An economic costing of obesity in First Nations communities in Canada

Angella MacEwan
with Barbara Clow and
M. J. Haworth-Brockman

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Abstract

This study investigates the costs of overweight and obesity for specific groups of First Nations peoples in Canada, using data from the First Nations Regional Longitudinal Health Survey (RHS). The researcher was able to calculate Population Attributable Fraction (PAF) and Relative Risk (RR) for six chronic illnesses that are deemed to be linked to obesity: Type 2 diabetes, hypertension, coronary artery disease, congestive heart failure, asthma, and chronic back pain. These calculations were then compared with a meta-analysis of the Canadian population, conducted by Anis et al. (2010) and only the PAF and RR for chronic back pain are significantly different for First Nations.

The researcher attributed costs based on the PAFs as calculated where possible, and used those calculated by Anis et al. (2010) where the RHS sample size did not permit calculation of a significant PAF for the First Nations population. Costs for each chronic illness identified were based on the Economic Burden of Illness in Canada (EBIC), a standard measure developed and utilized by the Public Health Agency of Canada, and the National Health Expenditure Database published by the Canadian Institute for Health Information. The analysis demonstrated that the direct costs of obesity due to chronic illness among First Nations surveyed in the RHS to be at least $100 million for 2003, the year the first RHS was conducted. This baseline information can be used by First Nations to track and evaluate prevention and intervention strategies to promote the health of their communities.

Introduction

In recent years, researchers, practitioners, policy makers, and a host of non-governmental organizations have raised an alarm about rising rates of overweight and obesity and the potential impact of these trends on health, both nationally and internationally (Gard and Wright, 2005). In 2010, for example, the World Health Organization estimated that there were more than 1 billion overweight adults and over 300 million obese adults worldwide (World Health Organization, 2010). Similarly, the Public Health Agency of Canada reported that aapproximately one in four Canadian adults was obese, according to measured height and weight data from 2007-2009 (Public Health Agency of Canada, 2010).

At the root of these deep concerns about healthy weight is the association between obesity and specific chronic illnesses, including Type 2 diabetes and cardiovascular diseases. Some populations appear to be at greater risk of overweight and obesity as well as associated chronic diseases. Chronic illnesses take a heavy toll – on individuals, families, communities. The physical and emotional impact of chronic illnesses has been well-documented (Wee, 2005) and increasing attention is being paid to the economic burden of disease. Those living with chronic illnesses are likely to lose work time and wages when they are sick or when they are consulting health-care providers. They may also incur out-of-pocket expenses for specific foods, medical supplies and equipment, medications, and transportation. Chronic illnesses consequently pose significant economic challenges for individuals and families. Health-care systems are also increasingly strained by rising rates of chronic diseases. For example, Birmingham *et al.* (1999) estimated that in 1997 the direct cost of obesity was 2.4% of Canadian health-care spending on all diseases. Katzmarzyk and Janssen (2004) estimated that the direct cost of obesity in 2001 was $1.6 billion, 2.6% of the total health-care costs in Canada (Katzmarzyk and Janssen, 2004).

While we have national and some provincial studies of the economic costs of obesity, limited attention has been paid to sub-populations, in Canada or elsewhere. Yet research demonstrates that rates of obesity and related chronic conditions differ by region, age, sex, racial and ethnic identity, and other variables, with the result that the costs of obesity – for individuals, communities and health care systems – can also fluctuate. For example, the costs of treating chronic conditions are greater for individuals living in rural and remote communities because

they have to bear the expense of travelling to care facilities and specialists that are typically found only in large urban centres. In Canada, prevalence of overweight and obesity are highest in First Nations, Inuit, and Métis communities. According to the Canadian Community Health Survey, in 2007, the obesity rate for off-reserve Aboriginal adults was 24.8% as compared to 16.6% for non-Aboriginal adults (Public Health Agency of Canada, 2008). Data from the 2002/03 First Nations Regional Longitudinal Health Survey (RHS) likewise demonstrate that the prevalence of obesity is also high among on-reserve First Nations people: 31.8% of adult men, 41.1% of adult women, 14.0% of youth and 36.2% of children (First Nations Regional Longitudinal Health Survey, 2007). Not surprisingly, there are also higher rates of diabetes and heart disease among Aboriginal people in Canada. According to Health Canada, for example, rates of diabetes have skyrocketed in Aboriginal communities: "From a disease that was virtually unknown among First Nations, Inuit and Métis people fifty years ago, the prevalence of diabetes among First Nations is now at least three times the national average, with high rates occurring in all age groups" (Health Canada, 2001). Higher rates of obesity-related health conditions translate into higher health care costs. For example, by 2025 the costs of Type 2 diabetes in Manitoba are projected to increase by 130 percent province as a whole, but by 330 percent for registered Indians (Jacobs, et al., 2000; Lavoie and Forget, 2006).

Economic costing analysis can be a powerful tool for influencing public policy priorities and making the case for more preventative health spending and more targeted preventative health programs. For example, Colman and his colleagues at GPI Atlantic undertook a series of economic costing projects related to chronic disease, smoking, food security, and obesity in several provinces (GPI Atlantic). In the case of Nova Scotia, they found that the estimated direct costs were at least $120 million, or 6.8% of the province's 1999-2000 health care budget, well above estimates of national health-care spending (Colman, 2000). Moreover, by comparison only 2% of the provincial health care budget was devoted to health promotion and illness prevention. These findings prompted the Nova Scotia government to invest more in health promotion efforts, including the creation of a new Department of Health Promotion and Protection (*Chronicle Herald*, 2009). Although most economic costing research has not led to these kinds of pivotal shifts in policy and programming, it can establish as a baseline against which to measure changes in the economic impact of particular conditions as well as the value and efficacy of interventions.

The Atlantic Centre of Excellence for Women's Health and Prairie Women's Health Centre of Excellence embarked on this project for several reasons. First, while rates of overweight and obesity – and related chronic illnesses – are higher in Aboriginal than in non-Aboriginal populations in Canada, an economic costing has not been undertaken with these populations. This project consequently aimed to address a significant gap in the literature. Second, because rates of obesity and chronic diseases are so much greater in Aboriginal communities, it is imperative to assess investments in prevention and other interventions over time. The findings from this research can be used by First Nations communities as well as researchers and policy makers to identify effective interventions and to promote the health of Aboriginal populations. Third, a significant proportion of the work on economic health costing, including on obesity, does not address differences between and among women and men (Birmingham, et al., 1999; Colman, 2000, Mirolla, 2004, Anis, et al., 2010). A recent report by Colman and Hayward (2009), on the economic costs of obesity in Alberta is one of the few studies that explore such differences (Colman and Hayward, 2009). They found that in 2005 the costs attributable to overweight and obesity were higher for males than for females over the age of 15 years, largely because of "the high obesity-attributable cost of coronary heart disease in males relative to females ($242.8 million in males compared to $63.9 million in females, $2005)" (Colman and Kayward, 2009). These findings are significant in that they suggest the need for interventions aimed at adult males, at least in the province of Alberta. In the same way, our research contributes to the literature by providing evidence about the costs of obesity among First Nations women and among men in Canada.

Overview

This report is divided into six sections. In the first part, we describe the data sources used for this study. The second section describes Body Mass Index, the most common measure of overweight, as well as its limitations. The third section provides an account of the prevalence of obesity in Canada and internationally, paying attention to the impact of sex and race/ethnicity. The fourth part briefly discusses the association between weight and chronic health conditions. The fifth section describes the methodology and estimates the costs associated with managing obesity-related chronic conditions. Wherever possible we consider how prevalence rates and economic

costs vary by sex. The report concludes with a summary of findings and recommendations for further work.

Data Sources

There are few comprehensive data sets of health indicators for First Nations, Inuit and Métis populations (Health Council of Canada, 2005). Two national surveys provide the largest body of health statistics for Aboriginal peoples in Canada: the First Nations Regional Longitudinal Health Survey (RHS) and the Canadian Community Health Survey (CCHS). The RHS originated in response to the absence of First Nations reserve and Inuit populations in Statistics Canada longitudinal health surveys (First Nations Centre, 2006). It is coordinated and governed by the First Nations Information Governance Centre and national and regional First Nations organizations according to the principles of OCAP – Ownership, Control, Access, and Possession. The RHS is a longitudinal survey, with three data collections to date – 1997, 2002/3 and 2007/8 – conducted with First Nations children and adults living in First Nations communities. According to the FNIGC 22,602 surveys were collected for the 2002/03 RHS, "from 238 First Nations communities in 10 regions. This is the largest number First Nations individuals and First Nations communities whom have ever participated in a national level health survey. As a result, RHS Phase 1 (2002/03) was able to produce national level statistics on all of its measures" (FNIGC 2010).

The CCHS is a cross-sectional national survey conducted by Statistics Canada, which collects information about health status, health care use and health determinants for the Canadian population each year (prior to 2007 every two years) with a wide-scale sample of Canadians 12 years of age and older, excluding First Nations Reserves, many communities in the territories, and a few other sub-populations. Most components of the CCHS are collected via telephone, and thus exclude potential respondents who do not have household telephones. The CCHS operates on a two-year collection cycle. The first year of the survey cycle ".1" is a large sample, general population health survey designed to provide reliable estimates at the health region level. The second year of the survey cycle ".2" has a smaller sample and is designed to provide provincial level results on specific focused health topics. The comprehensive survey allows for analysis of health data at a regional level, across Canada.

A third data source addressing the health and well-being of Aboriginal populations is the Aboriginal Peoples Survey (APS), also conducted by Statistics Canada. It is collected on a five-year cycle and captures data on the social and economic conditions of off-reserve First Nations , Inuit, and Métis peoples ages six and older in Canada.

Our research uses data from the RHS – the only national health survey conducted on reserves and in First Nations communities. The data used in this study were from the 2002/2003 survey of youth and adults, 15 years and older.

Defining and Measuring Obesity

Overweight and obesity are overwhelmingly defined by body mass index (BMI) a ratio of weight to height. The value is determined by dividing a person's weight in kilograms by their height in metres squared: i.e. weight (kg)/height^2 (m). According to the World Health Organization, overweight begins at a BMI greater than 25, obesity begins at a BMI greater than 30 (World Health Organization, 2010). Obesity is further divided into three classes, "according to the increased health risks associated with increasing BMI levels: class I /BMI >30; class II BMI >35; class III BMI > 40" (Katzmarzyk and Mason, 2006).

Research demonstrates that BMI is far from an ideal measure of health or fitness, especially across ethnic groups. BMI was developed and tested primarily among people of European descent, with the result that it is often inaccurate for people of non-European descent (Duncan, Schofield, Duncan, Kolt & Rush, 2004; Health Canada, 2003a; Razak et al., 2007). For example, Pacific Island women in New Zealand have a lower percentage of body fat (38.9 percent) at a BMI of 30 than do European women (42.5 percent) (Tyrrell et al., 2001). Duncan et al. (2004) consequently advocated the development of BMI scales that are specific for ethnic populations and countries in order to more accurately gauge overweight and obesity prevalence rates and related health risks. Other researchers have criticized the use of BMI as an isolated indicator of obesity (Potvin et al., 1999) and have asserted the need to incorporate other, more reliable predictors of health risk measures, such as waist circumference (Assembly of First Nations,

2007b; Duncan et al., 2004; Janssen, Katzmarzyk & Ross, 2004). The relationship between weight and health and/or fitness is more complex than analysis of BMI measures alone will allow. Despite the existence of more accurate models that account for multiple aspects of body composition, BMI continues to be the most prevalent method used in Canada and the developed world for defining obesity because it is considered the most cost-effective and practical method available (Duncan et al., 2004).

One factor affecting the consistency of data is that some surveys use participants' self-reports of weight and height to calculate BMI, while others undertake physical measurements of respondents. Self-reported measures of height and weight have been found to under-represent obesity as defined by BMI across populations, creating concerning bias and tend (Booth, Hunter, Gore, Bauman & Owen, 2000; Elgar & Stewart, 2008; Roberts, 1995; Strauss, 1999). This is a serious issue, as under-reporting appears to be more common among individuals with higher BMIs (Katzmarzyk & Ardern, 2004). Both the 2004 Canadian Community Health Survey (CCHS) and the 2002/2003 First Nations Longitudinal Health Research Survey (RHS) used direct measurements to calculate BMI, to improve the accuracy of the results. While the survey data used in this project were based on direct measures of BMI, we recognize that BMI may not be an ideal measure for overweight and obesity and that this may affect understanding of the risk of adverse health effects for First Nations populations.

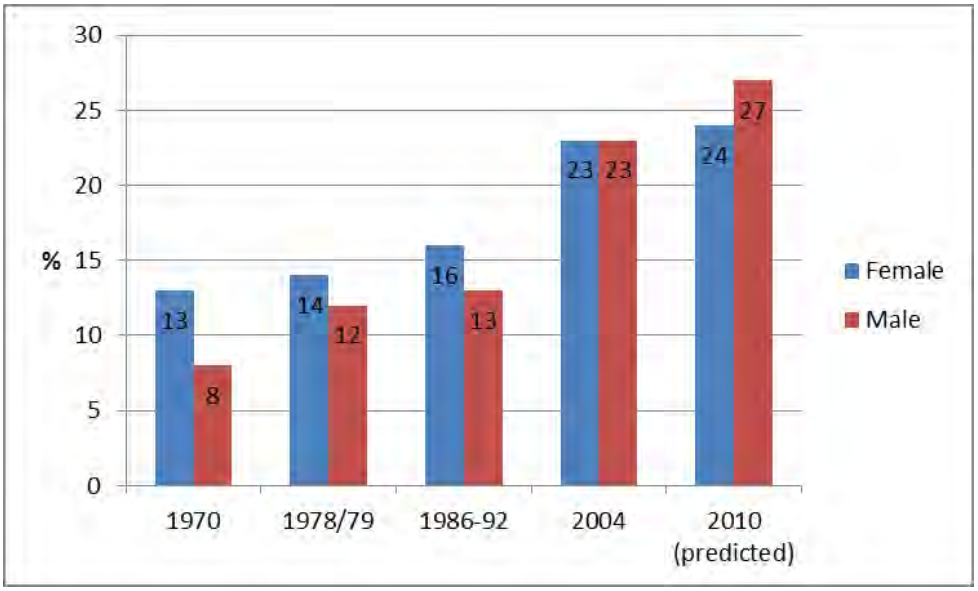
Trends in Overweight and Obesity

A study of obesity in OECD nations found little consistency in trends across member countries (Sassi et al., 2009). Some countries are seeing a rise in overweight, which the OECD calls "pre-obesity", while others report rising obesity but steady or lowering pre-obesity trends. The report notes that trends for men and women are also not consistent across countries. While the overall international and OECD trend has been that women have been more likely to be obese, and men more likely to be overweight, this is not the case for all countries. For example, Spain, Italy, and England all reported higher obesity rates for men in their most recent studies. Rates of overweight are rising faster for women than men in the U.S and England, but faster for men than women in Finland and Spain. Of particular note for this discussion, the OECD report concluded

that sex has "significant interactions with other individual characteristics, such as socio-economic condition or ethnicity" in the likelihood of individuals becoming overweight or obese (Sassi, et al., 2009). Women with lower incomes, less education, and from traditionally disadvantaged ethnic groups are more likely to be overweight or obese in most OECD countries. There does not appear to be a similar interaction between obesity and socio-economic factors for men.

Canadian data support these findings. In 2004, nearly 60% of Canadians were considered overweight or obese using BMI (Figure 1). Moreover, the rates of obesity appear to be increasing – from 10% of the population in 1970 to 23% in 2004. Obesity has risen among all adult age groups but continues to peak in middle age. Patterns of obesity have also shifted by sex. In the past, men were more likely than women to be overweight, but less likely to obese. By 2004, the rates of obesity among female and male adults were identical and Luo et al. (2007) predicted that by 2010, obesity rates for men would outstrip those for women. At the same time, as with data from OECD countries in general, the 2004 CCHS data shows an inverse relationship between socio-economic factors and obesity for women in Canada, but not for men.

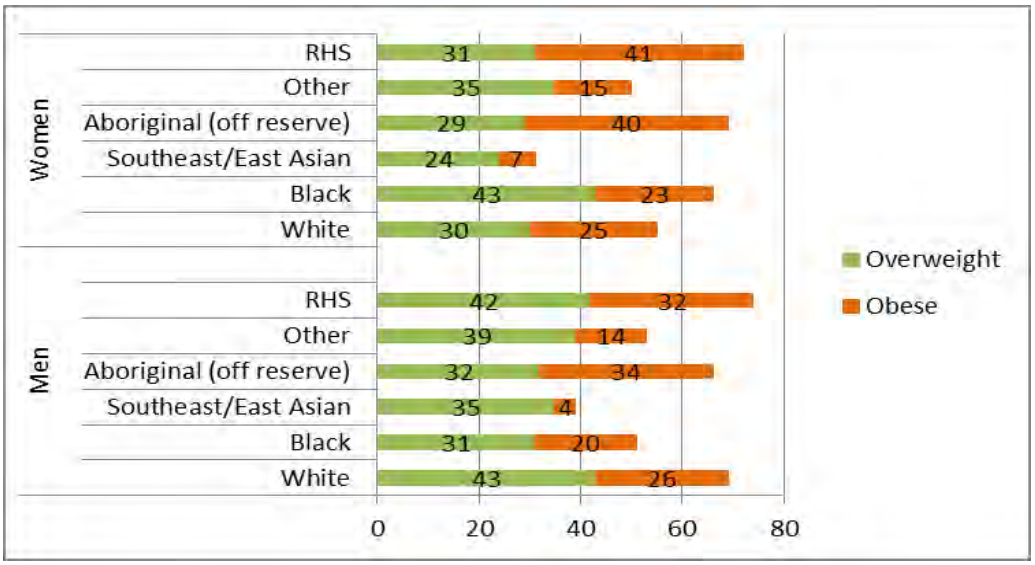
Figure 1. Trends in adult obesity rates by sex, Canada.



Source: Luo, W., H. Morrison, M. de Groh, C. Waters, M. DesMeules, E. Jones-McLean, A. Ugnat, S. Desjardins, M. Lim, and Y.Mao. (2007).The Burden of Adult Obesity in Canada, *Chronic Diseases in Canada,* 27(4): 135-144.

Variations in patterns of overweight and obesity are also evident by race and ethnicity. The 2004 Canadian Community Health Survey (CCHS) reported findings for 5 ethnic/racial groups, and the 2002/2003 First Nations Regional Health Survey (FNRHS) reported findings for First Nations communities across Canada. These data are combined for the purposes of comparison in Figure 2 below.

Figure 2. Overweight and obesity rates by selected ethnicity/race and sex, Canada, CCHS 2004 and RHS 2002/03.



Sources: M. Tjepkema, (2005). *Nutrition: Findings from the 2004 Canadian Community Health Survey - Adult Obesity in Canada*, Ottawa: Statistics Canada; Assembly of First Nations. (2007a). *First Nations Regional Longitudinal Health Survey (FNRHS) 2002/2003 - Report on Selected Indicators by Gender.* Ottawa: Assembly of First Nations and First Nations Information Governance Committee.

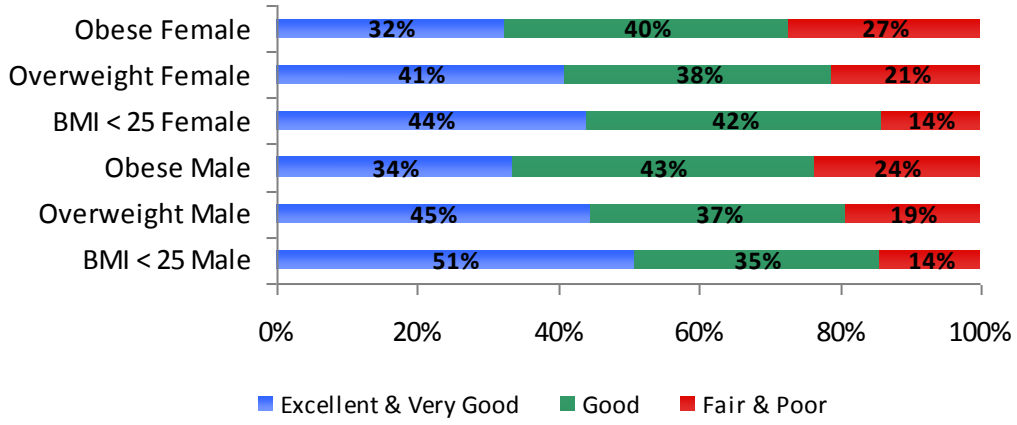
Overweight and obesity rates shown in Figure 2 illustrate that off-reserve Aboriginal and First Nations women (40% and 41%, respectively) have noticeably higher rates of obesity than women in other ethnic groups, at levels almost double the national average of 23.1%. Rates of overweight among off-reserve Aboriginal women (29%) and First Nations women (31%) are similar to those of white females (30%), but considerably less than rates found for Black women (43%) and greater than those for Southeast/East Asian women (24%). First Nations and off-reserve Aboriginal men have obesity rates that are almost 50% higher (32% and 34%, respectively) than the national average for adult males (22.9%). Levels of overweight are very similar for white males (43%) and First Nations men (42%), while off-reserve Aboriginal men

have a lower rate of overweight (32%). Rates of overweight for Black and Asian men were 31% and 35%, respectively. These numbers would indicate that obesity, in particular, is an acute issue for off-reserve Aboriginal and First Nations women and men.

Health and Weight

The data collected by the RHS show a clear association between health and obesity. As shown in Figure 3, while more than 30% of all women rated their health as "Excellent or Very Good", and 35% or more said their health was "Good", First Nations women were more likely to rate their own health as "Fair or Poor" if they were overweight (21%) or obese (27%), than First Nations women who had a BMI of 25 or under. Similarly, 27% of obese First Nations men rated their own health as "Fair or Poor", compared with 19% of First Nations men who were overweight and only 14% of First Nations men with a BMI under 25.

Figure 3. Self-rated health among First Nations respondents, by sex and BMI classification, 2002/2003.

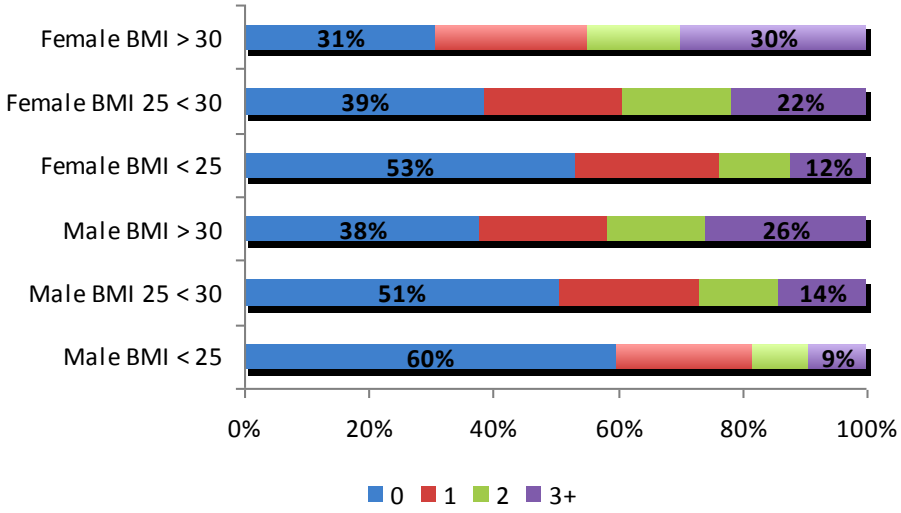


Source: Custom data tabulation from RHS 2002/2003.

This relationship continues when we examine the number of medical conditions reported by survey respondents. Figure 4 shows that among First Nations people, 30% of obese women report 3 or more medical conditions, compared to only 9% of women with a BMI between 18 and 25. Similarly 26% of obese males reported having 3 or more medical conditions, compared

with 14% of males in the overweight range (BMI 25-300) and only 9% of males with BMIs of 25 or less.

Figure 4. Number of medical conditions reported, by sex and BMI category, First Nations adults, 2002/3.



Source: Custom data tabulation from RHS 2002/2003.

Concerns raised by practitioners, researchers and policy makers about rising rates of overweight and obesity are based on the association between greater body weight and the prevalence and severity of many chronic illnesses, including Type 2 diabetes, cardiovascular diseases, musculo-skeletal conditions, respiratory conditions, and several kinds of cancer. Because rates of obesity are high among First Nations and Aboriginal people in Canada, it is reasonable to expect to find high rates of many chronic health conditions. Table 1 provides chronic disease rates among First Nations adults (females, males and total adults), from RHS data, compared with the rates found in the total adult populations surveyed in the CCHS.

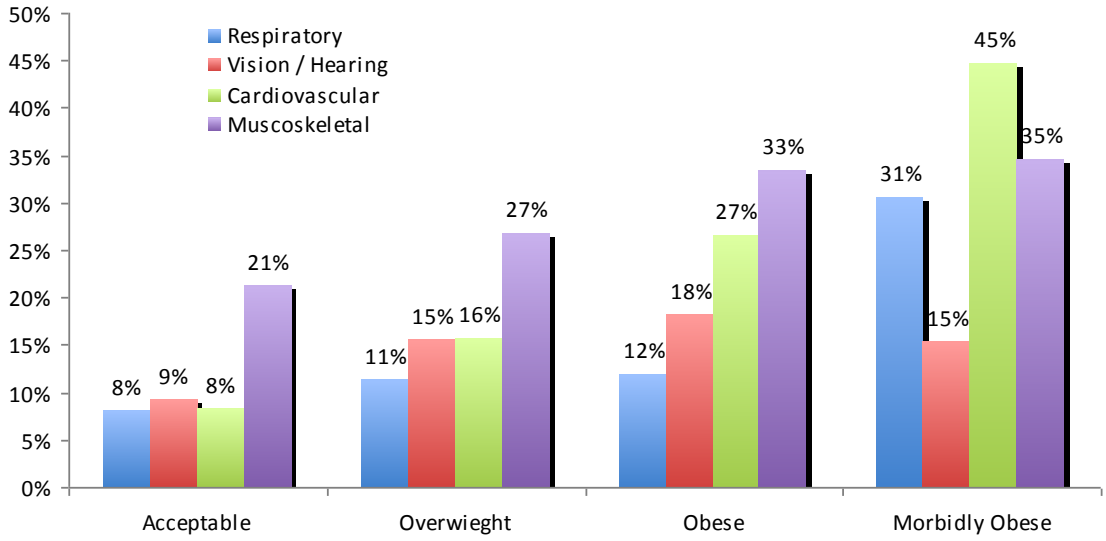
Table 1. Chronic health condition rates among First Nations adults by sex, 2002/2003, and age-adjusted rates of chronic health conditions for total adult populations, RHS 2002/2003, CCHS 2004.

	FNRHS				CCHS
	Men (Not age adjusted)	**Women** (Not age adjusted)	**Total Adults** (Not age adjusted)	**Total Adults** (Age-adjusted)	**Total Adults** (Age-adjusted)
Diabetes, any type	12.9%	16.0%	14.5%	19.7%	5.2%
Diabetes, any type (age 20-34)	*1.7%*	*6.5%*	*4.1%*	--	--
Diabetes, any type (age 35-54)	*17.2%*	*17.9%*	*17.5%*	--	--
Diabetes, any type (age 55+)	*33.7%*	*38.5%*	*36.2%*	--	--
Arthritis	15.1%	21.9%	18.4%	25.3%	19.1%
Rheumatism	2.3%	4.2%	3.2%	--*	-*
Chronic back pain	14.1%	14.1%	14.1%	16.7%	21.4%
Asthma	7.3%	12.2%	9.7%	10.6%	7.8%
Heart disease	4.9%	5.0%	4.9%	7.6%	5.6%
High blood pressure	12.9%	17.0%	14.9%	20.4%	16.4%
Cancer	--	--	--	2.4%	1.9%

Source: Assembly of First Nations. (2007a). *First Nations Regional Longitudinal Health Survey (FNRHS) 2002/2003 - Report on Selected Indicators by Gender*. Ottawa: Assembly of First Nations and First Nations Information Governance Committee. *Age-adjusted rheumatism is included in arthritis totals.

The higher rates of chronic diseases among First Nations adults seen in Table 1 are associated with overweight and obesity in the population. Figure 5 illustrates that the rates of four chronic conditions rise as BMI increases in the First Nations population.

Figure 5. Reported chronic conditions, by weight category, First Nations adults, RHS 2002/3.



Source: Assembly of First Nations. (2010). *RHS 2002/03 Adult Survey – Chapter 8: Physical Activity, Body Mass Index, and Nutrition, p.102.* Ottawa: Assembly of First Nations and First Nations Information Governance Committee.
Note: Acceptable Weight in the RHS is defined as a BMI of 18.5-25, which corresponds to "normal" weight in the Canadian Community Health Survey and most other health surveys.

Economic Costing Analysis

There are several possible approaches to economic costing. The three main ones are: prevalence-based financial accounting; incidence-based cost-of-illness approach; prevalence-based cost-of-illness approach. Each of these approaches has strengths and limitations. A prevalence-based financial accounting, such as Lavoie and Forget's (2008) "The Cost of Doing Nothing: Implications for the Manitoba Health Care System", can be particularly relevant to an economic analysis of First Nations health. This type of accounting would have been required if we wished to undertake a prevalence-based economic costing at the community level. This approach, combined with a discussion of the fragmentation of health care delivery for Aboriginal peoples in Canada, might be useful line of inquiry in the future.

Incidence-based cost-of-illness analysis estimates the lifetime cost of cases diagnosed in a given year. This type of analysis lends itself more readily to community level observations, as it

requires specific comparisons of inputs and outcomes. The approach can be combined with cost-effectiveness analysis (CEA), which compares the costs and outcomes of two or more courses of action. It is usually expressed as the cost per quality adjusted life year (QALY). Given gaps in data, however, it was not possible to adopt this type of analysis for this project, but may be a valuable for further study.

In this analysis, therefore, we used a prevalence-based cost-of-illness approach, which involves estimating the total cost of a disease for a given year, establishing rates of obesity, and determining what proportion of cases of each illness could be attributed to obesity. This type of analysis is useful for generalized larger scale evaluations, partly because a larger population is more likely to have individuals at all stages of the diseases under consideration.

The first step involved determining which illnesses were relevant to our analysis. Birmingham et al. used 10 chronic illnesses in a 1999 analysis, while Katzmarzyk and Janssen (2004) chose a more conservative approach and only used 7 chronic illnesses. Colman (2000) used more than 10 chronic illnesses considered to be appropriate in an analysis for the Nova Scotia population. (See Appendix A for a chart of conditions considered by previous Canadian studies).

Our selection of chronic illnesses was informed by those illnesses included in the FNRHS, and those used by previous studies, especially Anis, et al. (2010).

Once we determined which diseases to include, we needed to determine how obesity adds to the risk of suffering from each chronic condition. Medical studies frequently undertake analysis to attribute 'relative risk' (RR) factors to co-morbid conditions. Anis, et al. (2010) conducted a meta-analysis of medical literature to find the RR of 18 chronic illnesses that are co-morbid with obesity. The RR was then used along with the prevalence of obesity and individual chronic conditions to determine a PAF for each chronic condition. A PAF can be thought of as the excess fraction of chronic illness in the population under consideration (Hanley, 2001). This means it is the percentage of chronic illness (and the cost of treating it) that can be attributed to obesity. For example, say that 1/3 of the population is obese, but 50% of people with heart disease are obese. The excess fraction of obese people with heart disease can be attributed to obesity. Below is an

example calculation, using hypothetical numbers related to heart disease to illustrate the calculation of PAF (CF means fraction of cases):

The formula used was:

$$PAF_{total} = 1 - (CF_0 \times \frac{1}{RR_0} + CF_1 \times \frac{1}{RR_1} + CF_2 \times \frac{1}{RR_2})$$

where $RR_0 = 1$, and:

$$CF_0 = \frac{\#of\_normal\_weight\_heart\_disease\_cases}{Total\_\#of\_heart\_disease\_cases} = \frac{20}{100} = 0.2,$$

RR_1 = Relative risk of heart disease that can be attributed to overweight = 1.5,

$$CF_1 = \frac{\#of\_overweight\_heart\_disease\_cases}{Total\_\#of\_heart\_disease\_cases} = \frac{30}{100} = 0.3,$$

RR_2 = Relative risk of heart disease that can be attributed to obesity = 2,

$$CF_2 = \frac{\#of\_obese\_heart\_disease\_cases}{Total\_\#of\_heart\_disease\_cases} = \frac{50}{100} = 0.5.$$

Then,

$$PAF_{total} = 1 - (0.2 \times 1 + 0.3 \times \frac{1}{1.5} + 0.5 \times \frac{1}{2}) = 0.35 = 35\%$$

In our fictional example above, 35% of the cost of treating heart disease can be attributed to overweight and obesity.

We were able to calculate a significant PAF and RR from RHS data for 6 chronic illnesses: Type 2 diabetes, hypertension, heart disease (coronary artery disease & congestive heart failure combined), asthma, and chronic back pain. For cancer, pulmonary embolism, stroke, and gallbladder disease we use the PAF and RR as calculated by Anis et al (2010), because the data available from the RHS was insufficient to calculate a First Nation specific PAF and RR (Table 2). We therefore are making an assumption that for these illnesses, First Nations persons have

identical PAF and RR as the general population. This is a reasonable and conservative assumption based on the comparison of RR and PAF.

Table 2. Chronic illnesses used in prevalence-based cost-of-illness economic costing analyses, and the approach adopted.

Chronic Illness	Comment
Type 2 Diabetes	
Cancer	PAF from Anis et al. used for 7 types of cancer.
Hypertension	The RHS collected data on 'High Blood Pressure", which is used as a proxy for hypertension in this text.
Heart Disease	The RHS did not differentiate between Coronary Artery Disease (CAD) and Congestive Heart Failure (CHF). Therefore we calculated a PAF for Heart Disease, and applied this to the costs for both CAD and CHF. Based on comparisons to Anis et al. (2010) this may result in an underestimation of costs for CHF.
Gallbladder Disease	PAF from Anis et al. used for gallbladder disease,.
Chronic Back Pain	
Osteoarthritis	The RHS collected data on arthritis, rheumatism, and osteoporosis, none of which are easily matched up to available cost data, and so osteoarthritis was excluded from our analysis.
Asthma	
Pulmonary Embolism	PAF from Anis et al. used for pulmonary embolism,.
Stroke	PAF from Anis et al. used for stroke,.

Table 3 shows the relative risk ratios calculated by Anis, et al. (2010), and the comparable relative risk ratios calculated from the 2002/2003 FNRHS. Our RR calculated from the FNRHS data are significantly different from Anis et al. for hypertension and for Type 2 diabetes for males, and chronic back pain at $p < .05$ (using a simple t-test). The FNRHS RRs are not significantly different from Anis et al.'s findings for heart disease, asthma, and Type 2 diabetes among women.

Table 3. Comparison of Relative Risk (RR) calculations from Anis, et al. (2010, Supplement) and our calculations of RR from RHS 2002/2003.

		Overweight		Obese	
		Males RR (CL)	Females RR (CL)	Males RR (CL)	Females RR (CL)
Hypertension	Anis et al.	1.28 (1.10–1.50)	1.38 (1.27–1.51)	1.84 (1.51–2.24)	1.90 (1.77–2.03)
	FNRHS	**2.13** (1.637, 2.766)	**2.44** (1.965, 3.025)	**5.38** (4.212, 6.879)	3.74 (3.061, 4.569)
Type 2 Diabetes	Anis et al.	2.27 (1.67–3.10)	3.40 (2.42–4.78)	5.13 (3.81–6.90)	11.10 (8.23–14.96)
	FNRHS	**4.42** (3.204, 6.089)	**3.81** (2.923, 4.956)	**10.67** (7.819, 14.553)	**7.25** (5.654, 9.297)
Asthma	Anis et al.	1.20 (1.08–1.33)	1.25 (1.05–1.49)	1.43 (1.14–1.79)	1.78 (1.36–2.32)
	FNRHS	**1.62** (1.229, 2.135)	**1.35** (1.081, 1.696)	**1.86** (1.405, 2.463)	**1.85** (1.513, 2.272)
Chronic Back Pain	Anis et al.	1.59 (1.34–1.89)	1.59 (1.34–1.89)	2.81 (2.27–3.48)	2.81 (2.27–3.48)
	FNRHS	ns	ns	**1.30** (1.066, 1.573)	**1.33** (1.114, 1.594)
CAD	Anis et al.	1.41 (1.16–1.72)	1.82 (1.41–2.36)	1.81 (1.45–2.25)	2.69 (2.05–3.53)
CHF	Anis et al.	1.31 (0.96–1.79)	1.27 (0.68–2.37)	1.79 (1.24–2.59)	1.78 (1.07–2.95)
FNRHS (Heart Disease)	FNRHS	ns	**1.48** (1.02, 2.159)	**2.38** (1.644, 3.452)	**2.13** (1.516, 2.989)

Table 4. Comparison of Population Attributable Fraction (PAF) calculations from Anis, et al. (2010) and our calculations of PAF from RHS 2002/2003.

		Overweight PAF		Obese PAF	
		Male	Female	Male	Female
Hypertension	Anis et al.	6.79%	8.11%	33.07%	30.31%
	FNRHS	16.5%	17.4%	48.6%	43.8%
Type 2 Diabetes	Anis et al.	22.73%	18.36%	52.71%	57.54%
	FNRHS	26.0%	19.7%	55.9%	57.8%
Asthma	Anis et al.	7.36%	5.76%	17.03%	29.67%

	FNRHS	16.9%	7.5%	17.8%	24.0%
Chronic Back Pain	Anis et al.	10.15%	7.71%	20.45%	25.84%
	FNRHS	n.s.	n.s.	8.3%	11.5%
Coronary Artery Disease	Anis et al.	8.80%	12.10%	17.50%	17.50%
Congestive Heart Failure		10.50%	6.80%	14.80%	16.00%
Heart Disease	FNRHS	8.8%	9.3%	28.6%	28.7%

Table 5. Relative Risk (RR) calculations from Anis et al. (2010, Supplement, Table 5) for illnesses for which we were not able to obtain FNRHS data.

	Overweight		Obese	
	Male	Female	Male	Female
Cancer				
Breast, Postmenopausal	N/A	1.08 (1.03–1.14)	N/A	1.13 (1.05–1.22)
Colorectal	1.51 (1.37–1.67)	1.45 (1.30–1.62)	1.95 (1.59–2.39)	1.66 (1.52–1.81)
Endometrial	N/A	1.53 (1.45–1.61)	N/A	3.22 (2.91–3.56)
Esophageal	1.13 (1.02–1.26)	1.15 (0.97–1.36)	1.21 (0.97–1.52)	1.20 (0.95–1.53)
Kidney	1.40 (1.31–1.49)	1.82 (1.68–1.98)	1.82 (1.61–2.05)	2.64 (2.39–2.90)
Ovarian	N/A	1.18 (1.12–1.23)	N/A	1.28 (1.20–1.36)
Pancreatic	1.28 (0.94–1.75)	1.24 (0.98–1.56)	2.29 (1.65–3.19)	1.60 (1.17–2.20)
Cardiovascular Diseases				
Pulmonary Embolism	1.91 (1.39–2.64)	1.91 (1.39–2.64)	3.51 (2.61–4.73)	3.51 (2.61–4.73)
Stroke	1.23 (1.13–1.34)[†]	1.15 (1.002–1.32)[†]	1.51 (1.33–1.72)[†]	1.49 (1.27–1.74)[†]
Other				
Gallbladder Disease	1.61 (1.40–1.85)[†]	1.44 (1.05–1.98)[‡]	2.38 (2.06–2.75)[†]	2.32 (1.17–4.57)[‡]

[†]According to Anis et al: "If indicated, the relative risks calculated from the rations of proportions (RR_Ps) were used; otherwise, the incidence rate ratios (IRRs) were used."

[‡]According to Anis et al: "Both RR-Ps and IRRs were used."

"Cancer: cases, not mortality and indicated by physician diagnosis of cancer."

Table 6. PAF Calculations from Anis et al. (2010, Supplement Table 5) for illnesses that we were not able to obtain from FNRHS data.

	Overweight		Obese	
	Male	Female	Male	Female
Cancer				
Breast, Postmenopausal	N/A	2.8 (1.0–4.5)	N/A	3.5 (1.5–5.5)
Colorectal	15.5 (12.6–18.4)	10.8 (7.7–13.9)	16.2 (11.2–21.2)	12.5 (10.6–14.5)
Endometrial	N/A	9.8 (8.1–11.4)	N/A	33.4 (29.9–36.9)
Esophageal	5.4 (0.9–9.9)	4.7 (-1.2–10.5)	5.2 (-1.1–11.5)	5.2 (-1.8–12.2)
Kidney	12.4 (9.9–14.9)	15.2 (12.8–17.6)	13.9 (10.6–17.1)	23.4 (20.5–26.3)
Ovarian	N/A	5.0 (3.6–6.4)	N/A	6.2 (4.5–7.8)
Pancreatic	8.8 (-2.2–19.8)	6.3 (-0.4–13.0)	22.3 (12.8–31.9)	12.8 (3.9–21.8)
Cardiovascular Diseases				
Pulmonary Embolism	19.9 (8.9–31.0)	14.9 (6.1–23.7)	30.8 (21.0–40.7)	32.6 (22.9–42.3)
Stroke	8.4 (4.8–12.0)	4.3 (-0.1–8.7)	11.3 (7.4–15.2)	11.8 (6.8–16.9)
Other				
Gallbladder Disease	9.6 (6.4–12.8)	9.2 (2.6–15.9)	19.6 (15.6–23.6)	21.3 (3.1–39.5)

The direct costs in an economic costing analysis refer to the health care resources expended such as hospital care, radiological or laboratory tests, ambulatory services, physician services, services by other health professionals, medications, and nursing home care (Birmingham *et al.*, 1999; Colditz, 1992; Starky, 2005). Anis, Birmingham, and Katzmarzyk use "The Economic Burden of Illness in Canada" (EBIC) to determine costs. The EBIC, published by Health Canada, and recently taken up by the Public Health Agency of Canada, is an accounting of direct and some indirect costs broken down by illnesses. The most recent EBIC data available from Health Canada is for the year 2000.[1]

[1] EBIC 2000 data were provided by the Public Health Agency of Canada.

The EBIC is useful because it calculates the portion of total direct costs that are attributable to various illnesses, broken down into six categories. So, to calculate direct costs for 2003, we used the portion of direct costs that were attributable to each chronic illness from the EBIC 2000, and the 2003 cost estimates for each category from the National Health Expenditure Database. The portion of this cost that is attributable to First Nations persons is calculated based on the relative prevalence of each chronic disease. Since we do not have costs of treatment available by sex, we cannot provide a cost breakdown by sex.

Table 7. Total direct costs of obesity for First Nations people living on reserves in Canada in 2003, in thousands of dollars.

	Cost due to overweight	Cost due to obesity	Total cost attributable to overweight and obesity
Type 2 Diabetes	$10,641.48	$26,795.70	$37,437.19
Cancer*			
Breast, Postmenopausal	$124.43	$156.17	$280.60
Colorectal	$1,662.61	$1,811.19	$3,473.80
Endometrial	$123.66	$421.98	$545.64
Esophageal	n/a	$42.26	$42.26
Kidney	$268.39	$352.74	$621.13
Ovarian	$76.95	$94.90	$171.85
Pancreatic	n/a	$421.89	$421.89
Total Cancer	$2,256.03	$3,301.12	$5,557.16
Cardiovascular Diseases			
Hypertension	$5,828.49	$10,804.00	$16,632.49
Coronary Artery Disease	$4,501.55	$14,216.86	$18,718.41
Congestive Heart Failure	$1,575.15	$4,974.66	$6,549.81
Pulmonary Embolism*	$490.73	$894.63	$1,385.36
Stroke*	$1,657.09	$3,106.66	$4,763.75
Other			
Asthma	$2,128.92	$3,773.78	$5,902.70
Gallbladder Disease*	$622.91	$1,378.72	$2,001.63

Chronic Back Pain	n/a	$1,020.42	$1,020.42
Total	$29,702.36	$70,266.56	$99,968.91

*Indicates insufficient FHRHS data. Costs were calculated based on Anis, et al., 2010 using the PAFs shown in Table 5.

This analysis indicates that direct cost of obesity-related chronic illness among First Nations surveyed in the RHS is at least $100 million for 2003, the year the first RHS was conducted.

Conclusion

Our analysis demonstrates that, as with non-Aboriginal populations, chronic illnesses related to obesity are costly to all involved. Our goal in undertaking this analysis was to measure some of the direct costs of obesity-related chronic conditions in order to establish a baseline for First Nations communities and support health promotion and illness prevention efforts. As Colman and Hayward have observed, "Economic costing studies can provide a crucial first step for future economic evaluations of the cost-effectiveness of interventions designed to reduce obesity levels in society" (Colman and Hayward, 2010).

This study is the first to consider the economic costs of obesity-related chronic diseases in First Nations communities, which means there is more work to be done. Our analysis considered only the direct costs of chronic diseases associated with obesity and it would be valuable to assess indirect costs, which Colman argues are likely higher (Colman, 2000). In other words, these findings are a highly conservative estimate of the costs to First Nations communities of obesity and related chronic conditions. In the future, researchers should assess other measurable costs, such as lost economic output due to absenteeism, early retirement, or premature death (Colditz, 1992; Katzmarzyk and Janssen, 2004; Starky, 2005). It would be useful as well to undertake research on other indirect costs, such as transportation, medical supplies and devices, medications, child and elder care, etc., that are not always measured in national surveys. Transportation costs, in particular, may be especially high for First Nations communities located in remote regions. Further, it is important to bear in mind that many of the indirect costs of obesity-related chronic conditions, such as physical pain and emotional suffering, may not be

"measureable". Qualitative research in these areas would complement quantitative studies, providing a more accurate picture of the full range of indirect costs associated with obesity and related chronic illnesses.

More attention to sex and gender differences is also needed. Our efforts to assess the costs of obesity-related chronic diseases for First Nations women and men were hampered by data limitations as well as by fiscal and time constraints. Colman and Hayward's study from Alberta demonstrated the value of getting and using sex-disaggregated data as well as the importance of understanding the differential impact of obesity-related chronic conditions on women and men (Colman and Hayward, 2010).

Finally, further economic costing analyses should be undertaken with First Nations communities to assess – against the current baseline – the impact of health, economic, and social policies and programs aimed at reducing rates of obesity and preventing obesity-related chronic conditions. Information gathered through this process could support the development of more, and more effective interventions. As Colman and Hayward have concluded, "By focusing attention on the economic burden of obesity, and on the associations of obesity with chronic disease and other health conditions, costing studies such as this one can mobilize societal and governmental interest and resources towards setting priorities for obesity prevention" (Colman and Hayward, 2010).

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APPENDIX A - Comparison of chronic diseases used by previous Canadian economic costing analyses.

Co-morbidities	Anis et al (2010)	Katzmarzyk & Janssen (2004)	Colman (2000)	Birmingham *et al.* (1999)
Cancer:				
kidney	✓	X	X	X
colorectal	✓	✓	✓	✓
prostate	✓	X	X	X
ovarian	✓	X	X	X
uterine/endometrial	✓	X	✓	✓
oesophageal	✓	X	X	X
pancreatic	✓	X	X	X
post-menopausal breast	✓	✓	✓	✓
Heart Disease:				
hypertension	✓	✓	✓	✓
coronary artery disease [CAD]	✓	✓	✓	✓
congestive heart failure [CHF]	✓	X	X	X
pulmonary embolism	✓	X	✓	✓
stroke	✓	✓	✓	✓
dyslipidaemia/ hyperlipidaemia	X	X	✓	✓
Type 2 diabetes	✓	✓	✓	✓
gallbladder disease	✓	✓	✓	✓
chronic back pain	✓	X	*estimate*	X
osteoarthritis	✓	✓	*estimate*	X
asthma	✓	X	*estimate*	X