An Economic Analysis of Adult Obesity in Canada

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Abstract

This paper provides a thorough exploration of socio-economic, genetic and behavioral factors of overweight and obesity in Canada. In particular, such determinants as gender, age, racial background, education level, living conditions, household income, fruits and vegetables consumption, frequency of physical exercises, number of hours spent at work, and food consumption expenditures by types of food purchasing locations are analyzed. For this analysis I combine data from the CCHS (Cycle 1.1) and the FOODEX. I estimate regression models where body mass index is the dependent variable, and I also estimate Probit models to analyze the determinants of the probability of being overweight. Analysis by age and gender groups is performed. There are a number of new interesting findings. It is found that among younger individuals body mass index grows faster with age for men than for women. However, this trend reverses itself for older individuals. The analysis of food consumption behavior shows that eating in fast food restaurants contributes to increasing body weights of Canadians more than eating meals purchased in table service restaurants or food prepared at home.

1. Introduction

This paper addresses determining factors of growing obesity rates in Canada. The proportion of Canadian adults considered overweight and obese increased from 40.0% and 9.7% in 1970–1972 to 50.7% and 14.9% in 1998 (Katzmarzyk, 2002). According to the Canadian Community Health Survey, in 2004 59.2% of Canadians aged 18 or older were overweight and 23.1% obese (Tjepkema, 2005). People who are overweight or obese suffer more frequently from hypertension, type 2 diabetes and coronary artery disease. Obesity can also lead to premature death, stroke, gallbladder disease, osteoarthritis, sleep apnea, asthma, breathing problems, cancer, high blood cholesterol, menstrual irregularities, hirsutism, stress, incontinence, and depression (Auld, 2004). The economic burden of obesity in 1997 in Canada was estimated to be $1.8 billion or 2.4% of the total health care expenditures (Birmingham et al., 1999). According to more recent estimates the cost of obesity amounts to $4.3 billion (Starky, 2005).

The roots of obesity are complex and include many different factors such as, for example, economic, behavioral, social or genetic factors. As obesity rates in Canada are growing, it is important to analyze the factors that generate this trend for purposes of developing effective policy instruments to tackle the problem. According to the Canadian Minister of State (Public Health): "Encouraging and supporting healthy weights will require cooperative action across all sectors and levels of government … social, economic, physical and environmental factors must be addressed to create environments that will support Canadians in making healthy choices" (Starky, 2005). While there is substantial economic analysis of obesity performed in the United States, the research in Canada is noticeably less advanced. Canadian papers on obesity among adults are usually limited to general overview of the problem, and in many cases only basic statistical approaches are used.

In this paper I fill the gap in the literature by providing a thorough exploration of determining factors of obesity in Canada including genetic, behavioral and socioeconomic factors. The role of food consumption behavior is also analyzed.

2. Literature Overview

2.1 Research of Obesity in the United States

Chou et al. (2004) analyze the factors that determine the growth of obesity rates in the United States. The authors base their research on the 1984–1999 Behavioral Risk Factor Surveillance System. They perform a regression analysis of obesity rates and estimate the influence of socio-economic characteristics as well as state level measures like per capita number of fast-food and full-service restaurants, prices of meals in different types of restaurants, prices of food consumed at home, cigarettes and alcohol prices, and indoor smoking laws. Results show that the increase in the per capita number of restaurants makes the most significant contribution to the growth in obesity rates in the United States, accounting for 61% of the growth in body mass index and 65% of the increase in percentages of people with obesity in the total population. The next substantial factor is the real price of cigarettes, representing 21% of the increase in obesity. The authors explain the latter correlation by a substitution effect between calories and nicotine. Food prices have an inverse effect on obesity trend. As the price of meals consumed at home and in restaurants fall, obesity rates grow. Contribution of food prices to obesity rates was estimated to be 12%, with 7% related to prices of food consumed at home. Prices of alcohol products turned out to have a small influence on obesity rates.

The analytical framework of Chou et al. (2004) presents obesity as a result of satisfaction of other goals. For example, by enjoying certain types of foods and drinks with high number of calories, or by satisfying social needs when eating in restaurants, or by saving time when eating in fast food establishments, an individual may give up her or his goal of sustaining a healthy weight.

Chou et al. (2005) use individual-level data from the First, Second, and Third National Health and Nutrition Examination Surveys to explore obesity rate factors. In addition to analyzing such factors as ethnicity, age, gender, household income, marital status, years of formal education, state restaurant density, state smoking regulations, including laws against smoking in public places and the cigarette tax, they also consider the influence of state gasoline taxes on individual body mass index and obesity. There is a non linear relationship between obesity rates and the gasoline tax. Body mass index levels increase with gasoline tax when taxes are low, and decrease at higher levels of tax. The authors suppose that this indicates that, as gas prices increase, people travel less to locations where they could purchase healthy foods, like, supermarkets. Gasoline tax is believed to increase the cost of food prepared at home. Results for the other variables are similar to those of Chou et al. (2004).

Rashad (2006) employs the First, Second, and Third National Health and Nutrition Examination Surveys to estimate a structural model of the determinants of adult obesity. To control for the potential endogenity of some explanatory variables, such as caloric intake (adjusted for activity level) and smoking, a set of reduced form equations for these outcomes is estimated simultaneously with the obesity equation. An array of state-level characteristics are used as instruments. In his OLS regressions, the author finds a strong positive correlation between food intake and smoking rates. He finds that obesity rates are growing with age. Blacks, Hispanic females, and married men are more likely to be overweight. People with higher education, on the other hand, have a lower probability of being overweight. The two-stage least squares (TSLS) models still show strong dependency of obesity rates on calories intake for females, but not for other groups. Marriage status is a significant obesity factor for males in these models. The author also identified that smoking and family income have different effect on obesity rates, depending on racial and gender groups. Higher family income results in higher obesity rates for males, but not for females.

Philipson et al. (1999) rely on economic theory to analyze obesity in developed countries. The authors believe that an individual's decisions regarding body mass are influenced by time availability and financial resources. They also incorporate technological progress in their analysis, as it increases general productivity as well as the quality of medical services. The authors also examine economic determinants of obesity. Among the economic factors that shape calories intake are food prices and income. Calories expenditure is defined by occupation, housing, transportation, and exercise. Technological change reduces the average number of calories expended at work as well as the number of calories needed for performing household chores. Among policy instruments addressed by the paper are education about health dieting and exercises, taxes and subsidies. The authors also discuss alternative theories of obesity, for example, the view that an individual's weight is a signal of social status, and the alternative theory of food addictions. The authors also discuss possible directions of future research. In particular, they suggest analyzing how physical activity on the job influences body weight. They also suggest researching how gender and marital status affect obesity rates. The authors argue that the increase in obesity rates is self limiting, since income growth due to technological progress could not only result in increase in sedentary activities, but also result in higher demand for "thinness".

Performing a longitudinal analysis of developed countries, Bleich et al. (2007) estimate the relative contribution of increased caloric intake and reduced physical activity on obesity. Their results show that increases in obesity rates can be primarily attributed to increases in calories consumption. The authors also estimate multivariate regression models and use simulation analysis to study the technological and socio-demographic determinants of this dietary excess. Their findings indicate that the increase in caloric intake is related to technological innovations, reduced food prices as well as changing socio demographic factors which involve urbanization and increased labor force participation of women.

Burke et al. (2007) address the social determinants of growing obesity rates in the United States over the last 30 years. The authors incorporate both food and non-food consumption in their analysis. They also look at how social norms affect individual's body weight, and introduce a notion of "desired weights." There is a desire to weigh less than an average individual in the society. But with falling prices and increased obesity rates, an average individual becomes more likely to be overweight, and consequently "desired weights" also increase, resulting in further increase in obesity rates. In addition, the paper analyzes the basal metabolic rate, a physiological factor that influences individual's inclination to gain weight. Their model is calibrated to American women in the 30- to 60-yr-old age bracket using data from the Behavioral Risk Factor Surveillance System (BRFSS). The authors compare the predicted weight distributions to National Health and Nutrition Examination survey data spanning (intermittently) the years 1976-2000. The findings of the paper indicate that as food prices fall, "desired weights" shift up, but with a lag of several years. They also find a concave relationship between body weight and the metabolism rate. Therefore, as individual's body weight grows, her chances of gaining additional weight increases. In this situation, it is harder for an individual to predict her future weight as there is an underestimation of how food consumption influences body weight. The model of endogenous norms developed by the authors predicts that population weights would increase as prices fall, but that the marginal increase becomes smaller. However, the authors note that if the metabolism curve becomes flat after a certain point, which is feasible, then population body weight could continue to grow.

There are also a number of papers addressing the issue of growing childhood obesity. According to Ogden et al (2002), "Between 1960 and 1988-1994, the prevalence among 6 –through 11-year old children increased from 4% to 11%. During this same period, the prevalence among 12- through 19-year old increased from 5% to 11%." Though the primary focus of this paper is adult obesity, it is important to mention that child and youth obesity may be a determining factor of adult obesity.

2.2 Research of Obesity in Canada

Auld et al. (2005) use cross sectional data on middle-aged adults in the United States and Canada to analyze the "obesity gap" between the two countries. They find that such socio-demographic factors as income, education, race, and living arrangements do not explain the "obesity gap." The authors argue that even if the distributions of these variables were identical in both countries, a person from the U.S. would, on average, still be "somewhat heavier" than a Canadian. The research, however, revealed substantial differences across socio-demographic groups in the size of the "obesity gap". The authors also address the importance of contextual factors on obesity, such as prices of fast food, prices of fruits and vegetables, and per capita number of supermarkets. However, the paper is primarily focused on social demographic groups and does not analyze contextual factors of obesity in Canada. The authors limit their analysis to contextual factors of obesity in the Unites States as they had no comparable Canadian data.

Tjepkema (2005) looks into the trends of obesity rates in Canada, and analyzes body mass index by regions, social and demographic groups as well as by lifestyle based on Cycle 2.2 of the CCHS. The paper finds that 23.1% of Canadians were obese in 2004 (approximately 5.5 million people) of which 15.2 % are of type I, 5.1% of type II, and 2.7 % of type III. The types of obesity are identified by body mass index levels, with the levels increasing from obesity of type I to type III. See Appendix B for a definition of body mass index and information on types of obesity.

Tjepkema (2005) also looks at the increase in obesity rates across gender, age, geographical groups. He concludes that people in the 25 to 35 age bracket had the largest increase in obesity rates. The percentage of obese people in this group more than doubled in the last 27 years rising from 8.5% to 20.5%. The distribution of males and female obesity also differs by obesity types.

Women are more likely to have obesity of type III than men, though men are more likely to be overweight than women. Obesity rates do not differ greatly by province. There are some exceptions: men's obesity rates were higher than the national level (22.9%) in Newfoundland and Labrador (33.3%) and Manitoba (30.4%). Women's obesity rates were significantly higher than the national figure (23.2%) in Newfoundland and Labrador (34.5%), Nova Scotia (30.3%) and Saskatchewan (32.9%).

The paper also analyzed the influence of behavioral factors on obesity rates. For example, it was noted that respondents who ate fruits and vegetables more often were less likely to be obese. Another behavioral factor of obesity discussed by Tjepkema (2005) is physical activity. People whose leisure time was sedentary had a higher body mass index. 27.0% of physically inactive men were obese, while obesity rate for active men was 19.6%. For women higher obesity rates where noted not only among respondent with sedentary leisure time, but also among those who were moderately active. Marital status of men according to Tjepkema (2005) did not have significant influence on the levels of body mass index, while it was noted that obesity rates increase among widowed women. Another factor analyzed in the paper is education level. Both for females and males with postsecondary education, obesity rates were lower than for those with only high school diploma. As for income, male obesity rates increase with income. Body mass index levels of women are higher in middle and upper middle income households. In high income households, however, women were less likely to be obese.

The paper also looks into relationship between high body mass index and different chronic conditions. For example, high blood pressure was reported by 10% of respondents with normal body mass index. This rate for overweight people was 15% and for obese respondents- 20%. Type 2 diabetes was reported by 2.1% of male respondents with normal body weight versus 3.7% for overweight respondents and 11% for obese respondents. Similar patterns were noted for females. Chances of heart disease also increase with body weight. The following rates were reported by male respondents: normal body mass index - 2.8%, overweight - 6%, obese - 8%. For women chances of heart disease do not increase as fast with body mass index, but were higher for women with type III obesity.

It should be noted that Tjepkema (2005) does not use a regression approach when analyzing obesity factors. The author compares obesity rates among groups of individuals defined by gender, age or other characteristics. As such, it is possible that the Tjepkema (2005) findings may be the results of correlations between explanatory variables – a possible confounding factor.

Starky (2005) provides a brief overview of obesity in Canada. The author notes that obesity factors are related to food intake and expenditures of calories. The author lists such factors of obesity as sedentary lifestyles due to urban planning and technological change, increasing portion sizes and the poor availability of nutritional food choices in schools and workplaces. He mentions that researches have different view on whether calories intake or expenditure play a more important role in the growing obesity rates. He includes a quote from Katzmarzyk et al. (2004): "there is no consensus as to whether the current obesity epidemic in North America is primarily the result of high levels of physical inactivity or high dietary intake of energy-dense foods, and it is likely that both dietary intake and physical inactivity have played a role in the increasing prevalence of overweight and obesity." The article also provides an overview of possible factors of obesity in a chart form (see Appendix D). This chart contains an analysis of different types of factors and allows for a better understanding of the different determinants of obesity. The chart divide factors by geographical scales and includes such categories as local, national, international factors. It also includes factors that result from an individual's behavior. However, no statistical or regression analysis is performed to evaluate these factors in the article.

Starky (2005) also looks into the economic burden of obesity. The author proposes to divide costs related to high body mass index levels into direct and indirect costs. The former involves actual payment, and the latter includes negative outcomes and losses to the population's welfare. The author presents a summary of results of different research on obesity costs in Canada. As different authors include different negative outcomes, as well as have different methodology in estimation, results vary from a cost of 1.8 billion to 5.3 billion in 2001. Direct costs include hospital care, physician services, drugs, healthcare research, and indirect costs could include premature death, short-term and long-term disabilities caused by health problems related to obesity (Starky, 2004).

Raine (2004) summarizes the current knowledge related to the nature and extent of the obesity problem with regard to prevention and control, the factors of obesity, effectiveness of strategies for addressing obesity and its determinants. The paper also identifies directions for future policy research. The paper, however, does not perform a regression analysis to evaluate the impacts of different factors on obesity.

Raine (2004) firstly looks into the current trends in Canada as well as in North America and internationally. The data shows a steady increase in overweight and obesity rates in all of the industrialized countries. Though the increase in number of overweight and obese people in Canada is not as high as in the Unites States, it is still substantial.

When evaluating the negative effect of increasing obesity, Raine (2004) includes the following data which is based on the research performed by Peeters et al. (2003): "Overweight (body mass index = 25.0 to 29.9) was associated with a loss of more than three years of life for both male and female non-smokers. Obesity (body mass index > 30.0) at age 40 was associated with a loss of 7.1 years of life for females and 5.8 years for men. Obese smokers lost more than 13 years of life compared to normal weight smokers". Research conducted in Canada revealed the following results: "between 1985 and 2000, the population attributable risk of death associated with overweight and obesity increased from 5.1% to 9.3% of all deaths among 20- to 64-year-olds" (Raine, 2004).

Raine (2004) also discusses determining factors of obesity. He first looks at genetic factors. Obesity is possibly due to specific genes that enable human body to accumulate energy in times of food abundance. This function is vital when there is variation in food availability, and was useful, in earlier stages of development of human society, when food availability was dependent on a large number of factors. Given their different genetic background, some people are more susceptible to gain weight.

The author also discusses behavioral factors of obesity, like dieting and physical activities. When discussing diet trends the author mentions that per capita energy availability per day stayed relatively stable at approximately 3,170 kilocalories over the 1976 to 1991 period. In the 1990s, there was a dramatic increase in food availability. Per capita energy availability per day increased to 3,674 kilocalories by 2001, making for a 16% increase. The author mentions that the substantial increase still holds if adjustments in calculation of per capita energy availability are taken into consideration. To better understand physical inactivity in Canada the author analyzes data from the Canadian Community Health survey from 2000-2001, which revealed that "80% of Canadian adults aged 20+ (77% of men and 82% of women) are insufficiently active for health benefits. 25% fewer (59% of women and 53% of men) are sedentary" (Raine , 2004).

Barham et al. (2008) look at gender difference in income level as a possible determining factor of obesity in Canada. Using data from the Canadian Community Health Survey, they show that income matters. A strong positive association between income and body mass index can be noted for men. For women, however, higher income leads to a lower body mass index. One of the reasons for this difference, according to the authors, could be the fact that body mass may be a determinant of income for women, but not for men. The authors also find that income is a more significant factor for women, than for men. For example, "adding $2,350 income to low-income women decreases their probability of being obese by 4%" (Barham et al., 2008), while for men the results are not obvious.

Barham et al. (2008) also look at other possible factors of overweight and obesity. According to their finding the likelihood of being obese increases with age, though the significance of this factor decreases with age. Married people are also more likely to be obese, and marital status increases the chances of being obese for men more than for women. The number of children also matters, increasing body mass index of both men and women, with a significantly stronger effect for women. Education is another factor analyzed by the authors. They find that body mass index, as well as obesity, are inversely related to education attainment.

The paper also includes geographical and ethnic factors. They find that people in metropolitan areas are less like to be overweight and obese. This is explained by more opportunities for walking in the cities. There is a difference in probability to be obese and overweight amount Canadian provinces. People who live in British Columbia and Quebec are less likely to have high body weights than those who live in Ontario; while those who live in Atlantic Canada are more likely than Ontarians to be overweight and obese. Their analysis of ethnicity showed that people of Asian origin have lower body mass index. High body mass index levels were noted among aboriginal population. Women with African origin are more likely to have high body mass index than white women. However, black men are less likely to have as high a body mass index as white men. Finally, the authors find that immigrants have lower body mass index levels than Canadian-born. However, this effect gradually goes away with time.

Barham et al. (2008) examine lifestyle characteristics of Canadians. They conclude that men who drink heavily have higher body mass index levels. Women who are heavy drinkers, on the hand, tend to have lower levels of body mass index and less likely to be obese. Smokers, regardless of gender have lower body mass index and are less likely to be obese than non-smokers. The authors also find that frequency of physical activity is a significant determining factor of body mass index levels and probability of being obese. They also find that the number of hours spent at work does not influence body mass index levels significantly. What matters is whether respondents are physically active at work or not.

Vanassel et al. (2006) analyze the distributions of body mass index, leisure-time physical activity and daily fruit and vegetable consumption using Cycle 2.1 of the CCHS. They map obesity rates (body mass index $\geq$30), rates of low level of leisure-time physical activity (less than 1.5 kcal of energy expenditure per day), and rates of low fruit and vegetable consumption (less than five times a day) for the 106 Canadian Health regions to illustrate the geographical differences. The authors use cartograms in addition to traditional mapping to take into account of differences in population density between these areas. The research gave the following results: "The rates of obesity varied substantially between the 106 Canadian health regions: from 6.2% in Vancouver to 47.5% in aboriginal population area". At the health region level, low leisure-time physical activity and low fruit and vegetable consumption are both good predictors of obesity (odds ratio of 9.2 and positive predictive value of 93% when considered simultaneously)".

3. Contribution of the Paper

This paper addresses gaps in the Canadian literature on the determinants of being overweight or obese. I provide a more thorough exploration of socio-economic, genetic and behavioral factors than has been done in the existing literature. In particular, I analyze such determinants as gender, age, racial background, education level, living conditions, household income, fruits and vegetables consumption, frequency of physical exercises, number of hours spent at work, and food consumption expenditures by types of food purchasing locations.

There are three main contributions of this work. First, I perform a detailed analysis by age groups. While Auld et al. (2005) address genetic and socioeconomic factors using Canadian data, they focus only on the population 35 to 44 years of age. I address this limitation by examining similar factors using Canadian respondents from 20 to 64 years of age. Barham et al. (2008) include Canadians 18 to 64 years of age, but I extend their analysis of age as a determinant of body mass index by estimating separate regressions for each age group. Estimating separate regressions for each age group, rather than simply using age dummies, could provide a better understanding of the true determining factors. Finally, Tjepkema (2005) includes an analysis of obesity by age groups for adults over 18 years of age, but he does not use a regression approach.

Second, I provide a more complete investigation of behavioral factors compared to what has been done in the literature. Clearly, one's caloric consumption and expenditure have direct implications on body weight and on the probability of being obese. In this paper I examine respondents' fruit and vegetables consumption, frequency of physical exercises, and number of hours spent at work.

Tjepkema (2005) has looked at behavioral factors using Canadian data, but not in a regression framework. Only by controlling for a full set of socioeconomic and genetic factors can one identify the contribution of behavioral factors. Barham et al. (2008), the only paper that performs an analysis of behavioral factors in Canada using a regression approach, includes such behavioral factors as hours at work, and frequency of physical activity, but not fruits and vegetables consumption. Unlike Barham et al. (2008), I analyze the effect of hours of work using a dichotomous variable that indicates whether a person works long hours or not.

The third contribution of this paper is the analysis of how food consumption patterns influence body mass index levels of Canadians. In fact, this is the first paper to perform a statistical analysis of food consumption factors of obesity in Canada. This paper presents an extension of an analysis of behavioral patterns of food consumption by estimating the effect of family food expenditures on body mass index and the probability of being obese. I look at the influence of family food expenditures by types of food purchasing locations, such as fast food restaurants, table service restaurants, and supermarkets. Food purchasing behavior is presented as a percentage of total food expenditures. The decision to use these particular variables is based on work of Chou et al. (2004). They looked at per capita restaurant density and food prices. Individual's relative food expenditures by type of purchasing location could reflect the influence of relative food prices and accessibility of food stores and restaurants.

4. Data Description

Two Statistics Canada data sets are used: the Canadian Community Health Survey (CCHS) and the Family Food Expenditure Survey (FOODEX). In both cases I use the public use files. The analysis performed in this paper requires the integration of the two surveys. Since 2001 is the last year FOODEX is available, I restricted my attention to Cycle 1.1 of the CCHS which is also for 2001.

Cycle 1.1 of the CCHS is a cross-section survey that was conducted between September 2000 and November 2001. It was conducted for 136 health regions, covering all provinces and territories, excluding individuals living in Indian Reserves, and Crowns Lands, members of Canadian armed Forces and residents of some remote areas. The survey samples 133,300 respondents. Only persons 12 years and older who lived in private occupied dwellings were included in the survey. The survey covers 98% of the Canadian population within the age limit. The CCHS provides information on health determinants, health status, and health system utilization across Canada. The survey includes questions on a wide variety of health related questions including: general health, height and weight, smoking, alcohol consumption, blood pressure check, fruit and vegetable consumption, physical activities, chronic conditions, injuries, and mental health. In addition the survey collected data on economic, social, demographic, occupational and environmental determinants of health.

The Family Food Expenditure Survey for 2001 collected information on food expenditures and quantities purchased by households in Canada. Respondents were asked to record data on food purchased during a 2 week period. The survey was conducted in 10 Canadian provinces. The total number of households that participated in the survey is 5,643. The summary file has 11,034 weekly records and 79 variables. Among the topics covered by the survey are the following: composition of households, characteristics of the reference person, the spouse and the dwelling, personal income in the last 12 months, food and beverages purchased while away from home, food and beverages purchased from stores by type of store, and food and beverages from restaurants by type of restaurant.

The sample used in the regression analysis includes individuals from 20 to 64 years of age, as information on body mass index in the CCHS data set is available only for individuals in this age range. Pregnant women are excluded because their increased body mass would not reflect obesity. Finally, immigrants are included in the sample, but only those who lived in Canada for 10 or more years, because factors influencing obesity of more recent immigrants could differ substantially from those for Canadian-born. With these sample restrictions the total number of observations in my sample is 83,460.

5. Summary Statistics

Table 1 provides some summary statistics of the CCHS variables used in the regression analysis. I also provide a brief description of the variables below. A detailed description of the CCHS variables can be found in Appendix A. In all cases, I use the same variable names in my summary statistics tables as in my results tables.

The *bmi* variable is the body mass index of respondents. It is the key dependent variable in my regression analysis. The body mass index accounts for the height of individuals. The exact formula used to calculate the *bmi* variable can be found in Appendix B. Values for the *bmi* variable are taken directly from the CCHS data base.

The mean *bmi*, as can be seen in Table 1, is 25.68 (the standard deviation is 4.63), which is close to the mean found by Auld et al. (2005), despite the fact that they analyze only respondents 35 to 44 year of age. The fact that I include both younger and older individuals may explain the similarity in *bmi.*

Males, as indicated by the *male* dichotomous variable, make up 51% of all respondents in the sample. Females (*female*) are in default group. Individuals are divided into two racial groups: whites and those of other racial background (non whites). Non whites (*nonwhite*) are the default group. 89% of respondents in the sample are white. Auld et al. (2005) also finds a similar ratio of white respondents. Respondents who were born outside Canada are indicated by the *immigrant* variable. Canadian-born (*canadian*) respondents are in default group. Immigrants who had been in the country 10 years or more make up 16% of my sample.

Table 1

Summary Statistics of CCHS Variables

	Number of observations	Full sample	Female	Male
bmi	83,460	25.6758	24.9487	26.3746
		(4.6321)	(4.9743)	(4.1595)
white	82,132	0.8926	0.8884	0.8967
		(0.3096)	(0.3149)	(0.3043)
*nonwhite**	82,132	0.1074	0.1116	0.1033
		(0.3096)	(0.3149)	(0.3043)
male	83,460	0.5099		
		(0.4999)		
*female**	83,460	0.4901		
		(0.4999)		
*somesecondary**	82,664	0.174	0.1636	0.184
		(0.3791)	(0.3699)	(0.3875)
secondary	82,664	0.2066	0.2175	0.1961
		(0.4049)	(0.4126)	(0.3970)
somepostsec	82,664	0.0893	0.0918	0.0869
		(0.2852)	(0.2887)	(0.2816)
postsec	82,664	0.5301	0.5271	0.5331
		(0.4991)	(0.4993)	(0.4989)
alone	82,719	0.1137	0.1066	0.1204
		(0.3174)	(0.3087)	(0.3255)
spousenoch	82,719	0.2318	0.2402	0.2237
		(0.4220)	(0.4272)	(0.4168)
*spousechild**	82,719	0.3749	0.3701	0.3794

		(0.4841)	(0.4828)	(0.4852)
singlepar	82,719	0.0483	0.0792	0.0188
		(0.2144)	(0.2700)	(0.1359)
otherlcond	82,719	0.2314	0.2038	0.2576
		(0.4217)	(0.4029)	(0.4373)
*hhinc_0_14**	76,227	0.0691	0.0816	0.0572
		(0.2536)	(0.2738)	(0.2322)
hhinc_15_29k	76,227	0.1233	0.1398	0.1076
		(0.3287)	(0.3468)	(0.3098)
hhinc_30_49k	76,227	0.2201	0.2288	0.2119
		(0.4143)	(0.4200)	(0.4087)
hhinc_50_79k	76,227	0.2997	0.2906	0.3084
		(0.4581)	(0.4540)	(0.4619)
hhinc_80	76,227	0.2878	0.2592	0.3149
		(0.4527)	(0.4382)	(0.4645)
*age_20_24**	83,460	0.1115	0.1097	0.1132
		(0.3147)	(0.3125)	(0.3168)
age_25_34	83,460	0.2083	0.1994	0.2169
		(0.4061)	(0.3996)	(0.4122)
age_35_44	83,460	0.2788	0.2819	0.2759
		(0.4484)	(0.4499)	(0.4470)
age_45_54	83,460	0.243	0.2482	0.2381
		(0.4289)	(0.4319)	(0.4259)
age_55_64	83,460	0.1583	0.1608	0.1559
		(0.3651)	(0.3674)	(0.3628)
fruit_veg	82,508	4.5745	4.9119	4.2489
		(2.6486)	(2.6329)	(2.6228)
phys_activ	79,118	21.7414	21.666	21.8183
		(21.6847)	(21.1505)	(22.2166)
long_hours	67,935	0.1668	0.0936	0.2283
		(0.3728)	(0.2913)	(0.4198)
*canadian**	82,913	0.8409	0.84	0.8417
		(0.3658)	(0.3666)	(0.3650)
immigrant	82,913	0.1591	0.16	0.1583
		(0.3658)	(0.3666)	(0.3650)

Standard deviations are in parenthesis. *denotes control groups.

There are 5 age groups specified in the model: 25 to 34 years of age (*age_25_34*), 35 to 44 years of age (*age_35_44)*, 45 to 54 years of age (*age_45_54)*, 55 to 64 years of age (*age_55_64)* and those 20 to 24 years of age (*age_20_24*) – the default group. Auld et al. (2005) only includes respondents in the 35 to 44 age bracket. In my sample, however, 39% are over 44 years of age and 33% are below 35.

Education is divided into four groups: less than secondary education (*somesecondary*), which is the base group, secondary education (*secondary)*, some post-secondary education (*somepostsec)*, and post-secondary education (*postsec*). 17% of respondents have less than a secondary education, 21% have finished secondary education, 9% did not finish the post-secondary education, and 53% have a post-secondary degree. In general, the education level of respondents in my sample is only slightly lower than in the Auld et al. (2005) paper.

Household income is divided into 5 groups: $0 to $14,999 (*hhinc_0_14*), $15,000 to $29,999 (*hhinc_15_29*), $30,000 to $49,999 (*hhinc_30_49*), $50,000 to $79,999 (*hhinc_50_79*), and $80,000 and up (*hhinc_80*). Respondents whose household's income is less than $15,000 are used as the base group in the regression analysis. 7% of respondents in the sample used in this paper have annual income less than $15,000, 12% earn between $15,000 and $29,000, 22% between $30,000 and $49,999, 30% between $50,000 and $79,999, and 29% earn $80,000 or more.

Living conditions categories are distinguished by whether a respondent lives with a spouse or not, and whether she or he lives with children or not. Respondents who live with a spouse and with children (*spousechild*) are in default group. The indicator variable for those living alone is *alone,* for those who live with a spouse but without children is *spousenoch,* for single parents it is *singlepar*, and for other living conditions, the indicator *otherlcond* is used. The *otherlcond* group includes respondents who live with others as an unattached individual, children living with single or both parents, and other possible living conditions. 37% of respondents in the sample live with a spouse and with children, and 23% live with a spouse, but without children, 11% live alone, 4% are single parents, 23% have other living conditions. Auld et al. (2005) find more people living with a spouse with children, making up 57% of their sample, while those who live with a spouse but without children represent only 12% of the sample. The differences can be explained by the choice of age groups used. Respondents 35 to 44 years of age are more likely to live with a spouse and children, than younger respondents or people in their fifties or sixties.

Respondents' fruit and vegetable consumption is described by the variable *fruit_veg,* which represents the number of servings of fruits and vegetables consumed in a day. The mean is 4.57. The number of physical exercises over 15 minutes performed by a respondent each month is represented by the variable *phys_activ,* with a mean of 21.74 episodes per month. *long_hours* indicates respondents who work more than 50 hours per week. Respondents who work less than that are in the base group. 17% of respondents work 50 or more hours per week.

Table 2 presents some summary statistics for the variables from the FOODEX that are used in the analysis.

Table 2

Summary Statistics for Consumption Behavior Analysis Variables from the FOODEX Data Set

	Full sample	Female	Male
fastfood_share	0.0902	0.0882	0.0927
	(0.1456)	(0.1442)	(0.1473)
tableserv_share	0.1568	0.1407	0.1775
	(0.2233)	(0.2125)	(0.2349)
supermar_share	0.5569	0.5723	0.5371
	(0.3260)	(0.3259)	(0.3252)
Number of observations	7,458	4,283	3,175

Standard deviations are in parenthesis.

The *fastfood_share* variable is a share of total weekly family expenditures spent on fast food meals. Fast food restaurants "have no table service…customers order the food at a counter and choose to "eat-in" or "take-out" " (Statistics Canada, 2003a). The *tableserv_share* variable is a share of total weekly food expenditures spent on meals in table service restaurants. Table service restaurants is described as a restaurant, bar or pub that serves "food and beverages at a table or an eating counter" (Statistics Canada, 2003a). Purchases in both fast food and table service restaurants cover breakfasts, lunches, dinners and between-meals snacks and non-alcoholic beverages. The *supermar_share* variable is a share of total weekly expenditures spent on purchases in supermarkets. It includes "food and beverages purchased from stores locally and on day trips" (Statistics Canada, 2003a). Supermarkets are defined as retail stores that offer "a wide variety of mostly grocery items (food and non-food)" (Statistics Canada, 2003a).

6. Analysis of Factors of Obesity

6.1 Overview

Regressions where *bmi* is the dependent variable are estimated for genetic, behavioral, and socioeconomic factors separately. By estimating separate regressions and comparing their estimated parameters with those of a full regression (where all variables are included), it is possible to analyze whether differences in model specification results in different parameters estimates, and thus get a better understanding of the significance of controlling variables. It is, however, necessary to recognize that by analyzing the effect of each set of factors separately, there is a possibility that the error term could be correlated with the explanatory variables, which could result in omitted variable bias.

6.2 Obesity Factors Related to Genetics

Genetic factors, which include physiologic characteristics, determine how a person's body is accumulating and using energy. According to Raine (2004), genetic characteristics could explain 20% to 75% of body mass index differences. At different ages, people have different metabolism levels which could reflect in the ability to gain weight and define difference in body mass index levels across age groups. Racial background could also play an important role in how body can accumulate weight. Historically different races had different need to accumulate energy which could reflect in genetic susceptibility to obesity. Gender is another genetics related factor.

I regress *bmi* on gender, racial background and age. The exact specification takes the form:

$$bmi = \beta_0 + \beta_1\, white + \beta_2\, male + \beta_3\, age\_25\_34 + \beta_4\, age\_35\_44 + \beta_5\, age\_45\_54 + \beta_6\, age\_55\_64 + \mu \quad (1)$$

The equation is estimated for the full sample, and also by gender. Estimated parameters are presented in Table 3.[1] All parameters are statistically significant.

Table 3

BMI OLS Regression Estimates: Genetic Factors

	Full Sample	Female	Male
white	1.0244*	0.7337*	1.3348*
	(0.0507)	(0.0753)	(0.0672)
male	1.4415*		
	(0.0314)		
age_25_34	1.4764*	1.3332*	1.6094*
	(0.0582)	(0.0892)	(0.0750)
age_35_44	1.9004*	1.7336*	2.0679*
	(0.0556)	(0.0844)	(0.0722)
age_45_54	2.6074*	2.7394*	2.4757*
	(0.0567)	(0.0859)	(0.0739)
age_55_64	2.7945*	3.2381*	2.3558*
	(0.0613)	(0.0928)	(0.0799)
constant	22.1186*	22.3479*	23.3065*
	(0.0664)	(0.0967)	(0.0850)
Number of observations	82,132	42,373	39,759
R^2	0.06	0.04	0.04

Standard errors are in parenthesis. *denotes significance at 5% level.

[1] All regressions are weighted using the weights provided by the CCHS.

Table 3 shows that male respondents are more likely to have higher body mass index levels than females, with an estimated difference of 1.44 – which is much larger than what Auld et al. (2005) found (i.e. 0.48). The difference could be due to the fact that Auld et al. (2005) only looked at the 35 to 44 age group, while I include individuals from 20 to 64 years of age. The gender difference is significantly larger for younger and older groups which could explain why the gender parameter estimated by Auld et al. (2005) is lower.

White respondents have, on average, a higher body mass index. The full sample estimate for the *white* variable is 1.0244, which means that being white adds a point to the individual's body mass index. As body weight is considered to be normal if the body mass index is within 18.5 to 24.9 points range, the addition of one point can be considered significant. Both white woman and men are more likely to be overweight than their non-white counterparts, but racial differences play a more important role for men than for women. The *white* estimate is 1.3348 for males and 0.7337 for females.

As can be seen in Table 3, the parameters estimates for the different age groups indicate that body mass index levels are growing with age. Respondents in the 25 to 34, 35 to 44, 45 to 54, and 55 to 64 age groups have body mass index 1.4764, 1.9004, 2.6074, and 2.7945 points higher than respondents 20 to 24 years of age, respectively. Interestingly, the age effect varies across gender. Men's body mass index grows faster than women' for respondents 20 to 44 years of age. Starting from the age of 45, body mass index growth for men slows down and actually slightly decreases for those who are 55 to 64 years of age, while for women it continues growing and catches up to men's level.

6.3 Behavioral Factors of Obesity

Calories intake and expenditure are determined by decisions that people make on daily basis, and thus are determined by behavioral patterns. People can choose what kind of food to eat, where to it, and how often. People plan, for example, how to spend their leisure time and for how long to engage in physical activities. More time an individual spends at work, less time she or he has for active leisure activities as well as for purchasing and preparing healthy foods. The behavioral regression specification takes the form:

$$bmi = \beta_0 + \beta_1\, fruit\_veg + \beta_2\, phys\_activ + \beta_3\, long\_hours + \mu \quad (2)$$

I estimate the regression equation for the full sample, by gender, and also by age groups. The results can be found in Tables 4 and 5.

Table 4

BMI OLS Regression Estimates: Behavioral Factors by Gender

	Full sample	Female	Male
fruit_veg	-0.0655*	-0.0319*	-0.0154**
	(0.0069)	(0.0106)	(0.0089)
phys_activ	-0.0135*	-0.0237*	-0.0072*
	(0.0008)	(0.0013)	(0.0011)
long_hours	0.8036*	0.1944*	0.5499*
	(0.0486)	(0.0927)	(0.0552)
constant	26.0752*	25.3943*	26.4939*
	(0.0383)	(0.0598)	(0.0479)
Number of observations	63,722	31,680	32,042
R^2	0.01	0.01	0.01

Standard errors are in parenthesis. *denotes significance at 5% level.

Table 5

BMI OLS Regression Estimates: Behavioral Factors by Age

	Full sample	20-24	25-34	35-44	45-54	55-64
fruit_veg	-0.0655*	-0.0409*	-0.0949*	-0.1059*	-0.0569*	-0.0668*
	(0.0069)	(0.0202)	(0.0151)	(0.0124)	(0.0138)	(0.0191)
phys_activ	-0.0135*	0.0003	-0.0039*	-0.0086*	-0.0222*	-0.0216*
	(0.0008)	(0.0023)	(0.0017)	(0.0016)	(0.0018)	(0.0025)
long_hours	0.8036*	0.6408*	0.7357*	0.8437*	0.8218*	0.3813*
	(0.0486)	(0.1729)	(0.0999)	(0.0851)	(0.0955)	(0.1338)
constant	26.0752*	23.8951*	25.6773*	26.1468*	26.9152*	27.2463*
	(0.0383)	(0.1125)	(0.0809)	(0.0686)	(0.0770)	(0.1096)
Number of observations	63,722	5,798	14,337	19,724	16,205	7,658
R^2	0.01	0.00	0.01	0.02	0.02	0.02

Standard errors are in parenthesis. *denotes significance at 5% level. ** denotes significance at 10%.

As one would expect, more frequent consumption of fruits and vegetables decreases one's body mass index, as the estimated parameter for variable *fruit_veg* is negative (i.e. -0.0655). The *fruit_veg* variable can take values from 0 to 80, while the mean is 4.6. If an individual increases daily fruits and vegetables consumption by 2.64 servings, the standard deviation of the *fruit_veg* variable, her or his body mass index will decrease by about 0.17 points. It should be noted that the effect is more significant for women (-0.0319) than for men (-0.0154). This gender difference disappears when more controlling variables are included into the regression.

The estimated parameter for the physical activities variable, as could be predicted, is negative (-0.0135). This dependence is logically explainable as more physical exercises results in an increase in calories expenditures. The *phys_activ* variable can take values from 0 to 257 and its mean is 21.7. If an individual increases the monthly number of physical activities over 15 minutes by 21.68, the standard deviation of the *phys_activ* variable, his or her body mass index will decrease by 0.29 points. It is interesting to note that the effect of physical exercises is more important for women, with an estimated parameter of -0.0237 as compared to -0.0072 for men. Thus, it can be concluded, that in order to decrease body weights, men have to put in more effort into exercise than women, while decreasing of frequency of physical activities has a more significant increasing influence on body mass index for women than men.

As for the number of hours spent at work, this parameter has a predictable positive influence on body mass index levels, as people who work longer hours could have less time available for healthy foods preparation or engaging in healthy physical activities. Interestingly, there is a significant difference in how long hours spent at work influence body mass index levels of men and women. It is substantially higher for men. The *long_hours* estimate is 0.5499 for men, while for women it is 0.1944. This, perhaps, could be explained by the fact that career oriented women give more attention to their appearance than do career oriented men, as there could be higher discrimination of overweight women than overweight men in the work environment. Also it could be the result of the fact that men and women work in different sectors of the economy.

Estimation results by each age group are presented in Table 5. It can be inferred from these estimates that the effect of fruits and vegetables consumption (*fruit_veg*) appears to grow with age, although it tapers off for older groups. The parameters are -0.0409, -0.0949, -0.1059, -0.0569, -0.0668 for those who are 20 to 24, 25 to 34, 35 to 44, 45 to 54, and 55 to 64 years of age, respectively. Thus, if an individual increases the number of fruits and vegetables servings per day by 10, her body mass index would decrease by about 1 point for those 25 to 44 years of age.

The importance of physical activities grows approximately up to the age of 54, as parameter estimates for the *phys_activ* variable equal 0.0003, -0.0039, -0.0086, -0.0222, and -0.0216 for those who are 20 to 24, 25 to 34, 35 to 44, 45 to 54, and 55 to 64 years of age, respectively. Thus, if an individual increase the number of monthly physical activities over 15 minutes by 10, his or her body mass index would almost not change if she or he is 20 to 24 years of age, and decrease by 0.2 points if she or he is 45 to 64 years of age, respectively. Therefore, the importance of physical activities for purposes of sustaining healthy body weights is the highest for those who are 45 to 64 years of age.

Long working hours matters for all age groups. The effect is the largest for those 35 to 54 years of age (i.e. the parameter estimates of about 0.8). Perhaps this could be explained by the fact that among those who are 35 to 54 years of age there are more office employees as compared to other age groups.

6.4 *Socioeconomic Factors of Obesity*

Socioeconomic characteristics such as education, living conditions, income, or place of birth could also be significant factors for being overweight and obese. For example, people with higher education, could have better abilities to acquire knowledge on healthy dieting or exercising. One could assume that people living with children have less time available for preparation of healthy meals. Advertisement of fast food restaurant is often aimed particularly at children's audience, which could be a factor for families with children. Some studies, (e.g. Tjepkema (2005)), have shown (See Appendix F) that men who were never married have higher rates of obesity compared to men with other marital status. For women the highest obesity rates are among widows. Finally, people with higher salaries could have better possibility to purchase healthy foods or eat in table service rather than in fast food restaurants.

I regress *bmi* on education level, living conditions, household income, as well as an indicator that shows whether an individual is foreign or Canadian born. The exact specification takes the form:

$$bmi = \beta_0 + \beta_1\, secondary + \beta_2\, somepostsec + \beta_3\, postsec + \beta_4\, alone + \beta_5\, spousenoch + \beta_6\, singlepar + \beta_7\, otherlcond + \beta_8\, hhinc\_15\_29 + \beta_9\, hhinc\_30\_49 + \beta_{10}\, hhinc\_50\_79 + \beta_{11}\, hhinc\_80 + \beta_{12}\, immigrant + \mu \quad (3)$$

Tables 6 present parameters estimates for the full sample as well as for women and men separately. Table 7 shows the equation (3) estimates by age groups.

Table 6 shows that respondents who did not drop out of high school have lower body mass index levels as compared to those who did. In addition, individuals with some or completed post-secondary education have lower body mass index levels than high school graduates. For the full sample, the estimates for the *somepostsec* and *postsec* variables are -1.2426 and -1.0807, while that of the *secondary* variable is -0.7577. Thus, body mass index level actually increases for those who finished postsecondary education if compared to those who did not.

Table 6

BMI OLS Regression Estimates: Socioeconomic Factors by Gender

	Full sample	Female	Male
secondary	-0.7577*	-0.9801*	-0.3631*
	(0.0562)	(0.0852)	(0.0714)
somepostsec	-1.2426*	-1.4859*	-0.8302*
	(0.0707)	(0.1064)	(0.0903)
postsec	-1.0807*	-1.4372*	-0.6065*
	(0.0489)	(0.0756)	(0.0611)
alone	-0.5026*	-0.4729*	-0.6956*
	(0.0602)	(0.0936)	(0.0746)
spousenoch	-0.0603	0.0041	-0.1135*
	(0.0446)	(0.0667)	(0.0571)
singlepar	-0.7789*	-0.5178*	-0.5770*
	(0.0828)	(0.1030)	(0.1592)
otherlcond	-0.9165*	-0.7873*	-1.1640*
	(0.0457)	(0.0715)	(0.0566)
hhinc_15_29	0.1043	-0.0170	0.2341*
	(0.0807)	(0.1124)	(0.1123)
hhinc_30_49	0.2274*	-0.0853	0.5086*
	(0.0758)	(0.1077)	(0.1037)
hhinc_50_79	0.1496*	-0.4753	0.6261*
	(0.0758)	(0.1090)	(0.1026)
hhinc_80	0.0587	-1.0085	0.7754*
	(0.0779)	(0.1133)	(0.1044)
immigrant	-0.4496*	-0.2790	-0.6588*
	(0.0464)	(0.0695)	(0.0595)
constant	26.8295*	26.8261	26.8217*
	(0.0784)	(0.1133)	(0.1054)
Number of observations	74,938	38,383	36,555
R^2	0.02	0.02	0.02

Standard errors are in parenthesis. *denotes significance at 5% level. ** denotes significance at 10%.

Table 7

BMI OLS Regression Estimates: Socioeconomic Factors by Age

	Full sample	20-24	25-34	35-44	45-54	55-64
secondary	-0.7577*	0.2757	-0.1878	-0.7848*	-0.7154*	-0.4189*
	(0.0562)	(0.1990)	(0.1420)	(0.1086)	(0.1103)	(0.1199)
somepostsec	-1.2426*	-0.6718*	0.0403	-0.8181*	-1.0947*	-0.4617*
	(0.0707)	(0.2036)	(0.1668)	(0.1439)	(0.1541)	(0.1801)
postsec	-1.0807*	-0.4288*	-0.6482*	-1.0091*	-0.8816*	-0.5838*
	(0.0489)	(0.1877)	(0.1256)	(0.0977)	(0.0964)	(0.0954)
alone	-0.5026*	-0.9632*	-0.9745*	-0.3188*	-0.5733*	-0.6199*
	(0.0602)	(0.3009)	(0.1307)	(0.1109)	(0.1197)	(0.1434)
spousenoch	-0.0603	-0.6445*	-0.4962*	-0.2712*	-0.0140	-0.3162*
	(0.0446)	(0.2716)	(0.1024)	(0.0986)	(0.0860)	(0.1066)
singlepar	-0.7789*	-0.8308**	-1.0379*	-0.9853*	-0.6763*	-0.2684
	(0.0828)	(0.4743)	(0.1985)	(0.1342)	(0.1531)	(0.2369)
otherlcond	-0.9165*	-1.0026*	-0.3224*	0.1395	-0.0223	-0.2031
	(0.0457)	(0.2303)	(0.0926)	(0.0962)	(0.1116)	(0.1548)
hhinc_15_29	0.1043	0.6487*	0.0385	-0.1270	-0.0133	0.0957
	(0.0807)	(0.2298)	(0.1906)	(0.1654)	(0.1724)	(0.1583)
hhinc_30_49	0.2274*	0.5137*	0.1760	0.1468	0.0889	-0.0783
	(0.0758)	(0.2258)	(0.1811)	(0.1535)	(0.1593)	(0.1531)
hhinc_50_79	0.1496*	0.4070**	-0.0936	0.0552	-0.0828	0.0825
	(0.0758)	(0.2270)	(0.1818)	(0.1527)	(0.1562)	(0.1581)
hhinc_80	0.0587	0.4351**	-0.2125	-0.2450	-0.0691	-0.2094
	(0.0779)	(0.2279)	(0.1876)	(0.1566)	(0.1595)	(0.1677)
immigrant	-0.4496*	-1.2799*	-0.8828*	-0.8554*	-0.5527*	-0.8427*
	(0.0464)	(0.2440)	(0.1178)	(0.0878)	(0.0862)	(0.0933)
constant	26.8295*	24.5915*	26.2110*	26.7798*	27.3948*	27.4590*
	(0.0784)	(0.3060)	(0.1937)	(0.1574)	(0.1610)	(0.1660)
Number of observations	74,938	5,961	15,745	21,555	18,558	13,119
R^2	0.02	0.02	0.01	0.01	0.01	0.01

Standard errors are in parenthesis. *denotes significance at 5% level. ** denotes significance at 10%.

The gender analysis shows that education is a more significant factor for women than men. For the *secondary*, *somepostsec*, *postsec* variables women have parameter estimates of -0.9801,

-1.4859, -1.4372, while for men the estimates are -0.3631, -0.8302, -0.6065, respectively.

Table 7 shows that for most age groups having secondary and higher levels of education results in body mass index levels lower than for those who dropped out of high school. The one exception is high school graduates who are 20 to 24 years of age for whom the parameter estimate is positive (i.e. 0.2757). It is, however, not statistically significant.

For the full sample, the *alone* variable has a coefficient estimate of -0.5026. Thus, it can be inferred that people who live alone have lower body mass index levels than those who live with a spouse and with children – the base group. Single parents who are indicated by the *singlepar* variable have a parameter estimate of -0.7789. Those, who live with a spouse but without children, indicated by the *spousenoch* variable, with a parameter estimate of -0.0603 (not statistically significant) have slightly lower level of body mass index than those couples, who live with children. The parameter estimate for this variable becomes both statistically and economically significant when more control variables are included into analysis as presented later. Thus, being single decrease one's body mass index. Having children on the other hand increases it. As single parents have body mass index lower than those who live with a spouse but without children, being single has a more significant decreasing effect on body mass index than the increasing effect of having children.

Table 6 shows that living alone for women is a slightly less significant decreasing factor for body mass index than for men. The parameter estimate for the *alone* variable is -0.4729 for females while for men it is -0.6956. Also, the effect from being a single parent is just slightly stronger for men (i.e. -0.5770) than for women (i.e. -0.5178).

For all age groups those who live with a spouse with children have the highest levels of body mass index. Those who live alone have the lowest body mass index levels among the youngest (20 to 24 years of age) and the oldest (55 to 64 years of age), for other groups single parents have the lowest body mass index levels. There is a significant difference in how living condition influence body mass index levels of individuals of different age. For most of the parameter significance is higher for younger individuals, especially for those who are 20 to 34 years of age.

There is a significant difference in how income determines body mass index levels between women and men. For males body mass index levels increase with income, as the parameters estimates are 0.2341, 0.5086, 0.6261, 0.7754 for the income groups $15,000 to $29,999, $30,000 to $49,999, $50,000 to 79,999, $80,000 and over, respectively. Body mass index of women decreases with income with parameters estimates of -0.0170, -0.0853, -0.4753, -1.0085 for the same income groups respectively. However, parameter estimates for women are not statistically significant.

Among all age groups analyzed, parameters estimates of the variables indicating level of household income are statistically significant only for those who are 20 to 24 years of age. For these respondents, just like for the full sample, individuals who make $15,000 and over in a year have higher body mass index levels than those who make less.

Immigrants have lower body mass index than Canadian-born for the regression estimated using the full sample as well as for all regressions estimated by gender and age groups. According to Table 6, full sample, being an immigrant decreases body mass index levels by 0.4496. The decrease is more significant for males than for females, as the estimate for male immigrants is -0.6588, while for female immigrants it is -0.2790.

The parameter estimate of the *immigrant* variable for those 20 to 24 years of age (-1.2799) is a more significant decreasing factor than for other age group. For immigrants 45 to 54 years of age being foreign born is the least significant, as the parameter estimate is -0.5527. For other age groups, immigrants on average have a body mass index 0.8 to 0.9 points lower than Canadian born. Younger immigrants have probably lived less time in Canada than those in older age groups, and thus it can be inferred that the difference in body mass index level between foreign and Canadian born individuals diminishes with time.

6.5 Estimation of a Regression With All Factors Included

The model with the following specification is estimated:

$$bmi = \beta_0 + \beta_1\, white + \beta_2\, male + \beta_3\, secondary + \beta_4\, somepostsec + \beta_5\, postsec + \beta_6\, alone + \beta_7\, spousenoch + \beta_8\, singlepar + \beta_9\, otherlcond + \beta_{10}\, hhinc\_15\_29 + \beta_{11}\, hhinc\_30\_49 + \beta_{12}\, hhinc\_50\_79 + \beta_{13}\, hhinc\_80 + \beta_{14}\, age\_35\_44 + \beta_{15}\, age\_45\_54 + \beta_{16}\, age\_55\_64 + \beta_{17}\, fruit\_veg + \beta_{18}\, phys\_activ + \beta_{19}\, long\_hours + \beta_{20}\, immigrant + \mu \quad (4)$$

Results for the full sample as well as for males and females separately are presented in Table 8. The results for the age groups are shown in Table 9.

Table 8

BMI OLS Regression Estimates: All Specified Factors by Gender

	Full sample	Female	Male
white	0.7609*	0.5465*	0.9739*
	(0.0708)	(0.1079)	(0.0919)
male	1.5596*		
	(0.0379)		
secondary	-0.2392*	-0.5359*	-0.1147
	(0.0650)	(0.1052)	(0.0808)
somepostsec	-0.3946*	-0.6419*	-0.2924*
	(0.0807)	(0.1278)	(0.1023)
postsec	-0.5457*	-0.8397*	-0.3961*
	(0.0577)	(0.0958)	(0.0705)
alone	-0.6079*	-0.6529*	-0.6189*
	(0.0645)	(0.1043)	(0.0802)
spousenoch	-0.1847*	-0.2849*	-0.1287*
	(0.0510)	(0.0781)	(0.0660)
singlepar	-0.2443*	-0.3322*	-0.6809*
	(0.0898)	(0.1135)	(0.1676)
otherlcond	-0.1024**	0.0323	-0.2457*
	(0.0548)	(0.0867)	(0.0693)
hhinc_15_29	0.2057*	0.1885	0.2873*
	(0.1048)	(0.1476)	(0.1482)
hhinc_30_49	0.3535*	0.2737*	0.5855*
	(0.0979)	(0.1393)	(0.1373)
hhinc_50_79	0.2600*	-0.0596	0.6952*
	(0.0972)	(0.1395)	(0.1355)
hhinc_80	0.1037	-0.6251*	0.8541*
	(0.0989)	(0.1433)	(0.1370)
age_25_34	1.4169*	1.3715*	1.4687*
	(0.0714)	(0.1099)	(0.0922)
age_35_44	1.7579*	1.7355*	1.7944*
	(0.0725)	(0.1098)	(0.0949)
age_45_54	2.5337*	2.8219*	2.2674*
	(0.0743)	(0.1120)	(0.0978)
age_55_64	2.6144*	3.1625*	2.1345*
	(0.0869)	(0.1348)	(0.1117)
fruit_veg	-0.0264*	-0.0211**	-0.0255*

	(0.0072)	(0.0111)	(0.0093)
phys_activ	-0.0112*	-0.0187*	-0.0054*
	(0.0009)	(0.0014)	(0.0011)
long_hours	0.3649*	0.2524*	0.3840*
	(0.0503)	(0.0962)	(0.0568)
immigrant	-0.4171*	-0.4364*	-0.4207*
	(0.0605)	(0.0935)	(0.0777)
constant	23.0741*	23.9059*	23.8660*
	(0.1405)	(0.2084)	(0.1856)
Number of observations	57,831	28,544	29,287
R^2	0.08	0.06	0.05

Standard errors are in parenthesis. *denotes significance at 5% level. ** denotes significance at 10%.

Table 9

BMI OLS Regression Estimates: All Specified Factors by Age

	Full sample	20-24	25-34	35-44	45-54	55-64
white	0.7609*	-0.2263	0.4398*	1.0818*	1.2479*	0.9417*
	(0.0708)	(0.2109)	(0.1468)	(0.1381)	(0.1435)	(0.2035)
male	1.5596*	1.6722*	1.8930*	1.8459*	1.2799*	0.6891*
	(0.0379)	(0.1251)	(0.0812)	(0.0680)	(0.0765)	(0.1078)
secondary	-0.2392*	0.5903*	0.2793**	-0.6105*	-0.5300*	-0.0757
	(0.0650)	(0.2228)	(0.1586)	(0.1189)	(0.1249)	(0.1588)
somepostsec	-0.3946*	-0.0554	0.3778*	-0.4931*	-0.8578*	-0.1894
	(0.0807)	(0.2290)	(0.1848)	(0.1568)	(0.1712)	(0.2343)
postsec	-0.5457*	0.2455	-0.1888	-0.8432*	-0.6082*	-0.3173*
	(0.0577)	(0.2137)	(0.1408)	(0.1079)	(0.1104)	(0.1299)
alone	-0.6079*	-1.0796*	-1.1106*	-0.5247*	-0.5294*	-0.4218*
	(0.0645)	(0.3249)	(0.1338)	(0.1138)	(0.1276)	(0.1820)
spousenoch	-0.1847*	-0.6055*	-0.5521*	-0.2664*	0.1274	-0.2364**
	(0.0510)	(0.2946)	(0.1062)	(0.1019)	(0.0932)	(0.1334)
singlepar	-0.2443*	-0.2122	-0.2363	-0.3220*	-0.1484	-0.0151
	(0.0898)	(0.5737)	(0.2186)	(0.1420)	(0.1630)	(0.2906)
otherlcond	-0.1024**	-1.1372*	-0.4091*	0.1413	0.1055	0.3772**
	(0.0548)	(0.2579)	(0.0997)	(0.1032)	(0.1227)	(0.1984)
hhinc_15_29	0.2057*	0.5808*	-0.0062	-0.0057	0.3781	0.0184
	(0.1048)	(0.2529)	(0.2253)	(0.2104)	(0.2333)	(0.2776)
hhinc_30_49	0.3535*	0.6702*	0.2366	0.2356	0.3335	0.4140

	(0.0979)	(0.2497)	(0.2127)	(0.1956)	(0.2148)	(0.2597)
hhinc_50_79	0.2600*	0.4554**	0.0523	0.2431	0.2091	0.4807**
	(0.0972)	(0.2512)	(0.2130)	(0.1939)	(0.2110)	(0.2591)
hhinc_80	0.1037	0.5414*	-0.1265	-0.0631	0.2857	0.4022
	(0.0989)	(0.2523)	(0.2183)	(0.1971)	(0.2130)	(0.2661)
age_25_34	1.4169*					
	(0.0714)					
age_35_44	1.7579*					
	(0.0725)					
age_45_54	2.5337*					
	(0.0743)					
age_55_64	2.6144*					
	(0.0869)					
fruit_veg	-0.0264*	-0.0172	-0.0401*	-0.0444*	-0.0032	-0.0300
	(0.0072)	(0.0225)	(0.0154)	(0.0128)	(0.0145)	(0.0216)
phys_activ	-0.01128*	-0.0008	-0.0034**	-0.0103*	-0.0235*	-0.0230*
	(0.0009)	(0.0025)	(0.0018)	(0.0016)	(0.0019)	(0.0027)
long_hours	0.3649*	0.3851*	0.3006*	0.3114*	0.4787*	0.1618
	(0.0503)	(0.1854)	(0.1037)	(0.0885)	(0.1008)	(0.1435)
immigrant	-0.4171*	-1.4466*	-0.6958*	-0.1682	-0.0963	-0.6535*
	(0.0605)	(0.2995)	(0.1486)	(0.1185)	(0.1074)	(0.1298)
constant	23.0741*	23.5419*	24.5360*	24.7764*	25.3220*	26.0072*
	(0.1405)	(0.4166)	(0.2806)	(0.2491)	(0.2708)	(0.3480)
Number of observations	57,831	4,970	13,275	18,086	14,693	6,807
R^2	0.08	0.05	0.06	0.06	0.05	0.04

Standard errors are in parenthesis. *denotes significance at 5% level. ** denotes significance at 10%.

In the regressions with more controls included the parameter estimates for genetic related factors such as racial background, gender, and age are similar to the results obtained earlier. It could be noted that the estimate for the *white* variable became less significant (i.e. 0.7609 for the full sample). There were also some changes in the estimates for the age variables, but they do not affect the overall signs and patterns.

Regression with all specified variables included resulted in slightly less significant estimates for the parameters describing education attainment, but with similar patterns and same signs as in earlier estimation for most of the parameters. There are few exceptions that should be noted. For the full sample the parameter estimates for the *postsec* variable (-0.5457) became more significant relative to the *somepostsec* variable estimate (-0.3946), and thus the results show even stronger inverse dependency of body mass index and education level. Also parameters estimates for the *secondary* and *somepostsec* variables for those who are 25 to 34 years of age became statistically significant, and are, unlike in other age groups, positive and, thus, increase body mass index levels if compared to the levels of the base group – high school drop outs. Estimates for these variables are 0.2793 and 0.3778, respectively. Perhaps, the effect of having secondary or some post-secondary education on body mass index levels comes later in life. Another possible explanation is that having only secondary or some post-secondary education has similar effect on younger generations as being a high school drop-out had for older generations, as general education level of population increases. F tests of the null hypotheses that the coefficients of the *somepostsec, postsec* and *secondary* variables for the full sample are equal showed that these hypotheses can be rejected for all combinations of these variables at 5% level of significance.

The following changes can be noted for the living conditions variables. First, those who live alone have the lowest body mass index levels for the full sample as well as across all age groups, while before in the middle age groups single parents had the lowest body mass index levels. F tests of the null hypotheses that the coefficients of the *alone* and *spousenoch* variables are equal showed that at 1% level of significance it can be rejected for the full sample. Testing of the *alone* and *singlepar* variables showed that the null hypothesis can also be rejected. Testing of the *spousenoch* and *singlepar* variables showed that at 10% level of significance the null hypothesis cannot be rejected for the full sample.

Also, gender difference between men and women who live alone diminished, i.e. the *alone* variable estimates are -0.6529 and -0.6189, for men and women, respectively. On the other hand, a more significant gender difference appears between single mothers and single fathers as parameter estimates for the *singlepar* variable are -0.3322 and -0.6809, respectively. Finally, estimate for the *spousenoch* parameter for women became statistically significant (-0.2849) and more significant than for men (-0.1287).

There were no significant changes in signs or patterns for house hold income variables estimates. It could be noted though, that parameter estimate for women who make from $30,000 to $49,999 became statistically significant. As it has positive sign, it can be inferred that women in the lower middle income level have the highest body mass index levels.

The new regression did not result in changes in signs of parameter estimates for behavioral factors. However, there were changes in significance of some estimates. As a result, gender difference in the size of parameter estimates for the *fruit_veg* variable disappeared. Also gender difference for the *long_hours* became smaller (i.e 0.2524 for women and 0.3840 for men).

The inclusion of a full set of controls does not change the sign of the *immigrant* variable. Foreign born individuals still on average have a body mass index lower than Canadian born.

However, gender differences disappear. For men the parameter estimate is equal to -0.4380, while for women -0.4646.

Table 9 presents the influence of racial background on body mass index levels by age groups, analysis of which has not yet been done in this paper. It can be seen that being white increases body mass index for individuals 25 to 64 years of age. The *white* estimates for those who are 25 to 34, 35 to 44, 45 to 54, and 55 to 64 years of age are 0.4398, 1.0818, 1.2479, 0.9417, respectively. Thus, racial background has relatively high impact on the 45 to 54 age group, and a relatively lower impact for individuals 25 to 34 years of age.

Gender is another factor yet to be analyzed by age groups. For all age groups, males have higher body mass index levels than females. The parameter estimates of the *male* variable for those who are 20 to 44 years of age are in the 1.7 to 1.8 range. Older age groups have lower estimates: 1.2548 for those who are 45 to 54 and 0.6251 for those who are 55 to 64 years of age. Thus, in older age groups there is less difference in body mass index levels between genders, which is in line with earlier conclusion based on the estimates from Table 3.

Estimated parameters can be compared to those found by other researches. For example, the racial background variable *white* has a positive sign in the regression presented in Table 8. Auld et al. (2005), on the other hand, found that whites have lower levels of body mass index than non-whites. A more detailed analysis by Barham et al. (2008) shows, for example, that those of Asian origin have lower levels of body mass index, while those of Aboriginal and Latin American origin have higher levels of body mass index than whites. Auld et al. (2005) find that men with secondary and some post-secondary education have higher body mass index levels and those who finished post-secondary education have lower body mass index levels than those who dropped out of high school. Estimation performed in this paper however showed an inverse correlation of educations attainment and body mass index levels for both genders. It can be also noted that unlike in estimation presented above, according to Auld et al. (2005), the difference between body mass index of single fathers and men who live with spouse and children is not significant.

6.6 Regression Analysis of Probability of Being Overweight or Obese

In this section I focus on the probability of being overweight. I use a standard definition for being overweight i.e. if body mass index is 25 points or higher. This way it is possible to verify some of the earlier findings and get a better understanding of factors that could determine increasing overweight and obesity rates. I use a probit model.

$$\Pr(\textit{overweight} = 1|X) = F(X\,\beta) \quad (5)$$

where F(·) is a normal distribution function, overweight is a dichotomous variable equal to 1 if the person is overweight and X is the vector of controls.

I use the same controls as in model (4). I control for gender, age, racial background, education level, income level, living arrangements, fruits and vegetables consumption, frequency of physical activities, work hours (overtime or not), and place of birth (foreign or Canadian-born). Results of the probit estimation are presented in Table 10. It shows the marginal effect, i.e. the change in the probability of being overweight when there is a change in an explanatory variable. This marginal effect is evaluated at the mean values of the control variables.

Table 10 Probit Regression Estimates: All Specified Variables

	dF/dx	Std. Err
white	0.0091	(0.0090)
male	0.1769*	(0.0045)
secondary	-0.0169*	(0.0073)
somepostsec	-0.0320*	(0.0093)
postsec	-0.0432*	(0.0064)
alone	-0.0661*	(0.0064)
spousenoch	-0.0077	(0.0061)
singlepar	-0.0516*	(0.0093)
otherlcond	-0.0424*	(0.0072)
hhinc_15_29	0.0197**	(0.0103)
hhinc_30_49	0.0314*	(0.0099)
hhinc_50_79	0.0317*	(0.0100)
hhinc_80	0.0195**	(0.0104)
age_25_34	0.1292*	(0.0091)
age_35_44	0.1601*	(0.0091)
age_45_54	0.2397*	(0.0092)
age_55_64	0.2806*	(0.0105)
fruit_veg	-0.0051*	(0.0009)
phys_activ	-0.0008*	(0.0001)
long_hours	0.0401*	(0.0057)
immigrant	-0.0635*	(0.0078)
constant	-0.1781*	(0.0157)
Number of observations	57,831	
R^2 (pseudo)	0.05	

*denotes significance at 5% level. ** denotes significance at 10%.

The estimates of the probit model that are presented in Table 10 have same signs and similar patterns to the estimates obtained earlier for body mass index regression for the full sample (see

Table 8). The only change that can be noted is a smaller difference between estimates for $30,000 to 49,999 and $50,000 to $79,999 income groups, i.e. 0.0314 and 0.0317, respectively. Earlier results showed that individuals from the first group have higher body mass index levels than from the second, i.e. estimates are 0.3535 and 0.2600, respectively.

7. Analysis of Food Consumption Behavior and Related Contextual Factors of Obesity

7.1 Overview

Contextual factors of obesity include various indirect determinants that influence an individual's behavior in regard to calories consumption and expenditure and, thus, could influence her level of body mass index. For example, food prices could influence an individual's decision on the amounts and types of foods purchased and consumed. Popularity of TV and computer entertainment could as well have an influence. The availability of gyms, sidewalks, and other sport related facilities in a certain geographic area are other examples of contextual factor of obesity.

In this section I extend the analysis of food consumption behavior by looking at the types of food purchases and examine their impact on an individual's body mass index. Particularly, I look at the share of food expenditures spent at fast food restaurants, table service restaurants, and supermarkets. Such analysis could provide some understanding of such contextual factors as food prices and restaurant and supermarket density.

7.2 Variables for Food Consumption Behavior Analysis

There is no information in the CCHS on food expenditures. Therefore, this information was taken from the FOOFEX survey and then integrated into the CCHS data set. For this purpose, I created 72 mutually exclusive groups. These groups were defined by gender, age, income and marital status. Marital status was used instead of living condition for the purpose of increasing the number of observations per group and thus getting more representative values of means.[2] Respondents were divided into 4 groups: 25 to 34, 35 to 44, 45 to 54, and 55 to 64 years of age. Those who are 20 to 24 years of age, who were included in previous regression analysis, were dropped from the samples used for food expenditures analysis due to the fact that the FOODEX data set does not allow to distinguish this age group among those who are 1 to 24 years of age. Income parameter was presented by 3 categories: low (those who make from $0 to $29,000 annually), middle (those who make $30,000 to $79,000), and high ($80,000 and above). Marital status was set to be one of the following three types: married, separated, or single. Those who were in common law relationship were considered as married. Separated include those who were widowed or divorced or separated due to other reasons.

Mean values for each group for relative food expenditures in fast food restaurants, full services restaurants, and supermarkets were transferred from the FOODEX data set to the one created from the CCHS data. For example, a married man who makes less than $30,000 and who is between 25 and 34 years of age is assigned a food expenditure estimated from the FOODEX. All individuals with the same characteristics are assigned the same estimates.

7.3 Model Specification and Results

The model with the following specification is estimated:

[2] The means are calculated using weights provided by FOODEX.

$$bmi = \beta_0 + \beta_1\, white + \beta_2\, male + \beta_3\, secondary + \beta_4\, somepostsec + \beta_5\, postsec + \beta_6\, alone + \beta_7\, spousenoch + \beta_8\, singlepar + \beta_9\, otherlcond + \beta_{10}\, hhinc\_15\_29 + \beta_{11}\, hhinc\_30\_49 + \beta_{12}\, hhinc\_50\_79 + \beta_{13}\, hhinc\_80 + \beta_{14}\, age\_35\_44 + \beta_{15}\, age\_45\_54 + \beta_{16}\, age\_55\_64 + \beta_{17}\, immigrant + \beta_{18}\, fastfood\_share + \beta_{19}\, tableserv\_share + \beta_{20}\, supermar\_share + \mu \quad (6)$$

Estimation results are presented in Tables 11 and 12.

Table 11

BMI OLS Regression Estimates with Food Expenditures by Gender

	Full sample	Female	Male
white	0.8821*	0.6647*	1.1191*
	(0.0673)	(0.1016)	(0.0874)
male	1.4360*		
	(0.0385)		
secondary	-0.4433*	-0.6766*	-0.2545*
	(0.0581)	(0.0886)	(0.0750)
somepostsec	-0.4991*	-0.5715*	-0.4461*
	(0.0776)	(0.1181)	(0.1000)
postsec	-0.7436*	-0.9548*	-0.5587*
	(0.0505)	(0.0794)	(0.0634)
alone	-0.6225*	-0.7573*	-0.6068*
	(0.0696)	(0.1184)	(0.0835)
spousenoch	-0.2649*	-0.4060*	-0.1698*
	(0.0469)	(0.0719)	(0.0601)
singlepar	-0.4211*	-0.5267*	-0.6327*
	(0.0889)	(0.1208)	(0.1622)
otherlcond	-0.0466	0.2054*	-0.3545*
	(0.0592)	(0.0966)	(0.0727)
hhinc_15_29	-0.0536	-0.1404	0.0706
	(0.0849)	(0.1195)	(0.1196)
hhinc_30_49	-0.0744	-0.1980	0.3747*

	(0.0871)	(0.1295)	(0.1187)
hhinc_50_79	-0.2501*	-0.6399*	0.4497*
	(0.0866)	(0.1292)	(0.1172)
hhinc_80	-0.4046*	-1.2412*	0.5756*
	(0.1001)	(0.1649)	(0.1290)
age_35_44	0.4306*	0.4002*	0.3070*
	(0.0527)	(0.0795)	(0.0699)
age_45_54	1.2204*	1.5210*	0.7628*
	(0.0555)	(0.0829)	(0.0743)
age_55_64	1.2897*	1.7345*	0.5555*
	(0.0728)	(0.1148)	(0.0962)
immigrant	-0.3796*	-0.3531*	-0.4286*
	(0.0548)	(0.0834)	(0.0704)
fastfood_share	3.1804*	-0.5590	-1.1708
	(0.7957)	(1.7818)	(0.8926)
tableserv_share	1.2103**	-1.0418	0.4659
	(0.6305)	(1.0974)	(0.7804)
supermar_share	2.3460*	0.5568	0.2810
	(0.5223)	(0.8148)	(0.7099)
constant	22.9388*	25.2194*	25.3616*
	(0.4132)	(0.6777)	(0.5494)
Number of observations	68,334	34,909	33,425
R^2	0.05	0.04	0.03

Standard errors are in parenthesis. *denotes significance at 5% level. ** denotes significance at 10%.

Table 12

BMI OLS Regression Estimates with Food Expenditures by Age

	Full sample	25-34	35-44	45-54	55-64
white	0.8821*	0.3358*	1.0794*	1.0935*	1.1642*
	(0.0673)	(0.1354)	(0.1261)	(0.1324)	(0.1600)
male	1.4360*	1.9347*	1.8229*	1.2691*	0.5308*
	(0.0385)	(0.0900)	(0.0694)	(0.0757)	(0.0945)
secondary	-0.4433*	-0.0367	-0.6420*	-0.5636*	-0.3810*
	(0.0581)	(0.1402)	(0.1071)	(0.1099)	(0.1201)
somepostsec	-0.4991*	0.1968	-0.6351*	-1.0289*	-0.4253*

	(0.0776)	(0.1647)	(0.1418)	(0.1531)	(0.1798)
postsec	-0.7436*	-0.3891*	-0.9090*	-0.8364*	-0.5783*
	(0.0505)	(0.1244)	(0.0963)	(0.0960)	(0.0954)
alone	-0.6225*	-0.9904*	-0.6233*	-0.5134*	-0.5183*
	(0.0696)	(0.1661)	(0.1276)	(0.1328)	(0.1682)
spousenoch	-0.2649*	-0.6849*	-0.2728*	0.0663	-0.3445*
	(0.0469)	(0.1010)	(0.0970)	(0.0859)	(0.1076)
singlepar	-0.4211*	-0.4926*	-0.5723*	-0.2238	-0.0175
	(0.0889)	(0.2246)	(0.1500)	(0.1710)	(0.2570)
otherlcond	-0.0466	-0.3528*	0.1194	0.0577	-0.0524
	(0.0592)	(0.1318)	(0.1042)	(0.1158)	(0.1608)
hhinc_15_29	-0.0536	-0.0840	-0.1579	0.0400	0.0437
	(0.0849)	(0.1880)	(0.1635)	(0.1717)	(0.1584)
hhinc_30_49	-0.0744	0.0306	-0.1577	0.6278*	-0.3342**
	(0.0871)	(0.1918)	(0.1735)	(0.1922)	(0.1904)
hhinc_50_79	-0.2501*	-0.3196**	-0.2663	0.3963*	-0.2272
	(0.0866)	(0.1916)	(0.1717)	(0.1910)	(0.1935)
hhinc_80	-0.4046*	-0.4629*	-0.4692*	0.6063*	-0.5438*
	(0.1001)	(0.2213)	(0.1903)	(0.2352)	(0.2604)
age_35_44	0.4306*				
	(0.0527)				
age_45_54	1.2204*				
	(0.0555)				
age_55_64	1.2897*				
	(0.0728)				
immigrant	-0.3796*	-0.7552*	-0.2386*	-0.1396	-0.5496*
	(0.0548)	(0.1381)	(0.1098)	(0.0988)	(0.1006)
fastfood_share	3.1804*	1.9557	12.2830*	-12.7546*	4.3833
	(0.7957)	(1.2197)	(2.0539)	(2.5720)	(3.8562)
tableserv_share	1.2103**	3.9497*	-0.8463	-8.9017*	5.6363*
	(0.6305)	(1.4150)	(1.3913)	(1.7068)	(1.9242)
supermar_share	2.3460*	5.8423*	1.6424	-7.2466*	2.9645*
	(0.5223)	(1.0503)	(1.2295)	(1.5163)	(1.3196)
constant	22.9388*	20.9287*	22.9819*	31.6733*	23.2579*
	(0.4132)	(0.8222)	(0.9232)	(1.1682)	(1.1661)
Number of observations	68,334	15,584	21,355	18,379	13,016
R^2	0.05	0.05	0.06	0.03	0.02

Standard errors are in parenthesis. *denotes significance at 5% level. ** denotes significance at 10%.

As can be seen from Table 11, the estimate for *fastfood_share* is 3.1804. This means that if an individual would increase the share of expenditure on fast food meals in total food expenditures by 10%, her or his body mass index would increase by 0.32 points. Similarly if the share of expenditures for meals in table service restaurants (*tableserv_share*) would increase by 10%, body mass index would increase by 0.12 points, and with a 10% increase of expenditures for food purchased in supermarkets (*supermar_share*), body mass index would increase by 0.23 points. This seems to be a high effect.

It can be noted that parameter estimate for the *fastfood_share* variable is more significant than either for *tableserv_share* or *supermar_share* variables. F test of the null hypotheses that the coefficients of any of these variables are equal to each other showed that it can be rejected at 5% level of significance. Thus, one can conclude that eating in fast food restaurant contributes to increasing body weights of Canadians more than eating in table service restaurants or food prepared at home. It is also interesting to note that the parameter estimate for *tableserv_share* is lower than either for *fastfood_share* or *supermar_share.* This indicates that those who eat in table service restaurants on average have lower body mass index levels than those who eat food prepared at home or in fast food restaurants. Wider variety of healthy choices that could be available for an individual in a table service restaurant could explain the difference. Also higher prices of the meals in table service restaurants could reflect in lower sizes of food portions consumed.

There is a large difference in parameter estimates for the food expenditures variables across age groups. For example, parameter estimates for the *fastfood_share* variable for those who are 35 to 44 years of age is 12.2830. For those who are 45 to 54 years of age this parameter is also significant, but is negative (i.e.-12.7546). It is hard to explain such a large difference, and further investigation is required. Parameter estimates for the *fastfood_share, tableserv_share,* and *supermar_share* variables for male or female samples turned out to be statistically insignificant.

Analysis of how food expenditures patterns influence probability of being overweight was also performed. For this purpose the *fastfood_share*, *tableserv_share*, and *supermar_share* variables were added to the probit regression analysis performed earlier (See equations 5 and Table 10). Results are presented in Table 13.

Results of estimation of the probit model are in line with findings on how food expenditures determine the *bmi* variable (See Table 11). Expenditures in fast food restaurants can more significantly increase individual's body mass index and probability of being overweight relative to expenditures in table service restaurants or supermarkets, i.e. the parameter estimates are 0.2844, 0.0432, and 0.1464 for the *fastfood_share*, *tableserv_share*, and *supermar_share* variables, respectively.

Table 13 Probit Regression Estimates: Model with Food Expenditures

	dF/dx	Std. Err.
white	0.0190*	(0.0082)
male	0.1682*	(0.0043)
secondary	-0.0314*	(0.0064)
somepostsec	-0.0365*	(0.0085)
postsec	-0.0586*	(0.0055)
alone	-0.0632*	(0.0070)
spousenoch	-0.0130*	(0.0055)
singlepar	-0.0578*	(0.0092)
otherlcond	-0.0229*	(0.0075)
hhinc_15_29	0.0154**	(0.0080)
hhinc_30_49	0.0173*	(0.0086)
hhinc_50_79	0.0164**	(0.0087)
hhinc_80	0.0088	(0.0105)
age_35_44	0.0362*	(0.0058)
age_45_54	0.1139*	(0.0062)
age_55_64	0.1593*	(0.0079)
immigrant	-0.0593*	(0.0068)
fastfood_share	0.2844*	(0.0816)
tableserv_share	0.0432	(0.0674)
supermar_share	0.1464*	(0.0563)
Constant	-0.1830*	(0.0444)
Number of observations	68,334	
R2 (pseudo)	0.03	

*denotes significance at 5% level. ** denotes significance at 10%.

8. Limitations

It should be noted that the regressors used in estimations of the models may be correlated with unobserved factors which would result in omitted variable bias. Having said, other papers in the literature also face the same problems, and except for Barham et al (2008), this issue is left unresolved.

9. Conclusion

First, an analysis of determining factors of body mass index by age groups gave a number of interesting results. For example, it was found that body mass index of men grows faster than for women up to the age of mid-forties. After that age body mass index growth of men slows down and even decreases, while for women it continues growing and catches up to men's level. Also, although all immigrants have body mass index lower than Canadian born, the age analysis shows that this parameter is more significant for younger immigrants, who are 20 to 24 years of age, and is less significant for those who are 45 to 54 years of age. In addition, it was found that those who are 25 to 34 years of age with secondary or some post-secondary education have body mass index levels higher than high-school dropouts, though in general education level is inversely related to the level of body mass index. Those who live alone have the lowest levels body mass index levels if compared to individuals with other living arrangements across all age groups[3], while those who live with spouse and children have the highest body mass index levels.

Second, an analysis of behavioral factors gave the following results. Physical exercises is more significant for women than for men. Thus, men have to put in more effort into exercise than women to get the same results. Those who are 25 to 44 years of age have a higher effect from fruits and vegetables consummation. The importance of physical activities for purposes of

3 F tests of the null hypotheses that the coefficients of the *alone* and *spousenoch* variables are equal showed that at 10% level of significance it cannot be rejected for individuals 55 to 64 years of age, while it can be rejected for other age groups, as well as for the full sample. Testing of the *alone* and *singlepar* variables showed that the null hypothesis cannot be rejected for individuals 20 to 24, 35 to 44, and 55 to 64 years of age, but it can be rejected for the full sample. Testing of the *spousenoch* and *singlepar* variables showed that at 10% level of significance the null hypothesis can be rejected only for those 45 to 54 years of age, and it cannot be rejected for the full sample.

sustaining healthy body weights is higher for those who are 45 to 64 years of age. Overtime work has a different effect on body mass index for women and men with a stronger increasing impact on body mass index levels of men.

Third, an analysis of the role of food consumption showed that eating in fast food restaurant contributes to increasing body weights of Canadians, more than eating meals purchased in table service restaurants or food prepared at home. Those who eat in fast food restaurants also have a higher probability of being overweight. On the other hand, those who eat in table service restaurants, on average, have lower body mass index levels than those who eat food prepared at home or in fast food restaurants.

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Appendices

Appendix A

Description of Variables

Variable	Description
bmi	Body mass index of respondent
white	Dichotomous variable that equals 1 if respondent is white, and 0 otherwise
male	Dichotomous variable that equals 1 if respondent is male, and 0 otherwise
secondary	Dichotomous variable that equals 1 if respondent has secondary education, and 0 otherwise
somepostsec	Dichotomous variable that equals 1 if respondent has unfinished unversity education, and 0 otherwise
postsec	Dichotomous variable that equals 1 if respondent has postsecondary education, and 0 otherwise
alone	Dichotomous variable that equals 1 if respondent is living alone, and 0 otherwise
spousenoch	Dichotomous variable that equals 1 if respondent is living with a spouse but without children, and 0 otherwise
singlepar	Dichotomous variable that equals 1 if respondent is a singular parent, and 0 otherwise
otherlcond	Dichotomous variable that equals 1 if respondent has other living conditions, and 0 otherwise
hhinc_15_29k	Dichotomous variable that equals 1 if household income from all sources in 2001 was between $15,000 and $ 29,999, and 0 otherwise
hhinc_30_49k	Dichotomous variable that equals 1 if household income from all sources in 2001 was between $30,000 and $ 49,999, and 0 otherwise
hhinc_50_79k	Dichotomous variable that equals 1 if household income from all sources in 2001 was between $50,000 and $ 79,999, and 0 otherwise
hhinc_80	Dichotomous variable that equals 1 if household income from all sources in 2001 was above 80k, and 0 otherwise
age_25_34	Dichotomous variable that equals 1 if respondent is between 25-34 years if age, and 0 otherwise
age_35_44	Dichotomous variable that equals 1 if respondent is between 35-44 years if age, and 0 otherwise
age_45_54	Dichotomous variable that equals 1 if respondent is between 45-54 years if age, and 0 otherwise
age_55_64	Dichotomous variable that equals 1 if respondent is between 55-64 years if age, and 0 otherwise
fruit_veg	Daily consumption of fruits and vegetables by respondent
phys_activ	Respondent's monthly frequency of physical activity lasting more than 15 min
long_hours	Dichotomous variable that equals 1 if respondent works more than 40 hours per week
immigrant	Dichotomous variable that equals 1 if respopndent is an immigrant, and 0 otherwise
fastfood_share	Individual's share of expenditures in fast food restaurants in total weekly expenditures
tableserv_share	Individual's share of expenditures in table service restaurants in total weekly expenditures
Supermar_share	Individual's share of expenditures in supermarkets in total weekly expenditures

Appendix B

Body Mass Index

Overweight and obesity are measured by body mass index (BMI), which is calculated by dividing individual's weight in kilograms by her or his height in meters squared. According to the World Health Organization, BMI is classified into six categories, which are used to identify related health risk:

	BMI range	Risk of developming health problems
Underweight	<18.5	Increased
Normal weight	18.5 to 24.9	Least
Overweight	25.0 to 29.9	Increased
Obese Class I	30.0 to 34.9	High
Obese Class II	35.0 to 39.9	Very high
Obese Class III	≥40.0	Extremely high

BMI is calculated as follows:

Metric: $BMI = weight(kg)/height(meters)^2$

Non-metric $BMI = weight(pounds)/height(inches)^2 x703$

For example, the weight cut points for a 5'10" (1.78m) person and a 5'4"(1.63m) person would be:

	Heigth 70"/1.78m Weight (pounds)	**(kg)**	**Heigth 64"/1.63m Weight (pounds)**	**(kg)**
Underweight	128 or less	58.4 or less	107 or less	49.0 or less
Normal weight	129-173	58.5-79.0	108-145	49.1-66.2
Overweight	174-208	79.1-94.8	146-174	66.3-79.5
Obese Class I	209-243	94.9-110.7	175-203	79.6-92.8
Obese Class II	244-278	110.8-126.5	204-232	92.9-106.1
Obese Class III	279+	126.6+	233+	106.2+

Source: Tjepkema, 2005

Appendix C

Trends in Prevalence of Overweight and Obesity Among Canadian Adults

Percentage Canadian Adults With BMI ≥ 25

	Nutrition Canada Survey 1970-1972	Canada Health Survey 1978-1979	Canadian Heart Health Surveys 1986-1992	CCHS 2004
Men	47	55.6	58.1	65.0
Women	33.9	42.3	40.6	53.4

CCHS: Canadian Community Health Survey

Sources: For 1970-1992 Torrance et al. (2002), Raine (2004); for 2004 Tjepkema (2005)

Percent Obese (BMI ≥ 30)

HPS	HPS	NPHS	NPHS	NPHS	CCHS	CCHS
1985	1990	1994	1996	1998	2000-2001	2004
5.6	9.2	13.4	12.7	14.8	14.9	23.1

HPS: Health Promotion Survey

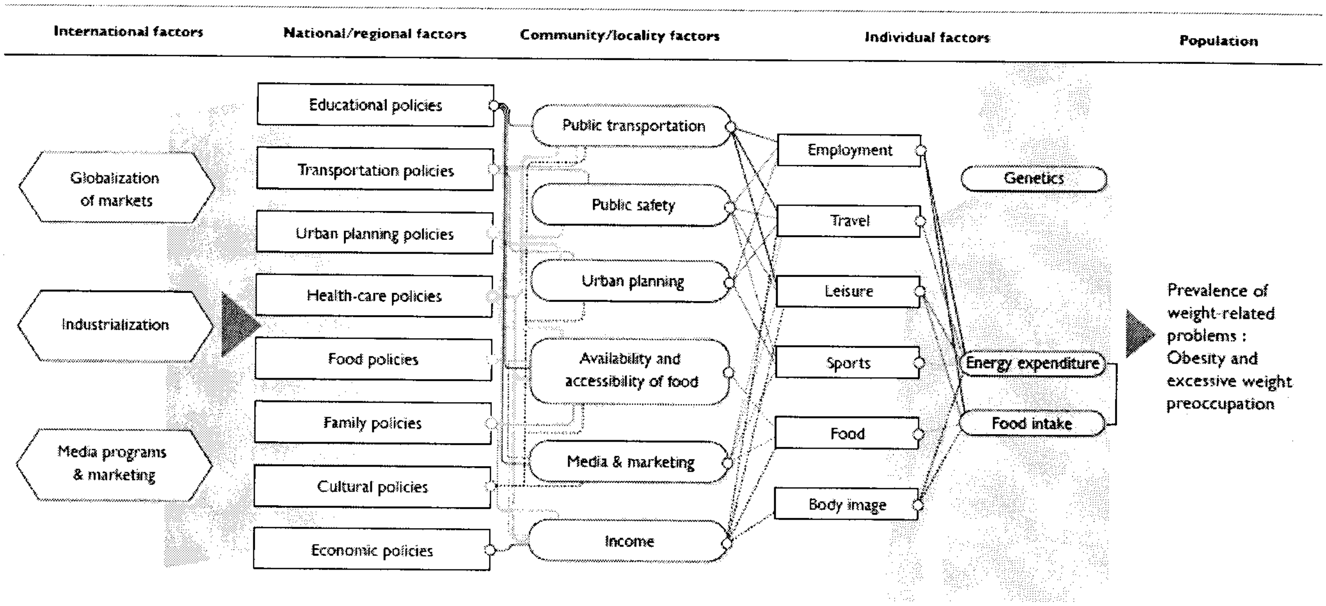
NPHS: National Population Health Survey

CCHS: Canadian Community Health Survey

Source: for 1985 – 2001 Katzmarzyk (2002); for 2004 Tjepkema (2005).

Appendix D

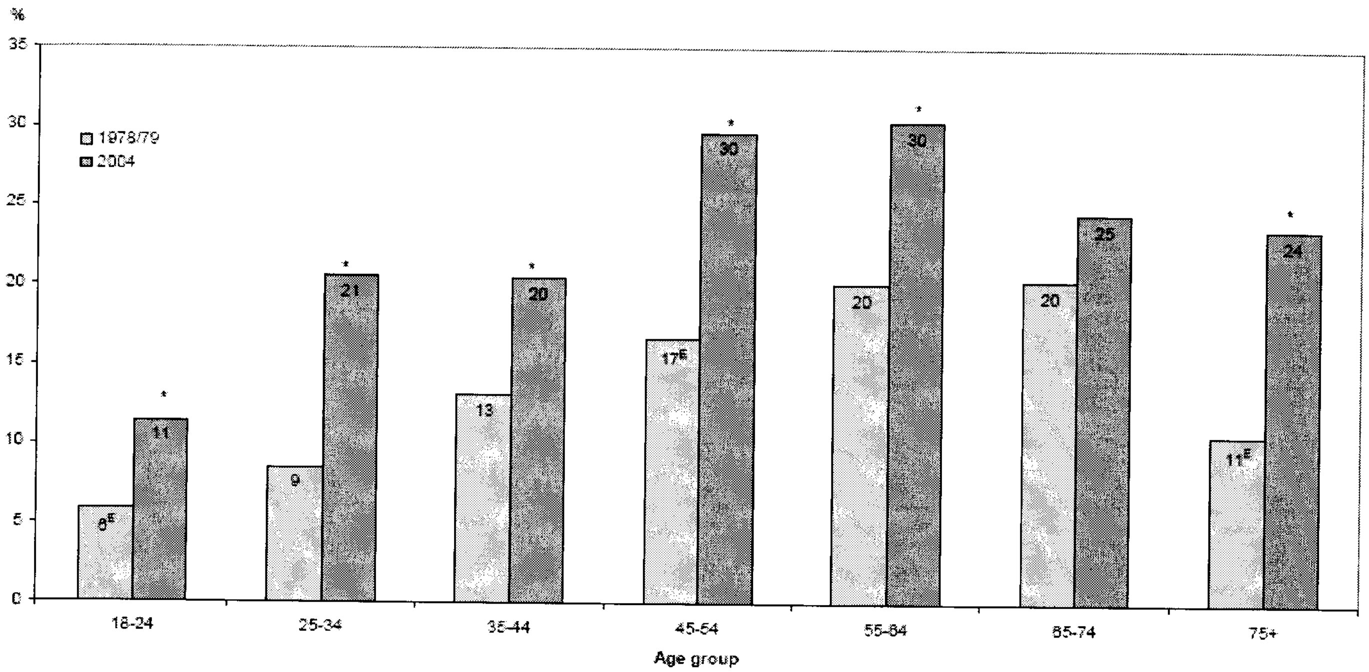
Causal web of factors influencing weight-related problems



Source: Groupe de travail provincial sur la problématique du poids (2004)

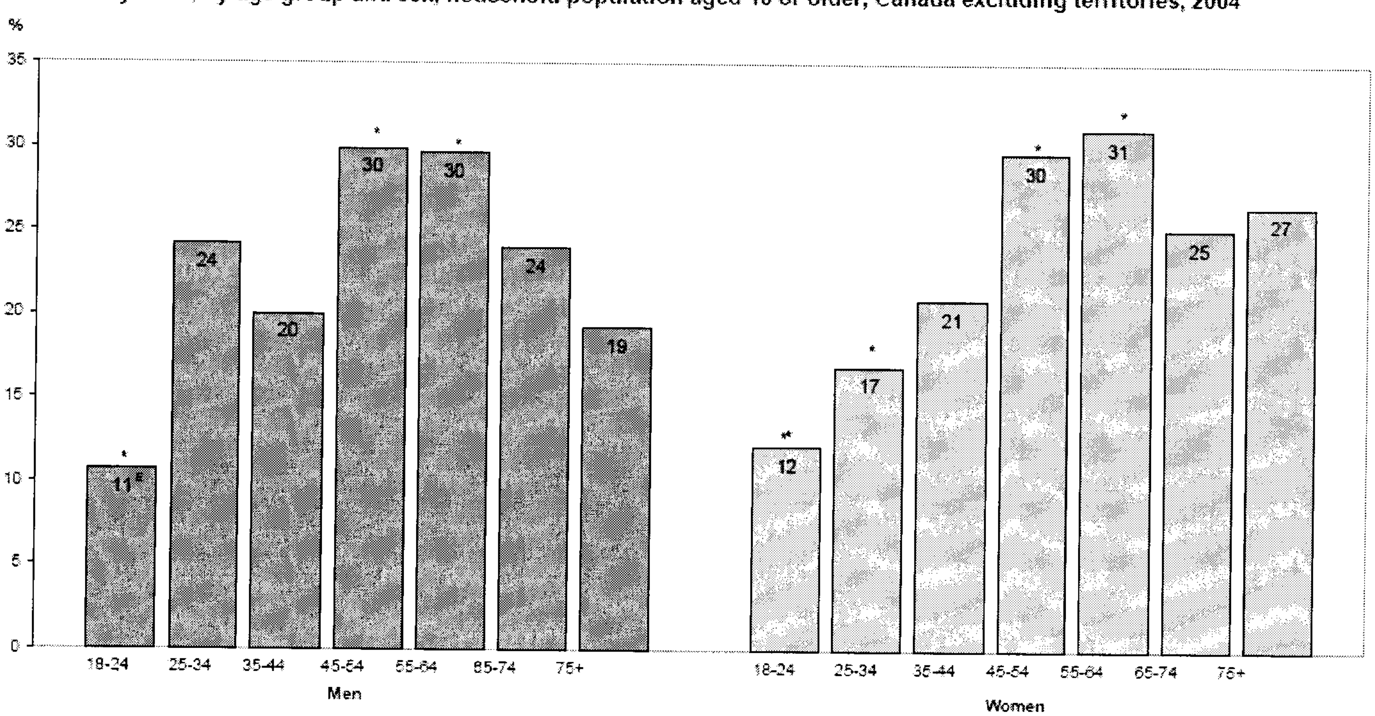
Appendix E   Obesity Rates by Age in Canada

Obesity rates, by age group, household population aged 18 or older, Canada excluding territories, 1978/79 and 2004



Data sources: 2004 Canadian Community Health Survey: Nutrition; 1978/79 Canada Health Survey
* Significantly higher than estimate for 1978/79 ($p < 0.05$)
E Coefficient of variation 16.6% to 33.3% (interpret with caution)

Obesity rates, by age group and sex, household population aged 18 or older, Canada excluding territories, 2004



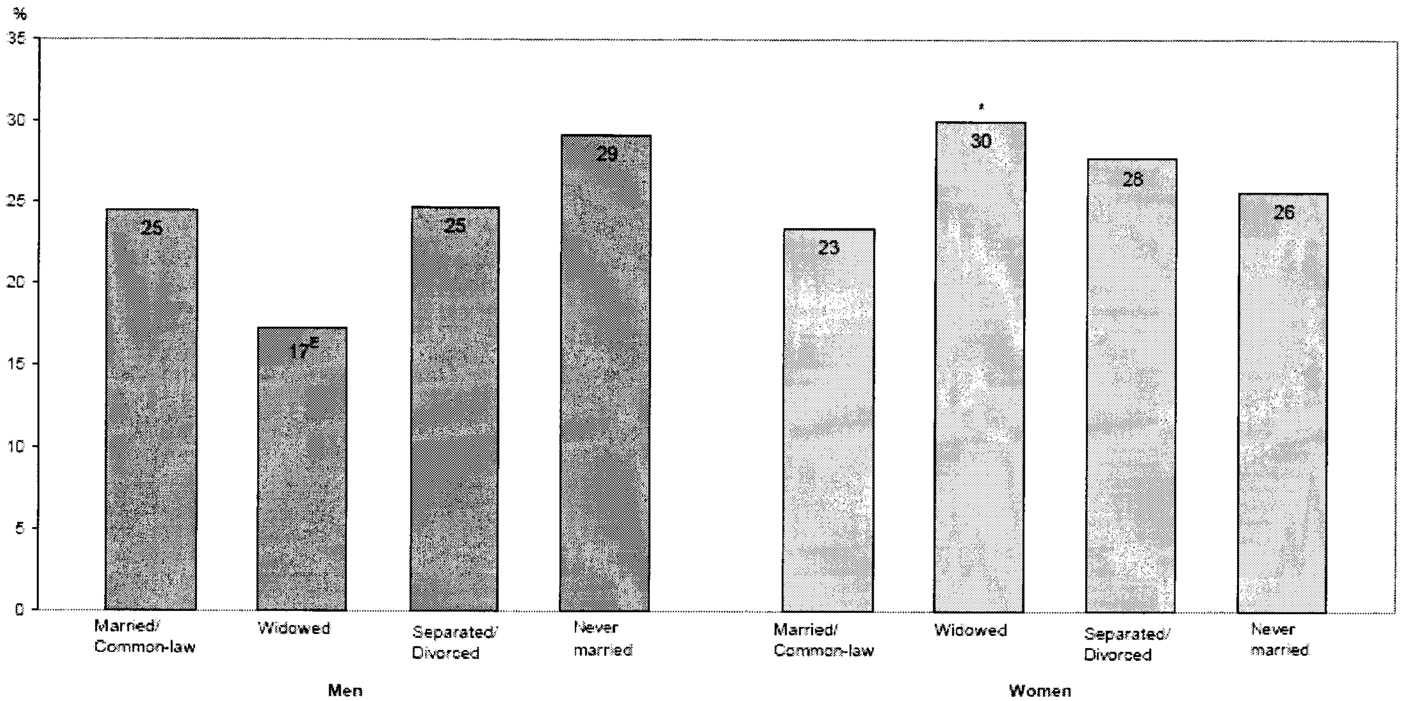
Data source: 2004 Canadian Community Health Survey: Nutrition
* Significantly different from overall rate for same sex ($p < 0.05$)
E Coefficient of variation 16.6% to 33.3% (interpret with caution)

Source: Tjepkema, 2005

Appendix F

Obesity Rates by Marital Status in Canada

Obesity rates, by marital status and sex, household population aged 25 or older, Canada excluding territories, 2004



Data source: 2004 Canadian Community Health Survey: Nutrition
* Significantly different from estimate for married/common-law ($p < 0.05$)
E Coefficient of variation 16.6% to 33.3% (interpret with caution)

Source: Tjepkema, 2005

Appendix G

OLS regression Estimated by Auld et al. (2005)

	Full sample	Male	Female
Body Mass Index (BMI)	25.6578	26.5910	24.7647
White	0.8905	0.8931	0.8881
Aged 40-45	0.4759	0.4736	0.4781
Male	0.4890	1.0000	-
Foreign Born	0.1475	0.1452	0.1497
Education - High School Drop Out	0.1333	0.1469	0.1203
Education - High School Graduate	0.2220	0.2112	0.2323
Education – Some College	0.0721	0.0664	0.0776
Education - College Graduate and Above	0.5726	0.5754	0.5698
Income - Less Than 15,000	0.0523	0.0466	0.0577
Income – Between 15,000 and 30,000	0.0968	0.0806	0.1122
Income – Between 30,000 and 50,000	0.1941	0.1958	0.1925
Income – Between 50,000 and 80,000	0.3027	0.3072	0.2983
Income - Above 80,000	0.3035	0.3236	0.2842
Income – Missing	0.0507	0.0461	0.0551
Living Alone	0.1100	0.1418	0.0795
Living with Partner/Spouse, No Child	0.1220	0.1213	0.1225

Source: Auld et al. (2005)

Appendix H
Full list of Variables Used by Chou et al. (2004)

Variable's Name	Definition
Body mass index	Weight in kilograms divided by height in meters squared
Obese	Dichotomous variable that equals 1 if body mass index ≥30 kg
Black non-Hispanic	Dichotomous variable that equals 1 if respondent is Black but not Hispanic
Hispanic	Dichotomous variable that equals 1 if respondent is Hispanic
Other race	Dichotomous variable if respondent's race is other than White or Black
Male	Dichotomous variable that equals 1 if respondent is male
Some high school	Dichotomous variable that equals 1 if respondent completed at least 9 years but less than 12 years of formal schooling
High school graduate	Dichotomous variable that equals 1 if respondent completed exactly 12 years of formal schooling
Some college	Dichotomous variable that equals 1 if respondent completed at least 13 years but less than 16 years of formal schooling
College graduate	Dichotomous variable that equals 1 if respondent graduated from college
Married	Dichotomous variable that equals 1 if respondent is married
Divorced	Dichotomous variable that equals 1 if respondent is divorced or separated
Widowed	Dichotomous variable that equals 1 if respondent is widowed
Household income	Real household income in thousands of 1982–1984 dollars
Age	Age of respondent
Restaurants	Number of fast-food restaurants and full-service restaurants per 10,000 persons in respondent's state of residence
Fast-food price	Real fast-food meal price in respondent's state of residence in 1982–1984 dollars
Full-service restaurant price	Real full-service restaurant meal price in respondent's state of residence in 1982–1984 dollars
Food at home price	Real food at home price in respondent's state of residence in 1982–84 dollars: weighted average of prices of 13 food items, weights are shares of each item in total food expenditures based on expenditure patterns of mid-management (middle-income) households
Cigarette price	Real cigarette price in respondent's state of residence in 1982–1984 dollars
Alcohol price	Real alcohol price in respondent's state of residence in 1982–1984 dollars: weighted average of prices of pure ounce of ethanol in beer, wine, and spirits; weights are shares of each item in total alcohol consumption
Private	Dichotomous variable that equals 1 if smoking is prohibited in private workplaces in respondent's state of residence
Government	Dichotomous variable that equals 1 if smoking is prohibited in state and local government workplaces in respondent's state of residence
Restaurant	Dichotomous variable that equals 1 if smoking is prohibited in restaurants in respondent's state of residence
Other	Dichotomous variable that equals 1 if smoking is prohibited in other public places such as elevators, public transportation, and theaters in respondent's state of residence