9 minutes/day, $p < 0.01$) in Sub-Saharan African migrant children to Australia aged 3-12 years, although they also engaged in less sedentary behaviours ($\beta =$ -43.0 minutes/day, $p < 0.05$) than more acculturated children.[77] This pattern was also observed in 6-17 year-old immigrant children to the US in the National Survey of Children's Health (NSCH) in 2003.[139] These studies show that immigrants eat more energy-dense foods and less fruits and vegetables with increasing time spent in the host country.

2.11 CVD risk factor changes in children and youth with acculturation

The prevalence of overweight and obesity has been compared between first generation and second generation immigrant children to see if acculturation is associated with an increase in overweight and obesity. Data from the National Longitudinal Study of Adolescent Health, based on a nationally representative sample of US youth in grades 7-12 (age 12-22 years, school year 1994-1995) showed that youth born outside the US had lower prevalence of obesity compared to those born in the US to immigrant parents.[78] Obesity increased more than two-fold (from 11.6% to 27.2%) between first- (foreign-born) and second-generation (children of immigrant parents or with one foreign-born parent) Asian American youth.[78] First generation immigrant children had a BMI increase of 0.59 kg/m^2 with each year of age compared to 0.73 kg/m^2 in second generation immigrant children and 0.82 kg/m^2 in Canadian-born children in a sample of elementary school children from an economically disadvantaged urban neighborhood in Montreal.[35] First generation immigrant youth in the UK were less likely to be obese than second generation immigrant youth (girls: OR 0.62 (95%CI 0.42;0.91), boys: OR 0.56 (95%CI 0.40;0.80)) in the Determinants of Adolescent Social Well-Being and Health study (DASH).[76] Using an acculturation scale, which focused on traditional culture retention with respect to diet, language, and social activities, Renzaho et al. showed that in Sub-Saharan African migrant children to Australia aged 3 to 12 years, children with low levels of acculturation had significantly lower levels of obesity compared to children with higher levels of acculturation (prevalence 9.8 vs. 32.0%).[77] In contrast, Quon et al. found a higher prevalence of obesity in first generation compared second generation youth of the Canadian National Longitudinal Survey of Children and Youth (NLSCY).[140] This observation may have been due to a much lower sample size of first generation immigrants compared to second generation immigrants, and to the underrepresentation of immigrant families owing to oversampling in rural areas.[141] Overall, studies show a largely consistent pattern of lower risk of obesity in first generation compared to second generation immigrant children.

2.12 Ethnic differences in CVD risk factors in children and youth living in Western countries

Ethnic differences in serum CVD risk markers in children have been determined in children living in high income countries. The Child Heart and Health Study in England (CHASE, 2004-2007), a large school-based study in a multi-ethnic sample of British children of White European, South Asian, Black African-Caribbean, and other Asian ethnicities between 9 and 10 years old reported ethnic differences in CVD risk markers in allegedly healthy children. Specifically, South Asian children had higher levels of insulin, triglycerides, and CRP, and lower HDL levels in comparison to children from other ethnic backgrounds.[79] Black African/Caribbean children had higher insulin and CRP levels but also higher HDL and lower triglyceride levels.[79] In the NHANES (1999-2002) population, higher insulin levels were found in African American female youth aged 12-17, when compared with Mexican Americans and Whites.[81] Higher insulin levels were also found in Black compared to White children aged 5-17 years in the Bogalusa Heart Study.[80]

Ethnic differences in body composition, body fat mass, and obesity prevalence have been reported. South Asian children were found to have a higher sum of biceps, triceps, subscapular, suprailiac skinfolds, and overall fat mass when compared to White European and Black elementary school children aged 9-10 years in the UK.[142] At the same fat mass, BMI was lower in South Asian children than in White Europeans.[142] South Asian children were also found to have 30% (95%CI 17%;44%) higher cord leptin concentrations adjusted for birthweight, indicating a higher fat mass at birth when compared to White children of the Born in Bradford study in the UK.[143] Overweight and obesity were 64% higher in Black children and youth compared to White children and youth born in the US in the 2003 NSCH.[144] However, children and youth from Asia had lower prevalence of overweight and obesity (15%) compared to White children and youth (23%) in the California Health Interview Survey (2003).[145]

Triceps, subscapular skinfold thickness, and systolic blood pressure were higher in primary school children of South Asian origin aged 7-11 years from a deprived urban area in the UK.[146] Harding et al. examined overweight, obesity, and blood pressure in a sample of White, Black, and South Asian 11 to 13 year-old youth in a school-based study in London, UK for the DASH study. Overweight and obesity were more prevalent among Black girls compared to White girls. Ethnicity was an independent predictor of blood pressure. Indian girls (South Asian) showed a higher prevalence of high normal diastolic blood pressure. The effect of excess weight on blood pressure was more pronounced in Indian (South Asian) youth than in other ethnic groups.[147]

CRP concentrations examined in the NHANES 1999/2000 in 3 to 19 year-old children and youth showed that Whites and African Americans had lower CRP levels than Mexican Americans.[148] This finding was also seen again in the NHANES 1999/2004 .[149] In contrast to findings in adults, Black children and youth did not have higher CRP concentrations than White children and youth.

In summary, Black children have a higher prevalence of obesity and high insulin levels compared to White children, but also have higher HDL levels. South Asian children appear to have the highest risk of CVD, which seems to be in part due their tendency to have a higher fat mass and a more unfavourable lipid profile.

2.13 Summary

Immigration to North America has been associated with an increase in CVD risk factors.[33,43,45,46] Non-European immigrants, who now form the largest group of newcomers to Canada, are more affected than European immigrants.[110] This may be due to the observation that non-European populations have a higher genetic risk of CVD that may become manifest with exposure to unhealthy Western lifestyle habits. The larger difference in stage of epidemiologic transition between the former and host country may also play a role. Newer immigrants to Canada tend to demonstrate healthier dietary behaviours and less sedentary behaviours but lower levels of physical activity.[132] Among adult immigrants, acculturation to North America is associated with the adoption of the Western diet,[122] increases in sedentary behaviours, and lower levels of physical activity but increasing levels of recreational physical activity with time.[132] Similar health behaviours and health status changes are observed in children and youth, in that they tend to demonstrate healthier dietary behaviours[76] but lower levels of physical activity.[75] However, the literature has focused predominantly on adult immigrant populations and has been limited to obesity as the CVD risk factor, with fewer reports documenting subclinical differences in blood pressure and blood lipids. There is a paucity of data on a range of CVD risk factors in children following migration. Factors associated with differences in CVD risk need to be investigated and identified to better understand the health needs of the growing immigrant population. Finally, it is also important to know the health status and health behaviours of immigrant children and youth to Canada to better identify if they may be at higher risk of CVD.

3 OBJECTIVES

The objectives of the proposed research are as follows:

3.1 Objective 1

To examine whether there are differences in CVD risk factors (obesity, elevated blood pressure, dyslipidaemia, and elevated CRP levels) between foreign-born (immigrant) children and youth and Canadian-born children and youth.

3.1.1 Hypothesis 1a

It is hypothesized that foreign-born children and youth will have overall lower mean levels of CVD risk factors than Canadian-born children and youth.

3.1.2 Hypothesis 1b

It is hypothesized that foreign-born children and youth will have overall lower prevalence of adverse levels of CVD risk factors than Canadian-born children and youth.

3.2 Objective 2

To examine whether there are differences in health behaviours (fruit and vegetable intake and physical activity) between foreign-born (immigrant) children and youth and Canadian-born children and youth.

3.2.1 Hypothesis 2a

It is hypothesized that foreign-born children and youth will have higher levels of fruit and vegetable intake than Canadian-born children and youth and that foreign-born children will have lower levels of leisure physical activity than Canadian-born children.

3.2.2 Hypothesis 2b

It is hypothesized that foreign-born youth and youth will be less likely to be physically active than Canadian-born youth.

3.3 Objective 3

To examine whether there is an association between immigrant status (being foreign-born compared to Canadian-born) and mean levels of CVD risk factors after adjusting for potential confounders.

3.3.1 Hypothesis 3a

It is hypothesized that there is a negative association between immigrant status (being foreign-born compared to Canadian-born) and mean levels of CVD risk factors after adjusting for potential confounders.

3.3.2 Hypothesis 3b

It is hypothesized that there is a negative association between immigrant status (being foreign-born compared to Canadian-born) and prevalence of adverse levels of CVD risk factors after adjusting for potential confounders

3.4 Objective 4

To examine whether there is an association between immigrant status (being foreign-born compared to Canadian-born) and levels of health behaviours (fruit and vegetable consumption and physical activity) after adjusting for potential confounders.

3.4.1 Hypothesis 4a

It is hypothesized that there is a positive association between immigrant status (being foreign-born compared to Canadian-born) and fruit and vegetable consumption in children and youth after adjusting for potential confounders. It is also hypothesized that there is a negative association between immigrant status (being foreign-born compared to Canadian-born) and levels of leisure physical activity in children.

3.4.2 Hypothesis 4b

It is hypothesized that there is a negative association between immigrant status (being foreign-born compared to Canadian-born) and being physically active in youth after adjusting for potential confounders.

4 ASSESSMENT OF CVD RISK

This chapter will provide an overview of measures used to assess body fatness, their advantages and disadvantages as well the reference values available to define at risk categories. This will be followed by discussion of the available reference values for blood lipids and CRP in children and youth. The chapter will conclude with the measurement and definition of at risk categories for blood pressure in children and youth.

4.1 Body fatness

There are a number of measures available to assess body fatness. The BMI has historically been seen as the most suitable and most widely used measure to screen for obesity but it is not a measure of abdominal fat and can not differentiate between lean and fat mass.[150–152] As obesity-related adverse health outcomes, which manifest in adulthood, are more strongly associated with abdominal fat in adults,[153–160] measures that correlate well with abdominal fatness provide a better assessment of CVD risk.

A BMI of $\geq$ 25kg/m^2 and $\geq$ 30kg/m^2 in adults is considered as overweight and obese, respectively.[11] In children, BMI cut-points to identify underweight, normal weight, overweight, and obesity are age- and gender-specific[161–163] because of changes in body composition during childhood and adolescence that are dependent on age and sex. The most commonly used cutoffs are those of the International Obesity Task Force (IOTF)[161] the Centers for Disease Control and Prevention (CDC)[163] and WHO growth charts.[162] The WHO growth charts are based on the WHO Multicentre Growth Reference Study, the National Health Examination Survey, and the NHANES.[164] The concept behind the WHO growth charts is that under ideal circumstances, the growth of children is similar worldwide. Based on the growth curves, the cut-points for overweight and obesity are between one and two standard deviations (SD) above the mean, and more than two SD above the mean, respectively (approximately 84th and 97.7th percentile). At age 19, the WHO cut-points converge with the adult cut-points for overweight (25.4 kg/m^2 for boys and 25.0 kg/m^2 for girls) and obesity (29.7 kg/m^2 for both sexes).

The disadvantage of the CDC cut-points is that they are based on an arbitrary statistical approach and not based on the analysis of health outcomes. These growth charts are meant for national and international comparisons. The CDC growth curves are based on cross-sectional measurements of five national samples of US children (National Health Examination Surveys II and III, NHANES I, II and III).[163] It is recommended that children and youth with BMIs above the 85th and 95th percentile for age and sex are considered at risk for overweight, and overweight, respectively.[165] The IOTF growth reference, developed for international comparisons, combined 6 large nationally representative surveys from Brazil, the UK, Hong Kong, the Netherlands, Singapore, and the US to define internationally applicable cut-points which correspond to the adult cut-points of 25 kg/m^2 and 30 kg/m^2 for overweight and obesity. Smoothed, country-specific centile curves were constructed, which intersect the corresponding cut-points of adult overweight and obesity, at 18 years of age. The concept of the IOTF growth reference is that overweight and obesity at 18 years of age are associated with adverse health outcomes in adults and can be traced back into childhood. Childhood overweight as per IOTF BMI cut-points has been shown to be related to adverse CVD risk factor levels in adulthood.[161,166,167] The IOTF cut-points for obesity are higher than the WHO cut-points especially in 8 to 13 year-old children. The CDC cut-points are lower than those of the WHO for younger children but IOTF cut-points are recommended for international use. Table 4.1 shows an overview of the BMI cut-points developed by the WHO, CDC, and IOTF.

Method	Overweight	Obesity
WHO	approx. 84th percentile, corresponding to 25.4 kg/m^2 for boys and 25.0 kg/m^2 for girls at age 19	approx. 97.7th percentile, corresponding to 29.7 kg/m^2 for both sexes at age 19
CDC	85th percentile	95th percentile
IOTF	Smoothed centile curve that intersects the adult overweight cut-off (25 kg/m^2) at age 18	Smoothed centile curve that intersects the adult obesity cut-off (30 kg/m^2) at age 18

Table 4.1: WHO, CDC, and IOTF cut-points for overweight and obesity in children and youth.
Abbreviations: *approx.* approximately; *WHO* World Health Organization; *CDC* Centers for Disease Control and Prevention; *IOTF* International Obesity Task Force.

Waist circumference is a measure of abdominal fat and can predict health outcomes in youth and adults.[168,169] Reference values for children are available. Fernandez et al. determined waist circumference percentiles in a nationally representative sample of African-American, European-American, and Mexican-American 12-19 year-old children and youth in NHANES III (1988-1994).[170] There are waist circumference percentiles available in British children and youth aged 5-16 years.[171] Waist circumference percentiles are also available for Canadian youth aged 11-18 years based on the 1981 Canada Fitness Survey.[172] Cook et al. developed smoothed percentile curves for children between 2 and 18 years, which intersect adult cut-point values of the Adult Treatment Panel (ATP) III criteria at 18 years of age (94th percentile in males and 84th percentile in females) using NHES III, NHANES 1999-2006, and Fels and Bogalusa study data.[173] The definition of risk most commonly used is the 90th percentile due to the observation that a child with a waist circumference above the 90th percentile is more likely to have abnormal blood lipids and high blood pressure.[169] De Ferranti et al. have used the 75th percentile to define risk (NHANES III) as they based their definition on the NCEP (National Cholesterol Education Program) ATP III adult definition of risk where the adult cut-points of 102 cm and 88 cm translated to the 72nd percentile in males and 53rd percentile in females.[174,175] The International Diabetes Federation (IDF) has recommended the 90th percentile as a definition of risk based on available studies, but plans to modify this recommendation based on future studies if necessary.[176]

Skinfold thickness is used to estimate subcutaneous fat, not visceral fat. Subcutaneous fat makes up about 40 to 60% of the total body fat. The Harpenden caliper is one of the most widely used and considered as one of the more reliable instruments for the assessment of skinfold thickness. Interobserver variability is the most significant problem with skinfolds measurement.[177] Standardized methods for the location of the site, grasping of the skin and positioning of the calipers, and an experienced observer can help to reduce measurement error.[178] Percentiles for triceps and subscapular skinfolds thickness in children based on the same sample of US children that was used for the CDC BMI reference curves have recently been published.[179] Since there were no available reference values for the sum of 5 skinfolds (triceps, biceps, subscapular, iliac crest, medial calf), the 90th age-specific within-sample percentile is proposed as a definition of risk in this study.

4.2 Blood lipids

Serum lipids are conveyed in a construction of lipoprotein complexes that contain cholesterol, triglycerides, and the apolipoproteins, which regulate lipid transport.[180]

Available reference values for children include the NCEP Pediatric Panel report[181] as well as the American Diabetes Association statement on type 2 diabetes in children and youth.[182] De Ferranti et al. have used pediatric percentiles equivalent to the adult triglyceride, HDL and cholesterol level percentiles.[174,183] Lambert et al.[184] in their study of CVD risk factors in a population-based sample of Quebec children and youth used recommendations from the American Heart Association (AHA) and the American Academy of Pediatrics (AAP)[185] as well from other pediatric studies[83,186] for thresholds of cholesterol, triglycerides, and LDL and HDL cholesterol. In a study to determine the prevalence of insulin resistance syndrome in the Quebec Child and Adolescent Health and Social Survey (QCAHS)[187] low HDL cholesterol was defined as values $\leq$ 25th percentile from the study population, similar to what was used in the Bogalusa Heart Study[188] and CVD Risk in Young Finns Study.[189] In a study to determine CVD risk by weight status in the same sample[184] < 1 mmol/L was used as the cut-point for low HDL cholesterol. A cut-point of > 1.7 mmol/L was used to identify an elevated triglyceride level, which is generally recommended and used for both children, youth and adults.[176 175] However, there are no official reference values available for children. The IDF recommends using adult reference values until research findings can provide more appropriate definitions.[176] Available reference values are summarized in Table 4.2.

4.3 Elevated CRP

CRP is an acute phase protein inflammatory marker which binds to LDL and has been found in atherosclerotic plaques.[195–197] The exact role CRP plays in the pathogenesis of coronary heart disease and CVD is still unclear but the association between CRP and CVD remains.[198,199] CRP improves risk prediction in those individuals not displaying traditional risk factors and it is also an independent predictor of CVD.[200,201] However, there is still controversy regarding the clinical utility of CRP in risk prediction of CVD.[198]

The AHA recommends a cut-point of 3.0mg/L for CRP and this cutoff has also been used for pediatric studies.[116,184]

4.4 High blood pressure

The Fourth report on the Diagnosis, Evaluation and Treatment of High Blood Pressure in Children and Youth defines elevated blood pressure based on blood pressure percentiles specific for gender, age (1-year intervals) and height (7 categories based on height percentiles) for systolic and diastolic blood pressure (50th, 90th, 95th, and 99th).[193] The height percentile is derived from normal growth charts. These norms were determined using data from 63,227 American children aged 1 to 17 years who participated in studies and surveys in the 1970s and 1980s.[202] Measurements below the 90th percentile are classified as normal. Pre-hypertension and hypertension is present if either systolic or diastolic pressure or both values are above the 90th percentile. Pre-hypertension is defined as a blood pressure between the 90th and 95th percentile. A value above the 95th percentile is considered hypertension.

Blood pressure should be measured at least twice during one sitting and ideally, on at least three different occasions.[203] The auscultatory method using a mercury column sphygmomanometer is commonly recommended because normative values were derived using this method. The mercury sphygmomanometer is being used less often because auscultatory methods are more prone to introduction of user error for example through rounding or subject digit preference.[71] In addition to this, there has is an ongoing international effort to eliminate the use of devices

	NCEP ATP III[181]	**IDF**[176]	**IDF**[176]	**Lambert**[184]	**De Ferranti**[174]
Age [years]	Adults	10-15	$\geq$ 16	9, 13, and 16	12-19
Population				QCAHS	NHANES III
BMI					
Overweight				$\geq 85^{th}$ *	
Obesity				$\geq 95^{th}$ *	
WC [cm]					
High (M)	> 102 cm		$\geq 90/94^{th}$ **		
High (F)	> 88 cm		$\geq 80^{th}$ **		
WC [percentile-based]					
High		$\geq 90^{th}$ †			
BP [mmHg]					
High	$\geq$ 130/85	$\geq$ 130/85	$\geq$ 130/85		
BP [percentile-based]					
High				$\geq 90^{th}$ ‡	$\geq 90^{th}$ ‡
HDL [mmol/L]					
Low (M)	< 1.03	< 1.03	< 1.03	< 1.0§	
Low (F)	< 1.29	< 1.29	< 1.03	< 1.0§	
CHOL [mmol/L]					
High (M)				$\geq$ 4.4§	
High (F)				$\geq$ 4.4§	
TG [mmol/L]					
High	$\geq$ 1.7	$\geq$ 1.7	$\geq$ 1.7	$\geq$ 1.7	$\geq$ 1.1

Table 4.2: A selection of available reference values to define CVD risk in adults, children and youth from definitions of the metabolic syndrome.

* Age- and sex-specific CDC growth charts

** WC $\geq$ 94 cm for Europid males and $\geq$ 80cm for Europid females, $\geq$ 90 cm for South and South East Asian, Japanese, South and Central American origin men and $\geq$ 80 cm for South and South East Asian, Japanese, South and Central American origin women

† Based on evidence from studies using the NHANES III population[190–192]

‡ National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Youth;[193]

§ Recommendations from the AHA and the AAP[185] and from other pediatric studies[186,194]

Abbreviations: *CVD* Cardiovascular disease; *NCEP ATP* National Cholesterol Education Program Adult Treatment Panel; *QCAHS* Quebec Child and Adolescent Health and Social Survey; *NHANES* National Health and Nutrition Examination Survey; *M* Male; *F* Female; *BMI* Body Mass Index; *WC* Waist circumference; *BP* Blood pressure; *HDL* High-density lipoprotein cholesterol; *CHOL* Cholesterol; *TG* Triglycerides.

containing mercury in health care practice, due to the neurotoxicity of mercury.[204] Oscillometric devices are currently becoming more common in practice. Measurements above the 90^{th} percentile using the oscillometric device should be confirmed using the auscultatory method. The size of the cuff is crucial for accuracy. Oscillometric devices are easier to use and inter-observer variation is eliminated.[205]

4.5 Summary

Age- and sex-dependent physiological changes during childhood and adolescence pose challenges for finding appropriate cut-points to define CVD risk. The use of a single number as a cut-point to define risk in adults is often not feasible for the definition of risk in children and youth. Therefore, percentile-based cut-points are used for identifying obesity and high blood pressure in these populations. This approach in turn has the inherent limitation that cut-points depend on the reference population chosen. The definition of CVD risk is well established for obesity and high blood pressure in children and youth, but not yet for others such as dyslipidaemia or elevated CRP. Sometimes, available established cut-points can not be used due to sample size restrictions when the numbers at risk are very low in some child and youth populations. There are several ongoing challenges inherent in the assessment of CVD risk in children and youth.

5 METHODS

5.1 Study design

The present study used data from the combined Canadian Health Measures Survey cycle 1 2007-2009 (CHMS)[206] and CHMS cycle 2 (2009-2011) to test the study hypotheses. The CHMS is a national, cross-sectional survey that examined physical and mental health, socio-demographic factors, nutrition, and physical activity in Canadians aged 6 to 79 years in cycle 1, and 3 to 79 years in cycle 2. The two-step data collection included a personal interview at the household followed by a visit to a Mobile Examination Centre to collect physical measures and biospecimens in the respondents. For cycle 1, fifteen collection sites were identified with the area frame of the Labour Force Survey (LFS). The 2006 Census was used as a frame to identify the household units. Household health interviews and physical measures examinations were conducted between 2007 and 2009. The overall response rate was 51.7%. A total of 5604 individuals participated in the physical examinations part of the survey. For cycle 2, eighteen collection sites were identified with the area frame of the LFS and the 2006 Census was used as a frame to identify the household units. Household health interviews and physical measures examinations were conducted between 2009 and 2011. The overall response rate was 55.5%. A total of 6395 individuals participated in the physical examination part of the survey.

As the present study is limited to children and youth, only data from participants aged 6 to 19 years were used. For children aged 6 to 11 years, an adult answered questions with assistance from the child. Children 12 years and older were asked to answer questions on their own. Children are categorized as 6-11 years and youth are categorized as 12-19 years.

5.2 Consent and Ethics

Participation in the CHMS survey was voluntary and this was stated in the introductory letter, brochure, video, and Information and Consent booklet. Respondents could ask CHMS staff any questions regarding risks of participating in the tests and the use of their data in a nine-point interactive consent process during the household interview and the visit to the Mobile Examination Centre.

Processes used for data collection in cycle 1 and cycle 2 of the CHMS were reviewed and approved by the Health Canada Research Ethics Board to ensure that internationally recognized ethical standards for human research were met and maintained.

5.3 Where research was conducted

Data analyses were conducted at the Atlantic Research Data Centre at Dalhousie University, Nova Scotia, Canada.

5.4 Sampling weights and bootstrap weights

The CHMS was designed to be a population-based, representative survey. Due to the complex survey design, oversampling of some regions and populations, and due to non-response, survey responses need to be weighted to be representative of the Canadian population.[207] The sampling weights for the CHMS were provided by Statistics Canada. Each individual is assigned a sampling weight, which can interpreted as the number of Canadians that individual represents.

Since standard error estimates from the weighted sample will be falsely low, Statistics Canada provides 500 bootstrap weights for the CHMS to obtain corrected variance estimates. Use of the bootstrap weights yields an estimate of the variance that would occur had different samples been selected by the same design.

5.5 Coefficient of variation

Statistics Canada recommends using the coefficient of variation (CV) as an indicator of the quality of estimates. The CV is the margin of error expressed as a percentage of the estimate. Statistics Canada policy requires that CVs are $\leq 33.3\%$ in order to be released for publication. CVs between 16.6% and 33.3% should be accompanied by a cautionary note stating that the estimate has a high sampling variability; CVs $> 33.3\%$ are seen as having unacceptable quality by Statistics Canada and release of these estimates is not recommended as conclusions based on these estimates will be unreliable and likely invalid.

5.6 Outcomes

The primary outcomes were markers of CVD risk: 1. general and abdominal obesity, 2. blood pressure, 3. blood lipids, 4. CRP. The corresponding variables in the CHMS are indicated by their variable name in uppercase italic font.

The secondary outcomes were measures of health behaviour including: 1. Fruit and vegetable intake, 2. Physical activity.

5.6.1 BMI

Weight (*HWM_13KG*) was taken on a calibrated digital scale (Mettler Toledo, Mississauga, ON, Canada). Standing height (*HWM_11CM*) was measured using a fixed stadiometer with a vertical backboard and a moveable headboard. The BMI was calculated from measured weight and height using the formula weight/height^2 [kg/m^2] (*HWMDBMI*). Overweight and obesity were classified using the age- and gender-specific BMI cut-point points for children and youth established by the IOTF.[166]

5.6.2 Waist circumference

Waist circumference (*HWM_14CM*) measurement was based on the Canadian Physical Activity, Fitness, and Lifestyle Approach (CPAFLA) protocol[208] using a 150 cm or a 200 cm Gulick tape measure. Waist circumference was measured at the mid-point between the bottom of the rib cage and the top of the iliac crest at the end of a normal expiration. Within-sample percentiles rather than external cut-points were used to define risk to be consistent with within-sample generated waist circumference z-scores. The raw value was converted to the corresponding within-sample percentile for age (*CLC_AGE*) and gender (*DHH_SEX*). Waist circumference was also converted to individual age- and sex-specific z-scores.

5.6.3 Skinfolds

Skinfolds were measured using the five site method of the CPAFLA protocol[208] with a Harpenden skinfold caliper and a Gulick tape measure (150 cm) to the nearest 0.2 mm. Each skinfold thickness was measured twice. The triceps skinfold thickness was measured on the midline of the back of the arm at the mid-point level between the acromium process and the tip of the olecranon process. Biceps skinfold thickness was measured over the biceps at the same level as the mid-point for the triceps. Subscapular skinfold thickness was measured below the inferior angle of the scapula at an angle of 45° to the spine. Iliac crest skinfold was measured in the mid-axillary line above the crest of the ilium. Medial calf skinfold was measured at the medial side of the calf at the point of the largest circumference. The sum of 5 skinfolds was then calculated (*SFMDS5*) and the raw value was converted to the corresponding within-sample percentile by age group and gender. The sum of 5 skinfolds was also converted to individual z-scores by year of age (*CLC_AGE*) and sex (*DHH_SEX*).

5.6.4 Blood pressure

Blood pressure was measured using a new protocol created for the CHMS based on previous work by Campbell et al.[209] All measurements were performed using the right arm, unless there were existing conditions which prevented the use of the right arm, using an automated blood pressure oscillometric blood pressure device (BP-300, BpTRU™ Medical Devices Ltd., Coquitlam, British Columbia). If there was a malfunction of the automated cuff, the measurement was performed with the auscultation method using the Littman™ Classic II pediatric stethoscope for children and a variety of manual blood pressure cuff sizes. Prior to measurement was a five minute resting period during which the respondent was asked to abstain from talking or moving. Using the BpTRU™ BP-300, the average of five replicate readings of 1-minute intervals was determined. A total of six blood pressure readings were performed, of which the average was based on the last five readings.

Each respondent's average systolic blood pressure (*BPMDPBPS*) and diastolic blood pressure (*BPMDPBPD*) were converted to z-scores, from which individual blood pressure percentiles were calculated using mixed effects linear regression model equations in Appendix B of the fourth report on the diagnosis, evaluation, and treatment of high blood pressure in children and youth.[193]

Example of computing blood pressure percentiles only for boys:
Mean survey height (for the full sample) was used to create z-scores for height, which are used in the polynomial below to create age- and height-adjusted systolic blood pressure for boys first.

$$BP = \beta_0 + \sum_{i=1}^{4} \beta_i AGE^i + \beta_{i+4} ZHT^i$$

In Stata syntax:

```
.regress systbp age10 age102 age103 age104 zht zht2 zht3 zht4 \\\
    [pw=wt_full] if sex == 1
```

This polynomial provides the coefficients to compute the age- and height-specific expected blood pressures for boys.

z- scores were computed as

$$\frac{systolic\ blood\ pressure - expected\ systolic\ blood\ pressure}{standard\ deviation}$$

and are then converted to age- and height-adjusted percentiles.

5.6.5 Laboratory CVD markers

Blood for measurement of total cholesterol and HDL cholesterol was collected by standard venipuncture. In a random sample of participants (approximately half of the sample), blood was taken after overnight fasting (fasted subsample) for measurement of triglycerides and LDL cholesterol. Blood samples were centrifuged within two hours and aliquotted within four hours of collection. The samples were stored either in the refrigerator or in the freezer until shipping. Samples were shipped once a week to the Health Canada reference laboratory in Ottawa. For further details on the laboratory assays see Table 5.1 and the CHMS documentation.[210]

The raw values were converted to the corresponding within-sample percentiles by age group and sex. As the distribution of CRP was skewed to the right, CRP was transformed into log(CRP) for further analysis.

	Test type	Test name	Reference range
CHOL	Colorimetric test Enzymatic method	Reflectance spectrophotometry	6-17 yrs: < 4.4 mmol/L
TRIG	Colorimetric test Enzymatic method	Reflectance spectrophotometry	< 1.70 mmol/L
LDL	Endpoint test	Assay	< 4.20 mmol/L
HDL	Colorimetric test Enzymatic method	Reflectance spectrophotometry	> 1.04 mmol/L
CRP	Two point rate test	Measured absorbance assay	0 - 3.0 mg/L

Table 5.1: Overview of laboratory tests used for blood lipids and inflammatory markers.

Abbreviations: *CHOL* Cholesterol; *TG* Triglycerides; *LDL* Low-density lipoprotein cholesterol; *HDL* High-density lipoprotein cholesterol; *CRP* C-reactive protein.

5.6.6 Diet

Fruit and vegetable intake was used as a proxy of diet quality. Fruit and vegetable intake is quantified as the sum of the self-/proxy-reported number of daily servings of fruit and vegetables (*GFVD17Y* to *GFVD23Y*). Fruit and vegetable intake was used as a continuous measure. Fruit and vegetable intake was also dichotomized using age and sex-specific recommendations for number of daily servings of fruit and vegetables from the Canada Food Guide.[211] Individuals were classified as meeting/not meeting the recommendations of fruit and vegetable servings per day. The cell size in the tabulations for immigrant youth was too low for release by Statistics Canada, therefore only the continuous variable was used for further analysis.

5.6.7 Physical activity

For 6-11 year-olds, physical activity was quantified as the sum of the self-/proxy reported sum of hours of participation in physical activity per week (*CPA_13*, *CPA_14*, *CPA_15*, *CPA_16*). For 12-19 year-olds, physical activity was quantified based on the self-/proxy-reported average monthly frequency of 24 physical activities lasting over 15 minutes. The estimated total daily energy expenditure (in kcal/kg/day) from these activities was calculated as the Physical Activity Index (*PACDPAI*). Individuals were classified as either active (≥ 3 kcal/kg/day), moderately active (1.5 to < 3 kcal/kg/day), or inactive (< 1.5 kcal/kg/day) based on their Physical Activity Index. The categories active and moderately active were combined and the variable was dichotomized into physically active/not active. Meeting the

Canadian Physical Activity Guidelines (at least 60 minutes of moderate to vigorous physical activity daily) could not be examined since the time spent on moderate to vigorous physical activity was not captured in the physical activity assessment of the CHMS.[212]

5.7 Definition of risk

5.7.1 BMI

Overweight or obesity as per IOTF growth reference was defined as the at-risk category for BMI. CVs were much higher than 33.3% in the overweight and obese categories, indicating a low number of individuals in these categories and consequently a high sampling variability, so this variable was dichotomized into normal weight versus overweight or obese. Unfortunately, after bootstrapping, CVs were still above 33.3% in foreign-born children.

5.7.2 Waist circumference

A waist circumference above the 75^{th} percentile was defined as high waist circumference. A value above the 90^{th} percentile for age was initially used, but the CVs for the estimates in those with a high waist circumference were considerably higher than 33.3%. Therefore, the cut-point value was lowered to the 75^{th} percentile.

5.7.3 Sum of 5 Skinfolds

A sum of 5 skinfolds above the 75^{th} within-sample percentile was defined as high sum of 5 skinfolds. The CVs of the estimates in the "high" category were above 33.3% when the 90^{th} percentile was used. As the reference values available in children are only for triceps and subscapular skinfolds thickness,[179] external reference values were not used to define risk.

5.7.4 Blood pressure

Blood pressure above the 75^{th} age, height and sex specific percentile was defined as elevated blood pressure. The CVs were above 33.3% in the 6-11 year-olds when the recommended 90^{th} percentile was used as the cut-point. Paradis et al. found mean systolic blood pressure to be 10 mmHg lower in the 2007-2009 CHMS than in the 2003-2006 NHANES data.[71,213] This could be a reason for the low number of individuals at risk when the 90^{th} percentile was used as a cut-point to define elevated blood pressure.

5.7.5 Laboratory CVD markers

A cholesterol level above the 75^{th} percentile was used to define high cholesterol. A cut-point of 4.4 mmol/L was initially used to define high total cholesterol. However, for consistency with the other risk factor cut-points used in this study, the 75^{th} percentile was used. A HDL cholesterol level less than or equal to the 25^{th} percentile was used to define low HDL, because the CV for the at-risk category were above 33.3% when 1 mmol/L was used. Similarly, when the cut-point of 1.7 mmol/L was used for triglycerides, the numbers at-risk were so low in the foreign-born groups that results could not be released as per Statistics Canada policy. A cut-point of the 75^{th} percentile was therefore used to define elevated triglycerides. However, because this variable is only measured in the (smaller) fasted subsample, CVs were still above 33.3% for both foreign-born groups. LDL cholesterol was not included in this analysis because it was not possible to combine data from cycle 1 and cycle 2 as LDL levels were directly measured in cycle 1 but derived in cycle 2. For this reason, Statistics Canada does not provide population weights for this variable for combining cycle 1 and cycle 2. CRP levels above the 75^{th} percentile were defined as elevated CRP. When 3.0 mg/L was used as the cut-point to define elevated CRP the CVs of the estimates were above 33.3% in both foreign-born groups.

Statistics Canada confidentiality and data quality guidelines were not met for the majority of analyses that used clinical cut-points, therefore a percentile-based approach was used.

5.8 Exposure

The main exposure of interest was immigrant status (immigrant/ foreign-born vs. Canadian-born) which is based on self- or proxy-reported (by the respondent or person most knowledgeable) the country of birth (*SDCGCB*). Those born in countries other than Canada were classified as immigrants/foreign-born and those who were born in Canada were classified as Canadian-born.

Question *SDC_Q11*:
In what country where you born?
Response categories: 1 = Canada; 2-20 = Countries other than Canada.

5.9 Covariates

5.9.1 Household education

Highest level of household education (*EDUDH10*) by any member of the household was used as a 3-level categorical variable (secondary school or less; some post-secondary education or college; university).

5.9.2 Household income adequacy

Household income adequacy (*INCDDIA4*) was used as a 3-level categorical variable (low, middle or high income adequacy). Household income adequacy takes into account the total household income from all sources in the 12 months before the interview and the number of people living in the household.

5.10 Statistical analysis

All analyses were done stratified by age group (6-11 years, 12-19 years). The age group 6-11 years represents the child population and the age group 12-19 years represents the youth population. These age groups follow Statistics Canada's sample stratification and they best account for pre- and post- pubertal differences in child physiology, while at the same time maintaining a sufficiently large sample size. The mean and SD, and relative frequency, of CVD risk factors is reported by immigrant status (foreign-born vs Canadian-born) and age group. The t-test was used to compare mean levels of CVD risk factors and health behaviours (fruit and vegetable intake, physical activity) between immigrant and Canadian-born children and youth. The χ^2 test was used to compare the prevalence of adverse levels of CVD risk factors between immigrant and Canadian-born children and youth.

To evaluate hypotheses 3a and 4a, linear regression was used. To evaluate hypotheses 3b and 4b, logistic regression was used. To adjust for potential confounders, income, education, sex, and age were included in the models. Education and income were chosen as confounders as they are both social determinants of health. Sex was included in the model to adjust for sex differences which ideally would have been looked at separately if the sample size had permitted. Age was included in the models because levels of CVD risk factors may be dependent on the child's or youth's age. Interactions were not explored due to sample size restrictions.

As mentioned earlier, with the exception of BMI and HDL it was necessary to use non-clinical cut-points to define at risk categories due to high sampling variability when using clinical cut-points. All estimates were obtained using sampling weights provided by Statistics Canada to account for design effect and non-response bias. Standard errors were estimated using a bootstrapping procedure[214] with 24 degrees of freedom as recommended by Statistics Canada for combining cycles 1 and 2 of this survey.[207] Stata Version 12 (Stata Corp, College Station, TX, USA) was used to perform the statistical analyses.

5.11 Power calculation

4211 children and youth were in the CHMS (cycle 1 2007-2009 and cycle 2 2009-2011). The proportion of immigrants in the whole sample was 22%. This proportion was used to estimate the number of immigrant children and youth in the

CHMS. The prevalence of obesity in the Canadian children aged 6-11 years is 13.2%.[65] Using these numbers, a power calculation estimated a power of 0.8 to detect a difference in prevalence of 5.0% of obesity in children aged 6-11 years.

The prevalence of obesity in the Canadian youth population aged 12-17 years is 10.2%.[65] Using these numbers, a power calculation for the sample estimated a power of 0.9 to detect a difference in prevalence of 5.0% of obesity in youth aged 12-17 years.

6 RESULTS

6.1 Descriptive Statistics

6.1.1 Socio-demographic characteristics of the study population

There were 2138 children (6-11 years) and 2073 youth (12-19 years) in the CHMS cycle 1 (2007-2009) and cycle 2 (2009-2011) combined. Table 6.1 documents the socio-demographic characteristics of the Canadian-born and foreign-born/immigrant study population. There were about 9% immigrants in the 6-11 year age group and about 9% immigrants in the 12-19 year age group. Foreign-born/immigrants had a significantly higher household education compared with Canadian-born in both age groups. In foreign-born children, 70.4% and 55.3% reported a household education at the university level in the 6-11 year-olds and 12-19 year-olds, respectively. Conversely, household income was lower in foreign-born than in Canadian-born children and youth. The majority of foreign-born individuals reported low household income adequacy in the 6-11 year-old child age group (38.7%) as well as in the 12-19 year-old youth age group (41.9%).

Table 6.2 documents the characteristics of foreign-born children and youth. Most foreign-born/immigrants were born in Asia (37.9% of immigrant children and 44.7% of immigrant youth). Overall, 61.0% immigrant children and 74.2% immigrant youth were born in lower to middle income countries. A higher proportion of immigrant children the spoke official languages English or French (49.8%) at home compared to immigrant youth (51.3%). In contrast, 93.9% Canadian-born children and 96.7% Canadian-born youth spoke the official languages English or French at home.

6.1.2 Anthropometric and laboratory measures by age

Anthropometric and laboratory measures in children are age-dependent. The measures used in this study are presented here to show the characteristics of the full sample by age.

Table 6.3 shows mean BMI, waist circumference, and sum of 5 skinfolds by age for the full sample. Mean BMI ranged between 15.9 (SD 2.1) and 24.3 (SD 3.9) kg/m^2 and increased with age. Mean waist circumference ranged from 53.4 (SD 5.4) and 80.0 (SD 9.5) cm and increased with age. Mean sum of 5 skinfolds ranged

	6-11 years		12-19 years	
	Canadian-born	**Immigrant**	**Canadian-born**	**Immigrants**
Sex				
Male [%]	51.0	54.0 ^{E}	51.4	50.2 ^{E}
Female [%]	48.9	46.0 ^{E}	48.6	49.8 ^{E}
Household education				
Secondary school or less [%]	14.5	6.7 ^{E**}	14.7	13.2 ^{E**}
College [%]	50.1	22.9 ^{E}	53.9	31.6 ^{E}
University [%]	35.4	70.4 ^{E}	31.5	55.3 ^{E}
Household income adequacy†				
Low [%]	23.7	38.7 ^{E}	18.0	41.9 ^{E***}
Middle [%]	27.5	27.4 ^{E}	28.5	29.5 ^{F}
High [%]	48.8	33.8 ^{F}	53.5	28.7 ^{E}

Table 6.1: Socio-demographics by age group and immigrant status (Canadian-born vs. foreign-born) in the CHMS cycle 1 (2007-2009) and cycle 2 (2009-2011).

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

^{E} Coefficient of variation between 16.6 and 33.3%. High sampling variability, interpret with caution.

^{F} Coefficient of variation > 33.3 %. Does not meet Statistics Canada quality standards. Conclusions based on this data are unreliable and most likely invalid. These data and any subsequent findings should not be published.

† Household income adequacy based on total household income and the number of people living in the household

from 38.5 (SD 17.5) mm at 6 years of age to 66.1 (SD 22.2) mm at 18 years of age.

Table 6.4 shows mean systolic and diastolic blood pressure by age for the full sample. Both mean systolic and diastolic blood pressure showed an increase with age. Mean systolic blood pressure ranged from 91.5 (SD 10.1) mmHg at age 6 to 100.7 (SD 6.6) mmHg at age 19. Mean diastolic blood pressure ranged from 59.1 (SD 9.2) mmHg at age 6 to 63.4 (SD 6.5) mmHg at age 18.

Table 6.4 shows mean systolic and diastolic blood pressure by age for the full sample. Both mean systolic and diastolic blood pressure showed an increase with age. Mean systolic blood pressure ranged from 91.5 (SD 10.1) mmHg at age 6 to 100.7 (SD 6.6) mmHg at age 19. Mean diastolic blood pressure ranged from 59.1 (SD 9.2) mmHg at age 6 to 63.4 (SD 6.5) mmHg at age 18.

Table 6.5 shows mean cholesterol, HDL, and CRP by age for the full sample. Mean cholesterol was higher in children than in youth. Mean cholesterol ranged from 3.9 (SD 0.6) mmol/L at age 14 to 4.3 (SD 0.7) mmol/L at age 8. Mean HDL ranged from 1.5 (SD 0.4) mmol/L at age 10 to 1.3 (SD 0.3) at age 12. Mean CRP ranged from 0.9 (SD 1.3) at age 13 and age 14 to 1.7 (SD 2.0) mg/L at age 18 with no apparent relationship between age and CRP level.

	6-11 years	12-19 years
Time since immigration		
5 years or less [%]	55.6 E	37.5 E
6 to 10 years [%]	43.3	29.9 E
More than 10 years [%]	1.1 F	32.6 E
Age at immigration (categories)		
Early childhood (5 years or less) [%]	60.9	31.1 E
Late childhood (6 to 11 years) [%]	39.1 E	39.9 E
Early adolescence (12 to 14 years) [%]	-	22.3 E
Late adolescence (15 to 19 years) [%]	-	6.7 E
Country of birth (by geography)		
Other North America [%]	16.8 E	7.6 E
South, Central America, Carribean and Africa [%]	23.2 E	29.5 E
Europe and Oceania [%]	22.2	18.2 E
Asia [%]	37.9 E	44.7
Country of birth (by income)†		
High income [%]	38.9 E	25.8
Low to middle income [%]	61.0	74.2
First language learned and still understood		
English or French or both [%]	45.6 E	20.7 E
Neither English or French [%]	56.4	79.1
Language usually spoken at home		
English or French [%]	49.8 E	51.3
Other [%]	50.2 E	48.7 E

Table 6.2: Sample characteristics for immigrant children in the CHMS cycle 1 (2007-2009) and cycle 2 (2009-2011).

† Higher income: Other North America, Europe and Oceania; Lower to middle income: South, Central America and Caribbean, Africa and Asia.
E Coefficient of variation between 16.6 and 33.3%. High sampling variability, interpret with caution.
F Coefficient of variation > 33.3 %. Does not meet Statistics Canada quality standards. Conclusions based on this data are unreliable and most likely invalid. These data and any subsequent findings should not be published.

6.1.3 Mean levels of CVD risk factors by year of age and immigrant status

Tables 6.6 to 6.13 show the mean BMI, waist circumference, sum of 5 skinfolds, systolic blood pressure, diastolic blood pressure, cholesterol, HDL, and CRP by age for Canadian-born and foreign-born children and youth. Mean BMI was similar between Canadian-born and foreign-born children ages 6 and 8 but was otherwise lower in foreign-born children and youth, except at age 19, where mean BMI was slightly higher in foreign-born youth (Table 6.6). At 6 and 7 years of age, mean waist circumference was higher in foreign-born children but from 8 to 19 years

Age [years]	**BMI** [kg/m^2]	**Waist circumference** [cm]	**Sum of 5 skinfolds** [mm]
6	15.9 (2.1)	53.4 (5.4)	38.5 (17.5)
7	17.3 (3.5)	57.4 (9.8)	46.2 (26.8)
8	17.5 (3.5)	59.7 (9.3)	49.2 (26.8)
9	18.3 (3.9)	62.1 (10.8)	56.0 (33.3)
10	18.7 (4.3)	64.3 (11.2)	58.5 (32.5)
11	19.2 (4.3)	65.9 (11.9)	56.8 (32.1)
12	20.3 (4.3)	69.4 (11.5)	59.2 (28.4)
13	20.4 (3.7)	70.8 (9.9)	61.3 (29.6)
14	21.8 (4.6)	73.5 (10.9)	59.6 (26.1)
15	22.8 (4.5)	76.1 (11.5)	59.8 (27.4)
16	23.0 (4.5)	76.5 (11.1)	57.8 (22.5)
17	23.3 (4.3)	77.8 (11.5)	61.9 (25.1)
18	24.1 (3.9)	79.5 (10.2)	66.1 (22.2)
19	24.3 (3.9)	80.0 (9.5)	65.5 (21.1)

Table 6.3: Mean (SD) BMI, waist circumference, and sum of 5 skinfolds by age for children and youth in the CHMS cycle 1 (2007-2009) and cycle 2 (2009-2011).
Abbreviations: *SD* Standard deviation; *BMI* Body mass index.

Age [years]	**Systolic blood pressure** [mmHg]	**Diastolic blood pressure** [mmHg]
6	91.5 (10.1)	59.1 (9.2)
7	92.8 (7.9)	60.8 (8.0)
8	93.4 (8.6)	61.1 (7.9)
9	94.4 (10.0)	62.1 (10.0)
10	94.9 (8.9)	60.9 (8.5)
11	95.7 (9.5)	61.8 (9.1)
12	95.3 (7.4)	60.8 (6.9)
13	95.8 (7.4)	60.9 (6.0)
14	96.8 (7.1)	61.3 (6.6)
15	100.3 (7.4)	62.9 (6.5)
16	100.1 (8.3)	62.8 (6.7)
17	100.3 (7.2)	63.2 (6.9)
18	100.4 (7.3)	63.7 (6.5)
19	100.7 (6.6)	63.4 (5.7)

Table 6.4: Mean (SD) systolic and diastolic blood pressure by age for children and youth in the CHMS cycle 1 (2007-2009) and cycle 2 (2009-2011).
Abbreviations: *SD* Standard deviation.

of age waist circumference was lower in foreign-born compared to Canadian-born children (Table 6.7). The sum of 5 skinfolds increased with age and was higher in foreign-born children and youth at 6, 7, 11, 16, 17, 18 and 19 years of age. Canadian-born children showed a more consistent increase in the sum of 5 skinfolds with age than foreign-born (Table 6.8). Mean systolic blood pressure in foreign-born children and youth aged 6 to 10 years, 14, 16, 18 and 19 years was lower than in Canadian-born, with differences up to 5 mmHg (Table 6.9). Mean diastolic

Age [years]	**Cholesterol** [mmol/L]	**HDL** [mmol/L]	**CRP** [mg/L]
6	4.1 (0.8)	1.4 (0.4)	1.1 (1.9)[E]
7	4.2 (0.8)	1.4 (0.3)	1.6 (2.8)[E]
8	4.3 (0.7)	1.4 (0.3)	1.1 (1.7)[E]
9	4.3 (0.8)	1.4 (0.4)	1.6 (3.0)[E]
10	4.4 (0.9)	1.5 (0.4)	1.6 (2.4)[E]
11	4.2 (0.9)	1.4 (0.3)	1.1 (2.2)
12	4.1 (0.8)	1.3 (0.3)	1.1 (1.6)[E]
13	4.0 (0.7)	1.3 (0.3)	0.9 (1.3)
14	3.9 (0.6)	1.3 (0.3)	0.9 (1.3)
15	4.1 (0.8)	1.3 (0.3)	1.3 (1.9)[E]
16	4.1 (0.7)	1.3 (0.3)	1.7 (2.8)[E]
17	4.1 (0.8)	1.3 (0.3)	1.7 (2.4)[E]
18	4.2 (0.7)	1.4 (0.4)	1.7 (2.0)[E]
19	4.2 (0.6)	1.3 (0.3)	1.5 (1.3)

Table 6.5: Mean (SD) cholesterol, HDL, and CRP by age for children and youth in the CHMS cycle 1 (2007-2009) and cycle 2 (2009-2011).

[E] Coefficient of variation between 16.6 and 33.3%. High sampling variability, interpret with caution.

Abbreviations: *SD* Standard deviation; *HDL* High-density lipoprotein; *CRP* C-reactive protein.

blood pressure was lower in foreign-born aged 6 to 11 years, as well as in those aged 14, 16 and 18 and 19 years (Table 6.10). There was no consistent pattern with age in Canadian-born and foreign-born children and youth for mean cholesterol levels. At age 6, 10 and 14, foreign-born children and youth had higher mean cholesterol than their Canadian-born peers. At all other ages, mean cholesterol was lower in foreign-born than in Canadian-born (Table 6.11). Mean HDL levels were higher in foreign-born children and youth at age 6, 9, 12, 13, 14, and 16. There was a trend toward lower HDL with age (Table 6.12). CRP did not correlate with age. Mean CRP was lower in foreign-born children and youth at ages 7, 8, 11, 12, 13, 14, 16, 17, 18. However, estimates showed a high variability for all groups and most estimates for foreign-born were in the unreliable quality range (Table 6.13).

	BMI [kg/m^2]	
Age [years]	**Canadian-born**	**Immigrants**
6	15.9 (2.1)	15.9 (1.1)
7	17.2 (3.6)	17.3 (2.4)
8	17.5 (3.4)	17.5 (3.2)
9	18.4 (3.9)	17.6 (4.1)
10	18.9 (4.5)	17.5 (2.8)
11	19.2 (4.4)	19.1 (3.8)
12	20.3 (4.3)	19.2 (3.5)
13	20.4 (3.6)	20.1 (3.9)
14	21.9 (4.7)	19.7 (2.4)
15	23.2 (4.5)	19.7 (3.8)
16	23.1 (4.5)	22.3 (3.9)
17	23.5 (4.6)	22.6 (2.3)
18	24.1 (3.9)	23.6 (2.9)
19	24.3 (3.9)	24.5 (3.4)

Table 6.6: Mean BMI (SD) by age and immigrant status (Canadian-born vs. foreign-born) in the CHMS cycle 1 (2007-2009) and cycle 2 (2009-2011).

Abbreviations: *SD* Standard deviation; *BMI* Body mass index.

	Waist circumference [cm]	
Age [years]	**Canadian-born**	**Immigrants**
6	53.4 (5.5)	53.8 (3.9)
7	57.3 (9.9)	58.2 (7.5)
8	59.8 (9.3)	58.6 (6.9)
9	62.2 (10.7)	60.9 (11.9)
10	64.6 (11.6)	61.6 (8.0)
11	66.1 (12.1)	64.1 (9.7)
12	69.6 (11.3)	64.7 (11.4)
13	70.9 (9.9)	70.0 (10.5)
14	73.9 (11.1)	67.9 (4.9)
15	76.9 (11.5)	68.9 (8.9)
16	76.7 (11.1)	74.2 (9.8)
17	78.5 (12.3)	74.5 (6.9)
18	79.9 (10.5)	75.7 (7.3)
19	80.0 (9.6)	79.9 (8.2)

Table 6.7: Mean (SD) waist circumference by age and immigrant status (Canadian-born vs. foreign-born) in the CHMS cycle 1 (2007-2009) and cycle 2 (2009-2011).

Abbreviations: *SD* Standard deviation.

	Sum of 5 skinfolds [mm]	
Age [years]	**Canadian-born**	**Immigrants**
6	37.4 (16.9)	51.2 (16.9)
7	46.0 (27.2)	47.6 (22.4)
8	49.2 (26.8)	47.9 (18.6)
9	56.7 (33.4)	48.4 (29.3)
10	59.3 (33.7)	52.9 (23.4)
11	56.7 (33.1)	57.9 (24.4)
12	59.5 (28.0)	53.8 (31.8))
13	61.7 (29.9)	57.2 (25.6)
14	60.9 (26.5)	45.1 (16.8)
15	61.1 (27.9)	48.4 (20.4)
16	56.7 (20.9)	68.5 (35.6)
17	59.7 (24.9)	71.7 (24.8)
18	63.7 (22.3)	84.9 (13.9)
19	64.0 (20.9)	78.2 (19.9)

Table 6.8: Mean (SD) sum of 5 skinfolds by age and immigrant status (Canadian-born vs. foreign-born) in the CHMS cycle 1 (2007-2009) and cycle 2 (2009-2011).

Abbreviations: *SD* Standard deviation.

	Systolic blood pressure [mmHg]	
Age [years]	**Canadian-born**	**Immigrants**
6	91.6 (10.5)	90.1 (3.6)
7	92.9 (7.9)	91.1 (6.1)
8	93.4 (8.5)	92.6 (10.3)
9	94.6 (10.0)	91.7 (9.5)
10	95.1 (9.2)	93.5 (6.4)
11	95.7 (9.3)	95.7 (10.3)
12	95.3 (7.4)	96.3 (7.3)
13	95.7 (7.3)	96.5 (7.9)
14	97.1 (7.1)	93.7 (7.3)
15	100.1 (7.3)	102.1 (8.4)
16	100.2 (8.2)	98.9 (9.2)
17	100.2 (7.6)	100.7 (5.6)
18	100.9 (7.3)	95.5 (6.7)
19	100.7 (6.7)	100.6 (6.3)

Table 6.9: Mean (SD) systolic blood pressure by age and immigrant status (Canadian-born vs. foreign-born) in the CHMS cycle 1 (2007-2009) and cycle 2 (2009-2011).

Abbreviations: *SD* Standard deviation.

	Diastolic blood pressure [mmHg]	
Age [years]	**Canadian-born**	**Immigrants**
6	59.4 (9.7)	56.7 (1.8)
7	60.9 (8.3)	59.9 (4.8)
8	61.2 (7.9)	57.6 (8.6)
9	62.2 (10.0)	60.6 (9.7)
10	61.5 (8.6)	57.7 (7.3)
11	61.8 (8.9)	61.7 (10.4)
12	60.7 (6.8)	61.2 (6.6)
13	60.8 (5.9)	61.7 (6.8)
14	61.5 (6.5)	59.4 (7.8)
15	62.6 (6.4)	65.4 (6.4)
16	62.8 (6.6)	62.2 (7.4)
17	62.7 (7.1)	65.4 (5.7)
18	63.9 (6.6)	62.4 (4.9)
19	63.6 (5.5)	61.4 (6.4)

Table 6.10: Mean (SD) diastolic blood pressure by age and immigrant status (Canadian-born vs. foreign-born) in the CHMS cycle 1 (2007-2009) and cycle 2 (2009-2011).
Abbreviations: *SD* Standard deviation.

	Cholesterol [mmol/L]	
Age [years]	**Canadian-born**	**Immigrants**
6	4.0 (0.8)	4.8 (0.6)
7	4.2 (0.8)	3.9 (0.4)
8	4.3 (0.7)	3.9 (0.7)
9	4.3 (0.8)	4.2 (0.9)
10	4.3 (0.9)	4.5 (0.8)
11	4.2 (0.9)	4.1 (0.8)
12	4.2 (0.7)	3.7 (0.8)
13	4.1 (0.7)	4.0 (0.7)
14	3.9 (0.6)	4.1 (0.4)
15	4.1 (0.8)	4.0 (0.4)
16	4.1 (0.7)	3.9 (0.7)
17	4.2 (0.8)	3.9 (0.8)
18	4.3 (0.6)	3.9 (0.8)
19	4.2 (0.6)	4.1 (0.4)

Table 6.11: Mean (SD) cholesterol by age and immigrant status (Canadian-born vs. foreign-born) in the CHMS cycle 1 (2007-2009) and cycle 2 (2009-2011).
Abbreviations: *SD* Standard deviation.

	HDL [mmol/L]	
Age [years]	**Canadian-born**	**Immigrants**
6	1.4 (0.4)	1.9 (0.2)
7	1.4 (0.3)	1.4 (0.3)
8	1.4 (0.3)	1.3 (0.4)
9	1.4 (0.4)	1.5 (0.4)
10	1.5 (0.4)	1.5 (0.3)
11	1.4 (0.3)	1.3 (0.3)
12	1.3 (0.3)	1.4 (0.4)
13	1.3 (0.3)	1.4 (0.4)
14	1.3 (0.2)	1.6 (0.3)
15	1.3 (0.3)	1.2 (0.2)
16	1.3 (0.3)	1.4 (0.4)
17	1.3 (0.3)	1.3 (0.3)
18	1.4 (0.4)	1.3 (0.2)
19	1.3 (0.3)	1.3 (0.2)

Table 6.12: Mean (SD) HDL by age and immigrant status (Canadian-born vs. foreign-born) in the CHMS cycle 1 (2007-2009) and cycle 2 (2009-2011).

Abbreviations: *SD* Standard deviation; *HDL* High-density lipoprotein.

	CRP [mg/L]	
Age [years]	**Canadian-born**	**Immigrants**
6	1.1 (2.1) [E]	1.5 (1.1) [E]
7	1.7 (2.9) [E]	0.9 (0.9) [F]
8	1.1 (1.7) [E]	0.5 (0.4)
9	1.5 (2.9) [E]	2.6 (5.5) [F]
10	1.5 (2.2) [E]	2.0 (3.1) [F]
11	1.2 (2.4)	0.7 (0.8) [E]
12	1.1 (1.6) [E]	0.7 (2.1) [F]
13	0.9 (1.4)	0.5 (0.8) [F]
14	0.9 (1.3)	0.6 (0.9) [F]
15	1.3 (1.8) [E]	1.6 (3.1) [E]
16	1.8 (2.8) [E]	0.9 (1.2) [E]
17	1.8 (2.6) [E]	1.2 (1.0) [F]
18	1.8 (2.1) [E]	1.6 (1.6) [F]
19	1.5 (1.2)	1.9 (2.1) [E]

Table 6.13: Mean (SD) CRP by age and immigrant status (Canadian-born vs. foreign-born) in the CHMS cycle 1 (2007-2009) and cycle 2 (2009-2011).

[E] Coefficient of variation between 16.6 and 33.3%. High sampling variability, interpret with caution.

[F] Coefficient of variation > 33.3 %. Does not meet Statistics Canada quality standards. Conclusions based on this data are unreliable and most likely invalid. These data and any subsequent findings should not be published.

Abbreviations: *SD* Standard deviation; *CRP* C-reactive protein.

6.1.4 Mean levels of CVD risk factors in Canadian-born and immigrant children

Table 6.14 shows the mean levels of CVD risk factors in Canadian-born and foreign-born children and youth. Waist circumference z-scores were significantly lower in immigrant youth compared to Canadian-born youth. There were no statistically significant differences in cholesterol, HDL, or triglyceride levels between Canadian-born and foreign-born children and youth.

	6-11 years		12-19 years	
Mean (SD)	Canadian-born	Foreign-born	Canadian-born	Foreign-born
Body fatness				
BMI (IOTF) [z-score]	0.7 (1.2)	0.5 (0.9)	0.7 (1.2)	0.4 (1.1)
Waist circumference [z-score]	0.0 (0.9)	-0.1 (0.7)	0.0 (1.1)	-0.3 (0.8)**
Sum of 5 skinfolds [z-score]	0.0 (0.9)	0.0 (0.7)	0.0 (1.1)	0.3 (1.1)
Blood pressure				
Systolic blood pressure [z-score]	0.0 (1.0)	-0.1 (0.8)	0.0 (1.0)	-0.1 (0.9)
Diastolic blood pressure [z-score]	0.0 (1.1)	-0.2 (0.9)	0.0 (0.9)	0.0 (0.9)
Blood lipids				
Total cholesterol [mmol/L]	4.2 (0.7)	4.3 (0.7)	4.1 (0.8)	3.9 (0.7)
HDL Cholesterol [mmol/L]	1.4 (0.3)	1.4 (0.3)	1.3 (0.3)	1.4 (0.3)
Inflammation marker				
log CRP [mg/dL]	-0.5 (1.3)	-0.4 (0.9)	-0.4 (1.2)	-0.5 (1.1)

Table 6.14: Mean (SD) levels of CVD risk factors by immigrant status and age group (Canadian-born vs. foreign-born) in the CHMS cycle 1 (2007-2009) and cycle 2 (2009-2011).

** $p < 0.01$

E Coefficient of variation between 16.6 and 33.3%. High sampling variability, interpret with caution.

F Coefficient of variation > 33.3 %. Does not meet Statistics Canada quality standards. Conclusions based on this data are unreliable and most likely invalid. These data and any subsequent findings should not be published.

Abbreviations: *SD* Standard deviation; *BMI* Body mass index; *IOTF* International Obesity Task Force; *HDL* High-density lipoprotein; *CRP* C-reactive protein.

6.1.5 Prevalence of adverse levels of CVD risk factors (based on clinical cut-points) in Canadian-born and immigrant children and youth

Table 6.15 shows the prevalence of CVD risk factors by age group and immigrant status using clinical cut-points to define risk. Most of these estimates are of unacceptable quality as per Statistics Canada guidelines due to CVs above 33.3%. As explained in the methods, most cut-points were lowered to the 75th percentile (Table 6.16), which moved the quality of the majority of the estimates into the acceptable range (CV between 16.6% and 33.3%). There was a trend toward lower prevalence of overweight, obesity, and high waist circumference in foreign-born compared to Canadian-born children and youth. The prevalence of high systolic and diastolic blood pressure was lower in foreign-born children but higher in foreign-born youth when compared to Canadian-born of the same age groups. The prevalence of low HDL was lower in foreign-born compared to Canadian-born children, however in youth, the prevalence of low HDL was slightly higher in foreign-born compared to Canadian-born. The prevalence of high cholesterol was higher in children than in youth. Foreign-born children had a 42.9% prevalence of high cholesterol and Canadian-born children had a 40.9% prevalence of high cholesterol. A quarter of foreign-born youth and almost one third Canadian-born youth had a cholesterol level above the clinical cut-point. The prevalence of elevated CRP was lower in foreign-born children but higher in foreign-born youth compared to Canadian-born of the same age groups.

	6-11 years		**12-19 years**	
Prevalence [%]	**Canadian-born**	**Foreign-born**	**Canadian-born**	**Foreign-born**
Body fatness				
BMI (IOTF)				
Normal weight	67.1	71.6 E	64.2	67.5 E
Overweight	17.5	10.9 F	18.4	18.5 E
Obesity	9.3	7.1 F	11.7	5.3 F
Underweight	6.1	10.4 F	5.8	8.7 F
Waist circumference $\geq$ 90th perc.	10.4	6.7	10.9	4.3
Blood pressure				
Systolic blood pressure $\geq$ 90th perc.	9.7	5.4 F	10.5	12.7 E
Diastolic blood pressure $\geq$ 90th perc.	10.2	6.7 F	9.0	9.2 E
Blood lipids				
Total cholesterol $\geq$ 4.4 mmol/L	40.9	42.9 E	32.7	24.8 E
HDL Cholesterol $\leq$ 1.0 mmol/L	6.9	4.0 E	13.1	13.9 F
Inflammation marker				
CRP $\geq$ 3.0 mg/dL	12.2	7.1 F	12.3	13.9 F

Table 6.15: Prevalence of adverse levels of CVD risk factors by immigrant status (Canadian-born vs. foreign-born) and age group using clinical cut-points in the CHMS cycle 1 (2007-2009) and cycle 2 (2009-2011).

E Coefficient of variation between 16.6 and 33.3%. High sampling variability, interpret with caution.

F Coefficient of variation > 33.3 %. Does not meet Statistics Canada quality standards. Conclusions based on this data are unreliable and most likely invalid. These data and any subsequent findings should not be published.

Abbreviations: *IOTF* International Obesity Task Force; *Perc.* Percentile; *BMI* Body mass index; *HDL* High-density lipoprotein; *CRP* C-reactive protein.

6.1.6 Prevalence of adverse levels of CVD risk factors (percentile-based) in Canadian-born and immigrant children and youth

Table 6.16 shows the prevalence of adverse levels of CVD risk factors in Canadian-born and foreign-born children and youth using percentile-based cut-points. One fifth to one third of children and youth in Canada are overweight or obese. The lowest prevalence of overweight and obesity was observed in immigrant children

(20.1%) and the highest prevalence was in Canadian-born youth (31.9%). Waist circumference above the 75th within-sample percentile was lowest in immigrant youth with a prevalence of 18.1% compared to 25.5% in Canadian-born youth. The prevalence of the sum of 5 skinfolds above the 75th percentile was higher in foreign-born/ immigrant children in both age groups. The prevalence of sum of 5 skinfolds above the 75th percentile was 28.6% in foreign-born children compared to 24.7% in Canadian-born children. The prevalence of the sum of 5 skinfolds above the 75th percentile was 32.7% in foreign-born youth compared to 24.0% in Canadian-born youth.

	6-11 years		12-19 years	
Prevalence [%]	**Canadian-born**	**Foreign-born**	**Canadian-born**	**Foreign-born**
Body fatness				
Overweight or obese BMI (IOTF)	28.5	20.1 ^{F}	31.9	26.0 ^{E}
Waist circumference $>$ 75th perc.	25.0	20.6 ^{E}	25.5	18.1 ^{F}
Sum of 5 skinfolds $>$ 75th perc.	24.7	28.6 ^{E}	24.0	32.7 ^{E}
Blood pressure				
Systolic blood pressure $>$ 75th perc.	22.8	11.4 $^{*\ E}$	22.4	21.9 ^{E}
Diastolic blood pressure $>$ 75th perc.	22.4	10.4 $^{*\ E}$	23.2	21.7 ^{E}
Blood lipids				
Total cholesterol $>$ 75th perc.	26.5	24.9 ^{E}	23.9	16.5 ^{F}
HDL Cholesterol $<$ 25th perc.	24.9	28.8 ^{E}	25.1	24.3 ^{E}
Triglycerides $>$ 75th perc.	24.4	26.3 ^{F}	24.8	19.4 ^{F}
Inflammation marker				
CRP $>$ 75th perc.	24.2	23.6 ^{F}	24.7	22.2 ^{E}

Table 6.16: Prevalence of adverse levels of CVD risk factors by immigrant status (Canadian-born vs. foreign-born) and age group using percentile-based cut-points in the CHMS cycle 1 (2007-2009) and cycle 2 (2009-2011).

* $p < 0.05$

^{E} Coefficient of variation between 16.6 and 33.3%. High sampling variability, interpret with caution.

^{F} Coefficient of variation > 33.3 %. Does not meet Statistics Canada quality standards. Conclusions based on this data are unreliable and most likely invalid. These data and any subsequent findings should not be published.

Abbreviations: *IOTF* International Obesity Task Force; *Perc.* Percentile; *BMI* Body mass index; *HDL* High-density lipoprotein; *CRP* C-reactive protein.

The prevalence of systolic and diastolic blood pressure above the 75th percentile was significantly lower in immigrant children (systolic blood pressure: 11.4% compared to 22.8%; diastolic blood pressure: 10.4% compared to 22.4%) compared to Canadian-born. The prevalence of systolic and diastolic blood pressure above the 75th percentile was lower in immigrant youth than in Canadian-born youth but the differences were not as large as in children.

The prevalence of cholesterol above the 75th percentile was lower in immigrants in both age groups (24.9% in immigrant children compared to 26.5% in Canadian-born children; 16.5% in immigrant youth compared to 23.9% in Canadian-born youth). The prevalence of HDL $\leq 25^{th}$ percentile was higher in immigrant children (28.8%) compared to Canadian-born children (24.9%). The prevalence of triglycerides above the 75^{th} percentile was higher in immigrant children compared to Canadian-born children and lower in immigrant youth compared to Canadian-born youth. However, these estimates are based on the fasted subsample and are considered unreliable in both age groups owing to a CV $> 33.3\%$. Foreign-born children and youth had a lower prevalence of CRP above the 75^{th} percentile compared to Canadian-born children and youth but the differences were small (foreign-born children 23.6%; Canadian-born children 24.2%; foreign-born youth 22.2%; Canadian-born youth 24.7%).

6.1.7 Mean number of fruit and vegetable servings and time spent on physical activity in Canadian-born and immigrant children and youth

As shown in table 6.17, immigrant children had on average one and a half less hours of physical activity per week than Canadian-born children. Immigrant children and youth had a lower number of daily fruit and vegetable servings compared to Canadian-born children. Weekly hours of physical activity and the amount of fruit and vegetable servings eaten daily were statistically significantly lower in foreign-born compared to Canadian-born children.

	6-11 years		12-19 years	
Mean (SD) / Prevalence [%]	**Canadian-born**	**Foreign-born**	**Canadian-born**	**Foreign-born**
Fruit and vegetable servings [1/day]	3.7 (1.8)	3.2 (1.5) *	3.5 (2.4)	3.4 (1.7)
Physical activity [hrs/week]	12.2 (4.6)	10.6 (4.0) **		
Physically active [%]			72.2	68.4 E

Table 6.17: Mean levels and prevalence of health behaviours by immigrant status (Canadian-born vs. foreign-born) and age group in the CHMS cycle 1 (2007-2009) and cycle 2 (2009-2011).

* $p < 0.05$; ** $p < 0.01$

E Coefficient of variation between 16.6 and 33.3%. High sampling variability, interpret with caution.

Abbreviations: *SD* Standard deviation; *hrs* Hours.

6.1.8 Prevalence of being physically active in Canadian-born and immigrant children and youth

As documented in Table 6.17, immigrant youth had a 3.8% lower prevalence of being physically active compared to Canadian-born children.

6.1.9 Summary

There is a general trend toward lower prevalence of adverse levels of CVD risk factors among immigrant children and youth compared to Canadian-born children and youth. However, only systolic and diastolic blood pressure among children, and waist circumference z-scores in youth were found to be statistically significantly lower. Elevated skinfold thickness is the only CVD risk factor with a higher prevalence in both immigrant children and youth. The prevalence of HDL $\leq 25^{th}$ percentile was highest in immigrant children. However, mean HDL was the same in both immigrant and Canadian-born children. Immigrant youth had a lower prevalence of cholesterol $\geq 75^{th}$ percentile compared to Canadian-born youth and both immigrant and Canadian-born children.

6.2 Multivariable analysis of the association between immigrant status and CVD risk factors

6.2.1 The association of immigrant status with levels of CVD risk factors and health behaviours in children

The association of immigrant status with mean CVD risk factors and health behaviours for children is shown in Table 6.18. Immigrant children had a significantly lower number of daily servings of fruit and vegetables (-0.61 [95%CI -1.14;-0.08]) and a significantly lower number of hours of physical activity (-1.59 [95%CI -2.58;-0.62]) compared to Canadian-born children after controlling for education, income, and sex. The addition of education, income and sex to the univariate model did not significantly improve the prediction of fruit and vegetable servings amount or physical activity levels when immigrant children are compared to Canadian-born children. The further addition of age to the multivariable regression models did not change the significance of the main effect (data not shown).

6.2.2 The association of immigrant status with the prevalence of adverse levels of CVD risk factors in children

The association of immigrant status with the prevalence of adverse levels of CVD risk factors for children is documented in Table 6.20. Immigrant children had 0.43 (95%CI 0.24;0.78) times the odds of having diastolic blood pressure above the 75^{th} percentile compared to Canadian-born children after controlling for education, income and sex. The addition of education, income and sex to the univariate model did not significantly improve the prediction of diastolic blood pressure above the 75^{th} percentile when immigrant children were compared to Canadian-born children. The further addition of age to the multivariable regression models did not change the significance of the main effect (data not shown).

	Unadjusted	**Model 1**†	**Model 2**‡
BMI z-score	-0.11 (-0.41;0.19)	-0.08 (-0.37;0.22)	-0.09 (-0.39;0.21)
WC z-score	-0.12 (-0.34;0.09)	-0.12 (-0.34;0.11)	-0.12 (-0.34;0.11)
Sum of 5 SF z-score	0.02 (-0.18;0.22)	0.03 (-0.21;0.26)	0.02 (-0.21;0.26)
Systolic BP z-score	-0.09 (-0.31;0.11)	-0.09 (-033;0.15)	-0.09 (-0.33;0.15)
Diastolic BP z-score	-0.21 (-0.48;0.05)	-0.21 (-0.50;0.08)	-0.21 (-0.50;0.08)
Cholesterol [mmol/L]	0.04 (-0.14;0.22)	0.05 (-0.14;0.24)	0.05 (-0.13;0.24)
HDL [mmol/L]	0.03 (-0.05;0.10)	0.02 (-0.06;0.09)	0.02 (-0.06;0.09)
logCRP [mg/L]	0.15 (-0.15;0.44)	0.11 (-0.21;0.43)	0.11 (-0.21;0.43)
F&V servings [1/day]	-0.49 (-0.95;-0.04)*	-0.63 (-1.16;-0.09)*	-0.61 (-1.14;-0.08)*
PA [hrs/week]	-1.68 (-2.66;-0.69)**	-1.49 (-2.50;-0.49)*	-1.59 (-2.58;-0.62)**

Table 6.18: Beta coefficients (95% CI) for the association of immigrant status with levels of CVD risk factors and health behaviours in children in the CHMS cycle 1 (2007-2009) and cycle 2 (2009-2011).

† Adjusted for education and income; ‡ Adjusted for education, income, and sex.

* $p < 0.05$; ** $p < 0.01$

Abbreviations: *CI* Confidence interval; *BMI* Body mass index; *WC* Waist circumference; *SF* Skinfolds; *BP* Blood pressure; *HDL* High-density lipoprotein; *CRP* C-reactive protein; *F&V* Fruits and vegetables; *PA* Physical activity.

	Unadjusted	**Model 1**†	**Model 2**‡
Overweight/obese	0.63 (0.29;1.32)	0.68 (0.33;1.39)	0.67 (0.33;1.37)
WC > 75^{th} perc.	0.78 (0.44;1.37)	0.83 (0.48;1.45)	0.82 (0.47;1.43)
Sum of 5 SF > 75^{th} perc.	1.22 (0.69;2.17)	1.34 (0.68;2.63)	1.34 (0.69;2.62)
Systolic BP > 75^{th} perc.	0.43 (0.22;0.87)*	0.47 (0.22;0.98)*	0.47 (0.23;0.98)*
Diastolic BP > 75^{th} perc.	0.40 (0.23;0.72)**	0.43 (0.24;0.77)*	0.43 (0.24;0.78)*
Cholesterol > 75^{th} perc.	0.92 (0.53;1.60)	0.98 (0.52;1.85)	0.98 (0.52;1.84)
HDL < 25^{th} perc.	1.22 (0.59;2.53)	1.21 (0.59;2.46)	1.21 (0.59;2.49)
CRP > 75^{th} perc.	0.97 (0.38;2.45)	0.95 (0.34;2.64)	0.94 (0.34;2.62)

Table 6.19: Odds ratios (95% CI) for the association of immigrant status with presence of adverse levels of CVD risk factors in children in the CHMS cycle 1 (2007-2009) and cycle 2 (2009-2011).

† Adjusted for education and income; ‡ Adjusted for education, income, and sex.

* $p < 0.05$; ** $p < 0.01$

Abbreviations: *CI* Confidence interval; *perc.* Percentile *BMI* Body mass index; *WC* Waist circumference; *SF* Skinfolds; *BP* Blood pressure; *HDL* High-density lipoprotein; *CRP* C-reactive protein.

6.2.3 The association of immigrant status with mean levels of CVD risk factors and health behaviours in 12-19 year-old youth

The association of immigrant status with levels of CVD risk factors and health behaviours for youth is shown in Table **??**. Immigrant youth had a significantly lower waist circumference z-score compared to Canadian-born youth (-0.23 [95%CI

-0.43;-0.03]) after controlling for education, income, and sex. The addition of education, income, and sex to the univariate model did not significantly improve the prediction of waist circumference z-score levels. Immigrant youth had a significantly higher sum of 5 skinfolds z-score compared to Canadian-born youth (0.31 [95%CI 0.09;0.53])after controlling for education, income, and sex. The addition of education, income, and sex to the univariate model significantly added to the prediction levels of sum of 5 skinfolds z-scores. The further addition of age to the multivariable regression models did not change the significance of the main effect (data not shown).

	Unadjusted	**Model 1**†	**Model 2**‡
BMI z-score	-0.30 (-0.63;-0.03)	-0.06 (-0.38;0.25)	-0.06 (-0.37;0.24)
WC z-score	-0.33 (-0.52;-0.13)**	-0.23 (-0.43;-0.03)*	-0.23 (-0.43;-0.03)*
Sum of 5 SF z-score	0.18 (-0.06;0.42)	0.31 (0.09;0.53)*	0.31 (0.09;0.53)*
Systolic BP z-score	-0.06 (-0.27;0.15)	-0.09 (-0.29;0.11)	-0.09 (-0.29;0.11)
Diastolic BP z-score	0.03 (-0.18;0.25)	-0.06 (-0.27;0.15)	-0.06 (-0.27;0.15)
Cholesterol [mmol/L]	-0.14 (-0.39;0.11)	-0.09 (-0.40;0.21)	-0.09 (-0.41;0.22)
HDL [mmol/L]	0.03 (-0.05;0.12)	0.02 (-0.05;0.09)	0.03 (-0.06;0.11)
logCRP [mg/L]	-0.08 (-0.42;0.25)	-0.13 (-0.48;0.22)	-0.13 (-0.47;0.20)
F&V servings [1/day]	-0.08 (-0.52;0.37)	-0.06 (-0.53;0.40)	-0.06 (-0.52;0.39)

Table 6.20: Beta coefficients (95% CI) for the association of immigrant status with levels of CVD risk factors and health behaviours in youth in the CHMS cycle 1 (2007-2009) and cycle 2 (2009-2011).

† Adjusted for education and income; ‡ Adjusted for education, income, and sex.

* $p < 0.05$; ** $p < 0.01$

Abbreviations: *CI* Confidence interval; *BMI* Body mass index; *WC* Waist circumference; *SF* Skinfolds; *BP* Blood pressure; *HDL* High-density lipoprotein; *CRP* C-reactive protein; *F&V* Fruits and vegetables.

6.2.4 The association of immigrant status with the prevalence of adverse levels of CVD risk factors in youth

The association of immigrant status with the prevalence of adverse levels of CVD risk factors in youth is shown in Table 6.21. Immigrant youth had 1.91 (95%CI 1.16;3.16) times the odds of having a sum of 5 skinfolds above the 75th percentile compared to Canadian-born youth, after controlling for education, income, and sex. The addition of education, income, and sex to the univariate model significantly added to the prediction of sum of 5 skinfolds above the 75th percentile. The further addition of age to the multivariable regression models did not change the significance of the main effect (data not shown).

	Unadjusted	Model 1†	Model 2‡
Overweight/obese	0.75 (0.43, 1.32)	0.93 (0.49, 1.75)	0.93 (0.49, 1.73)
WC $>$ 75th perc.	0.65 (0.35, 1.22)	0.79 (0.40, 1.56)	0.79 (0.41, 1.53)
Sum of 5 SF $>$ 75th perc.	1.54 (0.91, 2.61)	1.82 (1.07, 3.09)*	1.91 (1.16, 3.16)*
Systolic BP $>$ 75th perc.	0.98 (0.58, 1.64)	0.91 (0.54, 1.54)	0.91 (0.54, 1.53)
Diastolic BP $>$ 75th perc.	0.92 (0.53, 1.60)	0.73 (0.39, 1.39)	0.73 (0.39, 1.39)
Cholesterol $>$ 75th perc.	0.63 (0.30, 1.31)	0.75 (0.33, 1.72)	0.75 (0.32, 1.75)
HDL $<$ 25th perc.	0.96 (0.50, 1.83)	0.83 (0.43, 1.58)	0.82 (0.41, 1.64
CRP $>$ 75th perc.	0.87 (0.42, 1.79)	0.81 (0.39, 1.65)	0.79 (0.39, 1.58)
Physically active	0.83 (0.47, 1.47)	0.86 (0.49, 1.51)	0.86 (0.49, 1.49)

Table 6.21: Odds ratios (95% CI) for the association of immigrant status with presence of adverse levels of CVD risk factors in youth in the CHMS cycle 1 (2007-2009) and cycle 2 (2009-2011).

† Adjusted for education and income; ‡ Adjusted for education, income, and sex.

* $p < 0.05$; ** $p < 0.01$

Abbreviations: *CI* Confidence interval; *perc.* Percentile *BMI* Body mass index; *WC* Waist circumference; *SF* Skinfolds; *BP* Blood pressure; *HDL* High-density lipoprotein; *CRP* C-reactive protein.

6.3 Summary

Immigrant children had significantly lower odds of diastolic blood pressure above the 75th percentile, a lower number of daily fruit and vegetable servings, and less hours of physical activity compared to Canadian-born children. Immigrant youth had a significantly lower waist circumference z-score compared to Canadian-born youth. Immigrant youth had significantly higher odds of sum of 5 skinfolds above the 75th percentile as well as a higher sum of 5 skinfolds z-score.

7 DISCUSSION AND CONCLUSION

7.1 Summary of results

The present study examined the association between immigrant status (Canadian-born versus foreign-born) with CVD risk factors and health behaviours. We found that one fifth to one third of children and youth in Canada are overweight or obese. The lowest prevalence of overweight and obesity was observed in immigrant children (6-11 years) and the highest prevalence was seen in Canadian-born youth (12-19 years). Mean cholesterol levels were high in both Canadian-born and immigrant children. Immigrant children had slightly higher mean cholesterol, and the prevalence of high cholesterol ($\geq$ 4.4mmol/L) was approximately 40% for both Canadian-born and immigrant children. Prevalence of high cholesterol was lower in youth than in children, with lowest prevalence amongst immigrant youth. Mean HDL was lowest in Canadian-born youth. There was a trend toward a lower prevalence of adverse levels of CVD risk factors among immigrant children and youth in comparison to Canadian-born children and youth but only systolic and diastolic blood pressure above the 75^{th} percentile among children and mean waist circumference z-scores in youth were found to be statistically significantly lower. In contrast to the trend in CVD risk factors, self-reported levels of fruit and vegetable consumption and physical activity were higher in Canadian-born than in immigrant children and youth.

7.2 Discussion

Similar to our results among children and youth in the CHMS, Popkin and Udry, and Harding et al. found that immigrant children and youth to North America and to the UK, respectively, had lower prevalence of overweight and obesity than those born in the host countries in the National Longitudinal Study of Adolescent Health (1996) and the Adolescent Social Well-being and Health Study (2003).[76,78] These results are also supported by our findings in waist circumference. We found waist circumference z-scores in youth to be statistically significantly lower in immigrant youth compared to Canadian-born youth. General obesity and abdominal obesity were both lower in immigrants but subcutaneous fat was higher in immigrants. This may be indicative of differences in body composition and fat deposition patterns between immigrant and Canadian-born that impact CVD risk. South Asians and Blacks have been reported to have thicker truncal skinfolds but thinner peripheral skinfolds when compared to Caucasians.[215,216] Measures of central obesity have a stronger correlation with abdominal fat mass, laboratory CVD markers, and CVD outcomes.[217–220] A higher mean subcutaneous fat level but lower mean abdominal fat level suggests that immigrant children and youth have a more favourable fat distribution. Lower general and abdominal obesity in immigrant children and youth indicates a lower CVD risk compared to Canadian-born children and youth.

Levels of mean cholesterol and prevalence of high cholesterol ($\geq$ 4.4mmol/L) were highest in immigrant and Canadian-born children and lowest in foreign-born youth. Mean cholesterol levels seen in this study in 12 to 19 year-olds were similar to those seen in 12-17 year-olds from the NHANES III (1988 to 1994)[221] and NHANES 1999 to 2004.[70] Prevalence of high cholesterol among adults in the CHMS has been reported to be as high as 57% ($\geq$ 5.2 mmol/L).[27] Immigrant youth have lower levels of total cholesterol and a lower prevalence of adverse cholesterol levels than Canadian-born youth. Immigrant children do not have lower levels and prevalence compared to Canadian-born children. The reason for this higher prevalence in children is not clear. Levels of total cholesterol have been found to peak around 8 to 10 years of age.[70] It may be speculated that in some ethnic groups cholesterol peaks at higher levels around 8 to 10 years of age than in Canadian-born children. Even though mean cholesterol levels and prevalence of high cholesterol are lowest in immigrant youth, almost 25% still have high cholesterol.

The prevalence of HDL $\leq 25^{th}$ percentile was higher in immigrant children compared to Canadian-born children but mean HDL levels were similar between these two groups. In logistic and linear multiple regression analysis, the addition of the covariates education, income, and sex did not change the estimate of HDL $\leq 25^{th}$ percentile or of mean HDL levels. Chinese and South Asians form the majority of immigrants to Canada[107] and lower levels of HDL have been reported in South Asian children living in Western countries.[79] However, it is also possible that our estimate of HDL $\leq 25^{th}$ percentile is not entirely reliable in immigrant children due to the high sampling variability. This observation is supported by the finding of similar mean HDL levels in immigrant and Canadian-born children.

We found the prevalence of systolic and diastolic blood pressure $> 75^{th}$ percentile to be significantly lower in immigrant children compared to Canadian-born children. The difference in prevalence between immigrant and Canadian-born children was large but could not be explained by known factors. Immigrant youth also have lower prevalence of systolic blood and diastolic blood pressure $> 75^{th}$ percentile than Canadian-born youth. Paradis et al. found mean systolic blood pressure to be 10 mmHg lower in the 2007-2009 CHMS than in 2003-2006 NHANES data among children and youth.[71,213] Conversely, Paradis et al. found mean diastolic blood pressure measured in the CHMS to be 5 mmHg higher in boys and 2 mmHg higher in girls when compared to the NHANES population.[71,213] This finding may be related to the low prevalence (18%) of elevated systolic blood pressure ($> 75^{th}$ percentile) in normal weight children and youth reported by Maximova et al. in

CHMS 2007-2009 data.[222] Since the prevalence of normal body weight is higher in immigrant children and youth than in Canadian-born children and youth, this finding may partly explain the low prevalence in systolic blood pressure $> 75^{\text{th}}$ percentile found in this study. Another contributing factor to the low prevalence of systolic and diastolic blood pressure $> 75^{\text{th}}$ percentile found in immigrant children and youth in this study may be the fact that the age- and height-based blood pressure percentile determination used unweighted data, while the prevalence of blood pressure $> 75^{\text{th}}$ percentile was weighted to the Canadian population. Imbalances between the unweighted and weighted height and age data between Canadian-born and immigrant children would then account for the difference between the two groups. The trend of lower prevalence of systolic and blood pressure however remains in foreign-born children and youth, as seen in the lower systolic and diastolic blood pressure z-scores.

In contrast to the trend in CVD risk factors, Canadian children and youth showed higher levels of fruit and vegetable consumption and physical activity compared to immigrant children and youth. Immigrant children and youth have lower levels of both physical activity and fruit and vegetable consumption, with both being statistically significantly lower among children only. Lower physical activity levels are often seen in immigrant children when compared to children born in the US[139] and in immigrant adults when they are compared to Canadian-born adults.[37,52,130–132] Most immigrants come from low and middle income countries which do not have the availability of programs in place for organized physical activity as in North America. Despite this, they tend to be less sedentary as children[77,139] and as adults[223] and are more likely to use walking as a form of transportation.[131,132] Our observation of a lower fruit and vegetable intake is in contrast to what we expected to see and is also in contrast to what has been previously reported. Newer immigrants to North America or those with a lower level of acculturation have been reported to have healthier dietary behaviours.[119,120,122,123] This has also been seen in immigrant youth to the UK in the DASH Study.[147] A recent Canadian study on factors associated with BMI in Canadian-born and immigrant youth using the CCHS also found lower levels of fruit and vegetable consumption in immigrant youth.[224] This study proposed barriers imposed through lower income as an explanation. These barriers are realistic in that they make it more difficult to maintain healthier traditional diets.[225] In this study and that of Wahi et al. immigrant youth were observed to consume less fruit and vegetables than Canadian-born youth.[224] Young adults have been reported to consume the same amount as Canadian-born but immigrants of all ages together are reported to consume more fruits and vegetables than Canadian-born (CCHS).[59] Immigrants may be less accustomed and practiced on thinking about the composition of their meals as they have been less surrounded by messages on healthy eating than Canadian-born and these questions may be especially challenging for immigrant youth and young adults. It may also be that fruit and vegetable consumption is not a sensitive enough indicator alone of a healthy diet in children and youth. Additional information on the consumption of fast food, packaged foods, and processed foods may provide a better indicator of nutritional quality.

There is an overall trend to lower CVD risk factor levels in immigrant children and youth. Their better health may be due to self-selection for immigration, immigration admission screening, and maintenance of healthier lifestyle behaviours adopted in their former countries of residence.[57] The heterogeneity of the immigrant group may also mask predisposition for CVD in some ethnic groups. While we did not have the ability to examine ethic groups separately, our results indicate that higher CVD risk associated with ethnicity does not play a significant role. In general, immigrant children and youth appear to have a better CVD risk profile than Canadian-born children and youth.

7.3 Strengths

The strengths of this study are the wide range of objectively measured outcomes such as BMI, waist circumference, blood pressure, and blood lipids in a nationally representative sample. Non-response weighting based on Census Canada information has been used to reduce bias. Further, confounding of the association between immigrant status and CVD risk by socio-economic status was reduced by the use of multiple regression analysis.

7.4 Limitations

Our study also has some limitations. Immigrant health status is dependent on ethnicity, socio-economic factors, and the stage immigrants are at in the process of adaptation to the host society, culture and physical environment, also known as their level of acculturation. While the concept of acculturation is thought to be key to understanding the relationship between ethnicity and CVD risk over time, it is not an easy concept to measure. We were not able to examine differences in CVD risk factors with level of acculturation in this study as the sample size did not permit examination of risk factor trends with available proxy measures of acculturation. Such proxy measures of acculturation included time since immigration and language usually spoken at home. Country of birth was used to define immigrant status (foreign-born vs. Canadian-born) but the sample size did not permit examination of ethnic subpopulations and the investigation of the "healthy immigrant effect" by country of birth. This would have been important because of differences in CVD risk across groups in this diverse population. We were also not able to stratify the analysis by sex because of the sample size limitation. Females have been reported to acculturate faster than males,[34] so there may have been smaller differences in girls than in boys. We may not have a complete picture of the physical activity levels because the information on non-leisure physical activity is also not available from the survey, and this may have differed between the two groups. Immigrant children and youth may have better non-leisure physical activity levels as they have been reported, for example to be more likely to walk to school than non-immigrants.[131] Response accuracy and interpretation of the questions on health behaviour may also differ between Canadian-born and immigrant children and youth, which may have led to underestimation of health behaviour levels in immigrant children and youth. More acculturated immigrant respondents may have been overrepresented in the CHMS and this may have also underestimated the health advantage of immigrant children and youth over their Canadian peers. Lastly, given that we have studied multiple outcomes, it is possible that the statistically significant associations found are due to chance. However, the fact that the majority of associations displayed a similar trend of immigrant status being protective of CVD risk lends support to our findings and interpretation.

7.5 Directions for future research

Larger studies of immigrant health are needed to better identify ethnicity-specific CVD risk and to find reasons for these differences in the immigrant child and youth population. Larger prospective studies are needed to examine which factors contribute to the loss of health status in all immigrants. There is a need to better understand the process of acculturation in children and youth which understanding could inform the development of public health initiatives to increase physical activity and fruit and vegetable consumption in this population.

7.6 Importance to public health

Immigrant children and youth may have a health advantage over Canadian-born children and youth as determined by the trend to lower prevalence of adverse levels of CVD risk factors. However, due to lower consumption of fruits and vegetables, lower levels of physical activity and additional CVD risk in some ethnic groups, immigrant children and youth may also be at a higher risk of CVD later in life than those who are Canadian-born. Promotion of CVD health could include strategies that facilitate integration but allow for preservation of traditional non-Western dietary habits. Western diets could also be diversified to include some of these dietary habits, for example as in the recommendation of the dietary habits in the Canada Food Guide.[211] Knowing more about the factors that underlie the health advantage of recent immigrants could help to improve the health of all residents of Canada.[39] The prevalence of high cholesterol shows a need to create increased awareness for primary care providers and parents of the AHA Guidelines for CVD Health Promotion in all children and youth.[226] This includes the recommendation of a low-fat diet for children and youth with hypercholesterinaemia.

7.7 Conclusion

The current study was the first in Canada to examine the association between immigrant status and objectively measured CVD risk factors in a nationally representative sample of children and youth. We have demonstrated a trend toward an advantage of immigrant children over Canadian-born children and youth with regard to CVD risk factors. While our study was not able to examine if and for how long this advantage was maintained, numerous other studies in adults have demonstrated an assimilation of CVD risk between immigrants and their host country over time. Immigrant children and youth may have worse outcomes than their Canadian peers in the long run given the potentially higher genetic CVD risk in some ethnic groups. Larger, prospective studies are needed to better understand the association of acculturation with health behaviours and CVD risk factors in the immigrant child and youth population. There is a need for improvement in CVD risk factors through improvements in health behaviours of all Canadian children and youth to prevent translation into CVD later in life.

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