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Factors Influencing the Body Mass Index of Adults in Canada

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Factors Influencing the Body Mass Index of Adults in Canada

This paper explores socio-demographic, economic and behaviour factors influencing body mass index (BMI) amongst 20 to 64 year old adults in Canada. BMI scores in Canada have increased, with gains stemming from disproportionate increases in female BMI. Econometric results indicate higher BMI scores for males, those born in Canada, those in food insecure homes and whites. Age-gender interactions suggest different patterns of BMI adjustment over the life of males and females; a pronounced inverse quadratic relationship between with age and male BMI is noted, while female BMI increases with age. Education, used as a gauge of inequality, is inversely related to BMI, while income has a muted effect. BMI is inversely related to level of physical activity, an effect which is more pronounced for females in Canada. BMI has an inverse quadratic relationship with smoking behaviour, with higher BMI amongst former smokers than daily, occasional and non-smokers. BMI appears to be inversely related to intensity of alcohol consumption.

Keywords: Obesity, BMI, Canada, Socio-demographic, Economic, Adults

JEL Classification: I10, J1

Introduction

The prevalence of overweight and obesity amongst Canadians has grown (Katzmarzyk 2002a, 2002b; Tremblay et al. 2002; Belanger-Ducharme and Tremblay 2005; Katzmarzyk and Mason 2006; Contoyannis and Wildman 2007). While particular groups within the population are vulnerable to excess overweight and obesity (i.e. children, aboriginals and the poor), wider secular trends have important impacts. In particular, rising rates of overweight and obesity contribute to rising health care costs (McGinnis and Meyers, 1999). Estimates of the direct economic cost of obesity in Canada (e.g. hospital and other healthcare, physical and healthcare professionals, and drugs, etc.) equalled $1.8 billion in 1997 (Laird-Birmingham et al. 1999), or about 2.4 percent of all healthcare expenditures. More recently, estimates of the direct and indirect (including value of lost economic output) healthcare costs of obesity have been pegged at $4.3 billion, with direct costs equalling $1.6 billion, and indirect costs equalling $2.7 billion (Katzmarzyk and Janssen 2004).[1] Given the increasing prevalence of overweight and obesity in Canada, these economic costs cannot be ignored.

Body Mass Index (BMI) is typically used to characterize one's body shape; the growing trend in overweight and obesity in Canada reflects rising BMI scores. The increase in BMI amongst the Canadian population reflects an increase in energy intake relative to energy expenditure. This trend is not unique to Canada, with much research undertaken to explore the factors influencing BMI. The United States is no exception, where a rising rate of obesity is well documented (e.g., Cutler et al. 2003; Helmchen and Henderson 2004; Komlos and Baur 2004; Mujahid et al. 2005; Phuong Do et al 2007). Cutler et al. (2003) attribute rising BMI in the U.S. not to lack of energy expenditure, but to increased energy intake. In particular, they decompose caloric intake between 1977-1978 and 1994-1996 and conclude that calories per meal has not changed dramatically, but that more calories are consumed as snacks. Amongst males and females, the number of calories in a snack increased 90 and 112 percent, respectively, between 1977-1978 and 1994-1996 (Cutler et al. 2003 p.101, Table 2). Cutler et al. (2003) also note that

[1] Katzmarzyk and Janssen 2004 also peg the economic costs of physical inactivity at $5.3 billion.

increased obesity rates are correlated with "…access to new food technologies and to processed foods." (Cutler et al. 2003, p.94).[2]

Efforts to mitigate rising rates of obesity and overweight have been multi-facetted. In Canada, a number of social marketing campaigns have been used, such as the recently revived *Participaction* campaign, *Canada's Food Guide*, the *5-to-10 a day* program sponsoured by the Canadian Cancer Society, the Heart and Stroke Foundation of Canada and the Canadian Produce Marketing Association, as well as targeted programs, such as school nutrition programs and programs aimed at raising activity levels amongst at risk groups. Nevertheless, our understanding of the factors affecting BMI in Canada, and how these might change overtime, is still emerging. The purpose of this paper is to explore the factors shaping BMI in Canada using data from population and community health surveys from 1994 to 2005, and to see if the measured relationships are robust over different samples. Attention focuses on socio-demographic, economic and behaviour factors influencing individual BMI amongst 20 to 64 year old adults (both male and non-pregnant females) in Canada.[3] The next section of the paper surveys the recent BMI literature for Canada and elsewhere. Data used for the analysis is then discussed. Results from a model regressing individual BMI scores on socio-demographic, economic and behaviour factors are then presented and discussed. Conclusions and recommendations end the paper.

Previous Research

An enormous volume of clinical, epidemiological and population health literature has emerged on the issue of obesity and overweight (see Sokar-Todd and Sharma 2004 for a review of obesity research in Canada). In general terms, this literature explores differences in BMI across sub-groups of a defined population (see, for example, Markowitz and Cosminsky 2005). At the same time, literature has emerged which examines BMI via anthropometrics in the context of social science research.

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[2] Others have found evidence that rising obesity rates are associated with an increase in the marginal rate of time preference (Komlos et al. 2004; Smith et al. 2005).

[3] Those under 20 years of age are omitted from the analysis for several reasons. First, overweight and obesity amongst children and youths has been explored extensively elsewhere (see, for example, Tremblay and Willms 2000, 2003; Willms et al. 2003; and Phipps et al. 2006). Secondly, the data used in this analysis only has limited coverage of those under the age of 20, and so systematic differences in BMI by age cannot be explored across the entire sample.

The anthropometric literature related to BMI follows two streams: studies which seek to explain BMI for a given populations; and studies which use BMI as a covariate to explain particular economic or health outcomes. Examples of the latter include analysis of BMI effects on employment, wealth or earnings (Baum and Ford 2004; Zagorsky 2005; Paraponaris et al. 2005; Dinda et al. 2006; Brunello and D'Hombres 2007), longevity and mortality risk (Costa 1993; Henderson 2005; Linares and Su 2005; Sunder 2005), birth weights (Voigt et al. 2004; Mironov 2007) and early puberty (Hulanicka et al. 2007). Evolution of BMI in transitional economies has also been investigated (Cameron 2003; Koziel et al. 2004; Huffman and Rizov 2007; Knai et al. 2007).

A number of studies have examined the socio-demographic and economic factors influencing adult BMI. Gender is often an important dimension, with many studies reporting higher BMI for males than females (Tremblay et al. 2002; Cutler et al. 2003; Kimhi 2003; Chou et al. 2004; Gyenis and Joubert 2004; Rashad et al. 2006; Belanger-Ducharme and Tremblay 2005; Borghans and Golsteyn 2006; Heineck 2006; Kaushal 2007; Ver Ploeg et al. 2007). However, gender based differences can mask ethnic effects. Several studies report lower BMI for African-American males than females, but higher BMI for white and Mexican-American men (Komlos and Baur 2004; Mujahid et al. 2005; Phuong Do et al. 2007). Note too, that some have observed a gender catch-up, with female BMI increasing at a faster pace than male BMI (Borghans and Golsteyn 2006).

Given the sensitivity of children to rising rates of overweight and obesity, many studies have focused only on younger age cohorts (e.g. Tremblay and Willms 2000, 2003; Willms et al. 2003; Zellner et al. 1996, 2004; Phipps et al. 2006). Nevertheless, studies of adult BMI have included a polynomial of age as a covariate in BMI regression models (Chou et al. 2004; Costa-Font and Gil 2005; Rashad 2006; Rashad et al. 2006; Carson 2007; Huffman and Rizov 2007; Phuong Do et al. 2007; Ver Ploeg et al. 2007), while others include age-cohort effects via categorical dichotomous variables (Kimhi 2003; Komlos and Baur 2004) or parsed their data into finer age-based sub-sets (Cutler et al. 2003; Kaushal 2007). Regardless, the empirical evidence suggests an inverse-quadratic relationship between BMI and age.

Economic inequality is often cited as a factor explaining obesity (Vigerova et al. 2004; Drewnowski and Specter 2004; Godoy et al. 2005; Drewnowski and Darmon 2005). In this respect, income and/or education are often included to capture inequality effects. BMI (or obesity) has been reported to have a quadratic (Chou et al. 2004; Costa-Font and Gil 2005; Rashad 2006; Rashad et al. 2006) or inverse (Heineck 2006; Ver Ploeg 2007) relationship with income. An inverse relationship between BMI and education has been reported (Cutler et al. 2003; Chou et al. 2004; Rashad et al. 2006; Kaushal 2007), while others report mixed education effects (Komlos and Baur 2004; Heineck 2006; Rashad 2006; Huffman and Rizov 2007; Phuong Do et al. 2007). Occupation and social status have also been included to control for inequality (Komlos and Kriwy 2002; Heineck 2006; Carson 2007).

Other factors have been found to influence BMI. For instance, regional differences in BMI have been noted for Canada (Shields and Tjepkema 2006; Tjepkema 2006), Germany (Komlos and Kriwy 2002; Heineck 2006), and Russia (Huffman and Rizov 2007). Race has also been included as a covariate to explain BMI (Chou et al. 2006; Rashad 2006; Rashad et al. 2006; Phuong Do et al. 2007), while some parse the data based on race and analyze these sub-sets of data (Komlos and Baur 2004; Mujahid et al. 2005; Rashad 2006; Ver Ploeg et al. 2007). Previous analysis with Canadian data show marked differences, with off-reserve aboriginals and whites having higher BMI scores than other race groups (Belanger-Ducharme and Tremblay 2005; Tremblay et al. 2005). As well, immigrants in the U.S. and Canada have been reported to have lower BMI scores than non-immigrants (Tremblay et al. 2005; Belanger-Ducharme and Tremblay 2005; Kaushal 2007), although, immigrant BMI scores in Canadian appear to be converging with those of Canadian birth (Tremblay et al. 2005). Differences in BMI across marital status have been reported, with higher BMI reported for married individuals (Cutler et al. 2003; Costa-Font and Gil 2005; Rashad et al. 2006; Kaushal 2007; Phuong Do et al. 2007).

Differences in BMI across individuals with varying levels of physical activity and food security have been explored. Existing evidence suggests an inverse relationship between intensity of physical activity and BMI (Costa-Font and Gil 2005; Tremblay et al. 2005). Food security appears to play a role as well, with some recognizing the importance of income and the relative price of less healthy food to more nutritious foods (Chou et al. 2004; Drewnowski and Specter 2004; Drewnowski and Darmon 2005). However, the econometric evidence related to food security and physical activity is limited.

Modes of consumptive behaviour are also important factors shaping BMI. One would expect a positive relationship between BMI, caloric intake and foods with particular characteristics (*ceteris paribus*). The notion here is that BMI increases if the energy balance equation is positive. Indeed, Huffman and Rizov (2007) report a positive and significant relationship between BMI and calories consumed, and percent of calories from fat and protein. Smoking has been reported to have a negative relationship with BMI (Kahn et al. 1997; Costa-Font and Gil 2005; Rashad 2006; Huffman and Rizov 2007), a result attributed to increased metabolism and suppression of appetite amongst smokers (Huffman and Rizov 2007). While results are some what mixed concerning the relationship between alcohol consumption and BMI (Prentice 1995; Kahn et al. 1997), Costa-Font and Gil (2005) reported an inverse relationship between BMI and daily alcohol consumption. The impact of these consumptive behaviours has also been proxied with inclusion of the price of (or tax on) cigarettes and alcohol (Chou et al. 2006; Rashad et al. 2006). However, the role of smoking and alcohol consumption has generally received mixed attention in the econometric-based literature.

Nevertheless, some clear trends have emerged. Gender, age, income and education appear important covariates in explaining BMI. At the same time, some studies emphasize the role of ethnicity, marital status, food security and intensity of physical activity, as well as regional effects. While fewer studies are able to control for smoking and alcohol consumption, such behaviours offer scope for deeper insight. In light of this, these covariates will be included in the BMI-regressions which follow. Four key areas of contribution are important in this respect; namely, the role of: 1) smoking; 2) alcohol consumption; 3) physical activity; and 4) food security in shaping the BMI of adults in Canada.

Methods & Data

This analysis uses data from public use micro-files (PUMF) for two different Canadian health surveys, namely the 1994, 1996 and 1998 versions of the National Population Health Surveys (NPHS) and the 2001, 2003, and 2005 versions of the Canadian Community Health Surveys (CCHS). NPHS began in 1994 and included a variety of questions designed to enhance the information available for health care providers and policy makers. Different versions of the NPHS targeted individuals within households, those residing in health care institutions for a period longer than six months, and Canadians in Northern communities (i.e. Yukon and the Northwest Territories). The NPHS core health component survey for individuals in households targets about 17,000 observations. The 1998 version expanded this sample size to allow for supplemental questions provided by various provinces. Consequently the 1998 NPHS health component survey has about 81,000 records. The individuals within households NPHS data are used here. The CCHS extended the NPHS beginning in 2001. The intent of the CCHS is to provide information about determinants of Canadians' health, as well as information about health system utilization. The CCHS data reflects in-depth interviews with one randomly selected subject per interviewed household. The CCHS aims to sample about 130,000 respondents from health regions within each province.

The NPHS and CCHS data is used to estimate OLS regressions explaining individual BMI with a variety of covariates developed based on the literature review. As mentioned, particular attention is focused on adult Canadians 20 to 64 years of age.[4] Six versions of the OLS model are estimated in STATA 9.0 (with robust standard errors), one for each version of the NPHS and CCHS,[5] using sample weights provided in the PUMF.

To control for possible gender effects, the *MALE* dichotomous variable equals one if the subject is male, zero otherwise. Age effects are controlled via a series of age dichotomous variables: *A2024, A2529*, *A3034, A3539*, *A4044*, *A4549, A5054, A5559*, and *A6064* equal one if the respondent's age falls between 20-24, 25-29, 30-34, 35-39, 40-44,

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[4] The 2004 CCHS has BMIs for those over 65, while the 2005 CCHS has BMIs for children and those over 65. Since these age cohorts are not covered in the other surveys, and to better focus attention on adult BMIs, attention is focused on those aged 20-64 years of age.

[5] To ensure data are not contaminated with nonsensical BMIs, observations with BMIs in excess of 95 are dropped

45-49, 50-54, 55-59, and 60-64, respectively, zero otherwise, with *A4044* serving as the omitted category. To capture potential immigration effects, a dichotomous variable, *CNDIN*, assumes a value of one if the subject was born in Canada, zero otherwise.

Economic inequality is captured via education and income based dichotomous variables. *EDU1* equals one if the subject has at most some secondary school education, zero otherwise; *EDU2* equals one if the subject is a secondary school graduate, zero otherwise; *EDU3* equals one if the subject has some post-secondary education training, zero otherwise. Subjects with at least a post-secondary degree are the omitted category for the education group.

Four income-based dichotomous variables are included to further control for potential economic inequality. However, the variables do not reflect household income alone; rather, the "income" variables capture household income and size. In particular, the NPHS and 2001 and 2003 CCHS include a variable named income adequacy. Income adequacy is a blend of household income and household size, with categories corresponding to household income and size combinations shown in Appendix Table A1. Dichotomous variables are included for the lower income (*LI*), lower middle income (*LMI*), upper middle income (*UMI*) and high income (*HI*) categories, with the middle income category being the omitted group. Unfortunately, the 2005 CCHS PUMF does not include the income adequacy variable and it is not possible to exactly re-construct it from the available data. Instead, the 2005 CCHS includes an income decile variable which reflects household income, relative to low-income cut-off values corresponding to the respondent's household and community size. For the 2005 CCHS, *LI* corresponds to the first two income deciles, *LMI* to the third and fourth deciles, *UMI* to the seventh and eighth deciles and *UI* to the ninth and tenth deciles (the fifth and sixth deciles are the omitted group). While an approximation to income adequacy, this approach provides a relative sense of economic inequality.

Marital status is captured with a simple dichotomous variable (*MARRIED*) equal to one if the respondent is married or common law, zero otherwise. Four regional dichotomous variables are included: *AC* equals one, zero otherwise, if the respondent resides in Atlantic Canada; *PQ* equals one if the respondent resides in Quebec, zero otherwise; *WC* equals one if the respondent resides in the prairies (i.e. Manitoba, Saskatchewan, or Alberta), zero otherwise; and *BC* equals one if the respondent lives in British Columbia, zero otherwise. Respondents residing in Ontario are the omitted group for these regional variables. Differences in BMI across broad ethnic groups are captured via the *ETHNICITY* dichotomous variable, which equals one if the respondent is Caucasian, zero otherwise. Note that *ETHNICITY* is only available in the data sets after 1994.

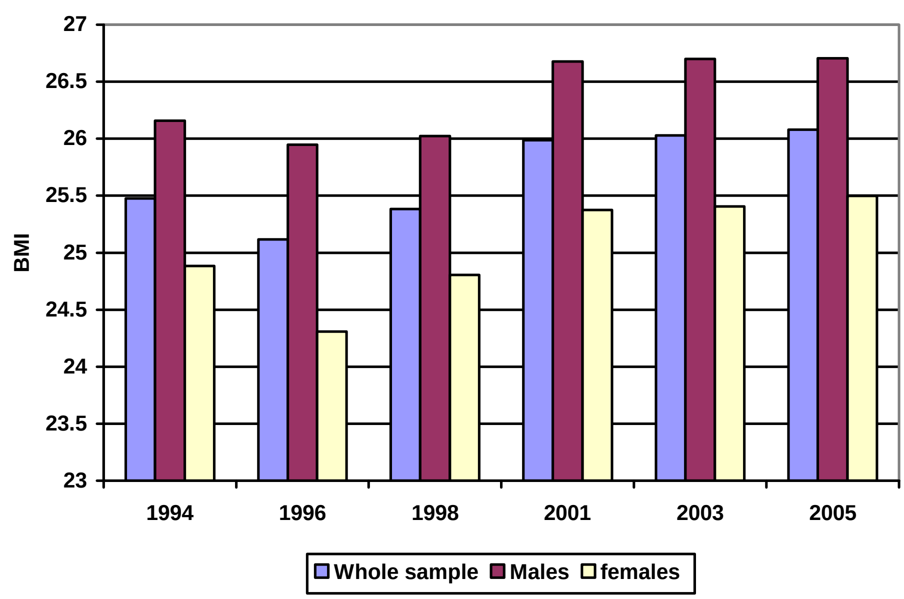
Beginning with the 1998 NHPS, the surveys included a derived variable representing food insecurity in the respondent's home. *FOODINSEC* assumes a value of one if this derived variable flags the household as being food insecure, zero otherwise. Note that the 2005 CCHS included a finer gradation of food security reflecting varying intensities of food insecurity. Because earlier surveys do not reflect these varying degrees of intensity, a simple dichotomous variable is used to reflect the incidence of food insecurity.

The NPHS included a derived index measuring respondent's level of physical activity. This index reflects respondent's self-declared frequency and intensity of exercise in the NHPS. The physical activity index has three possible categories: active, moderate and inactive. Dichotomous variables *ACTIVE* and *MODERATE* are included in the regression model to help control for respondent effort to control and/or maintain weight; the *INACTIVE* category is the omitted group. Smoking behaviour is captured with three dichotomous variables: *OSMOKE* equals one if the individual is an occasional smoker, zero otherwise; *FSMOKE* equals one if the individual is a former smoker, zero otherwise; and *NSMOKE* equals one if the individual reported never smoking, zero otherwise (the omitted group are daily smokers). Consumption of alcohol is captured with three dichotomous variables: *ODRINK* equals one if the individual is an occasional drinker, zero otherwise; *FDRINK* equals one if the individual is a former drinker, zero otherwise; and *NDRINK* equals one if the individual reported never drinking, zero otherwise (the omitted group are daily drinkers). To provide context, Table 1 shows the mean and standard deviations for BMI and the covariates in each year, while Appendix Table A2 shows the variable names for the corresponding NPHS and CCHS PUMFs.

Results

Overall, BMI amongst adults in Canada has increased from about 25.5 in 1994 to slightly over 26 in 2005 (see Figure 1). One peculiar change, however, is the marked reduction in mean BMI in 1996 and 1998 compared to 1994, an effect which others have noted (Katzmarzyk and Mason 2006; Tjepkema 2006). One possible explanation for the marked drop in BMI in 1996 and 1998 compared to 1994 is the mode of survey interview; in-person interviewing was used for about 80 percent of the 1994 NPHS, while telephone interviewing was used for about 95 percent of the 1996 and 1998 NPHS (Statistics Canada 2007). Differences in implementation could affect BMI when respondents self-declare height and weight without measurement via telephone interview, or without an interviewer present to at least qualitatively verify reported measures. Nevertheless, mean BMI increased over the period considered.

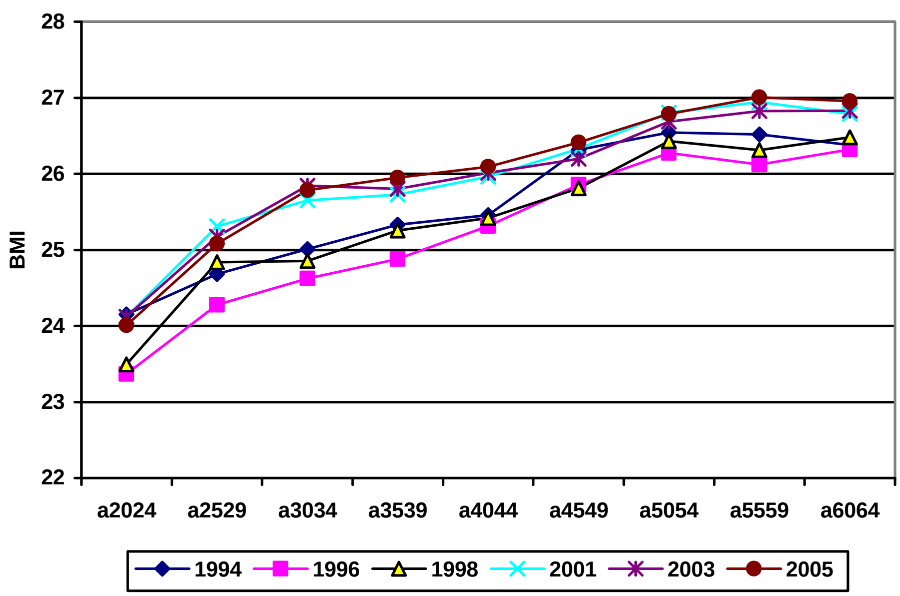
Figure 1. BMI of adults in Canada, 1994-2005, pooled and by gender



Differences in BMI across gender are evident, with males having higher mean BMI than females (see Figure 1). However, between 1994 and 2005, mean female BMI increased by more (0.651) than the mean male BMI (0.576), suggesting a narrowing of the BMI gap between adult men and women in Canada. (See Table 2 for BMI values across the whole sample, different genders and different age cohorts.)

Figure 2 plots mean BMI across age categories. Several points stand out. First, BMI generally increases with age, with a difference of about three BMI points between the 20-24 and 60-64 age cohorts. Second, BMI appears to increase at a faster pace amongst the 20 to 44 year old age cohorts (an increase of about two BMI points) than the 45 to 64 year old cohorts (whose BMI increased by about one BMI point). Lastly, changes in the BMI amongst older cohorts are small, or negative in some cases (e.g. the 1994 NPHS, and the 2001 and 2005 CCHS, see Table 2). Slowing down of the rate of gain in BMI could reflect several effects. First is an expected reduction in digestive system efficiency (Huffman and Rizov 2007) leading to weight loss in older age cohorts. A second possible effect is that dying is not random; those with high BMI early in life are less likely to survive to older ages, while those who do survive would be expected to have lower BMI, hence lowering the mean BMI in older age cohorts. Another possible explanation is that peaked interest in improving one's health in older age could translate into weight loss for some, thus slowing down of the gain in BMI, or even reducing mean BMI within older age-cohorts.

Figure 2. BMI of adults in Canada, 1994-2005, by age category



The bottom two panels of Table 2 and Figures 3 and 4, shows mean BMI by gender and age cohort. As the *y*-axis in Figures 3 and 4 are on the same scale, it is easy to see that males have higher mean BMI than females. Note, however, that mean females BMI generally increase across the age cohorts. The age profile for mean male BMI indicates larger increases for younger age-cohorts, and then a marked slowing of BMI increases beginning with the 30 to 39 year old group (this effect is pronounced for the three versions of the CCHS). Moreover, mean male BMI falls in the older (55-59 or 60-64) age cohorts. The broad conclusion is that female BMI is catching up to male BMI, and that female BMI generally increases through older age-cohorts, whereas mean male BMI begins to fall.

Figure 3. BMI of adult males in Canada, 1994-2005, by age category

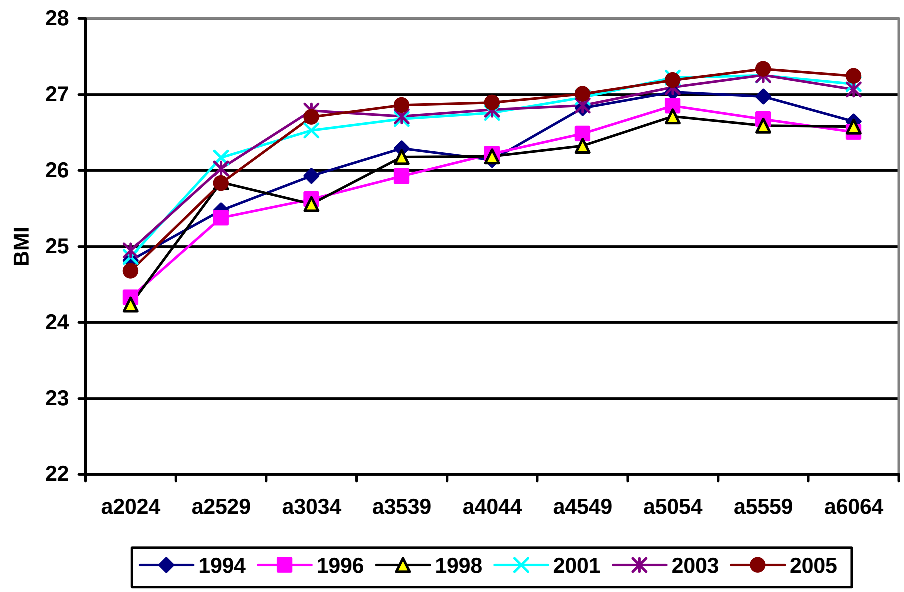


Figure 4. BMI of adult females in Canada, 1994-2005, by age category

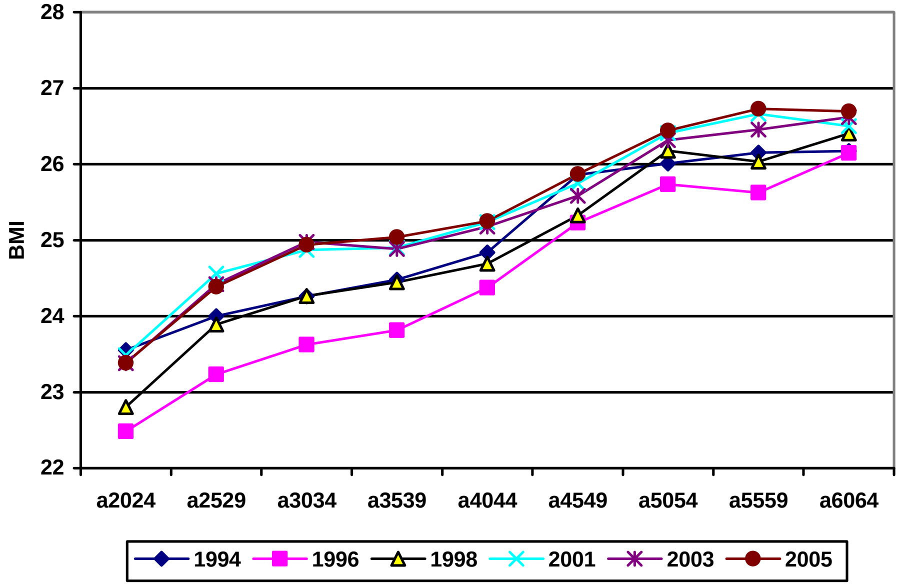


Figure 5 shows mean BMI across education levels, and lends support to the broad trend in previous research that BMI is inversely related to educational attainment. Such a result suggests potential inequality effects in shaping the pattern and rate of change in BMI. In the same respect, Figure 6 shows mean BMI across income adequacy profiles. Unlike the education profiles, BMI does not show marked trends or strong patterns across income adequacy levels. However, a weak pattern in the NPHS data suggests BMI increases as one moves though lower and lower middle income cohorts, peaks and then begins to decline. Recall that a similar pattern has been reported in previous research (Chou et al. 2004; Rashad 2006; Rashad et al. 2006).

Figure 5. BMI of adults in Canada, 1994-2005, by education attainment

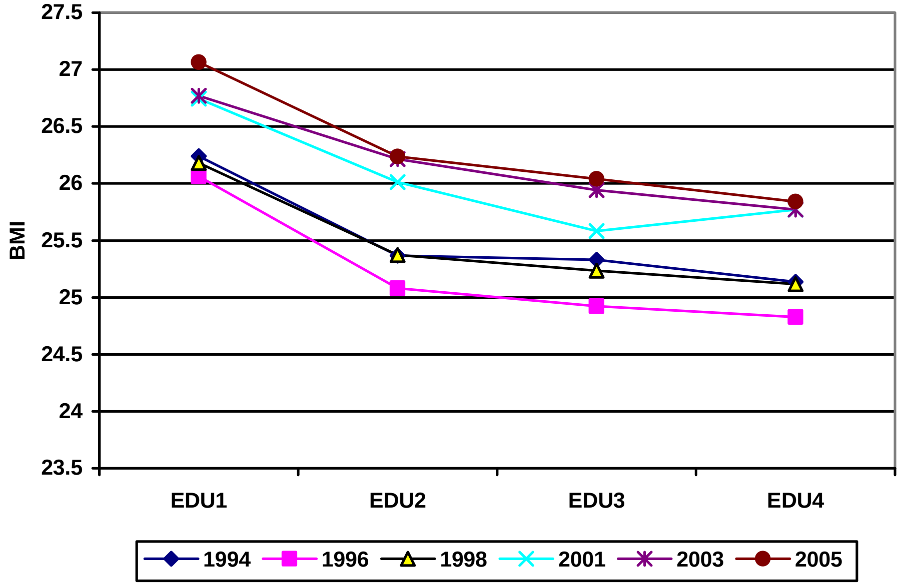


Figure 6. BMI of adults in Canada, 1994-2005, by income adequacy

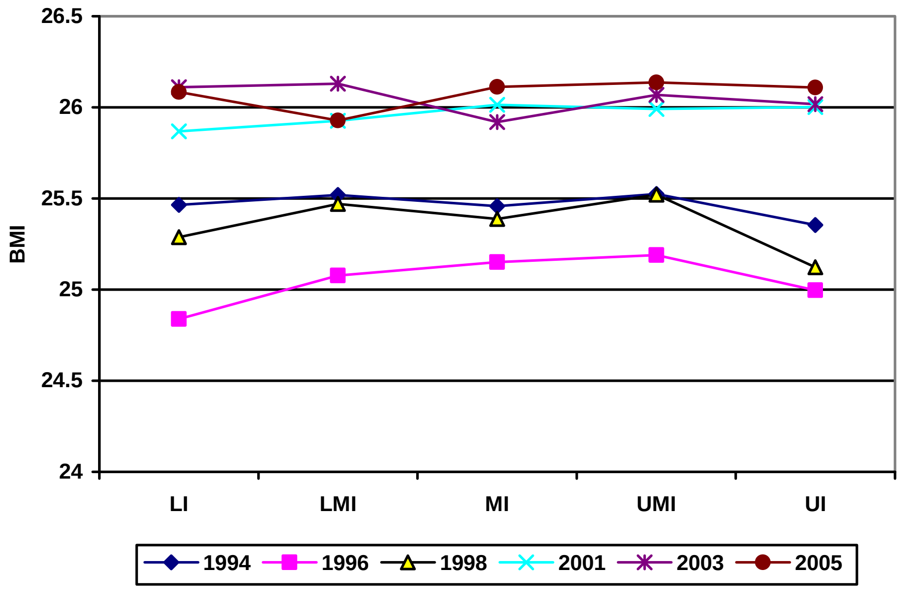


Figure 7 plots mean BMI in food secure and insecure households over time. For the periods in which *FOODINSEC* is available, food insecure households have higher mean BMI than food secure households. Moreover, the difference in mean BMI in food secure and insecure households increased dramatically in 2005. Mean BMI for white and non-white respondents are plotted in Figure 8; whites in Canada have higher BMI than non-whites in Canada, and the gap between the two, which appears to have narrowed in 2001 and 2003, widened in 2005. One remarkable trend relates to intensity of physical activity. Figure 9 plots mean BMI for the three physical activity groups over time. While the gap in BMI between inactive and moderate, and moderate and active was relatively stable until 2003, differences in mean BMI across these three groups widened in 2005. Mean BMI for those in the inactive group rose; mean BMI for those in the moderate group fell, while mean BMI for those in the active group fell by slightly more. Nevertheless, this latter figure points to influence of exercise on BMI.

Figure 7. BMI of adults in Canada, 1994-2005, by food security status

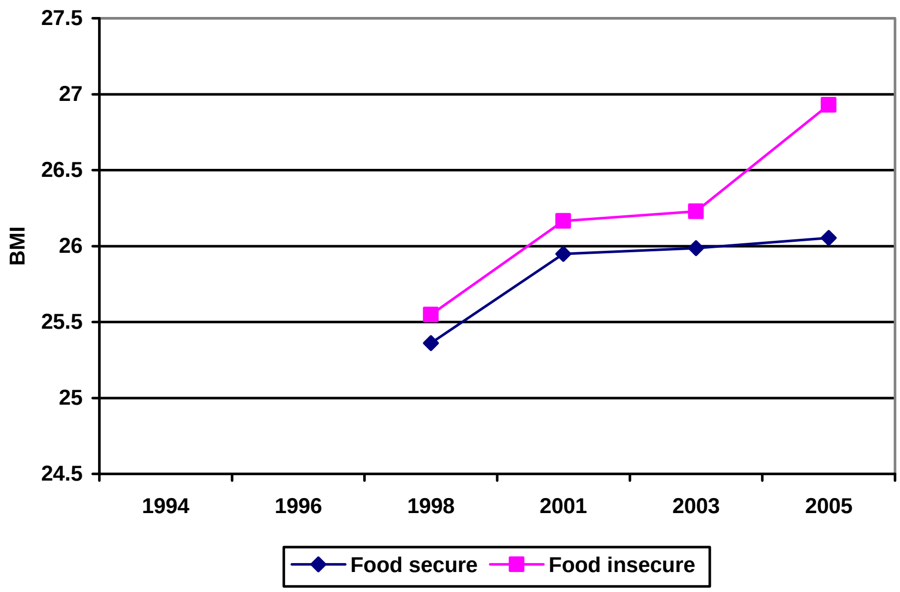


Figure 8. BMI of adults in Canada, 1994-2005, by race

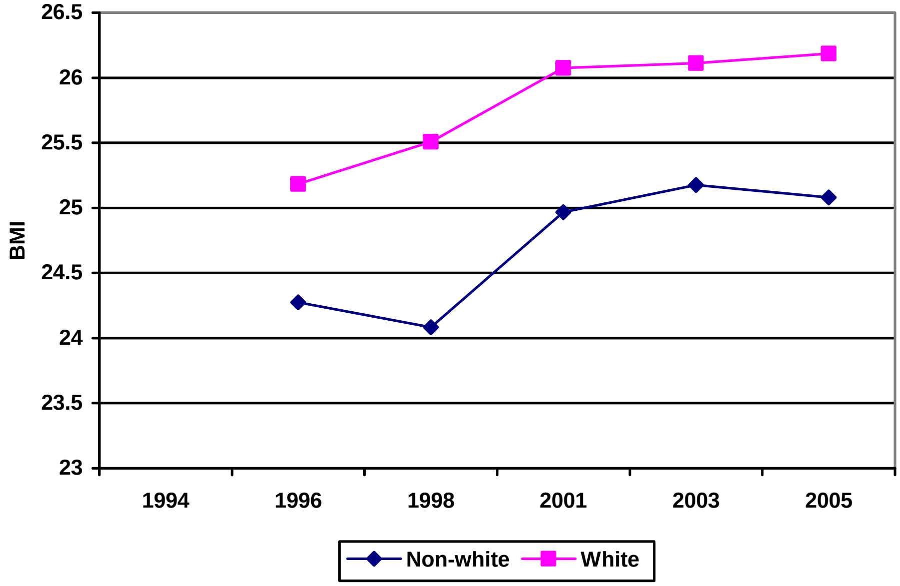
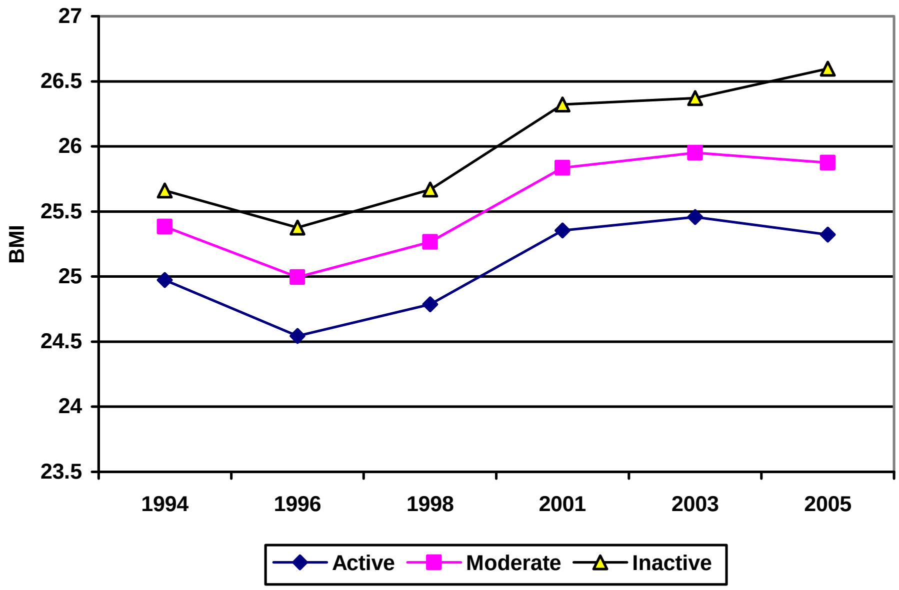


Figure 9. BMI of adults in Canada, 1994-2005, by physical activity group

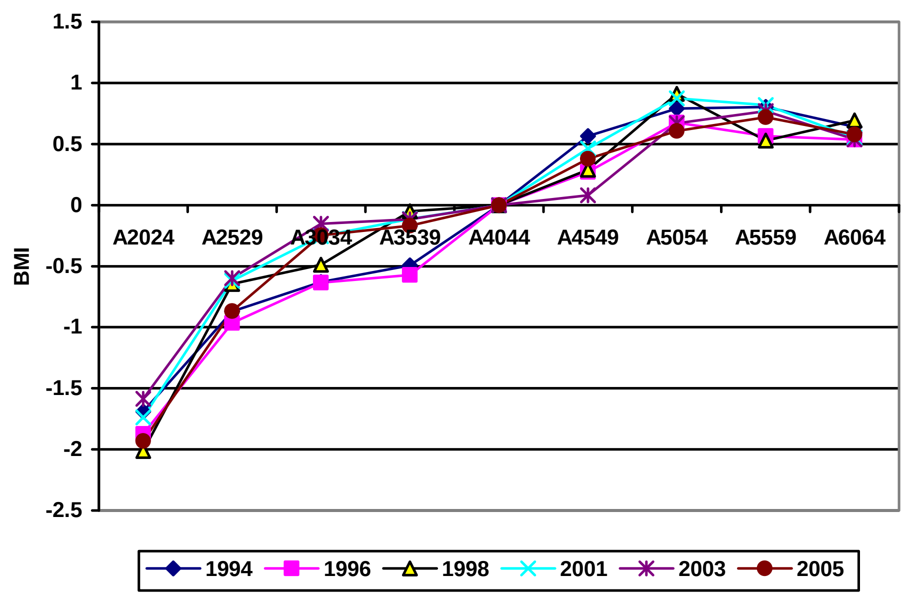


Multivariate Regression Analysis

While in isolation these trends and plots are informative, they do not allow one to control for all covariates. To this end, BMI is regressed on the covariates discussed above. The estimated OLS models (one for each survey year) have R^2 values all around 0.1, and the estimated coefficients are jointly significant (at one percent) in each model (see Table 3). The coefficient on the *MALE* variable is positive and significant (at the one percent level) in each model, reinforcing that males have higher BMIs than non-pregnant females. Note that the estimated *MALE* coefficients are markedly different from that reported in Rashad et al. (2006), suggesting that gender based BMI differences are wider in Canada than in the U.S.

Broadly speaking, coefficients on the different age cohort variables are highly significant. However, exceptions to the significance of the age cohort effects include those age cohorts straddling the omitted group. Nevertheless, the profile of the estimated age cohort coefficients shows that relative to the omitted group, BMIs are lower for those under the age of 40, but higher for those 45 years of age or older. Moreover, BMI peaks in the 50-54 or 55-59 age cohorts, then declines. Figure 10 plots the estimated age cohort coefficients, including the zero value for the omitted group, and illustrates the inverse quadratic relationship between BMI and age. As mentioned above, similar patterns of age-based changes in BMI have been reported previously in the literature (Kimhi 2003; Komlos and Baur 2004; Costa-Font and Gil 2005; Rashad et al. 2006; Carson 2007; Ver Ploeg et al. 2007).

Figure 10. Profile of the estimate age-cohort effects on BMIs of adults in Canada, 1994-2005



The coefficient on the variable reflecting individuals of Canadian birth (*CNDIN*) are all significant (at the one percent level) and positive. Moreover, the value of these coefficients appears to have increased from 0.84 in the 1994 NPHS to about one in the 2005 CCHS. Relative to those of non-Canadian birth, those born in Canada have higher BMIs and the difference between these two groups increased. While such a trend needs to be interpreted with great care (the PUMFs only differentiates between those of Canadian and non-Canadian birth), it points to those of Canadian birth as a contributor to the rising obesity trend. Caution must also be exercised as the non-Canadian birth group reflects a potential heterogeneity of individuals with different predispositions to overweight or obesity (Tremblay et al. 2005).

The estimated coefficients on the education variables are all significant and positive. As the omitted group represents post-secondary graduates or higher, these education coefficients indicate BMI is higher for those with lower levels of education. Moreover, BMI generally falls with progressively higher levels of educational attainment, suggesting an inverse relationship between BMI and education. Recognize, of course, that the measured relationship is associative, not causal. Nevertheless, two arguments support the measured relationship. First, it could be argued that higher educational attainment reflects great knowledge acumen and with this, greater ability to make more appropriate food/exercise regime choices. Alternatively, an economic inequality argument could be applied in that those with higher levels of education may have higher income, which enables them to make more appropriate food/exercise regime choices. Either way, both possible effects could lead to lower BMI for those with higher levels of education.

Except for two upper income and lower income coefficients, coefficients on *LI*, *LMI*, *UMI* and *UI* are insignificant. The negative and significant estimates for the *LI* coefficients in the 2001 and 2003 CCHS and the *UI* coefficients in 1996 NPHS and 2005 CCHS indicate lower BMI for those in these income groups in these years (relative to those in the middle income group). Lack of significance of income adequacy is not surprising; income is only one aspect of efforts to mitigate weight gain and hence BMI. Equally important are the relative prices of foods and other activities which might affect BMI. Taken in isolation, the income adequacy variables cannot reflect the latter. As will be seen shortly, however, food insecurity, which arguably reflects income and prices, is an important dimension in explaining BMI scores of adults in Canada.

Marital status plays a significant role in explaining BMI amongst adults in Canada. In particular, the coefficients on the *MARRIED* variable are all significant and positive, suggesting married and common law partners have higher BMI than those with some other marital status. Compared to observations drawn from Ontario (the reference group), the estimated coefficient for the regional variables have mixed effects. Where significant, the coefficients on the Atlantic Canada (*AC*) and western Canada (*WC*) variables are positive, suggesting respondents in these regions have higher BMI compared to those in Ontario. In contrast, all of the coefficients on *PQ* (respondents in Quebec) and *BC* (respondents in British Columbia) are negative, indicating relatively lower BMIs for those in Quebec and BC relative to Ontario.

As mentioned, the dichotomous variables for food insecurity and ethnicity are not available in the 1994 NPHS, while the food insecurity variable is not available in the 1996 NPHS. Nevertheless, the coefficients on the *FOODINSEC* variables are positive and significant when available, indicating respondents in food insecure houses have higher BMI scores than respondents in food secure households. Such a result is not surprising and has been suggested elsewhere (see, for example, Drewnowski and Specter 2004; Drewnowski and Darmon 2005). The notion here is that food insecure homes may forsake healthier, but more expensive, food choices, for those which are affordable but less healthy. In many respects, it is this food insecurity variable that reflects the economic conditions in income constrained homes facing high relative prices for foods which carry greater nutritional and dietary benefits.

Respondents indicating “White” ethnic origins (i.e. *ETHNICITY* equals one) had statistically significant and positive coefficient estimates. This indicates that whites have higher BMIs relative to non-whites. While this result reflects others’ work in Canada (Belanger-Ducharme and Tremblay 2005; Tremblay et al. 2005) it runs counter to research for the U.S., where whites are typically reported to have lower BMIs (Komlos and Baur 2004; Rashad et al. 2006; Ver Ploeg et al. 2007). Exploring the reasons for this race-based reversal in BMI across Canada and the U.S. would be an area of further research, and would likely relate to economic inequality amongst different ethnic groups in Canada and the U.S.

Coefficients on the dichotomous variables *ACTIVE* and *MODERATE* are all negative and, with two exceptions, statistically significant at the one percent level (the exceptions are for the *MODERATE* variable coefficient in the 1994 and 1996 NPHS). Moreover, within each model, the coefficient on *ACTIVE* is more negative than that on *MODERATE*, while the estimated coefficients on both *ACTIVE* and *MODERATE* become more negative overtime. These latter two points indicate that the gap in BMI across inactive, moderate and active individuals is growing overtime.

All estimated coefficients on the smoking variables are positive and significant at the five percent level or better; relative to daily smokers, occasional, former and non-smokers have higher BMIs. What is also interesting is that relative to daily smokers, former smokers have the highest BMIs amongst the smoking categories (the coefficient on the *FSMOKE* variables are larger than those on *OSMOKE* and *NSMOKE*). Weight gain associated with quitting smoking has been reported previously in the literature (Pinkowish 1999), while smokers have also been reported to have lower BMIs (Huffman and Rizov 2007) or a lower probability of being obese (Costa-Font and Gil 2005). However, the implied inverse quadratic relationship between BMI and intensity of smoking (i.e. non-, former or occasional smoker) has not been previously reported.

All but two coefficients on the alcohol consumption variables are significant and positive (the exceptions are for the *NDRINK* coefficients in 1994 and 1998). Nevertheless, relative to daily drinkers, non-, occasional, and former drinkers all have higher BMI scores. And, relative to the daily drinker omitted group, BMI is generally largest for occasional drinkers, followed by former drinkers and then non-drinkers. A similar result has been reported by Costa-Font and Gil (2005), where daily drinkers in Spain had a lower probability of being obese.

Impact of Gender

Gender specific versions of each regression model are also estimated (see Tables 4 and 5 for these results). The role of age in the gender specific models is similar to those in the overall model, although the reduction in BMI is more pronounced in the male models than in the female models. Income adequacy carries little significance in the male models, but has significant and more pronounced effects in the female models. In fact, coefficients on *UI* in the male models are generally positive indicating higher BMI for males in the upper income adequacy group, but negative (and more negative than in the overall models) in the female models.

One important distinction between the male and female models relates to food insecurity. *FOODINSEC* is only significant in the 2001 model estimated with male data (and only at ten percent), but is significant in the female models. Moreover, the estimated coefficients for *FOODINSEC* in the female models are larger than in the overall models. The latter implies females in food insecure households have higher BMIs than females in food secure households, and underscores the masking of possible effects when pooling data across gender. The physical activity variables have mixed significance in the male models, but are negative when significant. Coefficients on *ACTIVE* and *MODERATE* are highly significant in the female models, and negative. Moreover, the size of the coefficients on *ACTIVE* and *MODERATE* are larger in the female models than in the overall and male models. This means the difference in BMI for respondents in the *ACTIVE* or *MODERATE* and the *INACTIVE* group are larger for females than for males; being active or having moderate physical activity has a greater reduction on female BMI than on male BMI.

Lastly, coefficients on the smoking variables in the both female and male versions of the model reflect the same pattern as the overall model. However, compared to the overall models, the coefficients for the alcohol consumption variables are more muted in the male models than in the female models. Indeed, the estimates for *ODRINK*, *FDRINK* and *NDRINK* suggest a greater BMI difference between daily drinkers and other drinking categories for females than for males.

Summary and Conclusions

This paper explores the factors shaping BMI amongst adults in Canada using data from population and community health surveys from 1994 to 2005. Attention focuses on socio-demographic, economic and behavioural factors influencing individual BMI amongst 20 to 64 year old adults (both male and non-pregnant females) in Canada.

Results suggest that BMI for adults in Canada have increased, with appreciable gains stemming from increases in female BMI.

Econometric results indicate that males, those of Canadian birth, those in food insecure homes and whites have higher BMI than their respective complementary groups. BMI has a differentiate relationship with age-gender effects. An inverse quadratic relationship exists between BMI and age for adult males in Canada, while BMI for adult females in Canada increases through the considered age range. Education attainment, used as a gauge of inequality, is inversely related to BMI, while the role of household size adjusted income is muted. Behavioural variables are also important factors explaining BMI in Canada. As one might expect, BMI is inversely related to level of physical activity, an effect which is more pronounced for females in Canada. BMI also appears to have an inverse quadratic relationship with intensity of smoking behaviour. Interestingly, across the smoking intensity categories, and relative to daily smokers, BMI is highest for former smokers. Relative to daily drinkers, BMI appears to be inversely related to intensity of alcohol consumption.

Results also point to a number of actionable policy dimensions. It is clear that moving people out of food insecurity can contribute to lower BMI; targeting such efforts to particular at risk groups will be important. In this light, recall that the food insecurity coefficient was much larger in model estimated with females only than the overall and male models. Such a result suggests targeting of females in food insecure homes will be very important. Moreover, the widening gap in BMI between food secure and insecure households underscores the importance of efforts to alleviate food insecurity. Continued and enhanced social marketing efforts related to physical activity, e.g. Canada's *Particpaction* program, will also figure key in reducing (or at least slowing the rate of growth of) BMI in Canada. This is particularly true given the wider gap in BMI across those of different levels of physical activity; based on the 2005 CCHS data, drawing the inactive into an active lifestyle is more important now than ever before. Lastly, while cessation of smoking carries with it enormous health enhancing effects, the associated increase in BMI after quitting smoking highlights the importance of developing food consumption coping mechanisms upon quitting smoking.

References

Baum, C. and W. Ford. 2004. The wage effects of obesity: A longitudinal study. *Health Economics* 12: 885-899.

Belanger-Ducharme, F. and A. Tremblay. 2005. Prevalence of obesity in Canada. *Obesity Reviews* 6: 183-186.

Borghans, L. and B. Golsteyn. 2006. Time discounting and the body mass index: Evidence from the Netherlands. *Economics and Human Biology* 4: 39-61.

Brunello, G. and B. D'Hombres. 2007. Does body weight affect wages? Evidence from Europe. *Economics and Human Biology* 5: 1-19.

Cameron, N. 2003. Physical growth in a transitional economy: The aftermath of South African apartheid. *Economics and Human Biology* 1: 29-42.

Carson, S. 2007. Mexican body mass index values in the late-19th century American West. *Economics and Human Biology* 5: 37-47.

Chou, S., M. Grossman and H. Saffer. 2004. An economic analysis of adult obesity: Results from the Behavioural Factor Surveillance System. *Journal of Health Economics* 23: 565-587.

Contoyannis, P. and J. Wildman. 2007. Using relative distributions to investigate the body mass index in England and Canada. *Health Economics* 16: 929-944.

Costa, D. 1993. Height, weight, wartime stress and older age mortality: Evidence from the Union Army records. *Explorations in Economic History* 30: 424-449.

Costa-Font, J. and J. Gil. 2005. Obesity and the incidence of chronic disease in Spain: A seemingly unrelated probit approach. *Economics and Human Biology* 3: 188-214.

Cutler, D., E. Glaeser and J. Shapiro. 2003. Why have Americans become more obese? *Journal of Economic Perspectives* 17: 93-118.

Dinda, S., P. Gangopadhyay, B. Chattopadhyay, H. Saiyed, M. Pal, and P. Bharati. 2006. Height, weight and earnings among coalminers in India. *Economics and Human Biology* 4: 342-350.

Drewnowski, A. and S. Specter. 2004. Poverty and obesity: the role of energy density and energy costs. *American Journal of Clinical Nutrition* 79: 6-16.

Drewnowski, A. and N. Darmon. 2005. The economics of obesity: dietary energy density and energy cost. *American Journal of Clinical Nutrition* 82: 265S-273S.

Godoy, R., E. Goodman, R. Levins and W. Leonard. 2005. Anthropometric variability in the USA: 1971-2002. *Annals of Human Biology* 32: 469-486.

Gyenis, G. and K. Joubert. 2004. Socioeconomic determinants of anthropometric trends among Hungarian youths. *Economics and Human Biology* 2: 321-333.

Heineck, G. 2006. Height and weight in Germany, evidence from the German Socio-Economic Panel, 2002. *Economics and Human Biology* 4: 359-382.

Helmchen, L. and R. Henderson. 2004. Changes in the distribution of body mass index of white US men: 1890-2000. *Annals of Human Biology* 31: 174-181.

Henderson, R. 2005. The bigger the healthier: Are the limits of BMI risk changing over time? *Economics and Human Biology* 3: 339-366.

Huffman, S. and M. Rizov. 2007. Determinants of obesity in transition economies: The case of Russia. *Economics and Human Biology* 5: 379-391.

Hulanicka, B., A. Lipowicz, S. Koziel and A. Kowalisko. 2007. Relationship between early puberty and risk of hypertension/overweight at age 50: Evidence for a modified Barker hypothesis among Polish youth. *Economics and Human Biology* 5: 48-60.

Kahn, H., L. Tathar, C. Rodriguez, E. Calle, M. Thun and C. Heath. 1997. Stable behaviours associated with adult's 10-year change in body mass index and likelihood of gain at the waist. *American Journal of Public Health* 87: 747-754.

Katzmarzyk, P. 2002a. The Canadian obesity epidemic, 1985-1998. *Canadian Medical Association Journal* 166: 1039-1040.

Katzmarzyk, P. 2002b. The Canadian obesity epidemic: An Historical Perspective. *Obesity Research* 10: 666-674.

Katzmarzyk, P. and I. Janssen. 2004. The economic costs associated with physical inactivity and obesity in Canada: An update. *Canadian Journal of Applied Physiology* 39: 90-115.

Katzmarzyk, P. and C. Mason. 2006. Prevalence of class I, II and III obesity in Canada. *Canadian Medical Association Journal* 174: 156-157.

Kaushal, N. 2007. Do food stamps cause obesity? Evidence from immigrant experience. *Journal of Health Economics* 26: 968-991.

Kimhi, A. 2003. Socio-economic determinants of health and physical fitness in southern Ethiopia. *Economics and Human Biology* 1: 55-75.

Knai, C., M. Suhrcke and T. Lobstein. 2007. Obesity in Eastern Europe: An overview of its health and economic implications. *Economics and Human Biology* 5: 392-408.

Komlos, J. and M. Baur. 2004. From the tallest to (one of) the fattest: the enigmatic fate of the American population in the 20th century. Economics and Human Biology 2, 57-74.

Komlos, J. and P. Kriwy. 2002. Social status and adult heights in the two Germanies. *Annals of Human Biology* 29: 641-648.

Komlos, J., P. Smith and B. Bogin. 2004. Obesity and the rate of time preference: Is there a connection? *Journal of Biosocial Science* 36: 209-219.

Koziel, S., Z. Welon, T. Bielicki, A. Szklarska and S. Ulijaszek. 2004. The effects of the economic transition on the body mass index of conscripts in Poland. *Economics and Human Biology* 2: 97-106.

Laird-Birmingham, C., J. Nuller, A. Palepu, J. Spinelli and A. Anis. 1999. The cost of obesity in Canada. *Canadian Medical Association Journal* 160: 483-488.

Linares, C. and D. Su. 2005. Body mass index and health among Union Army veterans: 1891-1905. *Economics and Human Biology* 3: 367-387.

Markowitz, D. and S. Cosminsky. 2005. Overweight and stunting in migrant Hispanic children in the USA. *Economics and Human Biology* 3: 215-240.

McGinnis, J. and Meyers, L. 1999. Public policy and healthy eating. *Food Policy* 24: 335-341.

Mironov, B. 2007. Birth weight and physical stature in St. Petersburg: Living standards of women in Russia, 1980-2005. *Economics and Human Biology* 5: 123-143.

Mujahid, M., A. Diez Roux, L. Borrell and F. Bieto. 2005. Cross-sectional and longitudinal associations of BMI with Socioeconomic characteristics. *Obesity Research* 13: 1412-1421.

Paraponaris, A., B. Saliba and B. Ventelou. 2005. Obesity, weight status and employability: Evidence from French national survey. *Economics and Human Biology* 3: 241-258.

Phipps, S., P. Burton, L. Osberg, and L. Lethbridge. 2006. Poverty and the extent of child obesity in Canada, Norway and the United States. *Obesity Reviews* 7: 5-12.

Phuong Do, D., T. Dubowitz, C. Bird, N. Lurie, J. Escarce and B. Finch. 2007. Neighborhood context and ethnicity differences in body mass index: A multilevel analysis using the NHANES III survey (1988-1994). *Economics and Human Biology* 5: 179-203.

Pinkowish, M. 1999. Hand in glove: smoking cessation and weight gain. *Patient Care* 33: 134.

Prentice, A. 1995. Alcohol and obesity. *International Journal of Obesity Related Metabolic Disorders* 19: 44-50.

Rashad, I. 2006. Structural estimation of caloric intake, exercise, smoking and obesity. *Quarterly Review of Economics and Finance* 46: 268-283.

Rashad, I., M. Grossman and S. Chou. 2006. The super size of America: An economic estimation of body mass index and obesity in adults. *Eastern Economic Journal 32*: 133-148.

Shields, M. and M. Tjepkema. 2006. Regional differences in obesity. *Health Reports* (Statistics Canada Catalogue no. 82-003-XPE2005003) 17: 61-67.

Smith, P., B. Bogin and D. Bishai. 2005. Are time preference and body mass index associated? Evidence from the National Longitudinal Survey of Youth. *Economics and Human Biology* 3: 259-270.

Sokar-Todd, H. and A. Sharma. 2004. Obesity research in Canada: Literature overview of the last 3 decades. *Obesity Research* 12: 1547-1553.

Statistics Canada. 2007. National Population Health Survey – Household Component – Cross-section (NPHS). (http://www.statcan.ca/cgi-bin/imdb/p2SV.pl?Function=getSurvey&SDDS=3236&lang=en&db=IMDB&dbg=f&adm=8&dis=2, accessed Dec 13, 2007).

Sunder, M. 2005. Toward generation XL: Anthropometrics of longevity in the late 20th-century United States. *Economics and Human Biology* 3: 271-295.

Tjepkema, M. 2006. Adult obesity in Canada: Measured height and weight. Nutrition: Findings from the Canadian Community Health Survey (Statistics Canada catalogue no. 82-620-MWE2005001) 1: 1-32.

Tremblay, M., P. Katzmarzyk and J. Willms. 2002. Temporal trends in overweight and obesity in Canada, 1981-1996. *International Journal of Obesity* 26: 538-543.

Tremblay, M., C. Perez, C. Ardern, S. Bryan and P. Katzmarzyk. 2005. Obesity, overweight and ethnicity. Health Reports (Statistics Canada catalogue no. 82-003) 16: 23-34.

Tremblay, M. and J. Willms. 2000. Secular trends in the body mass index of Canadian children. *Canadian Medical Association Journal* 163: 1429-1433.

Tremblay, M. and J. Willms. 2003. Is the Canadian childhood obesity epidemic related to physical inactivity? *International Journal of Obesity* 27: 1100-1105.

Ver Ploeg, M., L. Mancino, B. Lin and C. Wang. 2007. The vanishing weight gap: Trends in obesity among food stamp participants (US) (1976-2002). *Economics and Human Biology* 5: 20-36.

Vigerova, J., P. Blaha, K. Osancova and Z. Roth. Social inequity and obesity in Czech school children. *Economics and Human Biology* 2: 107-118.

Voigt, M., G. Heineck and V. Hesse. 2004. The relationship between maternal characteristics, birth weight and pre-term delivery: evidence from Germany at the end of the 20th century. *Economics and Human Biology* 2: 265-280.

Willms, J., M. Tremblay and P. Katmarzyk. 2003. Geographic ad demographic variation in the prevalence of overweight Canadian children. *Obesity Research* 11: 668-673.

Zagorsky, J. 2005. Health and wealth: The late-20th century obesity epidemic in the U.S. *Economics and Human Biology* 3: 296-313.

Zellner, K., K. Kromeyer and U. Jaeger. 1996. Growth studies in Jena, Germany: Historical background and secular changes in stature and weight in children 7-14 years. *American Journal of Human Biology* 8: 371-382.

Zellner, K., U Jaeger, K. Kromeyer-Hauschild. 2004. Height, weight and BMI of schoolchildren in Jena, Germany – are the secular changes leveling off? *Economics and Human Biology* 2: 281-294.

Table 1. Summary statistics of the dependent and independent variables in the OLS regression models explaining BMIs of adults in Canada: 1994, 1996, 1998, 2001, 2004, 2005.

	1994		1996		1998		2001		2003		2005	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
BMI	25.476	4.220	25.117	4.478	25.384	4.599	25.988	4.781	26.030	4.784	26.079	5.028
MALE	0.464	0.499	0.494	0.500	0.476	0.499	0.471	0.499	0.482	0.500	0.482	0.500
A2024	0.108	0.310	0.094	0.292	0.091	0.287	0.078	0.269	0.073	0.259	0.083	0.275
A2529	0.122	0.328	0.121	0.326	0.112	0.315	0.097	0.296	0.100	0.300	0.104	0.305
A3034	0.155	0.362	0.152	0.359	0.132	0.338	0.116	0.320	0.119	0.324	0.117	0.322
A3539	0.144	0.351	0.154	0.361	0.154	0.361	0.142	0.349	0.123	0.329	0.116	0.321
A4549	0.110	0.313	0.107	0.309	0.113	0.317	0.129	0.335	0.121	0.326	0.106	0.308
A5054	0.090	0.284	0.093	0.291	0.106	0.308	0.116	0.320	0.127	0.332	0.118	0.323
A5559	0.079	0.270	0.080	0.271	0.081	0.273	0.094	0.292	0.120	0.325	0.122	0.327
A6064	0.074	0.262	0.071	0.258	0.075	0.263	0.079	0.270	0.096	0.295	0.104	0.305
CNDIN	0.868	0.339	0.851	0.356	0.850	0.357	0.872	0.334	0.892	0.310	0.874	0.332
EDU1	0.227	0.418	0.179	0.383	0.184	0.387	0.190	0.392	0.166	0.372	0.130	0.336
EDU2	0.162	0.368	0.181	0.385	0.148	0.355	0.200	0.400	0.180	0.384	0.158	0.365
EDU3	0.268	0.443	0.240	0.427	0.285	0.452	0.083	0.276	0.076	0.265	0.083	0.276
LI	0.077	0.266	0.049	0.216	0.053	0.224	0.052	0.222	0.047	0.212	0.175	0.380
LMI	0.118	0.322	0.095	0.293	0.087	0.282	0.077	0.266	0.063	0.243	0.174	0.379
UMI	0.382	0.486	0.415	0.493	0.391	0.488	0.376	0.484	0.365	0.481	0.213	0.410
UI	0.146	0.353	0.176	0.381	0.219	0.413	0.287	0.452	0.341	0.474	0.234	0.424
MARRIED	0.627	0.484	0.629	0.483	0.634	0.482	0.529	0.499	0.480	0.500	0.460	0.498
AC	0.215	0.411	0.057	0.232	0.236	0.425	0.141	0.348	0.160	0.366	0.068	0.251
PQ	0.152	0.359	0.042	0.200	0.174	0.379	0.184	0.388	0.338	0.473	0.289	0.453
WC	0.207	0.405	0.376	0.484	0.222	0.416	0.232	0.422	0.179	0.383	0.113	0.317
BC	0.134	0.341	0.023	0.150	0.100	0.300	0.136	0.343	0.187	0.390	0.138	0.345
FOODINSEC	N/A	N/A	N/A	N/A	0.118	0.323	0.180	0.384	0.178	0.383	0.030	0.169
ETHNICITY	N/A	N/A	0.926	0.261	0.913	0.282	0.921	0.269	0.914	0.281	0.903	0.295
ACTIVE	0.176	0.381	0.200	0.400	0.208	0.406	0.220	0.415	0.254	0.435	0.255	0.436
MODERATE	0.228	0.420	0.240	0.427	0.253	0.435	0.249	0.432	0.261	0.439	0.268	0.443
OSMOKE	0.047	0.212	0.042	0.201	0.041	0.198	0.046	0.209	0.053	0.225	0.057	0.232
FSMOKE	0.296	0.457	0.285	0.451	0.335	0.472	0.403	0.490	0.435	0.496	0.417	0.493
NSMOKE	0.338	0.473	0.385	0.487	0.334	0.472	0.2698	0.444	0.271	0.444	0.294	0.456
ODRINK	0.209	0.406	0.209	0.407	0.214	0.410	0.200	0.399	0.176	0.380	0.167	0.373
FDRINK	0.113	0.316	0.113	0.316	0.123	0.328	0.115	0.319	0.114	0.317	0.106	0.308
NDRINK	0.055	0.299	0.059	0.237	0.057	0.232	0.041	0.198	0.037	0.189	0.034	0.181
N	11373		39540		9948		71649		45290		56838	

Table 2. Mean BMI scores for adults in Canada, 1994-2005.

	1994	1996	1998	2001	2003	2005
Whole sample	25.476	25.117	25.384	25.988	26.030	26.079
			GENDER			
MALES	26.159	25.947	26.022	26.676	26.700	26.706
FEMALES	24.884	24.307	24.805	25.376	25.406	25.497
			AGE-COHORTS			
A2024	24.152	23.370	23.493	24.120	24.124	24.007
A2529	24.683	24.279	24.838	25.311	25.175	25.084
A3034	25.009	24.622	24.855	25.650	25.845	25.784
A3539	25.329	24.882	25.253	25.726	25.802	25.949
A4044	25.455	25.314	25.419	25.963	26.012	26.093
A4549	26.317	25.856	25.812	26.330	26.200	26.412
A5054	26.544	26.275	26.428	26.803	26.687	26.788
A5559	26.518	26.123	26.311	26.942	26.827	27.007
A6064	26.378	26.321	26.482	26.789	26.829	26.955
			MALES			
A2024	24.816	24.329	24.234	24.864	24.947	24.678
A2529	25.474	25.376	25.844	26.170	26.025	25.832
A3034	25.928	25.622	25.557	26.528	26.786	26.705
A3539	26.292	25.924	26.176	26.680	26.712	26.860
A4044	26.139	26.217	26.186	26.758	26.801	26.891
A4549	26.819	26.483	26.325	26.958	26.853	27.008
A5054	27.030	26.851	26.710	27.220	27.096	27.187
A5559	26.972	26.675	26.591	27.252	27.255	27.333
A6064	26.645	26.507	26.575	27.138	27.066	27.244
			FEMALES			
A2024	23.555	22.484	22.803	23.486	23.381	23.385
A2529	24.000	23.233	23.892	24.561	24.422	24.386
A3034	24.262	23.626	24.267	24.871	24.975	24.940
A3539	24.480	23.813	24.447	24.901	24.886	25.038
A4044	24.838	24.376	24.691	25.239	25.179	25.252
A4549	25.862	25.229	25.326	25.746	25.584	25.868
A5054	26.088	25.733	26.175	26.410	26.316	26.441
A5559	26.150	25.627	26.034	26.661	26.456	26.729
A6064	26.171	26.148	26.404	26.503	26.621	26.695

Table 3. Results of the OLS regression of BMIs for adults in Canada on socio-demographic, economic and behavioural covariates, using NPHS (1994, 1996, 1998) and CCHS (2001, 2003, 2005) data (t-statistics shown in italics beneath the coefficient estimate).

	1994	1996	1998	2001	2003	2005
MALE	1.509***	1.767***	1.504***	1.629***	1.744***	1.673***
	15.200	*20.950*	*13.770*	*33.500*	*23.240*	*29.090*
A2024	-1.690***	-1.874***	-2.013***	-1.739***	-1.585***	-1.931***
	-7.220	*-10.350*	*-9.240*	*-16.540*	*-9.460*	*-15.590*
A2529	-0.870***	-0.965***	-0.645***	-0.618***	-0.599***	-0.869***
	-4.300	*-5.280*	*-2.870*	*-6.330*	*-4.410*	*-7.240*
A3034	-0.630***	-0.635***	-0.488**	-0.256***	-0.154	-0.246**
	-3.350	*-3.770*	*-2.330*	*-2.840*	*-1.270*	*-2.310*
A3539	-0.494**	-0.573***	-0.052	-0.114	-0.115	-0.169
	-2.490	*-3.560*	*-0.250*	*-1.340*	*-0.900*	*-1.520*
A4549	0.565***	0.272	0.289	0.462***	0.079	0.378***
	2.760	*1.550*	*1.260*	*4.940*	*0.620*	*3.120*
A5054	0.789***	0.676***	0.911***	0.875***	0.670***	0.607***
	3.620	*3.680*	*4.050*	*9.240*	*4.140*	*5.110*
A5559	0.804***	0.565***	0.529**	0.818***	0.768***	0.720***
	3.670	*2.730*	*2.230*	*8.330*	*5.620*	*6.300*
A6064	0.642***	0.537***	0.694***	0.551***	0.538***	0.577***
	2.680	*2.730*	*2.750*	*5.160*	*3.680*	*4.920*
CNDIN	0.844***	0.639***	0.721***	0.791***	0.955***	1.008***
	5.750	*4.940*	*3.980*	*9.410*	*8.600*	*10.270*
EDU1	0.823***	0.927***	0.827***	0.737***	0.878***	0.870***
	5.370	*6.570*	*4.530*	*9.760*	*6.940*	*7.970*
EDU2	0.567***	0.401***	0.340**	0.378***	0.343***	0.322***
	3.810	*3.290*	*2.100*	*5.900*	*3.880*	*4.110*
EDU3	0.360***	0.315***	0.394***	0.162*	0.684***	0.395***
	2.790	*2.950*	*2.960*	*1.930*	*4.010*	*3.700*
LI	0.177	-0.137	-0.104	-0.343***	-0.403*	-0.121
	0.740	*-0.610*	*-0.390*	*-2.650*	*-1.890*	*-1.150*
LMI	0.211	0.290	0.203	0.010	0.074	-0.101
	1.100	*1.580*	*0.720*	*0.090*	*0.390*	*-1.060*
UMI	0.040	-0.100	0.143	-0.030	0.031	-0.128
	0.310	*-0.920*	*0.970*	*-0.420*	*0.290*	*-1.500*
UI	-0.203	-0.381***	-0.218	-0.102	-0.128	-0.304***
	-1.220	*-2.990*	*-1.340*	*-1.330*	*-1.120*	*-3.680*
MARRIED	0.248**	0.249**	0.268**	0.264***	0.323***	0.207***
	2.140	*2.430*	*2.130*	*4.840*	*4.430*	*3.130*
AC	0.182	0.611***	0.335**	0.409***	0.233**	0.426***
	1.280	*4.710*	*1.990*	*5.440*	*1.980*	*3.470*
PQ	-0.993***	-0.673***	-1.026***	-0.809***	-0.810***	-0.765***
	-6.910	*-5.570*	*-6.440*	*-11.770*	*-7.290*	*-10.530*
WC	-0.070	0.268***	0.180	0.216***	-0.101	-0.008
	-0.520	*3.800*	*1.160*	*3.270*	*-0.890*	*-0.080*
BC	-0.781***	-0.205	-0.398**	-0.397***	-0.827***	-0.390***
	-4.990	*-1.390*	*-2.290*	*-5.860*	*-7.850*	*-4.760*
FOODINSEC			0.537**	0.613***	0.552***	0.978***
			2.610	*8.340*	*4.570*	*4.100*
ETHNICITY		1.012***	1.089***	1.176***	0.815***	0.912***
		5.530	*5.080*	*11.470*	*5.920*	*8.270*
ACTIVE	-0.539***	-0.499***	-0.588***	-0.889***	-0.653***	-0.955***
	-4.410	*-4.760*	*-4.480*	*-15.720*	*-8.060*	*-14.580*

MODERATE	-0.070	-0.160	-0.332**	-0.358***	-0.215***	-0.529***
	-0.560	*-1.600*	*-2.540*	*-6.200*	*-2.600*	*-7.800*
OSMOKE	0.580**	0.402**	0.775***	0.660***	0.553***	0.471***
	2.170	*2.010*	*2.750*	*6.240*	*3.600*	*4.070*
FSMOKE	0.908***	1.007***	1.185***	1.116***	1.113***	1.074***
	6.730	*8.370*	*7.840*	*18.060*	*11.490*	*13.450*
NSMOKE	0.533***	0.632***	0.748***	0.873***	0.878***	0.695***
	3.880	*5.450*	*5.100*	*12.830*	*7.980*	*7.950*
ODRINK	0.600***	0.643***	0.567***	0.833***	0.784***	1.061***
	4.150	*5.430*	*3.820*	*12.020*	*8.240*	*12.500*
FDRINK	0.421**	0.578***	0.459**	0.817***	0.675***	0.928***
	2.210	*3.820*	*2.290*	*9.140*	*5.770*	*8.010*
NDRINK	-0.169	0.434**	0.265	0.225*	0.788**	0.543***
	-0.700	*2.230*	*1.080*	*1.680*	*2.410*	*2.880*
INTERCEPT	23.319***	21.861***	22.005***	22.276***	22.608***	22.940***
	85.510	*88.630*	*69.650*	*163.150*	*106.120*	*132.720*
N	11372	39540	9948	71649	45290	56838
R^2	0.103	0.113	0.107	0.105	0.100	0.101
F-stat[a]	29.73***	49.80***	27.45***	133.05***	67.71***	101.95***

a. F-test of the joint null hypothesis that the estimated slope coefficients are jointly equal to zero.
*** denotes significance at the one percent level
** denotes significance at the five percent level
* denotes significance at the ten percent level

Table 4. Results of the OLS regression of BMIs for adult males in Canada on socio-demographic, economic and behavioural covariates, using NPHS (1994, 1996, 1998) and CCHS (2001, 2003, 2005) data (t-statistics shown in italics beneath the coefficient estimate).

	1994	1996	1998	2001	2003	2005
A2024	-1.645***	-1.691***	-1.727***	-1.763***	-1.436***	-1.873***
	-5.960	*-6.860*	*-5.900*	*-12.340*	*-7.000*	*-12.060*
A2529	-0.782***	-0.995***	-0.629**	-0.487***	-0.572***	-0.819***
	-2.920	*-4.170*	*-2.140*	*-3.630*	*-3.260*	*-5.290*
A3034	-0.476*	-0.555**	-0.746***	-0.189*	-0.003	-0.110
	-1.920	*-2.440*	*-2.750*	*-1.580*	*-0.020*	*-0.810*
A3539	-0.186	-0.425*	-0.164	-0.038	0.019	-0.086
	-0.750	*-1.870*	*-0.610*	*-0.340*	*0.120*	*-0.640*
A4549	0.382	0.038	-0.310	0.250**	-0.075	0.254*
	1.400	*0.170*	*-0.980*	*2.050*	*-0.480*	*1.730*
A5054	0.708**	0.253	0.384	0.508***	0.365	0.001
	2.480	*1.010*	*1.300*	*3.940*	*1.440*	*0.001*
A5559	0.512*	-0.149	-0.013	0.224*	0.255	0.268*
	1.810	*-0.570*	*-0.040*	*1.690*	*1.550*	*1.890*
A6064	0.263	-0.199	-0.098	0.022	0.011	0.179
	0.810	*-0.740*	*-0.290*	*0.160*	*0.060*	*1.200*
CNDIN	1.071***	0.566***	0.773***	0.753***	0.901***	0.963***
	5.610	*3.380*	*2.990*	*6.590*	*6.200*	*8.150*
EDU1	0.815***	0.963***	0.786***	0.604***	0.643***	0.710***
	4.270	*5.470*	*3.160*	*6.440*	*4.270*	*5.910*
EDU2	0.637***	0.638***	0.258	0.315***	0.221*	0.358***
	3.310	*3.880*	*1.260*	*3.510*	*1.900*	*3.510*
EDU3	0.352**	0.323**	0.354**	0.018	0.521**	0.359***
	2.110	*2.290*	*2.080*	*0.150*	*2.560*	*2.640*
LI	-0.287	-0.342	-0.187	-0.155	-0.634*	-0.709***
	-0.920	*-1.100*	*-0.510*	*-0.790*	*-1.770*	*-5.320*
LMI	-0.133	0.059	-0.061	0.057	-0.224	-0.320**
	-0.510	*0.240*	*-0.140*	*0.340*	*-0.760*	*-2.470*
UMI	0.190	0.371***	0.356	0.222**	0.165	0.041
	1.170	*2.720*	*1.870**	*2.330*	*1.050*	*0.370*
UI	0.134	0.097	0.128	0.380***	0.192	-0.020
	0.670	*0.610*	*0.600*	*3.750*	*1.290*	*-0.180*
MARRIED	0.518***	0.357***	0.574***	0.389***	0.415***	0.452***
	3.540	*2.670*	*3.650*	*5.290*	*4.440*	*5.480*
AC	0.111	0.189	0.227	0.328***	-0.006	0.289*
	0.630	*1.200*	*0.980*	*3.150*	*-0.040*	*1.900*
PQ	-0.846***	-0.799***	-0.910***	-0.698***	-0.813***	-0.552***
	-4.400	*-4.910*	*-4.190*	*-7.680*	*-5.610*	*-6.040*
WC	-0.174	0.130	0.013	0.265***	-0.158	0.034
	-1.020	*1.420*	*0.070*	*3.010*	*-1.050*	*0.280*
BC	-0.487**	-0.314*	-0.246	-0.387***	-0.844***	-0.447***
	-2.450	*-1.690*	*-1.080*	*-4.170*	*-6.300*	*-4.280*
FOODINSEC			0.288	0.170*	0.187	0.225
			0.950	*1.660*	*0.960*	*0.790*
ETHNICITY		1.005***	0.878***	1.244***	0.577***	0.709***
		3.830	*2.990*	*9.070*	*2.950*	*5.070*
ACTIVE	-0.137	-0.220	-0.304*	-0.610***	-0.448***	-0.589***
	-0.870	*-1.520*	*-1.750*	*-8.080*	*-4.500*	*-6.990*
MODERATE	-0.008	0.047	-0.003	-0.146*	-0.046	-0.364***
	-0.050	*0.360*	*-0.010*	*-1.850*	*-0.420*	*-4.180*

OSMOKE	0.753**	0.468*	0.808**	0.866***	0.831***	0.531***
	2.460	*1.890*	*2.280*	*6.240*	*3.950*	*3.550*
FSMOKE	0.935***	1.071***	1.326***	1.198***	1.242***	0.968***
	5.530	*7.020*	*6.690*	*14.530*	*10.490*	*9.790*
NSMOKE	0.534***	0.645***	0.802***	0.999***	0.967***	0.713***
	3.080	*4.250*	*4.190*	*10.820*	*7.030*	*6.140*
ODRINK	0.274	0.404**	-0.023	0.369***	0.347**	0.585***
	1.360	*2.470*	*-0.110*	*3.260*	*2.420*	*4.590*
FDRINK	-0.011	0.135	-0.266	0.265**	0.389**	0.288*
	-0.040	*0.610*	*-0.900*	*2.130*	*2.440*	*1.880*
NDRINK	-1.013***	-0.078	-0.789**	-0.566***	0.811	0.504
	-2.930	*-0.290*	*-2.600*	*-2.870*	*1.090*	*1.540*
INTERCEPT	24.314***	23.497***	23.529***	23.668***	24.523***	24.790***
	72.070	*70.190*	*59.910*	*138.920*	*82.570*	*125.090*
N	5278	19534	4730	33714	21839	27399
R^2	0.090	0.081	0.087	0.087	0.067	0.073
F-stat[a]	11.76***	13.84***	10.73***	49.13***	22.14***	34.41***

a. F-test of the joint null hypothesis that the estimated slope coefficients are jointly equal to zero.
*** denotes significance at the one percent level
** denotes significance at the five percent level
* denotes significance at the ten percent level

Table 5. Results of the OLS regression of BMIs for adult females in Canada on socio-demographic, economic and behavioural covariates, using NPHS (1994, 1996, 1998) and CCHS (2001, 2003, 2005) data (t-statistics shown in italics beneath the coefficient estimate).

	1994	1996	1998	2001	2003	2005
A2024	-1.692***	-1.942***	-2.067***	-1.606***	-1.705***	-1.982***
	-4.690	*-7.380*	*-6.580*	*-10.510*	*-6.430*	*-10.260*
A2529	-0.942***	-0.944***	-0.622*	-0.728***	-0.609***	-0.931***
	-3.150	*-3.500*	*-1.850*	*-5.220*	*-2.950*	*-5.110*
A3034	-0.816***	-0.706***	-0.228	-0.347**	-0.281	-0.448***
	-2.930	*-2.910*	*-0.720*	*-2.590*	*-1.480*	*-2.740*
A3539	-0.809**	-0.736***	0.055	-0.162	-0.260	-0.272
	-2.630	*-3.250*	*0.180*	*-1.280*	*-1.290*	*-1.530*
A4549	0.752**	0.538**	0.924***	0.708***	0.272	0.521***
	2.460	*2.020*	*2.860*	*5.080*	*1.360*	*2.720*
A5054	0.861***	1.116***	1.461***	1.237***	0.975***	1.188***
	2.660	*4.180*	*4.360*	*9.050*	*4.970*	*6.340*
A5559	1.074***	1.154***	1.077***	1.365***	1.290***	1.140***
	3.270	*3.850*	*3.290*	*9.600*	*5.900*	*6.380*
A6064	0.938***	1.235***	1.383***	1.022***	1.039***	0.912***
	2.680	*4.310*	*3.710*	*6.310*	*4.480*	*5.020*
CNDIN	0.635***	0.637***	0.578**	0.822***	1.028***	1.037***
	2.870	*3.260*	*2.340*	*6.750*	*6.340*	*6.570*
EDU1	0.735***	0.880***	0.875***	0.820***	1.072***	1.069***
	3.050	*3.980*	*3.260*	*6.830*	*5.320*	*5.680*
EDU2	0.478**	0.137	0.369	0.380***	0.414***	0.226*
	2.170	*0.770*	*1.540*	*4.210*	*3.140*	*1.920*
EDU3	0.339*	0.314**	0.430**	0.281**	0.846***	0.393**
	1.720	*1.980*	*2.120*	*2.360*	*3.050*	*2.390*
LI	0.475	-0.006	-0.046	-0.501***	-0.236	0.322**
	1.370	*-0.020*	*-0.130*	*-2.910*	*-0.930*	*2.040*
LMI	0.379	0.431*	0.348	-0.080	0.238	0.081
	1.360	*1.650*	*1.020*	*-0.540*	*1.000*	*0.590*
UMI	-0.102	-0.583***	-0.054	-0.237**	-0.068	-0.349***
	-0.520	*-3.500*	*-0.250*	*-2.280*	*-0.460*	*-2.690*
UI	-0.614**	-0.913***	-0.588**	-0.616***	-0.453**	-0.692***
	-2.280	*-4.570*	*-2.410*	*-5.440*	*-2.600*	*-5.450*
MARRIED	0.122	0.319**	0.126	0.268***	0.294***	0.051
	0.680	*2.120*	*0.660*	*3.390*	*2.700*	*0.510*
AC	0.249	1.003***	0.442*	0.459***	0.455**	0.607***
	1.130	*4.890*	*1.870*	*4.300*	*2.490*	*3.230*
PQ	-1.084***	-0.548***	-1.117***	-0.919***	-0.807***	-0.951***
	-5.100	*-3.100*	*-4.900*	*-9.040*	*-4.780*	*-8.490*
WC	0.082	0.429***	0.424*	0.142	-0.040	-0.015
	0.400	*4.010*	*1.850*	*1.470*	*-0.240*	*-0.110*
BC	-1.055***	-0.159	-0.470*	-0.406***	-0.791***	-0.291**
	-4.430	*-0.700*	*-1.800*	*-4.160*	*-4.910*	*-2.330*
FOODINSEC			0.617**	0.957***	0.830***	1.372***
			2.240	*9.290*	*5.960*	*3.960*
ETHNICITY		0.959***	1.438***	1.042***	0.993***	1.109***
		3.840	*4.710*	*6.910*	*5.460*	*6.510*
ACTIVE	-0.961***	-0.801***	-0.903***	-1.222***	-0.917***	-1.386***
	-5.080	*-5.340*	*-4.550*	*-14.700*	*-7.060*	*-13.730*
MODERATE	-0.175	-0.386***	-0.701***	-0.554***	-0.395***	-0.711***
	-0.950	*-2.600*	*-3.710*	*-6.640*	*-3.220*	*-6.930*

OSMOKE	0.441	0.366	0.842**	0.437***	0.179	0.341*
	1.020	*1.140*	*2.050*	*2.780*	*0.810*	*1.950*
FSMOKE	0.925***	1.020***	1.069***	1.053***	0.982***	1.197***
	4.320	*5.380*	*4.680*	*11.510*	*6.210*	*9.450*
NSMOKE	0.429**	0.508***	0.607***	0.643***	0.707***	0.636***
	2.040	*3.000*	*2.750*	*6.490*	*4.180*	*4.980*
ODRINK	0.869***	0.831***	1.050***	1.165***	1.036***	1.382***
	4.440	*5.130*	*5.310*	*13.260*	*8.170*	*12.320*
FDRINK	0.817***	0.948***	1.135***	1.300***	0.921***	1.451***
	3.040	*4.670*	*4.260*	*10.390*	*5.430*	*8.660*
NDRINK	0.262	0.729***	1.015***	0.653***	0.739***	0.583**
	0.800	*2.730*	*3.010*	*3.690*	*2.760*	*2.480*
INTERCEPT	23.708***	21.974***	21.698***	22.488***	22.442***	22.763***
	59.260	*62.650*	*46.340*	*112.610*	*76.740*	*84.130*
N	6094	20006	5218	37935	23451	29472
R^2	0.092	0.108	0.111	0.104	0.099	0.105
F-stat[a]	15.53***	24.21***	17.14***	79.62***	39.70***	52.17***

a. F-test of the joint null hypothesis that the estimated slope coefficients are jointly equal to zero.
*** denotes significance at the one percent level
** denotes significance at the five percent level
* denotes significance at the ten percent level

Table A1. Income adequacy categories and related household income and size ranges

Income category	Household income	Household size
Lowest income	Less than $10,000	1 to 4 persons
	Less than $15,000	5 or more persons
Lower middle income	$10,000 to $14,999	1 or 2 persons
	$10,000 to $19,999	3 or 4 persons
	$15,000 to $29,999	5 or more persons
Middle income	$15,000 to $29,999	1 or 2 persons
	$20,000 to $39,999	3 or 4 persons
	$30,000 to $59,999	5 or more persons
Upper middle income	$30,000 to $59,999	1 or 2 persons
	$40,000 to $79,999	3 or 4 persons
	$60,000 to $79,999	5 or more persons
Highest Income	$60,000 or more	1 or 2 persons
	$80,000 or more	3 persons or more

Table A2. Mapping from NPHS and CCHS mnemonics to independent variables included in the OLS regressions.

	1994 NPHS	1996 NPHS	1998 NPHS	2001 CCHS	2003 CCHS	2005 CCHS
Male	SEX	DHC6_SEX	DHC8_SEX	DHHA_SEX	DHHC_SEX	DHHE_SEX
Age	AGEGRP	DHC6GAGE	DHC8GAGE	DHHAGAGE	DHHCGAGE	DHHEGAGE
Country of birth	DVBORNG	SDC6GCB	SDC8GCB	SDCAGCBG	SDCCGCBG	SDCEGCBG
Education	DVEDC294	EDC6G7	EDC8D3	EDUADR04	EDUCDR04	EDUEDR04
Income adequacy	DVINC594	INC6DIA5	INC8DIA5	INCADIA5	INCCDIA5	INCEDRCA
Region	PROVINCE	PRC6_CUR	PRC8_CUR	GEOAGPRV	GEOCGPRV	GEOEGPRV
Ethnicity	Not included	SDC6GRAC	SDC8GRAC	SDCAGRAC	SDCCGRAC	SDCEGCGT
Food insecurity index	Not included	Not included	FIC8F1	FINAF1	FINCF1	FSCEDHFS
Physical activity index	DVPAID94	PAC6DPAI	PAC8DPAI	PACADPAI	PACCDPAI	PACEDPAI
Smoking	DVSMKT94	SMC6DTYP	SMC8DTYP	SMKADSTY	SMKCDSTY	SMKEDSTY
Drinking	DVALT94	ALC6DTYP	ALC8DTYP	ALCADTYP	ALCCDTYP	ALCEDTYP