Making the Case for Primary Prevention:

An Economic Analysis of Risk Factors in Manitoba

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Strengthening connections for healthy sustainable communities

CancerCare MANITOBA

Alliance for the Prevention of Chronic Disease

Foreword

The Motivation

With more than half of Manitobans age 19 and over living with chronic health conditions, the burden of chronic disease impacts not only the health care system, as well as individuals and their families, but also the broader community. With health care costs – specifically illness – requiring an ever increasing portion of government budgets and subsequently tax payer dollars, the need for investment in addressing risk factors is clear. **This Economic Analysis is intended to support decision makers and those advocating for prevention, as they invest in the well-being of Manitobans.**

Keeping people healthier is the most effective way to reduce health care costs. This Economic Analysis looks at the potential savings in direct and indirect health care costs to Manitobans when three risk factors - smoking, physical inactivity and obesity - are addressed by implementing programs proven to be effective.

In Manitoba, 55% of the population is overweight or obese, 45% are inactive, and 27% are smokers. As a result of living conditions, some populations are more likely to experience these risk factors than others – this includes Manitoba's aging population, the growing Aboriginal population and an increasing number of new Canadians.

Given the many factors that impact health and well-being, the increasing burden of chronic disease will require a collaborative effort involving those who work to address economic, environmental, social and cultural well-being. Future investment must acknowledge that living conditions shape the well-being of Manitobans; living conditions, which for better or worse, are impacted by the quality of communities, housing situations, work settings, health and social service agencies, and educational institutions with which people interact.

The Challenge

The message from this economic analysis is clear – reducing the prevalence of risk factors for chronic disease will reduce health care costs and improve population health.

The challenge is to:

- **Shift the Paradigm to Prevention**
  Without a strong commitment and investment in addressing risk factors for chronic disease, the health care system will not be sustainable.

- **Broaden the Partnerships across Sectors and Settings**
  Given that many of the factors which determine well-being lie outside the control of the health care system, reducing rates of chronic disease requires the engagement of a broad range of stakeholders.

- **Conduct Research and Evaluation to Measure Effectiveness**
  Given the gap in knowledge regarding the effectiveness of activities and initiatives intended to address risk factors for chronic disease, there is a need to invest in better understanding the outcomes and related costs.

There is no time to lose.

-*The Steering Committee*
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Manitoba Economic Analysis for Primary Prevention

Executive Summary

The Heart and Stroke Foundation of Manitoba (HSFM), in partnership with the Alliance for the Prevention of Chronic Disease, CancerCare Manitoba, and Health in Common, have collaborated to develop an economic analysis of primary prevention of chronic disease in Manitoba. This project outlines the economic and health burden of preventable disease in Manitoba and provides stakeholders with important evidence for investing in primary prevention activities at the provincial, regional, and local levels.

Methods

This project was developed in consultation with many Manitoba experts. In preparing the analysis, a variety of primary data sources were accessed, including the *Canadian Community Health Survey (CCHS).* Manitoba-specific data sources were used to address several known limitations of the CCHS.

Prevalence and Cost of Risk Factors in Manitoba in 2008

The analysis focused on three key risk factors, each substantially associated with chronic disease – tobacco smoking, physical inactivity, and overweight/obesity. In order to assess the economic burden in Manitoba of the diseases attributable to these selected risk factors, both direct costs and indirect costs were assigned to the various diseases and then apportioned to each of the risk factors. The total direct costs in Manitoba attributable to the health effects of smoking, physical inactivity, and excess weight in 2008 are estimated at $492 million, while the indirect costs are estimated at $1.12 billion, yielding total attributable costs of $1.62 billion.

Economic Benefit of Reducing Risk Factors

An assessment of potential future changes in the economic burden associated with the risk factors of tobacco smoking, physical inactivity, and overweight/obesity was conducted based on the following three scenarios:

1. The proportion of the population with the risk factors remains at 2008 levels.
    - The ***annual*** economic burden associated with these risk factors would ***increase*** by $512 million from $1.62 billion in 2008 to $2.13 billion in 2026 (in 2008 constant dollars)
    - The ***cumulative increase*** in economic burden between 2008 and 2026 would be ***$4.7 billion***

2. The proportion of the population with the risk factors is reduced by 1% per year starting in 2011.
    - The ***annual*** economic burden in 2026 would ***decrease*** $210 million from a projected $2.13 billion (with no risk factor reduction) to $1.92 billion
    - The ***cumulative reduction*** in economic burden between 2011 and 2026 would be ***$1.77 billion***

3. The proportion of the population with the risk factors is reduced by 2% per year starting in 2011.
    - The ***annual*** economic burden in 2026 would ***decrease*** $424 million from a projected $2.13 billion (with no risk factor reduction) to $1.70 billion
    - The ***cumulative reduction*** in economic burden between 2011 and 2026 would be ***$3.58 billion***

Applying Available Evidence to Reducing Risk Factors

Potentially effective interventions for reducing risk factors were selected as examples for this analysis, exclusively for the purpose of the modelling exercise. The three interventions were a clinical smoking cessation program, a primary care-based physical activity program, and a North Karelia-style population-level nutrition program.

The key conclusion is that the total program costs over 16 years of $529 million are approximately equal to the estimated total health care costs avoided (i.e., $540 million). This result alone is very positive; vastly improved population health with a minimal increase in costs to the health care system. If one includes the indirect costs avoided associated with a reduction in premature mortality and morbidity, an even more compelling picture is produced; compared with $529 million in program spending, the total economic burden avoided would be about $1,775 million. *That is, combining direct and indirect costs avoided indicates a better than 3-to-1 return on investment over a 16-year period.*

This analysis focused on the impact of reducing three key risk factors. Much is at stake for Manitoba for controlling these sorts of exposures; their prevalence in the province is high, with 55% of the population overweight or obese, 45% inactive, and 27% being smokers. If the prevalence of these risk factors was reduced, some of the more significant health benefits would be as follows: deadly cancers of the mouth, throat and lungs would be reduced by up to 50%; type 2 diabetes would be reduced by up to 80%; and heart disease would decrease by as much as 50%. If the prevalence of the risk factors were to remain at 2008 levels through 2026, the cumulative increase in the economic burden would be $4.7 billion.

Potentially effective interventions for reducing risk factors were selected as examples for this analysis, exclusively for the purpose of the modelling exercise. There is no attempt to claim comprehensiveness based on the samples used in the model. As has been increasingly seen with the emerging global burden related to overweight/obesity, a broad, multi-platform effort to address the social determinants of health is called for in order to make the kind of progress required. This will mean health care leaders being actively joined by change agents in the arenas of transportation, urban design, poverty, food security, housing, etc.

Targeted prevention efforts through community-based and clinical programs, with a population focus, are urgently needed. Such programs can indeed be effective, as evidenced by interventions in Finland, Australia, and Canada. These countries demonstrated that sustained, comprehensive, and innovative programs can result in population-wide behaviour change and the desired health improvements in areas such as tobacco control, physical activity, and dietary improvement.

Implementing successful prevention programs at the population level is a complex and challenging task, but with long-term strategic investment, the huge burden of chronic disease in Manitoba can be addressed.

Introduction

The Heart and Stroke Foundation of Manitoba (HSFM), in partnership with the Alliance for the Prevention of Chronic Disease, CancerCare Manitoba, and Health in Common, have collaborated to develop an economic analysis of primary prevention of chronic disease in Manitoba. This project outlines the economic and health burden of preventable disease in Manitoba and provides stakeholders with important evidence for investing in primary prevention activities at the provincial, regional, and local levels.

The analysis focuses on three key risk factors – tobacco smoking, physical inactivity, and overweight/obesity. It was completed over the following three phases:

1. Estimate the current health and economic consequences of the risk factors in Manitoba.
2. Model the longer-term economic benefits of reducing the risk factors in Manitoba.
3. Estimate the cost of implementing selected interventions in Manitoba and then combine and summarize information on the longer-term costs and benefits of addressing the risk factors.

Detailed information on the process and results associated with each of these phases is included in the Supporting Documents at the end of this document. Definitions for various terms used throughout this document may be Supporting Document 4.

Methods/Process

As indicated in the *Acknowledgements* section, advice and input was sought from a variety of Manitoba experts.

In preparing the analysis, a variety of primary data sources were accessed. This includes the *Canadian Community Health Survey (CCHS)*, the *Canadian Tobacco Use Monitoring Survey (CTUMS)* as well as the following Manitoba-specific sources:

- *Manitoba RHA Indicators Atlas 2009* produced by the Manitoba Centre for Health Policy (MCHP)
- *In motion Survey* conducted by researchers at the Health, Leisure, and Human Performance Research Institute at the University of Manitoba
- *Manitoba Youth Health Survey*
- *Manitoba First Nations Regional Longitudinal Health Survey*
- *Population Projections from the Manitoba Bureau of Statistics*

In estimating the exposure of Manitoba's population to the risk factors of smoking, physical inactivity, and overweight/obesity, the analysis leaned heavily on CCHS data. The focus of CCHS data, and the current analysis, is on the population age 12 and over for the risk factors of smoking and physical inactivity and age 18 and over for the risk factor of overweight/obesity. Manitoba-specific data sources were used to address several known limitations of the CCHS, including the tendency to underestimate smoking prevalence and overestimate physical inactivity prevalence in youth and the lack of information for individuals living on First Nations Reserves (*see Supporting Document 1 for further details*).

In calculating direct costs, the approach of Anis et al. in their estimate of the economic burden of obesity and overweight in Canada in 2006 was adopted.[1,2] This involved the calculation of a Manitoba-specific population attributable risk for each of the related diseases and risk factors and estimating the Manitoba-specific costs associated with treating the various diseases. Only direct health care costs associated with publicly-funded health services were taken into account.

Adjustments in calculating the population attributable risk and associated costs were made to reduce the potential for double-counting costs in one individual with multiple risk factors.

Calculating indirect costs was based on the approach taken by the *Economic Burden of Illness in Canada, 1998* report which uses a modified human-capital approach. Both premature mortality and morbidity (short and long-term disability) were taken into account.

Costing sample interventions was based on resource requirements estimated in the literature and modified for Manitoba-specific costs.

Throughout the project, a conservative approach has been taken. This approach was taken in estimating both the economic burden associated with the identified risk factors as well as the costs of implementing sample interventions. For example, in estimating the economic burden associated with the risk factors, a unique analytic approach was applied which reduced the potential for double-counting costs associated with multiple risk factors in any one individual. When estimating the cost of implementing sample interventions, higher cost estimates were assumed when appropriate (e.g. the cost of name-brand nicotine-replacement therapy was used rather than generic pricing). The result is a conservative cost-benefit analysis.

Prevalence and Cost of Risk Factors in Manitoba in 2008

The factors of interest in this project, each marked by a substantial and significant association with chronic disease, are as follows:

- Tobacco smoking
- Physical inactivity
- Overweight/obesity

The first phase of the project involves an assessment of the economic burden in Manitoba of the diseases attributable to these selected risk factors. Both direct costs (e.g. healthcare) and indirect costs (those associated with morbidity and premature mortality) were assigned to the various diseases and then apportioned to each of the risk factors. *Note that a detailed version of this analysis and results may be found in Supporting Document 1.*

The results of the analysis, with all adjustments taken into consideration, are reflected in Table 1 below.

Table 1. Annual Economic Burden of Smoking, Physical Inactivity and Overweight/Obesity
Manitoba, 2008, By Gender
Adjusted for Selected CCHS Data Limitations and Multiple Risk Factors in One Individual
2008 Constant $'s

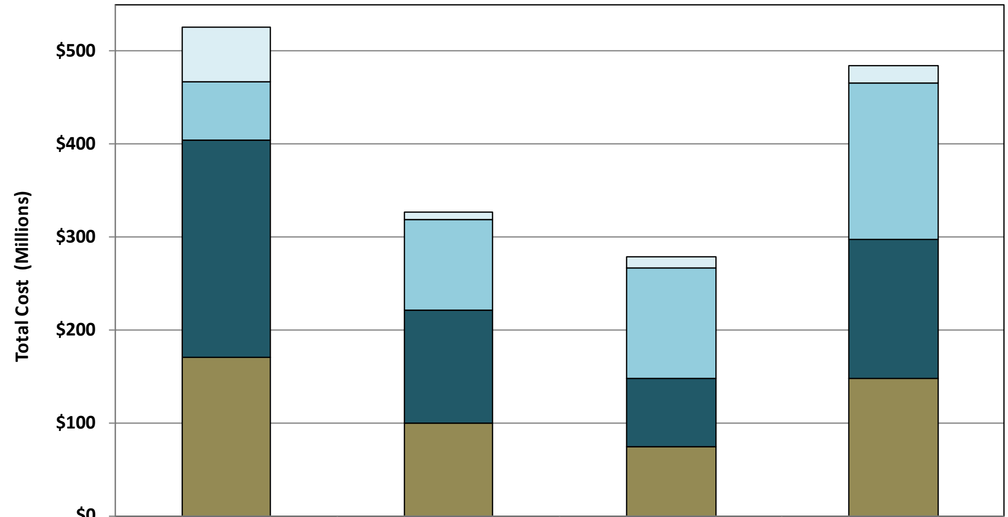
	% Population with RF	# Individuals with RF	Direct Cost per Individual with RF ($'s)	Indirect Cost per Individual with RF ($'s)	Total Cost per Individual with RF ($'s)	Total Direct Cost of RF (M$'s)	Total Indirect Cost of RF (M$'s)	Total Cost of RF (M$'s)
Males								
Smokers	29.8%	148,460	$687	$1,469	$2,156	$102.0	$218.0	$320.0
Inactive	43.0%	213,795	$209	$451	$660	$44.8	$96.4	$141.1
Overweight	40.9%	182,064	$185	$543	$728	$33.6	$98.9	$132.5
Obesity	21.2%	94,277	$644	$1,558	$2,202	$60.8	$146.8	$207.6
Subtotal						**$241.2**	**$560.1**	**$801.3**
Females								
Smokers	24.1%	125,268	$544	$1,100	$1,644	$68.1	$137.8	$206.0
Inactive	47.8%	248,077	$222	$529	$750	$55.0	$131.1	$186.1
Overweight	28.4%	133,127	$305	$790	$1,095	$40.6	$105.2	$145.8
Obesity	19.9%	93,411	$931	$2,028	$2,959	$86.9	$189.5	$276.4
Subtotal						**$250.7**	**$563.6**	**$814.3**
Both Genders								
Smokers	26.9%	273,728	$622	$1,300	$1,922	$170.1	$355.9	$526.0
Inactive	45.4%	461,872	$216	$493	$709	$99.8	$227.5	$327.3
Overweight	34.5%	315,191	$236	$647	$883	$74.2	$204.1	$278.3
Obesity	20.5%	187,688	$787	$1,792	$2,579	$147.7	$336.3	$484.0
Total						**$491.8**	**$1,123.7**	**$1,615.6**

The total direct costs in Manitoba attributable to the health effects of smoking, physical inactivity, and excess weight in 2008 are estimated at $492 million, while the indirect costs are estimated at $1.12 *billion*, yielding total attributable costs of $1.62 billion. The costs are divided relatively equally between males and females. It should be noted, however, that the economic burden associated with smoking is higher in males while the economic burden associated with excess weight and physical inactivity is higher in females. Finally, the well-known emergence of overweight/obesity as a public health concern is clearly indicated; the economic burden associated with these risk factors in Manitoba ($762.3 million) exceeds the economic burden associated with tobacco use ($526.0 million) in 2008. Figure 1 offers additional detail about the economic burden associated with each risk factor in the Manitoba population.

Figure 1. Estimated Direct and Indirect Economic Burden of Smoking, Physical Inactivity and Overweight/Obesity

Manitoba, 2008

Adjusted for Selected CCHS Data Limitations and Multiple Risk Factors in One Individual



	Smoking	Physical Inactivity	Overweight	Obesity
Indirect - S-T Disability	$59.4	$8.0	$12.0	$17.9
Indirect - L-T Disability	$62.2	$98.0	$118.1	$168.5
Indirect - Mortality	$234.2	$121.5	$73.9	$149.9
Direct Cost	$170.1	$99.8	$74.2	$147.7

The Economic Benefit of Reducing Risk Factors

The second phase of the project involves an assessment of potential future changes in the economic burden associated with the risk factors of tobacco smoking, physical inactivity, and overweight/obesity based on the following three scenarios:

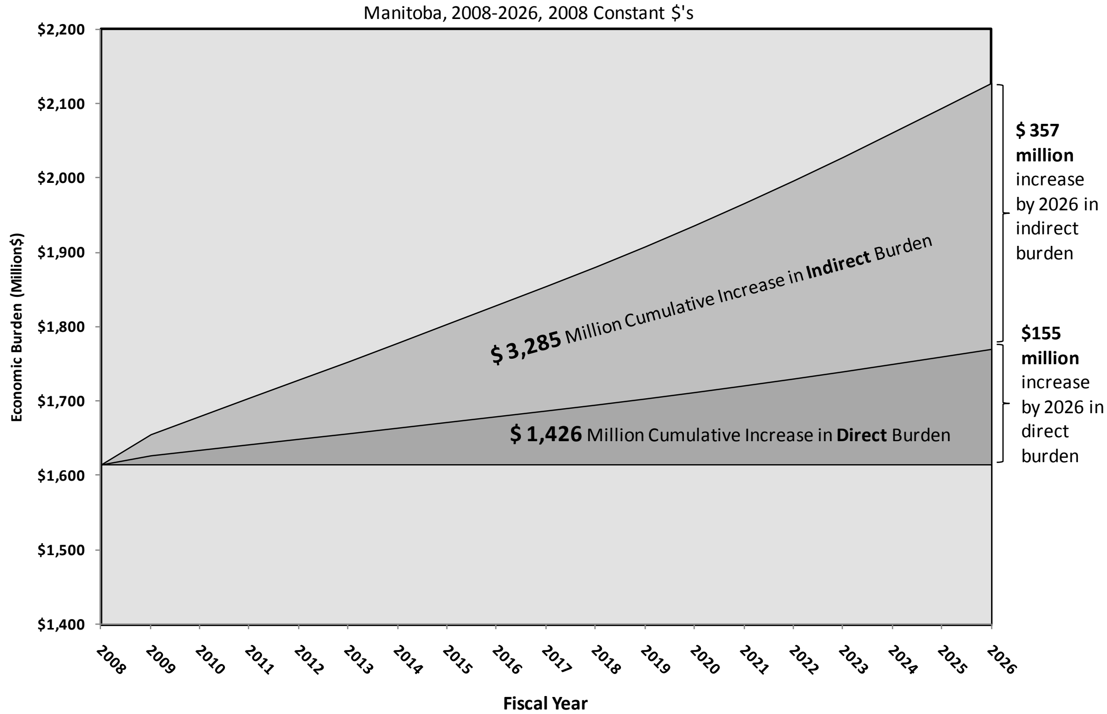
1. The proportion of the population with the risk factors remains at 2008 levels.
2. The proportion of the population with the risk factors is reduced by 1% per year starting in 2011.
3. The proportion of the population with the risk factors is reduced by 2% per year starting in 2011.

Note that the full version of the Phase 2 analysis may be found in Supporting Document 2.

Economic Impact of No Change in Risk Factor Prevalence

If the prevalence of the risk factors of smoking, physical inactivity, and overweight/obesity were to remain at 2008 levels through 2026, then the number of Manitobans who are current smokers would increase from 274,000 in 2008 to 352,000 in 2026, a change based solely on projected population growth. The number of physically inactive individuals would increase from 462,000 to 613,000. The number of obese Manitobans would increase from 188,000 to 251,000, while the number of overweight individuals would increase from 315,000 to 422,000. As indicated in Figure 2, the ***annual*** economic burden associated with these risk factors would also increase from $1.62 billion in 2008 to $2.13 billion in 2026 (in 2008 constant dollars), an ***increase*** of ***$511 million*** ($155 million in direct costs and $357 million in indirect costs). The ***cumulative increase*** in economic burden (calculated by adding together the annual increases over the 19 year period between 2008 and 2026) would be ***$4.7 billion*** ($1.4 billion in direct costs and $3.3 billion in indirect costs).

Figure 2. Changes in Economic Burden of Smoking, Physical Inactivity, Overweight, and Obesity
No Change in Risk Factor Prevalence
Manitoba, 2008-2026, 2008 Constant $'s



Assumptions Used in the Model

A model was developed to assess the potential change in economic burden associated with smoking, physical inactivity, and excess weight in Manitoba if the prevalence of these risk factors could be reduced. The model used the detailed analysis prepared for phase one of this project, together with the most recent population projections for Manitoba to 2026.

The following assumptions were made in modeling the change in economic burden in Manitoba to 2026 based on a 1% or 2% annual reduction in each of these risk factors:

1. The annual reduction in exposure prevalence would begin in the 2011 fiscal year.
2. Obese individuals would move into the overweight group while overweight individuals would move into the healthy weight group.
3. The health and economic benefits of reducing physical inactivity and weight would occur within a year after the risk factor reduction occurred. Within that time, the excess economic burden associated with physical inactivity and excess weight would return to that of the population cohort marked by a healthy level of the factor (i.e., “unexposed” to the risk factor).
4. The full health and economic benefits associated with smoking cessation would take 20 years to accrue, with the benefits increasing incrementally each year after smoking cessation.
5. The economic benefits of smoking cessation would be modelled on a cohort basis, taking into account the years since smoking cessation began.

Economic Impact of a 1% Annual Reduction in Risk Factor Prevalence

A 1% annual decrease in the risk factors would result in the following changes in the number of individuals in Manitoba with the risk factors in 2026:

- 301,000 smokers compared to 352,000 with no reduction
- 527,000 physically inactive individuals compared to 613,000 with no reduction
- 215,000/397,000 obese/overweight Manitobans compared to 251,000/422,000 with no reduction

As indicated in Figure 3, the ***annual*** economic burden in 2026 would ***decrease*** by ***$210 million*** ($64 million in direct costs and $146 million in indirect costs), from a projected $2.13 billion with no reduction to $1.92 billion. The ***cumulative reduction*** in economic burden between 2011 and 2026 would be ***$1.77 billion*** ($540 million in direct costs and $1.23 billion in indirect costs).

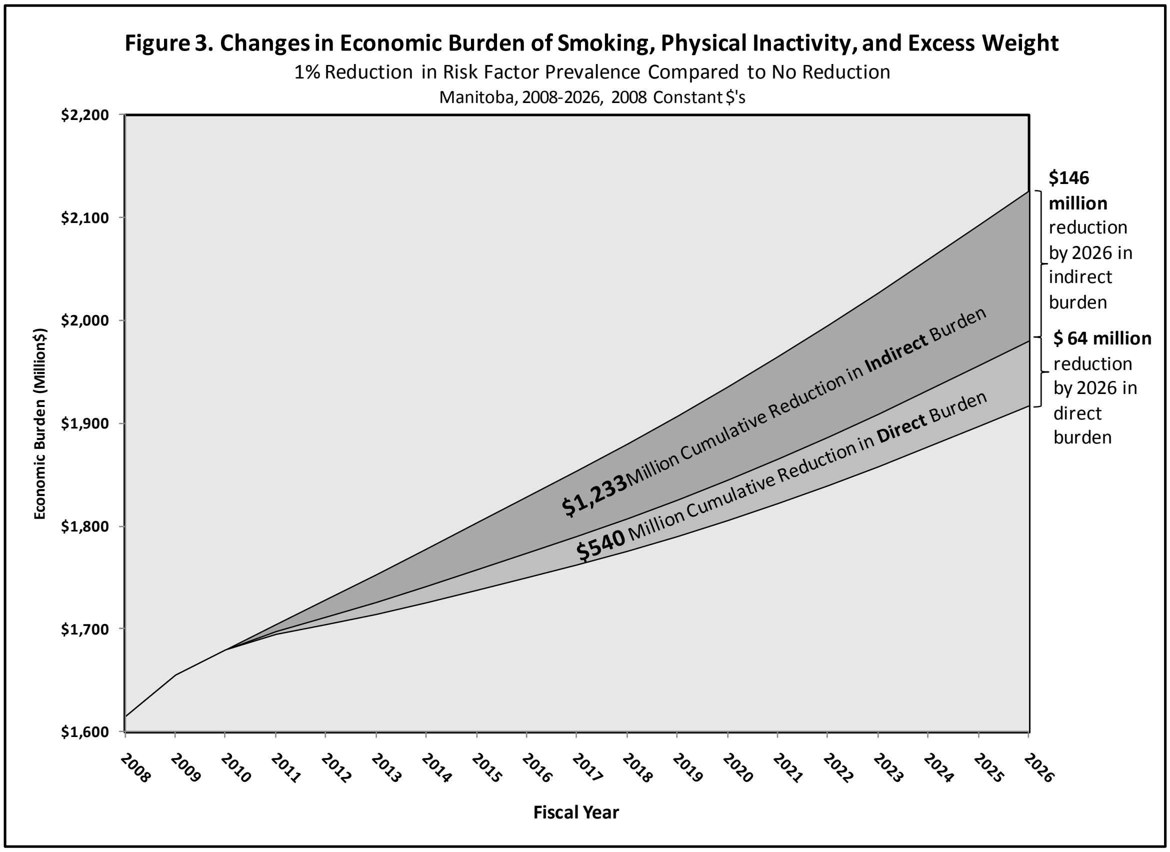


Figure 3. Changes in Economic Burden of Smoking, Physical Inactivity, and Excess Weight
1% Reduction in Risk Factor Prevalence Compared to No Reduction
Manitoba, 2008-2026, 2008 Constant $'s
Economic Burden (Million$)
$2,200
$2,100
$2,000
$1,900
$1,800
$1,700
$1,600
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
Fiscal Year
$1,233 Million Cumulative Reduction in Indirect Burden
$540 Million Cumulative Reduction in Direct Burden
$146 million reduction by 2026 in indirect burden
$ 64 million reduction by 2026 in direct burden

Economic Impact of a 2% Annual Reduction in Risk Factor Prevalence

A 2% annual decrease in the risk factors would result in the following changes in the number of individuals in Manitoba with the risk factors in 2026:

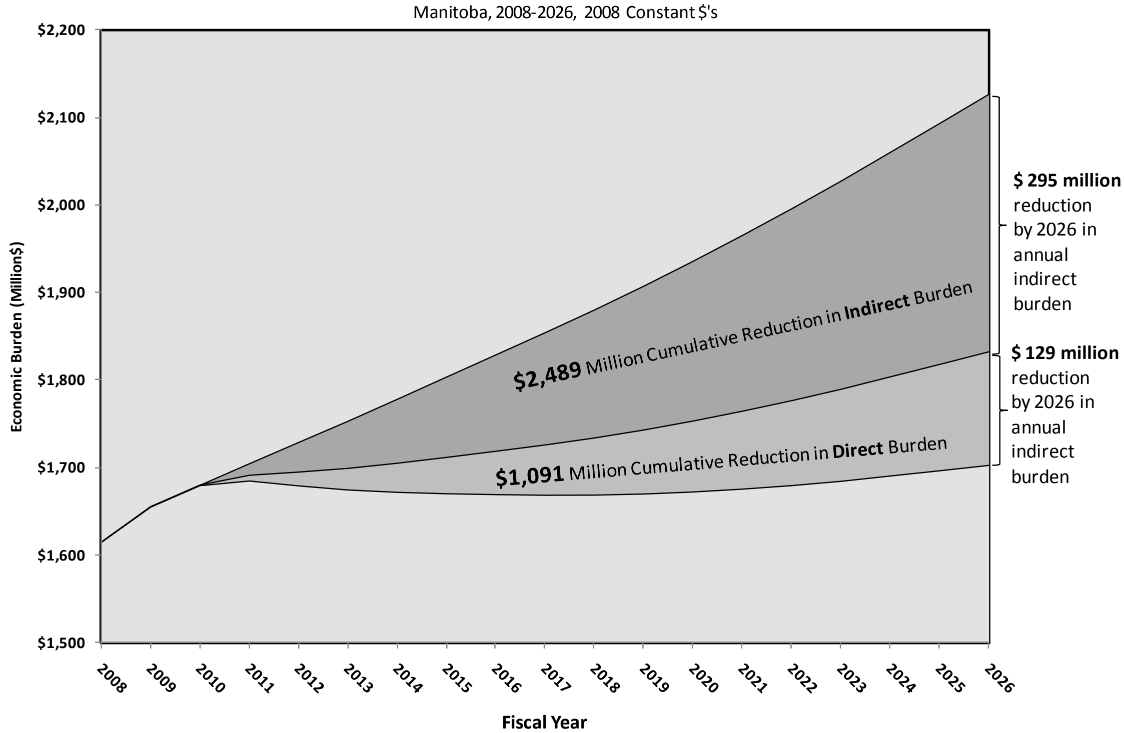
- 249,000 smokers compared to 352,000 with no reduction
- 438,000 physically inactive individuals compared to 613,000 with no reduction
- 178,000/372,000 obese/overweight Manitobans compared to 251,000/422,000 with no reduction

As indicated in Figure 4, the ***annual*** economic burden in 2026 would ***decrease*** by ***$424 million*** ($129 million in direct costs and $295 million in indirect costs), from a projected $2.13 billion with no reduction to $1.70 billion. The ***cumulative reduction*** in economic burden between 2011 and 2026 would be ***$3.58 billion*** ($1.09 billion in direct costs and $2.49 billion in indirect costs).

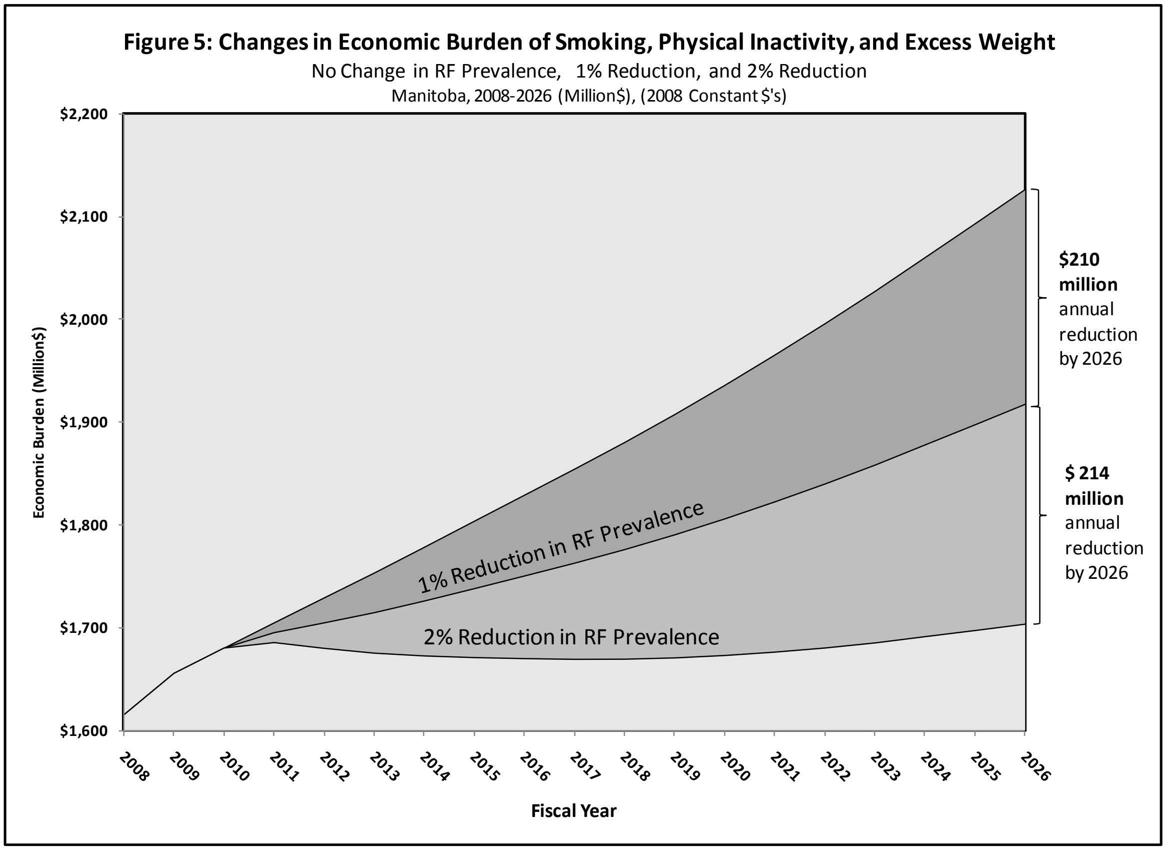
Figure 4. Changes in Economic Burden of Smoking, Physical Inactivity, and Excess Weight

2% Reduction in Risk Factor Prevalence Compared to No Reduction

Manitoba, 2008-2026, 2008 Constant $'s



The potential changes in the economic burden associated with no change, 1% annual reduction, and 2% annual reduction in risk factor prevalence are shown in Figure 5.



Applying Available Evidence to Reducing Risk Factors

The annual economic burden of $1.62 billion associated with the risk factors of smoking, physical inactivity, and excess weight in Manitoba is substantial. Reducing this economic burden is possible if the prevalence of the risk factors in the population can be decreased. The purpose of the final phase of this project was to:

- Determine the cost of implementing selected interventions of demonstrated effectiveness that could conceivably lead to a 1% or 2% annual reduction in the risk factors in Manitoba between 2011 and 2026

- Compare the costs of implementing these selected interventions with the costs avoided given a 1% or 2% annual reduction in the risk factors, as calculated in Phase 2 of the project

Note that the full version of the Phase 3 analysis may be found in Supporting Document 3.

Social Context of Prevention

The focus of this project is a modelling exercise, which presented challenges in selecting appropriate interventions. One limitation in the available research literature is that most primary prevention interventions are from the health care sphere. The exception involves the inclusion of the North Karelia-style population-level program (see below) in the modelling. Conceived and implemented four decades ago, the North Karelia Project in Finland was ahead of its time; the Project did not only embrace primary care partners and classic health education approaches, but sought to change Finnish government policy, industry practices, and other societal influences related to unhealthy nutrition and other risk factors. The findings from North Karelia challenge contemporary prevention efforts to engage agents and interventions well beyond the health care sphere.

Selecting Example Interventions to Cost

In the health care literature, there are a vast number of potentially effective interventions for reducing risk factors. ***The interventions selected for this analysis were done so exclusively for the purposes of this modelling exercise. Their selection does not imply a recommendation to implement them in Manitoba.*** A key criterion in selecting the interventions was the capability of generating supportable cost estimates related to implementation. While many effective interventions are described in the literature, few provide supporting cost data that would allow for a cost estimate of their implementation and expansion in Manitoba. In addition to this key criterion, the interventions chosen also demonstrated:

1. Clear evidence of effectiveness that conceivably could be reproduced within Manitoba's population
2. The potential for a substantial population effect in terms of reducing risk factors
3. Feasibility of implementation and uptake in a relatively short time frame and potential for sustainability

The interventions selected for this analysis that met the criteria were: clinical smoking cessation, green prescriptions related to physical activity, and a diet-related community program (similar to the well-known North Karelia Project of Finland) with the aim of reducing rates of overweight/obesity.

Even as the selections were made, it was important to continue recognizing that much more would be required in the end for the effort to qualify as a comprehensive risk factor reduction/prevention initiative.

Each of these three interventions is briefly described below, and then the costs for implementing these example programs in Manitoba are summarized.

Clinical Smoking Cessation

Although a comprehensive tobacco reduction program would be multi-faceted, the example chosen for modelling costs is a smoking cessation program which consists of nicotine replacement therapy (NRT) combined with clinician support sessions. The estimated program cost per smoker as defined in the base model is $548. The annual number of smokers needed to participate in the program in order to achieve a 1% or 2% reduction in smoking was estimated, with that figure then multiplied by the cost per participant to calculate the annual cost of operating the smoking cessation program. Based on a 1% annual reduction, this cost would increase from $4.9 million in 2011 to $6.0 million in 2026 (in constant 2008$). For the 2% annual reduction, the program costs would increase from $9.7 million to $12.1 million over the modelling period.

Reducing Physical Inactivity

The physical activity program chosen as an example for modelling costs is a primary care-based approach that is based upon the Green Prescription program of New Zealand. The model would have the following key elements:

- Consultation with a general practitioner to choose appropriate goals to increase physical activity
- Referral to a kinesiologist who does four follow-up calls to offer encouragement and support
- Newsletters and physical activity leaflets mailed out to participants

Program costs were derived by applying Manitoba-specific costs to the various program components, yielding an estimated cost per participant of $204.60. The annual number of inactive individuals needed to participate in the program in order to achieve a 1% or 2% reduction in physical inactivity was estimated, with that figure then multiplied by the cost per participant to calculate the annual cost of operating the program. Based on a 1% annual reduction, this cost would increase from $10.1 million in 2011 to $12.8 million in 2026 (in constant 2008$). For the 2% annual reduction, the costs would increase from $20.2 million to $25.9 million over the modelling period.

North Karelia-style Population-level Nutrition Program

The final intervention selected as an example addresses overweight/obesity. It is a multi-dimensional community-based program related to diet, activity, and tobacco reduction that was implemented in North Karelia, Finland in the 1970s. The main feature of the North Karelia program was the deployment of a team of professionals with various specializations to a field office that was responsible for health improvements in the region. The North Karelia team efforts were directed both to individuals and to the community as a whole. Team members consistently acted as communication agents throughout the community; this involved disseminating information on risk factors and prevention in various settings. Another important activity of the field office team was recruiting and training lay opinion leaders; these leaders then became an information conduit for community health education. There was a strong sense of collaboration and a great deal of volunteer energy harnessed in the North Karelia Project.

It is estimated that approximately 30 staff would be needed in Manitoba to generate an intensity of population coverage comparable to the North Karelia project. Based on published estimates for the North Karelia Project, the costs for a similar community-based program in Manitoba would be $6.2 million in the first year, increasing to $19.5 million in 2026. A key assumption associated with this estimate is that it would take five years to fully implement this intervention in Manitoba.

Summary of Cost of Program Implementation and Operation

Based on a 1% annual reduction in risk factors, the estimated costs of implementing a smoking cessation program, an activity prescription program, and a 'North Karelia'-type program in 2011 would be $4.9 million, $10.1 million, and $6.2 million, respectively, for a total of $21.1 million (see Table 2). Total annual costs would increase to $38.3 million (in 2008 constant dollars) by year 2026. Over the 16-year time period from 2011 to 2026, total program costs would be $529 million.

Table 2. Estimated Cost of Meeting Risk Factor Reduction Goals in Manitoba
By Intervention Type, 2011 to 2026
Based on a 1% Annual Reduction, 2008 Constant Million$

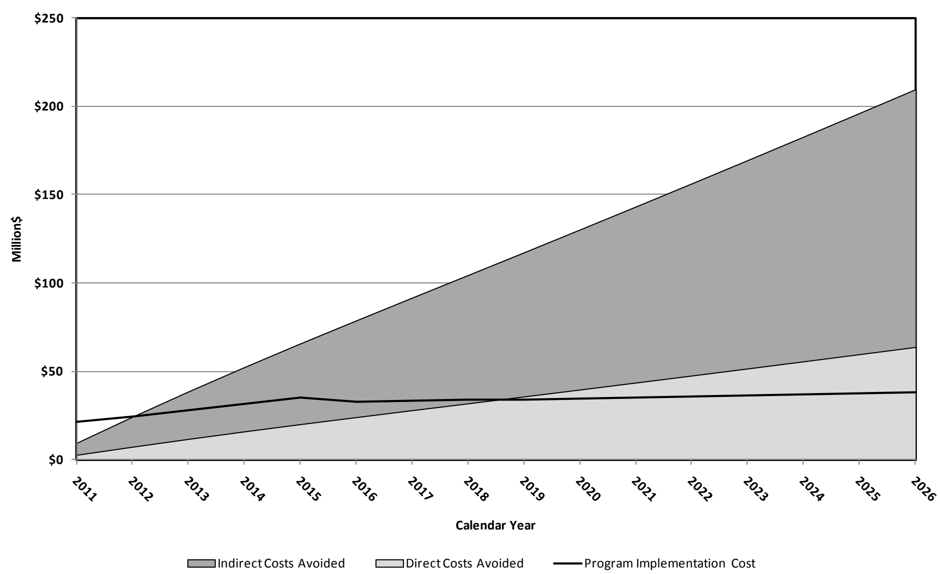
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	16-Year Total
								1% Annual Reduction									
Smoking Cessation	$4.85	$4.96	$5.01	$5.08	$5.13	$5.19	$5.26	$5.32	$5.39	$5.46	$5.54	$5.62	$5.71	$5.80	$5.89	$5.99	**$86.19**
Activity Prescription	$10.11	$10.36	$10.50	$10.65	$10.80	$10.96	$11.11	$11.27	$11.43	$11.60	$11.78	$11.97	$12.17	$12.38	$12.60	$12.82	**$182.49**
'North Karelia'	$6.15	$9.32	$12.53	$15.79	$19.11	$16.57	$16.83	$17.10	$17.37	$17.66	$17.95	$18.25	$18.56	$18.88	$19.20	$19.51	**$260.80**
Total	**$21.11**	**$24.63**	**$28.05**	**$31.52**	**$35.05**	**$32.72**	**$33.20**	**$33.68**	**$34.19**	**$34.71**	**$35.26**	**$35.84**	**$36.44**	**$37.06**	**$37.69**	**$38.32**	$529.48

Risk Factor Reduction Program Costs and Estimated Costs Avoided

Base Model

As outlined previously, a 1% annual reduction in the risk factors of smoking, physical inactivity, and overweight/obesity would lead to an estimated cost avoidance of $1.77 billion dollars (direct + indirect costs avoided) in Manitoba over the 16-year period from 2011 to 2026. If only direct costs avoided are taken into consideration, potential costs avoided are $540 million. By comparison, total program costs in this time period are estimated at $529 million (see Figure 6). That is, over the 16-year period, total program costs would be offset by direct costs avoided. *Annual* direct costs avoided would exceed *annual* program costs by 2019.

Figure 6. Risk Factor Reduction in Manitoba
Program Cost and Potential Total Costs Avoided
1% Risk Factor Reduction, 2011 - 2026
2008 Constant $'s



Not Achieving a Reduction in Overweight/Obesity

Instead of projecting that a "North Karelia"-type program would lead to a 1% annual reduction in the prevalence of overweight/obesity, an alternate assumption suggests that such a program would only halt the current increase in prevalence of overweight/obesity. Program costs would thus remain the same ($529 million), but potential direct costs avoided would only include those associated with smoking and physical inactivity (i.e. $264 million); hence total costs avoided are lower than in the base model. If indirect costs avoided are included, potential costs avoided are $844.5 million.

Evidence of Population-Based Risk Factor Reduction

Given the challenges associated with influencing overweight/obesity and the other risk factors, a legitimate question is whether population-based risk factor prevention programs are actually effective. A key assumption throughout this analysis has been that a reduction in risk factor prevalence will lead to a reduction in the chronic diseases attributable to that risk factor. There are very few population-based risk factor prevention programs that have shown success at this level of effectiveness (compared to noting either a short or longer-term reduction in risk factor prevalence but without the longer-term results showing an associated reduction in chronic disease).

Key Elements of a Successful Primary Prevention Program

A comprehensive review of successful risk factor prevention programs identified four fundamentals that are critical for any population-based prevention program, as follows:[3]

- **Sustained** over a long period of time
- **Comprehensive**: multiple approaches in multiple settings
- **Innovative**
- Balance a focus on the **individual's responsibility** within the context of **changes to the environment**

In the following subsections, three examples of successful population-based risk factor prevention programs are described. Each of these examples demonstrates these four fundamentals.

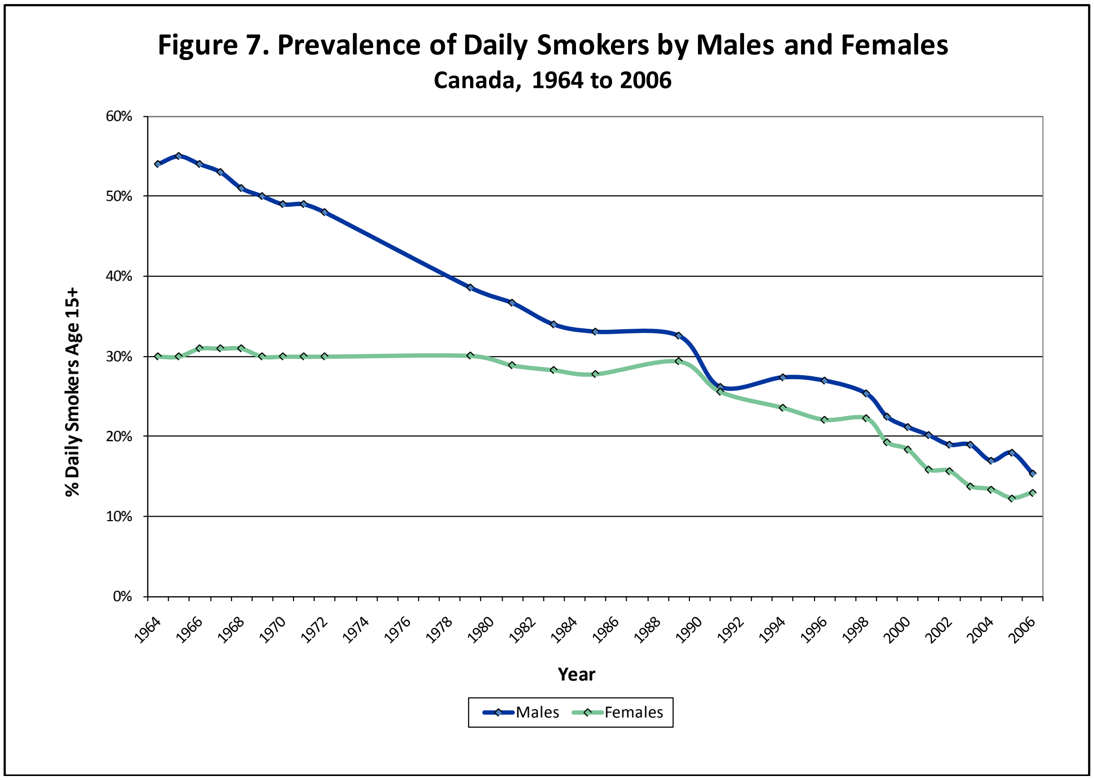
Given the limited number of such examples, we have included the Australian program on sun safety even though it is not one of the key interventions included in this analysis.

Canada: A World Leader in Tobacco Control

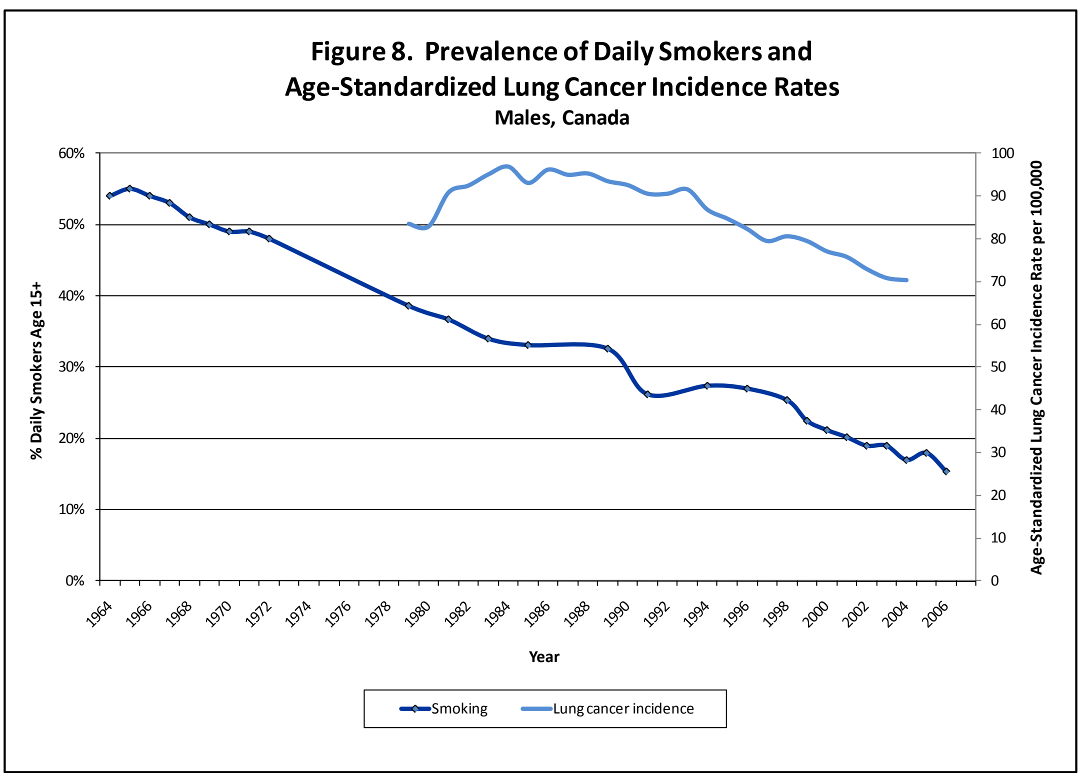
In the mid-1960s, 55% of Canadian men and over 30% of Canadian women were daily smokers. In 2006, the proportion of men who were daily smokers in Canada had decreased to 15.4% of the population, while the proportion of women daily smokers had decreased to just 13.0% (see Figure 7).[4]

This decrease in smoking prevalence can be ascribed in large part to long-standing and sustained chronic disease prevention and health promotion endeavours, which have been specifically associated with the following measures:[5]

- Price increases, mostly through taxation
- Controlling the advertising of tobacco products
- Counter-advertising
- Clinical cessation strategies
- Banning smoking in public places



The decrease in smoking prevalence in Canada has had a significant effect on trends in lung cancer incidence, particularly among men. The decrease in lung cancer incidence in Canada in males coincides with the decreasing prevalence of smoking in males, with the detailed results being consistent with a lag time of 20-30 years. Figure 8 indicates that the peak in lung cancer incidence in males in Canada occurred in the mid to late 1980s, while the peak in the prevalence of daily smoking in males occurred in the mid-1960s.[6]



Finland: Long-Term Changes in Diet and Smoking

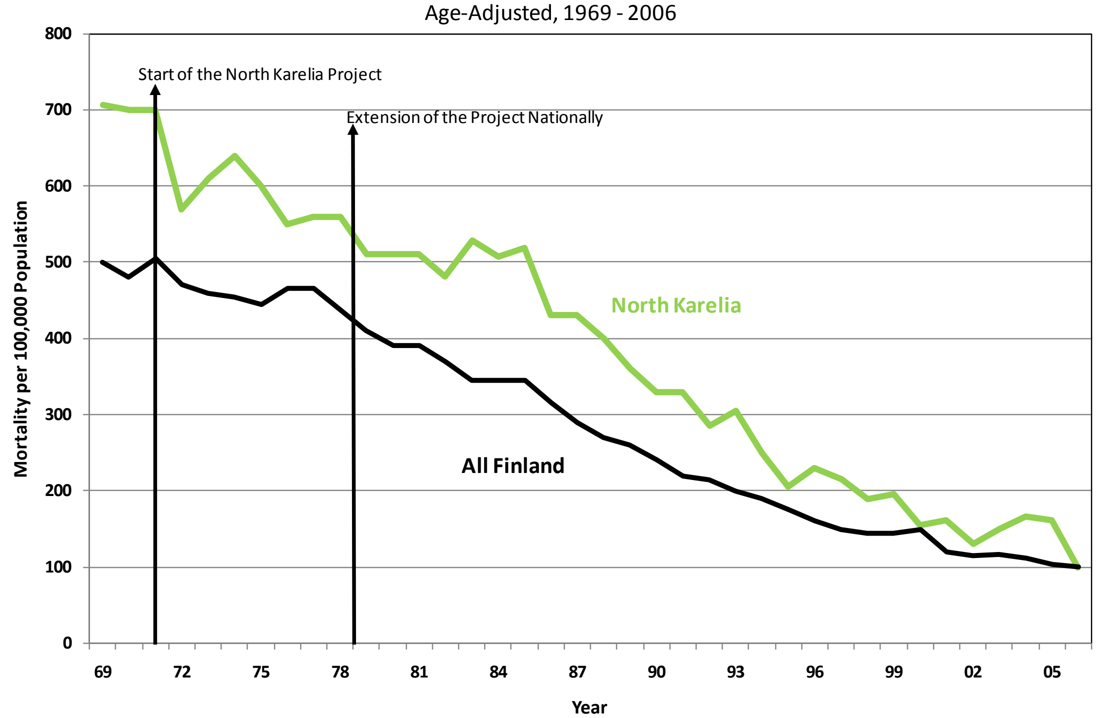
Studies comparing countries in the 1950s and 60s showed that coronary heart disease mortality rates in Finnish men were among the highest in the world. Furthermore, North Karelia's rate was 40% worse than the national statistic even though its economy was dominated by physically active jobs such as logging and farming. However, while strenuous work kept the Finns relatively slim, they still enjoyed their butter, whole milk, sausage, salt, and cigarettes; conversely, fruits and vegetables were rarely on the menu. In 1972, the people of North Karelia, Finland petitioned their government for help in improving the health of the population.

The ensuing series of population-based interventions became known as the North Karelia Project. The success of the project led to its national adoption in Finland five years later, in 1977. The encouraging health trend observed in North Karelia as early as 5 years after the launch of the Project has been steadily confirmed in the decades since. As Figure 9 shows, mortality due to coronary heart disease has dropped by approximately 80% in about 30 years. Further analysis suggests that at least three-quarters of the remarkable CHD mortality decline seen among middle-aged men in particular may be attributed to improvement in diet and decreases in smoking.[7]

Figure 9. Mortality Rates Due to Coronary Heart Disease

Males Aged 35-64, North Karelia and All of Finland

Age-Adjusted, 1969 - 2006



The success of the North Karelia Project has been associated with its comprehensive approach to risk factor change around the following six domains:

1. Improved clinical preventive services to identify high-risk individuals and provide treatment
2. Information to educate people about their health and how to maintain it
3. Motivate people towards healthy choices
4. Training to increase skills of self-control, management of one's environment, and collaborative action to increase physical assets and social capital with the potential to benefit health

5. Community organization to create social support and power for social action
6. Environmental change to create opportunity and support for healthy actions and improvements in unfavourable conditions

Australia: Sun Safety and Skin Cancer

As noted earlier, the Australian program on sun safety is included (even though sun safety is not one of the key interventions included in this analysis) due to the limited availability of successful, real-world population-based prevention programs that have demonstrated a change in the chronic disease associated with the risk factor. Furthermore, the population level prevention approach demonstrated in this program is not risk factor dependent, and could prove very applicable in the reduction of smoking, physical inactivity and obesity.

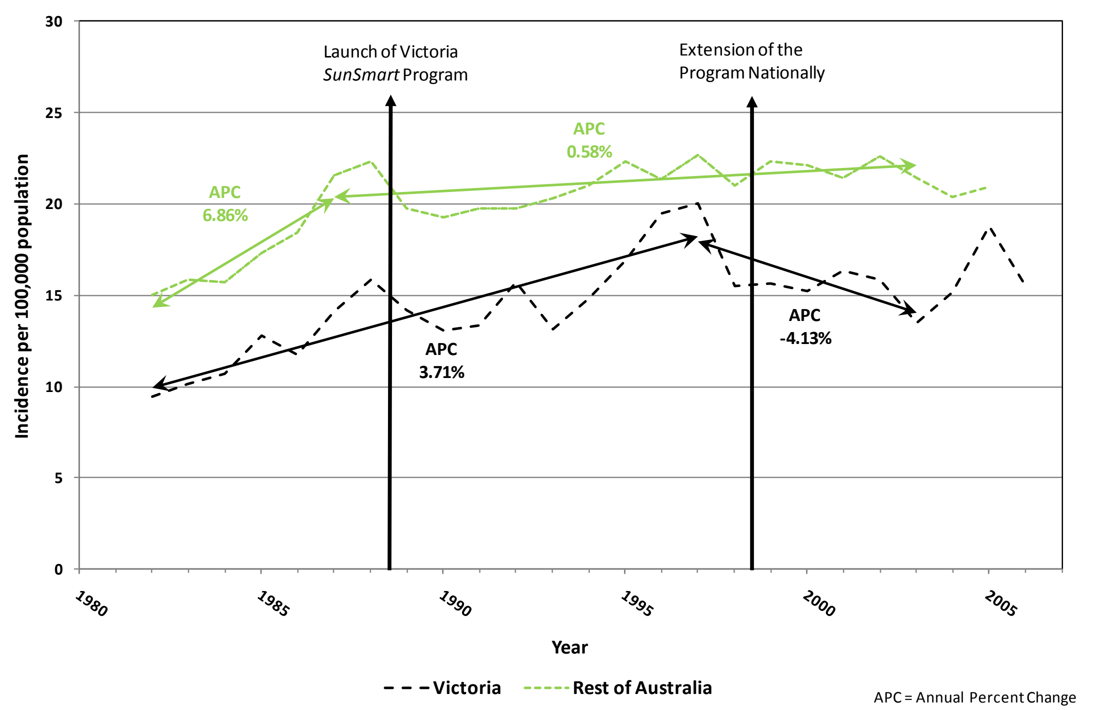
The most comprehensive and successful population-level skin cancer prevention programs have been conducted in Australia. Such programs have been an important focus for Australia because it is the country with the highest incidence and mortality rates for skin cancer in the world.[8] Various awareness campaigns and multi-component interventions at community, state, and national levels have not only resulted in changes in knowledge and attitudes but have also increased sun protection behaviours. These positive behavioural changes ultimately led to a reduction in melanoma incidence, as indicated in Figure 10.[9]

The Australian *SunSmart Program* was first launched in the state of Victoria in 1987, and continues to be used up to the present time. Building on a more basic, modestly funded campaign in the country known as *Slip! Slop! Slap!*, the Victorian approach has been progressively adopted by other Australian states.

Figure 10. Incidence Rates of Melanoma

In Victoria, Australia and the Rest of Australia

In Persons Aged 0-49 Year, 1982-2006



Conclusion

Three key risk factors substantially associated with chronic disease – tobacco smoking, physical inactivity, and overweight/obesity– have high prevalence in Manitoba, with the economic burden of the diseases attributable to these risk factors estimated at $1.62 billion in 2008. If the proportion of the population with the risk factors remains at 2008 levels, the cumulative increase in economic burden to 2026 would be $4.7 billion. If the proportion of the population with the risk factors is reduced by 1% per year starting in 2011, the cumulative reduction in economic burden to 2026 would be $1.77 billion. Taking this a step further, if the proportion of the population with the risk factors is reduced by 2% per year starting in 2011, the cumulative reduction in economic burden to 2026 would be $3.58 billion.

Potentially effective interventions for reducing risk factors were selected as examples for this analysis, exclusively for the purpose of the modelling exercise. The three interventions were a clinical smoking cessation program, a primary care-based physical activity program, and a North Karelia-style population-level nutrition program.

The key conclusion is that the total program costs over 16 years of $529 million are approximately equal to the estimated total health care costs avoided (i.e., $540 million). This result alone is very positive; vastly improved population health with a minimal increase in costs to the health care system. If one includes the indirect costs avoided associated with a reduction in premature mortality and morbidity, an even more compelling picture is produced; compared with $529 million in program spending, the total economic burden avoided would be about $1,775 million. *That is, combining direct and indirect costs avoided indicates a better than 3-to-1 return on investment over a 16-year period.*

Potentially effective interventions for reducing risk factors were selected as examples for this analysis, exclusively for the purpose of the modelling exercise. There is no attempt to claim comprehensiveness based on the samples used in the model. As has been increasingly seen with the emerging global burden related to overweight/obesity, a broad, multi-platform effort to address the social determinants of health is called for in order to make the kind of progress required. This will mean health care leaders being actively joined by change agents in the arenas of transportation, urban design, poverty, food security, housing, etc.

Targeted prevention efforts through community-based and clinical programs, with a population focus, are urgently needed. Such programs can indeed be effective, as evidenced by interventions in Finland, Australia, and Canada. These countries demonstrated that sustained, comprehensive, and innovative programs can result in population-wide behaviour change and the desired health improvements in areas such as tobacco control, physical activity, and dietary improvement.

Implementing successful prevention programs at the population level is a complex and challenging task, but with long-term strategic investment, the huge burden of chronic disease in Manitoba can be addressed.

Supporting Document 1: The Estimated Economic Burden of Smoking, Physical Inactivity, and Overweight/Obesity in Manitoba in 2008

The purpose of Supporting Document 1 is to provide detailed information on the process and results associated with estimating the current health and economic consequences of tobacco smoking, physical inactivity, and overweight/obesity in Manitoba.

The information required or generated for this phase included:

- The diseases found to be attributable to some extent to the risk factors of smoking, physical inactivity, and overweight/obesity
- The relative risk (RR) of the identified diseases with respect to each of the risk factors
- The proportion of the population 'exposed' (E) to each risk factor in Manitoba
- Calculation of the population attributable risk (PAR) based on RR and E
- Calculation of the direct health care costs associated with treating the respective diseases in Manitoba in 2008
- Calculation of the indirect costs related to both morbidity and mortality

In the following sections of this Supporting Document, each of these components will be detailed. PAR occupies an important role in the overall analysis, as briefly introduced below.

Population Attributable Risk and the Disease Burden of Risk Factors

Population attributable risk (PAR) is central to many contemporary studies of disease burden. As such, PAR will also be essential to the present project. PAR is the fraction or proportion of the population-wide burden of a specific disease that is caused by a particular risk factor. Causation in biology and medicine is a very complex topic. However, PAR offers a powerful way to interpret causation in the practical terms of prevention. In short, PAR is that *proportion of disease cases that will be removed if exposure to the risk factor is removed*.

There are different formulas applied to calculate PAR, although they are in the end mathematically equivalent. The most-used formula incorporates two component data points: relative risk (RR) of incident disease related to a risk factor, and the prevalence of exposure (E) to the risk factor in a particular population. These inputs for PAR will be explored in more detail in the next two major sections of this Supporting Document, including a description of the data sources and key information specific to this project. Later, the PAR concept will be outlined in more detail before it is applied to the task of calculating disease burden and costs related to modifiable risk factors in Manitoba.

Estimating the Relative Risk

Risk Factors and Relative Risk

All sorts of groups are compared to others in epidemiologic research to see if belonging to a particular group increases or decreases the risk of developing a disease. Other areas of medicine also use this concept, for example, comparing the effects of two different treatments on reducing disease symptoms. For the present project, the groups being compared are those with different exposures to a potentially modifiable chronic disease risk factor, specifically, tobacco smoking, physical inactivity, and overweight/obesity. The critical question is how much a risk factor influences the incidence of disease. In other words, identifying the degree to which it is associated with the disease (most importantly, where it is associated in a *causal* manner). To determine and communicate this idea, several measures of the strength of an association are employed in medicine.

Relative risk (RR) is a measurement of risk (or factor-disease association) that is used widely in epidemiological studies. It may be defined as the proportion of individuals experiencing an outcome (such as incident disease) in an exposed group divided by the proportion experiencing the outcome in the control (or unexposed) group. Specifically, RR of incidence is a fraction where the numerator and the denominator are the same metric, namely, the risk of incident disease as measured by proportion. Thus, RR by definition has no unit; it is simply a number representing a ratio or comparison of two risks—hence, the name "relative risk" and its synonym, "risk ratio."

Relative risk is commonly expressed as a decimal, such as 1.2, which means 0.2 times higher risk than in the unexposed group. This same measure of risk can also be expressed as a percentage increase, that is, a 20% increase in risk in the exposed group. As well, if the relative risk happens to be a whole number, such as 3.0 (or 300%), it is sometimes expressed as a "three-fold increase" in risk.

A RR of 1 indicates that there is no difference between two groups with different risk factor exposures in terms of their risk of disease. A RR of greater than 1 (RR>1) means that being exposed increases the risk of disease. In an important sense, generating a RR>1 in a scientific study is a way of *defining* a true risk factor. On the other hand, a RR of less than 1 means that the risk of disease is decreased upon exposure. An influence that causes this effect is sometimes referred to as a "protective factor."

These concepts and terms have direct application to the present project. A simple semantic shift allows most risk factors to be converted into a protective factor; a key complication is the fact that studies originating from *both* perspectives (risk increase *and* risk protection) do occur in the literature. The classic example of this phenomenon is physical inactivity and physical activity; in most cases, the former is thought of as a risk factor, and the latter as protective. Scientific literature related to prevention interventions exists for both topics: decreasing physical inactivity (or decreasing being sedentary) and increasing physical activity. To more closely parallel risk factors such as tobacco smoking and overweight/obesity, this project will generally focus on physical *inactivity* and its associated diseases (i.e., where RR>1).

Sources of RR Data

As noted earlier, RR is central to the calculation of the risk of disease in a population that is attributable to a risk factor, which in turn can be used to estimate the attributable costs.

Meta-analyses of multiple studies generate a risk picture that results in a "summary" or "pooled" RR figure that is more reliable. A comprehensive RR assessment reports on a collection of chronic diseases (e.g., pertinent major cancers) that are associated with a particular risk factor; such inventories are often assembled by a study group as the basis for calculating PARs within a particular jurisdiction, information which is then used in a cost-of-illness or burden-of-disease analysis related to that risk factor. Recent examples of these efforts in the **Canadian context** are listed in Table 1.

Table 1. PAR and Costing Related to Risk Factors Projects Developed by Canadian Study Groups						
Study Group Leaders	**Research Centre**	**Risk Factor**	**Key Metric**	**Publication Year**	**Jurisdiction**	**Reference**
Jurgen Rehm	Public Health Sciences Department, University of Toronto, Toronto ON	Smoking	RR	2006	n/a*	1
			PAR	2007	Canada	2
Aslam H. Anis & C. Laird Birmingham	Centre for Health Evaluation and Outcome Sciences, St. Paul's Hospital, Vancouver BC	Obesity/Overweight	RR	2009	n/a*	3
			PAR	2009	Canada	4
		Obesity	RR,PAR	1999	Canada	5
Peter T. Katzmarzyk	School of Physical and Health Education, Queen's University, Kingston ON	Obesity	RR,PAR	2004	Canada	6
		Physical Inactivity	RR,PAR	2004	Canada	6
			RR,PAR	2000	Canada	7
Ronald Colman	GPI*Atlantic*, New Haven NS	Obesity	PAR (Using RR from Ref 5)	2000	Manitoba	8

* Unlike PAR, the summary or pooled RR from international sources is not specific to a jurisdiction.

1 Rehm J, Baliunas D, Brochu S et al. *The Costs of Substance Abuse in Canada 2002* . 2006. Supplemental Table APP-11.
2 Baliunas D, Patra J, Rehm J et al. Smoking-Attributable Morbidity: Acute Care Hospital Diagnoses and Days of Treatment in Canada, 2002. *BMC Public Health* . 2007; 7: 247: 8pp.
3 Guh DP, Zhang W, Bansback N et al. The Incidence of Co-Morbidities Related to Obesity and Overweight: A Systematic Review and Meta-Analysis. *BMC Public Health* . 2009; 9: 88: 20pp.
4 Anis AH, Zhang W, Bansback N et al. Obesity and Overweight in Canada: An Updated Cost-of-Illness Study. *Obesity Reviews* . 2009. (Epublished ahead of print.)
5 Birmingham CL, Muller JL, Palepu A et al. The Cost of Obesity in Canada. *Canadian Medical Association Journal* . 1999; 160(4): 483-8.
6 Katzmarzyk PT, Janssen I. The Economic Costs Associated with Physical Inactivity and Obesity in Canada: An Update. *Canadian Journal of Applied Physiology* . 2004; 29(1): 90-115.
7 Katzmarzyk PT, Gledhill N, Shephard RJ. The Economic Burden of Physical Inactivity in Canada. *Canadian Medical Association Journal* . 2000; 163(11): 1435-40.
8 Colman R. *Cost of Obesity in Manitoba* . 2000.

The work of these Canadian study groups, especially in the compilation of RR information, is often cited by researchers in other jurisdictions. This is acceptable because, although there can be some genetic modification related to different ethnic groups, as well as influence from causal cofactors, RR data are usually assumed to be quite stable across human populations.[10]

Following the lead of other researchers, the Canadian summary work on RR will also be heavily drawn upon for this project. However, as will be made clear below, some augmentation was called for (in particular with respect to smoking) based on newer and/or more comprehensive analyses that are available.

The general criteria to select a RR source led to the following choices:

- For the sake of consistent methodology, an omnibus source covering a comprehensive list of the key diseases associated with the risk factor was preferred, rather than piecing together a large number of individual disease analyses
- A high quality meta-analysis was the first place to turn, where quality was determined by the range of studies and the combined sample size
- Total population data, as well as disaggregated information for males and females, were important
- 95% confidence intervals should be provided (in order to assess statistical significance)

It became evident that it was not possible to fulfill all of the criteria for each risk factor and disease.

RR Related to Smoking

Two main sources were consulted to assemble the information on RR for chronic disease related to smoking:

- With reference to cardiovascular disease and several other pathologies, the U.S. Surgeon-General's 2004 report on the health consequences of smoking[11]
- With reference to cancer, an Italian paper by Gandini et al. that conducted a detailed meta-analysis specific to all of the smoking-related cancers identified by the International Agency for Research on Cancer (IARC) in its 2002 monograph on *Tobacco Smoke and Involuntary Smoking* [12]

These sources offer several advantages over the best-known Canadian work in this area (by Rehm et al.). First, information is more consistently disaggregated for males and females. In addition, an independent meta-analysis was performed by Gandini et al. (with confidence intervals included). This contrasts with the approach of Rehm and colleagues, who tended to focus on the best meta-analysis or review for each disease of interest that was available in the literature at the time of their work.[13] In addition, the RR data are not usually disaggregated by gender, and confidence intervals are not provided. Thus, the Rehm data are used sparingly.

Table 2 provides the smoking- related RR information identified by the sources noted above.

Table 2. Smoking-Related Relative Risks

Current Smokers

Stratified by Disease Category and Gender

Disease category	IDC-9	Males	95% CI		Females	95% CI		Total	95% CI		Source
Neoplasms											
Lip, oral cavity, pharynx	140-149	10.90	NA		5.10	NA					Surgeon General, 2004
Esophagus	150	2.52	1.81	3.52	2.28	1.51	3.44	2.50	2.00	3.13	Gandini, 2008
Stomach	151	1.74	1.46	2.07	1.45	1.20	1.75	1.64	1.37	1.95	Gandini, 2008
Liver	155,156	1.85	1.21	2.83	1.49	1.12	1.98	1.56	1.29	1.87	Gandini, 2008
Pancreas	157	1.63	1.32	2.03	1.73	1.31	2.30	1.70	1.51	1.91	Gandini, 2008
Larynx	161	6.98			6.98			6.98	3.14	15.50	Gandini, 2008
Trachea, bronchus, lung	162	9.87	6.85	14.24	7.58	5.36	10.73	8.96	6.73	12.10	Gandini, 2008
Cervix uteri	180				1.83	1.51	2.21				Gandini, 2008
Urinary bladder	188	2.80	2.01	3.92	2.73	1.82	4.10	2.77	2.17	3.54	Gandini, 2008
Kidney, other urinary	189	1.59	1.32	1.91	1.35	1.05	1.73	1.52	1.33	1.74	Gandini, 2008
Cardiovascular Diseases											
Ischemic heart disease	410-414										
Aged 35–64 years		2.80	NA		3.10	NA					Surgeon General, 2004
Aged ≥65 years		1.50	NA		1.60	NA					Surgeon General, 2004
Other heart disease	390-398, 415-417	1.80	NA		1.50	NA					Surgeon General, 2004
Cerebrovascular disease	430-438										
Aged 35–64 years		3.30	NA		4.00	NA					Surgeon General, 2004
Aged ≥65 years		1.60	NA		1.50	NA					Surgeon General, 2004
Atherosclerosis	440	2.40	NA		1.80	NA					Surgeon General, 2004
Aortic aneurysm	441	6.20	NA		7.10	NA					Surgeon General, 2004
Other arterial disease	442-448	2.10	NA		2.20	NA					Surgeon General, 2004
Respiratory Diseases											
Pneumonia, influenza	480-487	1.47	NA		1.47	NA					Rehm, 2006
Bronchitis, emphysema	490-492	17.10	NA		12.00	NA					Surgeon General, 2004
Chronic airways obstruction	496	9.80	NA		9.80	NA					Rehm, 2006

Sources: Rehm, et al. *The Costs of Substance Abuse in Canada 2002, Supplemental Table APP-11*
Gandini, et al. *International Journal of Cancer*, 2008
U.S. Department of Health and Human Services, *The Health Consequences of Smoking: A Report of the Surgeon General*, 2004

RR Related to Overweight and Obesity

In preparation for their major update on the economic burden of overweight and obesity in Canada, Anis et al. prepared a formal systematic review and meta-analysis of the available literature on RR of chronic conditions associated with overweight and obesity. Their results are summarized in Table 3. It should be noted that the analysis did not control for physical inactivity since "physical inactivity is often poorly reported and requiring its inclusion would have reduced the number of included studies." [14]

Table 3. Weight-Related Summary RRs

For Chronic Diseases and Conditions, By Gender

	Overweight (25 ≤ BMI < 30)						Obesity (BMI ≥ 30)					
Chronic Comorbidity	M	95% CI		F	95% CI		M	95% CI		F	95% CI	
Hypertension	1.28	1.10	1.50	1.65	1.24	2.19	1.84	1.51	2.24	2.42	1.59	3.67
Type 2 diabetes	2.40	2.12	2.72	3.92	3.10	4.97	6.74	5.55	8.19	12.41	9.03	17.06
Coronary artery disease	1.29	1.18	1.41	1.80	1.64	1.98	1.72	1.51	1.96	3.10	2.81	3.43
Gallbladder disease				1.44	1.05	1.98	1.43	1.04	1.96	2.32	1.17	4.57
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
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
Colorectal cancer	1.51	1.37	1.67	1.45	1.30	1.62	1.95	1.59	2.39	1.66	1.52	1.81
Postmenopausal breast cancer				1.08	1.03	1.14				1.13	1.05	1.22
Endometrial cancer				1.53	1.45	1.61				3.22	2.91	3.56
Osteoarthritis	2.76	2.05	3.70	1.80	1.75	1.85	4.20	2.76	6.41	1.96	1.88	2.04
Oesophageal cancer	1.13	1.02	1.26									
Kidney cancer	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 cancer				1.18	1.12	1.23				1.28	1.20	1.36
Pancreatic cancer							2.29	1.65	3.19	1.60	1.17	2.20
Congestive heart failure							1.79	1.24	2.59	1.78	1.07	2.95
Asthma	1.20	1.08	1.33	1.25	1.05	1.49	1.43	1.14	1.79	1.78	1.36	2.32
Chronic back pain	1.59	1.34	1.89	1.59	1.34	1.89	2.81	2.27	3.48	2.81	2.27	3.48

Source: Anis et al. *Obesity Reviews* (2009)

RR Related to Physical Inactivity

Relative risk information for physical inactivity was based on the work of Katzmarzyk and Janssen.[15] Their analysis did in fact control for overweight and obesity, and thus the RR associated with physical inactivity is independent of the interaction with overweight and obesity. The authors did not, however, provide information on RR by gender. To determine any differences by gender, additional disease-specific analyses were sought that provided such information. For instance, the work by Wendel-Vos, et al. on the relationship between physical inactivity and stroke suggested that overall there was no significant difference between genders.[16] The gender difference for leisure-time physical activity and *hemorrhagic stroke* did approach significance (p=0.07), with a RR of 0.54 (95%CI 0.36-0.81) for males and 0.76 (95% CI 0.67-0.86) for females. Hemorrhagic strokes, however, constitute only 10-20% of total strokes. Two studies on the relationship between physical inactivity and colon cancer also found no significant gender differences with respect to RR.[17,18] Based on these results, it was assumed that there were no significant differences between males and females in terms of the RR for chronic disease associated with physical inactivity.

Table 4 provides a summary of the physical inactivity-related RR information.

Table 4. Physical Inactivity-Related Summary RRs
For Chronic Diseases and Conditions, By Gender

							Combined*		
Chronic Comorbidity	M	95% CI		F	95% CI			95% CI	
Coronary artery disease	1.45	1.38	1.54	1.45	1.38	1.54	1.45	1.38	1.54
Stroke	1.60	1.42	1.80	1.60	1.42	1.80	1.60	1.42	1.80
Hypertension	1.30	1.16	1.46	1.30	1.16	1.46	1.30	1.16	1.46
Colon cancer	1.41	1.31	1.53	1.41	1.31	1.53	1.41	1.31	1.53
Breast cancer				1.31	1.23	1.38			
Type 2 diabetes	1.50	1.37	1.63	1.50	1.37	1.63	1.50	1.37	1.63
Osteoporosis	1.59	1.40	1.80	1.59	1.40	1.80	1.59	1.40	1.80

Source: Katzmarzyk and Janssen, Canadian Journal of Applied Physiology (2004)*

Estimating the Population Exposed to the Risk Factor

As noted briefly above, once RR has been established, E is the other data point required to calculate PAR. A RR figure may be reliably generalized across different jurisdictions, especially if it is derived through multiple studies in multiple international settings.

The E metric differs from RR in an important way. In contrast with RR, exposure to a risk factor ***does*** vary from area to area and group to group, as well as over time. This is why E information is often a focus of ongoing public health surveillance. When the variable E data are combined with RR, they produce PARs that also vary from population to population. Thus, PAR information from one area (e.g., a province or state) cannot be assumed to apply to another; the assumption is that PAR will vary from population to population based on variation in the underlying E information. In addition, the PAR data can be quite different between groups living within the same province. For example, a higher proportion of socio-economically disadvantaged individuals are likely to be exposed to a risk factor compared with socio-economically advantaged individuals, and thus the PAR will be higher for the socio-economically disadvantaged group.

In summary, exposure (or risk factor prevalence) data that are as accurate as possible must be developed for each new jurisdiction. This underlines why high-quality, population-based registries and surveys are so important.

Sources of E Data

The population prevalence, or E, data for the risk factors of smoking, overweight/obesity, and physical inactivity were drawn from three main sources: the *Canadian Community Health Survey (CCHS)*, the *Canadian Tobacco Use Monitoring Survey (CTUMS)*, and Manitoba-specific studies. These sources are discussed in the following subsections.

Canadian Community Health Survey (CCHS)

The *CCHS* is a cross-sectional survey that collects information related to health status, health care utilization, and health determinants for the Canadian population. Prior to 2007, data collection occurred every two years for an annual period. Data are available for the 2001, 2003 and 2005 periods. In 2007, major changes were made to the survey design, resulting in yearly data collection; thus, data are available for 2007 and 2008. The target population of the CCHS is Canadians aged 12 years and older, living in privately occupied dwellings in health regions covering all provinces and territories. Excluded from the survey are individuals living on Indian Reserves and on Crown Lands, institutional residents, full-time members of the Canadian Forces, and residents of certain remote regions.

Canadian Tobacco Use Monitoring Survey (CTUMS)

CTUMS is a semi-annual survey that has been conducted for Health Canada since 1999, and provides data on tobacco use and related issues. The target population for this cross-sectional sample survey is all persons 15 years of age and over living in Canada, with the exception of: (a) residents of the Yukon, Northwest Territories, and Nunavut; and (b) full-time residents of institutions. The primary objective of the survey is to track changes in smoking status, especially for populations most at risk, such as 15 to 24 year olds.

Manitoba-Specific Sources

Three Manitoba-specific sources were used to obtain data regarding risk factor exposure. Two sources focus on physical inactivity levels (the *Manitoba RHA Indicators Atlas 2009* and the *in motion Survey*), while the emphasis of the third is Manitoba's youth (the *Manitoba Youth Health Survey*).

The *Indicators Atlas* was produced by the Manitoba Centre for Health Policy (MCHP) to provide indicators of population health status, health care use, and quality of care for residents of all 11 Regional Health Authorities (RHAs) of Manitoba.[19] The benchmark *in motion Survey*, released in 2007, was conducted by researchers at the Health, Leisure and Human Performance Research Institute at the University of Manitoba.[20] It was undertaken to obtain a baseline measurement of Manitobans' physical activity levels to compare against the minimum recommendations of Canada's Physical Activity Guide. A stratified random sample of adults from the 10 RHAs outside of Winnipeg, and from the twelve Community Areas within the Winnipeg Health Region, was surveyed by telephone in May and June of 2005.[21] The study is unique because it incorporates all types of physical activity; participants were asked about their level of engagement not only in sports or exercise, but also in routine physical activities.

A final resource for the project involved the *Manitoba Youth Health Survey*. It is a province-wide chronic disease risk factor surveillance system that was implemented at the community level between 2005 and 2008.[22] All 11 of Manitoba's RHAs participated in the survey in an effort to build prevention capacity in Manitoba. The survey was completed at 390 schools, covering approximately 50,000 students in grades 6 to 12. Students were asked to self-report their status on various risk factors, including tobacco use, nutrition, physical activity, self-esteem, and school connectedness.

For each of the risk factors in this project, one or more of the above sources was used to obtain population prevalence data for Manitoba. The specific variables measured by each of the sources are defined below for the three risk factors, and the data analysis methods are outlined. A special section on the risk factors in Manitoba youth appears at the end of this section of the Supporting Document.

Manitoba Geographic Areas

For the purposes of this project, Manitoba's 11 Regional Health Authorities were grouped into four geographic areas, based on work by the MCHP.

1. Rural South + Brandon
   - South Eastman
   - Central
   - Assiniboine
   - Brandon
2. Mid
   - North Eastman
   - Interlake
   - Parkland
3. North
   - Norman
   - Burntwood/Churchill
4. Winnipeg

Smoking Prevalence

The main data source used for smoking prevalence data is the *CCHS* (with *CTUMS* and the *Manitoba Youth Health Survey* used to assess trends in youth smoking); survey data regarding daily smokers and occasional smokers consistently offered the foundational information applied to this project. The status of "daily smoker" or "occasional smoker" was determined from the response to the question "At the present time do you smoke cigarettes every day, occasionally, or not at all?" as found in both CCHS and CTUMS. The term "current smoker" includes daily smokers and occasional (non-daily) smokers. The term "non-smoker" is a combination of "former smokers" and "never-smokers"; the latter two terms are defined differently in the two surveys. In CTUMS, a "former smoker" was not smoking at the time of the interview, but answered "YES" to the question "Have you smoked at least 100 cigarettes in your life?" In CCHS, the "former smoker" status is divided into two categories: "former daily smoker" (not smoking now, but used to smoke daily) and "former occasional smoker" (not smoking now, but has smoked at least one whole cigarette). In CTUMS, a "never-smoker" was not smoking at the time of the interview and answered "NO" to the question "Have you smoked at least 100 cigarettes in your life?"; in CCHS, a "never-smoker" was not smoking at the time of the interview and never smoked a whole cigarette.

Canadian Community Health Survey (CCHS)

The following figure and four tables provide information on smoking rates by geographic area and gender between 2003 and 2008, based on the CCHS. Multiple years of data are presented to allow for comparisons over time. In the modelling, the 2008 CCHS data was utilized.

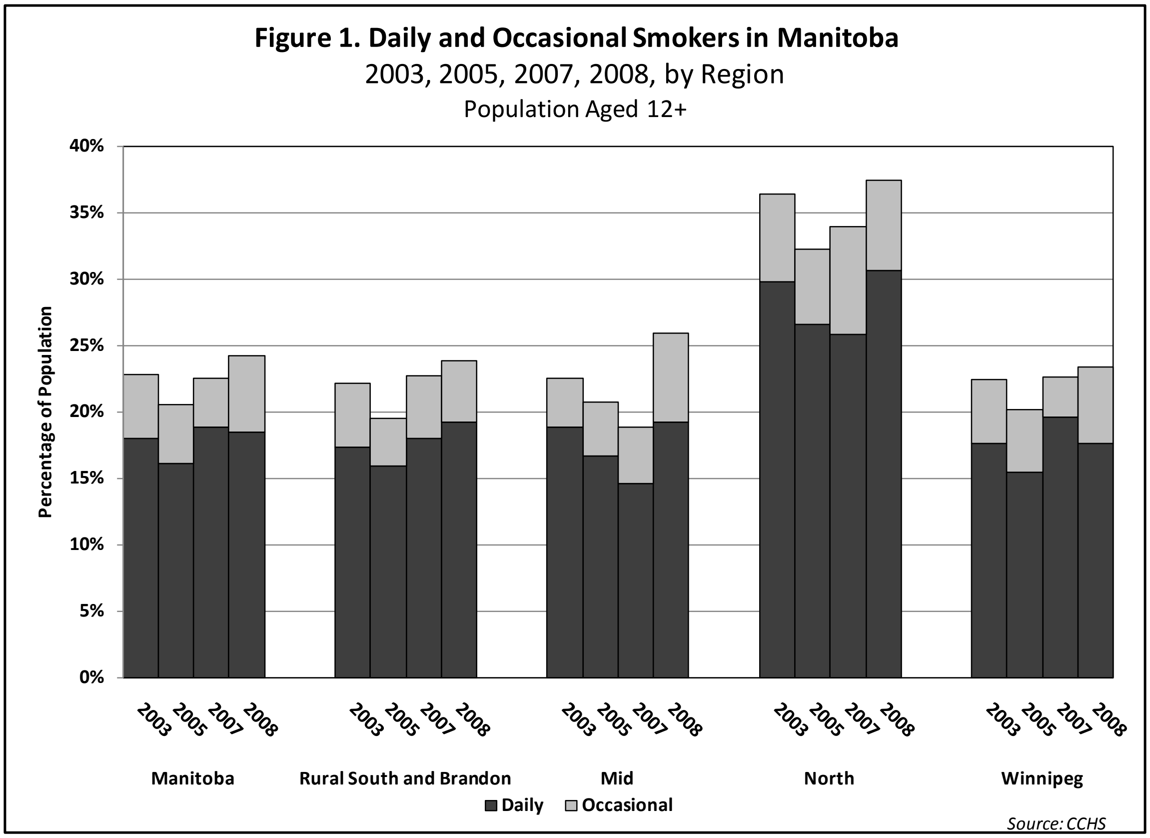


Table 5. Smoking in Manitoba
2008 CCHS
Ages 12 and Over

RHA	% Daily Males	% Daily Females	% Daily Total	% Occasional Males	% Occasional Females	% Occasional Total
Rural South + Brandon						
South Eastman	20.3%	15.5%	18.0%	5.4%	3.3%	4.4%
Central	23.8%	13.9%	18.9%	6.5%	5.7%	6.1%
Assiniboine	20.2%	16.2%	18.1%	2.2%	4.7%	3.5%
Brandon	31.0%	14.7%	22.7%	2.6%	4.1%	3.4%
Total Rural South + Brandon	23.4%	15.0%	19.2%	4.6%	4.6%	4.6%
Mid						
North Eastman	21.0%	22.1%	21.5%	6.5%	3.8%	5.2%
Interlake	14.5%	18.7%	16.5%	7.0%	10.0%	8.4%
Parkland	23.9%	21.0%	22.3%	7.4%	2.8%	4.9%
Total Mid	18.2%	20.2%	19.2%	7.0%	6.5%	6.7%
North						
Norman	28.3%	30.5%	29.5%	1.1%	5.5%	3.4%
Burntwood/Churchill	35.0%	27.6%	31.6%	7.3%	12.5%	9.7%
Total North	32.1%	29.0%	30.6%	4.6%	9.1%	6.8%
Winnipeg	19.1%	16.1%	17.6%	8.0%	3.7%	5.8%
Manitoba	**20.4%**	**16.7%**	**18.5%**	**6.9%**	**4.4%**	**5.7%**

Table 6. Smoking in Manitoba 2007 CCHS Ages 12 and Over						
	% Daily			*% Occasional*		
RHA	**Males**	**Females**	**Total**	**Males**	**Females**	**Total**
Rural South + Brandon						
South Eastman	16.2%	22.5%	19.2%	4.8%	2.1%	3.5%
Central	17.7%	11.2%	14.5%	5.8%	6.6%	6.2%
Assiniboine	22.6%	19.7%	21.1%	7.5%	3.8%	5.6%
Brandon	20.3%	18.5%	19.4%	1.8%	2.2%	2.0%
Total Rural South + Brandon	18.9%	17.2%	18.0%	5.3%	4.1%	4.7%
Mid						
North Eastman	16.1%	22.3%	19.2%	7.9%	1.9%	4.9%
Interlake	12.9%	12.6%	12.7%	6.6%	2.7%	4.6%
Parkland	16.0%	11.6%	13.8%	1.6%	3.4%	2.5%
Total Mid	14.5%	14.8%	14.6%	5.8%	2.7%	4.2%
North						
Norman	21.7%	26.3%	24.0%	6.7%	10.1%	8.4%
Burntwood/Churchill	30.5%	23.2%	27.2%	7.5%	8.4%	7.9%
Total North	26.8%	24.7%	25.8%	7.2%	9.2%	8.1%
Winnipeg	21.3%	18.0%	19.6%	4.7%	1.4%	3.0%
Manitoba	**20.0%**	**17.6%**	**18.8%**	**5.1%**	**2.4%**	**3.7%**

Table 7. Smoking in Manitoba 2005 CCHS Ages 12 and Over						
	% Daily			*% Occasional*		
RHA	**Males**	**Females**	**Total**	**Males**	**Females**	**Total**
Rural South + Brandon						
South Eastman	15.0%	17.4%	16.2%	3.7%	2.6%	3.2%
Central	17.2%	14.0%	15.6%	6.1%	1.9%	4.0%
Assiniboine	12.5%	14.5%	13.5%	2.5%	2.1%	2.3%
Brandon	19.3%	19.0%	19.1%	5.9%	4.2%	5.0%
Total Rural South + Brandon	15.9%	15.8%	15.9%	4.7%	2.5%	3.6%
Mid						
North Eastman	21.4%	13.7%	17.6%	2.1%	3.2%	2.6%
Interlake	17.2%	14.7%	16.0%	4.0%	1.9%	3.0%
Parkland	18.8%	16.1%	17.4%	8.6%	6.1%	7.3%
Total Mid	18.6%	14.8%	16.7%	4.7%	3.3%	4.0%
North						
Norman	28.5%	16.1%	22.4%	4.8%	8.3%	6.5%
Burntwood/Churchill	31.7%	29.6%	30.7%	5.2%	4.2%	4.7%
Total North	30.1%	23.0%	26.6%	5.0%	6.2%	5.6%
Winnipeg	15.8%	15.1%	15.4%	5.5%	4.1%	4.8%
Manitoba	**16.7%**	**15.5%**	**16.1%**	**5.2%**	**3.7%**	**4.4%**

Table 8. Smoking in Manitoba 2003 CCHS Ages 12 and Over						
	% Daily			*% Occasional*		
RHA	**Males**	**Females**	**Total**	**Males**	**Females**	**Total**
Rural South + Brandon						
South Eastman	20.6%	15.4%	18.1%	6.3%	3.7%	5.0%
Central	18.7%	14.0%	16.4%	8.6%	3.4%	6.0%
Assiniboine	19.0%	14.3%	16.6%	3.9%	3.5%	3.7%
Brandon	18.5%	19.4%	19.0%	4.5%	3.3%	3.9%
Total Rural South + Brandon	19.2%	15.4%	17.3%	6.2%	3.5%	4.8%
Mid						
North Eastman	17.2%	17.1%	17.2%	4.8%	1.9%	3.4%
Interlake	19.9%	19.5%	19.7%	4.1%	2.8%	3.5%
Parkland	20.5%	16.4%	18.4%	3.5%	5.8%	4.7%
Total Mid	19.4%	18.1%	18.8%	4.1%	3.4%	3.7%
North						
Norman	27.1%	20.6%	23.9%	3.8%	6.6%	5.2%
Burntwood/Churchill	37.7%	33.9%	35.9%	8.1%	7.9%	8.0%
Total North	32.4%	27.2%	29.8%	5.9%	7.2%	6.6%
Winnipeg	16.3%	18.8%	17.6%	5.1%	4.6%	4.8%
Manitoba	**17.9%**	**18.2%**	**18.0%**	**5.3%**	**4.3%**	**4.8%**

Overweight and Obesity Prevalence

A common statistical measurement used to categorize individuals as overweight or obese is the body mass index, or BMI. It compares an individual's height and weight through the formula weight (kg) divided by height (m) squared, or:

$$\frac{kg}{m^2}$$

Classifications according to BMI are as follows:

BMI < 18.5	Underweight
BMI $\geq$ 18.5 and < 25	Normal weight
BMI $\geq$ 25 and < 30	Overweight
BMI $\geq$ 30	Obese

The "obese" classification is usually divided into three subcategories, as follows:

BMI $\geq$ 30 and < 35	Obese – Class I
BMI $\geq$ 35 and < 40	Obese – Class II
BMI $\geq$ 40	Obese – Class III

It should be noted that the "normal weight" BMI cut-off has been dynamic historically; it ranged from 22.7 to 27.3 in the 1970s.[23] The possibility of a universal application of such cut-offs is the subject of international debate. For example, it has been recommended that populations within the Asia-Pacific region should have a lower BMI cut-off to define overweight and obesity; this is due to the fact that increases in health-related risk factors and comorbidities associated with obesity occur at a lower BMI in Asian populations than in other ethnic groups.[24,25,26] Debates continue in North America as well. In a study by Hu et al., it was reported that women with a BMI between 25.0 and 26.9, usually classified as overweight, in fact do *not* have a statistically elevated risk of premature mortality (all causes).[27]

To sum up, although it may be useful to use standard BMI classifications when comparing data from different studies and countries, "health risks associated with overweight and obesity are part of a continuum and at a given BMI may vary when a specific population is observed. These BMI cut-off points should be considered as a guide to allow for the comparisons among various populations and over time."[28]

Another measurement of overweight and obesity, in this instance specific to abdominal fat, is waist circumference (WC). It has been reported that obesity derived from WC measurements is a better predictor of many cardiovascular diseases than the traditional BMI measurement.[29] In cases where BMI may overestimate body fat (e.g., individuals with a muscular build) or underestimate body fat (e.g., individuals with less muscle, such as the elderly), WC may be a more useful measurement. The classifications for WC according to the World Health Organization are as follows:

Men	WC $\geq$ 94 cm	abdominally overweight
	WC $\geq$ 102 cm	obese
Women	WC $\geq$ 80 cm	abdominally overweight
	WC $\geq$ 88 cm	obese

Anis et al., for example, used WC data to analyze the obesity- and overweight-related co-morbidities of type II diabetes, hypertension, coronary artery disease, and gallbladder disease to determine the associated PAR, but used BMI for all other co-morbidities.[30] We followed the approach of Anis et al. in using WC rather than BMI to analyze the obesity- and overweight-related co-morbidities of type II diabetes, hypertension, coronary artery disease, and gallbladder disease.

Canadian Community Health Survey (CCHS)

The following figure and four tables provide information on overweight and obesity rates by geographic area and gender between 2003 and 2008, based on the CCHS. Multiple years of data are presented to allow for comparisons over time. In the modelling, the 2008 CCHS data was utilized.

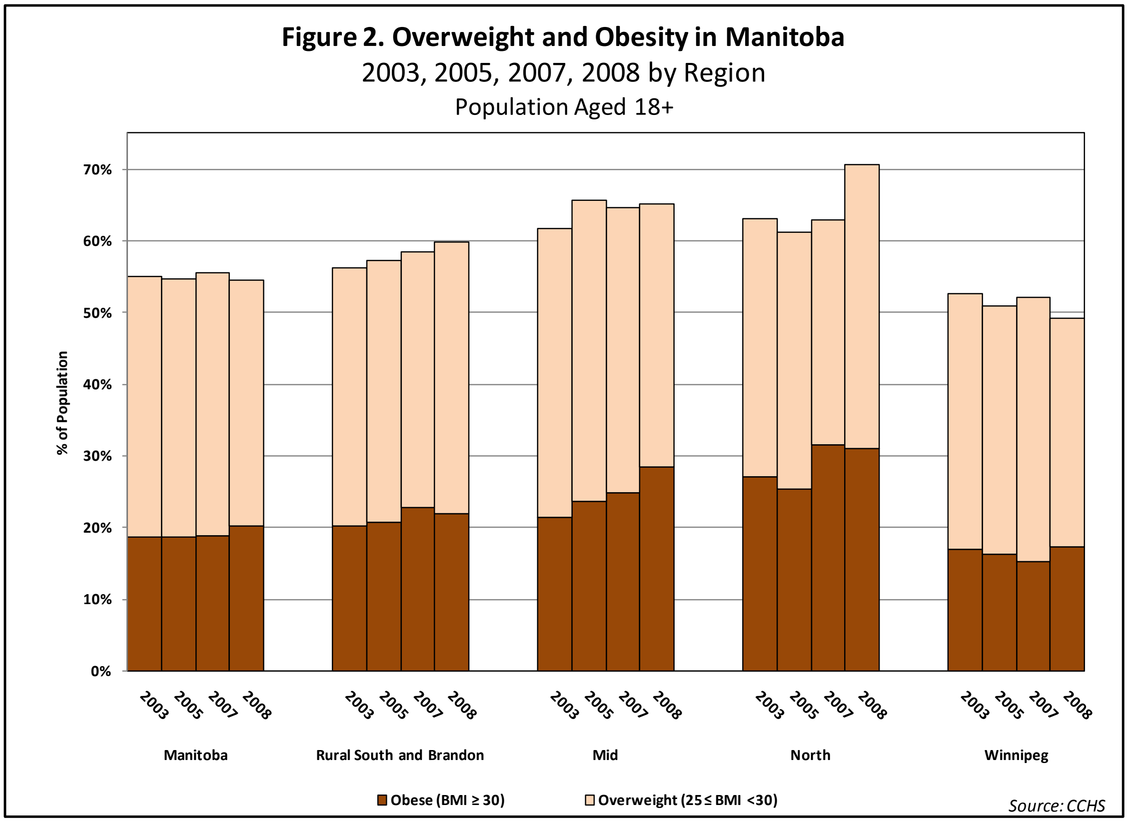


Table 9. Overweight and Obesity in Manitoba
2008 CCHS

Ages 18 and Over, Based on Self-reported Weight and Height

	% Overweight (25 < BMI < 30)			*% Obesity (BMI > 30)*		
RHA	**Males**	**Females**	**Total**	**Males**	**Females**	**Total**
Rural South + Brandon						
South Eastman	42.0%	42.9%	42.4%	22.8%	14.9%	19.1%
Central	48.9%	28.4%	39.3%	19.1%	19.4%	19.2%
Assiniboine	40.3%	32.7%	36.5%	30.3%	22.5%	26.4%
Brandon	35.4%	29.4%	32.4%	24.2%	24.5%	24.4%
Total Rural South + Brandon	**42.9%**	**32.8%**	**38.0%**	**23.4%**	**20.2%**	**21.9%**
Mid						
North Eastman	45.5%	28.0%	37.2%	19.4%	16.0%	17.8%
Interlake	35.6%	35.1%	35.4%	38.5%	30.5%	34.7%
Parkland	49.6%	30.1%	39.2%	28.2%	23.2%	25.5%
Total Mid	**41.1%**	**32.1%**	**36.7%**	**31.5%**	**25.2%**	**28.4%**
North						
Norman	41.2%	31.5%	36.4%	35.9%	28.0%	32.0%
Burntwood/Churchill	44.1%	40.0%	42.3%	29.7%	30.7%	30.1%
Total North	**42.8%**	**35.9%**	**39.6%**	**32.4%**	**29.4%**	**31.0%**
Winnipeg	39.0%	24.9%	31.9%	16.8%	17.8%	17.3%
Manitoba	**40.3%**	**28.0%**	**34.2%**	**20.9%**	**19.6%**	**20.3%**

Table 10. Overweight and Obesity in Manitoba
2007 CCHS

Ages 18 and Over, Based on Self-reported Weight and Height

	% Overweight (25 < BMI < 30)			*% Obesity (BMI > 30)*		
RHA	Males	Females	Total	Males	Females	Total
Rural South + Brandon						
South Eastman	45.2%	25.6%	36.3%	21.8%	23.1%	22.4%
Central	42.1%	30.7%	36.7%	22.6%	23.5%	23.0%
Assiniboine	37.3%	35.8%	36.6%	28.9%	20.2%	24.6%
Brandon	28.5%	35.6%	32.2%	21.6%	19.3%	20.4%
Total Rural South + Brandon	**39.2%**	**31.9%**	**35.7%**	**23.7%**	**21.7%**	**22.8%**
Mid						
North Eastman	42.2%	36.1%	39.3%	22.8%	21.1%	22.0%
Interlake	45.6%	37.1%	41.4%	21.2%	28.4%	24.7%
Parkland	45.5%	28.5%	37.0%	31.0%	25.0%	28.0%
Total Mid	**44.7%**	**34.7%**	**39.8%**	**24.0%**	**25.7%**	**24.8%**
North						
Norman	31.3%	30.5%	30.9%	31.2%	28.4%	29.9%
Burntwood/Churchill	37.0%	25.4%	31.7%	34.1%	31.7%	33.0%
Total North	**34.4%**	**27.8%**	**31.3%**	**32.8%**	**30.1%**	**31.6%**
Winnipeg	43.8%	29.9%	36.8%	17.3%	13.4%	15.3%
Manitoba	**42.5%**	**30.9%**	**36.8%**	**20.2%**	**17.3%**	**18.8%**

Table 11. Overweight and Obesity in Manitoba
2005 CCHS

Ages 18 and Over, Based on Self-reported Weight and Height

	% Overweight (25 < BMI < 30)			*% Obesity (BMI > 30)*		
RHA	Males	Females	Total	Males	Females	Total
Rural South + Brandon						
South Eastman	41.5%	29.9%	36.0%	16.1%	18.8%	17.4%
Central	38.4%	28.7%	33.7%	20.9%	22.2%	21.5%
Assiniboine	47.8%	29.5%	38.8%	24.2%	22.6%	23.4%
Brandon	44.7%	33.5%	38.9%	21.6%	17.1%	19.3%
Total Rural South + Brandon	**42.6%**	**30.1%**	**36.5%**	**20.8%**	**20.6%**	**20.7%**
Mid						
North Eastman	45.7%	35.6%	40.9%	23.1%	23.4%	23.2%
Interlake	46.0%	39.9%	43.0%	27.4%	23.8%	25.7%
Parkland	50.6%	31.7%	41.2%	17.0%	23.3%	20.1%
Total Mid	**47.1%**	**36.8%**	**42.0%**	**23.8%**	**23.6%**	**23.7%**
North						
Norman	37.3%	29.1%	33.6%	35.3%	17.9%	27.4%
Burntwood/Churchill	45.9%	29.1%	38.1%	25.9%	20.3%	23.3%
Total North	**41.6%**	**29.1%**	**35.9%**	**30.6%**	**19.1%**	**25.3%**
Winnipeg	41.3%	28.2%	34.6%	18.2%	14.5%	16.3%
Manitoba	**42.4%**	**29.7%**	**36.0%**	**19.9%**	**17.2%**	**18.6%**

Table 12. Overweight and Obesity in Manitoba 2003 CCHS Ages 18 and Over, Based on Self-reported Weight and Height	% Overweight (25 < BMI < 30)			% Obesity (BMI > 30)		
RHA	Males	Females	Total	Males	Females	Total
Rural South + Brandon						
South Eastman	43.7%	31.4%	37.9%	23.3%	14.4%	19.1%
Central	39.9%	29.6%	35.1%	21.3%	19.9%	20.6%
Assiniboine	43.2%	30.6%	36.8%	20.1%	20.7%	20.4%
Brandon	40.0%	28.6%	34.2%	25.2%	16.0%	20.6%
Total Rural South + Brandon	**41.6%**	**30.0%**	**36.0%**	**22.1%**	**18.3%**	**20.3%**
Mid						
North Eastman	40.8%	32.1%	37.0%	18.6%	21.6%	19.9%
Interlake	50.3%	28.2%	39.6%	23.2%	18.9%	21.1%
Parkland	53.9%	35.0%	44.6%	21.6%	25.0%	23.3%
Total Mid	**48.7%**	**30.9%**	**40.3%**	**21.6%**	**21.2%**	**21.4%**
North						
Norman	41.1%	30.6%	36.4%	22.3%	32.5%	26.9%
Burntwood/Churchill	42.6%	27.4%	35.4%	31.2%	23.2%	27.4%
Total North	**41.8%**	**29.0%**	**35.9%**	**26.6%**	**27.8%**	**27.1%**
Winnipeg	42.4%	28.8%	35.6%	18.2%	15.9%	17.0%
Manitoba	**43.0%**	**29.4%**	**36.3%**	**19.8%**	**17.4%**	**18.7%**

Physical Inactivity Prevalence

In order to determine the physical activity level of an individual and compare this across a population, the intensity level of the specific activities in which an individual participates must be classified. A standard way to accomplish this is to use metabolic equivalents (METs), or multiples of resting oxygen uptake. The MET is a ratio comparing a person's metabolic rate while at rest to their metabolic rate while performing a task; for example, an activity of 4 METs requires four times the amount of energy compared to when the body is at rest. One MET is defined as the energy cost of sitting quietly; it is equivalent to a caloric consumption of 1 kcal/kg/hour. The MET value is often expressed in three intensity levels: low (< 3 METs), moderate (3 to 6 METs), and vigorous (> 6 METs).[31]

Canadian Community Health Survey (CCHS)

In the CCHS, respondents were not asked to specify the intensity level of their activities. Therefore, MET values corresponding to the low intensity value were assigned to each of the activities in the survey. Some common activities and their corresponding MET values (assigned by CCHS for survey questions) are given below:

Walking for exercise	MET 3
Golfing	MET 4
Ice hockey	MET 6
Jogging or running	MET 9.5

The MET value is used in calculating the daily Energy Expenditure (EE) for each activity; this is a measure of the average daily energy expended during leisure time activities by the respondent in the past three months. It is calculated using the frequency and duration per session of the physical activity, as well as the MET value of the activity (see below).

Average Daily EE (Energy Expenditure for each activity) = (N x D x METvalue) / 365

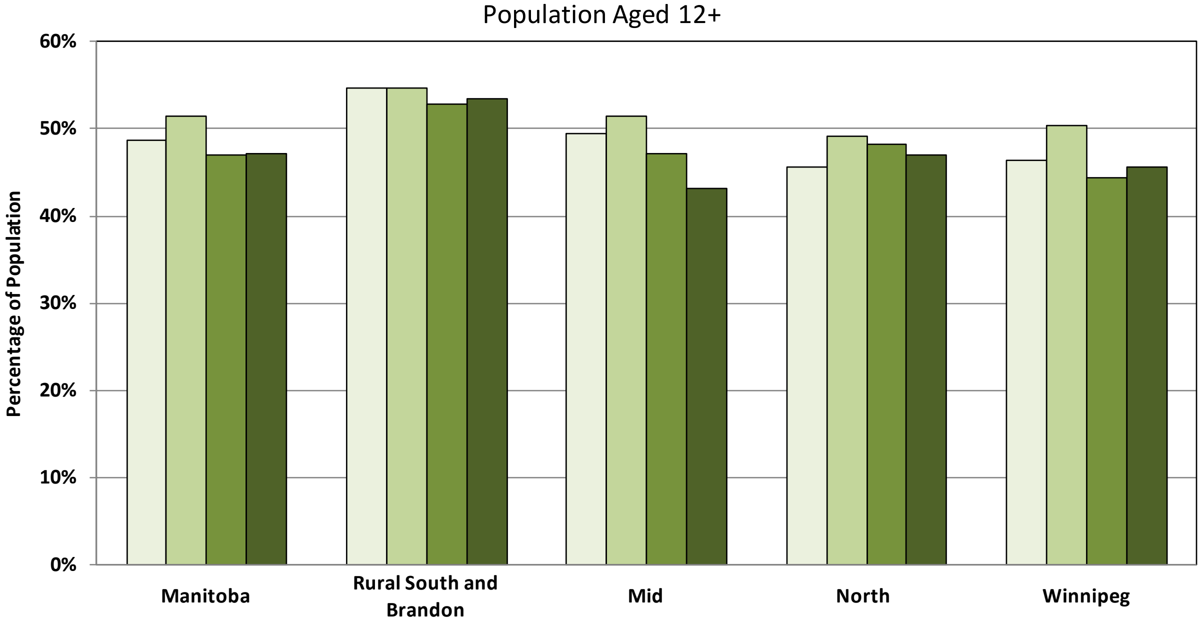
Where: **N** = number of times a respondent engaged in an activity over a 12-month period
D = the average duration in hours of the activity
MET value = energy cost of the activity expressed as (kcal/kg/hour)/365

CCHS respondents are then categorized as being “active,” “moderate,” or “inactive” based on the sum of the calculated average daily EE values (kcal/kg/day, or KKD) for their leisure time activities, as follows:

EE $\geq$ 3 KKD	Active
EE $\geq$ 1.5 and < 3 KKD	Moderate
EE < 1.5 KKD	Inactive

The following figure and four tables provide information on leisure-time physical inactivity by geographic area and gender between 2003 and 2008, based on the CCHS. Multiple years of data are presented to allow for comparisons over time. In the modelling, the 2008 CCHS data was utilized.

Figure 3. Leisure Time Physical Inactivity (<1.5 KKD) in Manitoba
2003, 2005, 2007, 2008, by Region
Population Aged 12+



	Manitoba	Rural South and Brandon	Mid	North	Winnipeg
2003	48.7%	54.6%	49.4%	45.6%	46.4%
2005	51.5%	54.7%	51.4%	49.1%	50.4%
2007	47.0%	52.9%	47.2%	48.3%	44.4%
2008	47.2%	53.5%	43.2%	47.0%	45.6%

Source: CCHS

Table 13. Leisure Time Physical Activity in Manitoba 2008 CCHS Ages 12 and Over						
	% Moderately Active or Active			*% Inactive*		
RHA	**Males**	**Females**	**Total**	**Males**	**Females**	**Total**
Rural South + Brandon						
South Eastman	46.7%	41.7%	44.3%	53.3%	58.3%	55.7%
Central	42.2%	48.0%	45.1%	57.8%	52.0%	54.9%
Assiniboine	45.5%	53.6%	49.7%	54.5%	46.4%	50.3%
Brandon	49.2%	46.7%	47.9%	50.8%	53.3%	52.1%
Total Rural South + Brandon	**45.3%**	**47.7%**	**46.5%**	**54.7%**	**52.3%**	**53.5%**
Mid						
North Eastman	53.1%	55.0%	54.1%	46.9%	45.0%	45.9%
Interlake	60.9%	57.0%	59.0%	39.1%	43.0%	41.0%
Parkland	50.5%	59.3%	55.3%	49.5%	40.7%	44.7%
Total Mid	**56.6%**	**57.1%**	**56.8%**	**43.4%**	**42.9%**	**43.2%**
North						
Norman	57.7%	54.1%	55.8%	42.3%	45.9%	44.2%
Burntwood/Churchill	50.6%	50.5%	50.6%	49.4%	49.5%	49.4%
Total North	**53.6%**	**52.3%**	**53.0%**	**46.4%**	**47.7%**	**47.0%**
Winnipeg	56.9%	52.0%	54.4%	43.1%	48.0%	45.6%
Manitoba	**53.9%**	**51.7%**	**52.8%**	**46.1%**	**48.3%**	**47.2%**

Table 14. Leisure Time Physical Activity in Manitoba 2007 CCHS Ages 12 and Over						
	% Moderately Active or Active			*% Inactive*		
RHA	**Males**	**Females**	**Total**	**Males**	**Females**	**Total**
Rural South + Brandon						
South Eastman	45.4%	52.0%	48.5%	54.6%	48.0%	51.5%
Central	41.9%	44.1%	43.0%	58.1%	55.9%	57.0%
Assiniboine	34.6%	53.7%	44.6%	65.4%	46.3%	55.4%
Brandon	64.8%	48.5%	56.3%	35.2%	51.5%	43.8%
Total Rural South + Brandon	**45.1%**	**49.0%**	**47.1%**	**54.9%**	**51.0%**	**52.9%**
Mid						
North Eastman	59.3%	55.0%	57.2%	40.7%	45.0%	42.8%
Interlake	54.2%	57.7%	56.0%	45.8%	42.3%	44.0%
Parkland	41.7%	41.5%	41.6%	58.3%	58.5%	58.4%
Total Mid	**52.6%**	**53.1%**	**52.8%**	**47.4%**	**46.9%**	**47.2%**
North						
Norman	58.7%	42.6%	50.5%	41.3%	57.4%	49.5%
Burntwood/Churchill	51.6%	53.8%	52.6%	48.4%	46.2%	47.4%
Total North	**54.6%**	**48.5%**	**51.7%**	**45.4%**	**51.5%**	**48.3%**
Winnipeg	58.8%	52.5%	55.6%	41.2%	47.5%	44.4%
Manitoba	**54.5%**	**51.6%**	**53.0%**	**45.5%**	**48.4%**	**47.0%**

Table 15. Leisure Time Physical Activity in Manitoba
2005 CCHS
Ages 12 and Over

	% Moderately Active or Active			% Inactive		
RHA	**Males**	**Females**	**Total**	**Males**	**Females**	**Total**
Rural South + Brandon						
South Eastman	46.7%	44.7%	45.7%	53.3%	55.3%	54.3%
Central	45.2%	35.8%	40.5%	54.8%	64.2%	59.6%
Assiniboine	40.4%	46.0%	43.3%	59.6%	54.0%	56.7%
Brandon	64.7%	50.3%	57.2%	35.3%	49.7%	42.8%
Total Rural South + Brandon	**47.8%**	**42.9%**	**45.3%**	**52.2%**	**57.1%**	**54.7%**
Mid						
North Eastman	61.0%	47.0%	54.0%	39.0%	53.0%	46.0%
Interlake	51.3%	47.0%	49.1%	48.7%	53.0%	50.9%
Parkland	43.9%	40.6%	42.2%	56.1%	59.4%	57.8%
Total Mid	**51.8%**	**45.4%**	**48.6%**	**48.2%**	**54.6%**	**51.4%**
North						
Norman	46.4%	52.6%	49.4%	53.6%	47.4%	50.6%
Burntwood/Churchill	57.4%	47.1%	52.3%	42.6%	52.9%	47.7%
Total North	**52.1%**	**49.7%**	**50.9%**	**47.9%**	**50.3%**	**49.1%**
Winnipeg	52.7%	46.8%	49.6%	47.3%	53.2%	50.4%
Manitoba	**51.4%**	**45.8%**	**48.5%**	**48.6%**	**54.2%**	**51.5%**

Table 16. Leisure Time Physical Activity in Manitoba
2003 CCHS
Ages 12 and Over

	% Moderately Active or Active			% Inactive		
RHA	**Males**	**Females**	**Total**	**Males**	**Females**	**Total**
Rural South + Brandon						
South Eastman	45.8%	46.2%	46.0%	54.2%	53.8%	54.0%
Central	46.9%	43.4%	45.1%	53.1%	56.6%	54.9%
Assiniboine	38.8%	45.5%	42.2%	61.2%	54.5%	57.8%
Brandon	55.5%	44.8%	49.9%	44.5%	55.2%	50.1%
Total Rural South + Brandon	**46.1%**	**44.8%**	**45.4%**	**53.9%**	**55.2%**	**54.6%**
Mid						
North Eastman	57.7%	53.3%	55.5%	42.3%	46.7%	44.5%
Interlake	50.1%	53.1%	51.6%	49.9%	46.9%	48.4%
Parkland	43.1%	45.1%	44.1%	56.9%	54.9%	55.9%
Total Mid	**50.2%**	**51.0%**	**50.6%**	**49.8%**	**49.0%**	**49.4%**
North						
Norman	66.1%	56.9%	61.7%	33.9%	43.1%	38.3%
Burntwood/Churchill	55.0%	39.1%	47.2%	45.0%	60.9%	52.8%
Total North	**60.6%**	**47.9%**	**54.4%**	**39.4%**	**52.1%**	**45.6%**
Winnipeg	59.1%	48.4%	53.6%	40.9%	51.6%	46.4%
Manitoba	**54.8%**	**47.9%**	**51.3%**	**45.2%**	**52.1%**	**48.7%**

Manitoba *in motion*

The *in motion* survey respondents (n=6,536) were asked to classify their physical activities – including work, transportation, and day-to-day activities, along with sports and exercise – as "light," "moderate," or "vigorous." Then, to reduce the error commonly associated with people's perceptions of physical activity intensity, corrections were applied to correspond with standard intensity classifications. First, intensity level was defined using METs, as follows: "light" activities require < 3 METs; "moderate" activities require 3-6 METs; and "vigorous" activities require > 6 METs. The intensity reported by respondents for each activity was then reviewed against the range of MET levels assigned to that activity in the Ainsworth Compendium.[32] For example, if a respondent reported "vigorous" bowling, this was compared with the Ainsworth MET value of 3.0 and the activity was reclassified as moderate. Using these assigned MET values, the average daily EE was calculated for each activity (as in the CCHS, outlined previously). The sum of the daily EEs for each respondent was calculated, then respondents were again categorized as Active, Moderate, or Inactive according to the previously outlined CCHS criteria, as well as according to whether physical activity guideline levels were attained (see Table 17).[33] It is important to note a key difference between the CCHS and the *in motion* survey: CCHS results are based on leisure-time activities only, whereas *in motion* encompasses work, travel, and day-to-day activities in addition to leisure-time items.

Table 17. % Adults (Age 18+) Meeting PAG* in Manitoba
Manitoba *in motion* Survey, 2007
By Region

RHA	Does not meet PAG	Meets PAG: Light	Moderate	Vigorous
Rural South & Brandon				
South Eastman	32.2%	11.4%	41.7%	14.7%
Central	29.4%	11.9%	40.6%	18.1%
Assiniboine	28.7%	12.1%	41.7%	17.6%
Brandon	30.3%	16.6%	34.2%	18.9%
Total Rural South + Brandon	**30.1%**	**13.0%**	**39.5%**	**17.3%**
Mid				
North Eastman	26.1%	11.4%	46.1%	16.3%
Interlake	27.4%	11.8%	40.1%	20.7%
Parkland	21.3%	11.0%	49.3%	18.3%
Total Mid	**25.0%**	**11.4%**	**45.1%**	**18.5%**
North				
Nor-Man	28.8%	15.9%	36.9%	18.3%
Burntwood / Churchhill	29.0%	16.7%	35.3%	19.0%
Total North	**28.9%**	**16.3%**	**36.1%**	**18.7%**
Winnipeg	32.1%	12.9%	33.2%	21.7%
Manitoba	**30.5%**	**13.0%**	**36.3%**	**20.2%**

Source: The Health, Leisure and Human Performance Research Institute - University of Manitoba. *in motion Report: Results of Baseline Survey of Physical Activity*. 2007

* PAG = Physical Activity Guideline

The Manitoba RHA *Indicators Atlas* used CCHS data combined from cycles 1.1, 2.1, and 3.1 (2001-2005) to determine total physical activity levels for respondents aged 15-75 years. Total physical activity is a derived variable from the CCHS based on the average daily EE for work and travel-related physical activity, integrated with leisure-time physical activity. Respondents were grouped into three categories (Active, Moderate, or Inactive) based on tertiles of average daily EE created from the pooled sample of all non-missing scores in the three CCHS cycles. The categories were as follows:

Active	≥ 27.7 KKD
Moderate	15.4-27.6 KKD
Inactive	0-15.3 KKD

Results were age- and sex-adjusted to the overall Manitoba survey frame, so values could be fairly compared across areas (see Table 18). The Manitoba survey frame refers to all people who could have been included in the survey based on the CCHS survey design, that is, civilians 12+ years old who do not live in an institution or in a First Nations community.

As was the case with the *in motion* study, the approach coordinated by the MCHP encompasses work, travel, and day-to-day activities in addition to leisure-time activities. This is an important advancement over relying on leisure-time activities only. One challenge, however, is that this approach excludes individuals who are not gainfully employed.

Table 18. Physical Activity Levels in Manitoba by Region
(Work + Leisure + Travel) Combined From 2001, 03, 05 CCHS
Age- and Sex-Adjusted Percent of Weighted
Sample Aged 15-75 Who Were Physically Active

	Active		Moderate		Inactive	
RHA	**M**	**F**	**M**	**F**	**M**	**F**
Rural South & Brandon						
South Eastman	43.0%	15.9%	32.0%	39.1%	24.9%	45.0%
Central	53.6%	21.2%	26.0%	27.1%	20.3%	51.7%
Assiniboine	52.5%	29.6%	29.6%	24.9%	17.8%	40.1%
Brandon	42.5%	24.3%	31.9%	32.6%	25.6%	43.2%
Total South	**50.7%**	**22.6%**	**28.7%**	**31.3%**	**20.7%**	**46.2%**
Mid						
North Eastman	44.3%	19.3%	32.1%	37.5%	23.7%	43.2%
Interlake	47.0%	22.3%	26.9%	40.9%	26.1%	36.8%
Parkland	49.0%	18.0%	28.2%	37.9%	22.8%	44.1%
Total Mid	**46.8%**	**20.4%**	**28.6%**	**39.4%**	**24.6%**	**40.3%**
North						
Nor-Man	41.3%	25.2%	37.0%	38.0%	21.7%	36.8%
Burntwood / Churchhill*	49.2%	19.9%	24.4%	37.9%	26.4%	42.3%
Total North	**44.9%**	**22.0%**	**31.7%**	**37.7%**	**23.3%**	**40.3%**
Winnipeg	32.1%	18.5%	35.8%	35.5%	32.1%	46.1%
Manitoba	**39.1%**	**19.8%**	**32.8%**	**35.2%**	**28.1%**	**45.1%**

Source: The Manitoba Center for Health Policy, *Manitoba RHA Indicators Atlas*, 2009 (Appendix table 3.37)

* Data for Churchill supressed due to small numbers or highly variable rates

Risk Factor Exposure in Manitoba's Youth

A key component of long-term changes in risk factor exposure includes addressing these issues in children and youth, before unhealthy behaviours are firmly entrenched. The following section therefore provides a focused overview of smoking, physical inactivity, and overweight in Manitoba's youth.

Canadian Community Health Survey (CCHS)

Data from the CCHS suggest that 10.0% of Manitoba's youth ages 12 -19 are current (daily and occasional) smokers (see Table 19), that 32% are physically inactive (see Table 20), and that 23.5% of those aged 12-17 are overweight or obese (see Table 21).

Table 19. Smoking in Manitoba
2003, 2005, 2007 & 2008 CCHS
Ages 12 to 19

	Daily			*Occasional*		
	Males	**Females**	**Total**	**Males**	**Females**	**Total**
2003	6.8%	11.9%	9.3%	4.4%	5.2%	4.8%
2005	5.1%	6.7%	5.9%	5.4%	2.7%	4.1%
2007	5.5%	5.7%	5.6%	5.6%	3.1%	4.4%
2008	13.3%	NA	NA	8.0%	NA	NA

Table 20. Leisure Time Physical Inactivity in Manitoba
2003, 2005, 2007 & 2008 CCHS
Ages 12 to 19

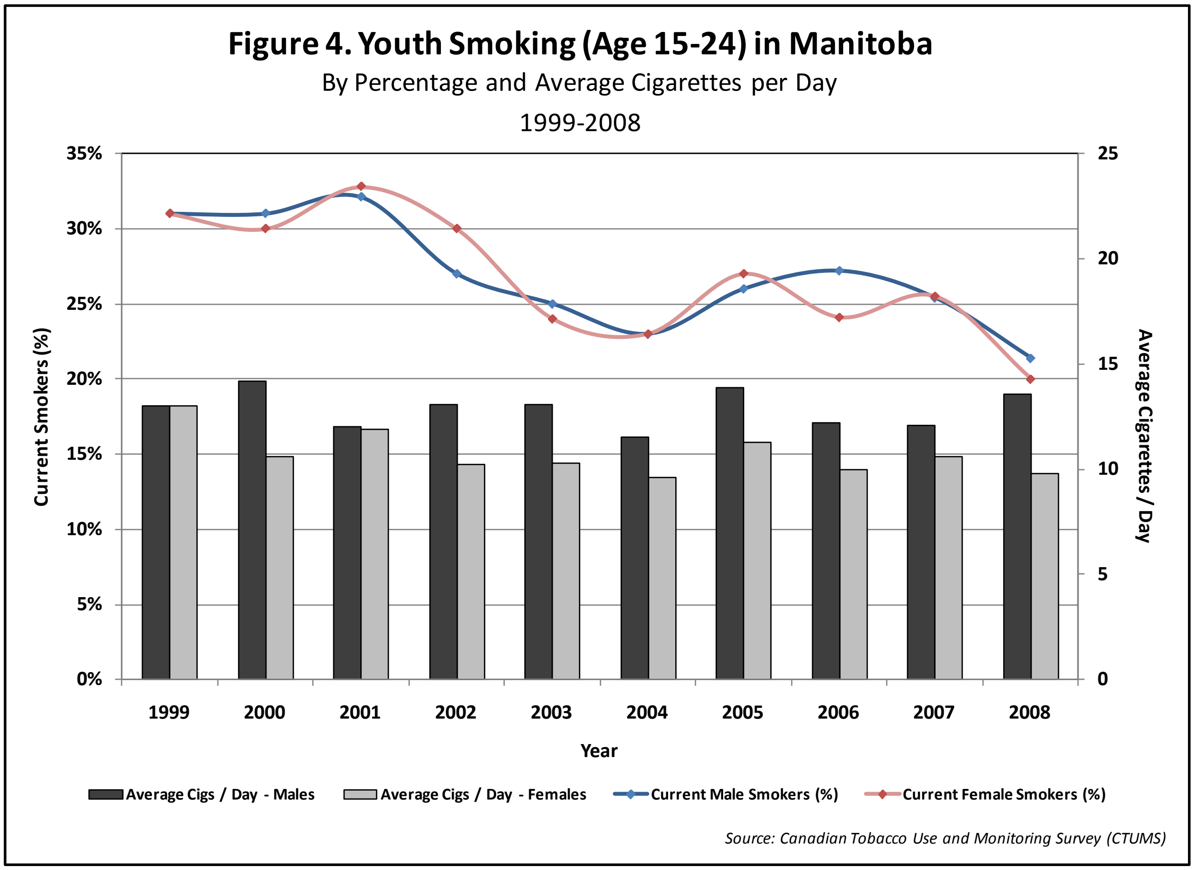
	Inactive		
Year	**Males**	**Females**	**Total**
2003	20.7%	32.8%	26.6%
2005	24.5%	40.2%	32.2%
2007	33.6%	27.2%	30.4%
2008	27.4%	36.7%	32.0%

Table 21. Overweight and Obesity in Manitoba
2005, 2007 & 2008 CCHS
Ages 12 to 17, Based on Self-reported Weight and Height

	Overweight or Obese (BMI >25)		
Year	**Males**	**Females**	**Total**
2005	25.8%	15.6%	NA
2007	26.2%	15.4%	20.5%
2008	32.1%	14.6%	23.5%

Canadian Tobacco Use Monitoring Survey (CTUMS)

Longer term data from CTUMS on youth (ages 15-24) smoking in Manitoba suggest a decline in the proportion of youth who are current smokers, from approximately 33% in 2001 to 15% in 2008 (see Figure 4). It should be noted, however, that when CCHS data are used to examine 2008 smoking rates in 20-24 year olds, 33.5% are considered to be daily or occasional smokers. Of particular note is the fact that the percentage in 20-24 year old *males* is as high as 41.2% (versus 25.3% in females).



Manitoba Youth Health Survey

As noted earlier, the *Manitoba Youth Health Survey* (MYHS) was a province-wide chronic disease risk factor surveillance system in which students in grades 6-12 were asked to self-report their status on various risk factors, including tobacco use, nutrition, physical activity, self-esteem, and school connectedness.

In the MYHS, BMI was calculated using the standard formula for adults:

$$BMI = weight\ (kg)/height\ (cm)^2$$

The US Centre for Disease Control (CDC) methodology for assigning BMI-for-age weight status was used. The CDC methodology is as follows:[34]

> *After BMI is calculated for children and teens, the BMI number is plotted on the CDC BMI-for-age growth charts (for either girls or boys) to obtain a percentile ranking. Percentiles are the most commonly used indicator to assess the size and growth patterns of individual children in the United States. The percentile indicates the relative position of the child's BMI number among children of the same sex and age. The growth charts show the weight status categories used with children and teens (underweight, healthy weight, overweight, and obese).*
>
> *BMI-for-age weight status categories and the corresponding percentiles are shown in the following table.*

Weight Status Category	***Percentile Range***
Underweight	*Less than the 5th percentile*
Healthy weight	*5th percentile to less than the 85th percentile*
Overweight	*85th to less than the 95th percentile*
Obese	*Equal to or greater than the 95th percentile*

Based on this approach, the MYHS found that 19.5% of Manitoba youth in grades 9-12 are overweight or obese (see Table 22).

The MYHS defined a daily smoker as someone who has smoked every day or almost every day in the 30 days preceding the survey. An occasional smoker is someone who:

- has smoked some days or only 1 or 2 days in the 30 days preceding the survey; OR
- has smoked a cigarette in the last 30 days, but did not specify a frequency; OR
- has not smoked a cigarette in the last 30 days but has smoked 100 or more cigarettes in their lifetime

Based on this definition, the MYHS found that 21.2% of Manitoba youth in grades 6-12 are current (daily or occasional) smokers (see Table 22). This is substantially higher than the 10.0% calculated by CCHS for this age group in 2007 (see Table 19), a fact that will permit a useful adjustment in the analysis later in the report. Interestingly, the opposite pattern was found when comparing CCHS to CTUMS for age 15-24 years, where the CCHS data suggested a higher rate of smoking.

In the MYHS, students were asked to estimate how many minutes of hard or moderate physical activity they did for each day of the previous week. They were asked to include only activities that lasted at least 15 minutes at one time. Physical activity can be estimated by kilocalories per kilogram of body weight per day (KKD). The following formula was used to determine KKD:

KKD = (Hard*6METS + Moderate*3METS)/7 days

Where “Hard” and “Moderate” are the total time spent doing that type of activity in the previous week, in hours.

Students were classified according to the following criteria:

Active: >8 KKD
Moderately active: 3-8 KKD
Inactive : <3 KKD

These criteria were chosen based on evidence that youth consistently over-report their activity levels. In addition, studies indicate that children and youth consistently require more physical activity than adults and >8KKD is a common criteria for identifying an active child.[35] By comparison, note that in the CCHS the respondents were considered physically inactive if they expended <1.5 KKD.

Based on this approach, the MYHS found that 19.3% of Manitoba youth in grades 6-12 are physically inactive (see Table 22). This is substantially lower than the 32.0% calculated by CCHS (see Table 20), again offering a basis for adjustment that will be introduced at the end of this report.

Table 22. Manitoba Youth Health Survey Results Grades 6-12, 2005-2008	Male	Female	Total
Overweight or Obese*	24.4%	14.4%	19.4%
Smoking			
Daily Smoker	9.7%	9.9%	9.8%
Occasional Smoker	11.5%	11.3%	11.4%
Physical Inactivity	16.4%	22.1%	19.3%

**(BMI ≥ 25) in Grade 9-12*

Estimating Population Attributable Risk

Importance of Population Attributable Risk

Since its introduction in the 1950s, the epidemiologic metric known as population attributable risk (PAR) [36] has gained ascendancy in both the research and practice arenas of public health. It is a powerful tool for understanding and communicating the burden of disease generated by a causal risk factor. For the current project, it is important to acknowledge the central role of PAR in estimating the economic burden of disease attributable to a particular risk factor or group of factors.

PAR goes beyond relative risk in important ways. Historically, the importance of a risk factor was often associated with the relative impact of the risk factor on the exposed group. That is, the higher the RR (or the alternate metric known as odds ratio) associated with the risk factor, the greater the importance and sense of urgency associated with that risk factor, at least within the exposed group. Thus, simply identifying a high RR could prompt action in, for instance, an occupational setting that involved regular contact with a toxic chemical.

This approach, however, essentially ignores the importance of the *prevalence* of the risk factor in the general population, as noted more than 30 years ago by a McMaster University professor who was a pioneer in understanding and applying PAR: "When examining diseases with several risk factors varying both in their relative risks and prevalences, it seems inadequate to compare the epidemiological importance of these factors using relative risk alone."[37] Indeed, a more suitable approach in this situation is to focus on PAR, a "measure which takes into account not only the strength of the physiologic effect of exposure, but also the number exposed to the risk factor in question."[38]

Meaning of the Measure

There are different ways of conceptualizing (and calculating) PAR. Essentially, the measure "combines information on prevalence and a measure of association to provide a quantitative estimate of the proportion of disease in the population that is directly attributable to a particular exposure."[39] Translating this idea into public health terms, PAR may be thought of as the proportion of disease that can be prevented if a risk factor were eliminated from the population; this is equivalent to the fraction of all cases (in exposed and unexposed subpopulations combined) that would not have occurred if the exposure had not occurred.[40] It is immediately clear how PAR bears directly on the linkage between chronic disease causation and public health prevention priorities.

The application of the PAR concept just described, technically the "PAR of incidence," does not represent the end of its usefulness. Similar to the range of different types of RR (e.g., RR of incidence, RR of mortality, etc.), the burden quantified by PAR also varies. The most common focus of PAR is incidence, but PAR related to mortality is also studied and reported; further, when information is also available on age of death, then PAR of "years of life lost" due to a risk factor may be calculated.[41] Sometimes a metric combining morbidity and mortality is used, such as disability-adjusted life years (DALYs).[42] The PAR of DALYs was in fact the foundation of the World Health Organization's well-known Global Burden of Disease project. Finally, it is even appropriate to speak of the "PAR of cost," for instance, the proportion of the total health care spending for a disease that may be attributable to obesity.

It is important to note that the PAR calculation for a particular disease-risk factor linkage depends on the burden metric in view at the time. For example, the PAR of postmenopausal breast cancer *incidence* associated with obesity is not the same as the PAR of *mortality* related to that disease and obesity. This means that if PAR is ever meant to be used as the *direct* basis for calculating mortality-related burden, a separate set of PAR calculations is required than those used for developing incidence-related PARs.

Calculating PAR

It is beyond the scope of this Supporting Document to derive the different equations used to calculate PAR, but it will suffice to say that two fundamental approaches have been used, both developed decades ago. Only one type will be described below, as it generates the basis for calculating PAR in the present project. It is important to note that the alternate approach to calculating PAR is algebraically identical to the equation provided below.

In 1953, the epidemiologist Mort Levin published a now famous paper called *The occurrence of lung cancer in man.*[43] He was part of the contingent of epidemiologists in the middle of the twentieth century that established the carcinogenicity of tobacco smoke.[44] But Levin's paper has also become well-known for introducing PAR and producing the first practical equation by which to calculate it.

That equation is:

$$\frac{E\,(RR-1)}{E(RR-1)+1}$$

Where: **E** is the proportion of the population exposed to the factor of interest
RR is the relative risk of cancer developing in the group exposed to the factor.

The practical implication of this equation is that identifying credible data for E (population prevalence of a risk factor of interest) and RR (relative risk of diseases causally related to the factor) is all that is required to begin calculating PAR.

Complications with PAR

The basic PAR equation provides an accurate calculation of PAR in the most simplified risk factor scenario, the so-called dichotomous system where only two risk factor states are considered, that is, *exposed* and *not exposed*.

There are two major complications that enter into a more comprehensive discussion of PAR, both reflecting a situation that more closely aligns with the real world encounter with chronic disease risk factors. The situations in view here are as follows:

1. RR and E information is available for a *range* of exposure intensities.
2. *Multiple* risk factors are being tracked in reference to causation of a specific disease.

The algebra involved with each of these situations is more complex than the basic Levin equation, as detailed below.

Polytomous Exposure

A risk factor is often experienced in a range of dosages—a phenomenon sometimes referred to as polytomous exposure. A typical example is the different intensities of cigarette smoking, and their association with varying levels of disease risk.

Where the various RRs specific to a range of risk factor exposures are known (and the associated exposure prevalence in each case), it is tempting to use the basic Levin formula to calculate a PAR relevant to each exposure subpopulation, e.g., PAR for light smoking, moderate, high, etc., and then sum the component PARs to get a combined PAR for "current smoking" (regardless of intensity). For reasons that cannot be elucidated here, this approach, which seems appropriate from a naïve viewpoint, actually generates incorrect combined PAR information. A different formula needs to be employed in such situations, which may be referred to as an *extended* Levin equation. In the case of a so-called trichotomous scenario of no, light (E_1), and heavy exposure (E_2), the correct equation would be:[45]

$$\frac{E_1(RR_1-1) + E_2(RR_2-1)}{E_1(RR_1-1) + E_2(RR_2-1) + 1}$$

Even without proving the algebra, it is easy to see that this equation is a "cousin" of the basic Levin equation, with two groups of terms represented, E and RR for the light and also for the heavy exposure situation (note that the third term, for no exposure, has by definition a RR of 1, so that the associated RR-1 term simply zeros out).

A final note must precede the application to a Manitoba analysis, namely, the fact the calculation of a combined PAR is not usually the end of the evaluation. Understanding the relative burden of the different exposure levels (and the prevention urgency specific to them) is often also a matter of some concern. Thus, there may be policy implications driven by knowing the relative disease burden of regular heavy smoking compared with occasional light smoking.

A great deal of analytic energy has entered into the task of disaggregating (often referred to as partitioning) a combined PAR to estimate the PARs specific to individual exposure levels. There is a growing volume of literature on the theory and practice of this task, with competing viewpoints. It is beyond the scope of this project to review the various approaches. Instead, it will suffice to say that a simple and adequate approach involves calculating the crude PARs for each exposure, and then using their relative sizes to disaggregate the "true" combined PAR calculated by the extended Levin equation.

This discussion of polytomous exposure has a direct bearing on the current project, allowing the refined analysis of PAR described above to be illustrated in the Manitoba context (see the subsection below on *PAR in Manitoba - Overweight and Obesity*).

Multifactorial System

The second complication with calculating PAR involves a multifactorial situation, that is, where a disease is caused by two or more factors acting independently or reinforcing one another to some degree (a phenomenon known as synergy).

Simply summing the exposure-specific PARs may result in an overall PAR>1, because it "double counts" cases that could be avoided by removing either one or the other exposure.

When complete information is known about the exposure to multiple causative factors and the RR related to each category of "sufficient causes" of disease, then the PAR for each individual factor can be estimated simply and accurately. However, when information on the risk factor overlap groups are lacking, it is important to resist the urge to simply add the crude PARs for each risk factor involved in order to obtain a combined PAR for the system. Researchers have determined that a better approximation of combined PAR is obtained using the following equation:[46]

$$1 - [(1 - PAR_1)\ (1 - PAR_2)]$$

where the notation PAR_1 stands for the population attributable risk related to the first factor (and so on). This equation can be easily extended to three or more factors.

It should be noted that this equation is most accurate when two conditions apply:

1. The risk factors involved are statistically independent (i.e., experiencing one makes an individual no more or less likely to experience the other, or the clustering of risk factors is limited)
2. Their joint effects are multiplicative (i.e., synergistic)

These two conditions can be shown to apply very well to a system involving obesity and smoking, and reasonably well to obesity and physical inactivity (see below). Equivalent investigations of smoking combined with inactivity are scarce.

Distribution of Risk Factors in Canadian and Comparable Populations

The first criterion for using the estimation formula provided immediately above is that the clustering of risk factors is modest. In other words, the percentage of the population exposed to any two factors is relatively small, which translates into the fact that the prevalence of risk factor A in the total population is similar to the prevalence in the subpopulation exposed to risk factor B. The following discussion, demonstrating compliance in this regard, draws on population-level information for obesity and physical inactivity developed from the 2003/04 CCHS, and for obesity and smoking based on the 2002 National Health Interview Survey in the United States.

First, research suggests that there is no *significant* difference between the proportion of obese individuals in the overall Canadian population and that in the subgroup that is physically inactive. This holds for both males and females, as follows: 27.0 % (95% C.I. 23.7-30.3) of physically inactive males are obese, compared to 22.9% (20.7-25.2) of all males; the comparable data for females are 26.8% (24.0-29.5) and 23.2% (21.3-25.1).[47] The figures in both cases are similar (they are not statistically significantly different); the suggestion of a slightly higher proportion of obesity among the physically inactive is consistent with expectations; however, the fact that there is not a very big deviation from total population obesity rates means that physical inactivity may not be as dominant a factor in obesity as, for instance, unhealthy diet.

Turning to the other risk factor pair, U.S. data suggest that the rate of obesity in the general population is similar to the rate among current smokers. That is, 24.1% of all males in the U.S. are obese, while 20.9% of males who smoke are obese (the equivalent proportions for females are 23.0% and 20.8%).[48] The fact that there is a slightly lower proportion of obesity among smokers is again consistent, given the known effects of smoking as an appetite suppressant.

Although it may seem counterintuitive, the conclusion from these data is that behavioural risk factor clustering, at least in North America, is modest. As such, the conditions of the first criterion are substantially matched.

Multiplicative Interaction of Risk Factors

The second criterion to consider involves the presence of joint effects with simultaneous exposure to two (or more) risk factors. Interaction between obesity and smoking is well-established.[49,50] Research based on over 80,000 individuals offers a good illustration of the synergistic effect of these two factors. In the study, the RR for all-cause mortality in women under 65 years with $30.0<BMI<34.9$ increased four-fold in the presence of tobacco use, that is, from 0.96 without current smoking to 3.82 with current smoking; the equivalent shift for men was 1.35 to 2.26.[51]

An effect of physical inactivity on morbidity and mortality that is independent of obesity has been demonstrated,[52,53,54] but evidence of an interaction with obesity also exists. It is fair to say that the interrelationship of physical activity and obesity on health outcomes, though well-studied, remains both complicated and controversial. However, a 2009 review was able to conclude that physical activity or cardiorespiratory fitness appears to reduce the health consequences associated with obesity to some degree. This type of joint effect is consistent with studies that focused on body fat percentage rather than BMI,[55] as well as those that examined obesity, fitness, and health markers specifically related to type 2 diabetes.[56] Ultimately, the 2009 review cited above also considered the reports of risk-inducing rather than protective effects, concluding that "the highest risk of morbidity or mortality was observed in individuals who were both obese and inactive or unfit."[57]

Disaggregating a Combined PAR

Finally, if there is an educational or policy interest in communicating PARs for individual risk factors (as is the case in this project), they may be estimated in a manner analogous to the disaggregation strategy introduced above for polytomous exposures.

Rather than applying this approach to a multifactorial system to calculate PAR of incidence, it will be extended in an innovative manner in order to adjust crude cost information in order to obtain a better estimate of total disease costs attributable to the combination of risk factors that are the focus of this project (i.e., smoking, overweight/obesity, and physical inactivity). In other words, the calculation strategy will be applied to PAR of cost (see the subsection below *Adjusting Costs in a Multifactorial System*).

PAR in Manitoba - Smoking

Table 23 provides the Manitoba-specific PAR for chronic diseases and conditions associated with smoking. Note that Manitoba area-specific PARs were also calculated based on differing levels of exposure in the four aggregated areas of the province. *Exposure data for Manitoba and the four areas are based on current smokers (both daily and occasional) using 2008 CCHS data.* More detailed information is available in the companion Excel spreadsheet(s) created for this project.

Table 23. Manitoba
Smoking-Related Summary RR and Population Attributable Risk
For Chronic Diseases and Conditions, By Gender

	Current Smokers			
	RR		PAR	
Disease Category	**Male**	**Female**	**Male**	**Female**
Neoplasms				
Lip, oral cavity, pharynx	10.90	5.10	66.9%	40.7%
Esophagus	2.52	2.28	23.7%	17.6%
Stomach	1.74	1.45	13.1%	7.0%
Liver	1.85	1.49	14.8%	7.6%
Pancreas	1.63	1.73	11.4%	10.9%
Larynx	6.98	6.98	55.0%	50.0%
Trachea, bronchus, lung	9.87	7.58	64.4%	52.4%
Cervix uteri		1.83		12.2%
Urinary bladder	2.80	2.73	26.9%	22.5%
Kidney, other urinary	1.59	1.35	10.7%	5.5%
Cardiovascular Diseases				
Ischemic heart disease				
Aged 35–64 years	2.80	3.10	26.9%	26.0%
Aged ≥65 years	1.50	1.60	9.3%	9.1%
Other heart disease	1.80	1.50	14.0%	7.7%
Cerebrovascular disease				
Aged 35–64 years	3.30	4.00	31.9%	33.4%
Aged ≥65 years	1.60	1.50	10.9%	7.7%
Atherosclerosis	2.40	1.80	22.2%	11.8%
Aortic aneurysm	6.20	7.10	51.5%	50.5%
Other arterial disease	2.10	2.20	18.3%	16.7%
Respiratory Diseases				
Pneumonia, influenza	1.47	1.47	8.7%	7.3%
Bronchitis, emphysema	17.10	12.00	76.7%	64.8%
Chronic airways obstruction	9.80	9.80	64.2%	59.6%

PAR in Manitoba - Overweight and Obesity

The earlier discussion on polytomous exposures applies to calculating PARs for the combined risk factor system involving overweight and obesity. These two categories lie on a continuum, similar to the different exposure intensities related to smoking. Thus, it is *not* algebraically accurate to calculate crude PARs for overweight and obesity, and then simply sum them to get a combined PAR for the risk factor system involving exposure to excess weight.

In short, the risk factor categories of overweight and obesity may be conceived as a part of a trichotomous exposure to excess or abnormal body weight (i.e., involving three categories related excess weight: no, intermediate, and heavy), with PAR calculations being handled accordingly. The following procedure was followed:

1. The extended Levin equation introduced above was employed to calculate a good estimate for the actual combined PAR for overweight and obesity. This figure is suitable for generating disease costs attributable to the risk factor system involving weight.
2. The crude PARs for each of overweight and obesity was calculated (using the basic Levin equation) and the ratio of the two figures applied to the true combined PAR, disaggregating it into a best estimate for the individual risk factors. These derived data offer a reasonable basis for generating disease costs specific to each of overweight and obesity.

Table 24 displays the resulting Manitoba-specific PAR for chronic diseases and conditions associated with overweight and obesity. Note that a Manitoba area-specific PAR was also calculated based on differing levels of exposure in the four aggregated areas of the province. *Exposure data for Manitoba and the four areas is based on 2008 CCHS data with BMI calculated using self-reported height and weight.* More detailed information is available in the companion Excel spreadsheet(s) created for this project.

Table 24. Manitoba

Weight-Related Population Attributable Risk

For Chronic Diseases and Conditions, By Gender

	Best Estimate of PAR			
	Overweight (25 < BMI < 30)		**Obesity (BMI > 30)**	
Disease Category	Male	Female	Male	Female
Hypertension	5.2%	8.7%	12.4%	19.3%
Type 2 diabetes	17.7%	23.6%	39.7%	49.6%
Coronary artery disease	5.4%	10.2%	10.8%	25.2%
Gallbladder disease		6.3%	7.3%	18.7%
Stroke	7.8%	3.8%	8.8%	8.3%
Pulmonary embolism	20.7%	16.3%	26.5%	26.5%
Colorectal cancer	14.6%	10.1%	14.2%	10.3%
Postmenopausal breast cancer		2.1%		2.4%
Endometrial cancer		11.0%		25.9%
Osteoarthritis	29.5%	15.6%	28.5%	13.6%
Oesophageal cancer	5.0%			
Kidney cancer	12.2%	15.4%	12.8%	20.1%
Ovarian cancer		4.6%		5.0%
Pancreatic cancer			21.2%	10.5%
Congestive heart failure			14.2%	13.3%
Asthma	6.9%	6.0%	7.6%	12.2%
Chronic back pain	15.7%	12.0%	22.4%	22.2%

PAR in Manitoba - Physical Inactivity

Table 25 provides the Manitoba-specific PAR for chronic diseases and conditions associated with physical inactivity. Note that a Manitoba area-specific PAR was also calculated based on differing levels of exposure in the four aggregated areas of the province. *Exposure data for Manitoba and the four areas is based on 2008 CCHS data.* More detailed information is available in the companion Excel spreadsheet(s) created for this project.

Table 25. Manitoba
Physical Inactivity-Related Summary RR and Population Attributable Risk
For Chronic Diseases and Conditions, By Gender

Disease Category	PAR M	PAR F
Coronary artery disease	17.2%	17.9%
Stroke	21.7%	22.5%
Hypertension	12.1%	12.7%
Colon cancer	15.9%	16.5%
Breast cancer		13.0%
Type 2 diabetes	18.7%	19.5%
Osteoporosis	21.4%	22.2%

Note that the PAR in this case is based on leisure-time physical inactivity. If the MCHP exposure data is used (including work- and travel-related physical activity along with leisure-time physical activity), the PAR information would be as follows:

Table 26. Manitoba
Physical Inactivity-Related Summary RR and Population Attributable Risk
For Chronic Diseases and Conditions, By Gender

Disease Category	PAR M	PAR F
Coronary artery disease	11.2%	16.9%
Stroke	14.4%	21.3%
Hypertension	7.8%	11.9%
Colon cancer	10.3%	15.6%
Breast cancer		12.3%
Type 2 diabetes	12.3%	18.4%
Osteoporosis	14.2%	21.0%

The most substantial difference is seen for males. Based on leisure-time physical activity, 45.2% of males and 52.1% of females would be considered inactive. Including work and travel-related physical activity reduces the proportion of inactive males/females in Manitoba to 28.1% and 45.1%, respectively, with the related PARs following in step.

Estimating the Economic Burden Associated with the Risk Factors

In estimating the economic burden associated with smoking, overweight / obesity, and physical inactivity in Manitoba, a prevalence-based cost-of-illness methodology was used to generate both direct (i.e., health care-related) and indirect (i.e., associated with illness-related morbidity and mortality) costs.

Calculation of Direct Costs

In calculating direct costs, the approach of Anis et al. in their estimate of the economic burden of obesity and overweight in Canada in 2006 was adopted.[58,59] Total direct costs / health expenditures in Canada and Manitoba for 2006, as itemized in the National Health Expenditure Database (NHEX), are shown on Table 27.[60] Total health expenditures in 2006 were $151.4 billion in Canada and $5.9 billion in Manitoba (3.89% of the Canadian total).

Table 27. Total Health Expenditure by Use of Funds in 2006—Current Dollars
($' 000,000)

						Other Professionals			Drugs						Other Health Spending			
	Population	Hospitals	Other Institutions	Physicians	Dental Services	Vision Care Services	Other	Sub-Total	Prescribed	Non-Prescribed	Sub-Total	Capital	Public Health	Administration	Health Research	Other	Sub-Total	Grand Total
Canada	32,576,100	**$42,957.6**	**$15,790.9**	**$20,027.2**	$10,306.4	$3,444.0	$2,485.9	**$16,236.4**	$20,901.8	$4,284.5	**$25,186.3**	**$7,249.3**	**$9,293.3**	**$5,264.3**	$2,732.5	$6,667.3	**$9,399.7**	**$151,405.0**
Manitoba	1,184,000	**$1,745.5**	**$764.0**	**$743.9**				**$499.4**			**$829.4**	**$241.8**	**$389.7**	**$186.9**			**$484.4**	**$5,885.0**
MB %	3.63%	4.06%	4.84%	3.71%				3.08%			3.29%	3.34%	4.19%	3.55%			5.15%	3.89%

Data Sources: Expenditures in Canada and Manitoba - CIHI National Health Expenditure Trends 1975–2009, Supplementary Tables A.3.1.1 (Canada) and D.1.7.3 (Manitoba)
Population from Statistics Canada http://www40.statcan.ca/l01/cst01/demo02a-eng.htm

From this data source, Anis et al. extracted expenditures on hospital care, physician services, other professionals (but excluding dental services), drugs, health research, and 'other' health care (see Table 28). These expenditures totalled $103.5 billion for Canada and $4.0 billion for Manitoba.[61]

Table 28. Health Expenditure by Use of Funds in 2006—Current Dollars
($' 000,000)

	Population	Hospitals	Physicians	Other Health Professionals	Drugs	Health Research	Other	Total
Canada	32,576,100	$42,957.6	$20,027.2	$5,930.0	$25,186.3	$2,732.5	$6,667.3	**$103,500.8**
Manitoba	1,184,000	$1,745.5	$743.9	$182.4	$829.4	$140.8	$343.6	**$3,985.6**
MB %	3.63%	4.06%	3.71%	3.08%	3.29%	5.15%	5.15%	**3.85%**

Data Sources: *Expenditures in Canada and Manitoba - CIHI National Health Expenditure Trends 1975–2009, Supplementary Tables A.3.1.1 (Canada) and D.1.7.3 (Manitoba)*
Population from Statistics Canada http://www40.statcan.ca/l01/cst01/demo02a-eng.htm

Based on health expenditures of $103.5 billion in Canada, Anis et al. allocated costs as follows:

> *All of these cost categories, except for hospital care, were allocated to each of the comorbidities using weights published in the Economic Burden of Illness in Canada (EBIC) for 1998. The NHEX hospital expenditures were allocated using Hospital Morbidity Database 2000/01from the Canadian Institute for Health Information. The proportion of total hospital expenditures attributable to each comorbidity was calculated by dividing the number of patient bed-days attributable to the comorbidity by the total number of patient bed-days in Canada.*[62]

A key assumption of this approach, acknowledged by Anis et al., is that "the distribution of costs for each cost category did not change significantly from 1998 to 2006."

The results of this allocation for Canada in 2006 are summarized in Table 29.

Table 29. Estimated Direct Costs of Comorbidities Related to Overweight and Obesity
Canada, 2006 ($' 000,000)

	ICD-9	Hospitals	Physicians	Other Health Professionals	Drugs	Health Research	Other	Total
Type 2 Diabetes	250.x0-250.x2	$572.0	$181.7	$53.1	$339.6	$29.6	$237.8	**$1,413.8**
Cancer								
Breast	174,175	$133.4	$65.0	$8.1	$59.8	$25.3	$59.5	**$351.1**
Colorectal	153,154	$639.3	$73.5	$9.2	$54.8	$28.6	$173.3	**$978.7**
Endometrial	179,181,182	$50.4	$14.3	$1.8	$10.7	$5.6	$16.3	**$99.1**
Oesophageal	150	$58.0	$5.5	$0.7	$4.1	$2.1	$15.4	**$85.8**
Kidney	189	$90.6	$16.9	$2.1	$12.6	$6.6	$26.6	**$155.4**
Ovarian	183	$79.2	$8.5	$1.1	$6.3	$3.3	$21.3	**$119.7**
Pancreatic	157	$126.4	$12.9	$1.6	$9.6	$5.0	$33.8	**$189.3**
Cardiovascular diseases								
Hypertension	401-405	$224.1	$392.3	$114.6	$1,786.0	$151.0	$791.3	**$3,459.3**
Coronary Artery disease	410-414	$2,753.0	$412.1	$51.5	$1,031.4	$3.6	$661.7	**$4,913.3**
Congestive heart failure	428	$1,096.0	$72.2	$9.0	$228.6	$10.9	$297.0	**$1,713.7**
Pulmonary embolism	415-417	$155.7	$20.1	$2.5	$53.3	$2.5	$45.5	**$279.6**
Stroke	430-438	$1,995.4	$117.3	$14.7	$36.0	$1.3	$474.9	**$2,639.6**
Other								
Asthma	493	$230.6	$302.0	$37.7	$603.7	$3.0	$260.5	**$1,437.5**
Gallbladder disease	574,575	$439.2	$43.1	$5.4	$42.7	$5.8	$121.2	**$657.4**
Osteoarthritis	715	$506.2	$169.5	$21.2	$296.9	$7.8	$150.4	**$1,152.0**
Chronic Back Pain	720-724	$420.4	$425.0	$53.1	$334.1	$14.2	$278.4	**$1,525.2**
Total		**$9,569.9**	**$2,331.9**	**$387.4**	**$4,910.2**	**$306.2**	**$3,664.9**	**$21,170.5**

Data Source: *Anis et al. Obesity Reviews, 2009*

Using an identical approach, the Manitoba costs were allocated to the same comorbidities / disease categories related to overweight/obesity, with the results for Manitoba in 2006 shown on Table 30.

Table 30. Estimated Direct Costs of Comorbidities Related to Overweight and Obesity
Manitoba, 2006 ($' 000,000)

	ICD-9	Total
Type 2 Diabetes	250.x0-250.x2	**$68.43**
Cancer		
Breast	174,175	**$13.71**
Colorectal	153,154	**$36.28**
Endometrial	179,181,182	**$3.47**
Oesophageal	150	**$3.13**
Kidney	189	**$5.79**
Ovarian	183	**$4.31**
Pancreatic	157	**$6.96**
Cardiovascular diseases		
Hypertension	401-405	**$133.22**
Coronary Artery disease	410-414	**$154.96**
Congestive heart failure	428	**$108.52**
Pulmonary embolism	415-417	**$8.93**
Stroke	430-438	**$115.12**
Other		
Asthma	493	**$51.73**
Gallbladder disease	574,575	**$23.73**
Osteoarthritis	715	**$56.25**
Chronic Back Pain	720-724	**$55.90**
Total		**$850.44**

These costs were then increased to 2008 dollars based on increases in expenditures in each cost category between 2006 and 2008 as indicated in CIHI *National Health Expenditure Trends 1975-2009* (see Table 31).[63]

Table 31. Total Health Expenditure by Use of Funds in 2006 and 2008 —Current Dollars
In Manitoba ($' 000,000)

	Hospitals	Physicians	Other Health Professionals	Drugs	Health Research	Other	Total
Manitoba - 2006	$1,745.5	$743.9	$182.4	$829.4	$140.8	$343.6	**$3,985.6**
Manitoba - 2008 Estimated	$2,046.2	$829.1	$230.5	$935.3	$164.2	$400.6	**$4,605.9**
% Increase	17.22%	11.45%	26.36%	12.78%	16.61%	16.61%	15.57%

Data Sources: Expenditures in Manitoba - CIHI National Health Expenditure Trends 1975–2009, Supplementary Table D.1.7.3

Consistent with this adjustment strategy, estimated direct costs for comorbidities associated with obesity and overweight in 2008 in Manitoba are summarized in Table 32.

Table 32. Estimated Direct Costs of Comorbidities Related to Overweight and Obesity
Manitoba, 2008 ($' 000,000)

	ICD-9	Total
Type 2 Diabetes	250.x0-250.x2	**$79.39**
Cancer		
Breast	174,175	**$15.84**
Colorectal	153,154	**$42.25**
Endometrial	179,181,182	**$4.02**
Oesophageal	150	**$3.65**
Kidney	189	**$6.73**
Ovarian	183	**$5.03**
Pancreatic	157	**$8.11**
Cardiovascular diseases		
Hypertension	401-405	**$152.73**
Coronary Artery disease	410-414	**$179.20**
Congestive heart failure	428	**$126.66**
Pulmonary embolism	415-417	**$10.34**
Stroke	430-438	**$134.53**
Other		
Asthma	493	**$59.13**
Gallbladder disease	574,575	**$27.64**
Osteoarthritis	715	**$65.15**
Chronic Back Pain	720-724	**$64.19**
Total		**$984.57**

In addition to the comorbidities associated with overweight and obesity, there are also a number of other comorbidities that are associated with smoking. These additional comorbidities fall within three general disease categories; cancers, cardiovascular diseases, and respiratory diseases. The *Economic Burden of Illness in Canada, 1998* was used to estimate the total direct expenditures for these three categories (see Table 33).[64] The distribution of direct costs in Manitoba for these three disease categories was based on the percent distribution in Canada for hospitals, physicians, and drugs. The distribution for other health professionals, health research, and 'other' was based on the percent distribution for Canada-Total. For example, *EBIC 1998* estimated that $1,838.7 million in total hospital expenditures ($27,638.4 million) in Canada was for cancer treatment, or 6.65%. It was assumed therefore that 6.65% of total hospital expenditures in Manitoba in 2006 ($1,745.5 million) would also be for hospital-based cancer treatment that year ($116.1 million).

Table 33. Total Health Expenditure by Use of Funds ($' 000,000)							
	Hospitals	**Physicians**	**Other Health Professionals**	**Drugs**	**Health Research**	**Other**	**Total**
Canada (Based on EBIC 1998)							
Cancer	$1,838.7	$333.1	NA	$210.2	NA	$80.4	**$2,462.4**
Cardiovascular Diseases	$4,161.8	$822.3	NA	$1,772.8	NA	$61.2	**$6,818.1**
Respiratory Diseases	$1,560.6	$776.7	NA	$1,109.7	NA	$14.4	**$3,461.4**
Sub-Total	**$7,561.1**	**$1,932.1**	NA	**$3,092.7**	NA	**$156.0**	**$12,741.9**
Total for Canada	**$27,638.4**	**$11,686.9**		**$12,385.2**		**$24,199.3**	**$75,909.8**
% of Total for Canada							
Cancer	6.65%	2.85%	NA	1.70%	NA	0.33%	3.24%
Cardiovascular Diseases	15.06%	7.04%	NA	14.31%	NA	0.25%	8.98%
Respiratory Diseases	5.65%	6.65%	NA	8.96%	NA	0.06%	4.56%
Sub-Total	**27.36%**	**16.53%**	NA	**24.97%**	NA	**0.64%**	**16.79%**
Manitoba Estimated in 2006							
Cancer							**$173.0**
Cardiovascular Diseases							**$493.8**
Respiratory Diseases							**$252.7**
Sub-Total	**$477.5**	**$123.0**	**$30.6**	**$207.1**	**$23.6**	**$57.7**	**$919.5**
Total for Manitoba	**$1,745.5**	**$743.9**	**$182.4**	**$829.4**	**$140.8**	**$343.6**	**$3,985.6**
% of Total for Manitoba							
Cancer							4.34%
Cardiovascular Diseases							12.39%
Respiratory Diseases							6.34%
Sub-Total	**27.36%**	**16.53%**	**16.79%**	**24.97%**	**16.79%**	**16.79%**	**23.07%**

Data Sources & Assumptions: *Expenditures in Canada - Economic Burden of Illness in Canada, 1998*

Distribution in Manitoba by disease category based on % distribution in Canada for hospitals, physicians and drugs. Other health professionals, health research and 'other' based on % distribution for Canada-Total.

Estimated hospital expenditures for specific cancers, cardiovascular diseases, and respiratory diseases were based on the proportion of hospital bed-days in Manitoba for a specific comorbidity (based on CIHI Hospital Morbidity data from 2000/01) divided by the total number of bed-days in Manitoba and then multiplied by the hospital expenditures in 2006 ($1,754.5 million). All other categories of expenditures were allocated based on the proportion of the disease in the total disease category (cancer, cardiovascular disease, or respiratory disease) based on hospital bed-days multiplied by the estimated expenditures allocated to the category in Manitoba. For example, in 2000/01, cancers of the trachea, bronchus, and lung generated 14,371 hospital bed-days in Manitoba out of a total of 95,803 bed-days for malignant neoplasms, or 15.0%. It was therefore assumed that 15.0% of the $21.2 million in physician costs allocated to cancers would be allocated to the specific cancers of the trachea, bronchus, and lung, or $3.18 million (see Table 34). Similarly, 15.0% of the $5.9 million in the 'other health professional' cost category would be allocated to cancers of the trachea, bronchus, and lung, and so on. The same approach was used to allocate costs to specific cardiovascular and respiratory diseases (see Table 34 for a summary of the results).

Table 34. Estimated Direct Costs of Comorbidities Related to Smoking Manitoba, 2006 ($' 000,000)		
	ICD-9	**Total**
Cancer		
Trachea, bronchus, lung	162	**$29.38**
Larynx	161	**$2.13**
Lip, oral cavity, pharynx	140-149	**$2.37**
Urinary bladder	188	**$5.54**
Stomach	151	**$5.22**
Liver	155, 156	**$3.76**
Cervix uteri	180	**$0.92**
Cardiovascular Diseases		
Other heart disease	390-398, 415-417	**$10.43**
Atherosclerosis	440	**$14.13**
Aortic aneurysm	441	**$17.66**
Other arterial disease	442-448	
Respiratory Disease		
Bronchitis, emphysema	490-492	**$62.47**
Chronic airways obstruction	496	**$23.05**
Pneumonia, influenza	480-487	**$113.17**
Total		**$290.24**

As noted earlier, costs were adjusted to 2008 dollars based on the increase in expenditures in each cost category between 2006 and 2008 as indicated in CIHI *National Health Expenditure Trends 1975-2009* (see Table 35).

Table 35. Estimated Direct Costs of Comorbidities Related to Smoking Manitoba, 2008 ($' 000,000)		
	ICD-9	**Total**
Cancer		
Trachea, bronchus, lung	162	**$34.23**
Larynx	161	**$2.48**
Lip, oral cavity, pharynx	140-149	**$2.76**
Urinary bladder	188	**$6.45**
Stomach	151	**$6.08**
Liver	155, 156	**$4.39**
Cervix uteri	180	**$1.08**
Cardiovascular diseases		
Other heart disease	390-398, 415-417	**$12.09**
Atherosclerosis	440	**$16.37**
Aortic aneurysm	441	**$4.13**
Other arterial disease	442-448	**$16.32**
Other		
Bronchitis, emphysema	490-492	**$72.00**
Chronic airways obstruction	496	**$26.57**
Pneumonia, influenza	480-487	**$130.43**
Total		**$335.38**

Finally, estimated direct costs were distributed between males and females based on the proportion of hospital bed-days in 2000/01 utilized by males and females for each comorbidity.

At this point, the estimated total direct costs for each comorbidity linked to the risk factors of interest (smoking, physical inactivity, overweight, and obesity) had been generated for Manitoba in 2008 dollars. The next step was to multiply these direct costs by the PAR between each risk factor and the associated comorbidity, as calculated earlier. Table 36 provides a summary of all relevant PARs that were so derived.

Table 36. Population Attributable Risk in Manitoba, 2008

		Smoking		Overweight		Obesity		Physical Inactivity	
	ICD-9	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**
Neoplasms									
Trachea, bronchus, lung	162	64.4%	52.4%						
Larynx	161	55.0%	50.0%						
Lip, oral cavity, pharynx	140-149	66.9%	40.7%						
Esophagus	150	23.7%	17.6%	5.0%					
Urinary bladder	188	26.9%	22.5%						
Kidney, other urinary	189	10.7%	5.5%	12.2%	15.4%	12.8%	20.1%		
Pancreas	157	11.4%	10.9%			21.2%	10.5%		
Stomach	151	13.1%	7.0%						
Liver	155, 156	14.8%	7.6%						
Cervix uteri	180		12.2%						
Endometrial cancer	179, 181, 182				11.0%		25.9%		
Ovarian cancer	183				4.6%		5.0%		
Breast cancer	174, 175								13.0%
Postmenopausal breast cancer	174, 175				2.1%		2.4%		
Colorectal cancer	153, 154			14.6%	10.1%	14.2%	10.3%	15.9%	16.5%
Cardiovascular Diseases									
Pulmonary embolism	415.1			20.7%	16.3%	26.5%	26.5%		
Congestive heart failure	428					14.2%	13.3%		
Ischemic heart disease	410-414			5.4%	10.2%	10.8%	25.2%	17.2%	17.9%
Aged 35–64 years		26.9%	26.0%						
Aged ≥65 years		9.3%	9.1%						
Other heart disease	390-398, 415-417	14.0%	7.7%						
Stroke/Cerebrovascular disease	430-438			7.8%	3.8%	8.8%	8.3%	21.7%	22.5%
Aged 35–64 years		31.9%	33.4%						
Aged ≥65 years		10.9%	7.7%						
Atherosclerosis	440	22.2%	11.8%						
Aortic aneurysm	441	51.5%	50.5%						
Other arterial disease	442-448	18.3%	16.7%						
Hypertension	401-405			5.2%	8.7%	12.4%	19.3%	12.1%	12.7%
Respiratory Diseases									
Asthma	493			6.9%	6.0%	7.6%	12.2%		
Bronchitis, emphysema	490-492	76.7%	64.8%						
Chronic airways obstruction	496	64.2%	59.6%						
Pneumonia, influenza	480-487	8.7%	7.3%						
Other									
Type 2 diabetes	250.x0, 250.x2			17.7%	23.6%	39.7%	49.6%	18.7%	19.5%
Gallbladder disease	574, 575				6.3%	7.3%	18.7%		
Osteoarthritis	715			29.5%	15.6%	28.5%	13.6%	21.4%	22.2%
Chronic back pain	720-724			15.7%	12.0%	22.4%	22.2%		

Multiplying the gender and comorbidity specific PAR with the estimated direct costs of treating that comorbidity in Manitoba in 2008 generated the results on Table 37. In unadjusted terms, the risk factors of smoking, overweight, obesity, and physical inactivity cost the Manitoba health care system $532.7 million in 2008.

Table 37. Estimated Direct Cost of Risk Factors in Manitoba

In $ Millions, 2008 (Unadjusted for Multiple Risk Factors in One Individual)

		Smoking			Overweight			Obesity			Physical Inactivity			Total		
	ICD-9	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
Neoplasms																
Trachea, bronchus, lung	162	$12.78	$7.54	$20.32										$12.78	$7.54	$20.32
Larynx	161	$0.87	$0.45	$1.32										$0.87	$0.45	$1.32
Lip, oral cavity, pharynx	140-149	$1.30	$0.33	$1.63										$1.30	$0.33	$1.63
Esophagus	150	$0.65	$0.16	$0.81	$0.14		$0.14							$0.78	$0.16	$0.94
Urinary bladder	188	$1.35	$0.32	$1.67										$1.35	$0.32	$1.67
Kidney, other urinary	189	$0.45	$0.14	$0.59	$0.51	$0.39	$0.90	$0.54	$0.51	$1.05				$1.50	$1.04	$2.54
Pancreas	157	$0.44	$0.46	$0.90				$0.82	$0.45	$1.27				$1.27	$0.91	$2.17
Stomach	151	$0.54	$0.14	$0.68										$0.54	$0.14	$0.68
Liver	155, 156	$0.40	$0.13	$0.53										$0.40	$0.13	$0.53
Cervix uteri	180		$0.13	$0.13										$0.00	$0.13	$0.13
Endometrial cancer	179, 181, 182					$0.44	$0.44		$1.04	$1.04				$0.00	$1.48	$1.48
Ovarian cancer	183					$0.23	$0.23		$0.25	$0.25				$0.00	$0.48	$0.48
Breast cancer	174, 175											$2.03	$2.03	$0.00	$2.03	$2.03
Postmenopausal breast cancer	174, 175					$0.26	$0.26		$0.30	$0.30				$0.00	$0.56	$0.56
Colorectal cancer	153, 154				$2.91	$2.24	$5.15	$2.82	$2.30	$5.13	$3.17	$3.69	$6.86	$8.90	$8.24	$17.14
Subtotal - Neoplasms		**$18.79**	**$9.79**	**$28.58**	**$3.56**	**$3.57**	**$7.13**	**$4.19**	**$4.85**	**$9.03**	**$3.17**	**$5.72**	**$8.89**	**$29.70**	**$23.93**	**$53.63**
Cardiovascular Diseases																
Pulmonary embolism	415.1				$0.96	$0.92	$1.89	$1.24	$1.50	$2.74				$2.20	$2.43	$4.63
Congestive heart failure	428							$8.09	$9.24	$17.33				$8.09	$9.24	$17.33
Ischemic heart disease	410-414				$5.65	$7.54	$13.19	$11.41	$18.58	$30.00	$18.09	$13.19	$31.28	$35.15	$39.31	$74.46
Aged 35–64 years		$9.73	$6.61	$16.34										$9.73	$6.61	$16.34
Aged ≥65 years		$6.39	$4.42	$10.82										$6.39	$4.42	$10.82
Other heart disease	390-398, 415-417	$0.61	$0.60	$1.21										$0.61	$0.60	$1.21
Stroke/Cerebrovascular disease	430-438				$4.78	$2.80	$7.58	$5.42	$6.09	$11.51	$13.30	$16.44	$29.73	$23.50	$25.32	$48.82
Aged 35–64 years		$3.43	$4.28	$7.71										$3.43	$4.28	$7.71
Aged ≥65 years		$5.52	$4.66	$10.18										$5.52	$4.66	$10.18
Atherosclerosis	440	$1.88	$0.94	$2.81										$1.88	$0.94	$2.81
Aortic aneurysm	441	$1.35	$0.76	$2.11										$1.35	$0.76	$2.11
Other arterial disease	442-448	$1.90	$0.99	$2.90										$1.90	$0.99	$2.90
Hypertension	401-405				$3.03	$8.21	$11.23	$7.23	$18.18	$25.41	$7.09	$11.95	$19.04	$17.35	$38.33	$55.68
Subtotal - Cardiovascular Diseases		**$30.82**	**$23.25**	**$54.08**	**$14.42**	**$19.46**	**$33.89**	**$33.40**	**$53.59**	**$86.99**	**$38.47**	**$41.58**	**$80.05**	**$117.11**	**$137.89**	**$255.00**
Respiratory Diseases																
Asthma	493				$1.45	$2.30	$3.75	$1.60	$4.66	$6.27				$3.06	$6.96	$10.02
Bronchitis, emphysema	490-492	$31.89	$19.69	$51.59										$31.89	$19.69	$51.59
Chronic airways obstruction	496	$10.31	$6.26	$16.57										$10.31	$6.26	$16.57
Pneumonia, influenza	480-487	$5.72	$4.74	$10.46										$5.72	$4.74	$10.46
Subtotal - Resiratory Diseases		**$47.93**	**$30.70**	**$78.62**	**$1.45**	**$2.30**	**$3.75**	**$1.60**	**$4.66**	**$6.27**	**$0.00**	**$0.00**	**$0.00**	**$50.99**	**$37.65**	**$88.64**
Other																
Type 2 diabetes	250.x0, 250.x2				**$7.05**	**$9.34**	**$16.39**	**$15.83**	**$19.62**	**$35.45**	**$7.46**	**$7.70**	**$15.16**	**$30.33**	**$36.66**	**$66.99**
Gallbladder disease	574, 575					**$0.99**	**$0.99**	**$0.87**	**$2.96**	**$3.82**				**$0.87**	**$3.94**	**$4.81**
Osteoarthritis	715				$7.50	$6.21	$13.72	$7.24	$5.39	$12.63	$5.44	$8.81	$14.25	$20.18	$20.41	$40.59
Chronic back pain	720-724				$4.32	$4.41	$8.73	$6.17	$8.15	$14.32				$10.49	$12.56	$23.05
Subtotal - Musculoskeletal Diseases		**$0.00**	**$0.00**	**$0.00**	**$11.83**	**$10.62**	**$22.44**	**$13.41**	**$13.54**	**$26.95**	**$5.44**	**$8.81**	**$14.25**	**$30.67**	**$32.97**	**$63.64**
Total (in $million)		**$97.54**	**$63.74**	**$161.28**	**$38.31**	**$46.27**	**$84.58**	**$69.29**	**$99.22**	**$168.51**	**$54.53**	**$63.81**	**$118.34**	**$259.67**	**$273.04**	**$532.71**

Adjusting Costs in a Multifactorial System

As noted earlier in the section *Complications with PAR*, it is inaccurate to simply add PAR data for each exposure in a multifactorial system; the double-counting that results will inflate the final combined PAR figure. The same thing applies to costs generated according to crude PARs of incidence (as displayed in Table 37). An equation was introduced earlier that adjusts for this effect and yields a better estimate of combined PAR over the multifactorial system, namely (for three factors):

$$1 - [(1 - PAR_1)\ (1 - PAR_2)\ (1 - PAR_3)]$$

This strategy can be applied to adjust the crude cost totals in the following way:

1. Calculate a crude PAR of cost for each of three risk factors (herein treating overweight/obesity as one factor categorized on a continuum of excess weight exposure) by dividing the crude costs for each factor by the total actual disease costs.
2. Insert these figures into the adjustment equation above (i.e., PAR_1=crude PAR of cost for tobacco smoking, etc.) in order to generate an adjusted PAR of cost for the multifactorial system.
3. Multiply total disease costs by this figure in order to obtain a good estimate for the true costs attributed to all three risk factors.
4. The final step disaggregates or partitions this new adjusted total to generate a notional sense of how the costs should be reasonably divided over the risk factors when they are considered in the context of a system rather than as discrete prevention targets. To accomplish this, one can return once again to the crude cost totals for each factor; dividing each of these by their sum (i.e., the crude cost total of $532.7 million) produces a ratio that then can be applied to the adjusted total costs (i.e., the $467.4 million in Table 38) to establish disaggregated total disease cost attributable to each risk factor. The resulting data are summarized in Table 38.

Table 38. Estimated Direct Cost of Risk Factors in Manitoba **In $ Millions, 2008** (Adjusted for Multiple Risk Factors in One Individual)		Smoking			Overweight			Obesity			Physical Inactivity			Total		
	ICD-9	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
Neoplasms																
Trachea, bronchus, lung	162	$11.22	$6.61	$17.83										$11.22	$6.61	$17.83
Larynx	161	$0.76	$0.39	$1.16										$0.76	$0.39	$1.16
Lip, oral cavity, pharynx	140-149	$1.14	$0.29	$1.43										$1.14	$0.29	$1.43
Esophagus	150	$0.57	$0.14	$0.71	$0.12		$0.12							$0.69	$0.14	$0.83
Urinary bladder	188	$1.19	$0.28	$1.47										$1.19	$0.28	$1.47
Kidney, other urinary	189	$0.40	$0.12	$0.52	$0.45	$0.34	$0.79	$0.47	$0.45	$0.92				$1.32	$0.91	$2.23
Pancreas	157	$0.39	$0.40	$0.79				$0.72	$0.39	$1.11				$1.11	$0.80	$1.91
Stomach	151	$0.48	$0.12	$0.60										$0.48	$0.12	$0.60
Liver	155, 156	$0.35	$0.11	$0.46										$0.35	$0.11	$0.46
Cervix uteri	180		$0.12	$0.12										$0.00	$0.12	$0.12
Endometrial cancer	179, 181, 182					$0.39	$0.39		$0.91	$0.91				$0.00	$1.30	$1.30
Ovarian cancer	183					$0.20	$0.20		$0.22	$0.22				$0.00	$0.42	$0.42
Breast cancer	174, 175											$1.78	$1.78	$0.00	$1.78	$1.78
Postmenopausal breast cancer	174, 175					$0.23	$0.23		$0.26	$0.26				$0.00	$0.50	$0.50
Colorectal cancer	153, 154				$2.55	$1.97	$4.52	$2.48	$2.02	$4.50	$2.78	$3.24	$6.02	$7.81	$7.23	$15.04
Subtotal - Neoplasms		**$16.49**	**$8.59**	**$25.08**	**$3.12**	**$3.13**	**$6.25**	**$3.67**	**$4.25**	**$7.92**	**$2.78**	**$5.02**	**$7.80**	**$26.06**	**$21.00**	**$47.06**
Cardiovascular Diseases																
Pulmonary embolism	415.1				$0.85	$0.81	$1.66	$1.08	$1.32	$2.40				$1.93	$2.13	$4.06
Congestive heart failure	428							$7.10	$8.11	$15.21				$7.10	$8.11	$15.21
Ischemic heart disease	410-414				$4.96	$6.61	$11.57	$10.01	$16.30	$26.32	$15.87	$11.58	$27.45	$30.84	$34.50	$65.34
Aged 35–64 years		$8.54	$5.80	$14.34										$8.54	$5.80	$14.34
Aged ≥65 years		$5.61	$3.88	$9.49										$5.61	$3.88	$9.49
Other heart disease	390-398, 415-417	$0.54	$0.52	$1.06										$0.54	$0.52	$1.06
Stroke/Cerebrovascular disease	430-438				$4.20	$2.45	$6.65	$4.76	$5.34	$10.10	$11.67	$14.42	$26.09	$20.62	$22.22	$42.84
Aged 35–64 years		$3.01	$3.75	$6.76										$3.01	$3.75	$6.76
Aged ≥65 years		$4.85	$4.09	$8.93										$4.85	$4.09	$8.93
Atherosclerosis	440	$1.65	$0.82	$2.47										$1.65	$0.82	$2.47
Aortic aneurysm	441	$1.19	$0.67	$1.85										$1.19	$0.67	$1.85
Other arterial disease	442-448	$1.67	$0.87	$2.54										$1.67	$0.87	$2.54
Hypertension	401-405				$2.66	$7.20	$9.86	$6.35	$15.95	$22.30	$6.22	$10.48	$16.70	$15.22	$33.63	$48.86
Subtotal - Cardiovascular Diseases		**$27.05**	**$20.40**	**$47.45**	**$12.66**	**$17.08**	**$29.73**	**$29.30**	**$47.02**	**$76.33**	**$33.75**	**$36.48**	**$70.24**	**$102.76**	**$120.99**	**$223.75**
Respiratory Diseases																
Asthma	493				$1.28	$2.01	$3.29	$1.41	$4.09	$5.50				$2.68	$6.11	$8.79
Bronchitis, emphysema	490-492	$27.98	$17.28	$45.26										$27.98	$17.28	$45.26
Chronic airways obstruction	496	$9.05	$5.49	$14.54										$9.05	$5.49	$14.54
Pneumonia, influenza	480-487	$5.02	$4.16	$9.18										$5.02	$4.16	$9.18
Subtotal - Resiratory Diseases		**$42.05**	**$26.93**	**$68.99**	**$1.28**	**$2.01**	**$3.29**	**$1.41**	**$4.09**	**$5.50**	**$0.00**	**$0.00**	**$0.00**	**$44.74**	**$33.04**	**$77.78**
Other																
Type 2 diabetes	250.x0, 250.x2				**$6.18**	**$8.19**	**$14.38**	**$13.89**	**$17.22**	**$31.10**	**$6.54**	**$6.75**	**$13.30**	**$26.61**	**$32.16**	**$58.78**
Gallbladder disease	574, 575					**$0.87**	**$0.87**	**$0.76**	**$2.59**	**$3.35**				**$0.76**	**$3.46**	**$4.22**
Osteoarthritis	715				$6.58	$5.45	$12.03	$6.35	$4.73	$11.08	$4.77	$7.73	$12.50	$17.71	$17.91	$35.61
Chronic back pain	720-724				$3.79	$3.87	$7.66	$5.41	$7.15	$12.57				$9.20	$11.02	$20.22
Subtotal - Musculoskeletal Diseases		**$0.00**	**$0.00**	**$0.00**	**$10.38**	**$9.32**	**$19.69**	**$11.76**	**$11.88**	**$23.64**	**$4.77**	**$7.73**	**$12.50**	**$26.91**	**$28.93**	**$55.84**
Total (in $million)		**$85.58**	**$55.93**	**$141.51**	**$33.61**	**$40.60**	**$74.22**	**$60.80**	**$87.06**	**$147.85**	**$47.85**	**$55.99**	**$103.83**	**$227.84**	**$239.58**	**$467.42**

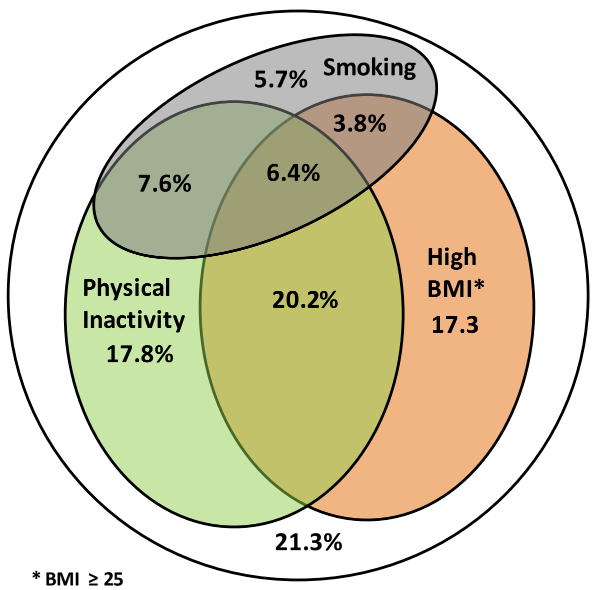
The various estimations ultimately reduce the crude cost total by 12.2%, from $533 million to $467 million. The more conservative adjusted figure has face validity in light of the known overlap of risk factor exposures in the Canadian population. As noted earlier, multiple exposures can produce an inflation of disease burden because of “double-counting” incident cases: the logical fact is that, regardless of multiple potential causes, any individual only gets a particular chronic disease once on any one occasion. Table 39 (with the same information diagrammed in Figure 5) provides information on the degree of potentially confounding risk factor overlaps, based on the Canadian Community Health Survey (CCHS) published in 2000.[65]

Table 39. Overlap of Risk Factor Exposures in the Canadian Population CCHS Cycle 1.1 (2000)			
Risk Factor Exposure in Individual	**Males**	**Females**	**Total**
None	20.0%	22.7%	21.3%
Smoking Only	5.3%	4.6%	5.7%
PIA Only	15.0%	29.2%	17.8%
High BMI Only	21.0%	11.0%	17.3%
Smoking + PIA	7.4%	7.2%	7.6%
Smoking + High BMI	4.2%	2.3%	3.8%
PIA + High BMI	20.4%	18.3%	20.2%
Smoking + PIA + High BMI	6.9%	4.7%	6.4%
Total	**100%**	**100%**	**100%**

High BMI = BMI ≥ 25; PIA - physically inactive = energy expenditure < 1.5 kcal/kg/day

Source: Klein-Geltink et al., *Chronic Diseases in Canada*, 2006.

Figure 5: Prevalence and Overlap of Chronic Disease Risk Factors in Canada
Canadian Community Health Survey, Cycle 1.1 (2000)



* BMI ≥ 25

Source: Klein-Geltink et al., *Chronic Diseases in Canada*, 2006.

Summing across the pertinent subcategories, the data indicate that 3.8+6.4=10.2% of the population is exposed to both current smoking and overweight/obesity, 20.2+6.4=26.6% to overweight/obesity and physical inactivity, and 7.6+6.4=14.0% to physical inactivity and current smoking. While the population overlap of exposure to high BMI and physical inactivity is more substantial, any correction related to double-counting disease burden is moderated by the fact that obesity and physical inactivity are known to have independent impacts on health.[66,67,68] When compared to the population percentages with multiple exposures, the 12.2% adjustment generated for Manitoba disease costs in a multifactorial system appears to be the appropriate "order of magnitude," thereby supporting the lower figure of $467 million as a reasonable adjusted estimate.

Calculation of Indirect Costs

The most commonly used method in valuing indirect costs is the human-capital approach. In this approach, gender- and age-specific average earnings are combined with productivity trends and years-of-life lost due to a specific disease/condition to estimate unrealized lifetime earnings. An important criticism of this method is that it places a higher value on the years of life lost for someone with higher earning potential (e.g., males aged 35-55) than someone with lower earning potential (e.g., females aged 75+).[69] In particular, unpaid work and leisure time are not explicitly accounted for in the human-capital approach.[70,71] Another concern raised is that the approach focuses on potential rather than actual productivity losses. For instance, it does not account for the fact that long-term absentees from the work force (whether due to death or long-term disability) are eventually replaced; from a societal perspective, this means that productivity is restored rather than permanently lost.

The *Economic Burden of Illness in Canada, 1998* (hereafter *EBIC, 1998*) report uses a modified human-capital approach that attempts to address some of the issues involved with valuing non-productive time.[72] We have followed the EBIC modified human capital approach in this project. The details are elucidated in the following sections related to societal losses associated with mortality and morbidity.

Approaches other than a modified human capital approach have also been suggested. For example, some of the concerns associated with the human-capital model are addressed in the willingness-to-pay approach.[73] It involves valuing years of life lost by estimating the average amount that an individual is willing to pay to gain an additional year of life, regardless of earning potential. Yabroff, for example, implements this approach by applying a value of $150,000 (USD) to each year of life lost, regardless of the gender or earning potential of the individual that died.[74] A key challenge of this approach involves determining how precisely to estimate the pertinent value.[75]

There is a final concern associated with the human-capital approach related to accounting for the reality of unproductive workers being replaced. This is addressed by the friction-cost method,[76] an approach that "advocates measuring actual production losses to society during the friction period between the start of an absence from work (resulting from short-term absence, long-term absence, disability, and mortality) and the time at which original productivity levels are restored."[77] The focus of this method is on lost production from the "perspective of firms, consumers and society, without accounting for the potential income lost on an individual basis."[78]

A major challenge of the various models of indirect costing is that they each generate very different results when applied to the same population. Applying the willingness-to-pay approach in the U.S. context, Yabroff found that the estimated economic costs of premature mortality due to cancer were eight times higher than those based on the human-capital approach.[79] The largest differences, of course, were in the population age 65+ years; this is because, in contrast with the willingness-to-pay method, the human-capital approach does not value the 'non-productive' time related to this age group. On the other hand, the friction-cost method tends to generate indirect costs that are approximately one-third those of the human-capital approach.[80] This wide variation, together with the fact that calculated indirect costs often dominate total direct costs, has led to substantial controversy among health economists and policy planners. As a consequence, indirect costs have often been explicitly excluded from formal economic evaluations.[81]

Mortality

EBIC, 1998 modified the standard human-capital approach by establishing a value not only for individuals in the paid workforce but also for those doing unpaid work (e.g., volunteers) and those who are not in the formal workforce (e.g., retirees). The discounted present value of lost production was calculated by 5-year age group and gender. A discount rate of 5% was used, with sensitivity analyses ranging from 0%-7%. Deaths counts and expected years-of-life lost were calculated by diagnostic category, gender, 5-year age-group, and province/ territory. The method accounts for “age- and sex-specific rates of life expectancy, average annual earnings, workforce participation rates, values of unpaid work, as well as labour productivity growth and the discounting of future production” (p. 37).

Morbidity

Long-Term Disability

EBIC, 1998 calculated the value of production lost due to long-term disability (>6 months) for both household and institutionalized populations. Weights for different levels of disability were assigned based on the severity of the disability. For example, a long-term disability that was reported as being somewhat severe in household populations was assigned a value of 0.5 (on a scale from 0.0 to 1.0). The adjusted estimates of long-term disability were then multiplied by age- and gender-specific average values of paid and unpaid labour. Long-term morbidity costs reflect only those losses that occur in 1998, not in future years.

Short-Term Disability

EBIC, 1998 calculated the value of production lost due to short-term disability (<6 months) for household populations based on information from the 1996/97 National Population Health Survey. A “day spent in bed” was assigned a weight of 0.8, whereas a day in which the respondent had to “cut down on things” was assigned a weight of 0.5. Lost productivity due to short-term disability was then calculated by diagnostic category, province/territory, age, and gender, and values for both paid and unpaid work applied.

Application of *EBIC, 1998* to Estimating Indirect Costs in Manitoba in 2008

The diseases of interest in the current project fall within one of six diagnostic categories within *EBIC, 1998*. Both the direct and indirect costs for these six categories are outlined in Table 40.

Table 40. Economic Burden of Illness in Canada by Diagnostic Category
Direct and Indirect Costs, Canada, 1998
Millions of Dollars

Diagnostic Category	Direct Costs					Indirect Costs				Total Costs
	Hospitals	Drugs	Physicians Care	Additional	Total Direct Costs	Mortality	Long-term Disability	Short-term Disability	Total Indirect Cost	(Direct + Indirect)
Cancer	$1,938.7	$210.2	$333.1	$80.4	$2,562.4	$10,622.1	$962.3	$173.6	$11,758.0	$14,320.4
Cardiovascular Diseases	$4,161.8	$1,772.8	$822.3	$61.2	$6,818.1	$8,250.0	$3,151.5	$253.3	$11,654.8	$18,472.9
Respiratory Diseases	$1,560.6	$1,109.7	$776.7	$14.4	$3,461.4	$1,646.8	$985.1	$2,437.8	$5,069.7	$8,531.1
Endocrine and Related Diseases	$477.0	$818.2	$255.6	$33.8	$1,584.6	$1,012.3	$815.7	$51.7	$1,879.7	$3,464.3
Digestive Diseases	$2,366.3	$752.2	$410.0	$11.5	$3,540.0	$1,134.3	$487.5	$692.4	$2,314.2	$5,854.2
Musculoskeletal Diseases	$1,441.6	$614.3	$578.2	$14.3	$2,648.4	$125.7	$12,597.0	$1,010.2	$13,732.9	$16,381.3
Total	**$11,946.0**	**$5,277.4**	**$3,175.9**	**$215.6**	**$20,614.9**	**$22,791.2**	**$18,999.1**	**$4,619.0**	**$46,409.3**	**$67,024.2**

Source: Public Health Agency of Canada, *Economic Burden of Illness in Canada, 1998*, 2002.

This information was used to determine a ratio between indirect and direct costs for each of the diagnostic categories and the type of indirect cost (see Table 41). For example, the indirect costs associated with cancer are 4.6 times (459%) times higher than the direct costs, largely due to the premature mortality associated with this generally deadly category of disease. On the other hand, indirect costs associated with musculoskeletal diseases[82] are 5.2 times higher than direct costs, but in this instance the majority of indirect costs are associated with long-term disability, rather than premature death.

Table 41. Economic Burden of Illness in Canada by Diagnostic Category Indirect Costs as % of Direct Costs, Canada, 1998				
		Indirect Costs		
Diagnostic Category	**Mortality**	**Long-term**	**Short-term**	**Total Indirect**
Cancer	415%	38%	7%	459%
Cardiovascular Diseases	121%	46%	4%	171%
Respiratory Diseases	48%	28%	70%	146%
Endocrine and Related Diseases	64%	51%	3%	119%
Digestive Diseases	32%	14%	20%	65%
Musculoskeletal Diseases	5%	476%	38%	519%

The calculated ratios were then applied to the attributable direct costs (after the adjustment for multiple risk factors in one individual) by diagnostic category to estimate the indirect costs related to the risk factors in Manitoba in 2008 (see Table 42).

Table 42. Estimated Indirect Cost of Risk Factors in Manitoba

In $ Millions, 2008 (Adjusted for Multiple Risk Factors in One Individual)

	Smoking			Overweight			Obesity			Physical Inactivity			Total		
Mortality															
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
Cancer	$68.3	$35.6	$104.0	$12.9	$13.0	$25.9	$15.2	$17.6	$32.9	$11.5	$20.8	$32.3	$108.0	$87.0	$195.1
Cardiovascular Diseases	$32.7	$24.7	$57.4	$15.3	$20.7	$36.0	$35.5	$56.9	$92.4	$40.8	$44.1	$85.0	$124.3	$146.4	$270.7
Respiratory Diseases	$20.0	$12.8	$32.8	$0.6	$1.0	$1.6	$0.7	$1.9	$2.6	$0.0	$0.0	$0.0	$21.3	$15.7	$37.0
Endocrine and Related Diseases	$0.0	$0.0	$0.0	$4.0	$5.2	$9.2	$8.9	$11.0	$19.9	$4.2	$4.3	$8.5	$17.0	$20.5	$37.5
Digestive Diseases	$0.0	$0.0	$0.0	$0.0	$0.3	$0.3	$0.2	$0.8	$1.1	$0.0	$0.0	$0.0	$0.2	$1.1	$1.4
Musculoskeletal Diseases	$0.0	$0.0	$0.0	$0.5	$0.4	$0.9	$0.6	$0.6	$1.1	$0.2	$0.4	$0.6	$1.3	$1.4	$2.7
Subtotal - Mortality	**$121.1**	**$73.1**	**$194.2**	**$33.3**	**$40.6**	**$73.9**	**$61.0**	**$88.9**	**$149.9**	**$56.8**	**$69.6**	**$126.4**	**$272.2**	**$272.2**	**$544.4**
Long-Term Disability															
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
Cancer	$6.2	$3.2	$9.4	$1.2	$1.2	$2.3	$1.4	$1.6	$3.0	$1.0	$1.9	$2.9	$9.8	$7.9	$17.7
Cardiovascular Diseases	$12.5	$9.4	$21.9	$5.9	$7.9	$13.7	$13.5	$21.7	$35.3	$15.6	$16.9	$32.5	$47.5	$55.9	$103.4
Respiratory Diseases	$12.0	$7.7	$19.6	$0.4	$0.6	$0.9	$0.4	$1.2	$1.6	$0.0	$0.0	$0.0	$12.7	$9.4	$22.1
Endocrine and Related Diseases	$0.0	$0.0	$0.0	$3.2	$4.2	$7.4	$7.1	$8.9	$16.0	$3.4	$3.5	$6.8	$13.7	$16.6	$30.3
Digestive Diseases	$0.0	$0.0	$0.0	$0.0	$0.1	$0.1	$0.1	$0.4	$0.5	$0.0	$0.0	$0.0	$0.1	$0.5	$0.6
Musculoskeletal Diseases	$0.0	$0.0	$0.0	$49.4	$44.3	$93.7	$56.0	$56.5	$112.5	$22.7	$36.8	$59.5	$128.0	$137.6	$265.6
Subtotal - Long-Term Disability	**$30.7**	**$20.3**	**$51.0**	**$59.9**	**$58.3**	**$118.2**	**$78.5**	**$90.2**	**$168.8**	**$42.7**	**$59.0**	**$101.7**	**$211.8**	**$227.8**	**$439.7**
Short-Term Disability															
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
Cancer	$1.1	$0.6	$1.7	$0.2	$0.2	$0.4	$0.2	$0.3	$0.5	$0.2	$0.3	$0.5	$1.8	$1.4	$3.2
Cardiovascular Diseases	$1.00	$0.76	$1.8	$0.47	$0.63	$1.1	$1.09	$1.75	$2.8	$1.25	$1.36	$2.6	$3.8	$4.5	$8.3
Respiratory Diseases	$29.62	$18.97	$48.6	$0.90	$1.42	$2.3	$0.99	$2.88	$3.9	$0.00	$0.00	$0.0	$31.5	$23.3	$54.8
Endocrine and Related Diseases	$0.00	$0.00	$0.0	$0.20	$0.27	$0.5	$0.45	$0.56	$1.0	$0.21	$0.22	$0.4	$0.9	$1.0	$1.9
Digestive Diseases	$0.00	$0.00	$0.0	$0.00	$0.17	$0.2	$0.15	$0.51	$0.7	$0.00	$0.00	$0.0	$0.1	$0.7	$0.8
Musculoskeletal Diseases	$0.00	$0.00	$0.0	$3.96	$3.55	$7.5	$4.49	$4.53	$9.0	$1.82	$2.95	$4.8	$10.3	$11.0	$21.3
Subtotal - Short-Term Disability	**$31.7**	**$20.3**	**$52.0**	**$5.7**	**$6.3**	**$12.0**	**$7.4**	**$10.5**	**$17.9**	**$3.5**	**$4.9**	**$8.3**	**$48.4**	**$41.9**	**$90.3**
Total Indirect															
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
Cancer	$75.6	$39.4	$115.1	$14.3	$14.4	$28.7	$16.9	$19.5	$36.4	$12.7	$23.0	$35.8	$119.6	$96.4	$215.9
Cardiovascular Diseases	$46.2	$34.9	$81.1	$21.6	$29.2	$50.8	$50.1	$80.4	$130.5	$57.7	$62.4	$120.1	$175.7	$206.8	$382.5
Respiratory Diseases	$61.6	$39.4	$101.0	$1.9	$3.0	$4.8	$2.1	$6.0	$8.1	$0.0	$0.0	$0.0	$65.5	$48.4	$113.9
Endocrine and Related Diseases	$0.0	$0.0	$0.0	$7.3	$9.7	$17.1	$16.5	$20.4	$36.9	$7.8	$8.0	$15.8	$31.6	$38.2	$69.7
Digestive Diseases	$0.0	$0.0	$0.0	$0.0	$0.6	$0.6	$0.5	$1.7	$2.2	$0.0	$0.0	$0.0	$0.5	$2.3	$2.8
Musculoskeletal Diseases	$0.0	$0.0	$0.0	$53.8	$48.3	$102.1	$61.0	$61.6	$122.6	$24.7	$40.1	$64.8	$139.5	$150.0	$289.5
Total - Indirect	**$183.5**	**$113.8**	**$297.2**	**$99.0**	**$105.1**	**$204.1**	**$147.0**	**$189.6**	**$336.6**	**$102.9**	**$133.5**	**$236.4**	**$532.4**	**$542.0**	**$1,074.3**

Overview of Results

Summary

The results of the direct and indirect cost analyses are summarized in Table 43 for each risk factor and for the multifactorial system where the factors are combined.

Table 43. Economic Burden of Smoking, Physical Inactivity and Overweight/Obesity
Manitoba, 2008, By Gender
Adjusted for Multiple Risk Factors in One Individual

	% Population with RF	# Individuals with RF	Direct Cost per Individual with RF ($'s)	Indirect Cost per Individual with RF ($'s)	Total Cost per Individual with RF ($'s)	Total Direct Cost of RF (M$'s)	Total Indirect Cost of RF (M$'s)	Total Cost of RF (M$'s)
Males								
Smokers	27.3%	134,873	$635	$1,360	$1,995	$85.6	$183.5	$269.1
Inactive	46.1%	225,415	$212	$457	$669	$47.8	$102.9	$150.8
Overweight	40.3%	179,734	$187	$551	$738	$33.6	$99.0	$132.6
Obesity	20.9%	94,476	$644	$1,556	$2,199	$60.8	$147.0	$207.8
Subtotal						**$227.8**	**$532.4**	**$760.2**
Females								
Smokers	21.2%	110,314	$507	$1,031	$1,538	$55.9	$113.8	$169.7
Inactive	48.3%	246,953	$227	$541	$767	$56.0	$133.5	$189.5
Overweight	28.0%	131,423	$309	$800	$1,109	$40.6	$105.1	$145.7
Obesity	19.6%	93,251	$934	$2,033	$2,967	$87.1	$189.6	$276.7
Subtotal						**$239.6**	**$542.0**	**$781.5**
Both Genders								
Smokers	24.2%	245,187	$577	$1,212	$1,789	$141.5	$297.2	$438.7
Inactive	47.2%	472,368	$220	$501	$720	$103.8	$236.4	$340.3
Overweight	34.2%	311,158	$239	$656	$894	$74.2	$204.1	$278.3
Obesity	20.3%	187,726	$788	$1,793	$2,581	$147.9	$336.6	$484.4
Total						**$467.4**	**$1,074.3**	**$1,541.8**

The total direct costs in Manitoba attributable to the health effects of smoking, physical inactivity, and excess weight are estimated at $467 million, while the indirect costs are estimated at $1.07 billion, yielding an overall total for adjusted costs of $1.54 billion in 2008.

Addressing Limitations in the CCHS Data

In estimating the exposure of Manitoba's population to the risk factors of smoking, overweight/obesity, and physical inactivity, the report has leaned heavily on Canadian Community Health Survey data. The summary exposure data for Manitoba based on CCHS is indicated in Table 44.

Table 44. Summary of Risk Factor Exposure in Manitoba
Based on 2008 CCHS

	Males	Females	Total	Age Group
% Overweight (25 < BMI < 30)	40.3%	28.0%	34.2%	18 and over
% Obesity (BMI > 30)	20.9%	19.6%	20.3%	18 and over
% Inactive (<1.5KKD)	46.1%	48.3%	47.2%	12 and over
% Current Smokers	27.3%	21.2%	24.2%	12 and over

There are, however, a number of key limitations with CCHS data. First, the information tends to underestimate smoking prevalence and overestimate physical inactivity prevalence in Manitoba's youth, as revealed by the results from the more detailed *Manitoba Youth Health Survey*. Second, CCHS does not capture information for individuals living on First Nations Reserves and on Crown Lands, for institutional residents, for full-time members of the

Canadian Forces, and for residents of certain remote regions. The most important exclusion with respect to the current project is the one involving individuals living on First Nations Reserves. In 2006, Manitoba's Aboriginal population was estimated at 100,645, or 8.4% of the total provincial population; of these, 55,355 lived on reserve.[83]

Results from the *Manitoba First Nations Regional Longitudinal Health Survey* suggest that the prevalence of smoking and overweight/obesity in these populations is substantially higher than the average for Manitoba (see Table 45).[84] Thus the exclusion of individuals living on First Nations Reserves in the CCHS would lead to an underestimate of exposure to these risk factors in the total Manitoba population.

Table 45. Manitoba First Nations Regional Longitudinal Health Survey 2002/03

Risk Factor	Child (0-11 yrs)	Youth (12-17 yrs)	Adult (18 yrs +)
Smoking	**29%** of caregivers reported that their child smokes	Current smokers: **42%**	Current smokers: **62%**
Physical Activity (PA)	78% of caregivers reported that their children get at least 30 min. of PA every day	30% are physically active either at school, at home, or in their leisure time	30% engaged in health promoting activities 3-6 hrs. per week; 18% did not participate in any such activities
Obesity[1]	**65%** were classified as overweight or obese	**41%** were classified as overweight or obese	**75%** were classified as overweight or obese

[1]BMI was determined from height and weight information collected in the survey

The CCHS data limitations can be addressed to some degree with adjustments made possible by using the *Manitoba Youth Health Survey* (MYHS) and the *Manitoba First Nations Regional Longitudinal Health Survey* results. The MYHS data were used to adjust for the CCHS underestimate of smoking prevalence and overestimate of physical inactivity prevalence in Manitoba's youth. To do so, smoking and physical inactivity rates were recalculated using CCHS data for Manitobans age 18 and older. The specific rates found in the MHYS were applied to the Manitoba population age 12-17 and the weighted average of the rates for the 12-17 and 18 and older groups recalculated. A similar approach was used to adjust for the estimated 55,355 individuals living on First Nations Reserves in Manitoba that are not included in the CCHS data. In this case, the *Manitoba First Nations Regional Longitudinal Health Survey* results were used. For obesity and overweight, the CCHS indicates that 54.5% of Manitoba adults are overweight or obese, compared to the *Manitoba First Nations Regional Longitudinal Health Survey* which suggests that 75% of Manitoba First Nations adults are overweight/obese. This higher rate was applied to the estimated subset Manitoba First Nations adults. The CCHS was used for all other Manitoba adults and then a weighted average for both groups combined was recalculated. The same approach was used to recalculate smoking rates in the 12-17 and 18 and older groups.

The summary risk factor exposure results for Manitoba, based on these adjustments, are indicated on Table 46. Overall, the percentage of the population age 18 and over that is overweight increased from 34.2% to 34.5%. For obesity, the increase was from 20.3% to 20.5%. The increase was larger for current smokers, moving from 24.2% to 26.9% of the population age 12 and over. The proportion of inactive individuals age 12 and over decreased slightly from 47.2% to 45.4%.

Table 46. Summary of Risk Factor Exposure in Manitoba Adjusted 2008 CCHS Data	Males	Females	Total	Age Group
% Overweight (25 < BMI < 30)	40.9%	28.4%	34.5%	18 and over
% Obesity (BMI > 30)	21.2%	19.9%	20.5%	18 and over
% Inactive (<1.5KKD)	43.0%	47.8%	45.4%	12 and over
% Current Smokers	29.8%	24.1%	26.9%	12 and over

Based on these changes in exposure data, the economic burden of smoking, physical inactivity, and overweight/obesity in Manitoba would expand from $1.54 to $1.62 billion in 2008, an increase of $73.8 million or 4.8% (see Table 47). The most important change related to the economic burden of smoking, which increased from $438.7 to $526.0 million (+ $87.3 million, or +19.90%). The estimated economic burden of overweight/obesity decreased marginally from $762.7 to $762.3 million (-$0.4 million, or -0.05%) while the estimated economic burden of physical inactivity decreased from $340.3 to $327.3 million (-$13.0 million, or -3.83%). These final adjustments yielded the foundational economic burden data to be employed in the balance of this project.

The total costs are divided relatively equally between males and females. It should be noted, however, that while the economic burden associated with smoking is higher in males, the economic burden associated with excess weight and physical inactivity is higher in women. The well-known rise of overweight/obesity as a public health and public finance concern is clearly displayed in this information. Figures 6 and 7 offer more detail for the economic burden (at both the population and individual level) associated with the Manitoba-developed exposure data for each risk factor.

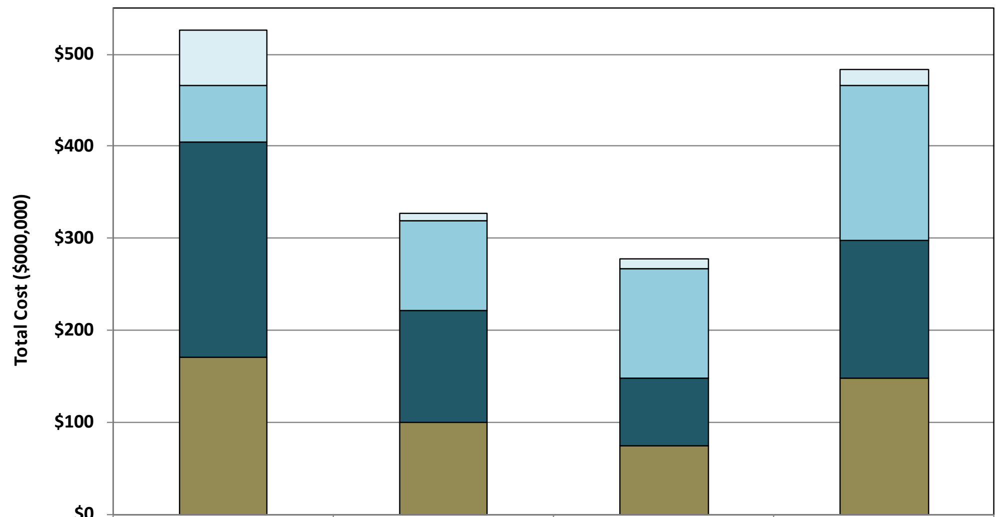
Table 47. Economic Burden of Smoking, Physical Inactivity and Overweight/Obesity
Manitoba, 2008, By Gender
Adjusted for Selected CCHS Data Limitations and Multiple Risk Factors in One Individual

	% Population with RF	# Individuals with RF	Direct Cost per Individual with RF ($'s)	Indirect Cost per Individual with RF ($'s)	Total Cost per Individual with RF ($'s)	Total Direct Cost of RF (M$'s)	Total Indirect Cost of RF (M$'s)	Total Cost of RF (M$'s)
Males								
Smokers	29.8%	148,460	$687	$1,469	$2,156	$102.0	$218.0	$320.0
Inactive	43.0%	213,795	$209	$451	$660	$44.8	$96.4	$141.1
Overweight	40.9%	182,064	$185	$543	$728	$33.6	$98.9	$132.5
Obesity	21.2%	94,277	$644	$1,558	$2,202	$60.8	$146.8	$207.6
Subtotal						**$241.2**	**$560.1**	**$801.3**
Females								
Smokers	24.1%	125,268	$544	$1,100	$1,644	$68.1	$137.8	$206.0
Inactive	47.8%	248,077	$222	$529	$750	$55.0	$131.1	$186.1
Overweight	28.4%	133,127	$305	$790	$1,095	$40.6	$105.2	$145.8
Obesity	19.9%	93,411	$931	$2,028	$2,959	$86.9	$189.5	$276.4
Subtotal						**$250.7**	**$563.6**	**$814.3**
Both Genders								
Smokers	26.9%	273,728	$622	$1,300	$1,922	$170.1	$355.9	$526.0
Inactive	45.4%	461,872	$216	$493	$709	$99.8	$227.5	$327.3
Overweight	34.5%	315,191	$236	$647	$883	$74.2	$204.1	$278.3
Obesity	20.5%	187,688	$787	$1,792	$2,579	$147.7	$336.3	$484.0
Total						**$491.8**	**$1,123.7**	**$1,615.6**

Figure 6. Estimated Direct and Indirect Economic Burden of Smoking, Physical Inactivity and Overweight/Obesity

Manitoba, 2008 ($000,000)

Adjusted for Selected CCHS Data Limitations and Multiple Risk Factors in One Individual

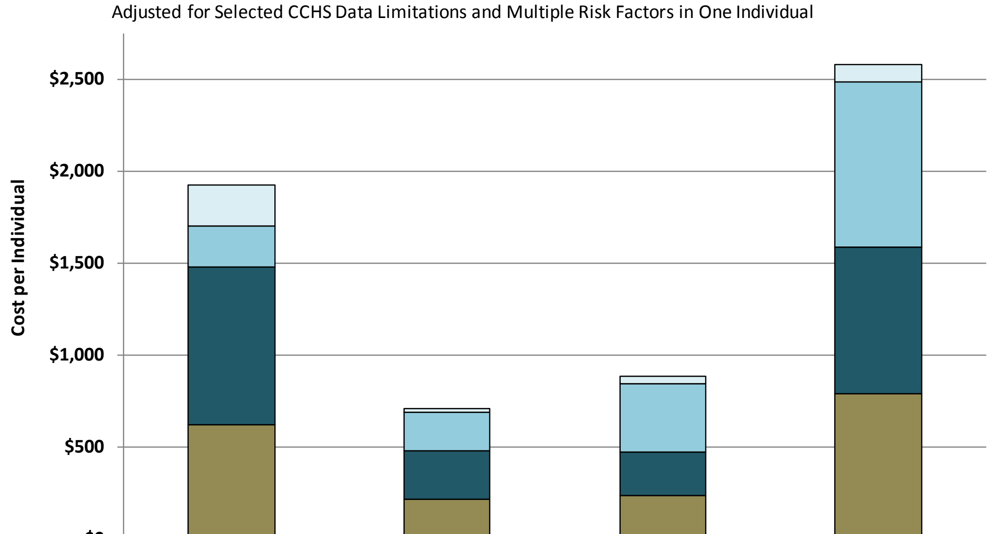


	Smoking	Physical Inactivity	Overweight	Obesity
Indirect - S-T Disability	$59.4	$8.0	$12.0	$17.9
Indirect - L-T Disability	$62.2	$98.0	$118.1	$168.5
Indirect - Mortality	$234.2	$121.5	$73.9	$149.9
Direct Cost	$170.1	$99.8	$74.2	$147.7

Figure 7. Estimated Direct and Indirect Economic Burden of Smoking, Physical Inactivity and Overweight/Obesity *per Individual with the Risk Factor*

Manitoba, 2008

Adjusted for Selected CCHS Data Limitations and Multiple Risk Factors in One Individual



	Smoking	Physical Inactivity	Overweight	Obesity
Indirect - S-T Disability	$217	$17	$38	$96
Indirect - L-T Disability	$227	$212	$375	$898
Indirect - Mortality	$856	$263	$235	$798
Direct Cost	$622	$216	$236	$787

A further challenge involved with using CCHS data is the reliance on only leisure-time physical activity in calculating the proportion of the population that is inactive. Both the Manitoba *in motion* survey and the work by the Manitoba Center for Health Policy (MCHP) have tried to address this limitation. The Manitoba *RHA Indicators Atlas* used CCHS data combined from cycles 1.1, 2.1, and 3.1 (2001-2005) to determine total physical activity levels for respondents aged 15-75 years. Total physical activity is a derived variable from the CCHS based on the average daily energy expenditure for work and travel-related physical activity, integrated with leisure-time physical activity. This analysis suggested that 28.1% of Manitoba males and 45.1% of Manitoba females are physically inactive, which may be compared with the 46.1%/48.3% as usually calculated based on CCHS (see Table 44). If the MCHP estimates of physical inactivity in Manitoba are entered into the economic model, then the annual economic burden associated with physical inactivity decreases from $327.3 to $277.7 million (-$49.6 million, or -15.2%). The reduction is greater for males (from $141.1 to $98.9 million) than for females (from $186.1 to $178.8 million). While the prevalence of physical inactivity based on *total* physical activity levels is available for Manitoba, the challenge remains that the majority of epidemiologic research in this area, including the calculation of relative risk (RR), is currently based on *leisure-time* physical activity/inactivity levels. This means that it may not be completely appropriate to simply combine total physical activity information with RR data abstracted from the literature; thus, an alternate economic burden estimate using total physical activity should be treated with caution.

Supporting Document 2: The Economic Benefits of Reducing Risk Factors

The purpose of Supporting Document 2 is to provide detailed information on the process and results associated with modelling the longer-term economic benefits of reducing the risk factors of tobacco smoking, overweight/obesity, and physical inactivity in Manitoba.

The key questions addressed in this Supporting Document are as follows:

1. If the proportion of the population with the risk factors was to remain at 2008 levels, what would be the economic impact in Manitoba in the future (specifically, to 2026) based solely on population growth and ageing?

2. If the proportion of the population with the risk factors was to be reduced by 1% per year starting in 2011, what would be the change in the economic burden in Manitoba in the future (to 2026)?

3. If the proportion of the population with the risk factors was to be reduced by 2% per year starting in 2011, what would be the change in the economic burden in Manitoba in the future (to 2026)?

The Benefits of Reducing Risk Factors

Smoking

A 1990 US Surgeon General's report focused on the health benefits of smoking cessation.[85] The major conclusions of the report were as follows:

- Smoking cessation has major and immediate health benefits for men and women of all ages. Benefits apply to persons with and without smoking-related disease.
- Former smokers live longer than continuing smokers.
- Smoking cessation decreases the risk of lung cancer and other cancers, heart attack, stroke, and chronic lung disease.
- Women who stop smoking before pregnancy or during the first 3 to 4 months of pregnancy reduce the risk of having a low birth weight baby to the level experienced by women who never smoked.
- The health benefits of smoking cessation far exceed any risks from the average 3 to 4 kg weight gain, as well as any adverse psychological effects that may follow quitting.

More recent research continues to support the findings of the Surgeon General's report on the benefits of smoking cessation.[86,87]

Despite these conclusions, several controversies exist regarding the potential reduced economic burden associated with smoking cessation.[88] The first of these is the issue of avoided costs attributable to the earlier deaths of smokers. In an often quoted study published in the *New England Journal of Medicine*, Barendregt and colleagues estimated that the direct medical costs of smokers are higher than non-smokers at any given age in the Netherlands, indeed, as much as 40% higher in older men. However, in older age groups, "the lower per capita cost of the non-smokers is outweighed by the greater number of people remaining alive." [89] Thus, based on the generally longer life enjoyed by former smokers, the investigators calculated that overall health care costs would *increase* by 7% for men and 4% for women if complete smoking cessation occurred. In blunt terms, this change is related to the earlier death experienced on average by smokers, at which point they no longer use health care resources. This study has been criticized for considering only a narrow scope of smoking-related diseases and for the lack of inclusion of indirect costs.[90]

A further controversy often noted in the debate about lifetime health care costs in smokers involves the idea that the early death of smokers spares them from poor health at the end of their life. Contrary to this position, a Danish study found that not only did smoking decrease life expectancy, it also decreased the number of self-rated years of good health. [91]

A third controversy associated with smoking-related costs is the apparent finding that direct medical care costs increase, rather than decrease, after a smoker quits, at least in the immediate post-quit period.[92,93] Fishman et al. suggest that there may be several reasons for this.[94,95] First, former smokers may seek medical care that they have delayed while smoking. Second, smoking cessation often coincides with or immediately follows a health event that motivates the effort to quit in the first place. This second issue is now often referred to as the *quitting ill* bias.[96]

The impact of the *quitting ill* bias was observed as early as the 1990 Surgeon General's report.[97] Table 1, reproduced from that source, clearly indicates that the overall mortality ratio for former smokers *increases* in the first two years after smoking cessation before declining to levels lower than that of a current smoker in year three and subsequent years. When former smokers with pre-existing illnesses are excluded, however, the overall mortality ratio for former smokers decreases *even* in the first two years after smoking cessation.

Table 1. Overall Mortality Ratios Among Current and Former Smokers, Relative to Never Smokers
by Gender and Duration of Abstinence at Date of Enrollment
ACP CPS - II

	Current Smokers	Former smokers – Duration of abstinence at enrollment (yr): < 1	1-2	3-5	6-10	11-15	≥ 16
Males							
1-20 cig/day	2.22	2.49	2.38	2.03	1.63	1.38	1.06
≥ 21 cig/day	2.43	2.77	2.64	2.25	2.04	1.77	1.27
Females							
1-20 cig/day	1.60	1.58	1.96	1.41	1.14	1.10	1.01
≥ 21 cig/day	2.10	3.39	2.58	2.03	1.60	1.38	1.15

	Current Smokers	Former smokers excluding those with cancer, heart disease, or stroke and those "sick" at interview – Duration of abstinence at enrollment (yr): < 1	1-2	3-5	6-10	11-15	≥ 16
Males							
1-20 cig/day	2.34	2.06	2.05	1.89	1.48	1.29	1.01
≥ 21 cig/day	2.73	1.85	2.15	1.90	1.77	1.65	1.19
Females							
1-20 cig/day	1.82	0.76	1.26	1.42	1.01	1.09	1.00
≥ 21 cig/day	2.46	3.33	2.15	1.44	1.46	1.18	0.95

Source: Table 2 from Chapter 3 of: U.S. Department of Health and Human Services, *The Health Benefits of Smoking Cessation - A Report of the Surgeon General*, 1990.

Table 1 also indicates that the overall mortality ratio decreases with time since smoking cessation. Kenfield and colleagues accessed information in the U.S. Nurses' Health Study to analyze the relationship between cigarette smoking and smoking cessation on total and cause-specific mortality.[98] This prospective observational study included 104,519 females with a follow-up period of 24 years. Table 2 and Figure 1 are based on information from this study.

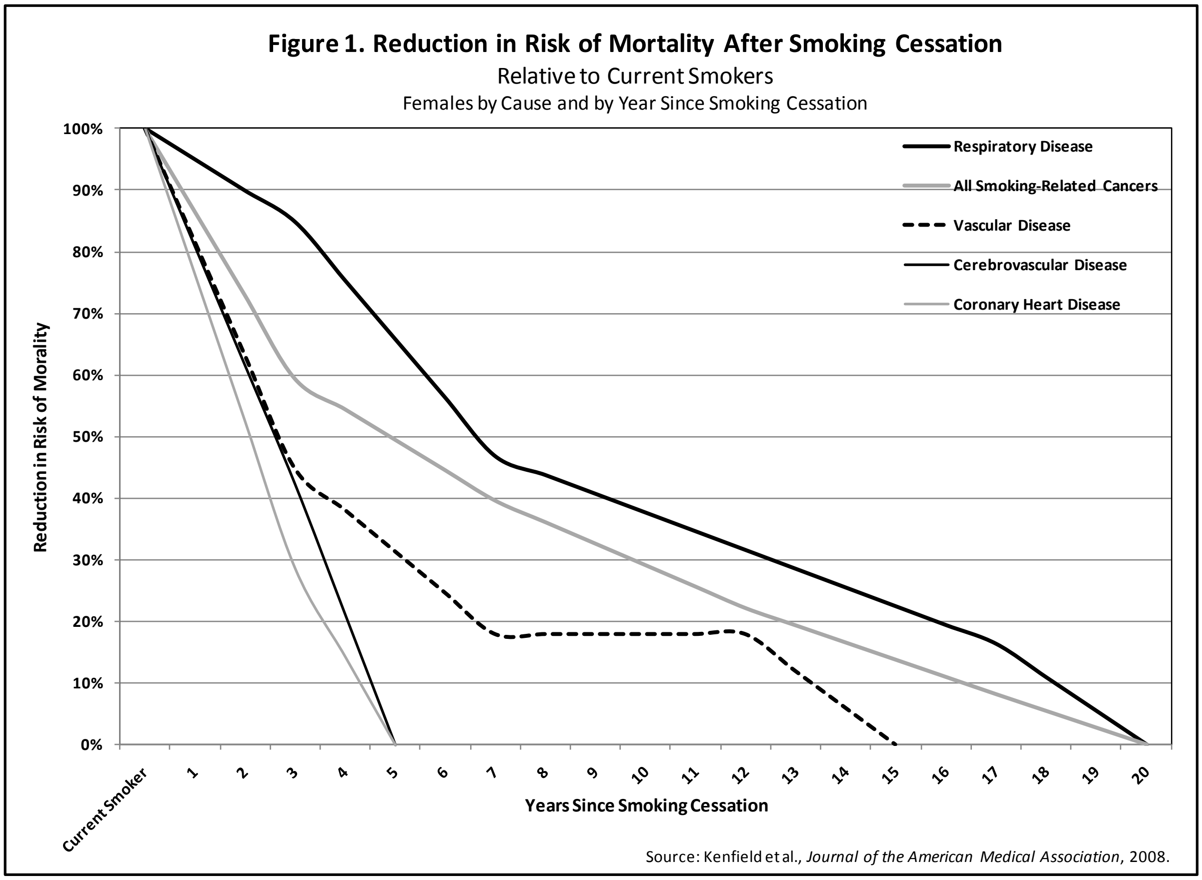
In summary, the excess risk of mortality (compared to a never smoker) from coronary heart and cerebrovascular disease disappears within five years after smoking cessation. The excess risk of mortality from vascular diseases takes 15 years, and the excess risk from respiratory disease and cancers takes approximately 20 years, to return to the level of a never smoker.

Table 2. Reduction in Risk of Mortality After Smoking Cessation
Females, by Cause and by Year Since Smoking Cessation

Years Since Quiting	**Total Mortality** HR	95% CI		Vascular Disease HR	95% CI		Coronary Heart Disease HR	95% CI		Cerebrovascular Disease HR	95% CI		Respiratory Disease HR	95% CI		All smoking-related cancers HR	95% CI	
Smoker	1.00			1.00			1.00			1.00			1.00			1.00		
< 5	0.74	0.69	0.80	0.63	0.54	0.74	0.50	0.40	0.64	0.63	0.45	0.87	0.86	0.69	1.08	0.65	0.56	0.76
5 - <10	0.55	0.51	0.60	0.45	0.38	0.54	0.37	0.28	0.48	0.41	0.28	0.60	0.51	0.39	0.67	0.48	0.41	0.57
10 - <15	0.49	0.45	0.53	0.45	0.38	0.54	0.40	0.31	0.53	0.42	0.28	0.61	0.37	0.27	0.50	0.33	0.27	0.41
15 - <20	0.43	0.39	0.47	0.39	0.33	0.47	0.36	0.28	0.48	0.44	0.31	0.63	0.23	0.16	0.33	0.21	0.16	0.27
≥ 20	0.34	0.32	0.36	0.28	0.25	0.32	0.23	0.19	0.28	0.32	0.25	0.41	0.11	0.08	0.14	0.17	0.14	0.19
Never Smoker	0.36	0.35	0.38	0.33	0.31	0.37	0.30	0.26	0.34	0.36	0.30	0.43	0.08	0.07	0.10	0.14	0.12	0.15

Source: Kenfield et al., *Journal of the American Medical Association* , 2008.

Current Smoker	1.00	100.0%	1.00	100.0%	1.00	100.0%	1.00	100.0%	1.00	100.0%	1.00	100.0%
1	0.91	86.5%	0.88	81.6%	0.83	76.2%	0.88	80.7%	0.95	94.9%	0.88	86.4%
2	0.83	72.9%	0.75	63.2%	0.67	52.4%	0.75	61.5%	0.91	89.9%	0.77	72.9%
3	0.74	59.4%	0.63	44.8%	0.50	28.6%	0.63	42.2%	0.86	84.8%	0.65	59.3%
4	0.69	52.0%	0.59	38.1%	0.47	14.3%	0.58	21.1%	0.77	75.3%	0.61	54.4%
5	0.65	44.5%	0.54	31.3%	0.44	0.0%	0.52	0.0%	0.69	65.8%	0.57	49.4%
6	0.60	37.1%	0.50	24.6%	0.40	0.0%	0.47	0.0%	0.60	56.3%	0.52	44.5%
7	0.55	29.7%	0.45	17.9%	0.37	0.0%	0.41	0.0%	0.51	46.7%	0.48	39.5%
8	0.54	27.8%	0.45	17.9%	0.38	0.0%	0.41	0.0%	0.48	43.7%	0.45	36.0%
9	0.53	25.9%	0.45	17.9%	0.38	0.0%	0.41	0.0%	0.45	40.7%	0.42	32.6%
10	0.51	24.1%	0.45	17.9%	0.39	0.0%	0.42	0.0%	0.43	37.6%	0.39	29.1%
11	0.50	22.2%	0.45	17.9%	0.39	0.0%	0.42	0.0%	0.40	34.6%	0.36	25.6%
12	0.49	20.3%	0.45	17.9%	0.40	0.0%	0.42	0.0%	0.37	31.5%	0.33	22.1%
13	0.48	18.4%	0.44	11.9%	0.39	0.0%	0.42	0.0%	0.34	28.5%	0.31	19.3%
14	0.47	16.6%	0.43	6.0%	0.38	0.0%	0.43	0.0%	0.31	25.4%	0.28	16.5%
15	0.45	14.7%	0.41	0.0%	0.38	0.0%	0.43	0.0%	0.29	22.4%	0.26	13.7%
16	0.44	12.8%	0.40	0.0%	0.37	0.0%	0.44	0.0%	0.26	19.3%	0.23	10.9%
17	0.43	10.9%	0.39	0.0%	0.36	0.0%	0.44	0.0%	0.23	16.3%	0.21	8.1%
18	0.42	7.3%	0.37	0.0%	0.34	0.0%	0.42	0.0%	0.21	10.9%	0.20	5.4%
19	0.40	3.6%	0.35	0.0%	0.32	0.0%	0.40	0.0%	0.19	5.4%	0.20	2.7%
20	0.39	0.0%	0.34	0.0%	0.30	0.0%	0.38	0.0%	0.17	0.0%	0.19	0.0%
21	0.37	0.0%	0.32	0.0%	0.27	0.0%	0.36	0.0%	0.15	0.0%	0.18	0.0%
22	0.36	0.0%	0.30	0.0%	0.25	0.0%	0.34	0.0%	0.13	0.0%	0.18	0.0%
23	0.34	0.0%	0.28	0.0%	0.23	0.0%	0.32	0.0%	0.11	0.0%	0.17	0.0%
24												
25												
Never Smoked	0.36	0.0%	0.33	0.0%	0.30	0.0%	0.36	0.0%	0.08	0.0%	0.14	0.0%



The disease-specific trends in the reduction in excess risk were applied to the disease-specific excess economic burden associated with individuals who smoke as calculated in **Phase 1** of the project. For females in Manitoba, the estimated trend in the excess annual economic burden of former smokers based on the years since smoking cessation is indicated in Table 6. That is, one year after smoking cessation, the annual direct and indirect costs would decrease from $1,644 (the annual cost of a female smoker in Manitoba in 2008) to $1,427 (or 87% of the 2008 annual costs). Five and ten years after smoking cessation, the annual costs would decrease to $646 and $373, respectively. Only after 20 years would the annual economic burden for a former smoker equal that of a never smoker. All costs are shown in constant 2008 dollars.

Table 3. Reduction in Total (Direct + Indirect) Costs After Smoking Cessation
Females, by Year Since Smoking Cessation

Years Since Quitting	Direct	Indirect			Subtotal Indirect	Total (Direct + Indirect)	% of $ vs. Smoker
		Mortality	Disability				
			Long-Term	Short-Term			
Current Smoker	$543.79	$711.54	$200.17	$188.68	$1,100.39	$1,644.18	100%
1	$474.24	$604.61	$171.22	$177.34	$953.16	$1,427.41	87%
2	$404.70	$497.67	$142.26	$166.00	$805.94	$1,210.63	74%
3	$335.15	$390.74	$113.30	$154.66	$658.71	$993.86	60%
4	$273.11	$321.37	$89.17	$136.45	$546.99	$820.09	50%
5	$211.06	$251.99	$65.04	$118.23	$435.26	$646.33	39%
6	$181.78	$222.26	$56.06	$101.23	$379.55	$561.33	34%
7	$152.50	$192.53	$47.07	$84.23	$323.83	$476.33	29%
8	$142.12	$177.29	$43.86	$78.71	$299.86	$441.97	27%
9	$131.73	$162.05	$40.65	$73.18	$275.88	$407.61	25%
10	$121.35	$146.80	$37.44	$67.66	$251.90	$373.26	23%
11	$110.97	$131.56	$34.23	$62.14	$227.93	$338.90	21%
12	$100.59	$116.32	$31.02	$56.61	$203.95	$304.54	19%
13	$89.31	$101.64	$27.35	$51.07	$180.06	$269.38	16%
14	$78.04	$86.97	$23.68	$45.53	$156.18	$234.21	14%
15	$66.76	$72.29	$20.01	$39.99	$132.29	$199.05	12%
16	$56.94	$59.38	$17.01	$34.50	$110.89	$167.83	10%
17	$47.12	$46.46	$14.01	$29.02	$89.49	$136.61	8%
18	$31.42	$30.97	$9.34	$19.35	$59.66	$91.08	6%
19	$15.71	$15.49	$4.67	$9.67	$29.83	$45.54	3%
20	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	0%

The information in Table 3 is based on research on smoking cessation in females. The literature is unclear whether the trends in reduced overall mortality based on years after smoking cessation are similar for males.[99,100] The data in Table 4 is based on the assumption that the overall and cause-specific trend in mortality following smoking cessation is in effect similar for males.

Table 4. Reduction in Total (Direct + Indirect) Costs After Smoking Cessation Males, by Year Since Smoking Cessation							
		Indirect					
			Disability				
Years Since Quitting	Direct	Mortality	Long-Term	Short-Term	Subtotal Indirect	Total (Direct + Indirect)	% of $ vs. Smoker
Current Smoker	$687.21	$977.46	$250.16	$240.93	$1,468.55	$2,155.76	100%
1	$601.50	$834.19	$214.92	$226.48	$1,275.60	$1,877.10	87%
2	$515.80	$690.92	$179.68	$212.04	$1,082.64	$1,598.44	74%
3	$430.09	$547.66	$144.43	$197.59	$889.68	$1,319.77	61%
4	$357.24	$462.93	$116.67	$174.58	$754.18	$1,111.43	52%
5	$284.40	$378.21	$88.91	$151.57	$618.69	$903.08	42%
6	$245.26	$334.27	$76.72	$129.81	$540.81	$786.07	36%
7	$206.12	$290.34	$64.54	$108.05	$462.93	$669.05	31%
8	$191.98	$267.10	$60.10	$100.95	$428.15	$620.13	29%
9	$177.83	$243.85	$55.67	$93.85	$393.37	$571.20	26%
10	$163.68	$220.61	$51.23	$86.75	$358.60	$522.28	24%
11	$149.54	$197.37	$46.80	$79.65	$323.82	$473.35	22%
12	$135.39	$174.12	$42.36	$72.56	$289.04	$424.43	20%
13	$119.82	$151.79	$37.19	$65.43	$254.42	$374.23	17%
14	$104.24	$129.47	$32.02	$58.31	$219.79	$324.03	15%
15	$88.67	$107.14	$26.85	$51.18	$185.17	$273.84	13%
16	$75.42	$87.62	$22.75	$44.14	$154.52	$229.94	11%
17	$62.18	$68.11	$18.65	$37.11	$123.87	$186.05	9%
18	$41.45	$45.41	$12.43	$24.74	$82.58	$124.03	6%
19	$20.73	$22.70	$6.22	$12.37	$41.29	$62.02	3%
20	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	0%

Overweight and Obesity

Assessing the health and economic benefits associated with weight loss is also marked by complexity and sometimes even controversy. The pertinent issues include the fact that fluctuations in weight may actually increase mortality compared with maintaining a steady weight, that an inappropriate focus on weight loss may increase the risk of eating disorders, and that a degree of overweight may actually be protective in individuals with respect to certain chronic conditions.[101]

Perhaps the most important issue is determining whether the weight loss is intentional or unintentional. The issue is similar to the *quitting ill* bias observed in smoking cessation studies, namely, unintentional weight loss may be associated with an underlying disease process that results in excess mortality. Results from early studies assessing weight loss in the general population found equivocal associations between weight loss and mortality.[102] These mixed results were based largely on observational studies that were not specifically designed to test the hypothesis that *intentional* weight loss reduces mortality.[103] The results are much different when the studies are designed to assess the differential effect associated with intentional vs. unintentional weight loss. In such a study by Gregg et al., the results suggest that *intentional* weight loss is associated with a 24% *lower* mortality rate (compared to those who report not trying to lose weight or who did not experience weight loss).[104] On the other hand, *unintentional* weight loss was associated with a 31% *higher* mortality rate. When intentionality was not taken into account, overall weight loss was associated with increased mortality, driven by the higher mortality associated with unintentional weight loss.

One further issue relates to the phenomenon that weight loss does not have to be successful to have a positive effect on health. In the study by Gregg et al., the authors observed that attempted weight loss was independently associated with reduced mortality, likely due to the fact that weight loss attempts are a marker for other forms of healthy behaviour.

The controversy about whether or not intentional weight loss is associated with a lower mortality rate seems to be ongoing.[105,106] One caution about this controversy is that it may be as much about politics as unbiased research, reminiscent of the days when tobacco companies consistently questioned the research linking cigarette smoking to a variety of diseases. For example, the recent review paper by Harrington and colleagues (cited immediately above) was funded by the World Sugar Research Organization, with the corresponding author being an employee of this organization and the lead author being an employee of The Sugar Bureau in London, England. Despite this fact, the acknowledgements for the paper indicate that "the authors have no conflicts of interest to declare."

Physical Inactivity

There is less controversy associated with the health and economic benefits of increasing physical activity levels. Research has consistently found that improving physical activity levels leads to an lower risk of premature death from all causes, as well as from specific diseases such as cancers, cardiovascular diseases and so on.[107,108,109,110,111,112,113]

One of the issues in this area is whether being physically active mitigates the effects of overweight and obesity. In their assessment of the results from the U.S. Nurses' Health Study, Hu and colleagues established that *both* increased weight and reduced physical activity are "strong and independent predictors of death."[114] This means that an individual who is overweight and physically active still has a significantly higher risk of death from all causes compared with an individual of healthy weight who is physically active. This relationship holds for the risk of death specifically related to cardiovascular diseases, as well as for cancer mortality and for deaths from all causes, as indicated in Table 5. The study by Hu et al. confirms the results found in numerous smaller studies. Katzmarzyk and co-authors[115] reviewed the approximately 170 articles published prior to February of 2003 and, based on their meta-analysis, determined that "both physical activity and adiposity are important determinants of mortality risk." Furthermore, "physically active individuals have a lower risk of mortality by comparison to physically inactive peers, independent of level of adiposity."

Table 5. Relative Risk of Death
By BMI and Physical Activity

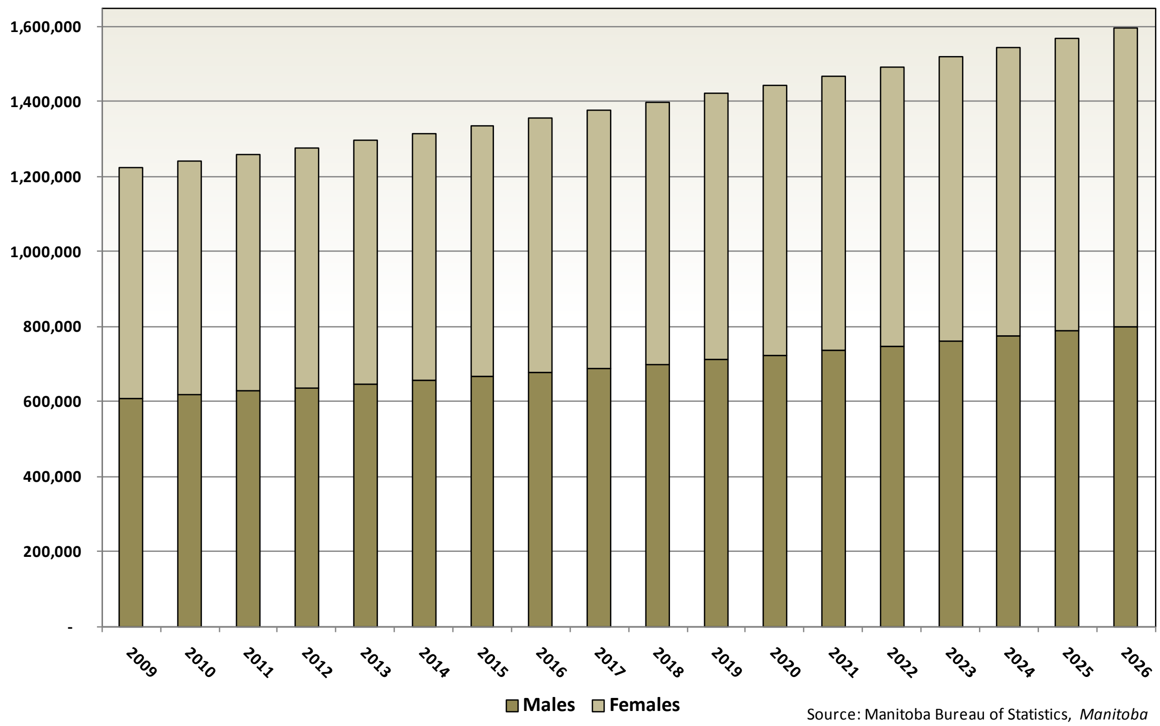
All Causes	**Physical Activity (hr/wk)**		
	≥3.5	*1.0 - 3.4*	*<1.0*
BMI <25.0	1.00	1.18	1.55
BMI 25.0 - 29.9	1.28	1.33	1.64
BMI ≥30	1.91	2.05	2.42
Cardiovascular Diseases	**Physical Activity (hr/wk)**		
	≥3.5	*1.0 - 3.4*	*<1.0*
BMI <25.0	1.00	1.51	1.89
BMI 25.0 - 29.9	1.58	2.06	2.52
BMI ≥30	2.87	4.26	4.73
Cancers	**Physical Activity (hr/wk)**		
	≥3.5	*1.0 - 3.4*	*<1.0*
BMI <25.0	1.00	1.09*	1.32
BMI 25.0 - 29.9	1.22	1.20	1.39
BMI ≥30	1.57	1.44	1.68

** Not significant, confidence interval includes 1.0*
Source Hu et al, NEJM, 2004.

Projected Manitoba Population

As will become clear below, population projections for the province are important to the analysis, estimates from the Manitoba Bureau of Statistics suggest that the Manitoba population will increase from 1,223,675 in 2009 to 1,596,294 in 2026 (or 30.5%).[116] The number of males is expected to increase at a slightly higher rate (from 609,323 to 800,863, or 31.4%) than the number of females (from 614,352 to 795,431, or 29.4%), as indicated on Figure 2a.

Figure 2a. Manitoba Population Projections
by Gender, 2009-2026



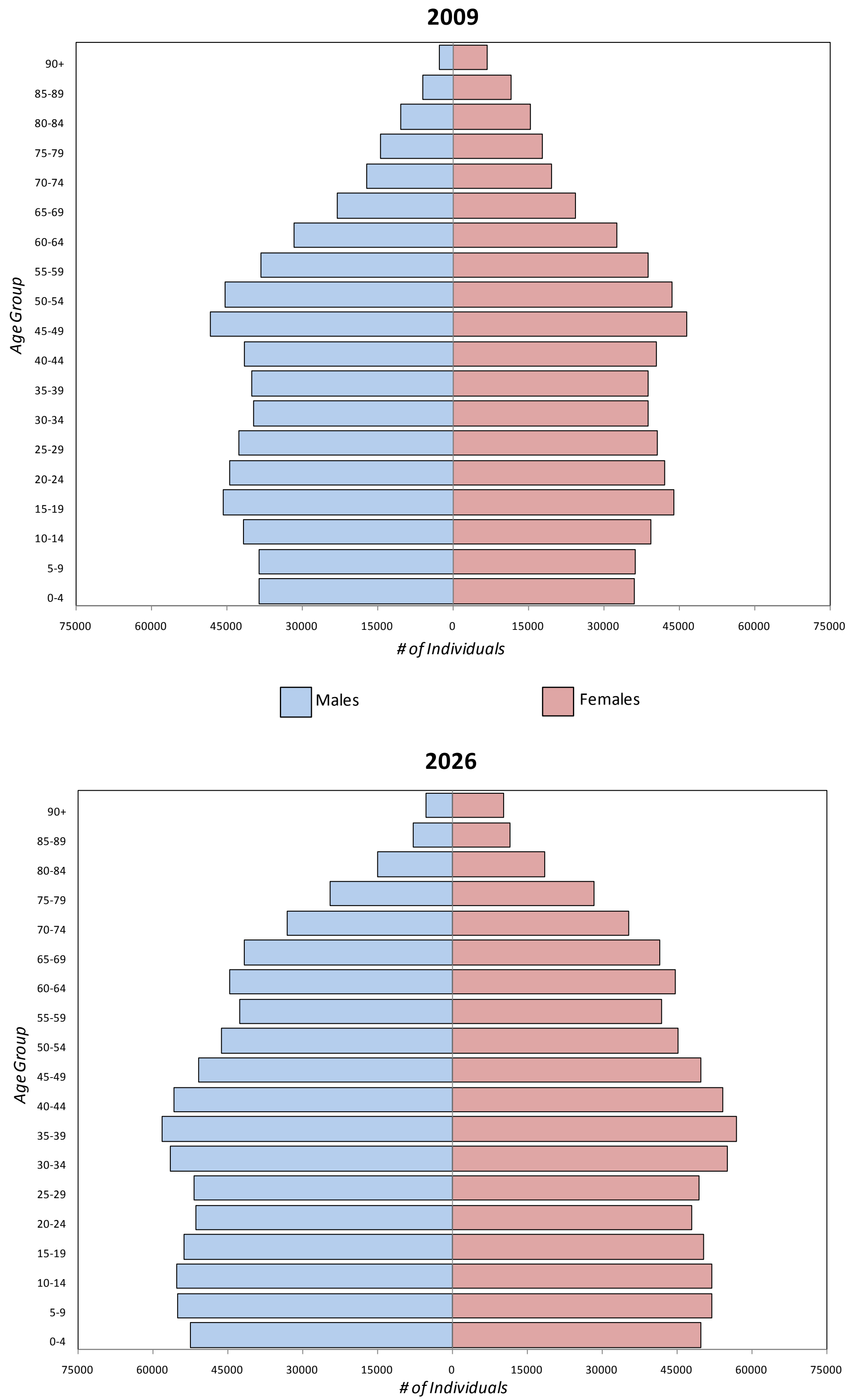
Source: Manitoba Bureau of Statistics, *Manitoba Population Projections 2008-2041,* 2010.

Population projections were provided by the Manitoba Bureau of Statistics using standard five-year age groups. Figure 2b includes population pyramids for 2009 and 2026.

Figure 2b.Population Demographics in Manitoba

Estimated 2009 and 2026

by Age Group and Gender



In the CCHS data, the denominator for calculating the proportion of the population with the risk factors of smoking and physical inactivity is the population age 12 years and over, while the denominator for overweight is the population age 18 years and over. To accommodate these age cut-offs for the purpose of analyzing the impact of risk factor rates within projected population numbers, the age 10-14 cohort was subdivided into age 10 and 11 years and 12 to 14 years, assuming an equal distribution across each year of age. Similarly, the age 15-19 cohort was subdivided into ages 15 to 17 years and 18 and 19 years (see Table 6).

Table 6. Manitoba Population Estimates
By Age Group and Gender
2009 to 2026

		2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
0-9	**M**	77,041	78,189	79,760	81,478	83,354	85,370	87,395	89,423	91,340	93,315	95,311	97,343	99,301	101,160	102,911	104,549	106,014	107,325
	F	72,338	73,526	74,924	76,684	78,600	80,434	82,546	84,590	86,585	88,576	90,467	92,393	94,246	96,006	97,664	99,213	100,602	101,844
	T	149,379	151,715	154,684	158,162	161,954	165,804	169,941	174,013	177,925	181,891	185,778	189,736	193,547	197,166	200,575	203,762	206,616	209,169
10-11	**M**	16,694	16,641	16,612	16,700	16,829	16,955	17,114	17,433	17,834	18,270	18,738	19,178	19,629	20,059	20,527	21,028	21,560	22,080
	F	15,792	15,641	15,580	15,601	15,692	15,874	15,989	16,207	16,570	16,990	17,403	17,894	18,369	18,844	19,333	19,805	20,306	20,795
	T	32,486	32,282	32,192	32,301	32,521	32,828	33,103	33,640	34,404	35,259	36,141	37,072	37,998	38,903	39,860	40,833	41,866	42,875
12-14	**M**	25,040	24,962	24,917	25,050	25,243	25,432	25,672	26,149	26,752	27,404	28,108	28,766	29,444	30,088	30,791	31,542	32,340	33,120
	F	23,688	23,461	23,371	23,401	23,539	23,810	23,983	24,310	24,855	25,484	26,104	26,842	27,554	28,267	29,000	29,708	30,459	31,193
	T	48,728	48,423	48,288	48,451	48,782	49,243	49,655	50,459	51,607	52,889	54,212	55,608	56,998	58,355	59,791	61,250	62,799	64,313
15-17	**M**	27,351	27,358	27,266	27,138	27,127	26,970	26,952	26,966	27,154	27,407	27,664	27,977	28,535	29,224	29,963	30,752	31,482	32,213
	F	26,404	26,386	26,249	25,997	25,803	25,618	25,444	25,403	25,482	25,675	26,009	26,252	26,655	27,283	27,995	28,699	29,503	30,266
	T	53,755	53,744	53,515	53,135	52,930	52,588	52,396	52,369	52,636	53,082	53,672	54,229	55,190	56,507	57,958	59,450	60,985	62,480
18-19	**M**	18,234	18,238	18,177	18,092	18,084	17,980	17,968	17,977	18,102	18,272	18,442	18,652	19,023	19,482	19,975	20,501	20,988	21,476
	F	17,603	17,591	17,499	17,332	17,202	17,078	16,962	16,936	16,988	17,116	17,339	17,501	17,770	18,189	18,664	19,132	19,669	20,178
	T	35,837	35,829	35,676	35,424	35,286	35,058	34,930	34,913	35,090	35,388	35,782	36,153	36,793	37,671	38,639	39,634	40,657	41,653
20-24	**M**	44,462	45,571	46,604	47,357	47,953	48,416	48,500	48,408	48,244	48,288	48,105	48,165	48,288	48,710	49,244	49,782	50,394	51,390
	F	42,200	43,502	44,831	45,745	46,373	46,755	46,774	46,582	46,189	45,910	45,664	45,452	45,478	45,715	46,142	46,803	47,294	48,031
	T	86,662	89,073	91,435	93,102	94,326	95,171	95,274	94,990	94,433	94,198	93,769	93,617	93,766	94,425	95,386	96,585	97,688	99,421
25-29	**M**	42,586	43,617	44,331	45,246	45,846	46,784	47,953	49,034	49,820	50,469	51,004	51,181	51,201	51,169	51,343	51,293	51,451	51,645
	F	40,737	41,805	42,635	43,496	44,354	45,243	46,564	47,903	48,817	49,472	49,909	50,012	49,932	49,677	49,537	49,429	49,323	49,423
	T	83,323	85,422	86,966	88,742	90,200	92,027	94,517	96,937	98,637	99,941	100,913	101,193	101,133	100,846	100,880	100,722	100,774	101,068
30-34	**M**	39,628	40,652	41,938	43,369	44,823	46,263	47,385	48,184	49,178	49,877	50,933	52,241	53,482	54,452	55,285	56,005	56,329	56,460
	F	38,766	39,647	40,756	42,043	43,235	44,590	45,716	46,601	47,511	48,438	49,419	50,858	52,343	53,435	54,269	54,884	55,131	55,159
	T	78,394	80,299	82,694	85,412	88,058	90,853	93,101	94,785	96,689	98,315	100,352	103,099	105,825	107,887	109,554	110,889	111,460	111,619
35-39	**M**	39,945	40,258	40,750	41,288	41,965	42,784	43,909	45,289	46,807	48,360	49,914	51,168	52,121	53,289	54,164	55,394	56,842	58,189
	F	38,834	39,203	39,504	39,960	40,876	41,872	42,835	44,023	45,385	46,666	48,123	49,370	50,398	51,472	52,566	53,714	55,286	56,871
	T	78,779	79,461	80,254	81,248	82,841	84,656	86,744	89,312	92,192	95,026	98,037	100,538	102,519	104,761	106,730	109,108	112,128	115,060
40-44	**M**	41,547	40,841	40,772	41,188	41,692	42,157	42,578	43,171	43,808	44,590	45,523	46,772	48,288	49,952	51,652	53,352	54,726	55,772
	F	40,561	39,826	39,865	40,376	40,907	41,313	41,774	42,166	42,709	43,717	44,814	45,890	47,200	48,699	50,117	51,710	53,069	54,183
	T	82,108	80,667	80,637	81,564	82,599	83,470	84,352	85,337	86,517	88,307	90,337	92,662	95,488	98,651	101,769	105,062	107,795	109,955
45-49	**M**	48,202	47,767	46,667	45,206	44,005	42,951	42,345	42,363	42,857	43,444	44,001	44,524	45,224	45,977	46,873	47,919	49,260	50,843
	F	46,565	46,645	45,873	44,671	43,167	42,055	41,414	41,537	42,127	42,739	43,233	43,787	44,279	44,930	46,041	47,239	48,401	49,775
	T	94,767	94,412	92,540	89,877	87,172	85,006	83,759	83,900	84,984	86,183	87,234	88,311	89,503	90,907	92,914	95,158	97,661	100,618
50-54	**M**	45,266	46,210	47,128	47,739	48,111	48,360	47,986	46,958	45,571	44,441	43,461	42,927	43,012	43,569	44,220	44,841	45,420	46,164
	F	43,546	44,161	45,076	45,700	46,336	46,863	46,991	46,276	45,136	43,701	42,656	42,080	42,262	42,907	43,574	44,124	44,727	45,261
	T	88,812	90,371	92,204	93,439	94,447	95,223	94,977	93,234	90,707	88,142	86,117	85,007	85,274	86,476	87,794	88,965	90,147	91,425
55-59	**M**	38,213	39,567	41,019	42,242	43,521	44,474	45,419	46,337	46,954	47,342	47,613	47,281	46,311	44,990	43,924	43,005	42,520	42,632
	F	38,839	39,959	40,812	41,871	42,583	43,011	43,633	44,550	45,181	45,827	46,365	46,513	45,836	44,742	43,359	42,362	41,825	42,028
	T	77,052	79,526	81,831	84,113	86,104	87,485	89,052	90,887	92,135	93,169	93,978	93,794	92,147	89,732	87,283	85,367	84,345	84,660
60-64	**M**	31,653	32,989	34,187	34,689	35,370	36,557	37,871	39,278	40,463	41,702	42,634	43,565	44,471	45,089	45,488	45,776	45,483	44,574
	F	32,612	34,108	35,303	35,682	36,463	37,704	38,799	39,631	40,664	41,363	41,791	42,411	43,321	43,955	44,605	45,147	45,307	44,661
	T	64,265	67,097	69,490	70,371	71,833	74,261	76,670	78,909	81,127	83,065	84,425	85,976	87,792	89,044	90,093	90,923	90,790	89,235
65-69	**M**	22,966	24,104	25,037	26,891	28,256	29,333	30,592	31,715	32,204	32,859	33,995	35,253	36,599	37,738	38,923	39,824	40,733	41,618
	F	24,393	25,269	26,290	28,202	29,773	31,128	32,556	33,697	34,064	34,821	36,019	37,079	37,889	38,896	39,585	40,015	40,630	41,524
	T	47,359	49,373	51,327	55,093	58,029	60,461	63,148	65,412	66,268	67,680	70,014	72,332	74,488	76,634	78,508	79,839	81,363	83,142
70-74	**M**	17,096	17,387	17,944	18,614	19,458	20,493	21,523	22,374	24,061	25,305	26,292	27,444	28,461	28,946	29,572	30,637	31,817	33,072
	F	19,674	19,848	20,373	20,989	21,813	22,617	23,437	24,397	26,192	27,671	28,941	30,273	31,349	31,716	32,451	33,593	34,607	35,382
	T	36,770	37,235	38,317	39,603	41,271	43,110	44,960	46,771	50,253	52,976	55,233	57,717	59,810	60,662	62,023	64,230	66,424	68,454
75+	**M**	33,399	33,774	34,161	34,471	34,916	35,362	35,861	36,610	37,408	38,482	39,731	41,020	42,371	44,482	46,435	48,299	50,332	52,290
	F	51,800	51,966	52,102	52,101	52,238	52,384	52,617	53,174	53,724	54,617	55,518	56,527	57,968	60,166	62,382	64,401	66,558	68,857
	T	85,199	85,740	86,263	86,572	87,154	87,746	88,478	89,784	91,132	93,099	95,249	97,547	100,339	104,648	108,817	112,700	116,890	121,147
TOTAL	**M**	**609,323**	**618,125**	**627,270**	**636,758**	**646,553**	**656,641**	**667,023**	**677,669**	**688,557**	**699,827**	**711,469**	**723,457**	**735,761**	**748,376**	**761,290**	**774,499**	**787,691**	**800,863**
	F	**614,352**	**622,544**	**631,043**	**639,851**	**648,954**	**658,349**	**668,034**	**677,983**	**688,179**	**698,783**	**709,774**	**721,134**	**732,849**	**744,899**	**757,284**	**769,978**	**782,697**	**795,431**
	T	**1,223,675**	**1,240,669**	**1,258,313**	**1,276,609**	**1,295,507**	**1,314,990**	**1,335,057**	**1,355,652**	**1,376,736**	**1,398,610**	**1,421,243**	**1,444,591**	**1,468,610**	**1,493,275**	**1,518,574**	**1,544,477**	**1,570,388**	**1,596,294**

Source: Manitoba Bureau of Statistics, *Manitoba Population Estimates 2008-2041*, 2010.

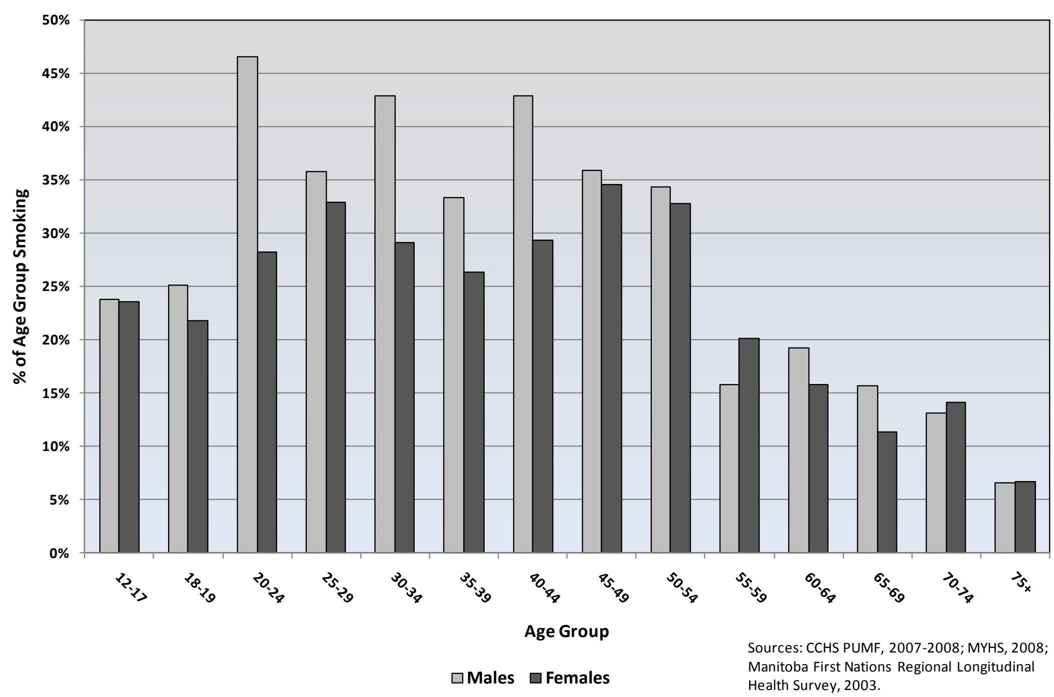
Economic Impact of No Change in Risk Factor Prevalence

If the proportion of the population with the risk factors was to remain at 2008 levels, what would be the economic impact in Manitoba in the future (to 2026) based solely on population growth and ageing?

As a first step in addressing this question, the Canadian Community Health Survey Public Use Microdata File (CCHS PUMF) for 2007/08 was accessed.[117] This data source provided information on the prevalence of smoking, physical inactivity, overweight, and obesity by gender- age-group in the Manitoba population based on combined CCHS data for 2007 and 2008. The following adjustments were then made to this data, similar to the approach taken to modifying the CCHS data in **Phase 1** of the project (see Supporting Document 1). First, the prevalence of smoking and physical inactivity in 12 to 17 year olds was replaced with data from the *Manitoba Youth Health Survey*. Second, the Manitoba *First Nations Regional Longitudinal Health Survey* results were used to adjust for the estimated 55,355 individuals living on First Nations Reserves in Manitoba who are not included in the CCHS data. The prevalence of smoking, overweight, and obesity was increased equally among all age groups to reflect the higher prevalence of these risk factors in that population. The result of these adjustments for the four risk factors of interest is shown on Figures 3 to 6.

Figure 3. Smoking in Manitoba

By Age Group, 2007-2008 Adjusted CCHS



Sources: CCHS PUMF, 2007-2008; MYHS, 2008; Manitoba First Nations Regional Longitudinal Health Survey, 2003.

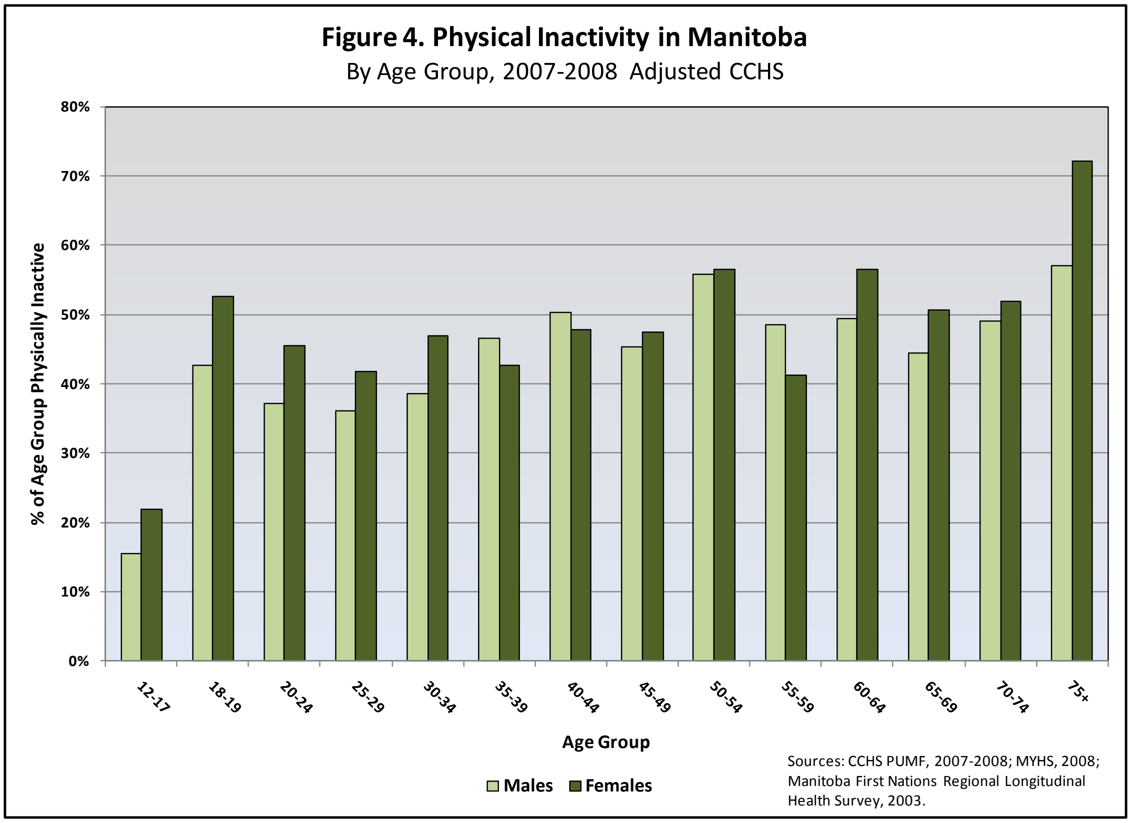


Figure 4. Physical Inactivity in Manitoba
By Age Group, 2007-2008 Adjusted CCHS
% of Age Group Physically Inactive
80%
70%
60%
50%
40%
30%
20%
10%
0%
12-17
18-19
20-24
25-29
30-34
35-39
40-44
45-49
50-54
55-59
60-64
65-69
70-74
75+
Age Group
Males
Females
Sources: CCHS PUMF, 2007-2008; MYHS, 2008; Manitoba First Nations Regional Longitudinal Health Survey, 2003.

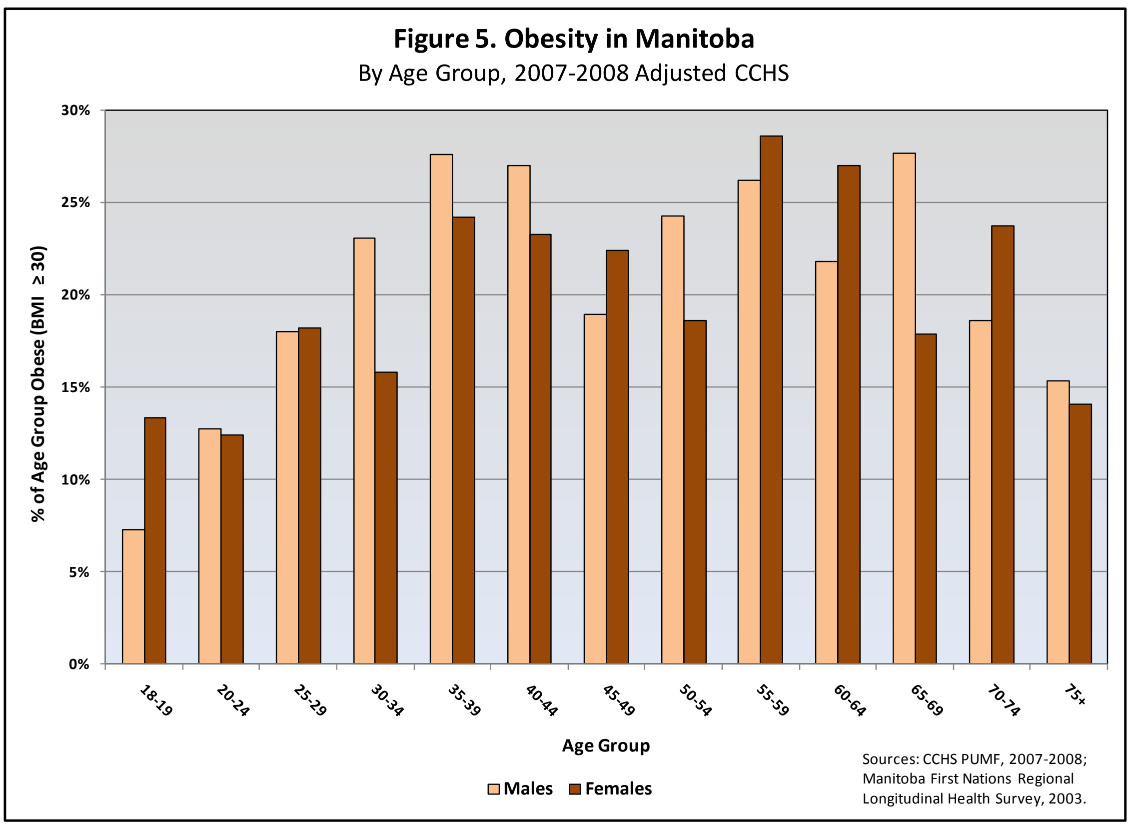
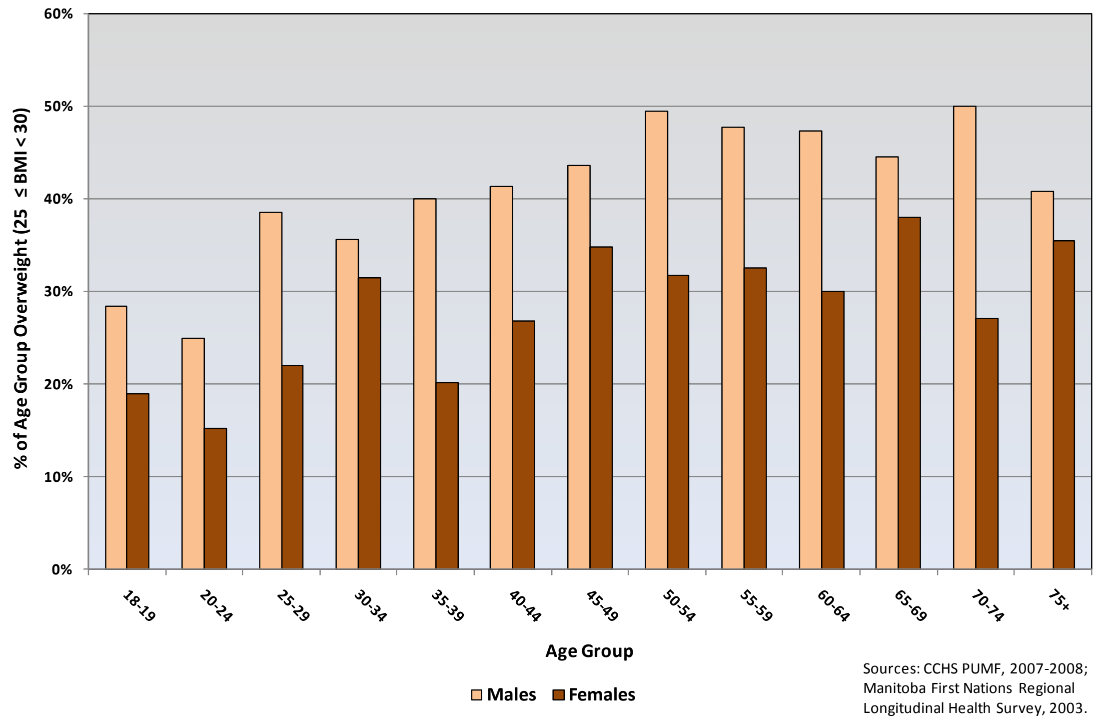


Figure 5. Obesity in Manitoba
By Age Group, 2007-2008 Adjusted CCHS
% of Age Group Obese (BMI ≥30)
30%
25%
20%
15%
10%
5%
0%
18-19
20-24
25-29
30-34
35-39
40-44
45-49
50-54
55-59
60-64
65-69
70-74
75+
Age Group
Males
Females
Sources: CCHS PUMF, 2007-2008; Manitoba First Nations Regional Longitudinal Health Survey, 2003.

Figure 6. Overweight in Manitoba
By Age Group, 2007-2008 Adjusted CCHS



The CCHS adjusted prevalence rates by age group and gender were then combined with population projections (see preceding section) in order to estimate the prevalence of the risk factors in the future (see Table 7). It should be noted that, while the prevalence rate of the risk factors was kept constant for the various gender- and age-groups, the changing mix of the population numbers per group over time resulted in slight changes in the prevalence for a risk factor across the total population. The 2008 estimated direct and indirect cost per individual with a risk factor was kept constant over the entire period so that changes in economic burden would be based solely on population growth. The cost per individual was multiplied by the number of individuals with the risk factor in each year to estimate the overall economic burden.

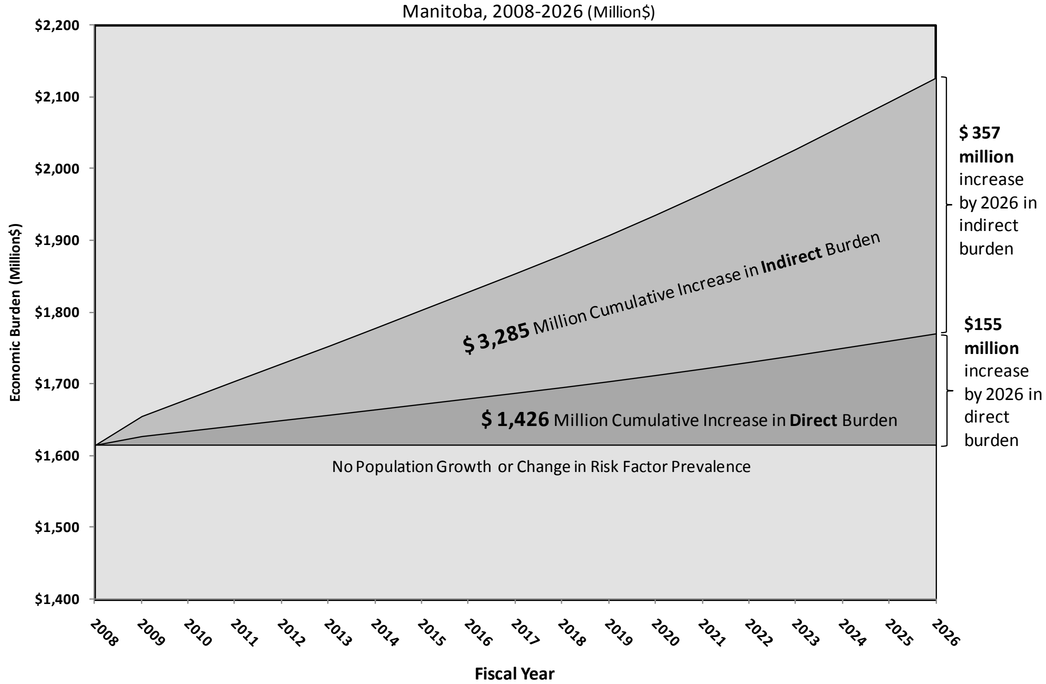
In 2008, the estimated annual economic burden of smoking, physical inactivity, and excess weight in Manitoba was calculated to be $1.62 billion, with $492 million in direct costs and $1.12 billion in indirect costs. By 2026, the annual burden would have risen to $2.13 billion ($647 million in direct costs and $1.48 billion in indirect costs), an overall increase of 31.4% based simply on population growth and ageing (see Table 7).

Table 7. Projected Economic Burden of Smoking, Physical Inactivity and Overweight/Obesity
Manitoba, 2026, By Gender
Adjusted for Selected CCHS Data Limitations and Multiple Risk Factors in One Individual
2008 Constant Dollars

	% Population with RF	# Individuals with RF	Direct Cost per Individual with RF ($'s)	Indirect Cost per Individual with RF ($'s)	Total Cost per Individual with RF ($'s)	Total Direct Cost of RF (M$'s)	Total Indirect Cost of RF (M$'s)	Total Cost of RF (M$'s)
Males								
Smokers	29.0%	194,493	$687	$1,469	$2,156	$133.7	$285.6	$419.3
Inactive	43.2%	289,975	$209	$451	$660	$60.7	$130.7	$191.4
Overweight	40.9%	247,995	$185	$543	$728	$45.8	$134.7	$180.5
Obesity	21.3%	128,919	$644	$1,558	$2,202	$83.1	$200.8	$283.9
Subtotal						**$323.3**	**$751.8**	**$1,075.1**
Females								
Smokers	23.4%	157,386	$544	$1,100	$1,644	$85.6	$173.2	$258.8
Inactive	48.1%	323,376	$222	$529	$750	$71.7	$170.9	$242.6
Overweight	28.4%	173,915	$305	$790	$1,095	$53.1	$137.4	$190.5
Obesity	19.9%	121,834	$931	$2,028	$2,959	$113.4	$247.1	$360.5
Subtotal						**$323.7**	**$728.6**	**$1,052.4**
Both Genders								
Smokers	26.2%	351,879	$623	$1,304	$1,927	$219.2	$458.8	$678.0
Inactive	45.6%	613,351	$216	$492	$708	$132.4	$301.6	$434.0
Overweight	34.7%	421,910	$234	$645	$879	$98.8	$272.1	$370.9
Obesity	20.6%	250,753	$784	$1,786	$2,570	$196.5	$447.9	$644.4
Total						**$647.0**	**$1,480.4**	**$2,127.4**

While the *annual* economic burden associated with the risk factors would increase from $1.62 billion in 2008 to $2.13 billion in 2026, the *cumulative* impact over the 18-year time period would be substantially higher, namely, $4.71 billion ($1.42 billion in direct costs and $3.29 billion in indirect costs), as indicated in Figure 6. The cumulative impact represents the total expected increase in the annual economic burden for all years from 2008 to 2026.

Figure 7. Changes in Economic Burden of Smoking, Physical Inactivity, Overweight, and Obesity
Manitoba, 2008-2026 (Million$)



Economic Impact of a Reduction in Risk Factor Prevalence

Modelling Assumptions

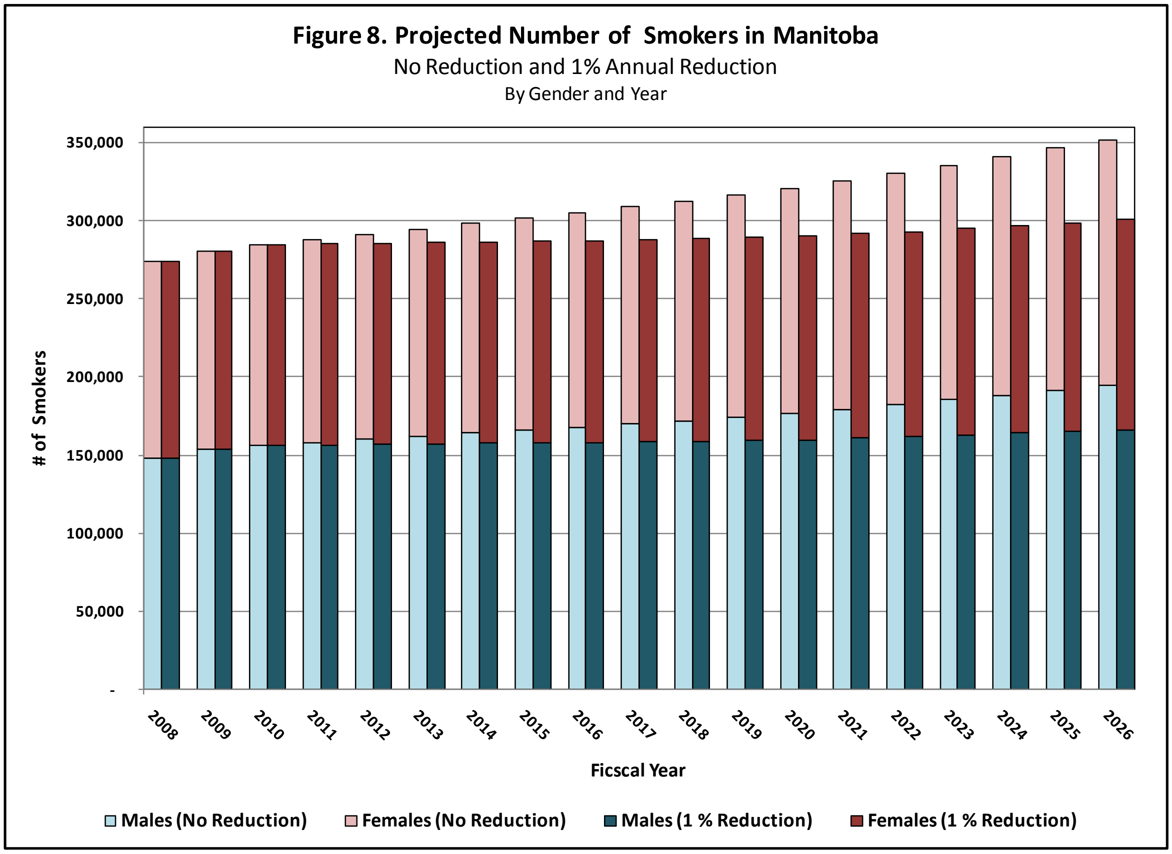
The following assumptions were made in modelling the change in the economic burden of smoking, physical inactivity and excess weight in Manitoba in the future (to 2026) based on a 1% or 2% annual reduction in each of these risk factors:

1. The annual reduction would begin in the 2011 fiscal year.
2. Improvements for obese individuals in any one year would mean moving into the overweight group, while positive change for overweight individuals involves moving into the healthy weight group.
3. The health and economic benefits of reducing physical inactivity and weight would occur within a year after the risk factor reduction occurred. Within that time, the excess economic burden associated with the physical inactivity and excess weight would return to that of the population within the healthier category (e.g., physically active and normal weight individuals).

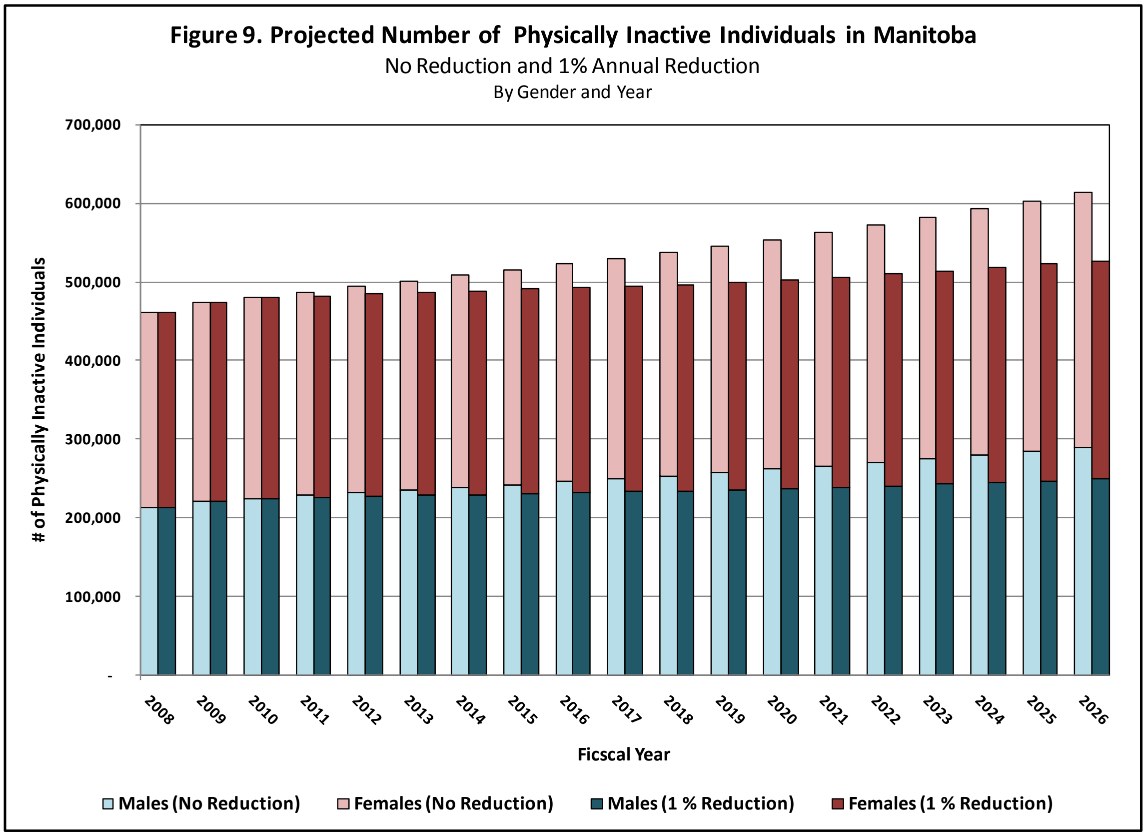
   This assumption is similar to that made by most modeling studies in this area.[118,119,120] A recent study by Byberg et al. did examine the potential lag effect associated with increased physical activity on total mortality.[121] Their study is based on a 35 year follow-up of 50 year old males. In this cohort, they did observe a lag time of 5-10 years after an increase in leisure time physical activity before total mortality rates decreased to levels seen in active males of a similar age. Whether a similar lag time is observed in females or in younger cohorts is yet to be determined.
4. The full health and economic benefits associated with smoking cessation would take 20 years to accrue, with the benefits increasing incrementally each year after smoking cessation as indicated in Tables 3 (for females) and 4 (for males).
5. The economic benefits of smoking cessation were modeled on a cohort basis, taking into account the years since smoking cessation began.

If the proportion of the population with the risk factors was to be reduced by 1% per year starting in 2011, what would be the change in the economic burden in Manitoba in the future (to 2026)?

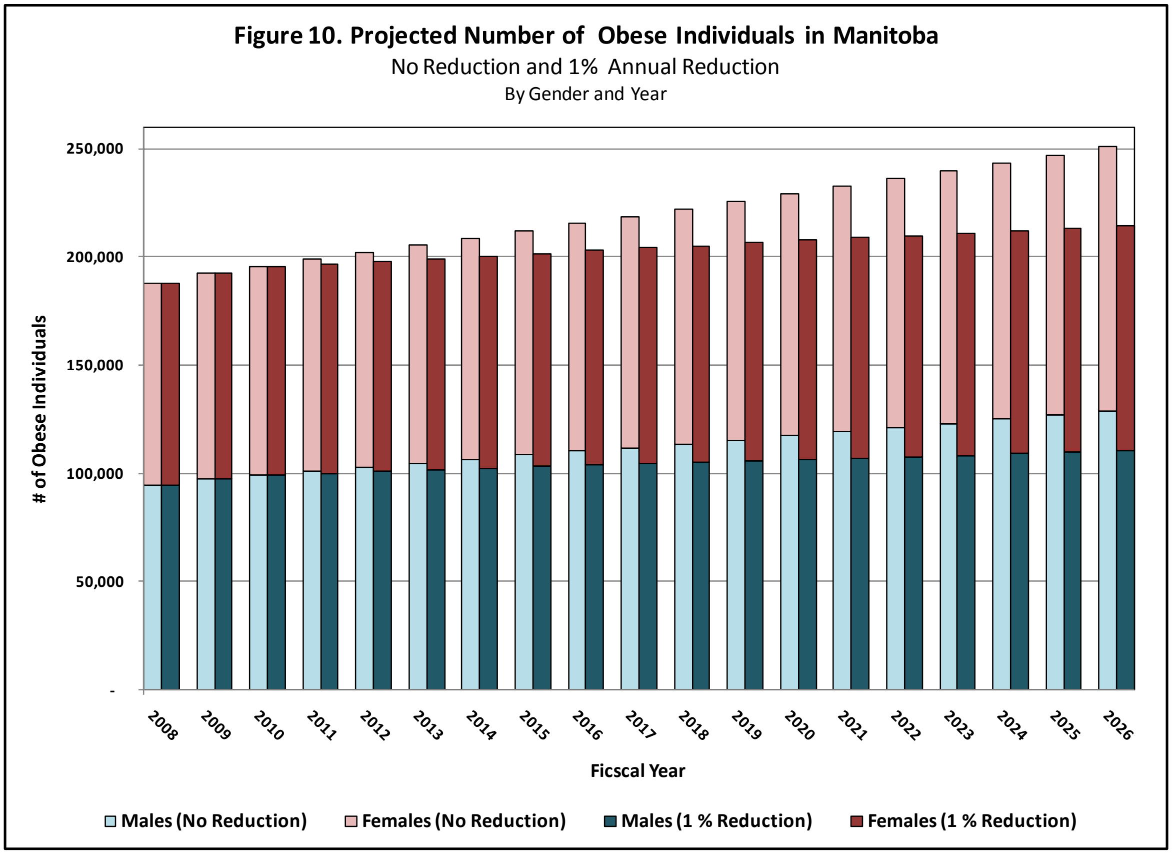
Based on an annual reduction of 1% starting in 2011, the number of individuals in Manitoba who are current smokers would decrease from a projected 352,000 (if prevalence is maintained at 2008 levels) to 301,000 in 2026, as indicated on Figure 8. That is, 51,000 fewer Manitobans would be current smokers in 2026 given the condition of a 1% annual reduction in smoking prevalence.



Based on an annual reduction of 1% starting in 2011, the number of individuals in Manitoba who are physically inactive would decrease from a projected 613,000 (if prevalence is maintained at 2008 levels) to 527,000 in 2026, as indicated on Figure 9. That is, 86,000 fewer Manitobans would be physically inactive in 2026 given the condition of a 1% annual reduction in physical inactivity prevalence.



Based on an annual reduction of 1% starting in 2011, the number of individuals in Manitoba who are obese would decrease from a projected 251,000 (if prevalence is maintained at 2008 levels) to 215,000 in 2026, as indicated on Figure 10. That is, 36,000 fewer Manitobans would be obese in 2026 given the condition of a 1% annual reduction in the prevalence of obesity. Note that the further assumption is that these 34,000 individuals would only move into the overweight group, rather than the healthy weight group.

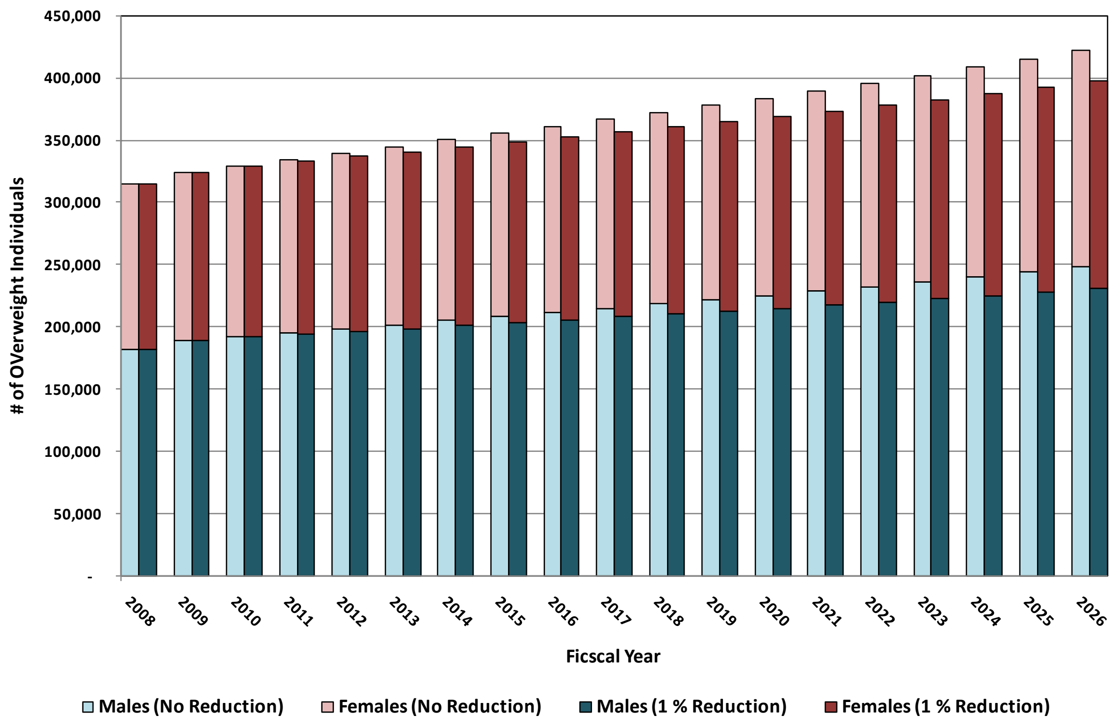


Based on an annual reduction of 1% starting in 2011, the number of individuals in Manitoba who are overweight would decrease from a projected 422,000 (if prevalence is maintained at 2008 levels) to 397,000 in 2026, as indicated on Figure 11. That is, 25,000 fewer Manitobans would be overweight in 2026 given the condition of a 1% annual reduction in the prevalence of obesity and overweight. This more modest decrease in the population of overweight individuals reflects the assumption that 36,000 formerly obese Manitobans have been added to the overweight category.

Figure 11. Projected Number of Overweight Individuals in Manitoba

No Reduction and 1% Annual Reduction

By Gender and Year



What is the change in the economic burden given a1% annual reduction in the risk factors of smoking, physical inactivity, and excess weight?

Earlier calculations suggested that if the prevalence of these risk factors was maintained at 2008 levels through to 2026, the annual economic burden would increase to $2.13 billion ($647 million in direct costs and $1.48 billion in indirect costs), as indicated in Table 7. A 1% annual reduction starting in 2011 would result in an estimated annual economic burden in 2026 of $1.92 billion ($583 million in direct costs and $1.33 billion in indirect costs), as indicated in Table 8.

This change reflects an overall annual decrease of $210 million ($64 million in direct costs and $146 million in indirect costs) by 2026, as shown in Figure 12. The cumulative decrease in economic burden between 2011 and 2026 would be $1.77 billion ($540 million in direct costs and $1.23 billion in indirect costs).

The reductions in the economic burden associated with each risk factor are shown in Figure 13. The overall annual decrease of $210 million in 2026 consists of $114 million for excess weight, $61 million for physical inactivity and $35 million for smoking. Over the entire time period between 2011 and 2026, the cumulative reduction in economic burden of $1.77 billion consists of $929 million for excess weight, $502 million for physical inactivity, and $343 million for smoking.

Table 8. Projected Economic Burden of Smoking, Physical Inactivity and Overweight/Obesity
Manitoba, 2026, By Gender ***(1% Annual Reduction)***
Adjusted for Selected CCHS Data Limitations and Multiple Risk Factors in One Individual
2008 Constant Dollars

	% Population with RF	# Individuals with RF	Direct Cost per Individual with RF ($'s)	Indirect Cost per Individual with RF ($'s)	Total Cost per Individual with RF ($'s)	Total Direct Cost of RF (M$'s)	Total Indirect Cost of RF (M$'s)	Total Cost of RF (M$'s)
Males								
Smokers	24.8%	166,304	$762	$1,628	$2,390	$126.7	$270.8	$397.5
Inactive	37.1%	249,114	$209	$451	$660	$52.2	$112.3	$164.5
Overweight	38.1%	230,891	$185	$543	$728	$42.6	$125.4	$168.0
Obesity	18.2%	110,381	$644	$1,558	$2,202	$71.1	$171.9	$243.1
Subtotal						**$292.7**	**$680.4**	**$973.1**
Females								
Smokers	20.0%	134,411	$605	$1,224	$1,829	$81.3	$164.5	$245.8
Inactive	41.3%	277,541	$222	$529	$750	$61.5	$146.7	$208.2
Overweight	27.2%	166,465	$305	$790	$1,095	$50.8	$131.5	$182.3
Obesity	17.0%	104,165	$931	$2,028	$2,959	$97.0	$211.3	$308.2
Subtotal						**$290.6**	**$654.0**	**$944.5**
Both Genders								
Smokers	22.4%	300,716	$692	$1,448	$2,139	$208.0	$435.3	$643.3
Inactive	39.2%	526,655	$216	$492	$708	$113.7	$259.0	$372.7
Overweight	32.6%	397,356	$235	$647	$882	$93.4	$256.9	$350.3
Obesity	17.6%	214,546	$783	$1,786	$2,570	$168.1	$383.2	$551.3
Total						**$583.2**	**$1,334.4**	**$1,917.6**

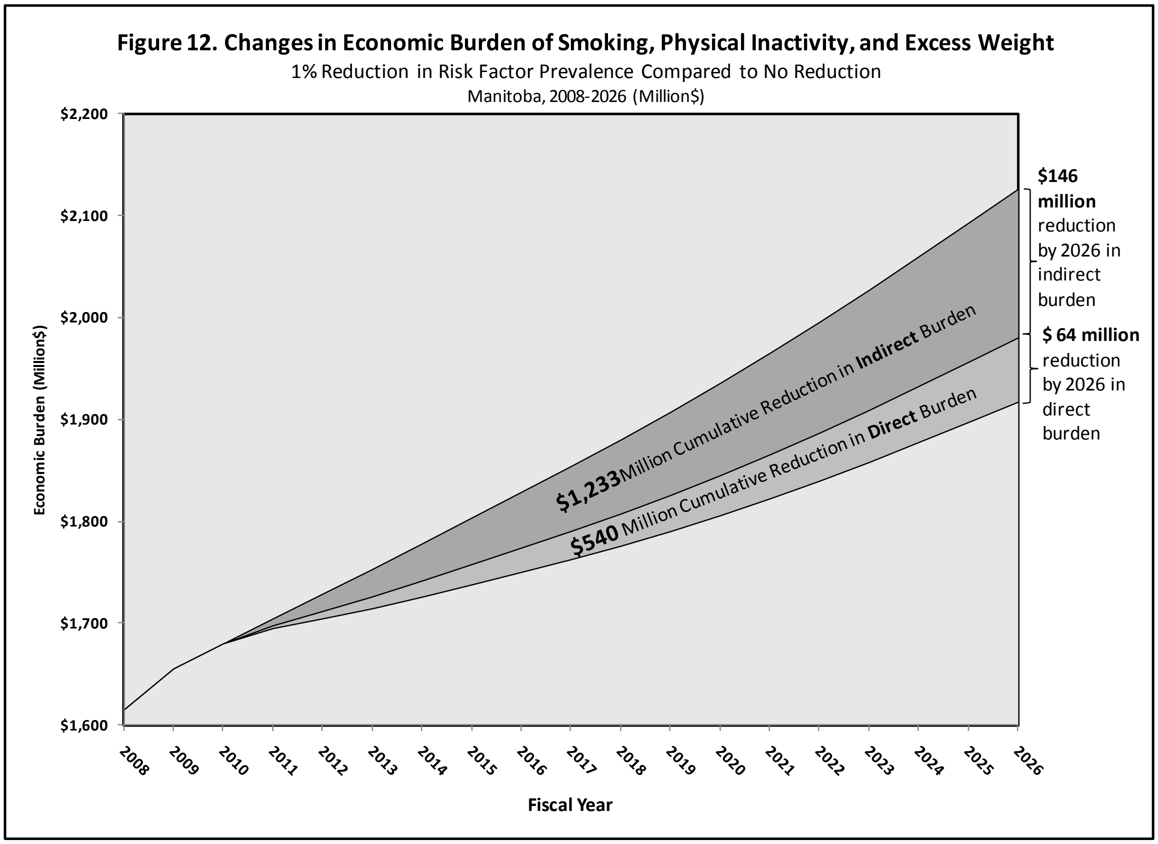


Figure 12. Changes in Economic Burden of Smoking, Physical Inactivity, and Excess Weight
1% Reduction in Risk Factor Prevalence Compared to No Reduction
Manitoba, 2008-2026 (Million$)
Economic Burden (Million$)
$2,200
$2,100
$2,000
$1,900
$1,800
$1,700
$1,600
$1,233 Million Cumulative Reduction in Indirect Burden
$540 Million Cumulative Reduction in Direct Burden
$146 million reduction by 2026 in indirect burden
$ 64 million reduction by 2026 in direct burden
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
Fiscal Year

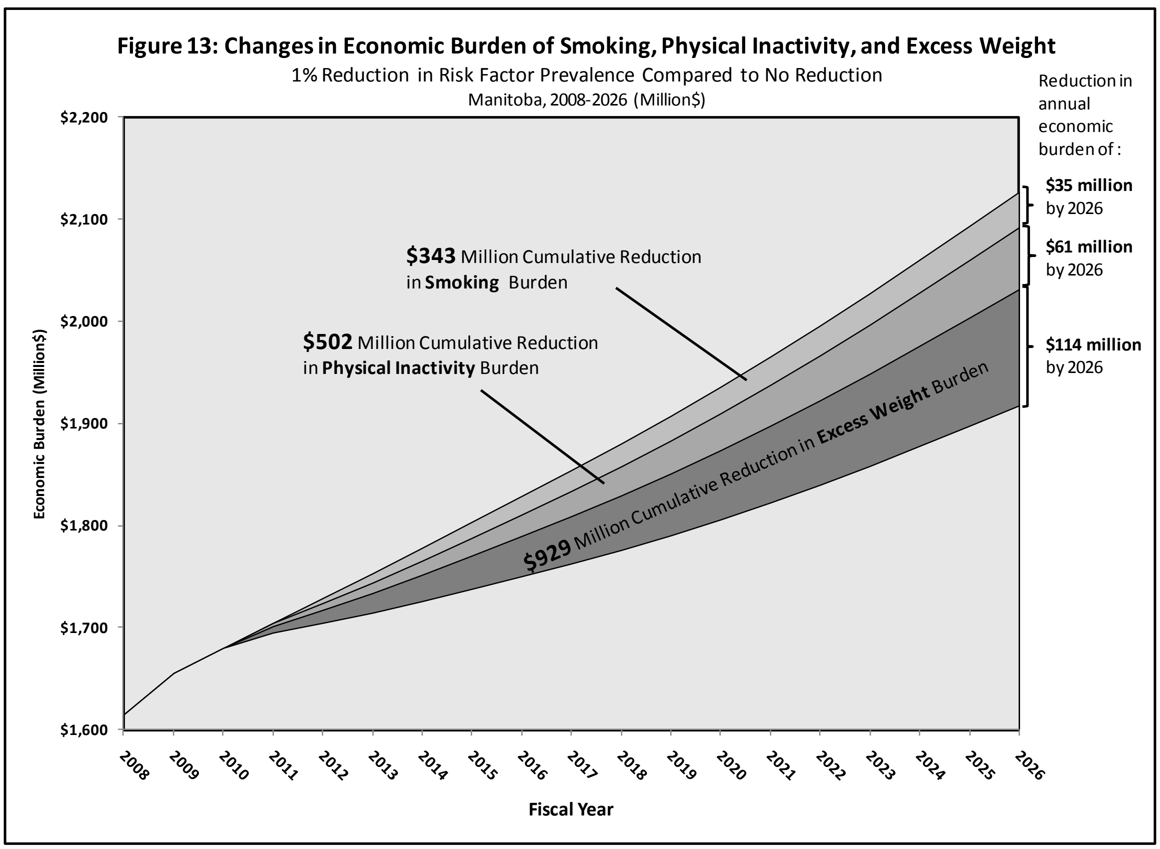


Figure 13: Changes in Economic Burden of Smoking, Physical Inactivity, and Excess Weight
1% Reduction in Risk Factor Prevalence Compared to No Reduction
Manitoba, 2008-2026 (Million$)
Economic Burden (Million$)
$2,200
$2,100
$2,000
$1,900
$1,800
$1,700
$1,600
$343 Million Cumulative Reduction in Smoking Burden
$502 Million Cumulative Reduction in Physical Inactivity Burden
$929 Million Cumulative Reduction in Excess Weight Burden
Reduction in annual economic burden of :
$35 million by 2026
$61 million by 2026
$114 million by 2026
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
Fiscal Year

Economic Impact of a 2% Annual Reduction in Risk Factor Prevalence

If the proportion of the population with the risk factors was to be reduced by 2% per year starting in 2011, what would be the change in the economic burden in Manitoba in the future (to 2026)?

As noted above (see Table 7), if the prevalence of these risk factors was maintained at 2008 levels through to 2026, the annual economic burden would increase to $2.13 billion ($647 million in direct costs and $1.48 billion in indirect costs). A 2% annual reduction starting in 2011 would result in an estimated annual economic burden in 2026 of $1.70 billion ($518 million in direct costs and $1.19 billion in indirect costs), as indicated in Table 9.

This change reflects an overall annual decrease of $424 million ($129 million in direct costs and $295 million in indirect costs) by 2026, as shown in Figure 14. The cumulative decrease in economic burden between 2011 and 2026 would total $3.6 billion ($1.1 billion in direct costs and $2.5 billion in indirect costs).

The reductions in the economic burden associated with each risk factor are shown in Figure 15. The overall annual decrease of $424 in 2026 consists of $230 million for excess weight, $124 million for physical inactivity and $70 million for smoking. Over the entire time period between 2011 and 2026, the cumulative reduction in economic burden of $3.58 billion consists of $1.87 billion for excess weight, $1.01 billion for physical inactivity, and $692 million for smoking.

Table 9. Projected Economic Burden of Smoking, Physical Inactivity and Overweight/Obesity
Manitoba, 2026, By Gender ***(2% Annual Reduction)***
Adjusted for Selected CCHS Data Limitations and Multiple Risk Factors in One Individual
2008 Constant Dollars

	% Population with RF	# Individuals with RF	Direct Cost per Individual with RF ($'s)	Indirect Cost per Individual with RF ($'s)	Total Cost per Individual with RF ($'s)	Total Direct Cost of RF (M$'s)	Total Indirect Cost of RF (M$'s)	Total Cost of RF (M$'s)
Males								
Smokers	20.5%	137,581	$870	$1,858	$2,728	$119.7	$255.7	$375.4
Inactive	30.9%	207,478	$209	$451	$660	$43.5	$93.5	$137.0
Overweight	35.2%	213,463	$185	$543	$728	$39.4	$115.9	$155.3
Obesity	15.1%	91,492	$644	$1,558	$2,202	$59.0	$142.5	$201.5
Subtotal						**$261.5**	**$607.7**	**$869.2**
Females								
Smokers	16.5%	111,001	$693	$1,402	$2,095	$76.9	$155.6	$232.5
Inactive	34.3%	230,838	$222	$529	$750	$51.2	$122.0	$173.2
Overweight	26.0%	158,873	$305	$790	$1,095	$48.5	$125.5	$174.0
Obesity	14.1%	86,162	$931	$2,028	$2,959	$80.2	$174.8	$255.0
Subtotal						**$256.8**	**$577.9**	**$834.6**
Both Genders								
Smokers	18.5%	248,582	$791	$1,655	$2,445	$196.6	$411.3	$607.9
Inactive	32.6%	438,316	$216	$492	$708	$94.6	$215.5	$310.2
Overweight	30.6%	372,337	$236	$648	$884	$87.9	$241.4	$329.3
Obesity	14.6%	177,653	$783	$1,786	$2,569	$139.2	$317.3	$456.4
Total						**$518.3**	**$1,185.5**	**$1,703.8**

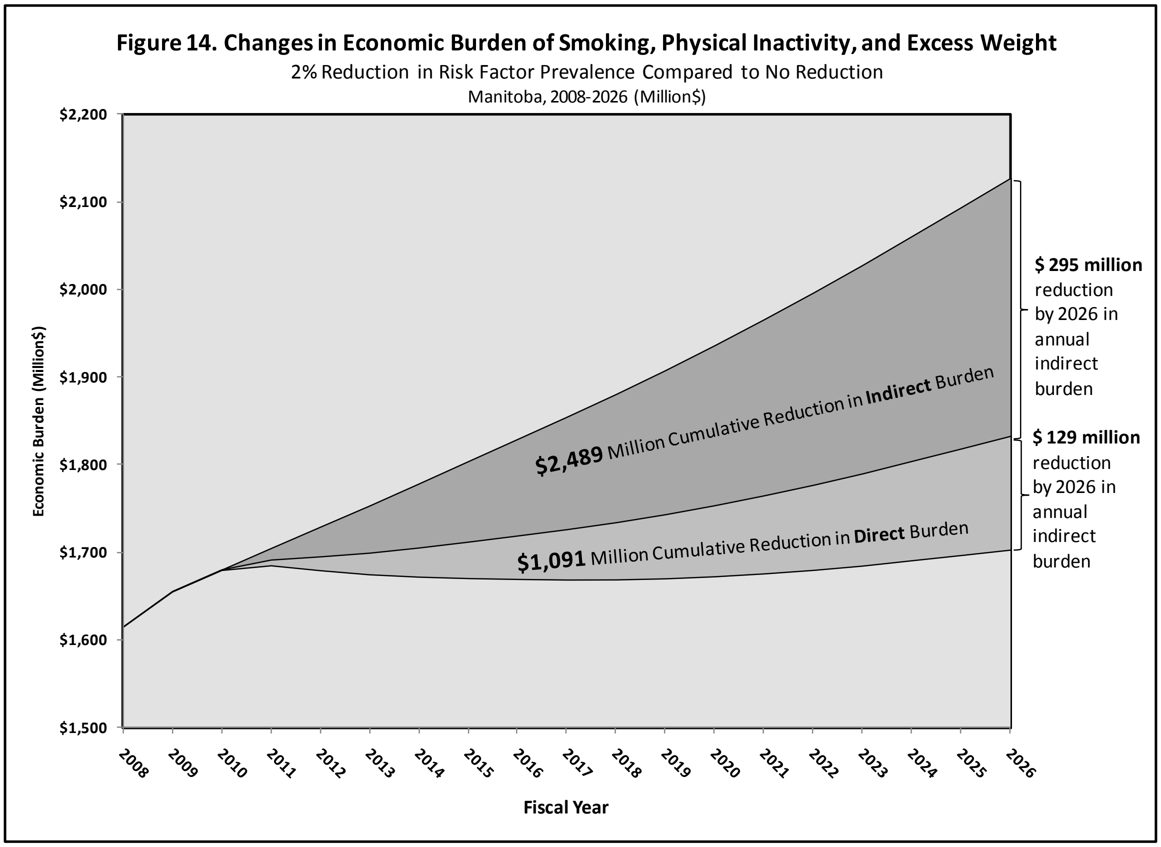


Figure 14. Changes in Economic Burden of Smoking, Physical Inactivity, and Excess Weight
2% Reduction in Risk Factor Prevalence Compared to No Reduction
Manitoba, 2008-2026 (Million$)
Economic Burden (Million$)
$2,200
$2,100
$2,000
$1,900
$1,800
$1,700
$1,600
$1,500
$2,489 Million Cumulative Reduction in Indirect Burden
$1,091 Million Cumulative Reduction in Direct Burden
$ 295 million reduction by 2026 in annual indirect burden
$ 129 million reduction by 2026 in annual indirect burden
2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026
Fiscal Year

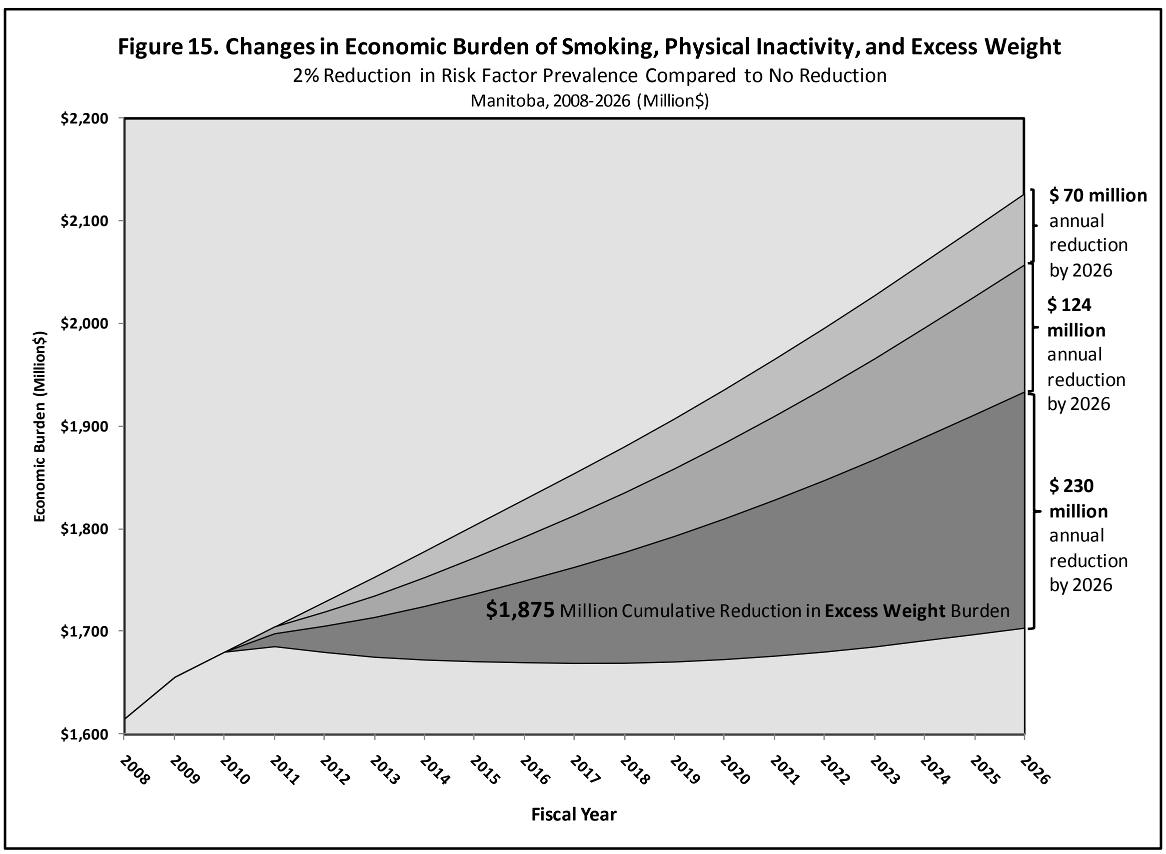


Figure 15. Changes in Economic Burden of Smoking, Physical Inactivity, and Excess Weight
2% Reduction in Risk Factor Prevalence Compared to No Reduction
Manitoba, 2008-2026 (Million$)
Economic Burden (Million$)
$2,200
$2,100
$2,000
$1,900
$1,800
$1,700
$1,600
$1,875 Million Cumulative Reduction in Excess Weight Burden
$ 70 million annual reduction by 2026
$ 124 million annual reduction by 2026
$ 230 million annual reduction by 2026
2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026
Fiscal Year

Summary and Conclusion

If the prevalence of the risk factors of smoking, physical inactivity, overweight and obesity remain at 2008 levels through 2026, then the number of Manitobans who are current smokers would increase from 274,000 in 2008 to 352,000 in 2026, based solely on projected population growth. The number of physically inactive individuals would increase from 462,000 to 613,000. The number of obese Manitobans would increase from 188,000 to 251,000, while the number of overweight individuals would increases from 315,000 to 422,000. The annual economic burden associated with these risk factors would also increase, from $1.61 billion in 2008 to $2.13 billion in 2026 (in 2008 constant dollars). The *cumulative* increase in economic burden between 2008 and 2026 would be $4.71 billion.

A 1% annual decrease in the risk factors would result in 301,000 current smokers, 527,000 physically inactive individuals, 215,000/397,000 obese/overweight Manitobans in 2026. The annual economic burden would decrease from a projected $2.13 to $1.92 billion in 2026. The *cumulative* reduction in economic burden between 2011 and 2026 would be $1.77 billion.

A 2% annual decrease in the risk factors would result in 249,000 current smokers, 438,000 physically inactive individuals, 178,000/372,000 obese/overweight Manitobans in 2026. The annual economic burden would decrease from a projected $2.13 to $1.70 billion in 2026. The *cumulative* reduction in economic burden between 2011 and 2026 would be $3.58 billion.

The model developed as part of Phase 2 can be utilized to run a variety of ‘what if’ scenarios, particularly with respect potential future changes in the prevalence of the risk factors.

Supporting Document 3: Sample Prevention Program Costs Compared with Potential Cost Avoidance by Reducing Risk Factors

The purpose of Supporting Document 3 is to provide detailed information on the estimated cost of implementing sample interventions in Manitoba and then to combine and summarize information on the longer-term costs and benefits of addressing the risk factors of tobacco smoking, overweight/obesity, and physical inactivity in Manitoba.

The key questions addressed in this Supporting Document are as follows:

1. What is the cost of implementing in Manitoba sample interventions of demonstrated effectiveness that could conceivably lead to a 1%/2% annual reduction in the risk factors between 2011 and 2026?
2. How does this cost compare to the direct and indirect costs avoided for a 1% and 2% annual reduction in the risk factors, as calculated in Supporting Document 2?

Selecting Initial Interventions to Cost

For the purposes of this project, it is necessary to select a few examples of potentially successful interventions for analysis. Four criteria were applied to narrow down the inventory to a small number of interventions for this analysis. The criteria were:

1. Clear evidence of effectiveness that conceivably could be reproduced within Manitoba's population
2. The potential for a substantial population effect in terms of reducing risk factors
3. Feasibility of implementation and uptake in a relatively short time frame and potential for sustainability
4. Capability of generating supportable cost estimates related to implementation

The examples selected for this analysis that met these criteria were; clinical smoking cessation, green prescriptions related to physical activity, and a diet-related community program (similar to the well-known North Karelia Project of Finland) with the aim of reducing rates of overweight/obesity.

Even as the selections were made, it was important to recognize that much more would be required in the end for the effort to qualify as a comprehensive risk factor reduction/prevention initiative.

Clinical Smoking Cessation

Background

Surveys of current smokers have shown that 45% to 60% intend to quit in the next 6 months.[122] There is evidence of the effectiveness for many smoking cessation interventions, especially those offered in the clinical context of primary care.[123] Given the long-term health effects that are at stake, it is especially important to support younger smokers in their quit attempts. While elevated disease risks do not disappear immediately, they are substantially reduced as the length of time since quitting becomes extended to years and decades.[124,125,126]

Primary Care Based Smoking Cessation Programs

Clinical supports may be defined as face-to-face delivery of preventive interventions by a clinician. Support sessions with a general practitioner (GP) are the most obvious example of this type of manoeuvre; the encounter with a health care provider can last as little as 10 minutes. It is important to note that the professional involved does not have to be a physician, and may even be someone without medical credentials but still trained in cessation counselling.[127] On the other hand, the "face-to-face" aspect of the definition would rule out distant communication modalities, such as quit line telephone counselling, Internet-based platforms, and text messages.

Medication should be included among the range of clinical supports for smoking cessation. Although a growing number of other pharmaceuticals are employed as aids to smoking cessation, nicotine replacement therapy (NRT) remains very popular in both clinical and self-help settings. The reason is simple: it increases the rate of quitting.[128] Introduced in gum form in 1984, NRT is now available in alternate delivery systems ranging from transdermal patches and lozenges to inhalers and sprays. According to the authoritative source *Treating Tobacco Use and Dependence: 2008 Update*,[129] NRT by transdermal patch remains the gold standard for cessation medications. Subsidizing the NRT used in a quit process could be strategic, since purchasing it can be prohibitive for some individuals, especially those in low-income groups.

As indicated in Table 1, "do-it-yourself" approaches (smoking cessation attempts without clinical or NRT support) are successful approximately 11% of the time.[130] If NRT is used, the success rate increases to 22%. At least four clinical sessions without NRT will increase the success rate to a similar level. Whereas each of these modalities on their own essentially double the abstinence rate (i.e., moving from about 11% to 21-22%), combining support sessions and NRT *triples* the abstinence rate compared with the "no support, do-it-yourself" scenario. From the perspective of a smoker trying to quit, this difference can be very important. Psychologically and practically, people are more likely to persist in trying to quit as many as three times (on average, assuming a success rate of 33%) rather than as many as nine times (on average, assuming an 11% success rate).

Table 1. Impact of Smoking Cessation Support

Intervention	Abstinence Rate (%)*	95% CI
No support	10.9	
Quitline counselling	12.7	
Brief advice (< 3 min)‡	13.4	
NRT only	21.7	
Support sessions (~ 10 min)		
4-8 sessions	20.9	18.1-23.6
> 8 sessions	24.7	21.0-28.4
Support sessions + NRT		
4-8 sessions	26.9	24.3-29.7
> 8 sessions	32.5	27.3-38.3

* Minimum 5-month follow-up
‡ Face-to-face input from a clinician re: quitting

Source: U.S. Surgeon General, *Treating Tobacco Use and Dependence: 2008 Update.*

Available evidence suggests that the approach combining clinical support and NRT is highly cost-effective. Indeed, a study by HealthPartners Research Foundation and Partnership for Prevention in the U.S. estimated that, if all smokers received brief clinical advice together with NRT, ***savings*** of just over $2,000 per quality-adjusted life year would be realized.[131]

Cost of Program Implementation in Manitoba

Assumptions - Nicotine Replacement Therapy

The following assumptions were made about one cost component of the program, nicotine replacement therapy:

- The 'patch' remains the gold standard – both in terms of effectiveness and acceptability with the general population. When Quebec implemented a reimbursement plan for smoking cessation medication between 2000 and 2004, over 80% of participants opted for the patch.[132]

- For the present project, details of using of the patch were determined through manufacturer's recommendations on websites,[133] and confirmed by a staff pharmacist in Brandon.
- From the perspective of NRT, smokers fall into two broad categories. The first includes individuals who smoke more than 10 cigarettes per day (>10 Cig) while the second includes individuals who smoke less than 10 cigarettes per day, weigh less than 100 pounds, or have a history of cardiovascular disease (<10 Cig).
- NRT usage for a >10 Cig smoker would start with 6 weeks at 21 mg dosage, followed by 2 weeks at 14 mg and 7 mg, respectively. <10 Cig smokers start with 6 weeks at 14 mg, followed by two weeks of 7 mg, with the option of repeating the latter course. For the purposes of modelling, it was assumed that <10 Cig smokers would complete the optional extra course of therapy, meaning both groups would complete a total of 10 weeks of NRT.
- Prices of the nicotine patch were obtained from two pharmacies in Manitoba, one in Winnipeg and one in Brandon. In an effort to develop the most conservative estimates, name-brand (i.e., Nicoderm) rather than generic pricing was used; there was perfect agreement between the two polled pharmacies. Prices were $31.99[134] for a weekly supply of each of the 21 mg, 14 mg, and 7 mg patches. The consistency between the 7, 14, and 21 mg patch prices, combined with the assumption that both groups of smokers will complete the same number of weeks of therapy, led to each smoker in the program incurring the same cost for NRT.

Assumptions - Clinician Support Sessions

The second cost component of the program involved support sessions by a clinician. The following assumptions were made about this component:

- Estimated costs were based on 10 support sessions (which qualifies for the most intensive category in the supporting literature, defined as >8 sessions).
- Cost estimates were developed for two types of clinicians, a general practitioner and a clinical nurse specialist.
- Physician costs were taken from the Manitoba Physician's Manual (April 1, 2010)[135] for the 'regional basic visit' category of general practice ($22.75). This category is defined as *'a service rendered to a patient who consults the physician for a condition – usually relatively minor. The assessment of the patient's condition is problem focused and little or no physical examination is included.'* Notably, this visit category is generally meant to be less than 10 minutes long, closely following the time suggested in the literature to accomplish basic physician counselling for smoking cessation.
- Nursing time was calculated by taking the hourly wage of a Registered Nurse Extended Practice (RNEP) – Year 4 from the Manitoba Nurses Union and then adjusting for benefits (23%) and unproductive time (40%). As with physician costs, this adjusted hourly wage was applied for 10 minutes per session over 10 sessions. This resulting cost is $131.62 for each individual participating in the intervention.
- An average of 3.08 individuals would need to go through the program to lead to one successful quitter, based on an achieved abstinence rate of 32.5% (see Table 1 above).

Results

The cost of NRT according to the program design offered above would range from $230 (for a generic product) to $320 (for a name brand product), as indicated in Table 2. As indicated, the higher cost estimate was used in the base model. Lower costs could be achieved by using a generic product and/or negotiating wholesale prices (rather than paying the retail price).

Table 2. Cost of Nicotine Patch Program
10 - Week Program, >10 Cig and <10 Cig
By Generic and Name Brand Manufacturers

>10 Cigs				<10 Cigs			
>10 cig/day				<10 cig/day OR < 100 lbs OR cardiovascular disease			
		Nicoderm	**Generic**			**Nicoderm**	**Generic**
Weekly Cost		$32	$23			$32	$23
Stage 1 (21 mg)	6 Weeks	$192	$138	**Stage 1 (14 mg)**	6 Weeks	$192	$138
Stage 2 (14 mg)	2 Weeks	$64	$46	**Stage 2 (7 mg)**	2 Weeks	$64	$46
Stage 3 (7 mg)	2 Weeks	$64	$46	Optional:			
				Stage 3 (7 mg)	2 Weeks	$64	$46
Total		**$320**	**$230**	**Total**		**$320**	**$230**

The cost of 10 support sessions was estimated to be $227.50 if a general practitioner (GP) is involved (see Table 3 below) and $131.62 if a clinical nurse specialist is involved (see Table 4). We have used the $227.50 cost estimate for a GP in the base model.

Table 3. Cost of Physician Support Sessions
For Smoking Cessation

Number of sessions	10
Cost per session	$22.75
Cost per patient	$227.50

Source: Manitoba Physicians's Manual, 2010. Cost of 'Regional Basic Visit'.

Table 4. Cost of Clinical Nurse Specialist
For Smoking Cessation

Number of sessions	10
Minutes per session	10
Total minutes of support	**100**
Hourly wage*	$48.45
Benefits (23%)	$11.14
Non-productive time (40%)	$19.38
Adjusted hourly wage	**$78.97**
Total cost	**$131.62**

* 2008 Manitoba Nurses Union Salaries. Hourly wage for RNEP - Year 4.

The estimated program cost per smoker going through the program as defined in the base model is $548 (see Table 5).

Table 5. Total Cost of Nicotine Patch Program
10 - Week Program, >10 Cig and <10 Cig
By Generic and Name Brand Manufacturers, and Type of Clinician Support

>10 Cigs				<10 Cigs			
>10 cig/day				<10 cig/day OR < 100 lbs OR cardiovascular disease			
		Nicoderm	**Generic**			**Nicoderm**	**Generic**
Weekly Cost		$32	$23			$32	$23
Stage 1 (21 mg)	6 Weeks	$192	$138	**Stage 1 (14 mg)**	6 Weeks	$192	$138
Stage 2 (14 mg)	2 Weeks	$64	$46	**Stage 2 (7 mg)**	2 Weeks	$64	$46
Stage 3 (7 mg)	2 Weeks	$64	$46	Optional:			
				Stage 3 (7 mg)	2 Weeks	$64	$46
Physician Cost	10 Sessions	$228	$228	**Physician Cost**	10 Sessions	$228	$228
Nurse Cost	10 Sessions	$132	$132	**Nurse Cost**	10 Sessions	$132	$132
Total NRT + Physician		**$548**	**$458**	**Total NRT + Physician**		**$548**	**$458**
Total NRT + Nurse		**$452**	**$362**	**Total NRT + Nurse**		**$452**	**$362**

As noted earlier, an abstinence rate of 32.5% means that an average of 3.08 smokers would need to go through the program to lead to one **successful quitter**. In 2011, a 1% reduction equates to 2,879 Manitobans needing to quit. In terms of program resources, 8,857 (2,879 times 3.08) smokers would need to go through the program, as indicated in Table 6.

Table 6. Annual Number of Smokers Who Need to Participate in a Smoking Cessation Program
2011 to 2026
Based on a 1% or 2% Annual Reduction

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
								1% Annual Reduction								
								Smoking Cessation								
Males	4,863	4,973	5,035	5,098	5,159	5,219	5,282	5,348	5,417	5,493	5,576	5,666	5,759	5,855	5,949	6,044
Females	3,994	4,079	4,124	4,171	4,219	4,267	4,317	4,366	4,420	4,476	4,537	4,601	4,670	4,743	4,816	4,891
Total	**8,857**	**9,052**	**9,159**	**9,269**	**9,378**	**9,487**	**9,598**	**9,714**	**9,836**	**9,969**	**10,113**	**10,267**	**10,429**	**10,598**	**10,765**	**10,935**
								2% Annual Reduction								
								Smoking Cessation								
Males	9,725	10,043	10,171	10,300	10,423	10,544	10,670	10,803	10,942	11,096	11,264	11,445	11,634	11,827	12,017	12,209
Females	7,989	8,239	8,331	8,426	8,523	8,621	8,720	8,821	8,928	9,042	9,165	9,294	9,434	9,582	9,729	9,880
Total	**17,714**	**18,282**	**18,502**	**18,726**	**18,946**	**19,165**	**19,390**	**19,623**	**19,871**	**20,138**	**20,429**	**20,740**	**21,068**	**21,409**	**21,745**	**22,089**

The annual cost of operating the smoking cessation program is determined by multiplying the number of participants by the cost per participant of $548. Based on a 1% annual reduction, this cost would increase from $4.85 million in 2011 to $5.99 million in 2026 (in constant 2008$). Using a similar analysis, for the 2% annual reduction, the costs would increase from $9.70 million to $12.09 million (see Table 7).

Table 7. Annual Cost of a Smoking Cessation Program in Manitoba
2011 to 2026
Based on a 1% or 2% Annual Reduction, 2008 Constant Million$

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
								1% Annual Reduction								
								Smoking Cessation (Name-Brand NRT + Physician Support Sessions)								
Males	$2.66	$2.72	$2.76	$2.79	$2.82	$2.86	$2.89	$2.93	$2.97	$3.01	$3.05	$3.10	$3.15	$3.21	$3.26	$3.31
Females	$2.19	$2.23	$2.26	$2.28	$2.31	$2.34	$2.36	$2.39	$2.42	$2.45	$2.48	$2.52	$2.56	$2.60	$2.64	$2.68
Total	**$4.85**	**$4.96**	**$5.01**	**$5.08**	**$5.13**	**$5.19**	**$5.26**	**$5.32**	**$5.39**	**$5.46**	**$5.54**	**$5.62**	**$5.71**	**$5.80**	**$5.89**	**$5.99**
								2% Annual Reduction								
								Smoking Cessation (Name-Brand NRT + Physician Support Sessions)								
Males	$5.32	$5.50	$5.57	$5.64	$5.71	$5.77	$5.84	$5.91	$5.99	$6.08	$6.17	$6.27	$6.37	$6.48	$6.58	$6.68
Females	$4.37	$4.51	$4.56	$4.61	$4.67	$4.72	$4.77	$4.83	$4.89	$4.95	$5.02	$5.09	$5.16	$5.25	$5.33	$5.41
Total	**$9.70**	**$10.01**	**$10.13**	**$10.25**	**$10.37**	**$10.49**	**$10.62**	**$10.74**	**$10.88**	**$11.03**	**$11.19**	**$11.36**	**$11.53**	**$11.72**	**$11.91**	**$12.09**

Reducing Physical Inactivity

Background

Lack of physical activity is closely associated with the incidence of several chronic diseases and a lower quality of life.[136] Similar to the desire seen across a smoking population to quit smoking, many sedentary people may be ready to change their level of physical activity. For example, a recent Danish study of 9,160 physically inactive persons between 16 and 79 years of age showed that, with the right support, over 50% of the respondents were ready to become more active.[137] An earlier British study showed that brief behavioural counselling matched to stage of readiness may be "valuable in encouraging healthy lifestyles among patients in primary care."[138]

Primary Care Based Physical Activity Programs

Primary care-based interventions for physical activity are aimed at improving patient heath through one-on-one meetings with a health care professional. There are several names for this approach, including "physical activity on prescription" and "exercise referral." Traditionally, the professional involved has been a general practitioner (GP), although it could also be a nurse, health educator, or facilitator with specialized physical activity training. GPs are, however, in contact with many patients throughout the year, and therefore represent an especially valuable resource in providing routine advice on initiating and adhering to a physical activity program.[139] They also are natural gateways in referring patients to other health care professionals and/or physical activity programs.

One potential advantage of primary care-based over community-based interventions is the flexibility to tailor approaches to address individual patient needs. When reviewing examples of successful primary care-based interventions, Eakin et al. noted a number of factors that were consistently linked to successful outcomes, including:[140]

- A series of encounters that could in fact be brief (3 to 10 minutes)
- A strict focus on physical activity tailored to patient characteristics and preferences
- Provision of supplementary written materials

Eakin and colleagues actually reviewed 10 studies of primary care-based physical activity interventions that evaluated short-term outcomes, 7 of which reported statistically significant increases in physical activity. This led the authors to conclude that "brief primary care-based interventions are effective in producing moderate short-term improvements in self-reported physical activity levels." More recently, evidence for effective maintenance of physical activity levels at 12-month follow-up after such programs have been demonstrated.[141,142] Facilitating adherence may be accomplished through prompts delivered by telephone, Internet, or mail—though the effectiveness of this sort of intervention has yet to be evaluated. [143]

Primary care-based approaches for increasing physical activity have been notable in the southern hemisphere. Australian researchers demonstrated that targeting GPs directly to encourage the use of the clinical interventions related to physical activity resulted in:[144]

- A 52% increase in advice provided to patients
- 20% of these patients becoming more active
- Half of those patients maintaining higher activity levels long enough to accrue health benefits

Importantly, the optimistic expectation of about a 20% increase in individuals elevating their activity to at least a moderate level was confirmed and generalized in a 2007 systematic review of 18 studies.[145]

One of the best-known and oldest primary care-based physical activity interventions is the so-called Green Prescription program of New Zealand, implemented as a pilot in 1995. The approach, which has since been put into operation across New Zealand, involves the following elements:[146]

- Primary care clinicians are offered four hours of training in the use of motivational interviewing techniques to give advice on physical activity and offer the Green Prescription
- Patients who have been identified as "less active" through screening at the reception desk, and who agree to participate, receive a prompt card that states their "stage of change," which in turn forms the basis of discussion with a health care professional on staff
- In the consultation, the primary care professional works with the patient to choose appropriate goals to increase physical activity; these goals, usually involving home-based physical activity or walking, are written on a distinctive green prescription form
- With the patient's consent, a copy of the green prescription is faxed to the local sports foundation; personal details such as age, weight, and existing health conditions are often included to preserve privacy
- Exercise specialists from the sports foundation make at least three telephone calls (lasting 10-20 minutes) to the patients over the next three months to encourage and support them; motivational interviewing techniques are used, and specific information about exercise or community groups is provided as appropriate
- Quarterly newsletters from the sports foundation about physical activity initiatives in the community, as well as other motivational materials, are sent to participants
- The staff of the general practice is encouraged to provide opportunistic feedback to the participant on subsequent visits

A clinical setting was chosen for the Green Prescription program since GPs and other professionals in the practice have relatively frequent access to a large proportion of the sedentary population. In addition, a physician's advice is generally well respected, and a 'prescription' represents an accepted interaction between physician and patient.

The initial review of the 1995 pilot focussed on a comparison of verbal versus written advice from a GP, that is, answering the following question: Would formal written advice (the Green Prescription) increase physical activity more than the usual 5 minutes of verbal advice? The results indicated a significant increase in the proportion of individuals participating in any physical activity, as well as a substantial number that increased physical activity over their baseline amount following a Green Prescription.[147]

A follow-up study assessing physical activity at one year post-intervention found that the Green Prescription program increased leisure time physical activity by an average of 34 minutes/week; as well, the proportion of individuals participating in at least 2.5 hours of exercise per week increased by 9.72%.[148] While the program was initially assessed in a general population, it has also been proven to be effective specifically in older adults (age 65+).[149]

According to early surveys, an estimated 48% to 65% of New Zealand GPs had adopted the Green Prescription approach.[150] More recent data show that about 13% of patients receive general physical activity advice in the clinical setting, while 3% receive a Green Prescription.[151]

Program costs for the Green Prescription have been estimated at NZ$170 per patient, while the incremental cost of converting one additional sedentary adult to an active state over a 12 month period is NZ$1,756.[152] A cost-utility analysis of the program over the full lifetime of participants pegged the cost per quality-adjusted life year (QALY) at NZ$2,053.[153] This is less than one-tenth of the average cost per QALY for accepted interventions in health care.

Cost of Implementation in Manitoba

The hypothetical activity prescription model for Manitoba was built on the ‘Green Prescription’ approach that was developed and continues to be used in New Zealand.

Assumptions

The following assumptions were made about the program for the Manitoba context:

- A general practitioner would spend approximately 7 minutes with the patient.
- Patients are referred to a kinesiologist[154] who would complete four follow-up calls, lasting 20 minutes each, to offer encouragement and support.
- Newsletters and physical activity leaflets would be mailed out to participants.
- The intervention would have a success rate of 9.72%, meaning that an average of 10.29 inactive individuals would need to participate to convert one individual into an active person.[155]
- Physician costs were calculated using the Manitoba’s Physician’s Manual (April 1, 2010) for a ‘regional basic visit’ ($22.75).[156]
- Kinesiologist costs were calculated based on a $50,000 salary, adjusting for benefits (23%) and unproductive time (40%).
- Additional expenses including ‘set-up and coordinating costs’ and ‘patient offset costs’ were taken from the paper by Elley et al.,[157] and adjusted to 2008CDN$ by using a historic currency exchange rate (1NZ$ = 0.626CDN$; July 1, 2001) and the Consumer Price Index of Canada (General, +16.7%).
- 40% program overhead cost was added to all of the above costs, with the exception of physician services.

Results

Two approaches were adopted to derive overall program costs. First, costs from the New Zealand program were converted into 2008 Canadian dollars (see Table 8). This resulted in a cost estimate of $138.00 per participant.

Table 8. Cost of New Zealand Green Prescription Program
per Patient enrolled in Program
In 2001NZD and 2008CAD

	2001NZD	2008CAD
Set-up and coordinating costs	$82.43	$60.17
Regional Sports Foundation support costs	$68.81	$50.23
General practice delivery of intervention costs	$14.59	$10.65
General practice follow-up support costs	$4.60	$3.36
Patient offset costs	$18.62	$13.59
Total program costs	**$189.05**	**$138.00**

Exchange Rate (1NZ$ =0.6255 CDN$)
Consumer Price Index (General) +16.7%

Source: Elley et al. *New Zealand Medical Journal*, 2004.

The second approach applied Manitoba-specific amounts (as specified above) to the various program cost categories. Based on this method, the estimated cost per participant was $204.60, as indicated in Table 9. The higher cost estimate was employed in the base model.

Table 9. Cost of Physical Activity Prescription Program per Individual Enrolled in the Program Manitoba	
Physician	
Number of sessions	1
Cost per session†	$22.75
Total physician costs	**$22.75**
Kinesiologist	
Number of sessions	4
Minutes per session	20
Total minutes	80
Salary	$50,000
Hourly wage	$25.83
Benefits (23%)	$5.94
Non-productive time (40%)	$10.33
Adjusted hourly wage	$42.10
Total exercise physiologist costs	**$56.13**
Program set-up and coordinating costs^	**$60.17**
Patient offset costs^	**$13.59**
Program overhead costs (40%)#	**$51.96**
Total program costs	**$204.60**

†Manitoba Physicians's Manual, 2010. Cost of 'Regional Basic Visit'.

^ Costs taked from Elley et al. New Zealand Medical Journal, 2004. Adjusted to 2010 CDN$ using 1NZ$ = 0.6255CDN$ (July 1, 2001 rate) and +16.7% consumer product index - general category.

#Overhead costs of 40% calculated on all costs except 'physician costs'.

As noted earlier, an inactive-to-active conversion rate of 9.72% means that an average of 10.29 inactive individuals would need to go through the program to generate one new active person. In 2011, a 1% reduction means that 4,801 inactive Manitobans would need to become active. In line with the effectiveness rate, this means that 49,392 inactive Manitobans would need to go through the program and require program resources, as indicated in Table 10.

Table 10. Annual Number of Inactive Manitobans Who Need to Participate in a Green Prescription Program 2011 to 2026

Based on a 1% or 2% Annual Reduction

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
1% Annual Reduction																
Physical Inactivity (Green Prescription)																
Males	23,142	23,734	24,094	24,456	24,829	25,206	25,580	25,959	26,354	26,764	27,194	27,640	28,114	28,600	29,104	29,615
Females	26,250	26,882	27,238	27,599	27,974	28,350	28,725	29,102	29,496	29,915	30,358	30,847	31,373	31,920	32,480	33,040
Total	**49,392**	**50,616**	**51,332**	**52,055**	**52,803**	**53,556**	**54,306**	**55,061**	**55,850**	**56,678**	**57,552**	**58,487**	**59,487**	**60,520**	**61,584**	**62,655**
2% Annual Reduction																
Physical Inactivity (Green Prescription)																
Males	46,284	47,931	48,671	49,404	50,158	50,918	51,675	52,440	53,237	54,065	54,934	55,835	56,793	57,774	58,792	59,823
Females	52,500	54,288	55,024	55,753	56,510	57,270	58,029	58,791	59,587	60,431	61,327	62,313	63,375	64,480	65,611	66,743
Total	**98,785**	**102,220**	**103,695**	**105,156**	**106,668**	**108,189**	**109,704**	**111,231**	**112,824**	**114,496**	**116,261**	**118,148**	**120,168**	**122,254**	**124,404**	**126,567**

The annual cost of operating a hypothetical Manitoba version of the Green Prescription program was determined by multiplying the number of participants by the cost per participant of $204.60. Based on a 1% annual reduction, this cost would increase from $10.11 million in 2011 to $12.82 million in 2026 (in constant 2008$). Based on a similar analysis, for a 2% annual reduction the costs would increase from $20.21 million to $25.90 million (see Table 11).

Table 11. Annual Cost of a Green Prescription Program in Manitoba 2011 to 2026 Based on a 1% or 2% Annual Reduction, 2008 Constant Million$																
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
1% Annual Reduction *Physical Inactivity (Green Prescription)*																
Males	$4.73	$4.86	$4.93	$5.00	$5.08	$5.16	$5.23	$5.31	$5.39	$5.48	$5.56	$5.66	$5.75	$5.85	$5.95	$6.06
Females	$5.37	$5.50	$5.57	$5.65	$5.72	$5.80	$5.88	$5.95	$6.03	$6.12	$6.21	$6.31	$6.42	$6.53	$6.65	$6.76
Total	**$10.11**	**$10.36**	**$10.50**	**$10.65**	**$10.80**	**$10.96**	**$11.11**	**$11.27**	**$11.43**	**$11.60**	**$11.78**	**$11.97**	**$12.17**	**$12.38**	**$12.60**	**$12.82**
2% Annual Reduction *Physical Inactivity (Green Prescription)*																
Males	$9.47	$9.81	$9.96	$10.11	$10.26	$10.42	$10.57	$10.73	$10.89	$11.06	$11.24	$11.42	$11.62	$11.82	$12.03	$12.24
Females	$10.74	$11.11	$11.26	$11.41	$11.56	$11.72	$11.87	$12.03	$12.19	$12.36	$12.55	$12.75	$12.97	$13.19	$13.42	$13.66
Total	**$20.21**	**$20.91**	**$21.22**	**$21.51**	**$21.82**	**$22.14**	**$22.45**	**$22.76**	**$23.08**	**$23.43**	**$23.79**	**$24.17**	**$24.59**	**$25.01**	**$25.45**	**$25.90**

Population-Level Nutrition Program Similar to the North Karelia Project

A Multi-Dimensional Community-Based Intervention Related to Diet and Activity

The poor health of the North Karelia region of Finland, especially with respect to cardiovascular disease, was already described earlier in this report. In response to the original appeal made by the citizens of North Karelia to the government, local and national authorities were mobilized, as well as experts from the World Health Organization (WHO). The resulting North Karelia Project classified its comprehensive approach to risk factor change around six domains:

1. Improved clinical preventive services to identify high-risk individuals and provide treatment
2. Information to educate people about their health and how to maintain it
3. Persuasion to motivate people towards healthy choices
4. Training to increase skills of self-control, management of one's environment, and collaborative action to increase physical assets and social capital with the potential to benefit health
5. Community organization to create social support and power for social action
6. Environmental change to create opportunity and support for healthy actions and improvements in unfavourable conditions

Recently, the principles and approaches of the North Karelia Project have begun to be applied to the growing burden of overweight/obesity in Finland. With this inspiration, it is appropriate to consider adapting this highly successful model to Manitoba with a view to arresting or reversing the prevalence of overweight/obesity and chronic co-morbidities in the province. Although overweight/obesity control was not the focus during the North Karelia Project, there were time periods and areas where at least a levelling off of the prevalence of overweight/obesity was observed. This was especially true for women. When one of the most successful population-wide nutrition campaigns in history produced admittedly modest results related to overweight/obesity, it lends credence to being conservative about predictions for programs in other jurisdictions.

Several aspects of the North Karelia Project need to be reproduced to maximize the potential for reducing a risk factor such as overweight/obesity and, ultimately, reducing related disease rates. The following insights have been proposed by Manitoban researcher Dr. Sara Kreindler, as well as by other reviewers, as a way of explaining why it has been so difficult to duplicate the North Karelia results in other parts of the world:[158]

- Evaluation plans connected to other projects have been less robust than in North Karelia
- It is possible that other community-based efforts have depended too much on "the old mass-media approach in disguise"
- Put differently, any components focused on health promotion and environmental changes have consisted of too small a dose to create a significant population effect
- The comparable projects mounted in the United States in the 1980s had more of a top-down design that was the opposite of the well-tested community development model where "trained facilitators follow the community's lead"

The main feature of the North Karelia Project at the field office level was the commissioning of a *team* with various specializations responsible for the whole region, rather than a series of generalists being assigned, for example, one to each community. According to founder of the North Karelia Project, Dr. Pekka Puska,[159] the field office team was always small, comprising a complement of about half a dozen; according to needs and the budget available, it ranged as high as 10 people. Thus, on average the staff-to-population ratio was about 1 to 30,000 (based on a North Karelian population in the 1970s of approximately 180,000).

While the field office team worked from a centralized location, there was also an attempt to localize efforts in a tangible way. For instance, a new office connected to the Project was established in each of the 12 community health centres of North Karelia. Among other benefits, Dr. Puska explained in a recent interview with the authors of this report that the localization of efforts helped to mobilize public health nurses and physicians in each area, thereby multiplying the personnel beyond the specific Project staff.[160] This approach was also consistent with the built-in momentum in Finnish society to organize at a municipal level. Some existing elements of the Regional Health Authority health promotion plan in Manitoba, including the recently funded Healthy Living teams, could be assigned to a new population-wide program related to diet and activity. The focus in this case would be creating a better balance between energy intake and energy expenditure across the population.

The preceding analysis suggests how the resources in a Manitoba project could be targeted. This would include a community-based approach to guide activities as much as possible, and interdisciplinary teams dedicated over multiple years to a diet/activity enhancement program in each region. Approximately 30 staff would generate an intensity of population coverage in Manitoba matching the North Karelia Project.

The activities of the team in North Karelia provide some guidance as to the range of work that could be taken on by program staff in Manitoba. Generally, the efforts were directed to both individuals and the community as a whole. Initially, the nurses working for the North Karelia Project managed a region-wide hypertension registry that was gradually populated with information derived through mass screening programs at country fairs, village markets, etc. Individuals with elevated blood pressure were referred to physicians and then monitored afterwards, as well as being prompted with respect to medications and lifestyle modifications.

Next, team members consistently acted as communication agents throughout the community. This involved disseminating information on risk factors and prevention is various settings, from supermarkets to homes to clubs to community meetings. The campaign began with simple pamphlets offering heart-healthy eating suggestions and tips for smoking cessation, but became more sophisticated. For instance, nutritionists on the team helped to run more intensive training courses and other community programs aimed at more healthful cooking. Project staff organized over 300 "Parties of Long Life," where families gathered to try out new, healthier recipes and listen to lectures by Puska and his colleagues.

Another important information conduit involved community health education diffused through lay opinion leaders from formal and informal groups. Public health nurses, physicians, and others connected to the team were involved with recruiting and training these leaders. Forming partnerships with other health organizations, such as the Heart Association, was also critical to this endeavour. The sense of collaboration and harnessing of volunteer energies was very deep, multiplying the official Project team and leveraging the program budget many times over. Ultimately, thousands of ordinary citizens cooperated through small actions such as displaying a motivational sticker or poster in their home or workplace.

Cost of Implementation in Manitoba

Assumptions

In modelling a ‘North Karelia’ style population-based intervention to address chronic disease risk factors, cost figures for dedicated personnel, materials, and some media work were adapted from Tosteson et al. 1997.[161] The authors reported costs of $10 (1985 USD) for each person reached by the North Karelia Project in the first year, with recurring costs of $5 (1985 USD) for each year after that by way of media reinforcement. For the Canadian version of a population-wide, diet-related health promotion program, the assumption was made that it would cost $10 (1985 USD) per person reached for the first year and $5 (1985 USD) for each subsequent year. These figures were adjusted to 2008 CAD using historical currency exchange rates (1 USD=1.35 CAD; July 1, 1985) and the Consumer Price Index of Canada (General, +81.1%), resulting in costs of $36.67 (2008 CAD) for the first year and $12.22 (2008 CAD) for each subsequent year. These data are summarized in Table 12. When modelling, it was assumed that one-fifth of the population would be reached each year for the first five years (with cohorts from previous years moving into the second cost bracket, etc.), resulting in the total population reaching the second cost bracket ($12.22) by year six.

Table 12. Cost Adjustment for North Karelia Style Community Prevention Program
per Individual in 1985 US$ and 2008 Constant CAD

	1985 US$	1985 CDN$	2008 CDN$
First year of program delivery	$10.00	$13.50	$24.45
subsequent years of	$5.00	$6.75	$12.22

Exchange Rate 1 US$ (1985) = 1.35 CDN$ (1985); Consumer Price Index (General Category) +81.1%

Results

Based on the preceding assumptions, the costs for a North Karelia style community-based program in Manitoba would be $6.15 million in the first year, increasing to $19.51 million in 2026 (see Table 13).

Table 13. Cost of Implementation of 'North Karelia' Style Community Prevention Program in Manitoba
5-year Staggered Model, 2008 Constant CAD

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Male	$3.07	$4.65	$6.25	$7.88	$9.54	$8.28	$8.42	$8.55	$8.70	$8.84	$8.99	$9.15	$9.31	$9.47	$9.63	$9.79
Female	$3.09	$4.67	$6.28	$7.91	$9.57	$8.29	$8.41	$8.54	$8.68	$8.82	$8.96	$9.11	$9.26	$9.41	$9.57	$9.72
Total	**$6.15**	**$9.32**	**$12.53**	**$15.79**	**$19.11**	**$16.57**	**$16.83**	**$17.10**	**$17.37**	**$17.66**	**$17.95**	**$18.25**	**$18.56**	**$18.88**	**$19.20**	**$19.51**

Summary Cost for Program Implementation and Operation

Based on a 1% annual reduction in risk factors, the estimated costs of implementing a smoking cessation, an activity prescription, and a ‘North Karelia’ type program in 2011 would be $4.85 million, $10.11 million, and $6.15 million, respectively, for a total of $21.11 million (see Table 14). Total annual costs would increase by 2026 to $38.32 million (in 2008 constant dollars). Over the 16-year time period from 2011 to 2026, total costs would be $529.48 million.

Table 14. Estimated Cost of Meeting Risk Factor Reduction Goals in Manitoba
By Intervention Type, 2011 to 2026
Based on a 1% Annual Reduction, 2008 Constant Million$

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	16-Year Total
									1% Annual Reduction								
Smoking Cessation	$4.85	$4.96	$5.01	$5.08	$5.13	$5.19	$5.26	$5.32	$5.39	$5.46	$5.54	$5.62	$5.71	$5.80	$5.89	$5.99	**$86.19**
Activity Prescription	$10.11	$10.36	$10.50	$10.65	$10.80	$10.96	$11.11	$11.27	$11.43	$11.60	$11.78	$11.97	$12.17	$12.38	$12.60	$12.82	**$182.49**
'North Karelia'	$6.15	$9.32	$12.53	$15.79	$19.11	$16.57	$16.83	$17.10	$17.37	$17.66	$17.95	$18.25	$18.56	$18.88	$19.20	$19.51	**$260.80**
Total	**$21.11**	**$24.63**	**$28.05**	**$31.52**	**$35.05**	**$32.72**	**$33.20**	**$33.68**	**$34.19**	**$34.71**	**$35.26**	**$35.84**	**$36.44**	**$37.06**	**$37.69**	**$38.32**	**$529.48**

Risk Factor Reduction Program Costs and Estimated Costs Avoided

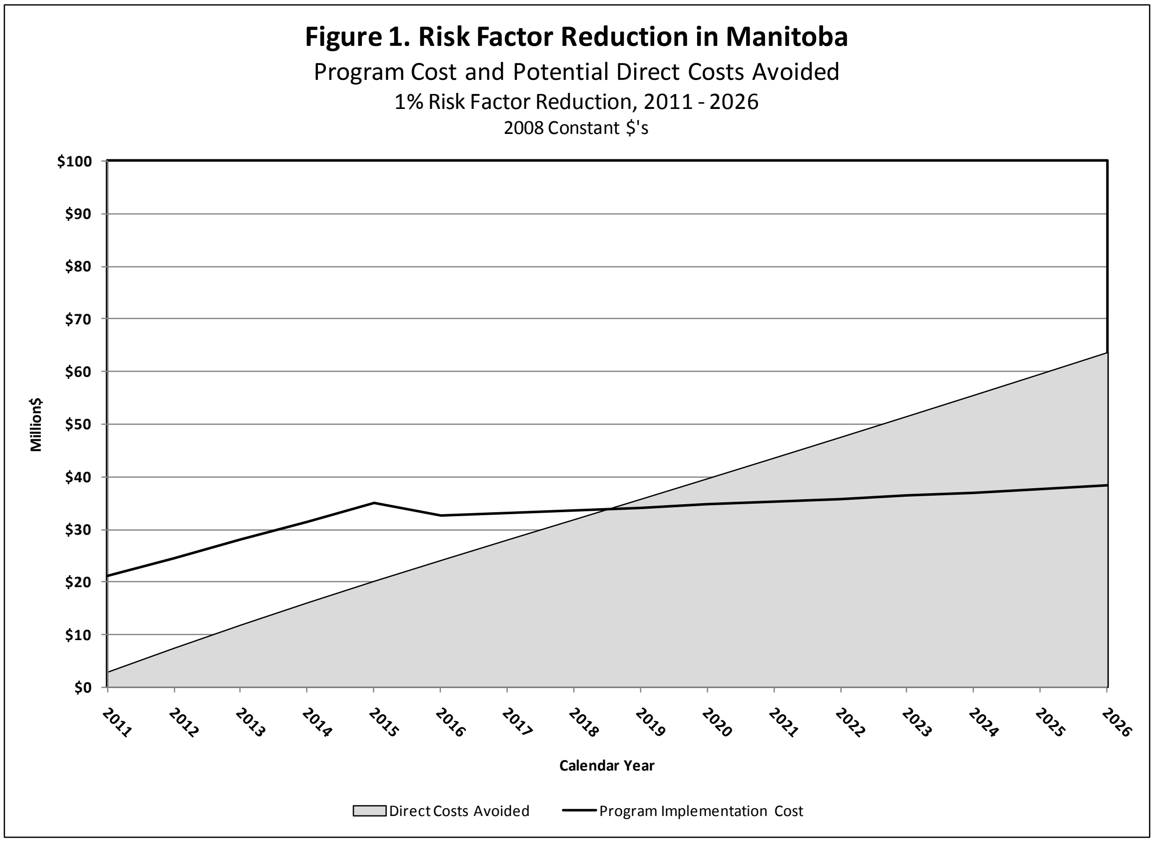
Base Model

As estimated in Supporting Document 2, a 1% annual reduction in the risk factors of smoking, physical inactivity, and overweight/obesity would lead to an estimated cost avoidance of $1.77 billion dollars in Manitoba over the 16-year period from 2011 to 2026 (see Table 15).

Table 15. Annual Direct and Indirect Costs Avoided With Risk Factor Prevalence Reduction in Manitoba
By Intervention Type, 2011 to 2026
Based on a 1% Annual Reduction, 2008 Constant Million$

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	16-Year Total
Smoking																	
Direct	$0.00	$1.60	$2.99	$4.17	$5.15	$5.95	$6.66	$7.28	$7.86	$8.42	$8.96	$9.46	$9.95	$10.40	$10.82	$11.21	**$110.90**
Indirect	$0.00	$3.33	$6.18	$8.57	$10.62	$12.32	$13.84	$15.18	$16.45	$17.66	$18.80	$19.88	$20.89	$21.84	$22.71	$23.52	**$231.78**
Total	**$0.00**	**$4.93**	**$9.17**	**$12.73**	**$15.77**	**$18.27**	**$20.50**	**$22.46**	**$24.32**	**$26.08**	**$27.76**	**$29.34**	**$30.84**	**$32.24**	**$33.54**	**$34.73**	**$342.68**
Physical Inactivity																	
Direct	$1.04	$2.10	$3.18	$4.27	$5.38	$6.50	$7.64	$8.80	$9.97	$11.16	$12.37	$13.59	$14.84	$16.11	$17.40	$18.72	**$153.06**
Indirect	$2.36	$4.78	$7.24	$9.73	$12.25	$14.81	$17.41	$20.04	$22.71	$25.42	$28.17	$30.97	$33.81	$36.71	$39.65	$42.65	**$348.74**
Total	**$3.40**	**$6.88**	**$10.42**	**$14.00**	**$17.63**	**$21.32**	**$25.05**	**$28.84**	**$32.68**	**$36.58**	**$40.54**	**$44.56**	**$48.66**	**$52.82**	**$57.05**	**$61.36**	**$501.80**
Overweight/Obesity																	
Direct	$1.86	$3.77	$5.71	$7.68	$9.68	$11.71	$13.77	$15.87	$17.99	$20.15	$22.35	$24.57	$26.83	$29.13	$31.46	$33.82	**$276.35**
Indirect	$4.39	$8.90	$13.48	$18.13	$22.86	$27.66	$32.53	$37.47	$42.50	$47.60	$52.77	$58.03	$63.37	$68.79	$74.30	$79.89	**$652.67**
Total	**$6.26**	**$12.67**	**$19.19**	**$25.81**	**$32.54**	**$39.37**	**$46.30**	**$53.34**	**$60.49**	**$67.75**	**$75.12**	**$82.60**	**$90.20**	**$97.92**	**$105.75**	**$113.71**	**$929.02**
Total																	
Direct	**$2.90**	**$7.47**	**$11.88**	**$16.11**	**$20.21**	**$24.17**	**$28.08**	**$31.94**	**$35.83**	**$39.73**	**$43.67**	**$47.63**	**$51.62**	**$55.64**	**$59.68**	**$63.76**	**$540.31**
Indirect	**$6.76**	**$17.01**	**$26.90**	**$36.43**	**$45.73**	**$54.79**	**$63.78**	**$72.70**	**$81.66**	**$90.68**	**$99.75**	**$108.88**	**$118.07**	**$127.33**	**$136.66**	**$146.05**	**$1,233.19**
Total	**$9.66**	**$24.48**	**$38.78**	**$52.54**	**$65.94**	**$78.96**	**$91.86**	**$104.64**	**$117.49**	**$130.41**	**$143.42**	**$156.51**	**$169.69**	**$182.97**	**$196.34**	**$209.81**	**$1,773.50**

Just under 1/3 ($540.31 million or 30.5%) of these total costs are direct health care costs. If only these direct costs are taken into consideration, then program costs would exceed annual costs avoided until 2019, at which point costs avoided would exceed annual program implementation costs (see Figure 1).



Over the 16-year period between 2011 and 2026, total program costs are estimated at $529.5 million while potential direct costs avoided are $540.3 million.

Sensitivity Analysis

Adjusting Program Cost Assumptions

For the base model, the assumptions used in estimating program costs have tended to be conservative, i.e., to err on the more costly side. To test the impact of these conservative assumptions on the overall program costs, the following assumptions were modified:

- For the clinical smoking cessation, use a clinical nurse specialist rather than a general practitioner and use generic rather than name brand NRT. This reduces the cost per smoker going through the program from $548 to $362 (see Table 5).
- For the physical activity prescription program, use a nurse rather than the combination of a physician and nurse and assume three 15-minute telephone sessions with an exercise physiologist earning $45,000 per year (compared to the base case in which four 20-minute sessions were included and the exercise physiologist annual salary was $50,000). This reduces the cost per participant from $205 to $161 (see Table 16).

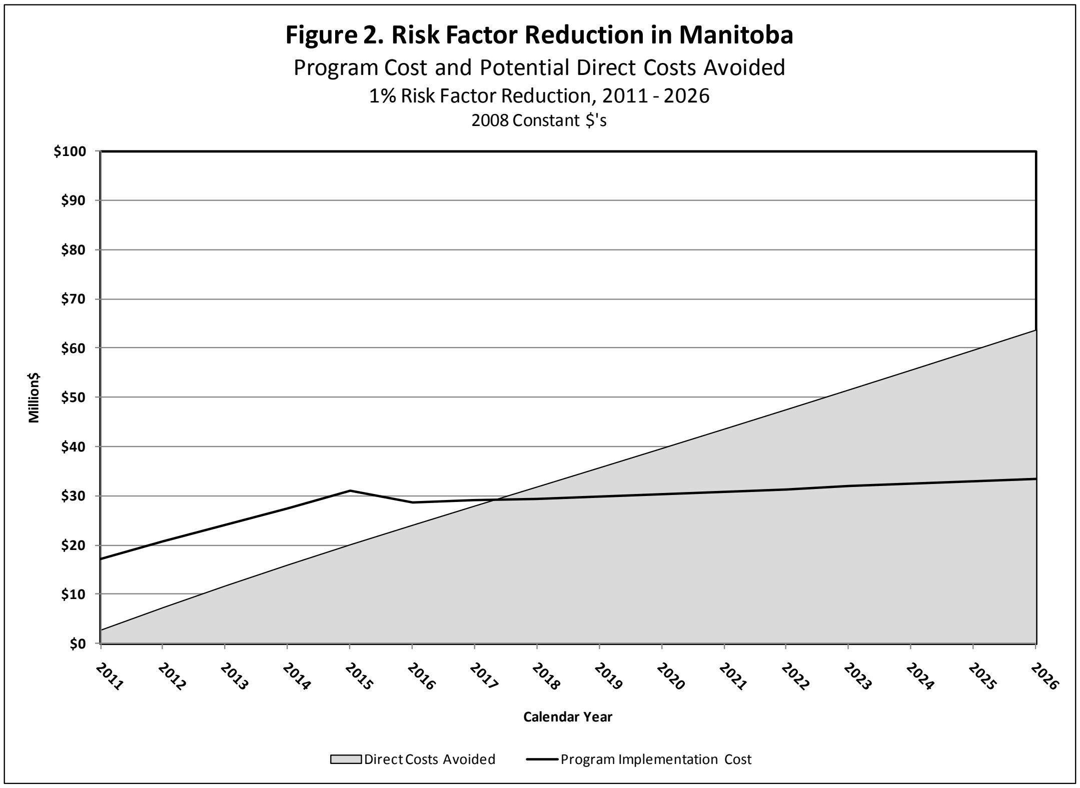
Table 16. Cost of Physical Activity Prescription Program per Individual Enrolled in the Program Manitoba	
Nurse	
Number of sessions	1
Minutes per session	13
Total minutes	13
Hourly wage*	$35.53
Benefits (23%)	$8.17
Non-productive time (40%)	$14.21
Adjusted hourly wage	$57.91
Total nursing costs	**$12.55**
Exercise physiologist	
Number of sessions	3
Minutes per session	15
Total minutes	45
Salary	$45,000
Hourly wage	$23.24
Benefits (23%)	$5.35
Non-productive time (40%)	$9.30
Adjusted hourly wage	$37.89
Total exercise physiologist costs	**$28.42**
Program set-up and coordinating costs^	**$60.17**
Patient offset costs^	**$13.59**
Program overhead costs (40%)#	**$45.89**
Total program costs	**$160.62**

* 2008 Manitoba Nurses Union Salaries. Hourly wage for Nurse III - Year 3.

^ Costs taked from Elley et al. New Zealand Medical Journal, 2004. Adjusted to 2010 CDN$ using 1NZ$ = 0.6255CDN$ (July 1, 2001 rate) and +16.7% consumer product index - general category.

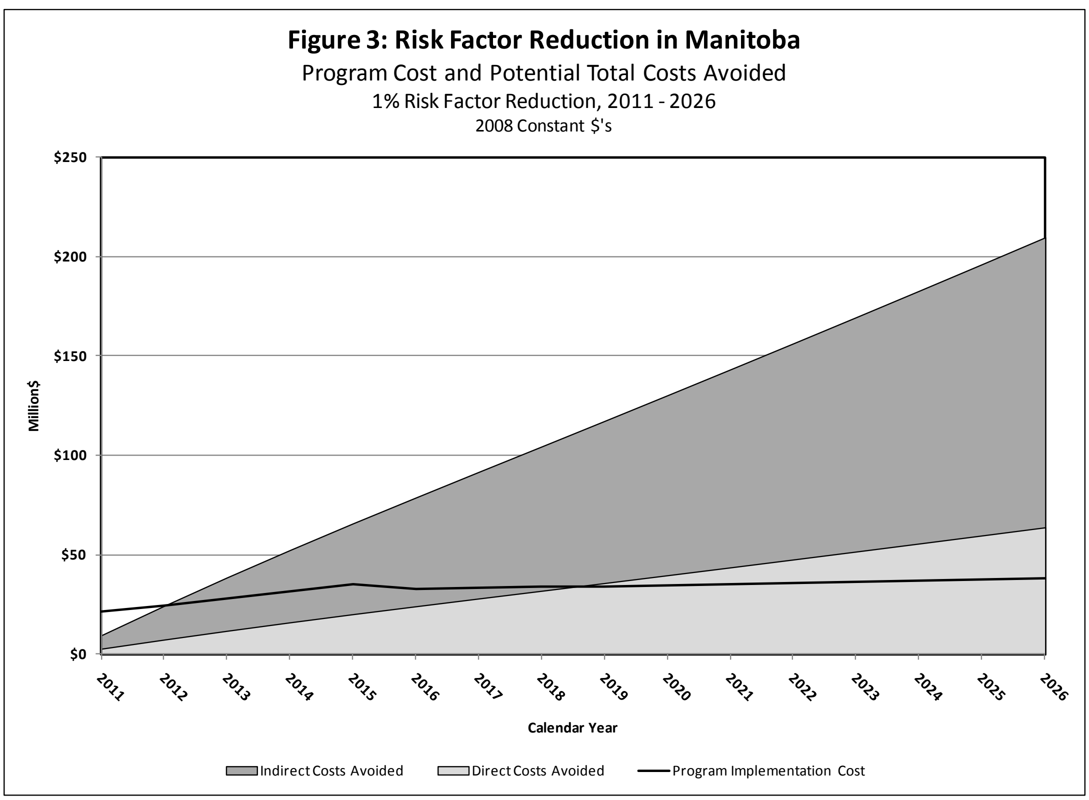
\# Overhead costs of 40% calculated on all costs

Based on these changes, estimated program costs over the 16-year period would be reduced from $529.5 million to $461.0 million (-$68.5 million or -12.9%). If only direct costs avoided are taken into consideration, then program costs would exceed annual costs avoided until 2017, at which point costs avoided would exceed annual program implementation costs (see Figure 2). This analysis generates a more favourable comparison between cumulative program costs ($461.0) million and the potential direct costs avoided ($540.3) million for the 1% reduction scenario.



Including Indirect Costs Avoided

If indirect costs are included, then annual costs avoided would exceed program costs within two years even under the more conservative costing analysis (see Figure 3). Over the 16-year period between 2011 and 2026, total program costs are estimated at $529.5 million, while potential costs avoided are $1.77 billion.



Not Achieving a Reduction in Overweight/Obesity

In the base model, it was assumed that the implementation of a 'North Karelia' type program in Manitoba would lead to a 1% annual reduction in the prevalence of overweight/obesity. An alternative assumption is that such a program would only be able to halt the current increase in prevalence of overweight/obesity. In the cost avoidance analysis in this scenario, only the avoided costs associated with smoking and physical inactivity would be included. In essence, this might be considered a type of worst-case scenario for the intervention program.

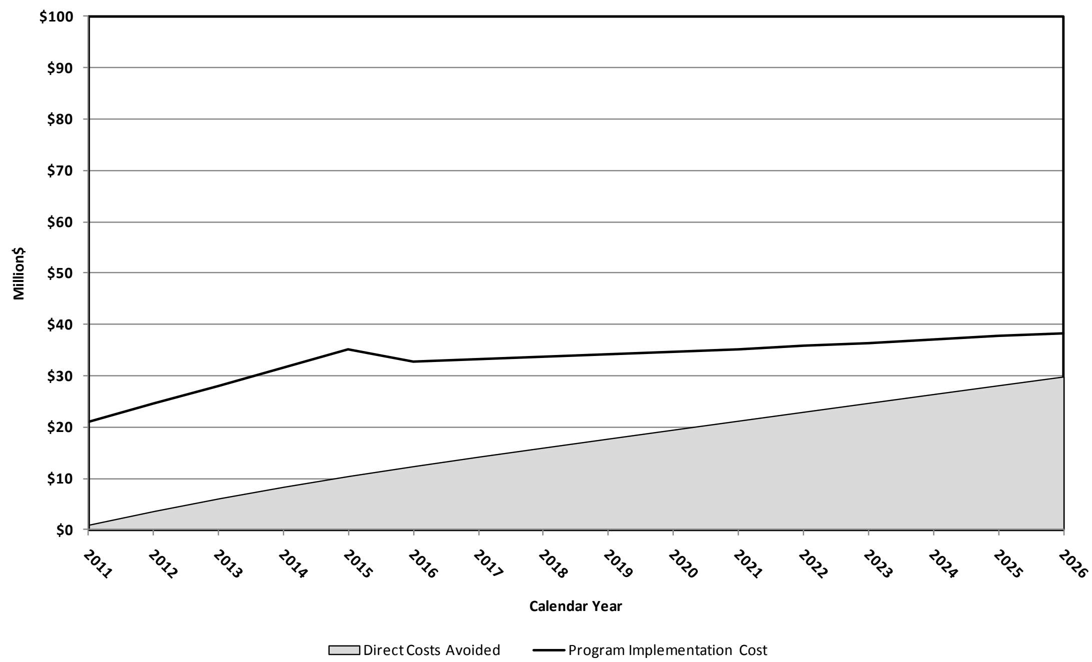
If only direct costs are included under these more stringent terms, then annual program costs would exceed annual costs avoided during the entire timeframe of the model (see Figure 4). Cumulatively, program costs over the 16- year period would remain at $529.5 million, while potential direct costs avoided would only be $264.0 million.

Figure 4. Risk Factor Reduction in Manitoba

Program Cost and Potential Direct Costs Avoided

1% Risk Factor Reduction for Smoking and Physical Inactivity

2011 - 2026, 2008 Constant $'s



If, however, indirect costs are included, then annual costs avoided would exceed program costs within five years (see Figure 5). Over the 16-year period between 2011 and 2026, total program costs are estimated at $529.5 million while potential costs avoided are $844.5 million.

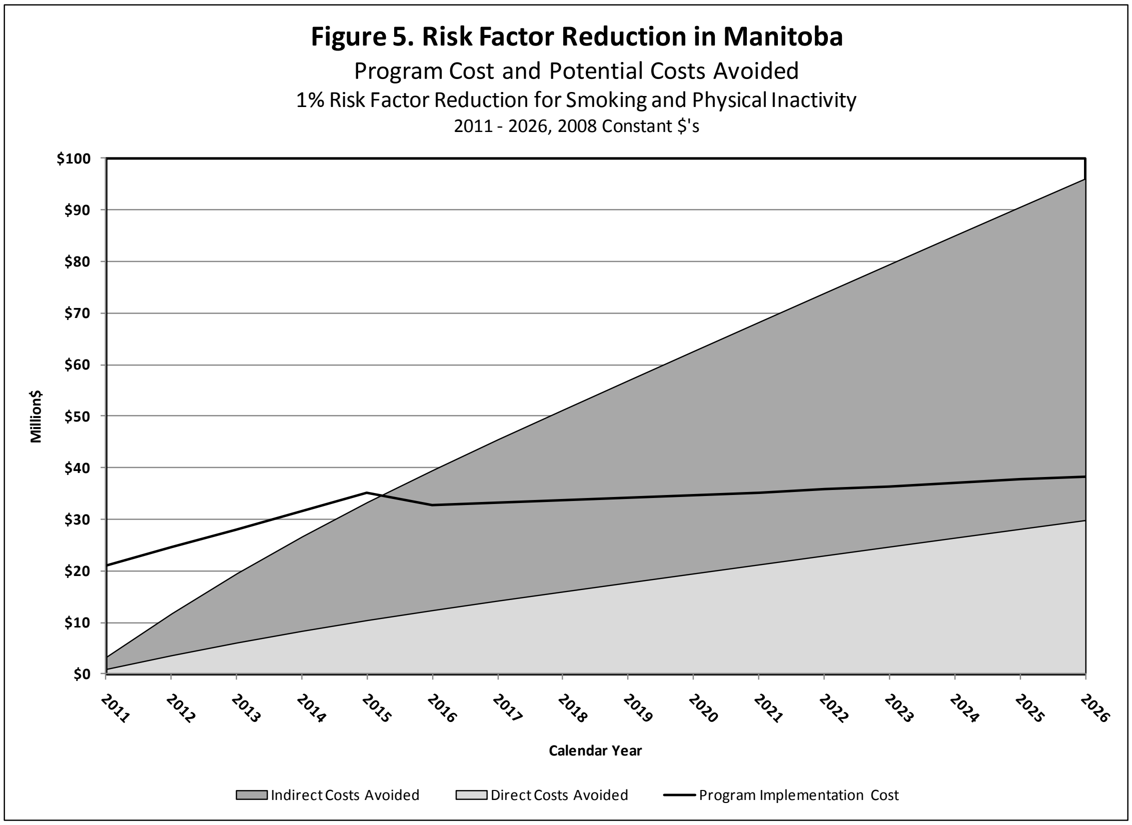


Table 17 summarizes the program costs and potential costs avoided for the base model and the two scenarios from the sensitivity analyses outlined above.

Table 17. Risk Factor Reduction in Manitoba
Program Cost and Potential Costs Avoided For Three Scenarios
1% Risk Factor Reduction, 2011-2026 (2008 Constant Million$)

		Potential Costs Avoided		
Scenario	Program Cost	Direct	Indirect	Total
Base Model	$529.5	$540.3	$1,233.2	$1,773.5
Adjusted Program Cost Assumptions	$461.0	$540.3	$1,233.2	$1,773.5
Not Achieving Reduction in Overweight/Obesity	$529.5	$264.0	$580.5	$844.5

Summary and Conclusion

The preceding Supporting Document combines the costs avoided associated with three sample interventions, graphically comparing the annual and cumulative totals against combined program costs. The main result for the “base case” modeling, which assumes a 1% annual reduction in prevalence of smoking, physical inactivity, and overweight/obesity in Manitoba, is that the total program costs over 16 years of $530 million are approximately equal to the estimated total direct costs avoided ($540 million). As shown in a sensitivity analysis, program costs could also be realistically reduced from $530 million to $461 million. Not surprisingly, adding in the indirect costs avoided improves even the base case picture, yielding about a 3.3 to 1 return on investment.

Two major cautions should be offered at this juncture. First, it is clear that the **suite of interventions** modeled is very limited, and therefore not representative of a fully comprehensive prevention program. As has been suggested in the body of the report, comprehensiveness is important. Even the limited program analyzed herein has its merits. The suite of interventions is still multi-component, it reflects both personal and environmental change modalities (in the ‘North Karelia’ type intervention), and it does address what are arguably the most pressing risk factors in an integrated way. This will allow for synergies to develop, for example, between the primary care exercise prescription and community-based physical activity efforts. Furthermore, the time line of 16 years fulfills another important criterion, namely, that prevention efforts should be sustained over the long-term in order to be most effective.

In the end, **the selection of the interventions to include depended on two characteristics that are critical to modeling: that the interventions are clearly effective or at least very promising, and that program costs are assignable**. Systematic reviews of trials and/or real-world experiences confirm the effectiveness of smoking cessation and physical activity schemes that operate within primary care. Therefore, they have been added with confidence to the package of interventions used in this modeling exercise.

The second major caveat relates specifically to the third intervention, namely, the ‘North Karelia’-type strategy operated at a community level to address the known diet and physical inactivity inputs associated with overweight/obesity. The literature suggests that overweight/obesity will remain a challenging obstacle that may be resistant to even aggressive interventions. Other jurisdictions have succeeded in only arresting the increase in prevalence, particularly when it comes to adults. Therefore, it seemed prudent to add a more conservative scenario within this arena as another sensitivity analysis. Specifically, this meant that the costs for the ‘North Karelia’ type program would be maintained, but there would be no off-setting cost avoidance related to reducing overweight/obesity prevalence. Even with this conservative approach, estimated total costs avoided still exceed program costs by year 6.

The ultimate **purpose of the entire project and report, and specifically of this third Supporting Document, is to encourage Manitoba to design and implement new prevention efforts targeting the reduction of common risk factors that lead to chronic disease**. The relevant motivations include:

- The fact that feasible, effective, and likely cost-effective interventions are available
- The potential for substantial improvement in population health in the province
- The estimate that *direct* costs avoided may closely match the program costs attached to a suite of selected, high-leverage interventions implemented over 16 years
- The fact that adding *indirect* costs avoided to the scenario almost certainly makes such a prevention program very attractive on a societal basis within Manitoba

Supporting Document 4: Definitions

Chronic disease: Disease of generally slow progression or frequent recurrence, and therefore affecting the afflicted individual over a longer period of time.
From a biological perspective, a chronic disease persists beyond the normal time for damaged tissue to heal. From the medical perspective, this type of disease can be controlled or managed but not cured (otherwise it would not be chronic). The category is usually contrasted with acute diseases, which are marked by rapid onset and/or a short duration before cure or death.

Direct Costs: Costs associated with resources expended for health care related to a particular disease. More formally, direct costs represent the value of all goods, services, and other resources consumed in providing health care or dealing with side effects or other current and future consequences of health care (reference: U.S. National Institutes of Medicine). As a category, it is usually contrasted with indirect costs (see below).

Two types of direct costs are direct health care costs and direct non-health care costs. Direct health care costs include costs of physician services, hospital services, drugs, etc. involved in delivery of health care. Direct non-health care costs are incurred in connection with health care, such as for care provided by family members and personal transportation to and from the site of care.

Indirect Costs: Costs related to productivity lost due to death or short- and long-term disabilities. More formally, indirect costs include:

- The costs of premature mortality
- The costs of lost work due to absenteeism or early retirement, impaired productivity at work, and lost or impaired leisure activity

A third cost category, intangible costs, includes pain, suffering, and grief; these are real, yet very difficult to measure, and therefore are often omitted from cost analyses.

Population Attributable Risk (PAR): The proportion of the population-wide burden of a specific disease that is caused by a particular risk factor. The most common "burden" analyzed in this way is disease incidence, but it is possible to think in terms of PAR of mortality and even PAR of disease-related costs. Even more pertinent to this project, PAR may be understood as *the proportion of disease that will be removed from a population if exposure to the risk factor is eliminated.*

The classic equation used to calculate PAR is as follows:

$$\frac{E\,(RR-1)}{E\,(RR-1)+1}$$

Where: **E** is the proportion of the population exposed to the risk factor of interest
RR is the relative risk of disease developing in the group exposed to the factor

Primary Prevention of Disease: The prevention of a disease or condition before it is initiated in an individual. This usually means intervening to *avoid* or *eliminate* exposure to a risk factor that causes disease. By this understanding, supporting not smoking in the first place *and* smoking cessation (before the onset of a tobacco-related disease) are both forms of primary prevention.

Risk Factor: A factor that influences the risk (or probability) of getting or dying from a disease. Note that this definition allows the list of risk factors to include beneficial influences (sometimes referred to as "protective factors").

There are many ways that risk factors may be categorized: factors that directly cause (or retard) disease development vs. factors that are indirectly related to disease; factors that are modifiable (e.g., physical inactivity) vs. non-modifiable (e.g., age); factors that are related to individuals vs. related to the environment; factors that are behavioural (e.g., tobacco smoking) vs. biological or metabolic (e.g., hypertension).

Relative Risk (RR): The chance of one group developing a health outcome (such as incident disease or death from a disease) compared to another group. RR is an important statistic in understanding the effect of being exposed to a risk factor. It is calculated as follows: the proportion of individuals experiencing an outcome in the exposed group divided by the proportion experiencing the outcome in the control (or unexposed) group.

Mathematically, a risk factor that increases the risk of getting a disease will have a RR for that disease that is greater than 1; conversely, a protective factor has a RR less than 1.

Risk Factor Prevalence: Degree of exposure, or the proportion of the population exposed to a risk factor, which is sometimes abbreviated as **E** when appearing in equations.

Sensitivity Analysis: A technique used to determine how different values of an independent variable will impact a particular dependent variable under a given set of assumptions. It is a way to predict the outcome of a decision if a situation turns out to be different compared to the key prediction(s).

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