Predicting Non-communicable Disease Based On Behavioral Risk Factors and Social Determinants of Health -- A Canadian Study

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ABSTRACT

In Canada, the concern over non-communicable diseases (NCDs), also known as chronic diseases, has become a major issue. With the significant increase of NCDs risk factors, Canadians are facing NCDs challenges. Two out of five Canadians, above the age of 12 years, have at least one NCD and 80% are at risk of developing a NCD. NCDs rates are affected by a complex interaction of factors including the underlying biological, behavioral, social, physical conditions, and health service related. This study only focused on behavioral and social conditions. The impact of social determinants of health (SDOH) and behavioral risk factors (BRFs) on individuals' probability of getting a NCD in Canada were assessed in this study. Both the independent effect of each risk factor and their multi-function effects were assessed. BRFs include unhealthy diet (low fruit and vegetable consumption), physical inactivity, tobacco use and harmful use of alcohol. The SDOH considered in this thesis include income, education level, marital status, age and work stress. The Canadian Community Health Survey (2010) data set was used in the analysis of this study. A sample of 62,909 individuals were investigated in the CCHS 2010 survey. Univariable and multivariable logistic regression models were used in the analysis. These results indicate that the socio-economic status is related to an individual's probability of getting a NCD. Higher socio-economic status is associated with better health, and people with less NCDs. Respondents who reported higher levels of education and income experienced fewer NCDs than respondents with lower education and income levels. Respondents with the highest work stress levels were more likely to have NCDs than those not so stressed. A healthy lifestyle, i.e. more fruit and vegetable consumption, being physically active, less smoking, is important to maintain better physical health in order to reduce the risk of having a NCD. Respondents who were obese and overweight were more likely to have NCD than those of normal weight. However, due to limitations of the data, the results regarding marital status and alcohol consumption were not clear and needs further research. Recommendations from both institutional level and community involvement policies were made in the conclusion chapter of the thesis.

RÉSUMÉ

Au Canada, l'inquiétude suscitée par les maladies non transmissibles (MNT), aussi connu comme les maladies chroniques, est devenue un enjeu majeur. Avec l'augmentation significative des facteurs de risque des maladies chroniques, les Canadiens sont confrontés à des défis des maladies chroniques. Deux Canadiens sur cinq, âgés de plus de 12 ans, ont au moins une maladie chronique et 80% sont à risque de développer une maladie chronique. Les taux de maladies chroniques sont affectés par une interaction complexe de facteurs comprenant les conditions sous-jacentes socio-économiques, culturelles, politiques et environnementales. Cette étude uniquement axé sur les conditions sociales et comportementales. Cette étude a évalué l'impact des déterminants sociaux de la santé (DSS) et des facteurs de risques comportementaux (FRC) sur la probabilité des individus d'obtenir la MNT au Canada. Tant l'effet indépendant de chaque facteur de risque que les effets multifonctionnels ont été évalués. Les FRC comprennent la consommation des fruits et des légumes, l'activité physique, l'usage du tabac et la consommation d'alcool. Les DSS considéré dans cette thèse comprennent mauvaise alimentation (faible consommation de fruits et légumes), l'inactivité physique, l'usage du tabac et l'usage nocif de l'alcool. L'ensemble de données, fourni par l''Enquête sur la santé dans les collectivités canadiennes (2010), a été utilisé dans l'analyse de cette étude. Un échantillon de 62 909 personnes ont été enquêtées dans l'ESCC 2010. Les modèles de régression logistique univariables et multivariables ont été utilisées dans l'analyse. Ces résultats indiquent que le statut socio-économique est lié à la probabilité d'obtenir un MNT d'un individu. Le statut socio-économique plus élevé est associé à une meilleure santé, et les gens avec moins des maladies chroniques. Les interrogés qui ont déclaré des niveaux plus élevés de scolarité et de revenu ont connu moins de maladies non transmissibles que les répondants ayant des niveaux faibles d'éducation et de revenu. Les interrogés avec les plus hauts niveaux de stress au travail étaient plus susceptibles d'avoir des maladies chroniques que ceux qui ne sont pas tellement stressés. Un mode de vie sain (e.g. plus de consommation des fruits et des légumes, être physiquement actif, moins de tabac) est important pour maintenir un meilleur état de santé et réduire le risque de maladies non transmissibles. Les interrogés qui étaient obèses et en surpoids étaient plus susceptibles d'avoir des maladies chroniques que ceux de poids normal. Toutefois, en raison de la limitation des données, les résultats concernant l'état matrimonial et la consommation d'alcool n'étaient pas clairs et ont besoin de la recherche continue. Les recommandations au niveau

institutionnel et des politiques de l'engagement communautaire ont été proposées dans la conclusion de cette étude.

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CHAPTER 1
BACKGROUND AND INTRODUCTION

1.1 INTRODUCTION

1.1.1 Non-communicable disease in Canada

A non-communicable disease (NCD) is a medical condition or disease that is by definition non-infectious and non-transmissible among people. NCDs have long been the leading causes of death in developed countries, but are no longer health issues limited to high-income countries (Beaglehole 2011). The prevalence of non-communicable diseases (NCDs) has been widely acknowledged as a major barrier to global development, threatening the accomplishment of international development goals (United Nations General Assembly 2011). The heavy burden that NCDs generate includes not only higher rates of mortality, but also a loss of economic productivity. According to a recent World Health Organization report, NCDs are the leading causes of death globally. Of the 57 million deaths that occurred globally in 2008, 36 million – almost two thirds – were attributed to non-communicable diseases, comprising mainly cardiovascular diseases, cancers, type 2 diabetes and chronic lung diseases (Alwan 2011). NCDs also impede the pace of economic development by reducing labor supply and productivity, creating poverty in low-income households and allocating resources for disease prevention rather than economic development (NCD Alliance 2011).

In Canada, the concern over NCDs has also become a major issue. With the significant increase of NCDs risk factors, Canadians are facing NCDs challenges. Two out of five Canadians, above the age of 12 years, have at least one NCD and 80% are at risk of developing a NCD. In Canada, 177,800 people are diagnosed with cancer each year, 1.6 million have heart disease or are living with the effects of a stroke, while over 3 million Canadians live with a chronic respiratory disease. Approximately two-thirds of deaths each year in Canada stem from NCDs. Seventy five thousand Canadians die each year due to cancer. People with diabetes have a doubled mortality rate when compared to those without diabetes. In 2007, cardiovascular diseases were the cause of approximately 70,000 deaths. NCDs are also a threat to the Canadian economy. The annual economic loss goes

beyond the health sector, comprising not only the direct health care costs ($68 billion), but also indirect costs resulting from indirect income and productivity loss ($122 billion)-double the direct health care costs. More working age (34-64) Canadians are living with a chronic disease, which increases their health expenditures and reduces their labor productivity. In 2010, Canadians spent at least $190 billion on chronic diseases annually. This expenditure is expected to increase each year as the prevalence of chronic diseases rise in the working age population. Each year, 0.4% of people aged 35-44 and 1.2% aged 45-64 are newly diagnosed with diabetes, leading to more productivity loss and health care costs (Public Health Agency of Canada 2013).

1.1.2 Risk factors for NCDs

NCDs rates are affected by a complex interaction of factors including the underlying socioeconomic, cultural, political and environmental conditions that exist across a nation such as Canada (Public Health Agency of Canada 2011). While some risk factors, such as age and genetics, are uncontrollable at the personal level, other risk factors can be controlled, including an unhealthy diet, tobacco use, alcohol consumption and physical inactivity which are among the leading causes of NCDs morbidity and mortality worldwide (Yusuf et al. 2004). Tobacco use is a risk factor for 6 of the 8 leading causes of death in the world, leading to approximately 6 million deaths each year. Over 600,000 deaths are due to second-hand smoke exposure, and the number is predicted to increase to 8 million by the year 2030 (NCD Alliance 2011). It is estimated that approximately 71% of all lung cancer deaths, 42% of chronic respiratory disease and about 10% of cardiovascular disease are caused by smoking (Alwan 2011). Alcohol consumption leads to 3.4% of the global NCD-related death burden, 5.0% of net year of life lost (YLL) and 2.4% of the net disability adjusted life years (DALYs) respectively (Parry et al. 2011). As indicated in some literatures, the intake of light to moderate amounts of alcohol is associated with reduced mortality and morbidity from several cardiovascular diseases, especially coronary heart disease (Klatsky et al. 1990; Fagrell et al. 1999; Wollin and Jones 2001). However, excessive alcohol consumption is a contributing factor in the occurrence of many cardiovascular diseases, including atrial fibrillation and hypertension. It also detrimentally affects the liver, and contributes to an increase in the incidence of diabetes. Unhealthy

diets are linked to four of the world's top ten leading risk factors causing death: high blood pressure, high blood glucose, overweight and obesity and high cholesterol (World Heart Federation 2014). Low vegetable and fruit consumption leads to almost 1.7 million deaths globally. Unhealthy diets, especially those high in fats, sugars and salt, significantly contribute to NCDs, including cardiovascular diseases, type 2 diabetes and certain cancers. Physical inactivity is directly related to NCDs. According to the World Health Organization, doing regular physical activity helps lower the risk of hypertension, stroke and depression. It also contributes to an individual maintaining a healthy body weight (Alwan 2011).

In Canada, one out of 2 individuals consumes fruits and vegetables below the recommended daily rate; one out of 2 adults and one out of 4 youth exercise insufficiently; one out of 5 smokes (Public Health Agency of Canada 2011). While in 2013, 18.9% (5.5 million) of Canadians aged 12 and over reported alcohol consumption that classified them as heavy drinkers (Statistics Canada 2013). Approximately one quarter of Canadian adults are obese. Two-thirds of the total Canadian population are deemed to be overweight with a significant proportion of these being classified as being obese. The increasing obesity rates will also drive NCDs rates (Public Health Agency of Canada 2011) . These behavioral risk factors contribute to mortality rates. Among all deaths, 17% (37,200 deaths) were due to tobacco use (Rehm et al. 2006a), over 9% (4,300 deaths) were attributed to people being overweight or obese (Rehm et al. 2006b), 6%, 4,000 deaths were caused by abuse of alcohol (Katzmarzyk and Ardern 2004), and 10% (21,000 deaths) were caused by physical inactivity in the period 1999-2000 (Katzmarzyk et al. 2000). The onset of many NCDs could be prevented or delayed by addressing these behavioral risk factors (Alwan 2011).

1.1.3 Social determinants of health

Apart from the burden of NCDs being attributed to the presence of behavioral risk factors, there is evidence that the social health determinants, including gender, income level and distribution, education, employment and health service availability are also associated with individual's risk of having a NCD. SDOH are related to behavioral risk factors and other factors (e.g. psychosocial and material in terms of access to health-related resources) underlying poor health outcome. For example, income and education level determine the

overall living conditions, affects quality of diet and influences the extent of alcohol consumption and tobacco use. Employment status influences people's income, while working conditions affect their stress and behaviors. All of these factors impact risk for NCDs. In the past few decades, an increasing literature has focused on describing and addressing the role of the social determinants of health (SDOH) on population health in the 21st century (Johnson et al. 2008).

Studies about these SDOH have been conducted all over the world. In Canada, the importance of living conditions on people's health has been advocated through government policy documents since the mid-1970s. Recent reports from Canada's Chief Public Health Office and the Public Health Agency of Canada stress the importance of SDOH (Mikkonen and Raphael 2010). Rather than medical treatment or lifestyle choices, these social determinants shape the health of Canadians, help explain the wider health inequalities that exist among Canadians, as well as affecting whether Canadians have increased risk for NCDs. Whether Canadians will experience cardiovascular disease, cancer, adult-onset diabetes and chronic respiratory disease is determined in large part by these SDOH.

Income is one of the most important SDOH, which also affects people's experience with NCDs. Income determines the overall living conditions, affects quality of diet and influences the extent of alcohol consumption and tobacco use. Income also impacts an individual's housing, diet, and education, which are all related to NCDs. In Canada, cardiovascular disease and adult-onset diabetes are much more common among the low-income population. Researchers have also shown that men in the wealthiest 20% of Canadian neighborhoods have 4 years additional life expectancy when compared to those in the poorest 20% neighborhoods, while the comparable difference for women is two years. Those living in the poorest neighborhoods have death rates that are 28% higher than those living in the wealthiest neighborhoods (Mikkonen and Raphael 2010). Employment and working conditions also have an influence on the risks of NCDs because these conditions affect people's income, stress level and health condition. According to Statistics Canada, one in three workers (32.4%) reported feeling stress during their

workday. Women scored higher (37%) than men (32%) on the stress level test (Mikkonen and Raphael 2010). Health service is also an important SDOH and affects whether people have NCDs. The Canada Health Act (1984) sets out requirements that provincial governments must follow in the application of their public health-care insurance plans, including public administration, universality, portability, comprehensiveness and accessibility. However, access to health care has been a continuing issue. Inequality exists in health care access for different population groups with different socio-economic status. Compared to the top 33% of income owners, the bottom 33% are 50% less likely to get care on weekends or evening, 50% less likely to find a specialist if they have health problems and 40% are more likely to wait longer for an appointment (Mikkonen and Raphael 2010). This inequality in access to health care services also results in a greater probability of individuals succumbing to a NCD.

The quality of these SDOH is strongly determined by the policies that governments put in place. Government decisions (laws, policies and regulations) affect Canadians' income level, income distribution, access to health service, employment status, and family benefits. Thus population-health interventions, which are policies or programs that shift the distribution of health risks by emphasizing the underlying socio-economic and environment conditions, are of significant value in improving the health status of Canadians and reducing the risk for NCDs. Researchers have found that much of the disease burden could be mitigated through early health interventions that have impacts both inside and outside the healthcare system (McDaid and Suhrcke 2011).

1.2. PROBLEM STATEMENT AND OBJECTIVES

Despite the impressive volume and breadth of research on SDOH (see for example Mikkonen and Raphael 2010, Kennedy et al. 2014, Kivimäki et al. 2006, for comprehensive reviews), as well as behavioral risk factors (see for example Rehm et al. 2006a, Plotnikoff et al. 2009, Parry et al. 2011, for comprehensive reviews), very few studies have combined various aspects of SDOH and behavioral risk factors (BRFs) in order to assess the impact of these factors on the risks of NCDs. Of the studies related to risk factors and social determinants of health that affect NCDs in Canada, none focus on the nation as a whole, but

rather narrow their target population to a specific group (Alamian and Paradis 2009) or a specific province (Lubans et al. 2012). Thus this thesis is designed to assess the potential influence of SDOH and BRFs on the whole Canadian population. Using cross-sectional data collected by Statistics Canada, on a national sample of Canadians in 2010, the Canadian Community Health Survey (CCHS), this research addresses three main specific objectives:

(1) Examine the effect that BRFs have on Canadians regarding their probability of developing a NCD
(2) Explore and document the relationships between certain SDOH (age, education, income, marital status and work stress) and a person's probability of developing NCDs
(3) Make policy recommendations from both institutional and community involvement levels.

1.3 ORGANIZATION OF THE STUDY

This study uses the Canadian Community Health Survey (CCHS) 2010 data, which is a cross-sectional survey that collects information related to health status, health care utilization and health determinants for the Canadian population. A large sample of respondents were surveyed to provide reliable estimates at the health region level. The CCHS covers approximately 98% of the Canadian population aged 12 and older. Univariable and multivariable (multiple) logistic regression will be used in this study and presented in this thesis. In the regression equations, the dependent variable is whether individuals have a NCD. This value will be set as 1 if this observation has at least one NCD. Otherwise the value will be set as 0, which means this observation doesn't have a NCD. Independent variables are the four BRFs (tobacco use, alcohol consumption, physical activity and diet) and the SDOH (age, education, income, marital status and work stress).

Chapter 2 presents a review of the relevant literature concerning chronic disease BRFs, SDOH and NCDs, as well as the methodology of studies predicting NCD risks. Chapter 3 consists of a description of the model data and the logistic regression model. Chapter 4 presents the analysis, results and discussion, followed by the conclusion and suggestions which are presented in Chapter 5.

CHAPTER 2
LITERATURE REVIEW

This literature review is divided into three main sections: Section 2.1 summarizes the current state of knowledge about the four BRFs (tobacco use, alcohol consumption, unhealthy diet and physical inactivity) and the clustering effects among them, Section 2.2 presents an overview of the SDOH and their relation with NCDs. Section 2.3 presents two methods for predicting NCDs risks and the method this study will apply.

2.1 NCDs BEHAVIORAL RISK FACTORS

2.1.1 Tobacco use

Smoking is one of the most important risk factors for non-communicable disease. Smokers have a higher risk to develop non-communicable diseases, including heart disease, stroke and lung cancer than non-smokers. It is estimated that smoking would increase the risk for coronary heart disease by 2 to 4 times, for stroke by 2 to 4 times, for lung cancer by 25 times in men and 25.7 times in women (U.S. Department of Health and Human Service 2014). Smokers have a higher risk for cardiovascular disease because smoking damages blood vessels and can make them thicken and grow narrower, increasing the heart rate and raising blood pressure. Smoking is also a risk factor for lung diseases (respiratory disease) because smoking damages people's airways. Smokers are 12 to 14 times more likely to die from chronic obstructive pulmonary disease (COPD) than non-smokers (U.S. Department of Health and Human Service 2014). In addition, smoking increases the risk of dying from cancer and other diseases in cancer patients. Thus smoking leads to diminished overall health, increases the risks for NCDs, increases absenteeism from work due to NCDs, and increases health care and medical treatment costs. Addiction to smoking results in poor families spending more on cigarettes and less on food, health care and education which leads to an increase in future poverty levels.

In Canada, smoking statistics come mainly from two surveys-The Canadian Tobacco Use Monitoring Survey and the Youth Smoking Survey. The Canadian Tobacco Use Monitoring

Survey is an annual survey which tracks changes in smoking status and amount smoked for 20,000 Canadians, especially youth aged 15 to 24, who are most at risk for taking up smoking. The Youth Smoking Survey monitors tobacco use in school-aged children (grades 6-12). In the Canadian surveys, smoking levels were classified into 4 categories, never smoked, former smokers, current daily smokers and current occasional smokers. Never smoked are those who have never tried a single cigarette, not even a few puffs. Former smokers include those who have smoked at least 100 cigarettes in their lifetime, but have not smoked at all during the 30 days preceding the survey. Current daily smokers are those who have smoked at least one cigarette per day for each of the 30 days before the survey. Current occasional smokers are those who have smoked at least one cigarette during the past 30 days, but have not smoked every day (Public Health Agency of Canada 2011) . According to these two surveys, in 2011, among Canadians aged 15 and older, 17.3% (approximately 4.9 million) were current smokers and the majority of smokers reported smoking daily (13.8% daily and 3.6% non-daily). Daily smokers in Canada smoked 14.4 cigarettes per day on average (Reid et al. 2014). The prevalence of smoking in Canada leads to economic loss in Canada due to health care costs and economic losses. The control of tobacco use is assumed to be a cost-effective and feasible intervention to slow down the NCD epidemic.

2.1.2 Alcohol consumption

Existing literature have addressed the relationship between alcohol consumption and NCDs. The intake of light to moderate amounts of alcohol is associated with reduced mortality and morbidity from several cardiovascular diseases, especially coronary heart disease (Klatsky et al. 1990; Fagrell et al. 1999; Wollin and Jones 2001). However, excessive alcohol consumption has been linked to increases in cancer, cardiovascular diseases, liver disease and mental disorders. For example, Parry et al. (2011) summarize the relationship between various patterns of alcohol consumption and different NCD outcomes. Alcohol consumption is causally related in varying degrees to 8 types of cancers. The cancer risk parallels the alcohol consumption volume. Excessive alcohol use is also associated with many cardiovascular diseases, including atrial fibrillation, hypertension, liver diseases and type 2 diabetes. These research findings support calls by the WHO to

carry out evidence-based strategies to reduce harmful alcohol use. Alcohol now appears in many NCD discussions. For example, the preparatory meeting for the September session in Moscow in April 2011 emphasized reducing alcohol consumption to alleviate the prevalence of NCDs (World Health Organization 2011). Also, at the recent NGO conference in Melbourne on health and the Millennium Development Goals during a session on NCDs, alcohol was recognized as one of the four major common risk factors for NCDs. However, of the 4 major risk factors, alcohol regularly receives the least attention because it is so much more part of the daily life of decision-makers and the alcohol industry lobbies to minimize the efforts of public health proponents to address the influence of alcohol use on NCDs. Alcohol marketing is associated with alcohol consumption. Exposure to media and commercial communications about alcohol is also linked to a greater likelihood that adolescents will initiate alcohol consumption, or drink more if they are already drinking at baseline (Anderson et al. 2009).

Over 80% of Canadian adults consume alcohol (Ialomiteanu et al. 2012). According to Statistics Canada, total consumption of alcohol increased by 13% on a per adult basis between 1996 and 2010 (Statistics Canada 2011). In 2004 the Canadian Addiction Survey conducted among people aged 15 or more estimated that about 17% of drinkers were consuming alcohol in a hazardous manner based on the Alcohol Use Disorders Identification Test score (Public Health Agency of Canada 2013). The increasing consumption of alcohol in Canada may be due to several socio-economic factors, including excessive marketing and advertising of alcohol products, higher income and purchasing power of Canadian people, easier access to alcohol for youth and increased daily stress. This increased alcohol consumption has generated many social and health problems, of which one obvious problem is NCD. Alcohol use is related to the development of many NCDs (Rehm et al. 2009). Many scholars have studied the relationship between excessive drinking and NCDs in Canada since the 90s. For example, Single et al. (1999) estimated mortality and morbidity attributable to alcohol, tobacco, and illicit drug use undertaken as parts of a larger investigation into the economic costs of substance abuse in Canada in 1992. The results showed that alcohol-attributable morbidity and mortality accounted for 3% of total mortality, 6% of total years of potential life lost, 2% of hospitalizations, and 3%

of total hospitalization days due to any cause in Canada in 1992. Besides, The Public Health Agency of Canada has published the chronic disease risk factor atlas. In the atlas, the alcohol consumption status quo has been summarized, covering alcohol consumption volume, the Canadian Addiction Survey and related chronic disease facts. In the atlas, heavy or high-risk drinking is defined as current drinkers who reported drinking five or more drinks on one occasion, 12 or more times a year. In 2005, 28% of youth aged 12-19 and 30% of men and 12% of women aged 20 years and over reported drinking heavily. The age group 20-24 has the highest prevalence of heavy drinking - 56% among men and 33% of women. The atlas also concluded that high-risk alcohol use is related to increased risks of over 60 chronic or acute conditions, including cancer, gastrointestinal diseases, neurological disorders, cardiovascular disease (especially stroke) and, for pregnant women, negative impacts on the fetus (Public Health Agency of Canada 2011).

2.1.3 Unhealthy diet

Dietary patterns can change the risk of developing NCDs. According to Dietary Guideline for Americans (2010), consuming too much of certain kinds of foods and ingredients, including sodium, solid fats, saturated and trans fatty acids, cholesterol, added sugars, increases the risk of some of the most common NCDs in the United States (U.S. Department of Agriculture and U.S. Department of Health and Human Services 2010). Cardiovascular diseases are to a large extent caused by unbalanced diet. Heart disease and stroke are the two major types of cardiovascular disease and could be reduced by eating less saturated and trans-fats, less salt, more fruits and vegetables. Reducing salt intake could also help reduce high blood pressure, which is a main cause of cardiovascular disease (Amine et al. 2002). On the contrary, other foods, including fruits and vegetables and whole grains, may decrease the risk of developing some NCDs. Eating adequate fruit and vegetables daily helps reduce the risk for cancer of the oral cavity, as well as stomach and colorectal cancer (Amine et al. 2002). Most literature has addressed the relationship between unhealthy diet and NCDs using fruit and vegetable consumption as a measure for diets. Daily consumption of sufficient amounts of fruits and vegetables is recommended as part of a healthy diet. Canada's food guide recommends that females aged 18 to 50 have 7 to 8 daily servings of fruit and vegetables, and males of the same age have 8 to 10 daily

servings of fruits and vegetables (Health Canada 2008). In epidemiological studies, fruit and vegetable intake has been associated with decreased mortality from a variety of health outcomes including obesity, hypertension and cardiovascular disease risk factors. Higher consumption of fruits and vegetables has been associated with a lower risk of coronary heart disease, stroke, diabetes, and some cancers. For example, Ortega (2006) concluded that adherence to a Mediterranean style diet, which is rich in fruits, vegetables and nuts help reduce the risk of cardiovascular disorders, cancers and coronary heart disease. In conclusion, to alleviate NCDs, interventions should be implemented to promote healthy eating habits by increasing fruit and vegetable consumption. Improving dietary habits is a challenging societal problem, which requires both population-based and multi-sector efforts.

The Canadian Nutrition Survey in 2004 indicated that 7 out of 10 children aged 4 to 8 had less than five servings of fruits and vegetables a day. Between the age level 9 to 13, 68% of the boys and 62% of the girls did not meet this standard. In 2008, only 50.1% of the Canadian females (6.8 million) and 37.0% of males (4.8 million) reported consuming fruits and vegetables 5 or more times per day (Garriguet 2007). Insufficient fruit and vegetable intake has increased the risk for NCDs among the Canadian population. The risk of developing NCDs results from long-term dietary patterns.

2.1.4 Physical inactivity

Physical inactivity is directly related with NCDs. According to World Health Organization, insufficient physical activity is the fourth leading risk factor for NCDs (World Health Organization 2009). Regular physical activity helps lower the risk of hypertension, stroke and depression. It also contributes to keeping a healthy weight. Public researchers at the WHO have estimated that participation in 150 minutes of moderate physical activity a week reduces the risk of heart disease by approximately 30%, diabetes by 27%, and breast and colon cancer by 21%-25% (World Health Organization 2010).

Regular physical activity has been widely recognized as an effective way to prevent a variety of health risks. Since 1995, the Canadian Society for Physiology and the Public

Health Agency of Canada have created the Canadian Physical Activity Guidelines to promote a healthy and physically active lifestyle for Canadians. The first publication was a Canadian physical activity guide for adults (aged 20–55 years) in 1998, for older adults (aged >55 years) in 1999, for children (aged 6–9 years) in 2002, and for youth (aged 10–14 years) in 2002 (Tremblay et al. 2011) . The New Canadian Physical Activity Guidelines in 2011 have concluded the shortcomings of the former ones and made a general improvement for different age groups. For children (aged 5–11 years) and youth (aged 12–17 years), it recommends at least 60 min of moderate- to vigorous-intensity physical activity daily, including vigorous-intensity activities at least 3 days per week, activities that strengthen muscle and bone at least 3 days per week. It advocated that adults aged 18–64 years should accumulate at least 150 min of moderate- to vigorous-intensity aerobic physical activity per week, in bouts of 10 min or more. For adults aged 65 years and older, it recommends at least 150 min of moderate- to vigorous-intensity aerobic physical activity per week, in bouts of 10 min or more to achieve health benefits and improve functional abilities (Tremblay et al. 2011). Despite guidelines to advocate healthy and active lifestyles and an increasing trend in physical activity among Canadian adolescents, many people still do not meet the recommended guidelines. According to the Canadian Community Health Survey (2005) data, 78% of Canadian youth do not meet the recommended guideline for optimal growth and development (Cameron et al. 2005). Thus, physical activity is an essential part of any strategy aimed at reducing NCDs.

2.1.5 Clustering effects among risk factors

The behavioral risk factors do not exist separately. On the contrary, some of them may work together to increase the risk of NCD. The co-occurrence of behavioral risk factors is defined as the simultaneous presence of two or more behavioral risk factors hereby referred to as ‘clustering’ (Ebrahim et al. 2004).

Several studies using both cross-sectional and longitudinal methods have explored the pairwise association between two risk factors. For example, the association between smoking and drinking, smoking and physical inactivity, smoking and unhealthy diet, physical inactivity and unhealthy diet, physical inactivity and drinking, and so forth.

Studies focusing on the relationship between smoking and drinking have found a consistent positive association between these two risk factors. Klatsky et al. (1977) carried out a survey of 91,569 Black, White and Asian adults to examine their alcohol consumption pattern. They found that heavy drinkers of both genders were more likely to smoke cigarettes than non-drinkers. The percentages of established smokers among persons taking 6+ drinks per day and among nondrinkers were respectively: white men, 58.4 and 29.1 per cent; white women, 67.9 and 21.5 per cent; black men, 73.4 and 23.7 per cent; black women, 58.9 and 20.8 per cent; Oriental men, 63.9 and 25.5 per cent; Oriental women, 60.0 and 11.8 per cent. A similar study in Canada also reached the same result. Dreher and Fraser (1967) found that smokers who consumed alcohol were far more likely to smoke heavily than smokers who did not consume alcohol in Ontario. The most obvious difference was observed for those who smoked over 40 cigarettes per day. Among the general smoking population, only 1.9% smoked over 40 cigarettes per day but for those who drank alcohol the number rose to 27.2%. In addition, 41% of the alcohol consumers had tried to quit smoking while only 4% succeeded. In summary, there appears to be a strong positive clustering of smoking and drinking, for both behaviors and amounts of consumption.

Smoking, based on a large literature, is also positively associated with other behavioral risk factors. For example, Laaksonen et al. (2002) carried out a longitudinal study of Finnish adults in 1997. They re-contacted the respondents who participated in national health behavior surveys in the year 1989/1990 after 7 years and examined whether each health behavior predicted later behaviors. The result showed that smoking was positively related with other health behaviors including physical activity and dietary behavior. Smoking was predictive of most other health behaviors. In another German study, the behaviors of 1,262 students at a German university were examined to analyze the clustering of these behaviors and assess individuals' readiness to change behaviors across multiple behaviors. Similarly, the results showed that smokers were more likely to have multiple problem behaviors. Of all smokers, 94% had at least two other health risks, including unhealthy diet and physical inactivity. Smokers ate one and a half serving of fruit

and vegetables per day less than non-smokers and had one and a half hour less physical activity than non-smokers per week (Keller et al. 2008). Similar results were found in a US study, using a sample of 1,559 workers in manufacturing activities who participated in a self-help physical activity intervention and who completed a computerized assessment battery about their smoking, dietary fat intake, physical activity, and demographic characteristics. Results showed that smokers were significantly more likely to have unhealthy dietary behavior and more likely to be physically inactive, compared to non-smokers (Emmons et al. 1994). Thus to conduct health promotion interventions, smokers are a particularly important target.

Physical activity is also associated with other behavioral risk factors, according to some past studies. For example, Johnson et al. (1995) analyzed the National Heart Foundation 1989 Risk Factor Prevalence Survey data of 9,054 respondents aged 20 to 69. A multivariate stepwise logistic regression was used to analyze the associations between leisure-time physical activity and other health behaviors. The results showed that physical activity was weakly associated with not smoking, following a special diet and moderate consumption of alcohol. These weak associations could influence health practices at the population level if the adoption of leisure activity promotes the adoption of other good health practices.

Simoes et al. (1995) used another measure for healthy diet—dietary fat intake. They examined the relations between leisure-time physical activity and dietary fat by using a sample of 29,672 adults in the 1990 Behavioral Risk Factor Surveillance System. By measuring the consumption of 13 high-fat food items and individuals' participation in physical activities and calculating fat and activity scores, they found that dietary fat and physical activity were strongly inversely associated. Higher physical activity frequency existed with lower dietary fat intake. Thus public health intervention targeting one behavior should also consider the other behaviors.

However, the relationship between physical activity and drinking alcohol is less clear. There is no consensus among past studies. For example, Smothers and Bertolucci (2001)

used data representative of the U.S. population (N = 41,104; 52.5% women), which were derived from the 1990 National Health Interview Survey. Multivariate logistic regression analyses were performed using lifetime abstainers as the reference group. The findings of this study could be explained by a J-shaped curve, showing that physically active lifestyle likelihood (odds ratios) increased from abstinence (1.00) to moderate drinking (1.84), then declined at heavier consumption (1.61). Thus, the likelihood of being physically active increases with light and moderate drinking then decreases with heavier alcohol consumption.

Besides the pairwise association between certain risk factors, a clustering effect may also exist among three or more risk factors. Several past studies have used diverse methods to explore the associations between three or more behavioral risk factors. For example, to understand the relationships among multiple risk factors, a study was conducted using a sample comprised of 1,559 workers in manufacturing industries who participated in a self-help physical activity intervention and who completed a computerized assessment battery about their smoking, dietary fat intake, physical activity, and demographic characteristics. The results of the study showed that 26% of the sample were smokers, 51% did not exercise regularly, and 35% consumed more than an estimated 40% of calories per day from fat. Among the smokers in the sample, only 12% had smoking as their only risk factors. Smokers were more likely to engage in poor dietary habits and physical inactivity than the non-smokers (Emmons et al. 1994).

Similarly, in a Swiss study, Chiolero et al. (2006) assessed clustering of multiple risk behaviors with the level of cigarette consumption, including heavy alcohol drinking, physical inactivity, low fruit and vegetables intake. A sample of 18,005 subjects (8,052 men and 9,953 women) aged >25 years was used. The result of the study revealed that smoking clustered with other risk factors. Smokers were more likely to consume less fruits and vegetables, more alcohol and exercise less compared to non-smokers.

In a New Zealand study, Tobias et al. (2007) analyzed co-occurrence of behavioral risk factors using the 2002-03 New Zealand Health Survey data. Multiple logistic regression

models were used to examine co-occurrence among risk factors. The study found that all four behavioral risk factors showed significant clustering in both males and females. Unhealthy behaviors were more clustered than healthy behaviors. The combination of smoking, too much alcohol drinking and low fruits and vegetables consumption showed the strongest association, while other three combinations of risk factors (smoking, physical inactivity and too much alcohol consumption) showed moderate clustering.

The studies were conducted both in developed and developing countries. For example, in a study conducted in a representative sample of adults between 25 to 64 years in five Asian countries (Bangladesh, India, Indonesia, Thailand and Vietnam), Ahmed et al. (2009) reported clustering of a substantial proportion (>70%) of these largely rural populations having three or more risk factors for NCDs. Clustering of risk factors (tobacco use, intake of fruits and vegetables, physical inactivity, blood pressure levels, and body mass index) was associated with increasing age, being male, and having more education.

Here in Canada, several studies have addressed clustering effects among behavioral risk factors. For example, Alamian and Paradis (2009) assessed the prevalence, socioeconomic distribution and clustering of five major NCDs behavioral risk factors (physical inactivity, sedentary behavior, tobacco smoking, alcohol drinking and high body mass index) in a representative sample of Canadian children and adolescents aged 10–17. Clustering was assessed using an observed to expected ratio method. The result of the study showed that 65% of Canadian youth had two or more behavioral risk factors. The prevalence of having multiple behavioral risk factors was greater among older youth and those from low socioeconomic status families.

Another study in Canada focused on a single province, Alberta. The prevalence, clustering, age trends, and gender differences of chronic-disease related risk factors among a large sample of adolescents (N=4,932) in Alberta were examined. Separate Chi-square analyses were conducted for the presence (yes, no) of each risk factor by gender and primary risk factor cluster (0, 1, 2, 3, 4, and 5) were analyzed by aggregating the risk factors. The study

found that approximately 82% of boys and 88% of girls had one or more risk factors, and approximately 43% of boys and 53% of girls across all age groups had two or more risk factors for chronic conditions (Plotnikoff et al. 2009).

In conclusion, pairwise association and clustering among three or more risk factors exist. Although some of the relationships are not obvious and some are still conflicting, they should be taken into consideration when carrying out public health interventions. Public health intervention should not be based on a single risk factor prevention approach. On the contrary, a comprehensive approach should be undertaken, integrating the clustering effect among these risk factors. In a later part of this thesis, the clustering effect among the risk factors is taken into consideration when doing econometric analysis on the risk factors. For example, smoking and drinking are considered together because of their obvious pairwise association and multi-function. Smoking is considered together with other risk factors, including physical inactivity and unhealthy diet, based on the past conclusion that smoking was positively associated with other risk factors.

2.2 SOCIAL DETERMINANTS OF HEALTH AND NCDS

SDOH are the conditions in which people are born, grow, live, work and age, and the systems for the prevention and treatment of disease and illness. The SDOH, including the underlying social, economic, political, environmental and cultural factors (and policy choices), are the structural drivers of the conditions of daily life (Commission on Social Determinants of Health 2008).

Prevalence of NCDs and individuals' likelihood of developing NCDs are influenced by SDOH to a large extent. In 2008, the Commission on Social Determinants of Health (CSDH) formalized a framework to describe the relationships between macro-level socio-economic and political factors, social stratification and the resulting patterns, or inequalities. The CSDH framework and its three domains—health inequity, intermediate determinants and structural determinants help illuminate root causes in the level and distribution of NCDs (United Nations Development Programme 2013). The intermediate determinants include education, occupation, income, gender and ethnicity. The structural determinants contain

governance, policy, cultural and societal norms and values.

2.2.1 Income

Income is one of the greatest SDOH. Income affects health in several ways. Income determines the overall living conditions, including level of housing, quality of diet, frequency of smoking and drinking, etc.

Previous studies discussed the impact of income on health since the 90s. A 1993 World Bank report examined the relation between gross national product (GNP) and life expectancy in over 100 countries. The report used life expectancy as an indicator for health. The report indicated that when GNP was low, increasing a small unit of GNP led to a large increase in life expectancy. As GNP increases, the life expectancy response levels off; i.e. correlation decreases (Mundial 1993).

Other studies used different measures as indicators for health. For example, using data from the National Survey of Families and Households, the Survey of Income and Program Participation, and the National Health Interview Survey, Ettner (1996) estimated the structural impact of income on health. He used self-assessed health status as an indicator for health. The result of the study indicated that increases in income significantly improved mental and physical health. Another study carried out in Germany used health satisfaction as an indicator for health. This study used the German Socio-Economic Panel (GSOEP) data between 1984 and 2002 to investigate the effect of income changes on health satisfaction of East and West Germans after reunification. This German study found evidence of a significant positive effect of income changes on health satisfaction, although the degree of the change was small (Frijters et al. 2005).

Whatever indicator scholars use, the results are similar. Higher income leads to a better overall health condition of the individual. In Canada, similar results have been generated from various studies. For example, in a book concerning sociological aspects of health care in Canada, Clarke (2004) concluded that economically disadvantaged groups have also been burdened with poor health. Higher income Canadians live an average of 5.7 years

longer than those with the lowest income levels. Mikkonen and Raphael (2010) have studied SDOH in Canada. They point out that income determines Canadians' overall living conditions, including psychological functioning, health-related behaviors, as well as quality of other basic prerequisites of health such as housing. Not only does actual income affect health conditions, but income distribution determines population health levels. A more even income distribution generates better (and more even) health condition per person. Canada is facing an increasing degree of income inequality. According to a recent report by the Organization for Economic Co-operation and Development (OECD), Canada has experienced the greatest increases in income inequality from the 1990s to the mid-2000. From 1984 to 2005, the net worth of the top 10% of Canadian families increased from $659,000 to $1.2 million, while the bottom 30% of Canadian families moved into greater debt (Organization for Economic Co-operation and Development 2009). Those in the lower income group could not afford to eat balanced meals and thus could not benefit from sufficient nutrition. Also, they could not afford equal access to social resources, including gymnastics, sports clubs, as could wealthier Canadians. Thus reducing inequalities in income in Canada is an important issue so as to improve the overall health of Canadians.

Income, as one of the important SDOH, also affects individuals' probability of getting NCDs. However, the degree of influence is still unclear and may vary for different types of NCDs and different population groups. For example, a 2008 study in Porto Alegre, Brazil, measured the relationship between cardiovascular disease and socioeconomic level by district. The study found that the premature death rate for CVD was 2.6 times higher in poorer districts compared to richer districts (Bassanesi et al. 2008). On the other hand, in a study in South Africa, Phaswana-Mafuya et al. (2013) conducted a national survey in 2008 with a sample of 3,840 individuals aged >50 to determine the socio-demographic factors predictive of the presence of NCDs. Multivariable logistic regression was used in the study. The result showed that having greater wealth is associated with the presence of NCDs, which is contrary to the former study result.

Despite numerous studies regarding income and health, there is no study investigating the relations with income and NCDs in Canada. So in the later part of this study, the impact of

income on NCD likelihoods will be examined to better take actions to improve Canadians' health condition and prevent NCDs.

2.2.2 Education

Education is another important SDOH. Better education leads to better health condition through the following pathways. First, the level of education is highly correlated with other SDOH such as income, employment status and working environment. Besides, education allows people to understand how their behavior may affect their health. Moreover individuals with higher education are more willing to participate in civic activities and political processes (Mikkonen and Raphael 2010).

Since the 90s, scholars have studied the relationship between education and health. For example, Ross and Wu (1995) explained the positive association between education and health: (1) work and economic conditions, (2) social-psychological resources, and (3) healthy lifestyle. They used two samples, the first data set coming from a national probability sample of U.S. households in which respondents were interviewed by telephone in 1990 (2,031 respondents, ages 18 to 90), and the second coming from a national probability sample of U.S. households in which respondents ages 20 to 64 were interviewed by telephone first in 1979 (3,025 respondents), and then again in 1980 (2,436 respondents). They used self-reported health and physical functioning as two indicators and measurements for health status. The results showed that compared to the poorly educated, well-educated respondents were more likely to get employed, work more and have higher income. Besides, better-educated people reported a greater sense of control over their lives and health. They could better control their behaviors, reduce unhealthy behaviors such as smoking and drinking, and increase exercise frequency. Thus higher education attainment not only improves health directly, but also improves health indirectly by affecting work and economic conditions, healthy lifestyles, and social resources.

Existing literature have also discussed the relationship between education level and NCDs. For example, a study carried out within the framework of an ongoing Demographic

Surveillance System (DSS) in Vietnam used a verbal autopsy (VA) approach to identify cause of death in a cohort of approximately 250,000 person over a five-year period from 1999 to 2003. The results of the study showed that education was an important factor for survival in general. Compared with cancer and other NCD causes, higher cardiovascular disease (CVD) rates were observed among those without formal education. Evidence from rural Vietnam suggests that the risk of dying from CVD among those with no formal education is 4.5 times higher than for those with primary and higher education (Huong 2006).

Similarly a Chinese study (Yang et al. 2010) estimated the prevalence of diabetes based on different socio-economic status, using a nationally representative sample of 46,239 adults, aged >20, from 14 provinces and municipalities. The study found that the prevalence of diabetes was associated with lower levels of education, which is similar to the result of another study in Buenos Aires, Argentina (Maio et al. 2009). The study in Argentina used cross-sectional data from a 2005 national risk factor survey and investigated the associations of individual- and area-level Socio-economic status with NCDs risk factors. Results indicated that low education and income were associated with increased odds of hypertension and diabetes.

Since education has been proven to be associated with health and NCDs and there is no existing literature discussing the impact of education on NCDs in Canada, the later part of this thesis would take education into consideration when studying the SDOH on NCDs. The influence of education on Canadians' NCDs risk would be examined.

2.2.3 Employment and working conditions

Employment and working conditions are also important SDOH. Researchers have identified a series of work dimensions which shape health outcomes, including employment security, physical conditions at work, work stress, working hours, opportunities for self-expression and individual development (Mikkonen and Raphael 2010).

Research evidence has shown that work stress is associated with higher risk for NCDs. High-stress jobs predispose people to NCDs such as CVD and high blood pressure (Mikkonen and Raphael 2010). In a study estimating the relative risk of coronary heart disease in association with work stress, Kivimäki et al. (2006) carried out a systematic review and meta-analysis of 14 prospective cohort studies. The observation data showed that employees with work stress had an average 50% more risk for coronary heart disease than those not under pressure.

Imbalances between work demands (e.g., time pressures, responsibility) and rewards (e.g., salary, respect from supervisors) always lead to health problems. For example, Stansfeld and Candy (2006) conducted a systematic review to clarify the associations between psychosocial work stressor and mental ill health. The results provided robust consistent evidence that high efforts and low rewards were risk factors for mental disorders, one of the chronic disorders.

In Canada, more than 1 in 4 Canadian workers described their day-to-day lives as highly stressful, according to the General Social Survey (GSS) in 2010 (Shields 2006). Such a high level of stress among Canadian workers generates health problems, economic loss, as well as pressure on the health care system. The mental health problems are estimated to cost employers about $20 billion annually and occupy more than three-quarters of short-term disability claims in Canada (The Conference Board of Canada 2011). Thus to reduce the burden Canadians get from work and to reduce the risk of NCDs as well as mental disorders, government policies must support Canadians' working life balance and special focus should be given to those working under high pressure.

2.3 REVIEW OF RISK PREDICTING STUDIES

Researchers have used two models to estimate the risks for having certain kinds of NCDs both in the absence and presence of risk factors. The usual method of analysis uses the linear logistic model, which generates odds ratios and permits adjustment for relevant covariates. Alternatively, when it is a cohort study, which includes several years of observation and update of data, the Cox proportional hazards model is used. The Cox

proportional hazards model is chosen when the outcome is determined after a fixed period of time (Peduzzi et al. 1987). These two models for risk predicting studies will be discussed in detail in the following section.

2.3.1 Logistic regression model

When the outcome of the study is binary (whether or not individuals get this type of disease), but there is no time considered, a logistic model is often selected. A logistic regression model generates an odds ratio. For a binary outcome (no event versus an event) and two treatment groups (control versus treated), the odds ratio is defined as the odds of having the event in the treated group relative to the odds in the control group (Peduzzi et al. 1987).

For example, in a study predicting chronic kidney disease, Fisher and Taylor (2009) used univariable and multivariable logistic regression models to estimate an individual's probability of chronic kidney disease, based on 14 traditional and non-traditional risk factors in a representative sample of the U.S. population in the Third National Health and Nutrition Examination Survey (NHANES III). The results of the univariable logistic regression showed the risk for chronic kidney disease with or without a certain kind of risk factor. For example, considering the risk factor—age, the result indicated that adults ≥ 60 years old (15.7%) were 27 times more likely to have chronic kidney disease than younger adults. For the risk factor—periodontal disease, the result showed that adults with periodontal disease (7.2%) were 4.5 times more likely to have chronic kidney disease than adults who did not have periodontal disease.

In the multivariable logistic regression, different risk factors were analyzed together to predict the probability of getting chronic kidney disease for each group. To compare the risks among people with the lowest risk group and the highest risk group, the authors of this study ran the regression and determined the risk probabilities for these two groups. The lowest risk group were respondents with none of the model's risk factors, while the highest risk group were those with all of the model's risk factors, including older (≥ 60 years), non-Hispanic white edentulous former smokers, with diabetes ≥ 10 years,

hypertension, macro albuminuria, high cholesterol, low HDL cholesterol, CRP= 12.80mg/dl, lower income, and hospitalization in the past year. The results showed that the probability for the lowest risk group was 0.06% while that for the highest risk group was as high as 98.3%.

2.3.2 Cox proportional hazards model

When not only the occurrence of an event but also the time to event is known, the Cox proportional hazards model is often employed. Unlike logistic regression, which generates an odds ratio, the Cox model generates relative risk and hazard ratios. The relative risk is the ratio of the probability of having the event in the treated group relative to the probability in the control group. The hazard ratio is the instantaneous event rate in the treated group relative to that of the control group. Such an approach differs from the linear logistic approach both in terms of the distributional assumptions and the functional relationship with the covariates (Peduzzi et al. 1987).

For example, in the Framingham heart study, which is a cohort study predicting the 30-year risk of cardiovascular disease, Pencina et al. (2009) prospectively followed 4506 participants of the Framingham Offspring cohort aged 20 to 59 years and free of CVD and cancer at baseline examination during 1971 to 1974 for the development of "hard" CVD events (coronary death, myocardial infarction, stroke). The authors used a Cox regression to assess the effect of cardiovascular disease risk factors measured at baseline on the long-term (30-year) risk of hard CVD. Because it was a cohort study lasting as long as 30 years, the related information was renewed once it was available in the process of the study. In 1971, some 5,124 offspring of the original cohort and their spouses were enrolled into the Framingham Offspring Study. Then in this study, constant monitoring of CVD events and mortality was performed and was available through the end of 2007 for this investigation. After that, a Cox regression with time-dependent covariates was conducted based on a short-term risk assessment. The study showed that the standard CVD risk factors (male sex, age, SBP, antihypertensive treatment, total and HDL cholesterol, smoking, and diabetes mellitus) were highly significant (0.01 level) in the multivariable model.

In another cohort study (Wilson et al. 1998), Cox proportional hazards model was also used to predict coronary heart disease risks using risk factor categories. At the baseline of the study, the patients were 2,489 men and 2,856 women, ranging from 30 to 74 years old. Then 12 years of follow-up was carried out. In the 12 years of follow-up, a total of 383 men and 227 women developed CHD, which was significantly associated with categories of blood pressure, total cholesterol, LDL cholesterol, and HDL cholesterol. The Cox proportional hazards models were used for the 12-year follow-up, by developing separate score sheets for each sex and using a system that assigned points for each risk factor based on the value for the corresponding β-coefficient of the regression analyses. The study results showed that a high blood pressure level was an important risk factor for coronary heart disease. After adjustment for other factors, 28% of CHD events in men and 29% in women resulted from blood pressure levels that exceeded high-normal. This study effectively predicted CHD risk in a middle-aged white population sample and helped physicians to predict multivariate CHD risk in patients without overt CHD.

For this thesis, micro data in the year 2010 will be used to analyze risk factors for certain types of NCDs and predict the risk of NCDs based on people's condition of risk factors. It is not a cohort study, thus a logistic regression model will be used.

CHAPTER 3
METHODS

This chapter provides a general overview of the methods applied in this study, including the models used—univariable logistic regression model and multivariable logistic regression model, as well as the data used in the regression. Description of the data includes source of data, recruitment and sampling, the study population, data collection procedures and measures for risk factors.

3.1 LOGISTIC REGRESSION MODEL

Regression models have been widely used in data analyses related to describing the relationship between a response variable and one or more explanatory variables. Similar to other regression models, the goal of the analysis using a logistic regression model is to find the best fitting and most parsimonious, clinically interpretable model to describe the relationship between an outcome; i.e. dependent or response, variable and a set of independent; i.e. predictor or explanatory variables (Hosmer and Sturdivant 2013).

Unlike the linear regression model, where the outcome variable is assumed to be continuous, in a logistic regression model the dependent variable is binary or dichotomous. When the outcome variable is discrete, taking on two or more possible values, the logistic regression model is the most frequently used method for analyzing this type of data.

Hosmer and Lemeshow (2004) provide an explanation of the basic model of logistic regression. Consider a collection of p independent variables denoted by the vector $x'= (x_1, x_2, \ldots, x_p)$. Let the conditional probability that the outcome is present be denoted by $P(Y=1|x)=\pi(x)$. The logit of the multiple logistic regression model is given by the equation

$$Y=\alpha+\beta_1 x_1+\beta_2 x_2+\ldots+\beta_p x_p \qquad (1)$$

where Y is a dichotomous (binary) dependent variable, it takes on two values: 0 and 1. Y=1

if yes, otherwise Y=0. X is the independent variable, i.e. predictor. Because the dependent variable, Y, is on the logit scale, the equation could also be expressed as

$$\log (p/1-p)= \alpha+\beta_1x_1+\beta_2x_2+...+\beta_px_p \quad (2)$$

in which case the logistic regression model is

$$\pi(x)=P(Y=1|x)=e^{Y}/1+e^{Y} \quad (3)$$

3.1.1 Univariable and multivariable logistic regression

Univariable analysis refers to statistical models in which there is only one independent variable, while multivariable analysis refers to those in which there are multiple independent or response variables (Katz 2003). In multivariable logistic regression, multiple variables are found on the right side of the model equation. In this type of statistical model, the relationship between various variables could be assessed. One can assess independent relationships while also adjusting for potential confounders (Hidalgo and Goodman 2013).

A univariable logistic regression would have a dichotomous outcome and one predictor, whereas a multiple or multivariable logistic regression model has a dichotomous outcome and multiple predictors (continuous or categorical). Thus, a univariable logistic regression model would have the form

$$\log(p/1-p)=\alpha+\beta X+ \varepsilon \quad (4)$$

By contrast, a multivariable or multiple logistic regression model would have the form:

$$\log(p/1-p)=\alpha+\beta_1X_1+\beta_2X_2+...+\beta_pX_p+\varepsilon \quad (5)$$

In the univariable logistic regression, X is a single predictor. The relationship between the single independent variable and the dependent variable will be assessed. While in a

multivariable logistic regression, X_1, X_2 … X_k are the predictors. This estimation of multivariable logistic regression indicates the relationship between the independent variables and the dependent variable, where the dependent variable is on the logit scale. Thus, the relationship between the dependent variable and the independent variables is analyzed.

3.1.2 Odds ratio

An odds ratio (OR) is a measure of the association between an exposure and an outcome. When a logistic regression is calculated, the regression coefficient (β_1, β_2, β_3 … β_p) is the estimated increase in the log odds of the outcome per unit increase in the value of the exposure. Since these coefficients are in log-odds units, they are often difficult to interpret, so they are often converted into odds ratios by exponentiating the coefficient by hand, or by using the logistic command in STATA. In other words, the exponential function of the regression coefficient (e^{β}) is the odds ratio associated with a one-unit increase in the exposure (Szumilas 2010).

The odds ratio represents the odds that an outcome will occur when given a particular exposure, compared to the odds of the outcome occurring in the absence of the exposure (Szumilas 2010). Odds ratios are widely used in case-control studies, as well as cross-sectional and cohort studies. Odds ratios are applicable to compare the relative odds of the occurrence of certain outcomes; e.g. disease or disorder, given exposure to certain related factors; e.g. health condition, economic conditions, social circumstances, etc. The odds ratio can also be used to analyze whether a particular exposure is a risk factor for a certain outcome, such as a chronic disease, and to compare the magnitude of various risk factors for that outcome; i.e. dependent variable. If OR=1, it means the exposure doses not affect the odds of the outcome. If OR>1, it means exposure is associated with higher odds of the outcome. If OR<1, it means exposure is associated with lower odds of outcome.

3.1.3 Model specification

In order to study the relationship between different BRFs and SDOH with an individual's probability of getting a NCD, the logistic regression model is defined as

$$\text{Log}(p/1\text{-}p)=\alpha+\beta1\ \text{age}+\beta2\ \text{education}+\beta3\ \text{income}+\beta4\ \text{work\_stress}$$
$$+\beta5\ \text{marital\_status}+\beta6\ \text{smoking}+\beta7\ \text{drinking}+\beta8\ \text{activity}+\beta9\ \text{fvc}+\beta10\ \text{bmi}\quad (6)$$

Where age means the age of the respondent; education stands for the highest level of education for the respondent; income is personal income level; stress is the work stress that the respondent is having; smoking is whether the respondent is a smoker and what type of smoker, drinking is the drinking behavior and frequency of the respondent; activity is the physical activity frequency of the respondent; fvc represents the total daily fruit and vegetable consumption of the respondent; BMI is the body mass index for the respondent. [1]Detailed information about this last independent variable will be discussed later in the chapter.

3.2 DATA DESCRIPTION

3.2.1 Source of data

The three objectives of this thesis were addressed using the data from the Canadian Community Health Survey (CCHS) in 2010. CCHS is a large nationwide representative survey of the Canadian population. The survey is designed to support Canadian health surveillance programs by providing health data at the national, provincial and intra-provincial level. It also provides a single data source for health research on small populations and rare characteristics in Canada. The survey covers a comprehensive range of aspects related to the health of Canadians, including their health status, health care utilization and health determinants for the Canadian population. The CCHS began in 1991 and is jointly conducted by the Canadian Institute for Health Information (CIHI), Statistics Canada and Health Canada. Given the large sample and the information generated, the survey offered a unique opportunity to investigate the BRFs for NCDs among Canadians and the related SDOH.

[1] Body Mass Index (BMI) is a person's weight in kilograms divided by the square of height in meters. A high BMI can be an indicator of high body fatness. BMI can be used to screen for weight categories that may lead to health problems but it is not diagnostic of the body fatness or health of an individual （Centers for Disease Control and Prevention 2015).

3.2.2 Study population

The Canadian Community Heath survey targets Canadians aged 12 years and older who live in private dwellings across the ten provinces and three territories, covering approximately 98% of the Canadian population aged 12 and older. Only persons living on Indian Reserves or Crown lands, residing in institutions and full-time members of the Canadian Forces and residents of certain remote regions are excluded from this survey.

3.2.3 Recruitment and sampling

In the CCHS studies, each province is divided into health regions (HR). Each territory is designated as a single health region. In the 2010 CCHS survey, data were collected from 114 health regions across the ten provinces and 3 territories, thus summing up to 117 total health regions.

The sample allocation strategy consists of three steps and regards all the HRs and provinces with equal importance. In the first step, a minimum size of 500 respondents per HR was imposed and 60,350 units were allocated in total. In the second step, the rest of the available sample was allocated by using an allocation proportional to the population size by province. Therefore, the total sample size is the sum of the sizes established by the first and the second step. The sample was then divided evenly between the two collection years, making the annual sample size of 2010 at 65,724 and 2009 at 65,762. Then in the final step, the provincial sample was allocated among its HRs proportionally to the square root of the estimated population in each HR. This three-step approach gives a sufficient sample for each HR. Then the sample was divided into area frame and list frames.

The CCHS used three sampling frames to select the sample of households: 49.5% of the sample of households came from an area frame, 49.5% came from a list frame of telephone numbers and the remaining 1% came from a Random Digit Dialing (RDD) sampling frame. For the last two collection periods of 2010, 40.5% came from the area frame, 58.5% from the list frame of telephone numbers and 1% from the RDD frame. The transfer of the sample from the area frame to the list frame was done to reduce collection costs.

3.2.4 Data collection

During January to December in 2010, computer-assisted interviewing (CAI) was used to conduct over 60,000 valid interviews. Approximately half the interviews were conducted in person using computer assisted personal interviewing (CAPI) and the other half were conducted over the phone using computer assisted telephone interviewing (CATI). Computer-assisted interviewing offers a case management system, which automatically records important management information for each attempt on a case and provides reports for the management of the collection process. It also offers an automated call scheduler, which is a central system to optimize the timing of call-backs. CAI also allows custom interviews for each respondent based on their individual characteristics and survey responses.

3.2.5 Measures

This section describes the various measures used in this thesis to carry out the logistic regression, including the measures for the BRFs and the SDOH.

Behavioral risk factors

Alcohol consumption was assessed using the variable "ALCDTTM" in the Canadian Community Health Survey in 2010. This variable was calculated based on the survey questions "ALC_1" and "ALC_2". ALC_1 asked the closed question: "During the past 12 months, that is, from one year ago to yesterday, have you had a drink of beer, wine, liquor or any other alcoholic beverage?" Respondent choices include: 1=yes; 2=no. ALC_2 asked the question: "During the past 12 months, how often did you drink alcoholic beverages?" Respondent choices include: 1=less than once a month; 2=once a month; 3=2 to 3 times a month; 4=once a week; 5=2 to 3 times a week; 6=4 to 6 times a week; 7=every day. Then the variable "ALCDTTM", which indicates the type of drinker the respondent is based on his/her drinking habits in the past 12 months, was derived based on these two questions. If ALC_1=2, it means the respondent did not drink at all in the past 12 months. If ALC_2=1, it means the respondent is an occasional drinker. If 2<=ALC_2<=7, it means the respondent is a regular drinker. This derived variable "ALCDTTM" was introduced in 2007. It was

created to allow the classification of all respondents according to their drinking habits in the past 12 months. Since there are 3 categories for this derived variable "ALCDTTM", in the logistic regression of this thesis, the independent variable for alcohol consumption is a categorical variable.

Tobacco use was analyzed using the derived variable "SMKDSTY" in CCHS 2010. This variable indicates the types of smoker of the respondent, based on his/ her smoking habits. This variable was derived from the survey questions "SMK_01A", "SMK_01B", "SMK_202", "SMK_05D". "SMK_01A" asked the question: "In your lifetime, have you smoked a total of 100 or more cigarettes (about 4 packs)?" The respondents could choose yes or no. "SMK_01B" asked the question: "Have you smoked a whole cigarette?" Respondents could also choose yes or no. "SMK_202" asked the question: "At the present time, do you smoke cigarettes daily, occasionally or not at all?" Respondents could choose daily, occasionally or not at all, based on their smoking frequency. "SMK_05D" asked the question: " Have you ever smoked cigarettes daily?" After gathering feedback from this separate questions from the survey, the variable "SMKDSTY" was derived and has 6 categories, including daily smoker, occasional smoker (former daily smoker), occasional smoker (never a daily smoker or has smoked less than 100 cigarettes lifetime), former daily smoker (non-smoker now), former occasional smoker (at least 1 whole cigarette, non smoker now) and never smoked (a whole cigarette). These six categories help us to divide individuals' smoking behavior and apply them in the regression. Thus, in the logistic regression, the independent variable smoking, is also a categorical variable with 6 categories.

Fruit and vegetable consumption was measured using the derived variable "FVCGTOT" in CCHS 2010. This variable classifies the respondent based on the total number of times per day he/she eats fruits and vegetables. It was derived from the question "FVCDTOT", which asks the number of times that a respondent eat fruits and vegetables per day. If FVCDTOT<5, which means the respondent eat fruits and vegetables less than 5 times per day, FVCGTOT=1. If 5<=FVCDTOT<=10, which means the respondent eats fruits and vegetables between 5 and 10 times per day, FVCGTOT=2. If FVCDTOT>10, it means the respondent eats fruits and vegetables more than 10 times per day, FVCGTOT=3. So the

derived variable "FVCGTOT" has three categories. In this study, the conditions that FVCGTOT=2 or 3 were combined together as "consuming more than 5 times servings of fruits and vegetables per day". So the independent variables for fruit and vegetable consumption in this study have two categories, i.e. consuming less than 5 times servings per day and consuming more than 5 times servings per day.

Physical activity was analyzed using the derived variable "PACDLTI" in CCHS 2010. This variable categorizes respondents as being "active", "moderately active", or "inactive" in the transportation and leisure time based on the total daily Energy Expenditure values (kcal/kg/day) calculated for PACDTLE. PACDTLE is also a derived variable. It is a measure of the average daily energy expended during transportation and leisure time physical activities by the respondent in the past three months. Then, if the daily energy expenditure was larger than 3, the respondent was deemed as "active". If 1.5<=PACDTLE<3.0, the respondent was recognized as moderately active. If the daily energy expenditure was smaller than 1.5, the respondent was physically inactive. Thus, in the regression, the categorical independent variable, physical activity index, has 3 categories.

BMI was also considered as a factor related to behavior, since BMI is calculated from the respondents' height and weight and weight is strongly correlated with people's exercise and eating behaviors. BMI is assessed using the derived variable "HWTDISW". It is a categorical variable based on "HWTDBMI", which is the body mass index calculated using self-reported height and weight. BMI is a comparison of "weight" relative to the "height" of the respondents. BMI is calculated by dividing weight in kilograms by height in meters squared. BMI=WEIGHT (KG)/ HEIGHT (METRES) SQUARED. After getting the body mass index for each respondent, the BMI was divided into different categories according to the following standard:

If 18.50 <=HWTDBMI<=24.99, the respondent has a normal weight. If 25.00<=HWTDBMI<=29.99, the respondent is overweight. If HWTDBMI>=30, the respondent is obese. According to Health Canada, this BMI classification system could be used as a screening tool to identify weight-related health risks at the population and individual levels. Normal weight means least health risk, underweight and overweight

means increased health risk, while obese means high health risk.

Social determinants of health

Income was assessed using the derived variable "INCGPER", which has 6 categories: no income; less than $20,000; $20,000 to $39,999; $40,000 to $59,999; $60,000 to $79,000; $80,000 or more. This variable was derived from the question: "What is your best estimate of the personal income from all sources, before taxes and deductions, in the past 12 months?" In order to make the logistic regression more clear, in this thesis the income levels were combined into 3 main categories: less than $40,000, $40,000 to $79,999 or more than $80,000.

Education was assessed using the categorical variable "EDUDR04". It has 4 categories: less than secondary school graduation, secondary school graduation, some post-secondary education and post-secondary degree/ diploma. In order to simplify the logistic regression in this thesis, the 4 categories were combined into two: lower education level, which stands for less than secondary school graduation and higher education level, which represents some post-secondary education.

Marital status is assessed using the variable "DHHGMS" in CCHS 2010. This is a categorical variable with four main categories: married, common-law, widowed/separated/divorced and single.

Work stress is based on the variable "GEN_09", which asks the stress level people experienced at work. This is a categorical variable with five answers, "not at all stressful, not very stressful, a bit stressful, quite a bit stressful and extremely stressful"

Other important factors

Age was assessed using the variable "DHHGAGE" in CCHS 2010. Originally in the CCHS, this variable has 16 categories. In order to simplify the regression and to make the results

clearer, the age categories were re-classified. The independent variable related to age in the logistic regression includes 5 categories: 12-24 years, 25-39 years, 40-54 years, 55 to 69 years and over 70 years.

Gender was analyzed separately in this regression. The whole sample was divided into two parts, one for male and one for female. This was done because the health condition for men and women differs a lot, classifying the whole dataset by different genders could reduce bias and make the regression results more significant.

In conclusion, this chapter has discussed the logistic regression model used in this thesis, both univariable and multivariable. The data used for the regression, including sources of data, study population, recruitment and sampling, data collection and measures for the data were then discussed. The next chapter will discuss the results from the regression analysis.

CHAPTER 4
RESULTS AND DISCUSSIONS

A total of 62,909 observations in the Canadian Community Health Survey (2010) that satisfied the research interests for this project in terms of variables were investigated. The study population was divided into two parts based on gender. Analyzing male and female observations separately makes the results more precise and comparable since gender plays an important role in health conditions. The sample size of females is 34,363 while that of males is 28,546. Each sample was used to develop both univariable and multivariable logistic regression models.

This chapter includes the descriptive analysis, which provide the characteristics of the study population for both males and females separately. The results of the univariable and multivariable logistic regression for both genders will be described. The similarities and differences between the two genders will be highlighted and discussed. Finally, the clustering effects of behavioral risk factors will be discussed.

4.1 FEMALE

4.1.1 Descriptive analysis: characteristics of the study population

In this section, the general characteristics of the female population will be presented along with the association between behavioral risk factors and social determinants of health with NCDs. The prevalence of the four main types of NCDs in the female population will then be summarized.

Table 4.1.1.1 includes two parts. The first part summarizes the general characteristics of the female population in the study. A total of 34,363 females 12 years or older participated in the 2010 Canadian Community Health Survey. Of all the female participants, 56.97% had completed some post-secondary education or were post-secondary graduates, while the other 39.93% had less than a completed secondary school education or were secondary school graduates. Of all the female participants, 40.15% were married. Those who were widowed/separated/divorced accounted for approximately one quarter of the whole female population, similar to those who were single. Those who were in a common-law

relationship accounted for 8.34% of the sample. Most women were in the lowest income group; 71.23% of the whole female sample. With respect to questions on work stress, only 5.19% of the female participants claimed to have no stress and 2.88% of the females claimed to be extremely stressful. Most females reported feeling some work stress, but at varying levels.

Table 4.1.1.1. Descriptive Summary and Association between Social Determinants of Health and NCDs (Female)

Social Determinants of Health	Sample		NCDs	
	Population	Percentage	Yes	No
Total	34,363	100%	12,637(36.78%)	21,726(63.22%)
Age (years)				
12-24	5,292	15.40%	709(13.40%)	4,583 (86.60%)
25-39	6,885	20.04%	1,037(15.06%)	5,848 (88.94%)
40-54	6,801	19.79%	1,841(27.07%)	4,960(72.93%)
55-69	8,655	25.19%	4,332(50.05%)	4,323(49.95%)
>70	6,730	19.59%	4,718(70.10%)	2,012(29.90%)
Education				
Less than secondary school or secondary school graduation	13,721	39.93%	5,967(43.49%)	7,754 (56.51%)
Some post-secondary or post-secondary graduation	19,577	56.97%	6,282(32.09%)	13,295(67.91%)
Personal Income				
Less than $40,000	18,795	71.23%	7,754(41.26%)	11,041 (58.74%)
$40,000-$79,999	6,102	23.12%	1,785(29.25%)	4,317(70.75%)
$80,000 or more	1,491	5.65%	378(25.35%)	1,113(74.65%)
Marital Status				
Married	13,797	40.15%	4,953(35.90%)	8,844 (64.10%)
Common-law	2,866	8.34%	697(24.32%)	2,169(75.68%)
Widowed/separated/divorced	8,755	25.48%	5,063(57.83%)	3,692(42.17%)
Single	8,868	25.81%	1,897(21.39%)	6,971(78.61%)
Work stress				
No stress at all	1,783	5.19%	445(24.96%)	1,338(75.04%)
Not very stressed	3,693	10.75%	851(23.04%)	2,842(76.96%)
A bit stressed	7,589	22.08%	1,678(22.11%)	5,911(77.89%)
Quite a bit stressed	4,490	13.07%	1,203(26.79%)	3,287(73.21%)
Extremely stressed	991	2.88%	323(32.60%)	668(67.4%)

The second part of table 4.1.1.1 summarizes the association between these social determinants of health and NCDs for the female respondents. In this study, the four main NCDs considered were cardiovascular disease, chronic respiratory disease, diabetes and cancer. Cardiovascular disease includes heart disease and high blood pressure. Chronic respiratory disease includes chronic obstructed pulmonary disease and asthma. The reason why these four types of NCDs were considered is that they are the four main types of NCDs and the leading causes of deaths from NCDs in the world (Alwan 2011).

In total, 63.22% of the female participants didn't have a NCD, while 36.78% had at least one of the four NCDs (Table 4.1.1.1). As age increases, the percentage of females having at least one NCD increases. For females 12 to 24 years old, only 13.40% had a NCD, while 70.10% of the females in the oldest age group, i.e. over 70 years old, had at least one NCD. In terms of education, in the lower education group, 43.49% of the female participants had a NCD. While in the higher education group, only 32.09% had a NCD. As income increases, the proportion of women having NCDs decreases. 41.26% of the women in the lowest personal income group; i.e. less than $40,000, had NCDs, while only 25.35% of those in the highest income group; i.e. $80,000 or more, had a NCD. These results support the idea that there is a casual link between income and education. In terms of marital status, 57.83% of the females who were widowed/separated/divorced had NCDs, while for those who were married, common-law or single, the proportion is much smaller. In terms of work stress, 32.60% of the women who were extremely stressful had NCD, while the proportion was smaller for those with less stress.

Table 4.1.1.2 presents a summary of the behavioral risk factors for females and contains two parts. The first part summarizes the behavioral risk factors for the female population in the study. Of the 34,363 female respondents, those who had less than 5 servings of fruits and vegetables per day were a slightly larger proportion of the female sample than those who had more than 5 servings per day, with the proportions being 48.86% and 45.36%, respectively. The remaining 5.78% were those who didn't answer this question in the CCHS 2010 study. In terms of physical activity, approximately half of the female participants were physically inactive, while those who were active or moderately active

both occupied one quarter of the whole female population.

Table 4.1.1.2. Descriptive Summary and Association between Behavioral Risk Factors and NCDs (Female)

Behavioral Risk Factors	Sample		NCDs	
	Population	Percentage	Yes	No
Total	34,363	100%	12,637(36.78%)	21,726(63.22%)
Fruit and vegetable consumption				
Less than 5 times servings per day	16,789	48.86%	10,519(62.65%)	6,270(37.35%)
More than 5 times servings per day	15,588	45.36%	5,434 (34.86%)	10,154(65.14%)
Physical activity				
Active	8,497	24.73%	2,193(25.8%)	6,304(74.2%)
Moderately active	8,766	25.51%	2,886(32.92%)	5,880(67.08%)
Inactive	16,404	47.74%	7,275(44.35%)	9,129(55.65%)
Smoking				
Daily smoker	5,101	14.84%	1,872(36.70%)	3,229(63.3%)
Occasional smoker	854	2.49%	263(30.80%)	591(69.20%)
Always an occasional smoker	516	1.50%	105(20.35%)	411 (79.65%)
Former daily smoker	7,934	23.09%	3,692(46.53%)	4,242(53.47%)
Former occasional smoker	4,843	14.09%	1,674(34.57%)	3,169(65.43%)
Never smoked	14,936	43.47%	4,965(33.24%)	9,971(66.76%)
Alcohol drinking				
Regular drinker	17,287	50.31%	5,391(31.19%)	11,836(68.81%)
Occasional drinker	7,245	21.08%	2,966(40.94%)	4,279(59.06%)
Did not drink in the last 12 months	9,369	27.26%	4,105(43.81%)	5,264(56.19%)
BMI				
Underweight	929	10.00%	265(28.53%)	664 (71.47%)
Normal weight	14,096	41.02%	4,206(29.84%)	10,070(70.16%)
Overweight	8,747	25.45%	3,913(44.74%)	4,834(55.26%)
Obese	5,730	16.67%	3,222(56.23%)	2,508(43.77%)

With respect to smoking, women who never smoked had the largest share (43.47%) of the female participants, while those who were former smokers, or daily or occasional smokers, represented approximately 40% of the total. Less than 20% of the females were current smokers. For alcohol consumption, 50.31% were regular drinkers and 21.08% were

occasional drinkers. In terms of the body mass index, 41.02% of the female participants had a normal weight. Approximately 40% were overweight or obese, based on the BMI and just 10% were underweight, based on the BMI (Table 4.1.1.2).

The second part of table 4.1.1.2 summarizes the association between behavioral risk factors and NCDs for the female respondents. These modifiable behavioral risk factors include tobacco use, physical inactivity, unhealthy diet and excessive consumption of alcohol. These four modifiable risk factors increase the risk for most NCDs or are the causes of most NCDs. As can be seen from the right hand two columns of table 4.1.1.2, 62.65% of the females who consumed less than 5 servings of fruits and vegetables per day had a NCD, while the proportion was much smaller (34.86%) for those who consumed more than 5 servings per day. With respect to physical activity, females who were physically inactive had the largest incidence of NCDs (44.35%), compared to those who were moderately active (32.92%) or active (25.8%). When referring to smoking, it was found that 46.53% of former daily smokers had a NCD. The proportion was smaller for current daily smokers (36.70%), current occasional smokers (30.80%), former occasional smokers (34.57%) and those who never smoked (33.24%). For alcohol consumption, only 31.19% of the regular drinkers had a NCD, while 40.94% and 43.81% of the occasional drinker and those who did not drink in the last 12 months had a NCD. In terms of body mass index, it was found that obese females had the greatest proportion of NCDs (56.23%), while only 29.84% of those who were of normal weight had a NCD.

Table 4.1.1.3 presents a summary of the prevalence of the four types of NCDs in the female population. In the data, 63.27% of the females had none of the four NCDs, 26.80% of the female participants had one NCD, 8.49% had two NCDs, 1.36% had three NCDs, and 0.08% had all four NCDs. Among those females who had only one NCD, cardiovascular disease was the most common disease, followed by chronic respiratory diseases. Among the females who had two NCDs, the most prevalent combinations were chronic respiratory disease and cardiovascular disease, as well as cardiovascular disease and diabetes. For those who had three diseases, most of these females had chronic respiratory disease, cardiovascular disease and diabetes. 28 women had 4 NCDs at the same time in CCHS

2010.

Table 4.1.1.3. Prevalence of NCDs (Female)

Number of NCDs	NCDs	Count	Sum	Percentage
4 NCDs	All the 4 NCDs	28	28	0.08%
3 NCDs	Chronic respiratory disease &cardiovascular disease &cancer	66	466	1.36%
	Chronic respiratory disease &cardiovascular disease &diabetes	333		
	Chronic respiratory disease &cancer& diabetes	9		
	Cardiovascular disease & cancer &diabetes	58		
2 NCDs	Chronic respiratory disease &cardiovascular disease	1,073	2,912	8.49%
	Chronic respiratory disease &cancer	78		
	Chronic respiratory disease & diabetes	125		
	Cardiovascular disease &cancer	252		
	Cardiovascular disease & diabetes	1,367		
	Cancer & diabetes	17		
1 NCD	Chronic respiratory disease	2,611	9,189	26.80%
	Cardiovascular disease	5,650		
	Cancer	309		
	Diabetes	619		
0 NCD	None of the 4	21,693	21,693	63.27%
Total		34,288	34,288	100%

4.1.2 Univariable logistic regression for female

In this section, the results of the univariable logistic regression analysis for females are discussed. Specific behavioral risk factors and social determinants of health are considered individually in order to obtain an understanding of the relationships between these factors and NCDs. For each factor, a hypothesis will be made based on the published literature and

then results of the univariable logistic regressions will be presented.

4.1.2.1 Social determinants of health and NCD

Table 4.1.2.1 summarizes the regression results for all the social determinants of health, including odds ratio, standard error, z value and p value, as well as 95% confidence interval. The standard error is used for testing whether the parameter is significantly different from 0; by dividing the parameter estimated by the standard error, a z-value can be determined. The standard errors can also be used to form a confidence interval for the parameter, as shown in the last two columns of this table. The columns of z and p>|z| provide the z-value and 2-tailed p-value used in testing the null hypothesis that the coefficient; i.e. parameters, is not significantly different from 0. By comparing the p-value with alpha-0.05, it could be determined whether the regression results are statistically significant. Coefficients having p values less than 0.05 are statistically significant; i.e. reject the null hypothesis and say that the coefficient is significantly different from 0. After checking whether the coefficient is statistically significant by comparing the *p*-value with 0.05, the relationship between the individual social determinants of health and NCD could be determined by checking the odds ratio. This ratio represents the odds that an outcome will occur, given a particular exposure, compared to the odds of the outcome occurring in the absence of the exposure (Szumilas 2010). Thus, the odds ratio can be used to compare the risks of getting a NCD when having or not having certain risk factors. Following these steps, the results in table 4.1.2.1 will be analyzed.

Hypothesis 1: The relationship between age and NCD

Published literature have presented the relationship between age and NCDs (Kennedy et al. 2014; Fontana 2009). Some of the studies found that aging is the greatest risk factor for a majority of NCDs driving both morbidity and mortality. Aging is associated with the development of serious NCDs, including type 2 diabetes, mellitus, cancer, heart, kidney and neurological diseases in mammals (Kennedy et al. 2014; Fontana 2009). Hypothesis 1 proposes that as age increases, the risk for NCDs also increases.

To test this hypothesis, a univariable logistic regression was carried out. Here the

independent variable is age, while the dependent variable is whether respondents have a NCD. As can be seen from table 4.1.2.1, the 95% confidence interval for each age group does not include 0. The *p*-values are all 0.00, which is less than 0.05. Thus, the odds ratios for these age groups are statistically significant. Setting females 12-24 years old as a reference group, the odds ratio for the older age groups are all larger than 1, which indicates that the odds for older age groups having a NCD is greater than the odds for the younger age group. This result supports the hypothesis that as age increases, the risk for NCDs also increases.

Hypothesis 2: The relationship between education and NCD

Over the past several decades, various sociological and epidemiological studies have suggested a relationship between education and health (Ross and Wu 1995; Grossman and Kaestner 1997; Mikkonen and Raphael 2010). Better education leads to better health conditions by increasing household income, improving employment status and working environment, and improvement in a healthy lifestyle (Mikkonen and Raphael 2010). Other scholars have also found that a higher education level was associated with lower levels of NCDs, for example, cardiovascular disease and diabetes (Huong 2006). Hypothesis 2 proposes that individuals with higher education levels are less likely to have NCD than those with lower levels of education.

To test this hypothesis, a univariable logistic regression was carried out. Here the independent variable is education level, while the dependent variable is whether the respondent had a NCD. As can be seen from table 4.1.2.1, the 95% confidence interval is from 0.59 to 0.64. The p-value is 0.00, which is less than 0.05, indicating that the odds ratios for these education groups are statistically significant. Setting women who had less than a completed secondary education or were secondary school graduates as a reference group, the odds ratio of 0.61 for the higher education group indicates that the odds of having a NCD for the higher education group over the odds of having NCDs for the lower education group is 0.61. In terms of percentage change, the odds for the higher education group having NCDs is 39%, less than the odds for the lower education group. Thus, females in the higher education group were less likely to have NCDs, which supports the

hypothesis.

Hypothesis 3: The relationship between income and NCD

Income is one of the greatest social determinants of health. Income affects health by determining the overall living standards of people. Published literature since the 1990s have presented the impact of income on health, in which it has been noted that income has a significant relationship with overall health conditions (Ettner 1996; Kawachi and Kennedy 1999; Marmot 2002). Based on such study results, hypothesis 3 proposes that females with higher personal income are at decreased risk of experiencing NCDs.

To test this hypothesis, a univariable logistic regression was performed. Here the independent variable of the regression is personal income, while the dependent variable is whether women have a NCD. As shown in table 4.1.2.1, the 95% confidence interval is from 0.55 to 0.63 for the middle-income group ($40,000 to $80,000) and from 0.43 to 0.55 for the high-income group ($80,000 or more). The p-values are 0.00 for both middle and high-income group, which are both less than 0.05, resulting in the statistically significant odds ratios. Setting women in the lowest income group (less than $40,000) as a reference group, the odds ratio of 0.59 for the middle income group indicates that the odds of having NCDs in the middle income group over the odds of having NCD in the low income group is 0.59. In terms of percentage change, the odds for middle income female having NCDs is 41% less than the odds for the low-income group. Similarly, when comparing the low income group with the high income group, the odds ratio of 0.48 shows that the odds for high income group having NCD is 52% less than the odds for low income group. In conclusion, females in the high-income group were least likely to have NCDs. As income increases, the risk of getting a NCDs decreases, which supports hypothesis 3.

Hypothesis 4: The relationship between marital status and NCD

Most previous studies focusing on the general populations of healthy adults found that married people tend to have higher levels of well-being and lower mortality rates (Diener 1999; Gove 1972; Kessler and Essex 1982; Ross and Mirowsky 1989), and enjoy better mental health (Berkman and Syme 1979). However, the relationship between marital

status and NCDs is still not clear, particularly the relationship between those in a common-law relationship and NCD. Hypothesis 4 states that married females were less likely to have NCD than those with other marital statuses.

To test this hypothesis, a univariable logistic regression was conducted. Here the independent variable of the regression is marital status, while the dependent variable is whether women have NCDs. As shown in table 4.1.2.1, the 95% confidence intervals do not include 0. The p-values are 0.00 for all the marital status groups. Thus, the odds ratios for marital status are statistically significant. Setting married women as a reference group, the odds ratio of 2.45 for the women who were widowed/separated/divorced indicates that the odds for women who were widowed/separated/divorced having a NCD is more than double that of the odds for married women. This result is in alignment with our hypothesis. Widowed females could have more mental tension and may have the responsibilities to bring up children alone, thus spending less money on themselves. However, compared to married women, the odds of having a NCD for those who were common-law and single are both smaller than the odds for the married women, which is contradictory to our hypothesis. The possible explanation is that singles are younger than married people. Thus, age is involved in this result. Singles also do not shoulder the responsibilities of bringing up children so they can spend more on health care expenditures on themselves.

Hypothesis 5: The relationship between work stress and NCD

Work stress is related to health conditions, as indicated from many published studies. For example, as shown in chapter 2, imbalances between work pressure and rewards always lead to health problems. High work stress levels are risk factors for mental disorders, one of the chronic disorders (Stansfeld and Candy 2006). The high level of stress among Canadian workers also generates physical and mental health problems (Conference Board of Canada 2011). Based on these studies, hypothesis 5 proposes that higher work stress levels result in higher risk for NCD.

To test this hypothesis, a univariable logistic regression for work stress and NCD was carried out. Here the independent variable is work stress and the dependent variable is whether females have a NCD. Women who reported being extremely stressed at work were set as the reference group. As seen in table 4.1.2.1, the 95% confidence interval is from 0.58 to 0.82 for those who had no stress at all, from 0.53 to 0.72 for those who were not very stressed, from 0.51 to 0.68 for those who were a bit stressed, 0.65 to 0.88 for those who experienced quite a lot of stress. The p-values are 0.00 for all these groups. Because the p values are less than alpha, and confidence intervals do not include 0, the results of the odds ratio are statistically significant. Since women who were extremely stressed during work are the reference group, the odds ratio of 0.69 for those who had no stress at all indicates that the odds of having a NCD for the women who were extremely stressed over the odds of having a NCD for those who had no stress at all is 0.69. In terms of percentage change, the result indicates that the odds for women who had extreme work stress having a NCD is 31% more than the odds for those who didn't have work stress. Similarly, when comparing other groups with the extremely stressed group, the odds ratio being smaller than 1 shows that the odds of women extremely stressed having a NCD is the highest. In other words, women who were extremely stressed at work had the highest risk for a NCD, which could support hypothesis 5.

Table 4.1.2.1. Univariable Logistic Regression model for Social Determinants of Health and NCDs (Female)

Social Determinants of Health	Odds Ratio	Std. Err	z	P>|z|	[95% Conf. Interval]	
Age (years)						
12-24	1.00	--	--	--	--	--
25-39	1.15	0.06	2.60	0.01	1.03	1.27
40-54	2.40	0.12	17.96	0.00	2.18	2.64
55-69	6.48	0.30	40.86	0.00	5.92	7.08
>70	15.16	0.73	56.23	0.00	13.79	16.67
Education						
Less than secondary school or secondary school graduation	1.00	--	--	--	--	--
Some post-secondary or post-secondary graduation	0.61	0.01	-21.17	0.00	0.59	0.64
Personal Income						
Less than $40,000	1.00	--	--	--	--	--
$40,000-$79,999	0.59	0.02	-16.66	0.00	0.55	0.63
$80,000 or more	0.48	0.03	-11.84	0.00	0.43	0.55
Marital Status						
Married	1.00	--	--	--	--	--
Common-law	0.57	0.03	-11.81	0.00	0.52	0.63
Widowed/separated/divorced	2.45	0.07	32.00	0.00	2.32	2.59
Single	0.49	0.02	-22.99	0.00	0.46	0.52
Work stress						
No stress at all	0.69	0.06	-4.30	0.00	0.58	0.82
Not very stressful	0.62	0.05	-6.13	0.00	0.53	0.72
A bit stressful	0.59	0.04	-7.28	0.00	0.51	0.68
Quite a bit stressful	0.76	0.06	-3.68	0.00	0.65	0.88
Extremely stressful	1.00	--	--	--	--	--

4.1.2.2 Behavioral risk factors and NCDs for female

Table 4.1.2.2 summarizes the regression results for the behavioral risk factors. Similar to the social determinants of health, the results also include the odds ratio, standard error, z value and p value, as well as the 95% confidence interval. Following the same steps, p value will be compared with alpha-0.05 to see whether the results are statistically significant. If the result is significant, the odds ratio will be analyzed. This part of analysis is also separated according to different hypothesis, as described in the following section of

this thesis.

Hypothesis 6: The relationship between fruit & vegetable consumption and NCD

In epidemiological studies, fruit and vegetable intake has been associated with decreased mortality from a variety of health concerns, including obesity, hypertension and cardiovascular disease risk factors. Previous studies have evaluated the relation between fruit and vegetable intake and the incidence of NCDs. For example, researchers have discovered that consuming more fruits and vegetables will reduce NCDs such as cardiovascular disease, diabetes and cancer (Hung et al. 2004; Ortega 2006). Hypothesis 6 proposes that individuals who consume more fruits and vegetables per day have less risk of having NCDs.

To test this hypothesis, a univariable logistic regression for fruit and vegetable consumption and NCD was carried out. Here the independent variable is frequency of fruit and vegetable consumption. The dependent variable is whether females have a NCD. Women who reported having less than 5 servings per day were set as the reference group. As can be seen from table 4.1.2.2, the 95% confidence interval is from 0.86 to 0.94 for those who consumed more than 5 servings per day. The p-value less than 0.05 indicates that the odds ratios are statistically significant. Since women who had less than 5 servings of fruits and vegetables per day were the reference group, the odds ratio of 0.90 for those who consumed more than 5 servings indicates that the odds of having NCDs for the women who ate more fruits and vegetables per day over the odds of having NCDs for those who ate less is 0.90. In terms of percentage change, the odds for women who had more than 5 servings of fruits and vegetables having NCDs is 10% less than the odds for those who ate less fruits and vegetables per day. In other words, women who consumed more fruits and vegetables per day were less likely to have a NCD, which does not reject hypothesis 6.

Hypothesis 7: The relationship between physical activity and NCD

Previous studies on the relationship between physical activity and NCDs have found that

insufficient physical activity is the fourth leading risk factor for NCDs. Regular physical activity helps lower the risk of cardiovascular disease, depression, diabetes and cancer (World Health Organization 2009). Based on previous studies, hypothesis 7 proposes that those who are physically inactive are at increased risk of developing NCDs.

To test this hypothesis, a univariable logistic regression was carried out. Here the independent variable of the regression is a physical activity index, including being physically active, moderately active or physically inactive. The dependent variable is whether women have a NCD. Female who were physically active were set as the reference group. As can be seen from table 4.1.2.2, the 95% confidence interval is from 1.32 to 1.51 for women who were moderately active and from 2.16 to 2.43 for those who were physically inactive. The p-values are 0.00 for both two groups, which are both less than 0.05. Because the p value is less than alpha, and the confidence intervals do not include 0, these results of the odds ratio are statistically significant. The results indicates that the odds for women who were moderately active having a NCD is 41% more than the odds for those who were physically active. The odds for women who were physically inactive almost double those who were physically active. In conclusion, women who were physically active were the least likely to have a NCD, while those who were physically inactive had the highest risk of getting NCDs. These results do not reject hypothesis 7.

Hypothesis 8: The relationship between smoking and NCD

Smoking is one of the most important risk factors for non-communicable diseases. Previous studies have found that smokers have a higher risk of developing non-communicable diseases than non-smokers, including heart disease, stroke and lung cancer (U.S. Department of Health and Human Services 2010). Thus in hypothesis 8 it is proposed that daily smokers were more likely to have NCDs than non-smokers and occasional smokers. Since the effect of smoking may take a long time to appear, in hypothesis 8 it is also proposed that former daily smoker were the most likely group to have a NCD.

To test this hypothesis, a univariable logistic regression for smoking and NCD was conducted. Here, the independent variable is the type of smoker, including current daily

smoker, occasional smoker, always an occasional smoker, former daily smoker, former occasional smoker and women who never smoked. The dependent variable is whether females have a NCD. Daily female smokers were set as the reference group. As can be seen from table 4.1.2.2, the 95% confidence interval for these different coefficients does not include 0 and the *p*-values are all less than 0.05. Thus, the differences are significant. Since daily female smokers are the reference group, the odds ratio of 1.50 for former female daily smokers indicates that the odds of having a NCD for females who were former daily smokers over the odds of having a NCD for those who were current daily smokers is 1.50. In terms of percentage change, it can be concluded that the odds for former daily smokers having a NCD is 50% more than the odds for those who are current daily smokers. This result supports our hypothesis that former daily smokers were more likely to have a NCD than current daily smokers because the smoking behavior needs time to affect health conditions. Compared to female daily smokers, the odds ratio of having a NCD for occasional smokers and non-smokers are smaller than 1, which indicates that occasional smokers and non-smokers were both less likely to have a NCD than daily smokers. It supports the hypothesis that daily smokers were more likely to have NCD than non-smokers and occasional smokers.

Hypothesis 9: The relationship between excessive alcohol consumption and NCD

Previous literature studying the correlation between excessive alcohol consumption and NCDs have reported that excessive alcohol consumption is strongly associated with cancer, cardiovascular diseases, liver disease and mental disorders. For example, researchers have found that excessive alcohol consumption is related to the development of many non-communicable diseases. With an increase in the consumption of alcohol, the risk of getting cancer also increases (Rehm et al. 2009; Parry et al. 2011). Thus, it is proposed in hypothesis 9 that women who consumed more alcohol have higher risks for NCDs than those who consumed less.

To test this hypothesis, a univariable logistic regression was conducted with the independent variable being the type of drinker and dependent variable being whether female respondent had a NCD. Regular female drinkers were set as the reference group. As

can be seen from table 4.1.2.2, the 95% confidence interval is from 1.45 to 1.62 for occasional female drinkers and from 1.63 to 1.81 for those who did not drink in the past 12 months. The *p*-values are 0.00 for both two groups, which are both less than 0.05, indicating the odds ratios for different alcohol consumption groups statistically significant. Because a regular drinker was set as the reference group, the odds ratio of 1.53 for the occasional drinker indicates that the odds of having a NCD for the occasional drinker over the odds of having a NCD for a regular drinker is 1.53. Similarly, when comparing women who did not drink in the past 12 months with a regular drinker, the odds ratio of 1.70 shows that the odds for women who did not drink having NCDs are 70% more than the odds for regular drinkers. The result rejects the hypothesis. The possible explanation for this result is that the survey question in CCHS 2010 only asked questions such as whether people drank in the past 12 months, frequency of drinking alcohol. Detailed information about how much people drank, what kind of alcohol they drank, and whether they participated in drinking activities such as binge drinking could not be seen in CCHS 2010. If someone didn't drink in 2010 but was a heavy drinker before 2010, she could have a higher odds of having a NCD.

Hypothesis 10: The relationship between BMI and NCD

A high BMI has been considered as an important risk factor for NCDs. Overweight adults are at an increased risk of developing numerous NCDs. Excess weight and obesity are risk factors for cardiovascular disease, certain cancers, diabetes, and mortality (Huang et al. 1997; Shoff and Newcomb 1998; Colditz et al. 1990; Manson et al. 1995; Willett et al. 1999; Boyan et al. 2012). Excess weight also leads to many other NCDs, such as hypertension and osteoarthritis (Boyan et al. 2012; Carman et al. 1994). Epidemiologists have conducted cohort studies to investigate the relationship between BMI and NCDs. For example, during a 10-year cohort study, the incidence of diabetes, gallstones, hypertension, heart disease, colon cancer increased as the weight for both men and women increased (Field et al. 2001). Thus, it is hypothsised that overweight and obese women were more likely to have NCDs than the women with normal weight.

Table 4.1.2.2. Univariable Logistic Regression model for Behavioral Risk Factors and NCDs (Female)

Behavioral Risk Factors	Odds Ratio	Std. Err	z	P>|z|	[95% Conf. Interval]	
Fruit and vegetable consumption						
Less than 5 times servings per day	1.00	--	--	--	--	--
More than 5 times servings per day	0.90	0.02	-4.65	0.00	0.86	0.94
Physical activity						
Active	1.00	--	--	--	--	--
Moderately active	1.41	0.47	10.23	0.00	1.32	1.51
Inactive	2.29	0.67	28.24	0.00	2.16	2.43
Smoking						
Daily smoker	1.00	--	--	--	--	--
Occasional smoker	0.77	0.06	-3.32	0.00	0.66	0.90
Always an occasional smoker	0.44	0.05	-7.24	0.00	0.35	0.55
Former daily smoker	1.50	0.06	11.06	0.00	1.40	1.61
Former occasional smoker	0.91	0.04	-2.22	0.03	0.84	0.99
Never smoked	0.86	0.03	-4.49	0.00	0.80	0.92
Alcohol drinking						
Regular drinker	1.00	--	--	--	--	--
Occasional drinker	1.53	0.04	14.66	0.00	1.45	1.62
Did not drink in the last 12 months	1.72	0.05	20.47	0.00	1.63	1.81
BMI						
Underweight	0.99	0.07	-0.02	0.98	0.86	1.16
Normal weight	1.00	--	--	--	--	--
Overweight	2.02	0.06	24.78	0.00	1.91	2.14
Obese	3.21	0.01	35.91	0.00	3.01	3.42

To test this hypothesis, a univariable logistic regression was conducted with the independent variable being the BMI index and the dependent variable being whether women have a NCD. Women who had normal weight were considered as the reference group. The *p* value of the underweight group is 0.981, much larger than 0.05. Thus the result for the underweight group is not significant. Compared to women who had normal weight, the odds of having NCDs for those who were overweight and obese are more than double that for women with normal weight. Obese women were even more likely to have

NCDs than the overweight women because the odds ratio for obese women is 3.21. Hypothesis 10 cannot be rejected, which indicates that overweight and obese women are more likely to have NCDs than women with normal weight.

4.1.3 Multivariable logistic regression for female

Table 4.1.3 presents the multivariable logistic regression model of social determinants of health and behavioral risk factors for NCD based on CCHS 2010 data. Only the significant results will be presented here.

As can be seen from table 4.1.3, the significant independent variables include age, personal income, work stress, smoking and BMI. As age increases, the odds of having a NCD also increases. As personal income increases, women were less likely to have a NCD. Compared to those who were extremely stressed, those who had less stress had less risk of NCDs. Compared to women who never smoked, daily female smoker experienced a 16% increase in the odds of having a NCD. Overweight and obese women were much more likely to experience NCDs compared to those with normal weight.

Table 4.1.3. Multivariable Logistic Regression Model of Independent Risk Factors for NCDs (Female)

Risk Factors	Odds Ratio	Std. Err	z	P>|z|	[95% Conf. Interval]	
Age						
12-24	1.00	--	--	--	--	--
40-54	1.80	0.17	6.29	0.00	1.50	2.16
55-69	4.22	0.41	14.90	0.00	3.49	5.10
Over 70	7.33	1.53	9.54	0.00	4.87	11.03
Personal income						
Less than $40,000	1.00	--	--	--	--	--
$40,000-$79,999	0.87	0.04	-2.79	0.01	0.79	0.96
$80,000 or more	0.77	0.06	-3.17	0.00	0.66	0.91
Work stress						
No stress at all	0.71	0.08	-3.20	0.00	0.57	0.87
Not very stressful	0.72	0.07	-3.36	0.00	0.60	0.87
A bit stressful	0.65	0.06	-4.85	0.00	0.55	0.77
Extremely stressful	1.00	--	--	--	--	--
Smoking						
Daily smoker	1.16	0.07	2.32	0.02	1.02	1.31
Never smoked	1.00	--	--	--	--	--
BMI						
Normal weight	1.00	--	--	--	--	--
Overweight	1.66	0.08	10.03	0.00	1.50	1.83
Obese	3.04	0.16	20.54	0.00	2.73	3.38

4.2 MALE

4.2.1 Descriptive analysis: characteristics of the study population

Similar to the analysis for female survey respondents, in this section, the general characteristics of the male respondents and the association between risk factors and social determinants of health with NCDs will be summarized and discussed. The prevalence of the four main types of NCD in the male population will then be presented.

Table 4.2.1.1 also includes two parts. The first part summarizes the general characteristics of the male participants in the survey, which could be seen in the two columns in the center of the table. Overall, there were 28,546 males aged 12 years or older participating

in the 2010 Canadian Community Health Survey. 56.27% of the male participants finished some post-secondary education or were post-secondary graduates, while the other 40.43% had less than a completed secondary school education or were secondary school graduates. Approximately 43.90% of the male participants were married. But different from female participants, the proportion of males who were single was larger than that for females, 34.37% and 25.81%, respectively. The percentage of males who were widowed/separated/divorced was smaller than that of females, 13.20% and 25.48% respectively. In terms of work stress, only 7.23% of the male participants stated that they had no stress at all and 2.76% of the males were extremely stressed. Most males also reported feeling some work stress, but of different levels.

The second part of table 4.2.1.1 summarizes the association between the social determinants of health and NCDs for the male participants. The proportions of males having these four NCDs based on different socio-economic groups were summarized. In total, 64.80% of the male participants did not have a NCD, while 35.20% had at least one of the four NCDs. As age increases, the percentage of males having at least one NCD also increases. For males between 12 to 24 years of age 13.54% had a NCD. Whereas 70.21% of the males in the oldest age group, i.e. over 70 years of age, had at least one NCD. In terms of education, in the lower education group, 43.49% of the male participants had a NCD, while in the higher education group, only 33.58% had a NCD, which is also similar to the situation for female participants. When considering income, it is appears that as income increases, the proportion of males having NCDs decreases. 40.60% of the male in the lowest personal income group; i.e. less than $40,000, had a NCD, while only 28.62% of those in the highest income group, i.e. $80,000 or more, had a NCD. For marital status, males who were widowed/separated/divorced also had the largest proportion of a NCD (50.69%), while for those who were married, common-law or single, the proportion was much smaller. When referring to work stress, it is apparent that 33.38% of the men who were extremely stressed had a NCD, while for those who had less stress the proportion was also smaller.

Table 4.2.1.1. Descriptive Summary and Association between Social Determinants of Health and NCDs (Male)

Social Determinants of Health	Sample		NCD	
	Population	Percentage	Yes	No
Total	28,546	100%	10,046(35.20%)	18,500(64.80%)
Age (years)				
12-24	5,519	19.33%	747(13.54%)	4.772 (86.46%)
25-39	5,445	19.07%	728(13.37%)	4,717 (86.63%)
40-54	6,185	21.67%	1,712(27.68%)	4,473(72.32%)
55-69	6,979	24.45%	3,713(53.20%)	3,266(46.80%)
>70	4,418	15.48%	3,146(70.21%)	1,272(29.79%)
Education				
Less than secondary school or secondary school graduation	11,541	40.43%	4,318(43.49%)	7,223 (56.51%)
Some post-secondary or post-secondary graduation	16,062	56.27%	5,394(33.58%)	10,668(66.42%)
Personal Income				
Less than $40,000	11,352	50.97%	4,610(40.60%)	6,742(59.4%)
$40,000-$79,999	7,522	33.78%	2,558(34.01%)	4,964(65.99%)
$80,000 or more	3,396	15.25%	972(28.62%)	2,424(71.38%)
Marital Status				
Married	12,532	43.90%	5,492(43.82%)	7,040(56.18%)
Common-law	2,383	8.35%	644(27.02%)	1,739(72.98%)
Widowed/separated/divorced	3,772	13.20%	1,912(50.69%)	1,860(49.31%)
Single	9,810	34.37%	1,979(20.17%)	7,831(79.83%)
Work stress				
No stress at all	2,065	7.23%	543(26.30%)	1,522 (73.70%)
Not very stressful	3,719	13.03%	862(23.18%)	2,857(76.82%)
A bit stressful	7,567	26.51%	1,831(24.20%)	5,736(75.80%)
Quite a bit stressful	3,799	13.31%	1,049(27.61%)	2,750(72.39%)
Extremely stressful	788	2.76%	263(33.38%)	525(66.62%)

Table 4.2.1.2 has two parts. The first part summarizes the behavioral risk factors for men in the study, which can be seen in the two columns in the center of the table. Among the 28,546 male respondents, a greater number of males had less than 5 servings of fruits and vegetables per day as compared to those who had more than 5 servings per day, with the proportions being 60.59% and 32.40%, respectively. The difference was larger than that

for the female group. In terms of physical activity, men who were physically inactive also made up the largest proportion. But the situation is a bit different for males as compared to females. Approximately half of the female participants were physically inactive, while only 41.73% of the male population was inactive. With respect to smoking, the proportion of men who never smoked was also the largest (33.04%). But this proportion was smaller than that for females (43.47%). Current smokers, whether daily or occasionally, made up only 20% of the whole male group. But former smokers accounted for approximately 40% of the whole male population, 28.22% for former daily smoker and 14.59% for former occasional smokers. For alcohol consumption, most of the men in the study drank alcohol in the last 12 months, with 64.97% being regular drinkers and 12.36% being an occasional drinker. For the body mass index, 31.71% of the male participants had a normal weight. More than half of men were overweight or obese. Only 0.86% of male participants were underweight.

The second part of table 4.2.1.2 summarizes the association between behavioral risk factors and NCDs for the male participants. As can be seen from the two columns on the right hand side of table 4.2.1.2, the proportion of men who had more than 5 servings of fruits and vegetables per day having NCDs was slightly smaller than those who had less than 5 servings, 32.31% and 35.49%, respectively.

Concerning physical activity, males who were physically inactive had the largest proportion of NCD (41.12%), compared to those who were moderately active (34.56%) or active (26.19%). With respect to smoking, former daily smokers in the male population also had the largest proportion of those having a NCD (52.31%), while the proportion was smaller for current daily smokers (32.27%), current occasional smokers (27.15%), and former occasional smokers (31.57%). Men who never smoked had

Table 4.2.1.2. Descriptive Summary and Association between Behavioral Risk Factors and NCDs (Male)

Behavioral Risk Factors	Sample		NCD	
	Population	Percentage	Yes	No
Total	28,546	100%	10,046(35.20%)	18,500(64.80%)
Fruit and vegetable consumption				
Less than 5 times servings per day	17,296	60.59%	6,138(35.49%)	11,158(64.51%)
More than 5 times servings per day	9,248	32.40%	2,988(32.31%)	6,260(67.69%)
Physical activity				
Active	8,865	31.06%	2,322(26.19%)	6,543(73.81%)
Moderately active	6,733	23.59%	2,327(34.56%)	4,406(65.44%)
Inactive	11,913	41.73%	4,899(41.12%)	7,014(58.88%)
Smoking				
Daily smoker	5,293	18.54%	1,708(32.27%)	3,585(67.73%)
Occasional smoker	825	2.89%	224(27.15%)	601(72.85%)
Always an occasional smoker	619	2.17%	93(15.02%)	526 (84.98%)
Former daily smoker	8,057	28.22%	4,215(52.31%)	3,842(47.69%)
Former occasional smoker	4,166	14.59%	1,315(31.57%)	2,851(68.43%)
Never smoked	9,432	33.04%	2,419(25.65%)	7,013(74.35%)
Alcohol drinking				
Regular drinker	18,545	64.97%	6,199(33.43%)	12,346(66.57%)
Occasional drinker	3,529	12.36%	1,351(38.38%)	2,178(61.72%)
Did not drink in the last 12 months	6,051	21.20%	2,329(38.49%)	3,722(61.51%)
BMI				
Underweight	246	0.86%	64(26.02%)	182 (73.98%)
Normal weight	9,059	31.71%	2,579(28.47%)	6,480(71.53%)
Overweight	10,103	35.39%	3,735(36.97%)	6,368(63.03%)
Obese	5,351	18.75%	2,757(51.52%)	2,594(48.48%)

the least likelihood of getting a NCD (25.65%). For alcohol consumption, the difference of getting a NCD among the three groups was not very significant. 33.43% of the regular drinkers had a NCD, while 38.38% and 38.49% of occasional drinkers and those who did not drink in the last 12 months had a NCD. In terms of body mass index, obese males also had the greatest proportion of a NCD (51.52%), while only 26.02% of those who had normal weight had a NCD.

Table 4.2.1.3 summarizes the prevalence of the four types of NCDs in the male population. Among the male participants, 64.83% had none of the four NCDs. 25.65% of them had one NCD, 8.13% had two NCDs, and 1.33% had

Table 4.2.1.3. Prevalence of NCDs (Male)

Number of NCDs	NCDs	Count	Sum	Percentage
4 NCDs	All the 4 NCDs	18	18	0.06%
3 NCDs	Chronic respiratory disease &cardiovascular disease &cancer	52	378	1.33%
	Chronic respiratory disease &cardiovascular disease &diabetes	220		
	Chronic respiratory disease &cancer& diabetes	8		
	Cardiovascular disease & cancer &diabetes	98		
2 NCDs	Chronic respiratory disease &cardiovascular disease	592	2,318	8.13%
	Chronic respiratory disease &cancer	41		
	Chronic respiratory disease & diabetes	81		
	Cardiovascular disease &cancer	246		
	Cardiovascular disease & diabetes	1,318		
	Cancer & diabetes	40		
1 NCD	Chronic respiratory disease	1,818	7,310	25.65%
	Cardiovascular disease	4,472		
	Cancer	266		
	Diabetes	754		
0 NCD	None of the 4	18,476	18,476	64.83%
Total		28,500	28,500	100%

three NCDs together, while 0.06% had all four NCDs. Similar to female participants, among those males who had only one NCD, cardiovascular disease was the most common disease, followed by chronic respiratory diseases. Among the men who had two NCDs, the most prevalent combinations were chronic respiratory disease and cardiovascular disease, as well as cardiovascular disease and diabetes. For those who had three diseases together, most of them had chronic respiratory disease, cardiovascular disease and diabetes. Among the men, 18 individuals had 4 NCDs at the same time.

4.2.2 Univariable logistic regression for male

In this section, the results of the univariable logistic regression analysis for males are discussed. Similar to the analysis of female participants, specific behavioral risk factors and social determinants of health will also be considered individually in order to obtain detailed information about the relationships between these factors with NCDs. For each factor, the hypothesis generated will be based on previous research and then tested with univariable logistic regressions.

4.2.2.1 Social determinants of health and NCDs for male

Table 4.2.2.1 summarizes the regression results for all the social determinants of health, including odds ratio, standard error, z value and *p* value, as well as 95% confidence interval for male. The coefficient is tested for statistical significance by comparing the *p*-value to 0.05. The relationship between the individual social determinants of health and NCDs can be determined by checking the odds ratio. Following these steps, the results in table 4.2.2.1 will be analyzed based on different hypotheses.

Hypothesis 11: The relationship between age and NCD

Hypothesis 11 proposes that as age increases, the risk for NCDs also increases for men.

To test this hypothesis, a univariable logistic regression was carried out. Here the independent variable is age, while the dependent variable is whether men have a NCD. As can be seen from table 4.2.2.1, the p values for men in the 40 to 54, 55 to 69 and over 70 years age groups are smaller than 0.05. However, the p value for the men in the 25 to 39 year age group is above the 0.05 p value; i.e. 0.80. This indicates that the difference between the 12-24 and 25-39 age groups is not statistically significant. But for the other age groups, the results are statistically significant. Men aged 12-24 years of age were set as the reference group, the odds ratio for the older age groups are larger than 1 indicating that the odds for older age groups having NCDs is more than the odds for the younger age group. As age increases, the odds of having a NCD for men also increases. This result

supports the hypothesis that as age increases, the risk for NCDs for men also increases.

Hypothesis 12: The relationship between education and NCDs

Hypothesis 12 proposes that men with higher education levels are less likely to have a NCD.

To test this hypothesis, a univariable logistic regression was carried out. Here the independent variable is education level, while the dependent variable is whether men have a NCD. As can be seen from table 4.2.2.1, the 95% confidence interval is from 0.80 to 0.89. The p-value is 0.00, which is less than 0.05. Because the p value is less than alpha, and the confidence interval does not include 0, the result of the odds ratio is statistically significant. Setting men who had less than a completed secondary education or were secondary school graduates as a reference group, the odds ratio of 0.85 for the higher education group indicates that the odds of having a NCD for the higher education group over the odds of having a NCD for the lower education group is 0.85. In terms of percentage change, the odds for males with higher education levels having NCDs is 15% less than the odds for the lower education group. Thus, males in the higher education group were less likely to have a NCD, therefore hypothesis 12 is not rejected.

Hypothesis 13: The relationship between income and NCDs

Hypothesis 13 also proposes that males with higher personal income are at decreased risk of experiencing NCDs.

To test this hypothesis, univariable logistic regression was carried out. Here the independent variable of the regression is personal income, while the dependent variable is whether men have NCDs. As can be seen from table 4.2.2.1, the 95% confidence interval is from 0.71 to 0.80 for the middle-income group; i.e. $40,000 to $80,000, and from 0.54 to 0.64 for the high-income group; i.e. $80,000 or more. The *p*-values are 0.00 for both middle and high-income groups, which are both less than 0.05, indicating that the odds ratios for these income groups are statistically significant. Setting men in the lowest income group; i.e. less than $40,000, as the reference group, the odds ratio of 0.75 for the middle income

group indicates that the odds of having a NCD in the middle income group over the odds of having a NCD in the low income group is 0.75. In terms of percentage change, the odds for middle income males having a NCD is 25% less than the odds for males in the low-income group. Similarly, when comparing the low income group with the high income group, the odds ratio of 0.59 shows that the odds for males in the high income group having a NCD is 41% less than the odds for males in the low income group. In conclusion, males in the high-income group were the least likely to have NCDs. As income increases, the risk of getting a NCD decreases, therefore hypothesis 13 is not rejected.

Hypothesis 14: The relationship between marital status and NCDs

Hypothesis 14 states that married men were less likely to have NCDs than those with other marital statuses.

To test this hypothesis, a univariable logistic regression was carried out. Here the independent variable of the regression is marital status, while the dependent variable is whether men have NCDs. As could be seen from table 4.2.2.1, the 95% confidence intervals does not include 0. The p-values are 0.00 for all the marital status groups. Thus, the results of the odds ratio are statistically significant. Setting married men as a reference group, the odds ratio of 1.32 for the men who were widowed/separated/divorced indicates that the odds for men who were widowed/separated/divorced have an increase in 32% higher than the odds for married men. This result suggests the original hypothesis. However, compared to married men, the odds of having NCDs for those who were in a common-law relationship or single are both smaller than the odds for married men, which is contradictory to our hypothesis. Thus, for these two marital status, the hypothesis is rejected.

Hypothesis 15: The relationship between work stress and NCDs

Hypothesis 15 proposes that men with higher work stress experience higher risk for NCDs.

To test this hypothesis, a univariable logistic regression for work stress and NCD was carried out. Here the independent variable is work stress and the dependent variable is

whether males have a NCD. Men who reported extreme stress during their work were set as the reference group. As can be seen from table 4.2.2.1, the 95% confidence interval is from 0.60 to 0.85 for those who had no stress at all, from 0.51 to 0.71 for those who were not very stressed, from 0.54 to 0.75 for those who were a bit stressed, 0.65 to 0.90 for those who were quite a bit stressed. The p-values are 0.00 for all these groups. Because the p values are less than alpha, and the confidence intervals do not include 0, the odds ratios for these stress levels are statistically significant. Since men who were extremely stressed at work were the reference group, the odds ratio of 0.71 for those who had no stress at all indicates that the odds of having NCDs for men who were extremely stressed over the odds of having NCDs for those who had no stress at all is 0.71. In terms of percentage change, the odds for men who had extreme work stress having NCDs is 29% more than the odds for those who didn't have work stress. Similarly, when comparing other groups with the extremely stressed group, the odds ratio smaller than 1 indicates that the odds of men extremely stressed having NCDs is the highest. In other words, men who were extremely stressed at work had the highest risk for NCD, thus hypothesis 15 is not rejected.

Table 4.2.2.1. Univariable Logistic Regression model for Social Determinants of Health and NCDs (Male)

Social Determinants of Health	Odds Ratio	Std. Err	z	P>|z|	[95% Conf. Interval]	
Age (years)						
12-24	1.00	--	--	--	--	--
25-39	0.99	0.06	-0.25	0.80	0.88	1.10
40-54	2.45	0.12	18.42	0.00	2.22	2.69
55-69	7.26	0.33	43.02	0.00	6.64	7.95
>70	15.80	0.81	53.59	0.00	14.28	17.48
Education						
Less than secondary school or secondary school graduation	1.00	--	--	--	--	--
Some post-secondary or post-secondary graduation	0.85	0.02	-6.57	0.00	0.80	0.89
Income						
Less than $39,999	1.00	--	--	--	--	--
$40,000-$80,000	0.75	0.02	-9.14	0.00	0.71	0.80
$80,000 or more	0.59	0.02	-12.56	0.00	0.54	0.64
Marital Status						
Married	1.00	--	--	--	--	--
Common-law	0.47	0.02	-15.05	0.00	0.44	0.52
Widowed/separated/divorced	1.32	0.05	7.41	0.00	1.23	1.42
Single	0.32	0.01	-36.43	0.00	0.30	0.34
Work stress						
No stress at all	0.71	0.06	-3.75	0.00	0.60	0.85
Not very stressful	0.60	0.05	-5.97	0.00	0.51	0.71
A bit stressful	0.64	0.05	-5.62	0.00	0.54	0.75
Quite a bit stressful	0.76	0.06	-3.25	0.00	0.65	0.90
Extremely stressful	1.00	--	--	--	--	--

4.2.2.2 Behavioral risk factors and NCDs for male

Table 4.2.2.2 summarizes the regression results for the behavioral risk factors for men. This part of the analysis is also separated according to different hypothesis.

Hypothesis 16: The relationship between fruit & vegetable consumption and NCDs

Hypothesis 16 states that men who consume more fruits and vegetables per day have less risk of NCDs.

To test this hypothesis, a univariable logistic regression for fruit and vegetable consumption and NCD was carried out. Here the independent variable is the frequency of fruit and vegetable consumption for males. The dependent variable is whether men have a NCD. Men who reported having less than 5 servings per day were set as the reference group. As can be seen in table 4.2.2.2, the 95% confidence interval is from 0.82 to 0.92 for those who consumed more than 5 servings per day, the p-value is 0.00, which results in an odds ratio that is statistically significant. Since men who had less than 5 servings of fruits and vegetables per day was the reference group, the odds ratio of 0.87 for those who consumed more than 5 servings indicates that the odds of having a NCD for men who ate more fruits and vegetables per day over the odds of having a NCD for those who ate less is 0.87. In terms of percentage change, the results show that the odds for men who had more than 5 servings of fruits and vegetables having a NCD is 13% less than the odds for those who ate less fruits and vegetables per day. In other words, men who consumed more fruits and vegetables per day were less likely to have a NCD, which supports hypothesis 16.

Hypothesis 17: The relationship between physical activity and NCDs

Hypothesis 17 proposes that men who have more exercise were less likely to have a NCD.

To test this hypothesis, a univariable logistic regression was carried out. Here the independent variable of the regression is a physical activity index, including physically active, moderately active and physically inactive. The dependent variable is whether men have a NCD. Men who were physically active were set as the reference group. As can be seen from table 4.2.2.2, the 95% confidence interval is from 1.39 to 1.59 for men who were moderately active and from 1.85 to 2.09 for those who were physically inactive. The p-values are 0.00 for both two groups, which are both less than 0.05, and then the odds ratios are statistically significant. The results indicates that the odds for men who were moderately active having a NCD is 49% more than the odds for those who were physically active. The odds for men who were physically inactive almost double those who were physically active. In conclusion, men who were physically active were the least likely to have a NCD, while those who were physically inactive had the highest risk of getting a NCD. Given these results, hypothesis 17 is not rejected.

Hypothesis 18: The relationship between smoking and NCDs

Hypothesis 18 states that men who were daily smokers were more likely to have a NCD than non-smokers and occasional smokers. Former daily smoker were the most likely to have a NCD.

To test this hypothesis, a univariable logistic regression for smoking and NCD was conducted. Here the independent variable is the type of smoker, including current daily smoker, occasional smoker, always an occasional smoker, former daily smoker, former occasional smoker and men who never smoked. The dependent variable is whether men have a NCD. Daily male smokers were set as the reference group. As can be seen from table 4.2.2.2, the 95% confidence intervals for these different coefficients do not include 0 and the p-values are all less than 0.05 and thus the results are statistically significant. Since daily male smokers are the reference group, the odds ratio of 2.30 for former male daily smokers indicates that the odds of having a NCD for males who were former daily smokers over the odds of having NCD for those who were current daily smokers is 2.30. In terms of percentage change, the odds for former daily smokers having a NCD was more than double for those who were current daily smokers. This result also supports our hypothesis that former daily smokers were more likely to have a NCD than current daily smokers. Besides, compared to male daily smokers, the odds ratio of having a NCD for occasional smokers and non-smokers are smaller than 1, which indicates that occasional smokers and non-smokers were both less likely to have a NCD than daily smokers. These results support the hypothesis that daily smokers were more likely to have a NCD than non-smokers and occasional smokers.

Hypothesis 19: The relationship between excessive alcohol consumption drinking and NCDs

Hypothesis 19 also states that men who consumed increased levels of alcohol have higher risk of NCD.

To test this hypothesis, a univariable logistic regression was conducted with the independent variable being type of drinker and the dependent variable being whether men have a NCD. Regular male drinkers were set as the reference group. As can be seen from table 4.2.2.2, the 95% confidence interval is from 1.15 to 1.33 for occasional male drinkers and from 1.17 to 1.32 for those who did not drink in the past 12 months. The *p*-values are 0.00 for both groups, which are both less than 0.05, and therefore the odds ratio are statistically significant. Because regular drinkers were set as the reference group, the odds ratio of 1.24 for the occasional drinker indicates that the odds of having a NCD for the occasional drinker over the odds of having a NCD for the regular drinker is 1.24. Similarly, when comparing men who did not drink in the past 12 months with regular drinkers, the odds ratio of 1.24 shows that the odds for men who did not drink having NCDs is 24% more than the odds for regular drinkers. These results are also contradictory with our hypothesis and thus hypothesis 19 is rejected. CCHS 2010 only asked questions such as whether people drank in the past 12 months and frequency of drinking alcohol. Detailed information about how people drank, what kind of alcohol they drank, and whether they participated in drinking activities such as binge drinking were not included in the CCHS 2010 survey. If someone didn't drink in 2010 but was a heavy drinker before 2010, he could still have a high probability of having a NCD.

Hypothesis 20: The relationship between BMI and NCD

Hypothesis 20 states that overweight and obese men are more likely to have a NCD than those with normal weight.

To test this hypothesis, a univariable logistic regression was conducted with the independent variable being the BMI index and the dependent variable being whether men have a NCD. Men who had normal weight were considered as the reference group. The *p* value of the underweight group is 0.40, which is much larger than 0.05.

Table 4.2.2.2. Univariable Logistic Regression model for Behavioral Risk Factors and NCDs (Male)

Behavioral Risk Factors	Odds Ratio	Std. Err	z	P>|z|	[95% Conf. Interval]	
Fruit and vegetable consumption						
Less than 5 times servings per day	1.00	--	--	--	--	--
More than 5 times servings per day	0.87	0.02	-5.19	0.00	0.82	0.92
Physical activity						
Active	1.00	--	--	--	--	--
Moderately active	1.49	0.05	11.29	0.00	1.39	1.59
Inactive	1.97	0.06	22.20	0.00	1.85	2.09
Smoking						
Daily smoker	1.00	--	--	--	--	--
Occasional smoker	0.78	0.07	-2.94	0.00	0.66	0.92
Always an occasional smoker	0.37	0.04	-8.53	0.00	0.30	0.47
Former daily smoker	2.30	0.08	22.60	0.00	2.14	2.48
Former occasional smoker	0.97	0.04	-0.73	0.47	0.89	1.06
Never smoked	0.72	0.03	-8.57	0.00	0.67	0.78
Alcohol drinking						
Regular drinker	1.00	--	--	--	--	--
Occasional drinker	1.24	0.05	5.57	0.00	1.15	1.33
Did not drink in the last 12 months	1.25	0.04	7.18	0.00	1.17	1.32
BMI						
Underweight	0.88	0.13	-0.84	0.40	0.66	1.18
Normal weight	1.00	--	--	--	--	--
Overweight	1.47	0.05	12.47	0.00	1.39	1.57
Obese	2.67	0.96	27.35	0.00	2.49	2.87

Thus the result for the underweight group is not statistically significant, which is similar to the result for females. The odds of having a NCD for overweight men is 47% more than the odds of those who were normal weight. The odds for the obese men were more than double those with a normal weight. This indicates that obese men were even more likely to have a NCD than overweight men. These results could support hypothesis 20, which indicates that overweight and obese men are more likely to have NCDs than men with normal weight.

4.2.3 Multivariable logistic regression for male

Table 4.2.3 presents the multivariable logistic regression model of social determinants of health and behavioral risk factors for NCDs for males. The significant independent variables here include age, education, income, work stress, smoking and BMI.

Table 4.2.3. Multivariable Logistic Regression Model of Independent Risk Factors for NCDs (Male)

Risk Factors	Odds Ratio	Std. Err	z	P>|z|	[95% Conf. Interval]	
Age						
12-24	1.00	--	--	--	--	--
40-54	2.07	0.20	7.43	0.00	1.71	2.51
55-69	5.25	0.53	16.38	0.00	4.32	6.40
Over 70	11.54	1.95	14.48	0.00	8.29	16.07
Education						
Less than secondary school or secondary school graduation	1.00	--	--	--	--	--
Some post-secondary or post-secondary graduation	0.90	0.04	-2.26	0.02	0.82	0.99
Personal income						
Less than $40,000	1.00	--	--	--	--	--
$40,000-$79,999	0.83	0.06	-2.59	0.01	0.72	0.96
$80,000 or more	0.70	0.06	-4.50	0.00	0.60	0.82
Work stress						
No stress at all	0.60	0.07	-4.35	0.00	0.49	0.76
Not very stressful	0.60	0.06	-4.80	0.00	0.50	0.74
Quite a bit stressful	0.63	0.08	-2.91	0.00	0.61	0.91
Extremely stressful	1.00	--	--	--	--	--
Smoking						
Former daily smoker	1.29	0.07	4.41	0.00	1.15	1.44
Never smoked	1.00	--	--	--	--	--
BMI						
Normal weight	1.00	--	--	--	--	--
Overweight	1.42	0.07	6.88	0.00	1.29	1.57
Obese	3.02	0.17	19.61	0.00	2.71	3.38

As age increases, the odds of having NCDs also increases. Men with higher education level were less likely to have NCDs than those with lower education. As income increases, men were less likely to have a NCD. Former daily smokers were more likely to have a NCD. Compared to those who were extremely stressed, those who had less stress had less risk of NCD. Overweight and obese men were much more likely to experience NCD compared to those with normal weight.

4.3 Comparison between male and female

Both genders had a lot in common, as indicated by the results, but there are also some differences. These differences can be seen in the descriptive statistics, univariable and multivariable logistic regression results for the two genders.

First, in terms of descriptive statistics, men and women differ in personal income, marital status, physical activity and smoking. The proportion of women in the lowest income group, i.e. less than $40,000, is 71.23%, while only half of men were in this group. As for marital status, the proportion of males who were single is larger than that of female, 34.37% and 25.81% respectively. On the contrary, the percentage of males who were widowed/separated/divorced is smaller than that of females, 13.20% and 25.48%, respectively. Men were more physically active than women. Men who were physically inactive made up approximately 42% of the largest proportion of males. Approximately 47% of the female participants were physically inactive. Men smoked more than women. Among the male respondents, those who never smoked made up 33.04% of all male participants, whereas for women the proportion was larger, at 43.47%.

With respect to the univariable logistic regressions, the differences between both genders could also be seen in the results for education, income and marital status. Compared to less educated women, the odds of having NCDs for women in the higher education group is 39% lower, but for men, the difference is not so evident. The odds of having NCDs for men in the high education group is 16% less than the odds for those in the low education group. For income, the differences among different income groups are also larger for women than for men. The odds for middle income males having a NCD is 25% less than the odds for

males in the low-income group. But the comparable difference for women is 41%. The odds for high income males having NCDs is 41% less than that for men in the low income group, while the difference for females is 52%. When comparing the effect of marital status on NCDs for both genders, it is also worth noting that widowed women were more likely to have a NCD. The odds of having a NCD for widowed/ separated/ divorced women double that for married women, while the difference for men is only 32%.

From the multivariable logistic regressions, the most obvious difference between the genders is with physical activity. For men physical activity is a statistically significant indicator whereas for women it is statistically insignificant.

4.4 Clustering effects among risk factors

4.4.1 Risk factor prevalence for both genders

Table 4.4.1 indicates that among females, only 4.16% don't have any risk factors. But this proportion is larger than that for males (2.41%). 29.56% of the males have 4 risk factors, but only 13.69% of females have 4 risk factors. For females, 29.54% have 3 risk factors, while 33.14% have 2 risk factors.

Table 4.4.1. Prevalence of Risk Factors

Number of risk factors	Risk factors	Female			Male		
		Counts	Sum	Percentage	Counts	Sum	Percentage
4	Smoking &drinking &physical inactive &less F&V consumption	4,408	4,408	13.69%	7,691	7,691	29.56%
3	Smoking &physical inactive &less F&V consumption	1,341	9,513	29.54%	1,428	9,068	34.85%
	Smoking &drinking &physical inactive	2,476			2,846		
	Smoking &drinking &less F&V consumption	3,613			2,474		
	Drinking &physical inactive &less F&V consumption	2,083			2,320		
2	Less F&V consumption &physical inactive	1,542	10,670	33.14%	1,008	6,127	23.55%
	Less F&V consumption &smoking	580			324		
	Less F&V consumption &drinking	1,903			1,146		
	Physical inactive &smoking	718			535		
	Physical inactive &drinking	1,567			1,171		
	Smoking &drinking	4,360			1,943		
1	Less F&V consumption	1,051	6,268	19.47%	575	2,509	9.64%
	Physical inactive	1,193			537		
	Smoking	618			248		
	Drinking	3,406			1,149		
0	None of the 4	1,341	1,341	4.16%	627	627	2.41%
		32,200	32,200	100%	26,022	26,022	100%

4.4.2 Clustering effects among risk factors

In this section, the significant results of the clustering effect for both genders will be examined. For women, the clustering effect between smoking and physical activity exists. As can be seen in table 4.4.2.1, the p value is less than 0.05 and thus the odds ratio is statistically significant for the clustering variable, i.e. physical activity and smoking. The results indicate that compared to women who were physically active and who have never smoked, those who were physically inactive and who were former daily smoker were more

likely to have a NCD. The latter group had a 29% increase chance of having a NCD.

Table 4.4.2.1. Multivariable Regression with Clustering Effect for Female

Risk factors	Odds Ratio	Std. Err	z	P>|z|	[95% Conf. Interval]	
Age (years)						
12-24	1.00	--	--	--	--	--
40-54	1.76	0.15	6.78	0.00	1.49	2.07
55-69	4.38	0.37	17.62	0.00	3.72	5.16
>70	10.19	0.92	25.83	0.00	8.55	12.16
Education						
Less than secondary school or secondary school graduation	1.00	--	--	--	--	--
Some post-secondary or post-secondary graduation	0.91	0.03	-2.69	0.01	0.85	0.97
Personal income						
Less than $40,000	1.00	--	--	--	--	--
$40,000-$79,999	0.76	0.03	-6.97	0.00	0.71	0.82
$80,000 or more	0.68	0.03	-8.22	0.00	0.62	0.74
Marital Status						
Married	1.00	--	--	--	--	--
Common-law	1.15	0.03	-11.81	0.00	0.52	0.63
Widowed/separated/divorced	1.19	0.07	32.00	0.00	2.32	2.59
Single	1.11	0.02	-22.99	0.00	0.46	0.52
BMI						
Normal weight	1.00	--	--	--	--	--
Overweight	1.77	0.18	5.65	0.00	1.45	2.16
Obese	3.38	0.35	11.83	0.00	2.76	4.14
Physical activity						
Active	1.00	--	--	--	--	--
Inactive	1.14	0.08	1.99	0.04	1.00	1.30
Smoking						
Daily smoker	1.25	0.13	2.09	0.04	1.01	1.53
Occasional smoker	1.60	0.28	2.69	0.00	1.14	2.26
Always an occasional smoker	0.46	0.15	-2.43	0.02	0.24	0.86
Never smoked	1.00	--	--	--	--	--
Physical activity& smoking clustering						
Active & never smoked	1.00	--	--	--	--	--
Inactive & former daily smoker	1.29	0.13	2.56	0.01	1.06	1.56

Table 4.4.2.2. Multivariable Regression with Clustering Effect for Male

Risk factors	Odds Ratio	Std. Err	z	P>|z|	[95% Conf. Interval]	
Age (years)						
12-24	1.00	--	--	--	--	--
40-54	1.82	0.17	6.28	0.00	1.51	2.20
55-69	4.61	0.46	15.36	0.00	3.79	5.60
>70	10.27	1.71	13.97	0.00	7.40	14.23
Education						
Less than secondary school or secondary school graduation	1.00	--	--	--	--	--
Some post-secondary or post-secondary graduation	0.89	0.04	-2.50	0.01	0.81	0.97
Personal income						
Less than $40,000	1.00	--	--	--	--	--
$40,000-$79,999	0.88	0.05	-2.00	0.04	0.78	0.99
$80,000 or more	0.83	0.05	-2.98	0.00	0.73	0.94
Smoking						
Always an occasional smoker	0.71	0.12	-1.99	0.046	0.50	0.99
Former daily smoker	1.29	0.07	4.40	0.00	1.15	1.44
Never smoked	1.00	--	--	--	--	--
BMI						
Normal weight	1.00	--	--	--	--	--
Overweight	1.40	0.07	6.62	0.00	1.27	1.55
Obese	3.00	0.17	19.51	0.00	2.69	3.35
Work stress						
No stress at all	0.61	0.07	-4.31	0.00	0.50	0.77
Not very stressful	0.61	0.06	-4.77	0.00	0.50	0.75
A bit stressful	0.63	0.06	-4.75	0.00	0.52	0.76
Quite a bit stressful	0.75	0.08	-2.89	0.00	0.61	0.91
FVC consumption & Physical activity clustering						
More than 5 times FVC & physical active	1.00	--	--	--	--	--
Less than 5 times FVC & moderately active	1.29	0.15	2.15	0.03	1.02	1.63

For men, the clustering between fruit and vegetable consumption and physical activity exists. As can be seen in table 4.4.2.2, compared to men who ate more than 5 servings of

fruit and vegetable per day and who were physically active, those who ate less and were moderately active were more likely to have a NCD. Given the p value and the 95% confidence interval, the odds ratio between the two groups is statistically significant. The group that ate less than 5 fruit and vegetables per day and were moderately active had a 29% increase chance of having a NCD.

CHAPTER 5
CONCLUSIONS AND RECOMMENDATIONS

5.1 SUMMARY AND CONCLUSIONS

This study assessed the impact of the social determinants of health (SDOH) and behavioral risk factors (BRFs) on individuals' probability of getting a NCD in Canada. Unlike other studies in Canada, which discuss SDOH and BRFs separately (Mikkonen and Raphael 2010; Rehm et al. 2009) or targeted a specific group (Alamian and Paradis 2009) or province (Lubans et al. 2012), this study targeted the Canadian population and combined the effects of SDOH and BRFs together. Both the independent effect of each risk factor and their multi-function effect were assessed. BRFs include fruit and vegetable consumption, physical activity, tobacco use and alcohol consumption. The SDOH considered in this thesis include income, education level, marital status, age and work stress.

The Canadian Community Health Survey (CCHS) (2010) data set was used to undertake this study. A sample of 62,909 individuals were identified in the CCHS 2010. The study population was divided into two parts based on their gender. The sample size of female participants was 34,363 and the sample of males was 28,546. At the beginning of this study, 10 hypotheses were identified for each gender, including hypotheses for SDOH and BRFs. The first hypothesis was that as age increases, the risk of getting NCDs also increases. In the second hypothesis, individuals with higher education were predicted to be less likely to have a NCD. Hypothesis 3 was that individuals with a higher income level had less risk for NCDs than those with lower income. Hypothesis 4 was that married people were less likely to experience NCDs than those that fell into other marital status groups. Hypothesis 5 was that individuals under extreme work stress were more likely to have NCD than those that experienced reduced stress at work. Hypothesis 6 was that individuals who had more fruit and vegetable servings per day were less likely to get NCDs than those who consumed less of these foods. In hypothesis 7, it was predicted that individuals who were physically active were less likely to get NCDs than those were inactive or moderately active. Hypothesis 8 proposed that former daily smokers were the most likely to have NCDs and individuals who never smoke were the least likely to have

NCDs. Hypothesis 9 stated that individuals who consumed more alcohol were predicted to have higher risks for NCD. Hypothesis 10 was that overweight and obese people were more likely to have NCD than those with normal weight.

To test these hypotheses, univariable and multivariable logistic regression models were used to check the relations between the independent risk factors with individuals' probability of getting a NCD. A logistic regression model was used since the outcome variable is binary or dichotomous. Here the dependent variable was whether the individual had a NCD, and the independent variables were the risk factors for NCD. If individuals had one of the four main types of NCD (cardiovascular disease, chronic respiratory disease, diabetes and cancer) in 2010, the dependent variable was 1, otherwise it was 0. Odds ratios were produced by the regression, comparing the odds of having a NCD for individuals in different socio-economic groups and having different lifestyles. After univariable and multivariable logistic regression analysis, the clustering effects among the BRFs were analyzed, to see which combination of clustering was significant.

The results of the univariable and multivariable logistic regressions showed that the majority of SDOH and BRFs demonstrated consistency with the hypotheses. Generally, older respondents were more likely to have NCDs. Respondents who reported higher levels of education and income experienced fewer chronic health problems than respondents with lower education and income levels. Respondents with the highest work stress levels were more likely to have NCDs than those not stressed. For the BRFs, results indicated that respondents who consumed more fruits and vegetables per day had less risk of getting NCDs. Respondents who were physically active were less likely to have NCD than those who were inactive or only moderately active. Respondents who were former daily smokers were more likely to have NCDs than daily smokers, occasional smokers and those who had never smoked. Respondents who were obese and overweight were more likely to have NCDs than those of normal weight. These results indicated that socio-economic status were important in terms of individuals' health condition. Individuals with higher socio-economic status were more likely to have better health condition. A healthy lifestyle; i.e. more fruit and vegetable consumption, being physically active, less smoking, was

important in maintaining a healthier condition and reduced the risk of experiencing NCDs.

However, it is also noteworthy that several indicators of SDOH and BRFs provided inconsistent support for the chosen hypothesis, or only partly supported the hypothesis. For the relationship between marital status and individuals' probability of getting NCDs, the results showed that compared to married people, those who were widowed/divorced/separated were more likely to have NCDs, which was consistent with our hypothesis. Married people appeared to have less of a chance of having a NCD than those who were widowed/divorced/separated. But contrary to our hypothesis, the probability of married people getting NCDs was higher than those living common-law or single. One possible explanation is that married people are generally older than single people. Age also affects an individual's probability of getting a NCD. Another possible explanation is that married people could be more stressed when they have children, while single individuals do not have such a burden. Common-law is a special marital status. People who are in this status vary a lot, depending on their income, age and lifestyle. Thus it is hard to tell why people in this status have less risk for NCD.

Another inconsistent finding was that regular drinkers were less likely to have a NCD than occasional drinkers and those who did not drink in the past 12 months. One possible explanation is that only the frequency of drinking was indicated in the CCHS 2010 survey. The amount of alcohol respondents had was not measured. Thus occasional drinkers could be binge drinkers, while regular drinkers could be moderate drinker. If the daily drinkers were moderate drinker who drank red wine, but the occasional drinkers were those who drank excessively every time, the probability of the heavy occasional drinker of getting NCDs may be larger than those regular red wine drinkers. This provides a possible explanation for why the results were not consistent with the hypothesis. As indicated in the literatures (McGinnis and Foege 1993; Rehm et al. 2009; Single et al. 1999), heavy alcohol consumption is hazardous to human health, and alcohol is the second leading cause of preventable deaths after smoking in most industrialized countries. But there is also substantial evidence that the intake of light to moderate amounts of alcohol is associated with reduced mortality and morbidity from several cardiovascular diseases, especially

coronary heart disease (Klatsky et al. 1990; Fagrell et al. 1999; Wollin and Jones 2001). Moderate alcohol consumption reduces the risk for cardiovascular disease primarily by increasing high-density lipoprotein cholesterol and possibly by increasing plasminogen, tissue plasminogen activator, endothelial function, decreasing platelet aggregability, fibrinogen and lipoprotein. Red wine, containing antioxidants, has been purported to be especially cardioprotective (Vogel 2001). In the CCHS 2010 survey, only the frequency of alcohol consumption was included. What kind of alcohol respondents were drinking or whether respondents were heavy drinker was not collected in the survey.

The results of the study were similar for both genders, except for the following aspects. First, from the aspect of descriptive information, the results showed that male respondents were generally financially better-off than women. Men were also more physically active than women and generally speaking, men smoked more often than women. From the results of the univariable logistic regressions, the impact of education, income and marital status on individuals' risk of getting a NCD were higher for women than for men. For the multivariable logistic regressions, the most obvious difference was that physical activity was a statistically significant indicator for men but for women it was statistically insignificant.

5.2 POLICY RECOMMENDATIONS

5.2.1 Institutional level

A healthy diet plays an important role in decreasing the prevalence of NCDs. This can be seen in the results related to the consumption of fruit and vegetables. Incentives can be used to encourage individuals to eat a healthier diet. These could include subsidies for fruits and vegetables to decrease their price, which will result in an increase in the demand for these products. A school program could also be designed to provide each child with one or two servicing of fruits and vegetables per day. This would increase their tastes and preferences for these food items. Other jurisdictions have placed a tax on food items that are calorie dense but nutritionally poor. Such a tax would increase the price of these food items which will decrease their demand. Information and education, such as the nutrition facts tables, front of package labels, and the healthy eating guide could be promoted to

increase individual awareness of the nutritional quality of their food. Advertising calorie dense foods to children could also be banned or limited. Finally, some ingredients that go into processed foods; such as trans-fat or salt, could be regulated or restricted. This would improve the quality of process foods which would improve individual diets.

Tobacco use is another behavioural risk factor that impacts the prevalence of an individual acquiring a NCD. Additional taxes on tobacco can be gradually introduced making them more expense to purchase and thus decreasing their demand. A public information campaign as well as educational information should be made available to all Canadians to decrease the adoption of this risk factor. Other regulations, such as no smoking in restaurants, public buildings, etc., should be enforced and strengthened. In addition, special programs and medical assistance should be given to individuals who want to decrease or quit smoking.

The frequency, type and amount of alcohol that an individual consumes are behavioural risk factors that impact the prevalence of an individual getting a NCD. Increasing the tax on alcoholic beverages will decrease their demand. Information and education can be given to the general population about the risk of alcohol consumption and health, in particular NCDs. The selling of alcoholic beverages could be restricted to government regulated stores. Promotion and advertising of alcoholic beverages should be restricted. Finally, laws concerning alcohol destructive behaviour should be enforced; ex. drunk driving, etc.

The study results indicate that an increase in the physical activity levels of individuals decreases the prevalence of NCDs. A number of different policies can be used to promote physical activity. For example, the amount of time children have for gym in elementary and high school can be increased. This would get children used to undertaking physical activity on a daily basis. Subsidies can be given to children and adults to become more physically active. This could include tax rebates for individuals who join sports clubs and other physical activities. Information, education and public awareness can be used to increase the physical activity of individuals. An example of this type of program in the past

was the “Participation Program.” This program should be up-dated and re-introduced to the population. This program encourages increased activity of all ages on a daily basis.

In terms of work stress, companies can promote a better work environment and better work life balance. This could include free workshops on stress, gym facilities at work, and healthier food in the cafeteria. Government can support this effort by providing subsidies for companies that establish these programs in the work environment.

Technology can also be promoted to increase behavioural risk factors that promote a healthier life style. For example, apps on your phone can provide information to consumers on the healthiness of the food that they are purchasing which can impact on the diet they consume. Similarly, apps can be used to provide information to individuals on the amount of physical activity undertaken in a day. Several new technologies have been developed to monitor stress and other health indicators. The use of technology can provide information to individuals that can promote a healthier lifestyle.

5.2.2 Community involvement

However, to reduce NCDs, relying on institutional policies and strategies is not enough. Community involvement is also important. Community-based interventions should be included in combination with preventive health services. Government decentralization should be advocated in solving health issues. Behavior change and healthy lifestyles should be advocated within a larger social framework. Patients with NCDs should be informed of more healthy living suggestions and make informed decisions based on their own health condition. Technology in the modern world should be put into effect.

Urban design and city planning is important in building a more healthy-oriented city. Cities should be planned with more places for exercise, including bicycle pathways, running grounds, more parks and gyms. Mental health counselling and medical staff should be provided at the workplaces. Communities can also set aside land for community gardens so individuals can grow their own healthy food.

School lunch programs should be improved with more healthy food and less junk food. Fresh fruits and vegetables should be provided in schools and companies. So students and workers can form the habits of eating more fruits and vegetables per day. Cafeterias are also recommended to serve a healthy meal. Food companies are suggested to put nutrition facts on all their foods. Restaurants are advocated to put calorie facts on food menus.

5.3 LIMITATIONS OF THIS STUDY

First, given that CCHS 2010 survey was used as the data source for this study, the study was limited by the questions in the survey. Given the emphasis of this study, it would have been opportune to include more specific measures of SDOH and BRFs. For example, when considering individuals' diet and eating habits, other factors besides fruit and vegetable consumption are also important, such as whether an individual chooses or avoids certain foods because of concerns about fat, salt, cholesterol and calorie content. But since too many respondents answered "not applicable" to this question, there was not enough data for the logistic regression. When considering individuals' drinking behavior, the variables in the CCHS 2010 survey only included individuals' frequency of drinking alcohol, but did not indicate which type of alcohol individuals had or the amount, so the results about the impact of alcohol consumption on NCDs became vague and perhaps even counter-intuitive.

Second, this study analyzed only the cross-sectional data from CCHS 2010 survey, but some health conditions are the cumulative result of long-term lifestyle and socio-economic factors. So only using one year of data may cause bias in the results. For example, the impacts of smoking, alcohol consumption and dietary habits on individuals' health condition do not appear in the short-term. These behaviors have long-term effects on health and need longer observation periods. So only using cross-sectional data; i.e. CCHS 2010, may result in bias of some results, for example, the unclear result of alcohol consumption in this study. It was intended that a regression would be run for each kind of NCD for this study. But due to insufficient information about certain diseases and limited time, the results were inconsistent for some risk factors. Thus to study certain kinds of disease, a cohort study with sufficient information would be preferable.

Third, it was planned that this study would look at the effect of health service in Canada on individuals' probability of getting NCDs. But for some important variables to assess this question, too many respondents answered "not applicable". For example, when asking whether respondents experienced difficulties getting specialist care, 1,143 respondents chose "yes", 4,633 chose "no" and the remaining 57,133 chose "not applicable" "don't know" or "refusal". This is similar to other variables, such as whether respondents have a regular medical doctor. Thus, in the end significant results for the impact of health service could not be obtained.

5.4 FURTHER RESEARCH

To compensate for the limitation of this current study, further studies are recommended to focus on the following aspects. First, a cohort study is suggested. The current study used a cross-sectional data set; i.e. CCHS 2010 data, with a large sample size; i.e. 62,909 respondents. However, the impacts of living habits and socio-economic status on individuals' health condition take a long time to become identifiable and will require long-term observations. Thus, a study with a longer timeframe, for example 10 years, would be more appropriate.

A second area for future research is the relationship between marital status and NCDs. In the current study a logistic regression was carried out. The results indicated that married individuals were less likely to have NCDs than widowed/separated/divorced people. On the contrary, married individuals were more likely to have NCDs than those who were single or living common-law. Due to limitations in the data set, detailed discussions could not be carried out. The reason why individuals who were single or common-law were less likely to have NCDs than those who were married needs further investigation. Further studies are suggested to gather more information about these four marital statuses and to investigate the relationship between these four marital statuses and NCDs.

Another area for future research would be to investigate the relationship between alcohol consumption and NCDs. In this study, due to limitations of secondary data, the results were not clear. The results indicate that regular drinkers were less likely to have NCDs

than occasional drinkers and those who did not drink in the past 12 months, which is contrary to the hypotheses and would appear to be counter-intuitive. Further investigations should take into consideration more factors, for example, which kind of alcohol individuals are drinking and the amount of alcohol an individual consumes at any one time. More detailed information is needed to fully investigate the behavioral factors.

Besides, persons living on Indian Reserves or Crown lands, residing in institutions and full-time members of the Canadian Forces and residents of certain remote regions are excluded from the CCHS 2010 survey. However, these population groups are also important in Canada. Thus further research are suggested to include these population groups.

Finally, additional research could be undertaken on the access to health service and how it impacts on the prevalence of NCDs. This study intended to include health service as an independent variable, but due to the limitation in the CCHS 2010 data, this could not be investigated. Further studies are recommended to include more information on health care access and health services, such as the quality of health care service people receive, health education individuals get concerning NCDs. More comprehensive information on health service is needed before a logistic regression model can be utilized to investigate this factor.

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