

An Econometric Analysis of
the Obesity Problem in Canada's Aboriginal Population

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Abstract

This paper examines the factors that contribute to a high rate of obesity among Canadian's Aboriginal population. It compares Aboriginal people to the Canadian population as a whole to help identify the factors that lead to Aboriginal obesity using logit models of the probability of being obese.

The data used are from the Canadian Community Health Survey (CCHS) 2012: Annual Component Master File. The population studied is people aged 19 to 70 years old. Econometric analyses are performed to investigate the relationship between Aboriginal obesity and various risk factors. Based on the econometric analysis, I find that genetic differences, socioeconomic status (income and education) and some behavioral factors (smoking patterns, drinking patterns, sleep duration and frequency of exercise) are related to the high prevalence of obesity in the Aboriginal population.

Keywords

Aboriginal people, Obesity, Econometric analysis, CCHS 2012

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Although the research and analysis are based on data from Statistics Canada, the opinions expressed are those of the authors alone and do not represent the views of Statistics Canada.

1. Introduction

Aboriginal people have a very special status in Canada as indigenous people with specific land rights and a unique relationship with the Government of Canada. Although First Nations and Inuit health has improved in recent years, their health status is, in many respects, substantially poorer than that of the rest of the Canadian population (Garriguet 2008). Therefore, it is important to improve the health of First Nations and Inuit people. According to the 2007/2008 Canadian Community Health Survey, 25.7% of Aboriginal people aged above 18 years old self-reported being obese, compared to only 17.4% of the Canadian population. Obesity is associated with many chronic diseases such as diabetes, high blood pressure, heart attack and cardiovascular disease, so there is a reason to be concerned about the future health status of obese Aboriginal Canadian and it is necessary to explore the determinants of their obesity problem. Nevertheless, there is little research on the topic of Aboriginal obesity, although a series of health reports (Statistics Canada 2013, PHAC and CIHI 2011a, Statistics Canada 2007) highlight that weight problems are more severe among First Nation and Inuit groups than in the rest of population. My paper will focus on Aboriginal people and explore the determinants of their obesity problem.

The data used in this paper are from the Canadian Community Health Survey of 2012. After a descriptive analysis examining the prevalence of obesity among different sub-groups of the Aboriginal population, a logistic regression model will examine the relationships between the probability of obesity and individual characteristics. In addition, I will compare the results for overall Canadians and Aboriginal people. Through examining the difference between these two samples, I will explore determinants that contribute to Aboriginal people's high rate of obesity.

Section 2 provides an overview of obesity in the general population for Canada and other countries and for Aboriginal Canadians. Section 3 introduces the data source and offers a

descriptive analysis. Section 4 briefly introduces the logit model, which is the key analytic method used in the model in this paper. This discussion is followed by the definitions and descriptions of each variable included in the model. Section 5 presents estimates of one regression model for two samples to examine the determinants contributing to obesity prevalence among Aboriginal people. A comparison between the Aboriginal and the general population samples explores whether the high rate of obesity might be related to Aboriginal lifestyle or genetic factors not captured by differences in individual characteristics. The final conclusion and corresponding suggestions are given in section 6.

2. Literature Review

Obesity is a medical condition in which excess body fat has accumulated to the extent that it may trigger risk of chronic illness, reduce life expectancy and affect quality of life. Body Mass Index (BMI), which relates the body's weight with height, has been widely used and accepted as a simple method to classify medical risk by weight status (Villareal et al. 2005). In general, experts consider people whose BMI index is over 30kg/m^2 to be obese.

2.1 An Overview of Obesity

Over the past 20 years, a steady growth in the prevalence of obesity has been experienced in Canada and worldwide. Obesity has been called a global epidemic by the World Health Organization (WHO 2000), and it has become a major global public health issue. In 2006, around one-third of all adults in the United States and about one-sixth (17.4%) of all adults in Canada were obese (Burkhauser et al. 2009; Statistics Canada 2009). The CCHS and the report *Obesity in Canada* (PHAC and CIHI 2011a) both disclose this upward trend, which is shown in

Table 1. Tjepkema (2006) finds that the obesity rate of Canadian adults is high and rising, but still below the obesity rate in the United States.

The obesity rate also differs across provinces in Canada (Statistics Canada 2014). The province with the lowest rate is British Columbia at 15.0%; it is below the national average of 18.8%. The second lowest province is Ontario, with an obesity rate of 17.9%. The provinces / territories with the highest rate are Newfoundland and Labrador (29.4%) and Nunavut (29.4%). The rest of the provinces are above the national level. Gotay et al. (2013) detail the distribution of obesity rates across Canada using heat maps, and demonstrate that the prevalence of obesity has been on the rise in most provinces over the past 11 years and is still climbing.

Sassi et al. (2009) select 13 OECD countries and find that obesity rates have been rising for years for men across all countries. For women, the trend is also roughly increasing. Obesity rates in England and the United States are considerably higher than in most other countries. Moreover, disparities in obesity still exist across social groups. More educated and higher socio-economic status women tend to have lower rates, while mixed patterns are observed in men.

2.2 The Obesity Situation in the Aboriginal Population

According to the *Canadian Community Health Survey 2007/2008* (Statistics Canada 2009), 25.7% of Aboriginal people are obese, which is much higher than the 17.4% of non-Aboriginal people. Similarly, the 2006 Aboriginal Peoples Survey (Statistics Canada 2007) reports that approximately 26% of Aboriginal people reported themselves to be obese. In the report *Obesity in Canada* (PHAC and CIHI 2011a), it was found that a higher rate of obesity remains among Aboriginal people. Within the Aboriginal group, the rate of adult obesity is similar for Inuit, Métis and off-reserve First Nations populations.

The obesity problem not only exists among adults but also among children and youth. It is estimated that in 2004 around 20% of Aboriginal children aged 6 to 14 years old were obese (Statistics Canada 2007). The prevalence of obesity is also higher among Aboriginal youth than among non-Aboriginal youth. The 2007/08 CCHS indicates that 6.7% of Aboriginal youth aged 12 to 17 years old were obese, compared with 4.4% of non-Aboriginal youth. Obesity has been identified as a significant health problem in the Aboriginal population according to the report *Aboriginal Women and Obesity in Canada: A Review of the Literature* (ACEWH 2009).

The report *Obesity in Canada* (PHAC and CIHI 2011) shows that many chronic health conditions are correlated with obesity among First Nations. For example, 65.7% of obese First Nations adults had at least one chronic disease, a considerably higher proportion than for non-obese First Nations. ACEWH (2009) concludes that the majority of First Nations adults with diabetes fall within the obesity ranges. Tjepkema (2006) points out that as BMI increases, the risk of having chronic diseases such as high blood pressure, diabetes, and heart disease goes up.

Outside Canada, obesity is also prevalent among indigenous people in the United States, Australia, New Zealand and the Pacific islands. Story et al. (1999) finds a higher rate of obesity among American Indians. According to the 1987 National Medical Expenditure Survey, about 34% of American Indian men and 40% of American Indian women are obese, compared to the U.S.' overall rates of 24% and 25% respectively. Adult Pima Indians have the highest prevalence of obesity (over 60% for both men and women). Story et al. note that genetic, behavioral and lifestyle factors, low income status and developmental factors may contribute to the high prevalence of obesity among American Indians. Similarly, Liao et al. (2003) compare American Indians with other minority populations using statistics from the Racial and Ethnic Approaches to Community Health Survey 2010 (REACH), and find a higher rate of obesity among Indians than among other minority populations.

Burns and Thomson (2006) state that the obesity problem is a very important issue for indigenous populations in Australia. The prevalence of obesity among Indigenous people (29%) is considerably higher than that of the non-Indigenous group (17%). The situation of Torres Strait Islanders is particularly bad; 61% are reported to be overweight or obese. Burns and Thomson conclude that the transition to a western lifestyle, expensive fresh food and reduced physical activity as well as increased social welfare payments and decreased employment were the likely reasons driving the high prevalence of obesity among Australian Indigenous people.

2.3 Determinants of Obesity

In recent years, many studies have focused on identifying the determinants of the obesity epidemic. The factors that are generally taken into consideration are socio-demographic, socio-economic status, and lifestyle factors such as dietary patterns, physical activity, and other related determinants.

Silvestrov (2008) explores the socio-economic, genetic and behavioural factors associated with overweight and obesity in Canada. He finds that body mass index grows faster with age for young men than for young women. Baum and Ruhm (2009) find that age is positively associated with body mass index in America. Kanter and Caballero (2012) find that there are gender disparities in obesity among developed countries, with more men than women being overweight or obese.

Many studies argue that socio-economic status is a determinant of obesity in many studies, including for Aboriginal people. Ng et al. (2011) assess the relationship between obesity and three elements of socio-economic status (employment, education and income), as well as demographic and lifestyle factors, for Aboriginal people in Canada. They find that a lower level

of educational attainment is associated with the higher probability of obesity among non-Aboriginal Canadians, but that the reverse is true for Aboriginal Canadian women. Several factors have different impacts on obesity for Aboriginal men and women. A positive association between obesity and income is observed among Aboriginal men, while income is negatively related to the probability of obesity among Aboriginal women. Furthermore, although employment is not significantly associated with obesity for non-Aboriginal people, being employed reduces the probability of obesity among Aboriginal males and females. Hajizadeh et al. (2013) examine associations between obesity risk and socioeconomic inequality across Canada based on the Canadian Community Health Surveys (CCHSs). They suggest that income inequality is an important factor that explains the concentrations of obesity among certain groups of people. Economically disadvantaged women and affluent men are more likely to be obese.

Lack of physical activity may be another factor that contributes to obesity risk. Lakdawalla and Philipson (2002) argue that long-run growth in average body weight may be caused by changes in lifestyle. Technological improvements tend to gradually shift people from strenuous work to sedentary work, which makes people less physically active and reduces job-related exercise. Katzmarzyk (2008) highlights the importance of physical activity in the prediction of obesity. She suggests that physical activity is an important correlate of obesity and related co-morbidities in Aboriginal Canadians. Tjepkema (2006) shows, using logistic regression models, that obese people tend to engage in less physical activity and consume vegetables and fruits infrequently.

Many studies show that dietary pattern is another factor that leads to a higher prevalence of obesity. Lakdawalla and Philipson (2002) speculate that agricultural innovation lowers the price of goods and expands the supply of food, which results in increased or excessive quantity

of food and calorie consumption by people. Around forty percent of the recent growth in weight appears to be due to agricultural innovation that has lowered food prices. This may be one of the causes of the increase in the rate of obesity globally. Chou et al. (2002) provide a theoretical and empirical examination of determinants of obesity. They show that as the value of time rises, people tend to reduce their home time. The condensed home time leads to an increased demand for convenience food, which normally contains higher calories. Additionally, they find that the downward trend in food prices is associated with an upward trend in body weight. Bleich et al. (2008) start from the perspective of individual energy balance to analyze the causes of the obesity epidemic across developed countries. They argue that caloric intake is related to technological innovations as well as increased urbanization. Similarly, Silvestrov (2008) finds that people who eat in fast food restaurants tend to gain more weight than those who prefer table service or homemade food. Garriguet (2008) argues that, in the age range from 19 to 30 years, Aboriginal women have a higher rate of obesity because of their high consumption of dietary fat. The study suggests that Aboriginal people's obesity might be due to their high protein and low fibre dietary patterns of consumption.

Chou et al. (2002) find a positive cigarette price effect on the likelihood of obesity. Normally, a smoker's metabolism is higher than that of a non-smoker. Stopping smoking often makes individuals gain weight. Therefore, they speculate that an increase in the price of cigarettes may be an explanation for the up-trend in obesity.

In addition to the reasons discussed above, Schoenborn (2008) shows that duration of sleep has a potential relevance to obesity. She demonstrates that adults who sleep less than 6 hours per night have the highest rate of obesity (33%). Taheri et al. (2006) also obtain the same result, and suggest that people have a good sleep in order to prevent obesity. Marshall et al.

(2008) suggest that sufficient sleep is necessary to avoid obesity, as the existing data show the association of short sleep duration with a high BMI.

Alcohol is suspected as a reason for the steady growth of obesity rates because it contains many calories and does not substitute for food. However, many studies have shown that moderate drinking can help people lose weight. Edwards (2007) concludes that the frequency of drinking alcohol has a positive effect for moderate drinking, but that binge drinking increases the probability of obesity, based on data from CCHS for 2003. Tolstrup et al. (2008) use logistic regression to test whether drinking frequency in the U.S. is related to changes in body weight. They find a negative association between drinking frequency and the probability of obesity for females but not for males. Gruchow et al. (1985) infer that alcohol calories may not be efficiently utilized due to the fact that drinkers have a lower chance of being obese. Thompson et al. (1988) report that increased alcohol intake is associated with a decreased intake of carbohydrates, total fat, saturated fatty acids and monounsaturated fatty acids. Arif and Rohrer (2005) explore the relationship between obesity and alcohol consumption in the non-smoking US population. They find that alcohol is effective in preventing obesity, because people who drink frequently have a lower probability of obesity. They suggest that the effect of moderate alcohol consumption in controlling weights should be further explored.

Genetic factors are another important reason for the high prevalence of obesity among Aboriginal people. Both Edwards (2007) and Garriguet (2008) partially attribute the high risk of obesity among Aboriginal Canadians to genetic factors. Hegele et al. (1996) find that “the T54 variant of the intestinal fatty acid-binding protein is associated with differences in fat metabolism in Aboriginal population (p 34),” which may be a potential reason for the high rate of obesity among the Aboriginal population. Story et al. (1999) conclude that a “thrifty gene” is one of the

reasons contributing to high rates of obesity among American Indian people. The high prevalence of obesity results from the continuous feast-famine cycles that Indian people have experienced in the past. Historically, many American Indian tribes experienced periods of plentiful food alternated with periods of famine. Only a person who had an ability to store energy efficiently would survive.

2.4 Analytical models

The selections of analytical models used by previous studies were made based on the type of variable to be analyzed. For those models in which the dependent variable is not continuous but discrete or binary (i.e. obese/not obese; like/dislike/indifferent), three types of econometric models could theoretically be used. They are the linear probability model (LPM), the logit model and the probit model. Many studies so far have employed these methods in their analyses.

Chou et al. (2002) employ a linear probability model (LPM) to explore the factors that contribute to obesity given the fact that the sample size is large. The authors base their research on the database Behavioral Risk Factor Surveillance System. They take many factors into consideration such as gender, marital status, education, age, prices of cigarette, alcohol, restaurant etc.

Silvestrov (2008) applies both the linear probability model and the probit model to investigate the determinants of obesity. The paper first used three linear regression models separately to test the relations of genetic, behavioral, and socioeconomic factors with obesity. Then the probit regression model is applied to give a better understanding of the factors that could determine the increasing obesity rate. The marginal effects of the probit model had the same signs and similar patterns as the OLS estimations.

Tjepkema (2006) applies logistic regression models to check the relations between obesity and some dietary and physical activity factors. Additionally, descriptive statistics are used to depict the proportion of obese adults related to selected characteristics. Katzmarzyk (2008) also uses a logistic/logit model to investigate ethnic differences in obesity and physical activity among Aboriginal and non-Aboriginal Canadians. The results show that no ethnic differences exists in the prevalence of physical inactivity; however, physical inactivity has an impact on the probability of obesity in both the Aboriginal and non-Aboriginal samples.

2.5 Summary

Through reviewing numerous studies related to obesity issues, I have found that obesity has become a global epidemic with steady growth year by year. The prevalence of obesity is higher among Aboriginal Canadians than in the rest of the population, and it has been recognized that Aboriginal people have the highest rate of obesity among all ethnic groups (Tjepkema 2006). Many studies have focused on the obesity issue and tried to explore the relationship between obesity and contributing factors in both Canada and internationally. However, there are very few studies that pay attention to Aboriginal people. Therefore the objective of this paper is to investigate the reasons that lead to a high rate of obesity among the Aboriginal population by comparing the overall Canadian population and Aboriginal people, and to fill the gap that remains in literature.

3. Data

3.1 Data Source

The data for this paper are from the *Canadian Community Health Survey, 2012: Annual component*. I chose to use the master file rather than the PUMF (public use Microdata File), because only the master file offers exact information indicating whether the respondents are Aboriginal or not. In this way I will have enough variables to test whether genes trigger a higher rate of obesity in the off-reserve Aboriginal population.

The Canadian Community Health Survey, 2012: Annual component is a cross-sectional survey that covers around 98% of the Canadian population who are over 12 years old. The survey was conducted in 115 health regions including all provinces and territories, but excludes residents living on Indian Reserves and on Crown Lands, institutional residents, full-time members of the Canadian Forces, and residents of certain remote regions.

The survey was designed to offer comprehensive information related to Canadian health issues such as alcohol use, cancer, chronic conditions, depression, diabetes, drug use, education, food security, health care, health professionals, income, labour force, mental health, smoking, and stressors. With respect to obesity, many informative variables are available to be applied in my analysis.

The sample size of the Canadian Community Health Survey is 62,103, including all of the respondents. The size of the Aboriginal sample,¹ which includes only off-reserve Aboriginal people,² is 3,299. After I remove all observations with missing values and drop individuals who are under 18 or older than 70 years old, the effective size of the sample used in this paper

¹ The definition of “Aboriginal” people is discussed in section 4.4.1.

² The exclusion of on-reserve Aboriginal people only is one of the limitations in this paper. See conclusion to this paper.

decreases to 41,365. The number of males and females are 19,083 and 22,282 respectively. In the Aboriginal sample, the actual number of respondents included in my analysis is 2,307 in total, with 1,055 males, and 1,251 females.

Although Aboriginal children and teenagers also suffer from obesity problems (Statistics Canada 2007), this paper will not focus on this group, since the standard for obesity for children is different from that for adults (Cole et al. 2005). Similarly, seniors (above 70) are more influenced by their body's functional decline than by their dietary habits and any other behavioral factors (Jensen and Friedmann 2002). That is the reason why I exclude these two groups from my research in this paper. Additionally, including observations with missing values in the regression will make the results inaccurate (Greene 2012), and hence lead to the wrong interpretation. Therefore missing values are dropped from my dataset.

3.2 Descriptive analysis

The descriptive analysis of the samples from the *Canadian Community Health Survey 2012: Annual component*, is provided in Table 3, Tables A1-A3 and depicted in Charts 1-7.³ Charts 1-7 are based on Tables A1-A3, which present detailed summary statistics for both the overall Canadian population and Aboriginal people. I can see from Chart 1 that the gender distribution for both samples is the same. The gender divides in my samples are both a little inclined toward females, with the number of females outnumbering the males by 8 percentage points.

Chart 2 shows some disparities between the general Canadian population and Aboriginal people in age distribution. The overall data are not particularly skewed towards any age group. Specifically, Chart 2 reveals that the proportion of Aboriginals surpass the proportion of

³ Sample survey weights were used in generating the statistics in Table 3 and Tables A1-A3.

Canadians in each age group under the age of 45. Table 3 also demonstrates the same phenomenon: the average age of Aboriginal people is younger than that of the general Canadian population, at 39.5 and 43.3 years old respectively.

There is a higher prevalence of obesity in the Aboriginal population than in the general Canadian population, as shown in Chart 3.⁴ Eighteen percent of the general Canadian population are obese, whereas in the sample of Aboriginal people, 27% of people are obese. Females outweigh males in both samples, with gaps of 2 and 3 percentage points respectively. The larger mean value of BMI in the Aboriginal sample also shows that Aboriginal people are heavier than the average Canadian. For more detail, Chart 4 gives the obesity distribution by gender and age in the sample of Aboriginal people. Except for the group aged 35-39, the rates of obesity for females are no less than the ones for males.

In addition to age, Table 3 also presents the mean values of frequency of physical activity, daily consumption of fruits and vegetables and body mass index for the two samples. In contrast to my expectations, off- reserve Aboriginal people appear to be more physically active than the general population, as the mean frequency of physical activity of Aboriginal people exceeds that of the overall Canadian population. More detailed information about the distribution of physical activity can be found in Chart 5, which reveals that the distribution of physical activity is fairly even within the two samples. The slight differences arise in the categories “occasionally exercise” and “frequently exercise.”⁵ A higher percentage of the general Canadian population exercise occasionally, while more Aboriginal people appear to participate in physical activities frequently.

In terms of daily consumption of fruits and vegetables, the general Canadian population consumes more servings of fruits and vegetables on average as shown in Table 3. Chart 6 gives

⁴ Obese people are those whose BMI equals or is greater than 30kg/m².

⁵ I define less than 10 times per month of exercise as “infrequent exercise”, 10-30 times as “occasionally exercise”, 30-60 times as “regularly exercise”, more than 60 times as “frequently exercise”.

the distribution in detail. Sixty-seven percent of Aboriginal people have less than 5 servings a day of fruits and vegetables, compared to sixty percent of the overall Canadian population. However, in the categories of 5-10 servings per day and more than 10 servings per day, the Canadian population as a whole outnumber Aboriginal people with gaps of 6 percentage points and 1 percentage point respectively.

A bachelor's degree seems to be a threshold in the distribution of highest level of education attained for the Aboriginal population and the overall Canadian population. A higher percentage of Aboriginal people than Canadians as a whole can be found in each category below the Bachelor's degree in Chart 7. However, only 17% of Aboriginal people in this sample have attained a bachelor's degree or higher, a proportion that is almost 50% lower than the overall Canadian population.

4. Model

4.1 Analytical techniques

Specifically, the dependant variable in this paper is *obese*, which is a dummy variable defined as follows:

$$Obese = \begin{cases} 1 & \text{if } bmi \geq 30 \quad (\text{i. e., the respondent is obese}) \\ 0 & \text{if } bmi < 30 \quad (\text{i. e., the respondent is not obese}) \end{cases} \quad (1)$$

Note that the dependent variable in this model has only two values, 1 and 0. It is not continuous but discrete. As mentioned before, three models could be used in this situation. They are the LPM, the logit model and the probit model. In practice, the linear probability model has some problems such as nonnormality of errors and heteroskedasticity of errors. Therefore, I used a nonlinear model - the logit model - which is suitable for binary choice models.

The logit model is a good way to deal with a model which contains a binary dependent variable. It can measure the relationships between the dichotomous dependent variable and the independent variables by predicting the probability of each possible outcome. The logit model is based on a latent variable model and is estimated by the method of maximum likelihood (Greene, 2007).

The logit model is based on the following logistic distribution:

$$F(x) = \frac{e^x}{1+e^x} = \Lambda(x) \quad (2)$$

where $F(\cdot)$ is the cdf of the logistic distribution. Therefore it can be represented as

$$p_i = P(y_i = 1 | x_i) = \Lambda(x_i' \beta) = \frac{e^{x_i' \beta}}{1+e^{x_i' \beta}} \quad (3)$$

$$1 - p_i = P(y_i = 0 | x_i) = \frac{1}{1+e^{x_i' \beta}} \quad (4)$$

where the link function is the cumulative probability distribution function. y_i is the observed dependent variable. x_i is a vector of independent variables and β is the vector of parameters in the model. i indexes observations.

The likelihood function for a random sample of n observations is

$$\mathcal{L}(\beta | y_i, x_i, i = 1, \dots, n) = \prod_{i=1}^n \{F(x_i' \beta)\}^{y_i} \{[1 - F(x_i' \beta)]\}^{1-y_i} \quad (5)$$

Taking logs of (5) I have

$$\begin{aligned} & \ln[\mathcal{L}(\beta | y_i, x_i, i = 1, \dots, n)] \\ &= \sum_{i=1}^n \{y_i \ln F(x_i' \beta) + (1 - y_i) \ln [1 - F(x_i' \beta)]\} \quad (6) \end{aligned}$$

The term within curly brackets is known as the log-density of the i th observation. The log-likelihood equation therefore for the logit model is thus

$$\ln \mathcal{L} = \sum_{i=1}^n \left\{ y_i \ln \left(\frac{e^{x_i' \beta}}{1 + e^{x_i' \beta}} \right) + (1 - y_i) \ln \left(\frac{1}{1 + e^{x_i' \beta}} \right) \right\} .$$

Unlike the OLS regression model, I cannot directly interpret and analyze the coefficient of the logit model, because the model is nonlinear. What I need to do instead is to calculate each explanatory variable's marginal effect, after I estimate the logit model.⁶ In this paper, all marginal effects are calculated for the reference person. This will give us the sense of how big an effect changes in the independent variables will have on dependent variable. Or in other words, how much will the independent variable influence the probability that the dependent variable equals 1. In my case, the marginal effects will show the effect of determinants on the probability that a person will be obese.

Another thing that should be noted is that sample survey weights are used in estimation in order to satisfy confidentiality restrictions.

4.2 Overview of model

To investigate the factors that contribute to a higher rate of obesity in the Aboriginal population, I will estimate models with different samples in order to determine the discrepancy between the average Canadian and Aboriginal people. The sample of the overall Canadian population will be used first to analyze the obesity problem across Canada. Then I will focus on the Aboriginal population.

I assume that obesity is determined by three kinds of variables - socio-demographic variables, socioeconomic variables and behavioral variables. Socio-demographic variables include the individuals' basic characteristics. In my model, age, gender, marital status, province

⁶ I use analysis software -Stata 13 in my research.

of residence and ethnicity are included.⁷ The second type of variable contains socioeconomic characteristics such as education and income. The behavioral variables reflect people's lifestyle, such as their dietary habits, frequency of physical activity, smoking pattern, drinking habits and sleep hours.

The annual component of the 2012 Canadian Community Health Survey offers comprehensive information related to obesity that can be used for my analysis. I chose BMI (Body Mass Index) as the indicator of obesity and included many variables from the database which may be factors that trigger people's obesity problems. The explanatory variables in my model include most of the determinants of obesity mentioned in the literature review. Through comparing the overall Canadian sample to the Aboriginal population, I will be able to identify the determinants that lead to the higher rate of obesity in the Aboriginal population.

4.3 Dependent variable

BMI is a measure of an individual's weight in relation to his or her height (Tjepkema 2006). In this paper, Body Mass Index (BMI) is used as the standard to identify whether respondents are obese or not. In the 2012 Canadian Community Health Survey, the BMI is based on individuals' self-reported heights and weights and calculated using the following equation.

$$\text{BMI} = \text{weight (kg)} / \text{height}^2.$$

As shown in Table 2, the World Health Organization (2006) classifies BMI into six categories and considers people whose BMI is over 25kg/m² and less than 29.9kg/m² to be overweight, while those over 30kg/m² are obese. Furthermore, obesity has been divided into

⁷ Within the sample of Aboriginal people, the model exclude the variable *Aboriginal*, which indicates if the respondent is the Aboriginal.

three categories: Class I (BMI 30.0-34.9), Class II (BMI 35.0-39.9) and Class III (BMI 40 or more). The health risk goes up along with the increase in level of obesity.

I follow the standard discussed above and as shown in equation (1), define *Obese* as a dichotomous dependant variable that equals 1 if BMI is greater than or equal to 30. Thus, the person who is obese is identified by a 1 with 0 for non-obese individuals.

4.4 Independent variables

In the model, I include three types of variables that may affect the dependent variable *obese*. They are socio-demographic variables, socioeconomic variables and behavioral variables. Each group of variables will be discussed in detail below.

4.4.1 Socio-demographic variables

Age is an important determinant of obesity. In this paper I exclude people who are aged under 18 or over 70. As stated before, the reasons for obesity in those groups are more complicated and should take more factors into consideration. Additionally, the standard for identifying obesity (BMI ≥ 30) may not be appropriate for those groups of people (Cole et al. 2005, Jensen et al. 2002).

Based on the CCHS variable *dhh_age*, I created ten dummy variables for ten age groups in my model. They are *age18_19* (equals 1 if the individual is in the range from 18 to 19), *age20_24* (equals 1 if the individual is between 20 and 24), *age30_34* (equals 1 if the individual is between 30 and 34), *age35_39* (equals 1 if the individual is between 35 and 39), *age40_44* (equals 1 if the individual is between 40 and 44), *age45_49* (equals 1 if the individual is between 45 and 49), *age50_54* (equals 1 if the individual is between 50 and 54), *age55_59* (equals 1 if the individual is between 55 and 54), *age60_64* (equals 1 if the individual is between 60 and 64),

and *age65_70* (equals 1 if the individual is between 65 and 70). The reference is a person who is aged between 25 and 29.

In the model the reference gender is female. Therefore, the variable *male* is created to distinguish males from females. As shown in Table 4, this dummy variable is based on the variable *dhh_sex* in the CCHS2012 database and equals one if the respondent is male.

dhh_ms is the variable in the CCHS2012 that indicates respondents' marital status. I classified the variable *dhh_ms* into four categories and generated three new dichotomous variables accordingly. The reference group contains the people who are married. In terms of the dummy variables that I generated, the first is *mar_single*, which refers to the group who are single. The people who are common law are in the second variable named *mar_comlaw*. The third category includes people who are previously married (widow, separate, divorced), named *mar_win_sep_div* in the model.

To better understand the distribution of obesity in Canada and compare the prevalence of obesity across the country, I include variables which show the location of residence of respondents. The variable *geo_prv* has 13 categories that cover 11 provinces and territories. I chose Ontario as the benchmark province and generated dichotomous variable for each other province accordingly: *geo_NL*, *geo_PE*, *geo_NS*, *geo_NB*, *geo_QC*, *geo_MB*, *geo_SK*, *geo_AB*, *geo_BC*. Also I combined the three territories into one, labeled *geo_TTR*. These variables will also help to test if differences in health care systems are associated with the prevalence of obesity.

Ethnicity is determined by the question: "Are you an Aboriginal person?" The possible answers include "Yes", "Refuse to answer", and "Don't know". The variable *aboriginal* is based on this question and is used to identify people who are Aboriginal. It is a binary variable that

equals one if the subject is Aboriginal. Through observing the marginal effect of this variable, I will be able to measure the gap between the Aboriginal people and the rest of the population.

4.4.2 Socioeconomic variables

As mentioned in the literature review, many people have found that income has a potential relationship with obesity (Levine 2011). Therefore, I include this factor in the model in order to analyze how strongly it affects obesity. The paper will also analyze in detail the impact of income on Aboriginal people.

There are several variables that provide information on respondents' income from different perspectives in the CCHS 2012 database. I chose the variable "total household income from all sources," because it best represents the level of a person's financial situation. I categorize this variable into seven groups and generated six separate dummy variables. Among the seven groups the reference is income from \$40,000 to \$59,999 per year. The other six classifications are people who earn less than \$19,999 per year, including no income; those who earn between \$20,000 and \$39,999; between \$60,000 and \$79,999; between \$80,000 and \$99,999; between \$100,000 and \$150,000; and those who earn more than \$150,000.

Education is divided into six categories. In the CCHS 2012, the variable contains ten classifications. I combined some levels together. The included variables are, namely: *edu_lessec* (less than secondary school), *edu_sec* (secondary school), *edu_sompostesec* (some post-secondary education), *edu_college* (college or less than a bachelor's degree), *edu_BA* (bachelor's degree), and *edu_aboveBA* (above bachelor's degree). Among these variables, a college education is the reference since the number of people in this group is the largest.

The results with respect to this determinant will indicate whether the level of education is correlated with a person's shape. It will also point out the magnitude of the influence that each level of education brings to individuals.

4.4.3 Behavioral variables

Physical activity is globally recognized as the one of the most important ways to keep fit and lose weight. This factor is therefore included in my model. In the database, it is described by the variable *pacdfm*, which measures the frequency of physical activities in one month.

I created very specific categories for this variable: *PAC_les10* (less than 10 times a month), *PAC_10_20* (10 to 20 times a month), *PAC_30_40* (30 to 40 times a month, which means a person exercises once a day at least), *PAC_40_50* (40 to 50 times a month), *PAC_50_60* (50 to 60 times a month), *PAC_60_70* (60 to 70 times a month which means the person exercises at least twice a day), *PAC_70_80* (70 to 80 times a month), *PAC_80_90* (80 to 90 times a month), *PAC_more90* (more than 90 times a month which means the respondent exercises at least 3 times a day). The reference is *PAC_20_30* (20 to 30 times a month).

Dietary habits are another cause of obesity. The daily consumption of fruits and vegetables can reflect people's habits and preferences for vegetables and fruits. More vegetables will help people to keep fit, since they contain few calories and are full of vitamins and nutrition (Tjepkema 2006). Daily consumption of fruits and vegetables was calculated from a series of questions asking respondents how often they consumed juices, fruit, green salad, potatoes, carrots and other vegetables per day. It is divided into three categories: consume less than 5 servings per day, consume 5-10 servings per day, and consume more than 10 servings per day. Less than 5 servings per day is selected as the benchmark and for the rest of the categories a dummy variables was generated, as can be seen in Table 4.

A number of studies have found that smoking patterns are associated with obesity, since smoking accelerates a person's metabolism (Chou et al. 2002). Therefore smoking should not be neglected factor when evaluating the reasons for obesity. Three types of smokers are described in the CCHS 2012 database: people who never smoke, people who occasionally smoke, and people who smoke daily. I created dummy variables for last two categories and chose the people who never smoke as the reference group in the model.

The variable *alc_2* in the CCHS 2012 describes people's drinking habits by measuring the frequency of drinking alcohol. This variable is relevant because I want to explore whether there is any relationship between the habit of drinking alcohol and obesity. The results will indicate the impact of people's drinking habits on obesity.

I divided this variable into eight categories: people who don't drink (*ALC_NA*), who drink less than once per month (*ALC_less1permonth*), who drink alcohol once a month (*ALC_1permonth*), who drink 2- 3 times a month (*ALC_2_3permonth*), who drink alcohol once a week, who drink 2-3 times a week (*ALC_2_3perweek*), who drink 4-6 times a week (*ALC_4_6perweek*), and who drink alcohol every day (*ALC_everyday*). The benchmark is the individual who drinks alcohol once a week.

The variable hours of sleep (*SLP_01*) indicates how many hours the respondent sleeps per night. I define four groups and create dummy variables for each: sleep 5-6 hours, sleep 7-8 hours, sleep 8-9 hours and sleep more than 9 hours. The people who sleep 6-7 hours are in the reference group.

For convenience, Table 4 lists all the variables retrieved from CCHS 2012 and all the variables included in the logit models, together with their definitions. Mean values of all dummy variables in the models can be found in tables A1-A3.

The reference individual in the model is a non-Aboriginal female, aged 25-30, has an income of \$40,000-60,000 per year, exercises 20-30 times per month, eats fruits and vegetables less than 5 times per day, doesn't smoke, drinks once a week, sleeps less than 5 hours every day, is married, has a college education, and lives in Ontario.⁸

5. Results

5.1 Analysis of the overall Canadian population

The result of the overall Canadian population are presented in Table 5. In terms of goodness of fit of my model, the likelihood ratio chi-square statistics are 2403.55 for the full sample, 906 for males and 1740.73 for females with p-values of 0.0000 for all three samples. These statistics tell us that my model as a whole does have explanatory power and fits significantly better than an empty model (i.e., a model with no predictors). However, the pseudo R^2 values for each sample are just 0.0547, 0.0442 and 0.0744 respectively. These small values imply that the models do not capture all the determinants of obesity.

From Table 5, I can see that the predicted probability that the reference person will be obese is 16.7%. Additionally, when I look in-depth by gender, I can see that females have a lower probability of being obese than males, equal to 14.09% versus 21.92% for males. The marginal effects in the remainder of Table 5 represent the change in the predicted probability as each explanatory variable changes.

Firstly, I examine the socio-demographic variables. According to the "full sample" column of Table 5, males are 2.4 percentage points more likely than females to be obese when I

⁸ Within the sample of Aboriginal people, the reference individual is Aboriginal, since there are no non-Aboriginal people in the sample. In the male subsample, the reference individual is male.

keep other factors fixed. This result is consistent with the report *Obesity in Canada* (PHAC and CIHI 2011).

With respect to age, I can see that the probability of obesity increases as people get older, but reaches a peak at 60-64 years old. People under 25 years old are less likely to be obese than people aged 25-30 years old. More specifically, people aged between 18 and 19 are least likely to be obese, – 9.8 percentage points less likely than the reference group. For people older than 30, I can see that as people enter the 35-40 years age bracket, the probability of obesity increases sharply, with the marginal effect increasing from 0.028 to 0.0614. Furthermore, this change is steeper in the male subsample; for males, the marginal effect jumps directly from 0.024 to 0.077. Thus in comparison to males, the changes for females are smoother. I can also see that those aged from 60 to 64 have the highest risk of being obese, 9.2 percentage points higher than the reference group.

The results also reveal distinct differences in the provincial distribution of obesity, holding all else constant. Manitoba has the highest marginal effect, implying that respondents from this province are 7.6 percentage points more likely to be obese than those residing in Ontario. On the other hand, BC has the lowest marginal effect (–3.6%), which means that residents of BC are less likely to suffer from an obesity problem. At the same time, the insignificance of the marginal effects for Quebec and the territories implies that the situation in those regions is similar to that in Ontario, when I control for other factors. In the remaining provinces, people are more likely to be obese than those in Ontario, holding all else constant.

Table 5 also reveals comparable results with respect to province of residence for women and men. The results are largely similar, but the probability of being obese in Nova Scotia, Manitoba, Alberta and the territories is much higher for females than for males. Gotay et al. (2013) also report similar results in their study.

Marital status appears to have little impact on the probability of being obese. According to Table 5, the marginal effects related to marital status are not statistically significant. This means that all people, no matter what their marital status, face the same probability of being obese, when I hold the remaining factors constant. Another interesting finding is that when I compare the results by gender, I observe opposite signs for men and women on the marginal effect of being single. A single man is 2 percentage points *less* likely than a married man to be obese, while a single woman is 2.7 percentage points *more* likely to be obese compared to a married woman.

Regarding ethnicity, Table 5 reveals a large disparity between Aboriginal people and the rest of the population. Aboriginal people are 6.4 percentage points more likely to be obese than non-aboriginal people, which means the predicted probability of being obese of the reference Aboriginal person is 23.1%. This result is close to the sample proportion in the CCHS 2012.

In the case of income, the results are somewhat surprising. Some previous studies point out that in developed countries, richer people normally are slimmer because they have more time and money to exercise and keep fit (Levine 2011). My result shows that the level of income, based on the full sample, does not play a key role in obesity in Canada. The report *Obesity in Canada-snapshot* (PHAC and CIHI 2011b) also states that "unlike other health issues such as mortality or life expectancy, for which there is a clear disadvantage for those with lower income, the relationship between income and obesity is not clear (p 2)." However, the male subsample is a special case. Males whose household income is more than \$100,000 per year have a higher propensity to be obese than males in other income classes.

In contrast, the level of education is negatively correlated with obesity. At the level of a bachelor's degree, people are 4.2 percentage points less likely to be obese than those with a

college diploma. Furthermore, the probability of obesity decreases by 6.8 percentage points as the level of education rises above the Bachelor's level. However, there is no clear difference in the probability of being obese between levels of education at the college level or below.

The results with respect to physical activity confirm that the more frequently people exercise per month, the lower their probability of being obese. However, I also notice that the effect of exercising 20-30 times per month is not significantly different from that of exercising 30-40 times per month, because the marginal effect of *PAC_30-40* is not statistically significant. Additionally, 70-80 times a month of physical activity are associated with the lowest probability of obesity and will give people the best chance of keeping fit, since its marginal effect reaches the lowest value (-5.69 percentage points). When people exercise more than this amount, there are diminishing returns.

Proper daily consumption of fruits and vegetables also helps people keep fit. The results show that people who have 5-10 servings of vegetables and fruits per day will be 0.9 percentage points less likely to be obese compared to the reference group, who eat fruits and vegetables less than 5 times per day. What's more, women and men are very different. Males seem to be more affected by dietary habits than females. When men consume 5 to 10 servings per day, then propensity to be obese is lower. Their probability of being obese continues to decrease as they increase the number of servings every day, by 3.1 percentage points. Females, in contrast, seem to be little affected by the frequency of fruit and vegetable consumption. Therefore, eating habits seem to be more important and effective for males who want to reduce weight.

Sleep patterns and smoking patterns are also related to people's obesity problems. Based on the marginal effects, proper sleep hours (7-8 hours a day) are associated with a lower probability of being obese for women. Nevertheless, the difference in sleeping patterns in the

male subsample is blurred, because the marginal effects of all categories are not statistically significant. This suggests that sleep hours do not drive males' obesity problems. Regarding smoking patterns, smoking is indeed negatively associated with obesity as I expected. An occasional smoker is 2.8 percentage points and a daily smoker is 5 percentage points less likely to be obese compared to a non-smoker. For males, the gap between different types of smokers is large. The marginal effect of *daily smoker* is almost triple the magnitude of that of *occasional smoker*, with decreases of 6.4 percentage points and 2.67 percentage points respectively. For females, the disparities between daily smokers and occasionally smokers is relatively small – only one percentage point.

One of the most striking findings is that the frequency of drinking alcohol is negatively related to the probability of obesity, as shown in Table 5. People who drink more than 2 times a week are less likely to be obese, compared to other drinking patterns which are less frequent than 2 times per week. For females, the effect of this factor is more obvious and larger. When they drink alcohol more than 4-6 times a week, the probability of being obese decreases by 6.2 percentage points as compared to 5.3 percentage points for males. Tolstrup et al. (2008) also find that drinking frequency is inversely related to waist circumference in women. Arif and Rohrer (2005) suggest further exploring the possible role of moderate alcohol drinking in controlling people's weights, based on their findings that “current drinkers had lower odds of obesity than non-drinkers” and “the odds of obesity were significantly lower among those who reported drinking frequently” (Arif and Rohrer 2005, 1).

5.2 Analysis of the Aboriginal population

Table 6 presents the results for the Aboriginal population. In terms of goodness of fit of my model, the p-values from the LR tests once again lead to the conclusion that the model has explanatory power and at least one of the regression coefficients in my model is not equal to zero. The pseudo R^2 values for each sample are 0.0637, 0.0943 and 0.0831 respectively. Although they are still very small, the LR tests indicate that the model does have some explanatory power.

In Table 6, I can see that the predicted probability of being obese of the reference Aboriginal person is 30.25%, which is almost double the rate of the overall Canadian population. If I analyze by gender, the model predicts that Aboriginal males have a probability of 24.73% of being obese, while Aboriginal females have a probability of 29.7%. These estimates are slightly larger than the actual proportion in the survey (25.7% with full sample).

I firstly examine the socio-demographic variables in detail. As for the previous sample, I include four factors in this group: gender, age, marital status and province of residence. The interesting thing is that, in contrast to the overall Canadian sample, there is no clear difference in obesity rates between Aboriginal males and females, since the marginal effect of *male* is not significant.

With respect to age group, people aged from 20 to 34 have similar probabilities of being obese. However, those aged 40-44 are 12.54 percentage points more likely to be obese than the reference individual, an increase of more than 40%. When it comes to age 55-59, the marginal effect jumps to 0.148, and then continues to increase to 0.149 for those aged 60-65. After that the marginal effect of increasing age drops a little, to 0.134. These results demonstrate that after Aboriginal people reach 55, the risk of being obese is up to 45.16% if I keep other factors fixed.

Turning now to the results by gender, for males the probability of being obese rises faster and higher than in the overall Aboriginal population as age increases. Aboriginal men from 18 to

34 years old face a similar probability of being obese. However, when Aboriginal men reach the age of 35-39 years old, the probability of obesity increases dramatically to 47.63% if I hold other factors to be the same as for the reference group. Moreover, the risk of becoming obese is highest at this age, even higher than for older age groups. Males aged 55-59 have the second highest propensity of being obese. The magnitude of the marginal effect is 0.2211. The marginal effect then goes down a bit to 0.1698 in the 60-64 age group, and goes up once again to 0.1912 in the 65-70 age group. In contrast, the highest probability of being obese for Aboriginal women is when they are between 60-64 years old; the second peak is when they are 40 - 44 years old. Aboriginal women under 20 have a lower probability of obesity.

Table 6 also demonstrates that marital status does not appear to be a driver of the obesity problem for Aboriginal people as a whole, because the marginal effects are not significant. The same pattern can be observed for Aboriginal women although the results are slightly different for men. Single men are 6.9 percentage points less likely to be obese than married men, when I use a 10% significance level.

The marginal effects for province of residence do not reveal much disparity between the provinces for Aboriginal people. At the 10% significance level, only Aboriginal individuals in BC appear to be less likely to be obese than those living in Ontario. The other provinces and territories are not statistically different from Ontario.

Another factor that has been shown to be associated with obesity is the individual's place in the social gradient (Ng et al. 2011). Next I will examine whether socioeconomic elements are related to obesity among aboriginal Canadians. Two determinants have been incorporated here: income and highest level of education.

In terms of income, Aboriginal people who earn less than \$150,000 a year experience a similar probability of being obese, because all the corresponding marginal effects are not statistically significant. But for the group that receives more than \$150,000 a year, the situation is slightly different. At the 10% level of significance, the marginal effect of the variable *inc_more150000* is significant. This shows that in the aboriginal population, people whose total household income is more than \$150,000 are 8.6 percentage points more likely to be obese than the reference person.

Education displays an interesting pattern. At the two extreme ends of the highest level of education attained, I observe the lowest probability of being obese. The magnitudes of the respective marginal effects are -11.97 and -10.59 percentage points. In other words, the least educated people and the most educated people are the least likely to be obese. The effects of other levels of education are similar, although there is still a negative association between obesity and a Bachelor's degree in the female subsample if the level of significance increases to 10%.

When the Aboriginal sample is disaggregated by gender, I observe huge diversity in the marginal effects of levels of education. Aboriginal men tend to be little influenced by the level of education, because all of the marginal effects are not significant. However, at the same time, the least educated women experience a large decrease in the probability of obesity. They are 14.6 percentage points less likely than the reference group (college education) to be obese. A similar decrease is also observed for highly educated Aboriginal women. At the 10% significance level, women with a Bachelor's degree or more are less likely to be obese than the reference group. Specifically, the most educated women have the least chance of being obese of all groups, with a

marginal effect of 0.1634. This result suggests that a low level of education may be an explanation for the prevalence of obesity in the Aboriginal population.

Behavioral factors such as frequency of physical activity, dietary habits, drinking patterns, frequency of smoking and sleep hours are also related to people's weight. Using the results in Table 6, I will try to figure out which of these factors are the most closely related to Aboriginal people's weight.

Turning to physical activity, other than *PAC_less10* and *PAC_80_90*, the rest of the variables related to frequency of physical activity do not have significant marginal effects. On the one hand, the results show that Aboriginal people who exercise less than 10 times per month have a higher probability of being obese than the reference group (exercise 20-30 times a month); those who exercise 80-90 times a month are also less likely to be obese. On the other hand, the results also show that there are no big differences between people who choose a frequency of exercise in the range between 10 and 80 times per month.

Within the male subsample, only the group that exercises 80-90 times per month differs from the rest in an important way; the rest of the groups are all similar. Alternatively, I can argue that 80-90 times of physical activity a month can significantly increase the likelihood of keeping fit. For men, the magnitude of the effect may be as large as 0.186. Women follow the same pattern as Aboriginal people as a whole. However, the magnitude of the marginal effect for those who exercise less than 10 times per month is higher than the one in the full sample (male and female).

For Aboriginal people, total daily consumption of fruits and vegetables does not appear to be an important factor that affects people's weight, since both marginal effects are not statistically significant. Regarding smoking, Table 6 shows that smoking by Aboriginal people,

especially males, is associated with a lower probability of being obese. Daily smokers and occasional smokers in the male sample are less likely to be obese, with marginal effects of -0.0889 and -0.1053 respectively. However, only Aboriginal women who smoke every day show a reduced propensity to be obese, with a decrease of 5.17 percentage points. Despite the negative relationship between smoking and obesity, smoking is still not encouraged for Aboriginal people, since it potentially threatens people's health and triggers many diseases such as lung cancer, stroke and bronchitis.

Frequent drinking is associated with a large decrease in the probability of obesity, especially among females. The magnitude of the marginal effect for daily drinking is as large as -11.54 percentage points. In contrast, Aboriginal people who drink less once a month are 8.934 percentage points more likely to be obese compared to the weekly alcohol drinker. For most other groups the effect is similar to the reference group, since the marginal effects are not statistically significant at the 5% significance level (except *ALC_4_6perweek* in the female subsample).

Once again men and women exhibit differences in terms of drinking alcohol in Table 6. Men's weights seem not to be related to their frequency of drinking, as the associated marginal effects are insignificant. However, there is an apparent association between drinking habits and obesity in the female subsample. Those who drink less than once per week are 10.07 percentage points more likely to be obese compared to the reference group. In contrast, women who frequently drink alcohol (more than 4 times a week) tend to have a lower probability of being obese than other drinkers. Still, although frequent drinking shows a negative association with the probability of obesity, especially among Aboriginal females, I still do not encourage Aboriginal people to try to adopt this method of preventing obesity, since an alcohol abuse problem exists in

the Aboriginal population in Canada as well. Alcohol damages people's digestive system, liver, brain, and nervous system (Aboriginal Healing Foundation 2007).

With regard to sleep hours, I see that none of the marginal effects are significant. This suggests that sleep is not an important factor related to Aboriginal obesity. If I relax the significance level to 10%, I can conclude that 8-9 hours of sleep may be negatively related to obesity for women, with a marginal effect of -0.11.

5.3 Comparing overall Canadian people and Aboriginal people

Overall, Aboriginal people have a much higher probability of being obese than Canadians as a whole. When comparing the same reference person, I can see that the probability of obesity among Aboriginal people is almost double that of the overall Canadian population. This is consistent with reports from *Obesity in Canada* (PHAC and CIHI 2011) and the *Canadian Community Health Survey 2012-user guide* (Statistics Canada 2013).

Table 6 contains a number of marginal effects which are not significant at the 5% significance level, but are at the 10% significance level and at the same time their magnitudes are relatively large. To better compare the results between Aboriginal and non-aboriginal people, I will only look at results which are significant at the 10% significance level to analyze and compare the results.

I find that in the overall Canadian population, males have a higher probability of obesity than females if I hold the remaining factors the same across the reference group. However, in the sample of Aboriginal people, there is no significant difference between males and females in the probability of becoming obese.

Regarding the influence of age, I can see clearly in Table 5 that each age group is distinguished from the reference group of 25-29 years, with either an increase or decrease in the probability of being obese. However, in Table 6, I can see that Aboriginal people aged 20–39 years old (a combination of four age groups) face a similarly high chance of being obese (if I employ a 5 % significance level); that is to say, 20 year old Aboriginal people are not less likely to be obese than the those in their 30s. It is also interesting to find that even the older Canadians have a smaller likelihood of being obese than young Aboriginal people. On the other hand, Aboriginal people have much higher marginal effects (i.e., increased probability of obesity compared to the reference group) than Canadians as a whole in the same age group. No age group in the overall Canadian full sample has a probability of obesity beyond 9.2 percentage points higher than the reference group, while for Aboriginal people, this probability is up to 14.9 percentage points higher. For Aboriginal people after age 55, the marginal effect hovers around 14 percentage points. Aboriginal seniors aged from 60 to 64 years have a surprisingly high probability of 45.16% of being obese, holding all else constant. These are dramatic increases in the probability of obesity.

With respect to marital status, Table 5 demonstrates contradictory results for single males and single females in the overall Canadian population. Single men are 2.04 percentage points less likely to be obese than married men, while there is a 2.77 percentage point increase in the probability of being obese for single females. This may be because in traditional families, married women bear more of the burden of housework and are mainly responsible for taking care of children, while married men, many suffer from more stress from work and lack time for frequent exercise, as they try to provide financial support for their family. However, for Aboriginal people, in the full sample or in subsamples, the marginal effects are all not significant.

I can conclude that for Aboriginal people, there is little relation between marital status and obesity.

Although Table 5 shows a large diversity across provinces in Canada within the sample of Canadians as a whole, the sample of Aboriginal people doesn't show this pattern. Only BC has a significantly lower propensity to be obese. This result implies that factors such as different healthcare schemes and divergent weather do not greatly affect Aboriginal people's prevalence of obesity.

As can be seen in Table 5, high income (more than \$100,000 per year) men face a greater chance of becoming obese than the reference group. Meanwhile, rich Aboriginal people (more than \$150,000 per year) are also 8.6 percentage points more likely to be obese than the reference person. The explanation for this phenomenon is probably that high income people are normally either in a senior position in a company or do high-risk or high-pressure work, and don't have enough time for physical activity. They also tend to eat out very often, either because of reduced time at home or frequent business dinner meetings (Chou et al. 2002). Additionally, Ng et al. (2011) show in their study that senior and middle management occupations are positively associated with BMI. They speculate that the reason is that males normally get benefits from a larger body size in terms of establishing power. All these reasons contribute to a positive relationship between high income and obesity. High-income Aboriginal people are likely similar to other high-income Canadians, and they enjoy the same level of health care and the same quality of food as well as having a similar work situation. Therefore they follow the same pattern as Canadians in general.

Canadians who have a Bachelor's or higher level of education are less likely to be obese than college educated Canadians. Moreover, I observe the same pattern in both the male and

female subsamples. Table 6 shows that highly educated Aboriginal people are less likely to be obese as well. Highly educated people normally pay attention to nutrition as well as the calories they consume every day, because they know the importance of choosing healthy food, doing appropriate physical activities and maintaining a healthy lifestyle. Therefore I argue that a good education helps people to keep their distance from obesity.

Theoretically, frequent physical activity helps people to keep fit and the more frequently people exercise, the more easily they can stay slim (Katzmarzyk 2008). I can see from Table 5 that the results for Canadians as a whole are consistent with this theory. As the frequency of physical activity increases, the chance of being obese decreases. When people exercise between 70 and 80 times per month, the magnitude of the marginal effect is the largest in absolute value, which means that those who exercise 70-80 times per month will be the least likely to be obese compared to those with other levels of physical activity. However, the situation is different for Aboriginal people. Only when they exercise 80-90 times per month will they have a significantly lower probability of being obese than the reference person, 19.93 percentage points lower. In other words, unless Aboriginal people exercise at a certain level (80-90 times per month), they will not experience the same effect in terms of obesity prevention as the average Canadian person, who can reduce the chance of becoming obese as they increase the frequency of exercise. However, I should also note that physically inactive (exercise less than 10 times per month) Aboriginal women face a higher chance of being obese than other Canadian women. This implies that although Aboriginal females find it less effective than other Canadian people to keep fit by doing physical activities, a proper volume of exercise per month is still suggested, since being physically inactive will cause them to face a 10.8 percentage points higher chance of being obese.

There is also a divergence between Canadians as a whole and Aboriginal people in terms of the effect of total consumption of fruits and vegetables. Table 5 indicates that proper consumption of fruits and vegetables (5–10 times a day) will decrease the opportunity of being obese for Canadians in general. More specifically, this dietary pattern is particularly effective for males. As Table 5 shows, the more servings a day they consume of fruits and vegetables, the less chance they will become obese. Nevertheless, the result for Aboriginal people is unexpected. Table 6 indicates that total consumption of fruits and vegetable has little impact on the probability of being obese. That is to say, changing eating habits may not help to reduce the high prevalence of obesity in the off-reserve Aboriginal population.

In general, people may think that drinking alcohol will trigger obesity because of the energy and sugar it contains. I get a very interesting and different result that implies that drinking alcohol frequently will *reduce* the probability of becoming obese, as shown in Tables 5 and 6. This effect is especially strong for females. Canadian women who drink alcohol every day are 6.2 percentage points less likely than weekly drinkers to be obese. I obtain an even more surprising result for Aboriginal women: if they drink alcohol 4 – 6 times a week, the probability of obesity will decrease by 18.89 percentage points. However, alcohol consumption does not seem to be significantly related to obesity in Aboriginal men. It should be noted that people who drink alcohol every day aren't necessarily alcoholics. Actually, many studies obtained similar findings to ours. Arif and Rohrer (2005) find that the odds of obesity are significantly lower among those who reported drinking frequently. Tolstrup et al. (2008) argue that drinking frequency is negatively associated with gains in waist circumference (WC) among females. The explanation for this finding may be that this variable is measured as a frequency, not as the amount consumed. Some research (e.g., Klesges et al. 1994) suggest that alcohol appears to

increase the body's metabolic rate significantly, so that it burns more calories rather than storing them as fat in the body. Some other studies (e.g., Colditz et al. 1991) have found that consumption of sugar decreases as consumption of alcohol increases. Moderate alcohol consumption may also have other benefits such as reducing the risk of cardiovascular disease, chance of diabetes and ischemic stroke. As mentioned before, the result should not be interpreted as recommending drinking as a method of preventing obesity, because alcohol abuse is pretty prevalent among the Aboriginal population and it damages people's health (Aboriginal Healing Foundation 2007).

The relationship between smoking patterns and obesity is similar for all Canadians and Aboriginal people. In the sample of Canadians, daily smokers and occasional smokers are both less likely to be obese than non-smokers, and daily smokers have the highest chance of avoiding obesity. Smoking has a similar effect for Aboriginal men, but less so for women. For Aboriginal males, the group that is the least likely to be obese is those who smoke occasionally. Only Aboriginal women who are daily smokers are significantly influenced by smoking.

The results show that adequate sleep can assist women to prevent obesity. In the sample of Canadian women, 7-8 hours of sleep is associated with the largest decrease in the probability of being obese. Meanwhile, in the sample of Aboriginal women, I observe a similar effect; Aboriginal women who sleep 8-9 hours are 11.02 percentage points less likely to be obese than those who sleep less than 5 hours. These findings are actually in accord with many studies that measure individuals' sleep habits and find a positive relationship between short sleep duration and obesity (Patel and Hu 2008). A similar result also can be found in Pan et al. (2011). They conclude that compared to women who slept seven hours a night, women who slept five hours or less were 15 percent more likely to be obese over the course of the study. The reasons are listed

as follows: first of all, lack of sleep may disrupt the hormone levels that are responsible for controlling hunger and thus stimulate people's appetite to eat more (Taheri et al. 2004). Also sleep deprivation may give people more time to eat and curb their physical activity because they feel tired during the day.

As a final note, it is interesting to point out that in Table 6, many insignificant marginal effects are large in magnitude (e.g., the marginal effect of *geo_NS* is 0.0945, which is big but not significant). I suspect that such results are due to the small sample size. Further exploration with a larger sample size would be worth doing in the future in order to obtain better insight to my results.

6 Conclusions

This paper tries to explore the factors that contribute to a high rate of obesity in the off-reserve Aboriginal population by comparing their obesity prevalence with that of the overall Canadian population. Econometric analyses were performed to investigate the relationship between Aboriginal obesity and various risk factors. I infer that genetic differences are probably responsible for part of the gap in obesity rates between Aboriginal Canadians and non-Aboriginal Canadians. In addition to genetic factors, I also found some other factors such as socioeconomic status and behavioral factors that contribute to their obesity problem.

The results of a logit model reveal a higher prevalence of obesity among the Aboriginal population than among the general Canadian population. Furthermore, the magnitude of the marginal effects and significances for many variables differ considerably between the Aboriginal and general Canadian populations.

A common belief is that younger people find it relatively easy to maintain body fitness and are less likely to be obese than older age groups because they have a higher metabolic rate,

less life stress and stay more physically active. While this is an accurate view of the general Canadian population it is not true for Aboriginal people. Aboriginal people in the 20 – 34 years age groups all face the same high risk of obesity. Furthermore, Aboriginal people over 55 years of age face an alarmingly high risk of obesity, i.e., approximately 45%.

Additionally, different geographic characteristics and health systems seem to have little impact on Aboriginal obesity rates. Across Canada and internationally, various studies all show that Aboriginal people tend to have a higher prevalence of obesity than the rest of the population. With respect to eating habits, I find that individual variation in daily consumption of fruits and vegetables has very little impact on Aboriginal obesity rates, in contrast to the overall Canadian population. Even physical activity has a limited impact on reducing their probability of obesity. Unlike the overall Canadian population, Aboriginal people appear not to be able to reduce their probability of obesity with physical activity unless they increase the frequency of their physical activities to 80-90 times monthly (which is a very high activity level only achieved by 1.37% of the overall Canadian population).

Liu et al. (2006) note a high prevalence of metabolic syndrome in the Aboriginal population, which may be related to the physical activity finding. Hegele et al. (1996) describe the metabolic science involved that makes fat metabolism different for the Aboriginal population and impacts on BMI: “genomic variation affecting the primary amino acid sequence of the intestinal fatty acid-binding protein would be related to variation in body mass index” and “the T54 variant of the intestinal fatty acid-binding protein is associated with differences in fat metabolism in this aboriginal population (p.34).” Combining my results with those of previous studies, I speculate that one of the reasons that leads to a high prevalence of obesity among the Aboriginal population is their genetic make-up.

Another factor contributing to obesity among Aboriginal people is socioeconomic status. Aboriginal males with the highest income have a higher probability of becoming obese. The possible explanations include less time for physical activity, more chances to eat outside than at home, and more stress from work or trying to build up a more powerful image in the work place.

Education plays an important role in Aboriginal obesity as well. Surprisingly, both poorly educated (i.e., less than secondary education) Aboriginal people of both genders and highly educated (i.e., Bachelor's degree and higher) Aboriginal women have a lower chance of becoming obese. I speculate that the reason behind these results may be that well-educated Aboriginal women know how to maintain a balanced and nutritionally healthy diet and know the importance of physical activity. This does not appear to be the case for similarly well-educated Aboriginal men. By contrast, poorly educated people of both genders may not be aware of the importance of nutritional balance because they lack such nutritional knowledge. It makes them less able to choose good quality food or the balance of nutrients needed for a healthy diet.

Their lifestyle also influences Aboriginal people's obesity. Being physically inactive (i.e., exercising less than 10 times a month) for women is associated with a higher probability of obesity. As mentioned above, more frequent physical activity is not associated with any statistically significant improvement in obesity prevalence.

Smoking, either daily or occasionally, is associated with lower obesity rates. This finding is consistent with the literature. There appears to be some unfortunate trade-off in health risks between smoking and obesity, even though it is clearly desirable that Aboriginal people avoid both smoking and lifestyle choices that result in obesity. Although Aboriginal people should not be encouraged to take up or to continue smoking, smoking is associated with a lower risk of developing obesity.

Drinking alcohol at a high frequency (more than 4 times per week) seems to benefit Aboriginal women in terms of obesity prevalence. This finding is similar to the one above for smoking and does not really form the basis for health promotion for Aboriginal women, because alcohol abuse is also severe among Aboriginal people and it will potentially disrupt people's digestive system, liver, brain, and nervous system (Aboriginal Healing Foundation 2007). Sleep hours are also related to the prevalence of obesity. Short duration of sleep makes Aboriginal women more likely to be obese compared to those who get 8-9 hours of sleep per night.

Furthermore, fruit and vegetable consumption does not seem to drive the high prevalence of obesity in the Aboriginal population, since the marginal effects of this variable are not statistically significant. I find the same conclusion in another study (Edwards 2007) which argues that fruit and vegetable consumption is not a significant predictor of obesity for Aboriginal people compared to other variables.

Based on their special health status (e.g., different fat metabolism), I suggest that Aboriginal people over 55 years old particularly should pay great attention to obesity, as the probability of being obese for this group may be as high as 45%. A proper amount of physical activity is also encouraged, even though the marginal effect of additional exercise for Aboriginal people is not statistically significant and lower than that for the overall Canadian population. For Aboriginal women, it is important to have adequate hours of sleep. Governments, on the other hand, should work to improve the overall level of Aboriginal education and knowledge of the benefits of healthy nutrition and daily physical activity. These have positive consequences for Aboriginal participation in the labour market, and should lead to overall health improvement due to obesity prevention.

One of the limitations of my study is the potential inaccuracy of the data. In the CCHS 2012, many variables are self-reported, which may lead to biases. For example, BMI is based on self-reported weight and height. I suspect that for some individuals, this variable is lower than its true value, because people frequently tend to self-report a higher height and lower weight.

Sample size is another limitation in this paper. Compared to the sample size of the Canadian sample, the size of the Aboriginal sample is very small: only 2307 compared to 41365. Consequently, in the sample of Aboriginal people, there are very few observations with certain characteristics (e.g., in Nova Scotia only 49 Aboriginal people were interviewed). This may be one of the reasons why there were numerous insignificant marginal effects for Aboriginal people. Furthermore, this research only focuses off-reserve Aboriginal people due to data limitations. Including both off-reserve Aboriginal people and on-reserve Aboriginal people may not only increase the sample size but also make this research more comprehensive and accurate.

Suggestions for future research are first of all, the Blinder - Oaxaca approach could be used to better decompose the differences between Aboriginal Canadians and non-Aboriginal Canadians into genetic and non-genetic factors.⁹ Second, pooling samples across years needs to be considered in order to enlarge the sample size for Aboriginal people and to gain a better insight to my results. Third, the problem of endogeneity may arise in the model, which leads to biases in the results. Socio-economic variables such as education or income might be correlated with the error term, since I did not include an employment variable in the model and it might be correlated with both obesity and the socio-economic variables. To resolve this kind of problem, IV estimation is recommended.

In conclusion, the causes of obesity are complex and varied and it is hard to capture all of the determinants of obesity in a single model. Limited by my knowledge and data, I include

⁹ Fairlie (2005) discusses how to apply the Blinder-Oaxaca method to logit and probit models.

contributing variables of three types—socio-demographic, socioeconomic and behavioral in my model, but am not able to include all of the potential factors.

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Tables

Table 1 Canadian Obesity Rates by Gender over Time

	Obese Men	Obese Women
2003	16.0	14.5
2004		
2005	16.9	14.7
2006		
2007	17.9	15.8
2008	18.3	16.2
2009	19.0	16.7
2010	19.8	16.5
2011	19.8	16.8
2012	18.7	18.0
2013	20.1	17.4

Source: Canadian Community Health Survey, 2003, 2005, 2007-2013
(<http://www.statcan.gc.ca/pub/82-625-x/2014001/article/14021/c-g/desc/14021-01-desc-eng.htm>)

Table 2 Body Mass Index (BMI) Categories

BMI category (range)	BMI index
Overweight and obese	≥25
Obese	≥30
Underweight	<18.5
Normal weight	18.5—24.9
Overweight (not obese)	25—29.9
Obese Class I	30.0—34.9
Obese Class II	35.0—39.9
Obese Class III	≥ 40.0

Source: Canadian Community Health Survey 2012: Annual Component

Table 3 Summary Statistics – Original Categorical Variables from CCHS

variable	overall Canadian people		Aboriginal people	
	mean	obs	mean	obs
Age (dhh_age)	43.34	41365	39.55	2307
Frequency of Physical Activity (pacdfm)	26.92	41365	28.91	2307
Consumption of fruits and vegetables (fvstot)	4.74	41365	4.28	2307
BMI (hwtbmi)	26.08	41365	27.35	2307

Source: Canadian Community Health Survey 2012: Annual Component

Table 4 Variable Names and Descriptions

Variables Names	Variable Description
Original Variables	
dhh_sex	Sex
dhh_age	Age
incdhh	Total household income from all sources
dhh_ms	Marital Status
slp_01	Number of hours spent sleeping per night
Hwtbmi	Body Mass Index (BMI) / self-report
Fvcgtot	categories of FV consumption
Pacdfm	Month. freq. - Leisure phys. Activity
smk_202	Type of smoke
alc_2	Frequency of drinking alcohol
edudh10	Highest level of education - respondent, 10 levels
geo_prv	Province of residence of respondent
Dependent Variable	
Obese	Dichotomous variable that equals 1 if body mass index ≥ 30 kg/m ²
Gender (reference: female)	
Male	Dichotomous variable that equals 1 if respondent is a man
Income (reference: inc_40000_59999)	
inc_les19999	equals 1 if total household income is less than 19999
inc_20000_39999	equals 1 if total household income is between 20000 to 39999
inc_60000_79999	equals 1 if total household income is between 60000 to 79999
inc_80000_99999	equals 1 if total household income is between 80000 to 99999
inc_100000_150000	equals 1 if total household income is between 100000 to 150000
inc_more150000	equals 1 if total household income is more than 150000
Age (reference: age 25-29)	
age18_19	equals 1 if age is between 18 and 19
age20_24	equals 1 if age is between 20 and 24

Variables Names	Variable Description
age30_34	equals 1 if age is between 30 and 34
age35_39	equals 1 if age is between 35 and 39
age40_44	equals 1 if age is between 40 and 44
age45_49	equals 1 if age is between 45 and 49
age50_54	equals 1 if age is between 50 and 54
age55_59	equals 1 if age is between 55 and 59
age60_64	equals 1 if age is between 60 and 64
age65_70	equals 1 if age is between 65 and 70
Frequency of Physical Activity (reference: PAC_20_30)	
PAC_less10	equals 1 if frequency is less than 10 times
PAC_10_20	equals 1 if frequency between 10 and 20 times
PAC_30_40	equals 1 if frequency between 30 and 40 times
PAC_40_50	equals 1 if frequency between 40 and 50 times
PAC_50_60	equals 1 if frequency between 50 and 60 times
PAC_60_70	equals 1 if frequency between 60 and 70 times
PAC_70_80	equals 1 if frequency between 70 and 80 times
PAC_80_90	equals 1 if frequency between 80 and 90 times
PAC_more90	equals 1 if frequency is more than 90 times
Daily Total Consumption of Fruits and Vegetables (reference: FV_less than 5)	
FV_5_10	equals 1 if daily consumption of FV is between 5 and 10 times
FV_more10	equals 1 if daily consumption of FV is more than 10 times
Smking Pattern (reference: SMK_NA)	
SMK_daily	equals 1 if smoke everyday
SMK_occ	equals 1 if smoke occasionally
Drinking Habit (reference: ALC_1 perweek)	
ALC_NA	equals 1 if don't drink
ALC_less1permonth	equals 1 if drink less than one time per month
ALC_1permonth	equals 1 if drink one time per month
ALC_2_3permonth	equals 1 if drink 2-3 times per month
ALC_2_3perweek	equals 1 if drink 2-3 times per week
ALC_4_6perweek	equals 1 if drink 4-6 times per week
ALC_everyday	equals 1 if drink everyday
Sleep Hours (reference: SLP_less than 5)	
SLP_5_6	equals 1 if sleep 5-6 hours per night
SLP_7_8	equals 1 if sleep 7-8 hours per night
SLP_8_9	equals 1 if sleep 8-9 hours per night
SLP_more9	equals 1 if sleep more than 9 hours per night
Marital Status (reference: mar_married)	
mar_comlaw	equals 1 if respondent is common law
mar_win_sep_div	equals 1 if respondent was married before
mar_single	equals 1 if respondent is single

Variables Names	Variable Description
Provincial Distribution (reference: geo_ON)	
geo_NL	equals 1 if respondent live in Newfoundland and Labrador
geo_PE	equals 1 if respondent live in Prince Edward Island
geo_NS	equals 1 if respondent live in Nova Scotia
geo_NB	equals 1 if respondent live in New Brunswick
geo_QC	equals 1 if respondent live in Quebec
geo_MB	equals 1 if respondent live in Manitoba
geo_SK	equals 1 if respondent live in Saskatchewan
geo_AB	equals 1 if respondent live in Alberta
geo_BC	equals 1 if respondent live in British Columbia
geo_TTR	equals 1 if respondent live in Territories
Highest level of Education (reference: edu_college)	
edu_lessec	equals 1 if the respondent got less secondary education
edu_sec	equals 1 if the respondent got secondary education
edu_sompostesec	equals 1 if the respondent got some post-secondary education
edu_BA	equals 1 if the respondent got bachelor degree education
edu_aboveBA	equals 1 if the respondent got above bachelor degree education
Ethnicity	
Aboriginal	equals 1 if the respondent is the aboriginal

Table 5 Marginal Effects for the Overall Canadian population

Variable	Marginal Effects		
	Full sample	Males	Females
Reference person*	0.1671	0.2192	0.1409
Male	0.024***		
age18_19	-0.0977***	-0.1279***	-0.081***
age20_24	-0.0531***	-0.058***	-0.05***
age30_34	0.0279***	0.024	0.034***
age35_39	0.0614***	0.077***	0.055***
age40_44	0.0629***	0.060***	0.073***
age45_49	0.0725***	0.074***	0.081***
age50_54	0.073***	0.065***	0.0859***
age55_59	0.0748***	0.075***	0.0804***
age60_64	0.0919***	0.083***	0.103***
age65_70	0.0636***	0.059***	0.069***
mar_comlaw	0.000294	-0.0127	0.0115
mar_win_sep_div	-0.00377	-0.0152	0.00014
mar_single	0.0047	-0.0204**	0.0277***
geo_NL	0.0254**	0.0576***	0.00708
geo_PE	0.0346**	0.0664**	0.0148
geo_NS	0.071***	0.031	0.1029***
geo_NB	0.039***	0.051***	0.033***
geo_QC	0.00587	-0.014	0.0179
geo_MA	0.076***	0.0452*	0.102***
geo_SK	0.0438***	0.0612***	0.031***
geo_AB	0.0596***	0.0158	0.094***
geo_BC	-0.0364***	-0.032***	-0.0395***
geo_TTR	0.0113	-0.020	0.042**
inc_les19999	0.00515	-0.02	0.015*
inc_20000_39999	-0.0036	-0.017*	0.0024
inc_60000_79999	-0.000138	-0.007	0.005
inc_80000_99999	0.00138	0.0062	-0.00257
inc_100000_150000	0.00916	0.019*	-0.00042
inc_more150000	0.0119	0.038***	-0.0139
edu_lessec	0.00614	0.0187	0.00082
edu_sec	0.00935	0.0186*	0.0044
edu_sompostesec	0.0112**	0.020**	0.0097
edu_BA	-0.0416***	-0.045***	-0.0408***
edu_aboveBA	-0.068***	-0.078***	-0.0622***
PAC_les10	0.0605***	0.059***	0.0629***
PAC_10_20	0.0323***	0.027***	0.035***
PAC_30_40	-0.007	0.0042	-0.0136*

Variable	Marginal Effects		
	Full sample	Males	Females
PAC_40_50	-0.0222***	-0.031**	-0.0174**
PAC_50_60	-0.025***	-0.029**	-0.0215**
PAC_60_70	-0.021**	-0.012	-0.0276**
PAC_70_80	-0.0569***	-0.064***	-0.054***
PAC_80_90	-0.0516***	-0.062***	-0.0463***
PAC_more90	-0.0485***	-0.052***	-0.0503***
FV_5_10	-0.0093**	-0.012*	-0.00542
FV_more10	-0.0129	-0.031*	-0.00138
SMK_daily	-0.05***	-0.064***	-0.0413***
SMK_occ	-0.0283***	-0.026**	-0.0318***
ALC_NA	0.019***	-0.0078	0.0368***
ALC_les1permonth	0.0639***	0.039***	0.0772***
ALC_1permonth	0.0303***	0.01	0.046***
ALC_2_3permonth	0.0198***	0.01	0.0299***
ALC_2_3perweek	-0.028***	-0.032***	-0.0303***
ALC_4_6perweek	-0.0495***	-0.053***	-0.0616***
ALC_everyday	-0.0483***	-0.048***	-0.0623***
SLP_5_6	-0.0334***	-0.00037	-0.0502***
SLP_6_7	-0.0315***	-0.014	-0.0406***
SLP_7_8	-0.0433***	-0.0278	-0.0507***
SLP_8_9	-0.0419***	-0.0209	-0.051***
SLP_more9	-0.0248*	-0.0126	-0.034**
Aboriginal	0.064***	0.064***	0.0653***
Observations	41365	19083	22282
LR chi2(61)	2403.55	906.22	1740.73
Prob > chi2	0.0000	0.0000	0.0000
Pseudo R2	0.0547	0.0442	0.0744

*** p<0.01, ** p<0.05, * p<0.1

Notes: (1) * indicates statistical significance at 10%, ** indicates statistical significance at 5%,

(2) ***indicates statistical significance at 1%.

(3) Reference person: a non-Aboriginal (female), aged 25-30, has an income of \$40,000-60,000 per year, exercises 20-30 times per month, eats fruits and vegetables less than 5 times per day, doesn't smoke, drinks once a week, sleeps less than 5 hours every day, is married, has a college education, and lives in Ontario.

Table 6 Marginal Effects for the Aboriginal population

Variables	Marginal Effects		
	Full sample	Males	Females
Reference person*	0.3025	0.2473	0.297
Male	-0.0198		
age18_19	-0.0936*	0.01357	-0.144**
age20_24	-0.0465	0.04986	-0.0853
age30_34	0.0685	0.07534	0.0855
age35_39	0.0863*	0.2285***	0.01274
age40_44	0.1254**	0.1312*	0.1504**
age45_49	0.0891*	0.0961	0.1295*
age50_54	0.0691	0.1349	0.028
age55_59	0.1485***	0.2211***	0.128*
age60_64	0.1491***	0.1698**	0.181***
age65_70	0.1336**	0.1912**	0.115
mar_comlaw	-0.0061	-0.0264	0.0171
mar_win_sep_div	-0.0365	-0.0142	-0.0513
mar_single	-0.0106	-0.0692*	0.038
geo_NL	-0.01945	0.0104	-0.0524
geo_PE	0.2065	0.386	NA
geo_NS	-0.0037	0.0945	-0.049
geo_NB	0.0597	-0.021	0.1865
geo_QC	-0.0372	-0.0342	0.0186
geo_MA	0.0829	0.144	0.0889
geo_SK	0.00838	0.0044	-0.000123
geo_AB	0.08724	0.109	0.1025
geo_BC	-0.0623*	-0.112**	-0.0178
geo_TTR	-0.0473	-0.0839*	0.01827
inc_les19999	-0.0023	-0.00895	-0.00639
inc_20000_39999	0.0285	0.0031	0.047
inc_60000_79999	-0.0159	0.00746	-0.0378
inc_80000_99999	-0.0419	-0.0501	-0.0313
inc_100000_150000	-0.0369	-0.03534	-0.0453
inc_more150000	0.0863*	0.0799	0.0567
edu_lessec	-0.1197***	-0.0754*	-0.1469***
edu_sec	0.0256	0.0719	0.0068
edu_sompostesec	-0.0216	-0.0183	-0.0186
edu_BA	-0.0633*	-0.048	-0.0759*
edu_aboveBA	-0.1059**	-0.019	-0.1635***
PAC_les10	0.0951***	0.0665	0.108**
PAC_10_20	0.0325	-0.011	0.0547
PAC_30_40	0.0093	-0.0172	0.0308

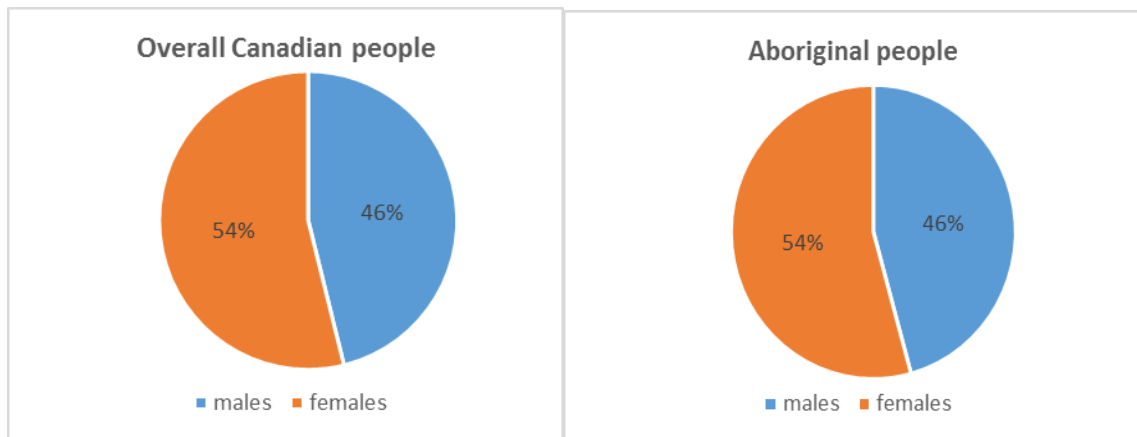
Variables	Marginal Effects		
	Full sample	Males	Females
PAC_40_50	0.00163	0.0219	-0.025
PAC_50_60	-0.0562	-0.0225	-0.0779
PAC_60_70	0.0125	0.00967	0.0202
PAC_70_80	-0.0257	0.0548	-0.0726
PAC_80_90	-0.1993***	-0.1864**	-0.1878**
PAC_more90	0.00091	-0.0145	0.0253
FV_5_10	-0.0126	-0.0000527	-0.0123
FV_more10	-0.0152	-0.0435	0.00513
ALC_NA	-0.0062	0.0362	-0.0278
ALC_less1permonth	0.08934**	0.06384	0.1007**
ALC_1permonth	0.0118	0.0655	-0.0234
ALC_2_3permonth	0.0165	0.0489	0.0017
ALC_2_3perweek	-0.0363	0.0077	-0.0766
ALC_4_6perweek	-0.0882*	-0.0104	-0.1889***
ALC_everyday	-0.1154**	-0.061	-0.1656**
SMK_daily	-0.0732***	-0.0889**	-0.0517*
SMK_occ	-0.0951**	-0.1053**	-0.0632
SLP_5_6	-0.0416	-0.1113	0.00157
SLP_6_7	-0.0531	-0.0770	-0.04344
SLP_7_8	-0.0638	-0.0679	-0.08416
SLP_8_9	-0.0544	-0.0119	-0.1102*
SLP_more9	0.0613	0.2213	-0.0301
Observations	2307	1055	1251
LR chi2(61)	179.82	118.84	129.76
Prob > chi2	0.0000	0.0000	0.0000
Pseudo R2	0.0637	0.0943	0.0831
*** p<0.01, ** p<0.05, * p<0.1			

Notes: (1) * indicates statistical significance at 10%, ** indicates statistical significance at 5%,
(2) *** indicates statistical significance at 1%.

(3) Reference person: an aged 25-30 (female), has an income of \$40,000-60,000 per year, exercises 20-30 times per month, eats fruits and vegetables less than 5 times per day, doesn't smoke, drinks once a week, sleeps less than 5 hours every day, is married, has a college education, and lives in Ontario.

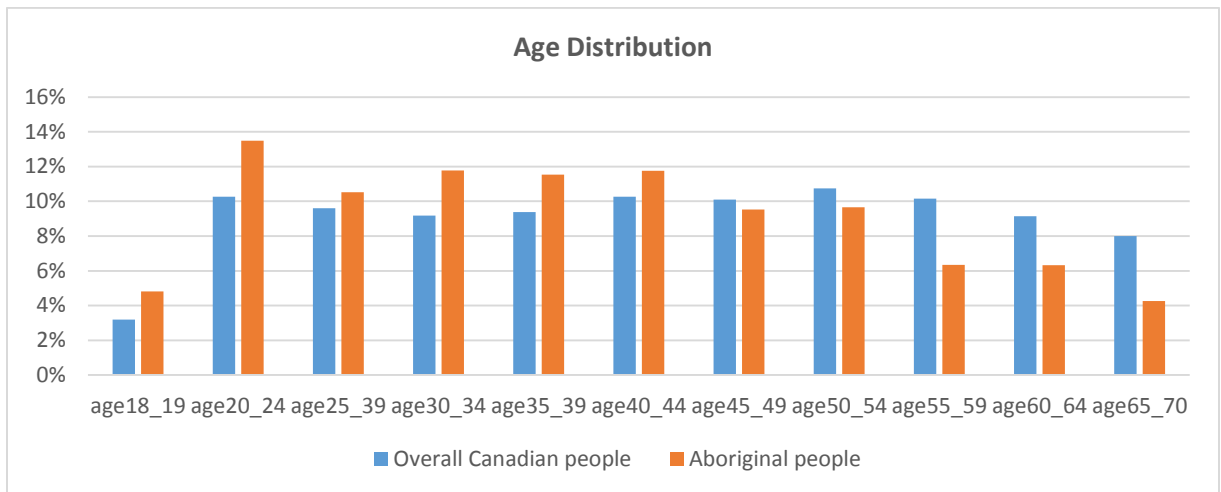
Charts

Chart 1 Gender Distribution



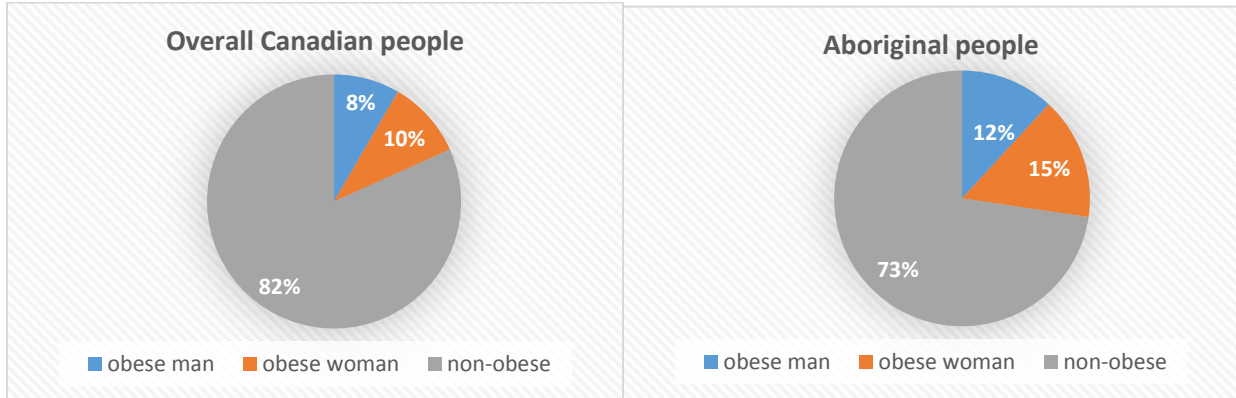
Source: Author's calculations from Canadian Community Health Survey 2012

Chart 2. Age Distribution



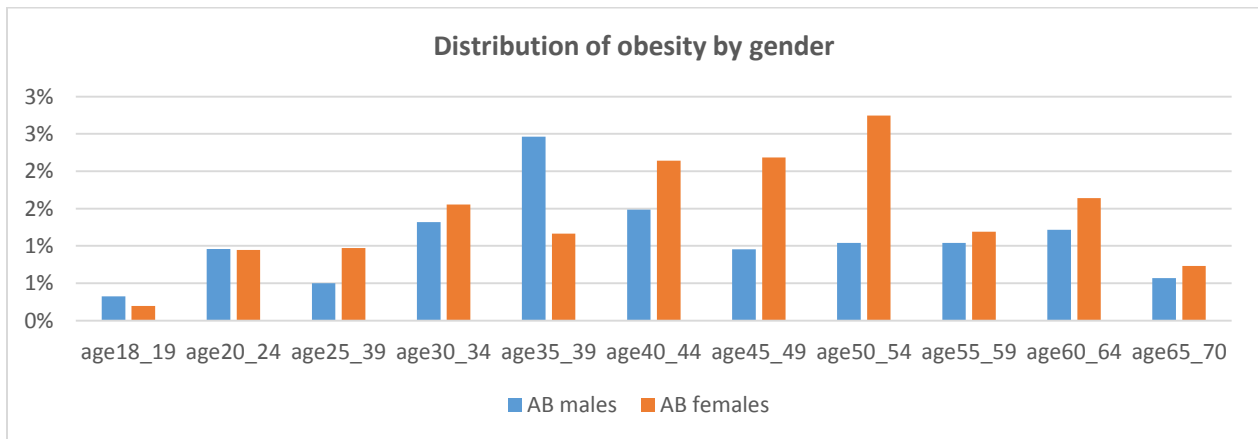
Source: Author's calculations from Canadian Community Health Survey 2012

Chart 3. Obesity Distribution



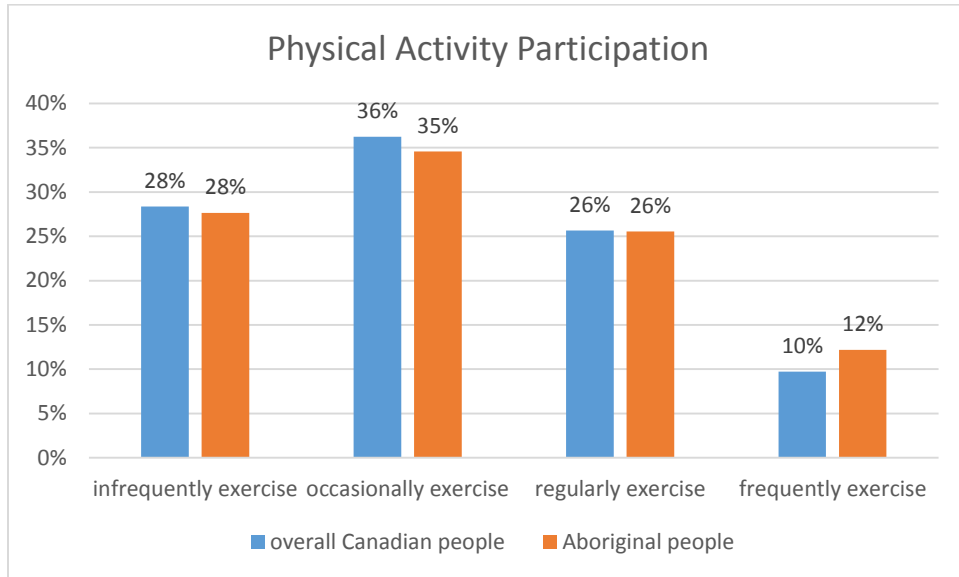
Source: Author's calculations from Canadian Community Health Survey 2012

Chart 4 Distribution of Obesity by Gender (Aboriginal people)



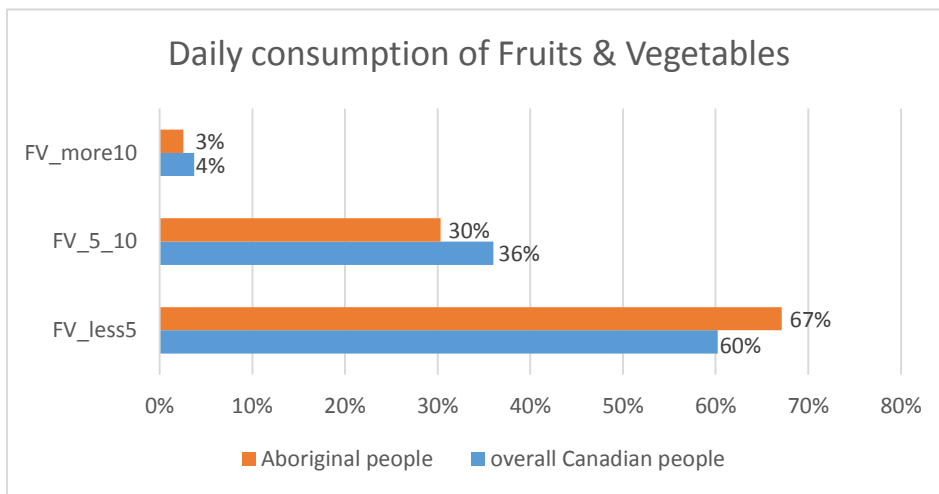
Source: Author's calculations from Canadian Community Health Survey 2012

Chart 5 Distribution of Physical Activity Participation



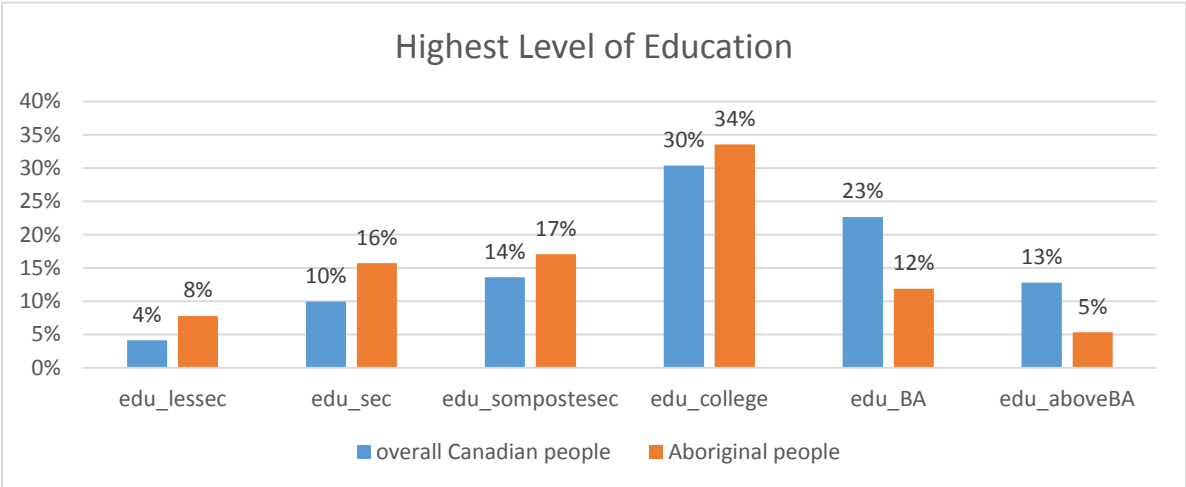
Source: Author's calculations from Canadian Community Health Survey 2012

Chart 6 Distribution of Daily Consumption of Fruits and Vegetables



Source: Author's calculations from Canadian Community Health Survey 2012

Chart 7 Distribution of Highest Level of Education



Source: Author’s calculations from Canadian Community Health Survey 2012

Appendix

A1. Summary Statistics – Dummy Variables from CCHS Used in Model

variable	overall Canadian people		Aboriginal people	
	mean	obs	mean	obs
Dependent variable				
Obese	0.1830	7,568	0.2732	630
Explanatory variables				
age18_19	0.0319	1,321	0.0481	111
age20_24	0.1027	4,249	0.1348	311
age25_39	0.0959	3,968	0.1053	243
age30_34	0.0917	3,795	0.1177	272
age35_39	0.0938	3,879	0.1154	266
age40_44	0.1026	4,245	0.1176	271
age45_49	0.1010	4,178	0.0953	220
age50_54	0.1075	4,445	0.0965	223
age55_59	0.1015	4,199	0.0634	146
age60_64	0.0914	3,779	0.0631	146
age65_70	0.0800	3,308	0.0427	98
mar_married	0.4706	19,467	0.3424	790
mar_comlaw	0.1123	4,646	0.1691	390
mar_win_sep_div	0.1558	6,444	0.1378	318
mar_single	0.2613	10,808	0.3507	809
geo_NL	0.0153	633	0.0426	98
geo_PE	0.0042	174	0.0008	2
geo_NS	0.0278	1,149	0.0354	82
geo_NB	0.0225	932	0.0218	50
geo_QC	0.2354	9,736	0.0990	228
geo_ON	0.3856	15,950	0.3063	707
geo_MA	0.0330	1,363	0.0990	228
geo_SK	0.0276	1,141	0.0680	157
geo_AB	0.1111	4,596	0.1379	318
geo_BC	0.1346	5,569	0.1552	358
geo_TTR	0.0030	123	0.0340	78
inc_les19999	0.0711	2,942	0.1450	335
inc_20000_39999	0.1560	6,451	0.1820	420
inc_40000_59999	0.1739	7,195	0.2049	473
inc_60000_79999	0.1626	6,726	0.1211	279
inc_80000_99999	0.1152	4,764	0.0894	206
inc_100000_150000	0.1885	7,797	0.1591	367
inc_more150000	0.1327	5,491	0.0984	227
edu_lessec	0.0416	1,720	0.0780	180

variable	overall Canadian people		Aboriginal people	
	mean	obs	mean	obs
edu_sec	0.0996	4,119	0.1572	363
edu_sompostesec	0.1362	5,635	0.1708	394
edu_college	0.3036	12,560	0.3354	774
edu_BA	0.2266	9,373	0.1186	274
edu_aboveBA	0.1277	5,283	0.0533	123
PAC_les10	0.2836	11,733	0.2766	638
PAC_10_20	0.2015	8,337	0.1965	453
PAC_20_30	0.1609	6,657	0.1493	344
PAC_30_40	0.1289	5,332	0.1437	332
PAC_40_50	0.0776	3,211	0.0832	192
PAC_50_60	0.0500	2,069	0.0287	66
PAC_60_70	0.0357	1,478	0.0421	97
PAC_70_80	0.0228	943	0.0163	38
PAC_80_90	0.0137	565	0.0128	29
PAC_more90	0.0251	1,040	0.0507	117
FV_les5	0.6024	24,919	0.6714	1549
FV_5_10	0.3603	14,904	0.3030	699
FV_more10	0.0373	1,543	0.0256	59
ALC_NA	0.1746	7,222	0.1676	387
ALC_les1permonth	0.1551	6,417	0.1811	418
ALC_1permonth	0.0781	3,229	0.0813	188
ALC_2_3permonth	0.1107	4,577	0.1560	360
ALC_1week	0.1459	6,036	0.1527	352
ALC_2_3perweek	0.2005	8,293	0.1650	381
ALC_4_6perweek	0.0668	2,762	0.0439	101
ALC_everyday	0.0684	2,829	0.0524	121
SMK_daily	0.1798	7,438	0.3234	746
SMK_occ	0.0550	2,273	0.0872	201
SMK_NA	0.7652	31,654	0.5894	1360
SLP_les5	0.0197	816	0.0170	39
SLP_5_6	0.0438	1,812	0.0528	122
SLP_6_7	0.0982	4,062	0.0800	184
SLP_7_8	0.1259	5,206	0.0888	205
SLP_8_9	0.0822	3,399	0.0718	166
SLP_more9	0.0185	766	0.0187	43

Source: Canadian Community Health Survey 2012: Annual Component

A2. Detailed Summary Statistics – Dummy Variables from CCHS Used in Model (Overall Canadian People)

Variable	Overall Canadian people							
	males				females			
	non-obese		obese		non-obese		obese	
	Mean	Obs	Mean	Obs	Mean	Obs	Mean	Obs
age18_19	0.0138	570	0.0007	30	0.0161	667	0.00138	57
age20_24	0.0435	1799	0.0046	189	0.0487	2014	0.00581	241
age25_39	0.0399	1652	0.0067	275	0.0429	1774	0.00599	248
age30_34	0.0357	1477	0.0067	278	0.0414	1711	0.00790	327
age35_39	0.0350	1446	0.0067	278	0.0408	1687	0.00874	362
age40_44	0.0375	1552	0.0106	438	0.0450	1861	0.00937	388
age45_49	0.0358	1483	0.0105	435	0.0437	1809	0.01095	453
age50_54	0.0376	1557	0.0103	425	0.0448	1855	0.01503	622
age55_59	0.0365	1509	0.0097	402	0.0437	1809	0.01171	485
age60_64	0.0326	1347	0.0106	439	0.0358	1482	0.0122	503
age65_70	0.0271	1121	0.0068	280	0.0367	1517	0.0100	414
mar_married	0.1611	6664	0.0566	2340	0.1962	8115	0.0568	2348
mar_comlaw	0.0403	1667	0.0110	457	0.0492	2034	0.0118	488
mar_win_sep_div	0.0420	1736	0.0132	546	0.0755	3124	0.0251	1038
mar_single	0.1126	4659	0.0245	1014	0.1000	4135	0.0242	1000
geo_NL	0.0049	201	0.0020	85	0.0063	259	0.0022	90
geo_PE	0.0013	55	0.0005	23	0.0017	72	0.0006	25
geo_NS	0.0093	385	0.0030	122	0.0113	467	0.0043	179
geo_NB	0.0071	295	0.0029	122	0.0091	376	0.0034	141
geo_QC	0.0906	3747	0.0187	776	0.1035	4280	0.0224	928
geo_ON	0.1442	5967	0.0323	1336	0.1711	7077	0.0382	1581
geo_MA	0.0123	511	0.0031	127	0.0139	575	0.0036	149
geo_SK	0.0093	385	0.0037	154	0.0111	461	0.0034	139
geo_AB	0.0436	1804	0.0098	405	0.0461	1907	0.0112	462
geo_BC	0.0099	408	0.0512	2118	0.0644	2664	0.0093	387
geo_TTR	0.0011	46	0.0003	12	0.0011	47	0.0004	16
inc_les19999	0.0226	934	0.0051	211	0.0334	1380	0.0111	459
inc_20000_39999	0.0520	2151	0.0109	450	0.0752	3,111	0.0197	813
inc_40000_59999	0.0622	2574	0.0145	599	0.0799	3,303	0.0181	748
inc_60000_79999	0.0674	2787	0.0132	546	0.0646	2,672	0.0163	675
inc_80000_99999	0.0444	1837	0.0104	430	0.0501	2,072	0.0099	411
inc_100000_150000	0.0708	2930	0.0189	783	0.0827	3,420	0.0155	642
inc_more150000	0.0556	2300	0.0133	551	0.0539	2,228	0.0085	350
edu_lessec	0.0145	598	0.0042	173	0.0166	685	0.0064	265
edu_sec	0.0378	1564	0.0098	407	0.0391	1617	0.0124	511

Variable	Overall Canadian people							
	males				females			
	non-obese		obese		non-obese		obese	
	Mean	Obs	Mean	Obs	Mean	Obs	Mean	Obs
edu_sompostesec	0.0487	2013	0.0149	616	0.0548	2266	0.0175	726
edu_college	0.1064	4400	0.0278	1149	0.1355	5603	0.0348	1440
edu_BA	0.0878	3631	0.0160	661	0.1066	4410	0.0161	665
edu_aboveBA	0.0505	2089	0.0073	304	0.0627	2595	0.0072	298
PAC_les10	0.1091	4511	0.0295	1222	0.1071	4430	0.0364	1506
PAC_10_20	0.0702	2902	0.0183	757	0.0907	3752	0.0233	962
PAC_20_30	0.0595	2460	0.0121	500	0.0752	3111	0.0147	608
PAC_30_40	0.0461	1906	0.0106	437	0.0620	2565	0.0108	447
PAC_40_50	0.0294	1217	0.0054	223	0.0371	1535	0.0059	245
PAC_50_60	0.0190	786	0.0032	133	0.0244	1008	0.0036	149
PAC_60_70	0.0137	565	0.0034	142	0.0165	681	0.0020	85
PAC_70_80	0.0100	414	0.0010	40	0.0107	445	0.0010	41
PAC_80_90	0.0062	256	0.0011	46	0.0057	234	0.0005	20
PAC_more90	0.0120	496	0.0017	69	0.0102	424	0.0008	35
FV_less5	0.2475	10237	0.0626	2589	0.2280	9432	0.0580	2398
FV_5_10	0.1148	4749	0.0218	903	0.1920	7941	0.0375	1553
FV_more10	0.0128	528	0.0019	78	0.0196	812	0.0035	147
ALC_NA	0.0529	2190	0.0119	492	0.0880	3641	0.0249	1028
ALC_les1permonth	0.0408	1690	0.0120	496	0.0782	3235	0.0278	1151
ALC_1permonth	0.0270	1,117	0.0063	262	0.0362	1497	0.0091	375
ALC_2_3permonth	0.0391	1,618	0.0096	399	0.0513	2121	0.0111	459
ALC_1week	0.0580	2,399	0.0144	597	0.0614	2,538	0.0111	460
ALC_2_3perweek	0.0897	3,710	0.0190	784	0.0781	3,230	0.0105	436
ALC_4_6perweek	0.0339	1,404	0.0058	239	0.0232	958	0.0021	88
ALC_everyday	0.0335	1,386	0.0073	301	0.0234	966	0.0024	100
SMK_daily	0.0792	3,277	0.0167	690	0.0660	2,729	0.0154	637
SMK_occ	0.0233	963	0.0037	155	0.0229	948	0.0047	193
SMK_NA	0.2725	11,274	0.0659	2725	0.3507	14,508	0.0790	3,267
SLP_less5	0.0075	310	0.0020	82	0.0068	282	0.0033	138
SLP_5_6	0.0173	717	0.0040	166	0.0176	729	0.0045	188
SLP_6_7	0.0394	1,632	0.0090	374	0.0388	1,605	0.0101	419
SLP_7_8	0.0475	1,963	0.0093	385	0.0573	2,368	0.0121	501
SLP_8_9	0.0281	1,161	0.0069	284	0.0398	1,645	0.0081	336
SLP_more9	0.0062	257	0.0012	50	0.0093	385	0.0020	85

Source: Canadian Community Health Survey 2012: Annual Component

**A3. Detailed Summary Statistics – Dummy Variables from CCHS Used in Model
(Aboriginal People)**

Variable	Aboriginal people							
	males				females			
	non-obese		obese		non-obese		obese	
	Mean	Obs	Mean	Obs	Mean	Obs	Mean	Obs
age18_19	0.0159	37	0.0032	7	0.0275	63	0.0020	5
age20_24	0.0610	141	0.0096	22	0.0536	124	0.0095	22
age25_39	0.0377	87	0.0050	11	0.0537	124	0.0097	22
age30_34	0.0382	88	0.0132	30	0.0511	118	0.0156	36
age35_39	0.0341	79	0.0246	57	0.0443	102	0.0116	27
age40_44	0.0470	108	0.0148	34	0.0333	77	0.0214	49
age45_49	0.0388	89	0.0095	22	0.0246	57	0.0218	50
age50_54	0.0213	49	0.0104	24	0.0391	90	0.0274	63
age55_59	0.0213	49	0.0104	24	0.0228	53	0.0119	27
age60_64	0.0166	38	0.0122	28	0.0213	49	0.0164	38
age65_70	0.0128	30	0.0057	13	0.0170	39	0.0073	17
mar_married	0.0967	223	0.0572	132	0.1244	287	0.0642	148
mar_comlaw	0.0511	118	0.0186	43	0.0694	160	0.0299	69
mar_win_sep_div	0.0342	79	0.0160	37	0.0603	139	0.0273	63
mar_single	0.1452	335	0.0381	88	0.1170	270	0.0503	116
geo_NL	0.0126	29	0.0087	20	0.0171	39	0.0039	9
geo_PE	0.0002	0	0.0005	1	0.0001	0	0.0000	0
geo_NS	0.0082	19	0.0061	14	0.0182	42	0.0032	7
geo_NB	0.0069	16	0.0070	16	0.0047	11	0.0027	6
geo_QC	0.0383	88	0.0097	22	0.0391	90	0.0115	27
geo_ON	0.1025	237	0.0336	78	0.1084	250	0.0622	144
geo_MA	0.0335	77	0.0093	21	0.0448	103	0.0117	27
geo_SK	0.0187	43	0.0109	25	0.0282	65	0.0104	24
geo_AB	0.0475	110	0.0172	40	0.0483	112	0.0246	57
geo_BC	0.0553	128	0.0135	31	0.0676	156	0.0190	44
geo_TTR	0.0137	32	0.0033	8	0.0117	27	0.0051	12
inc_les19999	0.0398	92	0.0175	40	0.0566	131	0.0323	75
inc_20000_39999	0.0571	132	0.0249	57	0.0675	156	0.0327	75
inc_40000_59999	0.0718	166	0.0245	57	0.0833	192	0.0249	57
inc_60000_79999	0.0385	89	0.0133	31	0.0513	118	0.0184	43
inc_80000_99999	0.0293	68	0.0059	14	0.0455	105	0.0095	22
inc_100000_150000	0.0543	125	0.0148	34	0.0628	145	0.0276	64
inc_more150000	0.0465	107	0.0189	44	0.0211	49	0.0091	21
edu_lessec	0.0266	61	0.0076	18	0.0302	70	0.0137	32
edu_sec	0.0511	118	0.0168	39	0.0632	146	0.0261	60

Variable	Aboriginal people							
	males				females			
	non-obese		obese		non-obese		obese	
	Mean	Obs	Mean	Obs	Mean	Obs	Mean	Obs
edu_sompostesec	0.0560	129	0.0247	57	0.0660	152	0.0241	56
edu_college	0.0943	217	0.0400	92	0.1291	298	0.0720	166
edu_BA	0.0450	104	0.0138	32	0.0510	118	0.0088	20
edu_aboveBA	0.0215	50	0.0067	15	0.0209	48	0.0041	9
PAC_les10	0.0812	187	0.0333	77	0.0993	229	0.0644	148
PAC_10_20	0.0642	148	0.0207	48	0.0802	185	0.0322	74
PAC_20_30	0.0489	113	0.0223	51	0.0620	143	0.0157	36
PAC_30_40	0.0555	128	0.0114	26	0.0608	140	0.0159	37
PAC_40_50	0.0290	67	0.0092	21	0.0284	66	0.0166	38
PAC_50_60	0.0117	27	0.0032	7	0.0105	24	0.0031	7
PAC_60_70	0.0129	30	0.0051	12	0.0207	48	0.0035	8
PAC_70_80	0.0040	9	0.0034	8	0.0077	18	0.0030	3
PAC_80_90	0.0067	15	0.0003	1	0.0054	12	0.0004	1
PAC_more90	0.0233	54	0.0109	25	0.0132	31	0.0026	4
FV_less5	0.2468	569	0.0897	207	0.2282	527	0.1027	237
FV_5_10	0.0810	187	0.0285	66	0.1483	342	0.0491	113
FV_more10	0.0096	22	0.0017	4	0.0117	27	0.0027	6
ALC_NA	0.0500	115	0.0210	49	0.0645	149	0.0329	76
ALC_les1permonth	0.0442	102	0.0242	56	0.0655	151	0.0492	113
ALC_1permonth	0.0249	58	0.0121	28	0.0324	75	0.0118	27
ALC_2_3permonth	0.0484	112	0.0151	35	0.0761	176	0.0175	40
ALC_1week	0.0466	107	0.0163	38	0.0647	149	0.0260	60
ALC_2_3perweek	0.0785	181	0.0191	44	0.0511	118	0.0134	31
ALC_4_6perweek	0.0170	39	0.0055	13	0.0202	46	0.0009	2
ALC_everyday	0.0279	64	0.0065	15	0.0138	32	0.0028	6
SMK_daily	0.1124	259	0.0388	90	0.1231	284	0.0486	112
SMK_occ	0.0329	76	0.0037	8	0.0345	80	0.0166	38
SMK_NA	0.1921	443	0.0774	179	0.2305	532	0.0894	206
SLP_less5	0.0025	6	0.0059	14	0.0066	15	0.0019	4
SLP_5_6	0.0165	38	0.0035	8	0.0248	57	0.0085	20
SLP_6_7	0.0319	74	0.0074	17	0.0278	64	0.0124	29
SLP_7_8	0.0380	88	0.0053	12	0.0365	84	0.0086	20
SLP_8_9	0.0208	48	0.0135	31	0.0274	63	0.0099	23
SLP_more9	0.0028	6	0.0015	3	0.0113	26	0.0038	9

Source: Canadian Community Health Survey 2012: Annual Component