

ESTIMATING THE ECONOMIC COST OF OBESITY IN CANADIAN POPULATIONS

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Introduction

The prevalence of obesity has increased at such a rapid rate worldwide that the World Health Organization has deemed obesity a “global epidemic.”¹ Obesity is considered to be the second-greatest preventable cause of death after cigarette smoking;² Canadian data demonstrates that almost 1 in 10 premature deaths can be related to excess weight.³

Presenting statistics as above can be effective in capturing (and even alarming) an audience, but unfortunately they can be misleading without given proper context. While the above statistics may accurately depict the increasing prevalence of and negative effects related to obesity they provide little information regarding *who* is at risk of premature death or disease, *why* these problems are occurring, or *how* they can be prevented.

If obesity really is such an “epidemic,” as described, how can we quantify it? The economic cost of obesity literature makes up a small portion of the total database of obesity-related publications and it grounds the obesity literature in a dimension everyone can understand, money. By adding cost to the equation we can add depth to our understanding of the obesity epidemic. For instance, some obese people may otherwise be relatively healthy and their weight should not be a cause for concern for themselves or for the healthcare system. While the body mass index

¹ World Health Organization. (1997) *Obesity: Preventing and Managing the Global Epidemic*, Report of a WHO Consultation on Obesity, Geneva.

² Mirolla, Michael. (2004) *The cost of chronic disease in Canada*. GPI Atlantic.

³ Ibid.

(BMI) classification of these people may indicate they are a part of the obesity epidemic they may not contribute to the *cost* epidemic, if such a thing exists.

The literature on cost of obesity often focuses on determining an overarching sum of all obesity-related economic costs without consideration of who, specifically, is accruing those costs. Without precise information on the patterns of accrument, the “epidemic” nature of obesity is transferred to cost estimates without pausing to consider the validity of this declaration. In reality obesity costs may be localized in a specific subgroup of the obese population rather than affecting it globally. The “who” aspect of obesity is extremely important in order to establish a complete understanding of the economic cost of obesity and to determine if obesity is as great of an economic issue as it is a health issue.

In a country where the population’s health depends on a publically funded system we can think of obesity-related costs as a negative externality where the financial burdens, accountable by only some, are borne by all. Given this, it must be emphasized that there is no blame implied by this research—as Dr. Ronald Colman explains, “obesity is.... a symptom of deeper social trends, including a junk food explosion, a more sedentary lifestyle, higher rates of stress and overwork, poverty, and nutritional illiteracy,”⁴ all of which affect the entire population and not just the obese.

This study aims to provide a more complete description of who suffers most severely from obesity in terms of both the prevalence of the disease and its associated costs. Literature estimating the cost of obesity is often highly aggregated

⁴ R. Colman, “Cost of Obesity in Manitoba,” *GPI Atlantic* (2000).

and combines data on all age groups, genders, and ethnicities. The proceeding research is designed to be highly comparable to existing literature in terms of data sources, time frame, and methodology; however, I will disaggregate across relevant variables to identify the most troublesome obese populations in Canada in terms of economic cost. The second goal of my research is to consider how these specific Canadian populations (age groups, genders, and ethnicities) are expected to grow to gain a more accurate prediction of how the total economic cost of obesity will change in the near future and whether those costs should be deemed an epidemic for our economy.⁵

I have used data from the Canadian Community Health Survey (CCHS) to analyze the trends in rates of obesity in Canada between 2000 and 2014. Prevalence rates of obesity are compared by gender as well as age to identify variances as they may appear. This age-sex specific data is then combined with information on comorbidities with well-established relationships to obesity in order to estimate the proportion of healthcare costs related to the comorbidities that can be attributed to obesity. Finally I apply the age-sex obesity rates to demographic growth forecasts to estimate the expected change in obesity rates and costs by 2036. The main finding from these processes is an increase in future costs due to an increasing proportion of elderly and Aboriginal people in the population.

This analysis is organized as follows. Section 1 provides an outline of the known trends in obesity in Canada including correlations with other health problems and three popular causal theories behind the upward obesity trend.

⁵ An “epidemic,” according to the Centre for Disease Control and Prevention (2012) is “an increase ... in the number of cases of a disease above what is normally expected in that population.”

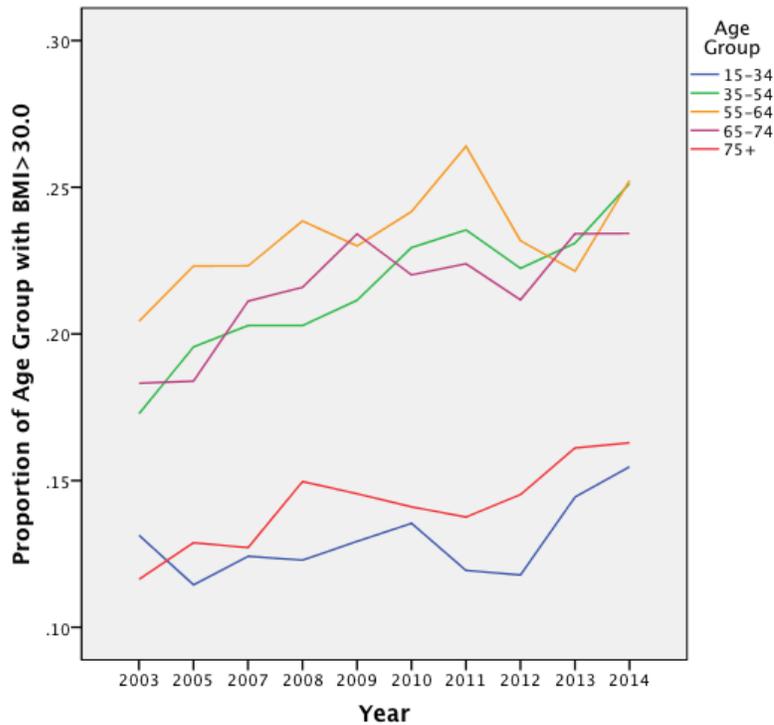
Section 2 describes the accepted and commonly used method of estimating the economic cost of obesity and Section 3 utilizes recent CCHS data to update the estimate of the economic cost of obesity in Canada and add valuable information on the distribution of costs by age and gender. Lastly section 4 then utilizes population projections from Statistics Canada to discuss how the cost of obesity may change in the near future.

1. Obesity – A Health Epidemic

An increase in the proportions of populations that are classified as overweight (25.0 kg/m² – 29.9 kg/m²) and obese (>30.0 kg/m²) has been observed worldwide. This trend is present in Canada as well, with the proportion of the population classified as “obese” increasing from 15% in 2003 to 20% in 2014 (p<0.001).⁶ This increasing trend is consistent for both males and females of all ages, leading to the conclusion that, in general, Canadians are becoming more obese (Figure 1).

⁶ See Table 5, page 31.

Figure 1 – Trends in obesity by age group over time



A number of theories have been presented to identify the causality behind the upward trend in obesity, including a decline in physical activity, an increase in sedentary behaviour, unhealthy eating habits, and increased reports of daily stress. Identifying the many factors causing the obesity epidemic would involve a lifetime's dedication to the subject. However, it is advantageous to provide a basic background of why our society is becoming increasingly obese. It is unlikely that any one of these factors holds independent explanatory power over the trend; therefore these theories will be briefly presented but their significance not analyzed.

The first factor influencing the rising rates of excess weight and obesity is the vast amount of time people are spending sitting, lying down, and being generally inactive. In 2013, Canadian adults spent on average 9.8 waking hours in sedentary

activities daily, 3.77 hours in light physical activity, and only 25 minutes in moderate or vigorous activity.^{7,8} The Canadian Society for Exercise Physiology recommends that Canadian adults should spend no more than 2 hours per day in sedentary activities.⁹ In 2005, the Canadian Community Health Survey (CCHS) reported that 47.9% of respondents age 12 and over spent their leisure time physically inactive.¹⁰ Modern leisure time is commonly occupied with TV-watching and computer activities, and modern jobs also commonly require extended sedentary periods in front of a computer. It is also known that those who populate the “physically inactive” category have 44% higher rates of obesity than those who are physically active. The increase in sedentary behaviour is partly responsible for the obesity epidemic.¹¹

Additionally, physical activity has been linked as an effective preventative measure to a number of the comorbid diseases of obesity. For example physical activity has been demonstrated to improve insulin sensitivity (even following just *one* active session), which is linked to a number of cancers;¹² 150 minutes of moderate physical activity per week lowered the risk of type II diabetes progression

⁷ Statistics Canada. *Table 117-0020 - Average time spent sedentary, household population by sex and age group, occasional (minutes per day)*, CANSIM (database).

⁸ Statistics Canada. *Table 117-0021 - “Average time spent being physically active, household population by sex and age group, occasional (minutes per day),”* CANSIM (database).

⁹ Canadian Society for Exercise Physiology, “Canadian Physical Activity and Sedentary Behaviour Guidelines” (2012)

¹⁰ Statistics Canada. *Table 105-0501 - “Health indicator profile, annual estimates, by age group and sex, Canada, provinces, territories, health regions (2013 boundaries) and peer groups, occasional,”* CANSIM (database).

¹¹ M. Mirolla, 2004.

¹² J.C. Brown, K. Winters-Stone, A. Lee, and K.H. Schmitz, “Cancer, Physical Activity, and Exercise,” *Comprehensive Physiology* 2, no. 4 (2012): 2775–2809.

by up to 58%;¹³ in people with arthritis, physical activity can decrease pain and improve joint function.¹⁴ These moderate lifestyle changes can therefore reduce the risk of negative comorbid conditions developing alongside obesity. Aggregated over a population these lifestyle changes could lead to a significant monetary savings in terms of reduced spending on prescription drugs, physicians, and hospitalizations.

Another factor driving the increasing rates of obesity is stress. In 2005 the CCHS reported 23.2% of adults experienced “quite a lot” of life stress, and 87.6% of adults experienced some amount of stress in their life.¹⁵ Associations between stress and obesity can be explained by considering human lifestyles far back in evolution. Centuries ago humans would have been subjected to high levels of stress to obtain and fight for food, such that food became a reward for enduring stress. In modern society, social stresses have replaced feeding stresses and food is far from scarce. Given the abundance of both food and stress, contemporary conditions chronically favour strengthening of the stress-food association. This mental association is reinforced by the fact that eating “comfort foods” actually decreases feelings of stress. In this manner, stress eating becomes a habit developed over an individual lifespan as well as a fundamental neural association for humans.¹⁶ Evidently the conditions of contemporary civilization—stress, idleness, and automation of previously physical labour—favour the development of obesity.

¹³ Ronald J. Sigal, Glen P. Kenny, David H. Wasserman, Carmen Castaneda-Sceppa, and Russell D. White. “Physical Activity/Exercise and Type 2 Diabetes,” *Diabetes Care* 29, no. 6 (2006): 1433-1438.

¹⁴ M. Shih, J.M. Hootman, J. Kruger, and C.G. Helmick, “Physical Activity in Men and Women with Arthritis: National Health Interview Survey, 2002,” *American Journal of Preventative Medicine* 30, no. 5 (2006).

¹⁵ Statistics Canada. *Table 105-0501*.

¹⁶ Mary Dallman, “Stress-induced obesity and the emotional nervous system,” *Trends in Endocrinology & Metabolism* 21, no. 3 (2010): 159-165.

Thus, in hindsight, it is not exactly surprising that obesity has become such a widespread health problem for Canadians.

People who have excess weight or are obese are at greater risk of developing a number of costly health problems and a number of these risk levels increase as the level of excess weight increases. For example overweight males are 2.4 (females 3.9) times more likely to develop type II diabetes than those with a healthy body mass index (BMI), however obese males are 6.74 (females 12.41) times more likely to develop type II diabetes.¹⁷ Additional conditions that the overweight population is at greater risk of developing include osteoarthritis, asthma, stroke, hypertension, heart failure, and certain cancers.^{18, 19}

Many of the conditions associated with obesity are chronic conditions that require ongoing medical observation, life-long prescription drug treatments, and the expertise of medical specialists. Given the chronic nature of the many comorbidities of obesity, the increase in healthcare usage and cost should be anticipated to be multiplicative and not a fixed one-time cost for every unit increase in the rate of obesity. For example recall that an obese woman is over twelve times more likely to be diagnosed with type II diabetes than a woman with a healthy BMI. One study estimated a patient with type II diabetes accrued €2,834 (4,068 CAD) *annually* in direct medical costs of physician and hospital visits, drug costs, and paramedical

¹⁷ D.P. Guh et al, "The incidence of co-morbidities related to obesity and over-weight: a systematic review and meta-analysis," *BMC Public Health* (2009)

¹⁸ Hans Krueger, D. Williams, A.E. Ready, L. Trenaman, and D. Turner, "Improved estimation of the health and economic burden of chronic disease risk factors in Manitoba," *Chronic Diseases and Injuries in Canada* 33, no. 4 (2013).

¹⁹ Hans Krueger, Joshua Krueger, and Jacqueline Koot, "Variation across Canada in the economic burden attributable to excess weight, tobacco smoking and physical inactivity," *Canadian Journal of Public Health* 106, no. 4 (2015).

visits (nurse, physiotherapist, dietician, etc.). So it should be anticipated that as rates of obesity increase the proportion of the population accruing large, chronic medical costs would increase.

As greater incidents of obesity are observed diagnoses of associated comorbidities have increased, leading to higher healthcare usage and costs. Premature deaths, diagnoses of comorbidities, and changes in quality of life have costs associated with them both in terms of medical costs but also in terms of value of life lost, and value of work/production forfeited. After considering all the costs related to obesity the critical question becomes: how much of these costs would be eliminated if everyone had a healthy BMI?

There is no question as to whether the country has become more overweight; the objective here is not to determine why this has happened or how we can turn back time to prevent it. Rather this condition will be taken as given and the proceeding objectives are:

- I. To quantify the obesity epidemic in Canada in terms of costs that could be avoided if the entire population resided in the healthy BMI weight class.
- II. To determine how weight-related health costs might evolve over the coming twenty years by considering how sub-groups of the Canadian population are projected to grow in the near future.

2. Measuring the Cost of Obesity

The economic cost of obesity (CO) is typically calculated by considering the relative risk of comorbid conditions (RR), the cost of those comorbid conditions (CM), and the proportion of the population that is obese (P):

$$CO_{itkg} = \sum_{g=1}^2 \sum_{i=1}^{15} \sum_{t=2000}^{2014} \sum_{k=1}^5 CM_{ikg} P_{tkg} RR_{ig}$$

where CM is the cost of all i significantly related comorbidities, P is the proportion of the population that is obese during every t year considered, k age groups and g genders, and RR is the relative risk of having a specific comorbidity if you are obese.

I followed this method to calculate the total economic cost of obesity however one unique feature of my calculation is the inclusion of age-specific data. Most research in this area fails to consider this factor, which I will later demonstrate has a significant effect on the final cost outcomes.

The “population attributable fraction” (PAF) method was used here to provide the proportion of disease incidence that could be avoided if all obese and overweight Canadians had weights within the healthy BMI range (20 – 24.9 kg/m²). The PAF is calculated using the formula:

$$PAF = \frac{P(RR - 1)}{P(RR - 1) + 1}$$

Sex-specific RR statistics were obtained from the 2009 meta-analysis of 89 longitudinal studies by Guh et al.²⁰ 18 comorbidities were identified in this study as

²⁰ Guh et al, (2009).

being significantly related to overweight and obese populations and the RR statistics were compiled for these conditions. This data was preferred over alternatives due to the inclusion requirements for studies based on consistent methodology and definition of obesity across all co-morbidities. These RR statistics were used to calculate the PAF statistic for the fifteen comorbidities considered.²¹ The full list of 18 comorbidities compiled by Guh et al was not included because of an incomplete overlap with the cost data available.

The *Economic Burden of Illness in Canada* (EBIC) tool was used to obtain the cost of the fifteen comorbidities in the most recent year available, 2008. Direct costs from the EBIC tool included costs from physicians and medical professionals, hospitals, and prescription drugs. These costs were specified for each comorbidity category and were grouped by sex and age groups. Indirect costs include premature mortality and morbidity (short and long-term disability). Mortality costs were calculated using the friction cost method by “multiplying the period of lost production by the dollar value of production.”²² According to the friction cost method the period of lost production is the period of time between losing an employee and replacing them with a previously unemployed candidate (i.e. the friction period). Production was valued according to average annual earnings by

²¹ Fifteen comorbidities included stroke, hypertension, heart failure, type II diabetes, low back pain, asthma, osteoarthritis, and uterine, kidney, esophageal, pancreatic, colorectal, kidney, ovarian, and prostate cancers.

²² Policy Research Division, Strategic Policy Directorate, Population and Public Health Branch, Health Canada. “Economic burden of illness in Canada (EBIC), 2005-2008,” *Health Canada* (2014): pg 56.

age, sex, and province. To adjust for the premature deaths of unemployed people the mortality costs were multiplied by the employment rate.²³

Morbidity costs were calculated in a similar manner however the period of lost production was the number of workdays missed due to illness or injury rather than the friction period for replacement of the employee.

I then multiplied the PAF statistics by the indirect and direct costs of the comorbidities from the EBIC tool to determine the proportion of cases of comorbid diseases that could be attributable to obesity and/or excess weight. This information was calculated *separately* for all age groups and genders to attain the most descriptive information possible. The costs attributable to obesity were then summed over sexes, age groups, and weight classes to find the total economic cost of obesity.

In the final section of my analysis I obtained population projections for 2006 to 2036 from Statistics Canada to predict how the total cost of obesity will likely change and grow as the population of the country does the same. Specifically, after obtaining the total economic cost of a certain group, for example the elderly, I adjusted this cost based on the projected growth of the elderly to find that group's cost in 2036.

Estimation of the economic cost of obesity is an essential step in understanding how the Canadian economy will be burdened as rates of obesity

²³ For a full description of the morbidity cost calculation see "Appendix 1: Mathematical representation of the mortality cost methods" in: <http://www.phac-aspc.gc.ca/publicat/ebic-femc/2005-2008/assets/pdf/ebic-femc-2005-2008-eng.pdf>.

increase. Often the estimations of these costs are highly aggregated over all population characteristics without consideration for how various groups may accrue costs differently. Disaggregation can more accurately depict how the costs are distributed, especially because data show that obesity affects men and women across age groups at different rates. As the population's age distribution moves away from a normal distribution towards a rectangular distribution (see figure 4) it will be essential to have this disaggregated cost information to predict how our healthcare systems will be burdened in the future.

There are many methods of indirect cost calculation and results can vary significantly based on which method is used. The calculation method used by the EBIC tool is the friction cost method. Friction costs estimate the cost to the employer in terms of lost production when having to replace (temporarily or permanently) the absent employee. This method takes in to consideration the unemployment rate and average annual earnings for the employee to estimate how long the "friction" period will be (i.e. how long it will take to replace them). For instance the friction period may be longer for a more skilled worker or in a time of relatively low unemployment.

Alternatively, the human capital method estimates the value in lost wages that the employee suffers from his/her absenteeism. There are two reasons that the human capital method should be preferred when analyzing indirect costs of obesity. First, obesity occurs in higher rates for the less educated.²⁴ Let us assume that the

²⁴ G.M. Torrance, M.D. Hooper, and B.A. Reeder, "Trends in overweight and obesity among adults in Canada (1970-1992)," *International journal of obesity and related metabolic disorders*, 26, no. 6 (2002): 797-804.

less educated are employed in unskilled positions where a replacement or substitute employee can be found without much delay. Due to this correlation between education and obesity, the friction period for obese individuals would on average be shorter than that of the healthy population. Because of this shorter friction period the friction cost method will lead to a lower estimate of indirect costs for obesity than perhaps is appropriate. Second, the friction cost method may underestimate the indirect costs of obesity due to the chronic nature of many of its comorbidities. This method considers costs from the employer's perspective. Therefore, the losses in productivity are one-time costs based exclusively on the length of the friction period and no value is placed on time lost (from the employee's perspective) due to premature death or permanent illness. The employer may lose two months of productivity having to replace one employee but if that employee has prematurely passed away they lose a lot more than just two months of productivity.

Additionally, the indirect cost estimates presented using the friction cost method do not value loss in productivity for seniors because they are considered non-earners. However according to Statistics Canada 13.4% of seniors are still active in the labour force.

Previous editions of the EBIC tool utilized the human capital model of indirect cost estimation and demonstrated that indirect costs could be crudely estimated at 89% of direct costs.²⁵ If this method were followed, and the indirect costs associated with seniors were reduced to 13.4% of its total value to account for the labour force participation rate in that age group, the total indirect costs would

²⁵ Mirolla, M. (2004).

increase from \$25.3 million (using the friction cost method) to \$1.5 billion, and the total economic cost would increase to \$6.5 billion.

Michael Mirolla (2004) points out that the “89%” figure for the indirect-direct cost ratio comes from considering costs for *all* disease categories, where the comorbidities of obesity are mostly chronic. Due to the chronic nature of the comorbidities, Mirolla estimates that the indirect-direct cost ratio specific for obesity-related diseases should be closer to 140%.²⁶ If this estimate were used, while again adjusting for the seniors’ labour force participation rate, the total indirect costs would increase from \$25.3 million to \$1.7 billion, and the total economic cost would increase to \$6.7 billion.

The technique of indirect cost calculation greatly impacts the final estimate of costs and the friction cost method used by the EBIC tool results in a conservative estimate of indirect costs that may be misrepresentative of the real impact of obesity in Canada.

The direct cost estimate is also conservative compared to other measures because it does not include every condition significantly associated with obesity and overweight; rather it includes the conditions for which the RR statistics available overlapped with the cost data available through the EBIC tool. For instance, additional conditions that have been included in other studies are gout, sleep apnea, infertility, and thyroid problems, among others.²⁷

²⁶ Ibid.

²⁷ Ibid.

Despite this, the EBIC tool presents its most recent data using the friction cost method therefore in order to have the most relevant information this method is accepted for the proceeding calculations.

There are some limitations to the analysis performed here. First, due to the availability of disease-specific cost information, not all conditions associated with obesity and excess weight were included in the total economic cost estimations. This results in cost estimates that are likely less than the true economic cost.

Additionally, the RR statistics are not specified by age but rather are specified only for male/female. There are many conditions that are more likely to develop later in life and/or are more or less likely to develop in certain ethnicities. Therefore it would be highly beneficial and informative to disaggregate the RRs of diseases by age to account for the conditions that are more or less likely to develop at certain ages.

The BMI data in the CCHS is derived from self-reported height and weight. When relying on self-reported data height is often over-estimated and weight under-estimated, thus when the BMI statistic is derived (kg/m^2) it would also be an under-estimate of the true value. The total economic cost estimates may then be lower than the true cost due to an underestimate of the real portion of the population that is overweight or obese.

CCHS panel data from 2000 to 2014 was considered in estimating the annual increase in obesity. Aside from the obvious limitations of estimating longitudinal trends using panel data (sampling error, unmatched subjects, etc.), the time period considered is fairly short to obtain a realistic picture of long-term obesity trends.

Although the regression coefficients provided describe these fifteen years significantly, there is no consideration for nonlinear time trends as the period considered is relatively short to capture such occurrences. Consider that the proportion of the population deemed obese must logically reach some maximum, which it may already be approaching. A longer time period would be preferred to determine whether the increase in rates of obesity are now diminishing and to gain insight into the long-term trends of obesity.

When considering multiple years and how the economic cost changes over time, it has been assumed that the RR, PAF, and healthcare costs have remained constant. However there could be some change in any one of these variables unconsidered here that would result in the total economic cost of obesity being more (or less) than this study estimated. One study by Hans and Joshua Krueger and Jacqueline Koot (2015) estimated that adjusting their cost estimates from 1998 EBIC cost data to 2008 EBIC cost data resulted in an 11.7% increase in economic costs for excess weight and obesity.²⁸ Given that the present study used the latter EBIC 2008 data and that the tool does not publish new data annually, I would be hesitant to extend this figure to the results here. I will acknowledge that there is likely some change in medical costs that occurred over the period of 2000 to 2014 that is held constant in this research, however the intent of this study was not to analyze how costs of healthcare changed over this period.

²⁸ Krueger et al, (2015).

3. Results

Table 1 summarizes the relative risks (RR) of conditions that are significantly associated with excess weight and obesity. For example overweight males are 1.23 times more likely to suffer from a stroke than males who are in the healthy BMI weight category. The largest RR associated with overweight and obesity is for type II diabetes, for which there is 6.74 greater likelihood for obese males and 12.41 for obese females, to suffer from the condition compared to non-obese individuals. The difference in the RR for type II diabetes between males and females is noteworthy—nearly twice as great for females—as well the RR of diabetes in both genders triples as weight increases from overweight to obese.

Table 1 – Relative risk of diseases for overweight and obese persons

	Overweight		Obese	
	Male	Female	Male	Female
Stroke	1.23	1.15	1.51	1.49
Hypertension	1.28	1.65	1.84	2.42
Heart Failure	1.31	1.27	1.79	1.78
Type 2 Diabetes	2.4	3.92	6.74	12.41
Low Back Pain	1.59	1.59	2.81	2.81
Asthma	1.2	1.25	1.43	1.78
Osteoarthritis	2.76	1.8	4.2	1.96
Uterine Cancer		1.53		3.22
Colorectal Cancer	1.51	1.45	1.95	1.66
Esophagus Cancer	1.13	1.15	1.21	1.2
Kidney Cancer	1.4	1.82	1.82	2.64
Ovarian Cancer		1.18		1.28
Pancreatic Cancer	1.28	1.24	2.29	1.6
Prostate Cancer	1.14		1.05	

Table 2 summarizes the direct and indirect economic costs attributable to overweight and obese Canadians and Figure 2 summarizes the results graphically. Costs are consistently higher for the obese category than for the overweight category, despite the fact that the prevalence of overweight is consistently higher than the prevalence of obesity (Table 4). This finding indicates that the per-individual healthcare costs for the obese are higher than for the overweight. Disaggregating costs by age groups allows for consideration of which age groups and generations are accruing the greatest costs. The results here demonstrate that costs are disproportionately skewed to older age groups. The youngest age group—ages 15 to 34—accounts for only 3.32% of the total economic cost, whereas the highest cost age group—ages 55 to 64—accrues 25.62% of the total economic cost. Two notes should be made regarding these conclusions. First, the younger two cohorts include an age span of twenty years, where the older three groups span only ten years. Despite this difference the older three age groups account for a significantly greater portion of the total cost. Second, it should be noted that indirect costs were only included for Statistic Canada’s definition of the “working age population,” and therefore were not included for subjects 65 and older. Statistics Canada, however, also estimates that 13.4% of Canadians ages 65 and older are still in the labour force so the assumption that this group accrues zero indirect costs based on lost production may result in an under-estimation of costs attributable to these age groups.²⁹ Any correction for the indirect costs attributable

²⁹ Statistics Canada. “Labour force characteristics by age and sex,” *Statistics Canada* (2016).

to older overweight adults would lead to this group accounting for an *even higher* portion of the total cost.

The total estimated economic cost is greater for males than females for ages 15 to 64; for ages 65 and older, the cost attributable to females is greater than males for both the overweight and obese categories.

Figure 2 – Proportion of total cost by age group

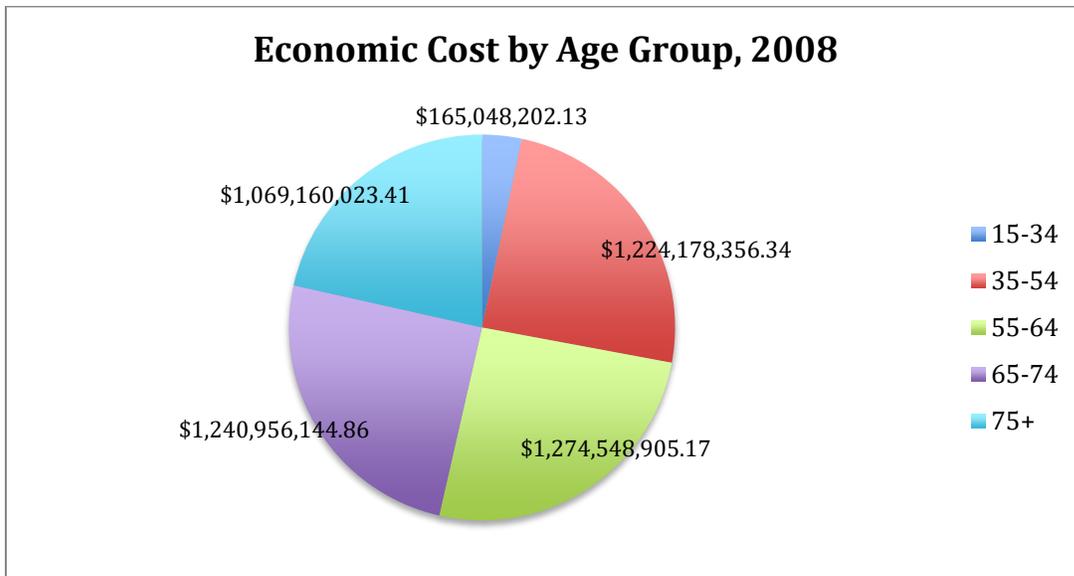


Table 2 – Direct costs of overweight and obese Canadians in 2008

Age Group		Overweight		Obese		Age group's proportion of total cost
		Males	Females	Males	Females	
15-34	Direct	\$36,035,216.37	\$34,049,090.64	\$42,322,458.94	\$52,293,373.78	3.32%
	Indirect	\$107,191.05	\$46,681.29	\$127,898.55	\$66,291.52	
35-54	Direct	\$307,043,590.07	\$211,385,543.43	\$393,889,950.21	\$300,680,844.34	24.61%
	Indirect	\$3,697,133.72	\$1,280,884.48	\$4,468,508.45	\$1,731,901.64	
55-64	Direct	\$274,434,340.43	\$268,794,626.49	\$371,231,255.28	\$346,347,014.73	25.62%
	Indirect	\$4,504,330.99	\$1,417,986.58	\$5,945,152.57	\$1,874,198.10	
65-74	Direct	\$277,724,659.69	\$285,370,067.93	\$335,440,350.50	\$342,421,066.75	24.95%
	Indirect	n/a	n/a	n/a	n/a	
75+	Direct	\$245,383,620.49	\$302,364,837.82	\$199,952,244.92	\$321,459,320.17	21.50%
	Indirect	n/a	n/a	n/a	n/a	
Total		\$1,148,930,082.81	\$1,013,730,424.26	\$1,547,315,524.70	\$1,346,095,535.20	\$4,973,891,631.91

Table 3 shows the PAF statistics for 2008. The statistics vary both by gender and age, indicating that the proportion of cost attributable to excess weight is not constant across these variables. The PAFs are highest for the 55 to 64 age group across all chronic diseases considered without exception; thus the proportion of costs attributable to excess weight are higher in this age group than any other.

Table 3 – Population attributable fraction (PAF) for Obesity in Canada, 2008

		15-34	35-54	55-64	65-74	75+
Acute but Ill-Defined Stroke	Male	.059	.094	.108	.099	.060
	Female	.046	.076	.094	.090	.068
Essential Hypertension		.094	.146	.167	.154	.095
		.123	.193	.231	.223	.175
Heart Failure		.088	.138	.159	.146	.090
		.072	.116	.141	.136	.105
Type II Diabetes		.414	.538	.578	.553	.417
		.531	.658	.707	.697	.631
Low Back Pain		.182	.269	.302	.281	.184
		.152	.234	.277	.267	.213
Uterine Cancer		.000	.000	.000	.000	.000
		.180	.272	.319	.309	.249
Colorectal Cancer		.105	.162	.185	.170	.106
		.061	.100	.122	.117	.090
Esophagus Cancer		.025	.041	.048	.043	.025
		.019	.033	.041	.039	.029
Kidney Cancer		.092	.143	.164	.150	.093
		.140	.216	.257	.248	.197
Ovarian Cancer		.000	.000	.000	.000	.000
		.027	.045	.056	.053	.040
Pancreatic Cancer		.137	.207	.235	.218	.138
		.056	.092	.113	.108	.082
Prostate Cancer		.006	.010	.012	.011	.006
		.000	.000	.000	.000	.000
Asthma		.050	.080	.093	.085	.051
		.072	.116	.141	.136	.105
Osteoarthritis		.282	.394	.433	.409	.285
		.087	.139	.169	.162	.126

Table 4 provides the prevalence rates for obesity and excess weight in men and women in 2008. The prevalence of both obesity and excess weight is higher in men than women, with the exception of obesity in the 75 and older age group. Prevalence of obesity is highest in the 55-64 age group and prevalence of overweight is highest in the 65-74 age group.

Table 4 – Proportion of obese and overweight by age groups, 2008

	15-34		35-54		55-64		65-74		75+	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Overweight	.31	.18	.44	.27	.44	.34	.45	.36	.44	.33
Obese	.12	.10	.20	.17	.24	.21	.22	.20	.12	.15

Figure 3 – Trends in rates of obesity over time

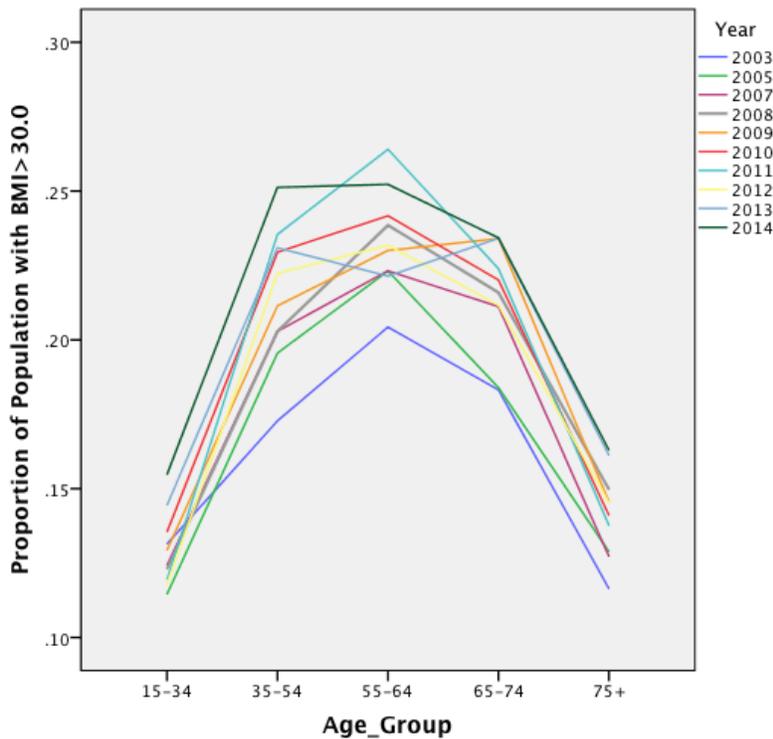


Table 6 shows the economic cost of obesity per capita calculated for each age group separately for the year 2008. Many studies have explored the economic cost of obesity by estimating the price tag of obesity across a broad population. Individualized cost estimates are then made in such studies by dividing the total cost by the total number of individuals classified as obese or overweight.³⁰ In the results at hand it is clear that various age groups account for vastly different proportions of costs and as such the method described above should be used with caution to calculate per-capita costs. In this study costs were calculated for each age-sex group and then these sub-total costs were divided by the total number of individuals in each age-sex group to obtain more specific per-individual costs. For example an obese male in the 15 to 34 age category will amass on average only \$82 in direct and indirect costs annually, where an obese male in the 75+ age category will amass \$2,446 on average annually.

Table 6 – Economic cost of obesity per capita

	15-34	35-54	55-64	65-74	75+
Male	\$82.38	\$417.63	\$834.53	\$1,491.58	\$2,446.59
Female	\$135.74	\$382.35	\$875.94	\$1,431.62	\$2,304.80

Note: Age groups 65-74 and 75+ contain only direct costs; all other age groups contain direct and indirect costs.

³⁰ For example see Krueger et al, 2013 and 2015.

4. Forecasting the Future Obesity Epidemic

The Canadian population is very diverse and continues to evolve across many dimensions such as age, gender, and ethnicity. Some demographics are growing faster and slower than others, and suffer from obesity at greater rates than others. As these population changes continue to occur overall costs of obesity may also change. Four demographic dimensions are highlighted here to forecast future obesity costs.

Immigrant Population

Immigration is an interesting lens through which to study time trends of obesity, especially in Canada where two-thirds of the population growth is from immigration.³¹ By 2036 the proportion of immigrants in Canada should reach 27% (an increase from 22% in 2011).³² Most studies find that upon arrival immigrants are less likely to be overweight than native-born Canadians; over time, however, their BMIs will increase. While still experiencing an increase in weight, non-white immigrants maintain average BMIs lower than native-born Canadians and white immigrants.³³ Additionally, landed immigrants are 4-5% less likely to be obese than non-immigrants.³⁴ This is a positive note for the overall health of the Canadian population as it becomes more immigrant-based, but does not reflect positively on the healthiness of the Canadian lifestyle. More information should be

³¹ L. Martel, "Recent changes in demographic trends in Canada," *Demography Division, Statistics Canada* (2015).

³² Ibid.

³³ F. De Maio, "Immigration as pathogenic: a systematic review of the health of immigrants to Canada," *International Journal for Equity in Health* 9, no. 27 (2010).

³⁴ M. Hajizadeh, M.K. Campbell, and S. Sarma, "Socioeconomic inequalities in adult obesity risk in Canada: trends and decomposition analyses," *The European Journal of Health Economics* 15, no. 2 (2014): 203-221.

gathered to determine if the positive effects of an increasing immigrant population will outweigh a significant portion of the increasing costs related to obesity in native-born Canadians.

Aboriginal Population

Regarding native-born Canadians, the Aboriginal population suffers enormously from the obesity epidemic. The rate of obesity in Aboriginal adults was 37.8% in 2004, compared to the rate of the rest of the adult population, 22.6%.^{35, 36} This high prevalence is observed across the entire Aboriginal population and for both *high and low* income and education levels, in contrast to non-Aboriginals who typically demonstrate negative correlations between obesity and socio-economic indicators.³⁷ One estimate predicts that the Aboriginal population will increase by 43% between 2006 and 2026—over double the predicted percent change in the general population—, indicating this group will easily be the fastest growing demographic in Canada.³⁸ The growth rate of this group, along with atypical trends of obesity affecting a broad spectrum of socioeconomic characteristics, make the Aboriginal population an area of great concern regarding the future costs of obesity.

The concerning rates of obesity in Aboriginals can in part be explained by the sub-par levels of health determinants in Aboriginal communities and reserves. As former Chief

³⁵ Katzmarzyk, P. T. "Obesity and physical activity among Aboriginal Canadians," *Obesity*, 16(1), (2008): 184-190.

³⁶ This estimate of obesity in Aboriginal populations comes from self-reported height and weight statistics. It is commonly accepted that in self-report data weight is under-reported and height is over-reported, leading to lower derived BMIs. It should thus be safe to expect that this estimate for obesity in Aboriginals is actually lower than in reality.

³⁷ Ng, C., Corey, P. N., Kue Young, T. "Socio-economic Patterns of Obesity Among Aboriginal and Non-Aboriginal Canadians," *Canadian Journal of Public Health/Revue Canadienne de Santé Publique*, 102(4), (2011): 264-268.

³⁸ Sharpe, A., Arsenault, J. "Investing in Aboriginal Education in Canada: An Economic Perspective," *Centre for the Study of Living Standards Research Report 2010-03*, (2010).

of the Assembly of First Nations Matthew Coon Come described, these poor quality health determinants, including housing, education, environment, and income among others, have lead to a “Third World health status”³⁹ for Aboriginals. The result of the low levels of health determinants is that these communities are vulnerable to developing a greater number of health problems. Thus the high levels of obesity observed here may not necessarily be righted by healthy lifestyle interventions due to underlying socioeconomic problems. Many of these Aboriginal populations may not be economically or socially equipped to deal with obesity-related health issues and socioeconomic inequality problems must be solved first before proceeding with health policy intervention.

Predicting the future of obesity for Aboriginals is extremely nuanced as it is unknown how the prevalence of obesity will change as improvements are made in northern housing, education, and infrastructure. The federal government has pledged \$1.2 billion over five years for First Nations, Inuit and northern communities to improve childcare and community health and recreation facilities, and an additional \$739 million dedicated to northern housing;⁴⁰ obesity rates in these communities should be observed closely to determine the effects of these investments.

Gender Differences

The PAF statistics vary by gender for most of the comorbidities considered. For some conditions males have a higher PAF (for example osteoarthritis and pancreatic cancer) and for some females are higher (type II diabetes). As noted previously, while the

³⁹ Adelson, Naomi, “The Embodiment of Inequity: Health Disparities in Aboriginal Canada, *Canadian Journal of Public Health* 96 (2005): S45-S61, http://www.jstor.org/stable/41994459?seq=1#page_scan_tab_contents.

⁴⁰ Morneau, William Francis, Minister of Finance, Government of Canada, “Chapter 2 – Growth for the Middle Class,” *Budget 2016* (2016): 85-128. <http://www.budget.gc.ca/2016/docs/plan/budget2016-en.pdf>

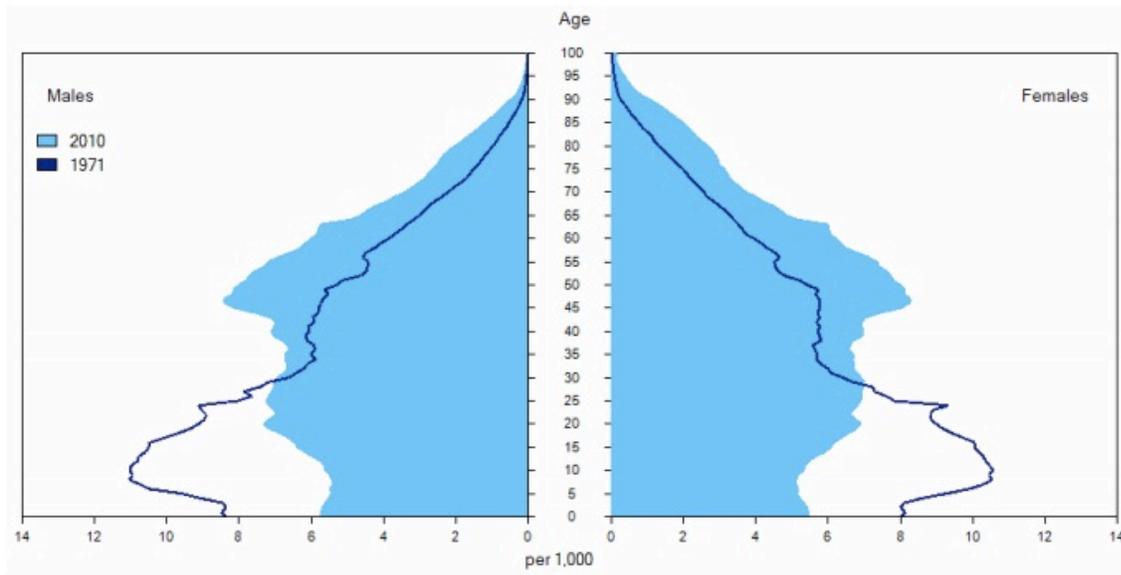
costs for younger people are higher for males than females, the opposite is true for the elderly. The population projections of either gender should therefore also be considered when determining how future costs of obesity might evolve. The projections for the next twenty years, however do not anticipate a change in the proportion of each gender in the population—50.4% female in 2009 and 50.5% female in 2036.⁴¹ Although costs may vary by gender, in the near future there is no reason to expect that the proportions of costs accumulated by either gender will be different than estimated here.

Ageing Population

Given that the older age groups (65+) contribute over 46% of the total economic cost of obesity, attention should be turned to how these costs will change as the Canadian population moves from a pyramid distribution to a rectangular distribution with a significantly larger portion of older people and fewer younger people (Figure 4).

⁴¹ Statistics Canada, Demography Division, (2010).

Figure 4 – Age pyramid of the Canadian population in 1971 and 2010



Note: reprinted from - Statistics Canada. (2010) *Annual Demographic Estimates: Canada, Provinces and Territories*, Statistics Canada Catalogue no. 91-215-X.

Despite the many other demographic factors that have roles in this issue, my quantitative forecast is limited to consider how changes in the age-sex profile of the Canadian population may affect the overall cost of obesity.

First, ordinary least squares regression results are presented in Table 5 for a model predicting the rate of obesity based on sex, age group, age group-squared, and year. All indicators are significant with $p < 0.001$. The results show that, all else constant, rates of obesity have increased 0.4% annually. The dummy variable for sex (male=1) shows that on average men have 0.15% higher rates of obesity than women.

Table 5 – Regression results for rate of obesity (standard errors)

Constant	-7.072*
	(0.831)
Age_Group	0.154*
	(0.005)
Age_Group ²	-0.025*
	(0.001)
Year	0.004*
	(0.000)
Sex	0.015*
	(0.003)
Adjusted R-squared	0.916
No. observations	100

* indicates significance at the 99% level.

The nonlinear age group coefficients that describe how obesity rates change as people progress through their lifespan can be interpreted with some basic calculus.

Our regression results are:

$$\frac{\partial Obesity}{\partial AgeGroup} = 0.154 - 2 * (0.025)AgeGroup$$

So the effect of an increase in age group on the rate of obesity depends on the current age group being considered. In other words, there is a significant nonlinear relationship between the rate of obesity and age group. The critical age group for which an increase in age would result in a decrease in the obesity rate can then be determined:

$$0.154 - 0.05AgeGroup \leq 0$$

$$AgeGroup \geq 3.08$$

As can be seen, the age group for which the significant negative coefficient on age group-squared will begin to have an overpowering effect over the positive coefficient is for age group 3.08, which can be rounded to age group 3—ages 55 to 64. Therefore, for ages 15 to 54, the effect of aging is positive on the rate of obesity. For ages 55 and older the effect of aging on the rate of obesity is negative.

A note should also be made that the lifespan trend—increasing rates of obesity in younger ages and decreasing rates of obesity in older ages—does not appear to be a cohort effect. The trend is present in all years considered, as shown in Figure 3.

Statistics Canada provides estimates for the growth of the Canadian population in the coming twenty years. These statistics show that by 2036 the proportion of the population aged 65 and older will have increased from 14% (in 2009) to 23-25%.

As summarized in Table 2, the elderly are some of the most “expensive” when it comes to the costs related to obesity. The OLS regression results in table 5 can be used to perform a basic adjustment for the anticipated increase in obesity rate for this age group. The regression coefficients estimate that obesity rates increased 0.4% annually over the time period considered. If this positive growth continues, the rate of obesity in the 65-74 age range will increase from 21% to 31.8%% by 2036, and from 13.5% to 24.3% in the 75+ age group.⁴² After adjusting for these changes the direct cost of obesity in the elderly increases to \$1.62 billion by 2036. However we must also consider the increase in the proportion of the population that occupies these older age categories. If an adjustment is made to account for the proportion of elderly increasing from 14% to 23% of the

⁴² Of course a continuous linear increase in obesity rates in the long run will become infeasible. However, given the non-diminishing trends in adult obesity and the increasing trends in childhood obesity in the recent past and the significance of the linear trend in the data presented here, the assumption of linearity will be held.

population, the total cost attributable to obese people age 65 and older would reach \$2.65 billion in 2036.

Both obesity and increasing longevity are new phenomena for human beings and economies. The growing proportion of elderly should be monitored closely as the current (and increasingly obese) population ages and as elderly people begin to live longer lives.

In 2008 the Canadian government spent a total of \$172.1 billion on healthcare, 3.7% of which would have to be allocated to cover the indirect and direct costs of obesity in that year.⁴³ Whether this spending should stir a level of concern on par with the health epidemic of obesity is unclear. However, the essential point to remember when discussing the costs of obesity is that in general obesity is *preventable*. Increasing daily activity, reducing the portion of time spent sitting and lying down, and finding strategies to reduce daily stress will all promote a decrease in the proportion of the population that is obese. This translates into a reduction in the proportion of the healthcare budget that is spent treating obesity and its related health problems. Additionally ensuring basic health determinants (housing, nutrition, income, etc.) are at acceptable levels for all Canadians will reduce negative health outcomes.

Thousands of studies and thought pieces are published on the topic of obesity, its negative associations, and its cost every year, and still rates of obesity are increasing worldwide. Robert Evans brusquely asks, “Is anyone really serious about this? Or should

⁴³Canadian Institute for Health Information, Spending and Health Workforce. (2014)

we just settle for preaching at [the obese]?”⁴⁴ Contemporary society is structured to support and promote obesity, to treat it rather than prevent it. The abundance of food, necessities at our fingertips, gym memberships feasible only for the wealthy and employed all beg to question: will public health interventions be not only persuasive but *necessary* steps to affect any noticeable change? Evans’ question makes one wonder if individuals have the conviction (or motivation) to make health and lifestyle changes on their own. How much of this lifestyle are people actually willing to forgo (if anything) to achieve healthiness?

Conclusion

In this study I demonstrate that the economic costs of obesity accrued by various groups are different. A great number of related studies aggregate costs over all ages however, here it is apparent that when discussing the projection of these costs we should disaggregate by age. Using this approach will allow us to make the most accurate predictions of future costs as both the costs for various ages differ and the growth rates of various age groups differ. I also argue that the friction cost method results in underestimates of indirect costs specifically when considering those associated with obesity.

⁴⁴ Evans, Robert G., “Fat Zombies, Pleistocene Tastes, Autophilia and the ‘Obesity Epidemic,’” *Healthcare Policy* 2, no. 2 (2006): 18-26.

The disaggregated data demonstrated that per-capita costs are higher for obese individuals than overweight individuals, despite the prevalence of overweight being higher than the prevalence of obesity. Additionally per-capita costs increase with age despite the prevalence of obesity declining with age.

I discuss the possibility that economic costs of obesity will change as the population distribution changes in terms of ages and ethnicities. When considering the many demographics of Canada, I found that due to their higher projected rates of growth we should be concerned about rising costs of obesity in the elderly, and Aboriginals. Obesity affects Aboriginals widely without favouring the educated or wealthy as observed in non-Aboriginal people.

There is no cause for concern of rising costs of obesity in one gender over the other. It is unclear if a rising proportion of immigrants in Canada will lead to lower healthcare costs related to obesity but this will be an area of interest in the near future. Without a harmonized prediction of these various populations' growth it would be unwise to attempt to make a unified prediction of how costs will change in the near future. A unified analysis of the expected changes in the Canadian population alongside information on obesity costs calculated for each of these demographic groups is the next step to generate an accurate prediction of forthcoming costs. This information will provide the necessary basis to perform a cost-benefit analysis for potential obesity prevention interventions.

These findings should be considered complementary to the existing literature on the economic cost of obesity in Canada. While replicating the methodology of many current publications, I add valuable information on per-capita costs of obesity in various populations. In addition to supplementing this vast topic, this new information raises

questions about how and to whom public health interventions should be initiated to maintain efficiency.

References

- Adelson, Naomi, "The Embodiment of Inequity: Health Disparities in Aboriginal Canada," *Canadian Journal of Public Health* 96 (2005): S45-S61,
http://www.jstor.org/stable/41994459?seq=1#page_scan_tab_contents.
- Brenner, D. "Cancer incidence due to excess body weight and leisure-time physical inactivity in Canada: Implications for prevention," *Preventative Medicine* 66 (2014): 131-139.
- Brown, J. C., Winters-Stone, K., Lee, A., and Schmitz, K. H. "Cancer, Physical Activity, and Exercise," *Comprehensive Physiology* 2, no. 4 (2012): 2775-2809.
<http://doi.org/10.1002/cphy.c120005>
- Canadian Institute for Health Information, Spending and Health Workforce. "National Health Expenditure Trends, 1975 to 2014," *Canadian Institute for Health Information* (2014).
https://www.cihi.ca/en/nhex_2014_report_en.pdf.
- Canadian Society for Exercise Physiology. "Canadian Physical Activity and Sedentary Behaviour Guidelines" (2012). http://www.csep.ca/CMFiles/Guidelines/CSEP_Guidelines_Handbook.pdf.
- Centers for Disease Control and Prevention; Center for Surveillance, Epidemiology, and Laboratory Services; Division of Education and Professional Development. "Principles of Epidemiology," *Centers for Disease Control and Prevention*, (2012).
<http://www.cdc.gov/opphss/csels/dsepd/ss1978/lesson1/section11.html>
- Colman, R. "Cost of Obesity in Manitoba," *GPI Atlantic* (2000).
- Dallman, Mary F. "Stress-induced obesity and the emotional nervous system," *Trends in Endocrinology & Metabolism* 21, no. 3 (2010): 159-165.
- De Maio, F. "Immigration as pathogenic: a systematic review of the health of immigrants to Canada," *International Journal for Equity in Health* 9, no. 27 (2010).
- Evans, Robert G., "Fat Zombies, Pleistocene Tastes, Autophilia and the 'Obesity Epidemic,'" *Healthcare Policy* 2, no. 2 (2006): 18-26.
- Guh, D.P. et al, "The incidence of co-morbidities related to obesity and over-weight: a systematic review and meta-analysis," *BMC Public Health* (2009).
- Hajizadeh, M., M.K. Campbell, and S. Sarma, "Socioeconomic inequalities in adult obesity risk in Canada: trends and decomposition analyses," *The European Journal of Health Economics* 15, no. 2 (2014): 203-221.
- Jönsson, B. "Revealing the cost of Type II diabetes in Europe," *Diabetologia* 45, no. 7 (2002)
Doi:10.1007/s00125-002-0858-x
- Katzmarzyk, P. T. "Obesity and physical activity among Aboriginal Canadians," *Obesity* 16, no. 1 (2008): 184-190.
- Katzmarzyk, P. T., and C. I. Ardern, "Overweight and obesity mortality trends in Canada, 1985-2000," *Canadian Journal of Public Health/Revue Canadienne de Sante'e Publique* 95, no. 1 (2004): 16-20.

- Krueger, Hans, D. Williams, A.E. Ready, L. Trenaman, and D. Turner, "Improved estimation of the health and economic burden of chronic disease risk factors in Manitoba," *Chronic Diseases and Injuries in Canada* 33, no. 4 (2013).
- Krueger, Hans; Joshua Krueger, and Jacqueline Koot, "Variation across Canada in the economic burden attributable to excess weight, tobacco smoking and physical inactivity," *Canadian Journal of Public Health* 106, no. 4 (2015).
- Martel, L. "Recent changes in demographic trends in Canada," *Insights on Canadian Society, Statistics Canada*. (2015) <http://www.statcan.gc.ca/pub/75-006-x/2015001/article/14240-eng.pdf>
- Mirolla, M. "The Cost of Chronic Disease in Canada," *GPI Atlantic*. (2004) <http://www.gpiatlantic.org/pdf/health/chroniccanada.pdf>
- Ng, C., P.N. Corey, and T. Kue Young, "Socio-economic Patterns of Obesity Among Aboriginal and Non-Aboriginal Canadians," *Canadian Journal of Public Health/Revue Canadienne de Santé Publique* 102, no. 4 (2011): 264-268.
- Public Health Agency of Canada, Canadian Institute for Health Information, "Obesity in Canada: A Joint Report from the Public Health Agency of Canada and the Canadian Institute for Health Information," *Canadian Institute for Health Information* (2011).
- Policy Research Division, Strategic Policy Directorate, Population and Public Health Branch, Health Canada. "Economic burden of illness in Canada (EBIC), 2005-2008," *Health Canada* (2014) <http://www.phac-aspc.gc.ca/publicat/ebic-femc/2005-2008/assets/pdf/ebic-femc-2005-2008-eng.pdf>.
- Sharpe, A., and J. Arsenault, "Investing in Aboriginal Education in Canada: An Economic Perspective," *Centre for the Study of Living Standards Research Report 2010-03* (2010).
- Shih, M., J.M. Hootman, J. Kruger, and C.G. Helmick, "Physical Activity in Men and Women with Arthritis: National Health Interview Survey, 2002," *American Journal of Preventative Medicine*, 30, no. 5 (2006): 385-393. doi:10.1016/j.amepre.2005.12.005
- Sigal, Ronald J., G. Kenny, D.H. Wasserman, C. Castaneda-Sceppa, and R.D. White, "Physical Activity/Exercise and Type 2 Diabetes," *Diabetes Care* 29 no. 6 (2006): 1433-1438. doi:10.2337/dc06-9910
- Singh, G. K., and M. Siahpush, "Ethnic-Immigrant Differentials in Health Behaviors, Morbidity, and Cause-Specific Mortality in the United States: An Analysis of Two National Data Bases," *Human Biology*, 74 no. 1 (2002): 83-109.
- Speccia, M., et al. (2014) "Economic impact of adult obesity on health systems: a systematic review," *European Journal of Public Health* 25 no. 2 (2014): 255-262.
- Statistics Canada, Demography Division, "Annual Demographic Estimates: Canada, Provinces, and Territories, 2009-2036," *Statistics Canada*. (2010), <http://www.statcan.gc.ca/pub/91-215-x/91-215-x2015000-eng.pdf>.
- Statistics Canada, "Labour force characteristics by age and sex," *Statistics Canada*. (2016), <http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/labor20a-eng.htm>.
- . "Projected population by age group and sex according to three projection scenarios," *Statistics Canada*, (2014), <http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/demo23g-eng.htm>.
- . Table 117-0020 - "Average time spent sedentary, household population by sex and age group, occasional (minutes per day)," *CANSIM* (database).

- . Table 117-0021 - "Average time spent being physically active, household population by sex and age group, occasional (minutes per day)," *CANSIM* (database).
- . Table 105-0501 - "Health indicator profile, annual estimates, by age group and sex, Canada, provinces, territories, health regions (2013 boundaries) and peer groups, occasional," *CANSIM* (database).
- Torrance, G. M., M.D. Hooper and B.A. Reeder, "Trends in overweight and obesity among adults in Canada (1970-1992): evidence from national surveys using measured height and weight," *International journal of obesity and related metabolic disorders: journal of the International Association for the Study of Obesity*, 26 no. 6 (2002): 797-804.
- Tremblay, M., P. Katzmarzyk and J. Willms, "Temporal trends in overweight and obesity in Canada 1981-1996," *International Journal of Obesity*, 26 no. 4 (2002): 538-543.
- Withrow, D. and D.A. Alter, "The economic burden of obesity worldwide: a systematic review of the direct costs of obesity," *Obesity Reviews*, 12 (2009): 131-141.
- Yang, Z. and A. Hall, "The Financial Burden of Overweight and Obesity among Elderly Americans: The Dynamics of Weight, Longevity, and Health Care Cost," *Health Services Research* 43, no. 3 (2008): 849-868.