

The Potential Impact of Pharmaceutical Interventions

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North York Corporate Centre

4576 Yonge Street, Suite 400

Toronto, ON M2N 6N4

Tel: (416) 782-7475

Fax: (416) 309-2336

www.riskanalytica.com

This report was prepared by RiskAnalytica on behalf of *Canada's Research-Based Pharmaceutical Companies* (Rx&D). The RiskAnalytica team members who contributed to this report are: Paul Smetanin, Carla Briante, David Stiff, and Lynette Katsivo. The assumptions and calculations underlying RiskAnalytica's Life at Risk simulation platform were prepared by RiskAnalytica as part of this study. The use and interpretation of the methodologies, data, assumptions and simulation outcomes is entirely that of the authors.

Data sources, advice and recommended literature sources that were relevant to the research were provided by subject-matter experts as part of our previous research and model development process. The views presented in this report are not necessarily those of the expert panel.

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EXECUTIVE SUMMARY

INTRODUCTION

The objective of the study was to estimate the potential health and economic benefits that may arise due to pharmaceutical interventions in a wide variety of illnesses. The interventions identified the opportunity available to improve the health and economic prospects of Canadians if pharmaceuticals could:

- Increase smoking cessation rates;
- Improve pain management to reduce the level of disability and related health costs;
- Help people lose weight;
- Reduce secondary complications of type 1 diabetes;
- Delay the onset of dementia;
- Decrease the number of people with chronic obstructive pulmonary disease (COPD) exacerbations;
- Improve the disability of people with rheumatoid arthritis through increased use of biologics and DMARDs;
- Reduce the impact of mental illness through improved disease management and remission; and
- Provide vaccines for infectious disease more quickly after a disease is identified.

In order to gauge the impact of such interventions, baseline estimates of the health and economic burden of eight chronic diseases, or chronic disease groups, were calculated using RiskAnalytica's Life at Risk platform. The expert-validated models included lung cancer, COPD, asthma, osteoarthritis, rheumatoid arthritis, type 1 diabetes, dementia and an aggregate group of eight major mental illnesses (mood disorders, anxiety disorders, schizophrenia, substance use disorders, cognitive impairment including dementia, conduct disorders, attention deficit hyperactivity disorder and oppositional defiant disorders). In addition, the potential health and economic impact of an influenza pandemic was estimated. The analysis then estimated the potential health and economic benefits of the interventions if pharmaceuticals had a low, moderate or high impact.

CONCLUSIONS

The assumed potential pharmaceutical-related interventions were shown to not only improve the quality of life of individuals with illness in Canada, but also produce significant direct health care savings

and improved economic productivity through decreased levels of disability in the labour force. Over the next 30 years, it was estimated that pharmaceutical-related interventions have the opportunity to:

- Prevent up to 700,000 fewer new cases of lung disease, reduce cumulative direct health costs by up to \$79 billion¹, and improve economic productivity by up to an average of \$6.8 billion² annually through increased smoking cessation rates;
- Improve pain management for osteoarthritis patients resulting in up to an average of \$52.7 billion annually in economic productivity benefits due to the decrease of disease's prevalence in the population and \$183 billion in cumulative direct health costs;
- Prevent up to 870,000 new cases of osteoarthritis through improved weight management and weight loss;
- Reduce the prevalence of mental illness in the population by 700,000 individuals by 2042 resulting in up to a total of \$132 billion direct cost savings and over an average of \$1.1 billion annually in indirect economic productivity benefits;
- Reduce the dementia-related informal caregiving burden of relatives and friends by up to a cumulative total of \$3.8 billion through delaying the onset of the disease;
- Reduce the disability of people with type 1 diabetes through the prevention of complications resulting in up to an average of \$549 million in indirect economic productivity benefits;
- Provide widespread vaccination more quickly in an infectious disease outbreak reducing infections and direct health costs by almost 95%;
- Save up to a cumulative total of \$94 billion direct health costs due to COPD exacerbations; and
- Improve the productivity and reduce the disability of people with rheumatoid arthritis to save up to a cumulative total of \$3.4 billion in direct health care costs.

These high-level impacts show that there exists significant opportunities for the assumed potential pharmaceutical-related interventions to make a significant impact on the future health and economic burden of illness in Canada. The comprehensive modelling of such interventions allows quantitative cases to be put forward in the context of the broad picture of the health of the Canadian population and economy.

¹ All direct costs are cumulative future value totals from 2012 to 2042. Present value costs are included in the analysis sections.

² All indirect economic productivity benefits are the annual average impact in future value terms for the period from 2012 to 2042

LIMITATIONS AND FUTURE RESEARCH

The study is demonstrative of the potential for significant value generation if the assumed interventions were to occur. In this regard, the study is limited to generally hypothetical interventions that ultimately need to be examined against actual pharmaceutical interventions and those potential interventions for which clinical trial data exists.

STRUCTURE OF THE REPORT

This report is divided into four sections:

- Section 1 provides details on the background, purpose and objectives of the study;
- Section 2 provides high level summary results of the intervention scenarios evaluated;
- Section 3 summarizes the findings for two detailed case studies; and
- Section 4 summarizes the major findings of this study.

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1 INTRODUCTION

1.1 STUDY OBJECTIVE

The objective of the study was to estimate the potential health and economic benefits that may arise due to pharmaceutical interventions in a wide variety of illness. To achieve this objective, the analysis:

1. Provided estimates of the current and future health and economic impacts of select diseases in Canada over the next 30 years;
2. Examined the impact of pharmaceutical interventions and/or hypothetical interventions on reducing the health and economic consequences of select diseases in Canada; and
3. Illustrated through specific case studies how the impact of potential pharmaceutical interventions can reduce costs to the health care system and improve the economic productivity of the labour force.

RiskAnalytica's Life at risk simulation platform was used to generate a base model of the current and future life and economic outcomes associated with select diseases in Canada. The diseases of focus include:

- Respiratory illnesses: lung cancer, chronic obstructive pulmonary disease (COPD), and asthma;
- Any mental illnesses including mood disorders, anxiety disorders, schizophrenia, substance use disorders, cognitive impairment including dementia, conduct disorders, attention deficit hyperactivity disorder and oppositional defiant disorders;
- Dementia: Alzheimer's disease, vascular dementia and any or all dementias;
- Arthritis: osteoarthritis and rheumatoid arthritis;
- Type I diabetes; and
- Pandemic influenza.

Using expert-validated data inputs from our previous models in these disease areas, the base model estimated the current impacts of disease and provided a forecast over a 30-year timeframe (for chronic diseases). The base model represents the status quo for each disease, where measures of health (incidence, prevalence and mortality) and economics (direct and indirect costs attributable to disease) can be computed. For infectious diseases, only short-term health and economic impacts were considered. The simulated outputs were used to generate a base model for each disease against which we can gauge the impact of the intervention scenarios considered.

For all previous models within the Life at Risk framework, all data inputs, model assumptions and outcomes were agreed upon and validated with leading subject matter experts (SMEs) in the field. Further details on the base models, data sources, assumptions and a list of SMEs can be found in our previous reports listed in the bibliography.

1.2 EXAMINING THE IMPACT OF BURDEN TO CHANGE: INTERVENTION SCENARIOS

The second objective of this study investigated the high-level impact of potential pharmaceutical interventions that aim to reduce the baseline burden. When compared to the baseline outcomes, the scenarios demonstrate the potential impact upon diseases of interest. It is important to note that many of the interventions considered are hypothetical in nature and simply aim to show the possible reductions in the baseline outcomes that could be achieved if a particular intervention was implemented. Where possible, interventions are supported by evidence or subject-matter expert opinion.

A total of seven potential pharmaceutical intervention scenarios were evaluated within the Life at Risk platform:

- Scenario 1: The impact of smoking cessation programs that provide support through medication in conjunction with counseling to assist people in quitting. The impacts of this scenario can be evaluated for both lung cancer and COPD; and indirectly for asthma through reducing exposure to second hand smoke.
- Scenario 2: The impact of hypothetical pain management medication on osteoarthritis.
- Scenario 3: The impact of a hypothetical medication as part of weight reduction program (reducing number of people with high BMI by 10%, 25%, and 50%) on reducing osteoarthritis incidence.
- Scenario 4: The impact of potential medication to increase remission in those with mental illness (where remission means no excess disability due to the illness) by 5%, 10% and 20% for all mental illnesses excluding dementia.
- Scenario 5: The impact of medication on delaying disease onset by 2, 5 and 10 years for all dementias.
- Scenario 6: The impact of a hypothetical intensive medication control program on type I diabetes.
- Scenario 7: The impact of antivirals and the timing of vaccine availability on pandemic influenza.

1.3 CASE STUDIES

To provide a closer examination of the potential impact of medication, two chronic diseases were selected as case studies to provide further details on the intervention impacts. The case studies provided baseline estimates for the economic burden of diseases including direct costs stratified by cost components (such as costs for hospitalizations, health professional visits, emergency department visits, medication or other health care services). The case studies considered were as follows:

1. The first case study provided a baseline estimate for the economic burden of rheumatoid arthritis including an estimate of direct costs stratified by key cost drivers such as drugs, biologics, disease modifying anti-rheumatic drugs (DMARDs), hospitalizations, tests, primary surgery, surgery revisions and other health services incurred by those with rheumatoid arthritis; as well as an estimate of the baseline prevalence of disease and indirect costs. Three intervention scenarios that aimed to increase the use of DMARD and biologic therapies for those with both early and late stages of the disease were evaluated to demonstrate how an increase in their use can shift or reduce the costs accrued in other direct health cost drivers; as well as reduce the indirect costs associated with the disease. The three intervention scenarios considered represent a best case, moderate case, and a worst case scenario for the change in HAQ response³ for early and late stage rheumatoid arthritis associated with DMARD and biologic therapies.
2. The second case study provided a baseline estimate of the burden of COPD including prevalence, direct and indirect costs associated with this disease. Here, direct costs were stratified by key cost drivers for COPD such as ambulatory visits, emergency visits, hospitalizations and medication use. Scenarios that aim to reduce the number of exacerbations through medication use were evaluated across each of the direct cost components in the model as well as the indirect costs.

³ The HAQ is a self-reported functional status that incorporates a disability index and pain scale. HAQ progression changes for those not taking DMARDs and biologics were obtained from the literature and mapped to our economic model. The decrease in HAQ for those on DMARDs and biologics were adopted from clinical trials recommended by subject matter experts and rheumatologists

2 HIGH LEVEL RESULTS

2.1 SMOKING CESSATION MEDICATION: COPD AND LUNG CANCER

RiskAnalytica's Life at Risk platform was used to examine the incidence, prevalence and mortality of major lung diseases in Canada, including:

- Asthma,
- Chronic obstructive pulmonary disease (COPD), and,
- Lung cancer

The model took into account the various risk factors that are associated with the incidence of lung disease as well as mortality due to lung disease. Risk factors in the model include:

- Smoking prevalence, smoking duration and smoking intensity;
- Second-hand smoke (SHS) exposure; and
- Outdoor air quality.

The model structure and data sources were determined in conjunction with a panel of subject matter experts in Canada including epidemiologists, researchers and clinicians. The expert panel ensured the quality and accuracy of the data inputs including prevalence and mortality estimates, relative risk estimates, health care utilization patterns and estimates of work-place productivity for each lung disease type. All data components used to develop this model were provided, recommended or verified by the expert panel. Details on the model implantation and data sources can be found in Smetanin *et al.* (2011).

2.1.1 LUNG CANCER

Based on the base model simulation results, lung cancer incidence will continue to rise over time. Over the next 30 years the annual number of new cases of lung cancer is expected to increase to over 28,000 by 2042, from 25,000 in 2012. Figure 1 and Table 1 illustrate the estimated future incidence of lung cancer in Canada by age and sex.

Figure 1 Annual incidence of lung cancer by age group and sex from 2012 to 2042

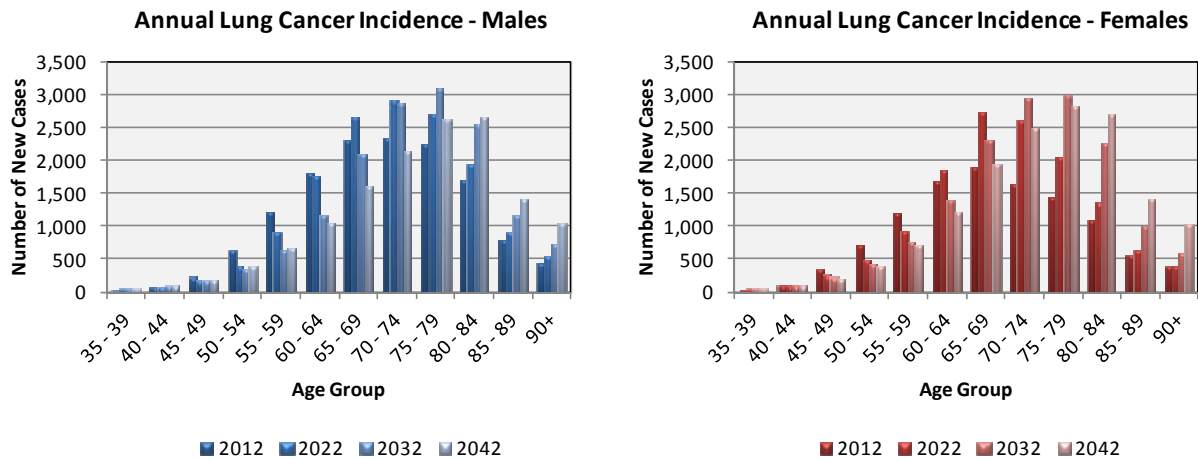


Table 1 Annual incidence counts and incidence rate by age group and sex for lung cancer from 2012 to 2042

		Annual Lung Cancer Incidence											
		Male				Female				Total			
		35 - 49	50 - 64	65 - 79	80+	35 - 49	50 - 64	65 - 79	80+	35 - 49	50 - 64	65 - 79	80+
2012	Number	357	3,617	6,901	2,896	476	3,562	4,925	2,016	832	7,179	11,826	4,912
	Per 100,000	9.7	102.7	389.7	554.3	13.0	98.6	249.0	241.4	11.3	100.7	315.4	361.8
2022	Number	289	3,032	8,252	3,338	393	3,231	7,346	2,370	682	6,263	15,598	5,708
	Per 100,000	7.7	81.1	316.8	472.6	10.7	1.0	256.6	235.1	9.2	1.9	285.3	333.0
2032	Number	319	2,133	8,034	4,449	369	2,517	8,228	3,849	688	4,650	16,262	8,299
	Per 100,000	8.3	58.4	250.6	393.2	9.8	68.4	238.1	255.4	9.0	63.4	244.1	314.5
2042	Number	336	2,069	6,336	5,097	367	2,302	7,212	5,122	703	4,371	13,548	10,219
	Per 100,000	8.9	54.2	191.6	317.6	9.9	60.5	206.3	249.3	9.4	57.4	199.2	279.3

Table 2 demonstrates the cumulative direct economic burden of lung cancer in Canada from 2012 to 2042, which amounts to over \$44 billion, in future value terms. The direct economic costs for lung cancer include adjuvant chemotherapy, chemotherapy, concurrent chemotherapy, and diagnosis specialist, end of life care, palliative chemotherapy, pre-diagnosis physicians, radiotherapy, support care only, surgery and surveillance. All costs were obtained from the Canadian Partnership against Cancer Risk Management Model Initiative for Costs and Utilization⁴

⁴ Lung cancer treatment probabilities, durations and costing information were taken from the Cancer Risk Management Model Initiative. The Cancer Risk Management Model Initiative has been made possible through a financial contribution from Health Canada, through the Canadian Partnership Against Cancer. The assumptions and calculations underlying the Life at Risk model were prepared by RiskAnalytica on behalf of the Ontario Lung Association and the responsibility for the use and interpretation of these data is entirely that of the author(s).

Table 2 Cumulative direct health costs indirect economic burden in the labour force from 2012 to 2042 due to lung cancer

Lung Cancer: Cumulative Economic Impact 2012 to 2042		
	Direct Costs	Indirect Burden
Future Value (millions)	\$44,044	\$127,865
Present Value (millions)	\$25,048	\$70,953

Discount Rate of 3% assumed for present value costs

The cumulative indirect economic burden of lung cancer in Canada, due to lost productivity in the labour force, amounts to \$127 billion in future value terms.

2.1.2 COPD

The increase in the number of people living with COPD is primarily driven by the continued higher smoking prevalence trends observed. Over the next 30 years it is expected that the number of people living with COPD will increase from over 2 million Canadians in 2012 to an estimated 3 and a half million Canadians in 2042. Figure 2 and Table 3 show the projected prevalence of COPD by sex and age-group. It is expected that by 2042, over 3 million Canadians will be living with COPD.

Figure 2 Number of people with COPD by age group and sex from 2012 to 2042

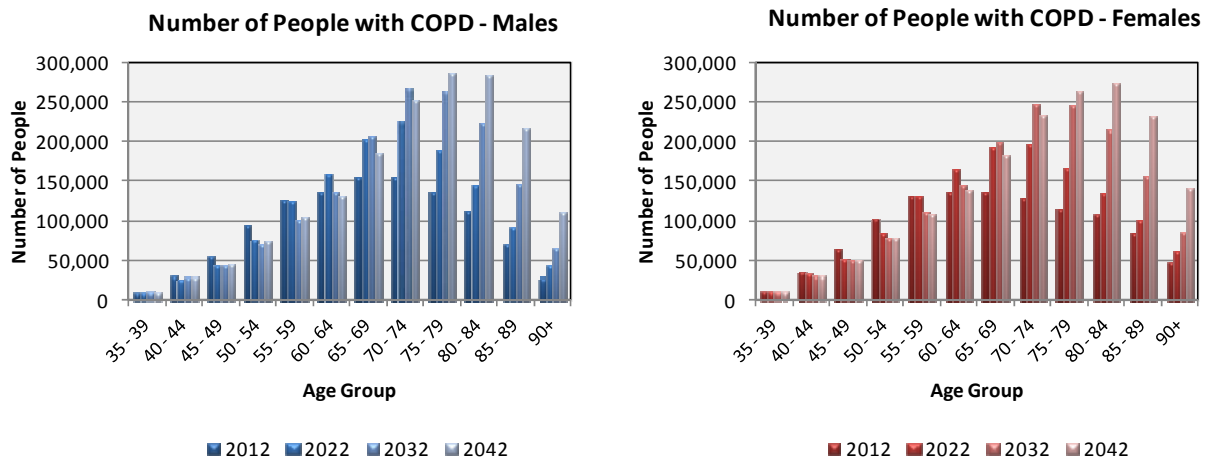


Table 3 Number of people, and percentage of the population, by age group and sex with asthma from 2012 to 2042

		COPD Prevalence											
		Male				Female				Total			
		35 - 49	50 - 64	65 - 79	80+	35 - 49	50 - 64	65 - 79	80+	35 - 49	50 - 64	65 - 79	80+
2012	Number	95,367	356,412	443,633	209,034	111,401	365,158	377,727	239,840	206,768	721,570	821,360	448,874
	Percent	2.6%	10.1%	25.1%	40.0%	3.0%	10.1%	19.1%	28.7%	2.8%	10.1%	21.9%	33.1%
2022	Number	78,468	356,462	616,583	277,459	94,479	375,847	557,781	296,978	172,947	732,309	1,174,364	574,438
	Percent	2.1%	9.5%	23.7%	39.3%	2.6%	0.1%	19.5%	29.5%	2.3%	0.2%	21.5%	33.5%
2032	Number	82,285	305,082	739,724	432,782	91,697	332,879	690,180	455,117	173,981	637,961	1,429,904	887,899
	Percent	2.1%	8.4%	23.1%	38.2%	2.4%	9.0%	20.0%	30.2%	2.3%	8.7%	21.5%	33.6%
2042	Number	83,782	308,940	722,545	611,365	88,723	323,923	677,897	644,517	172,505	632,863	1,400,441	1,255,882
	Percent	2.2%	8.1%	21.8%	38.1%	2.4%	8.5%	19.4%	31.4%	2.3%	8.3%	20.6%	34.3%

The cumulative direct economic burden of COPD in Canada from 2012 to 2042 amounts to over one trillion dollars (in future value terms). The direct economic costs included ambulatory care, emergency visits, health care professional visits, hospitalizations, patient travel, procedures and rehabilitation programs from Maleki-Yarzdi *et al.* (2010).

Table 4 Cumulative direct health costs and indirect economic burden in the labour force from 2012 to 2042 due to COPD

COPD: Cumulative Economic Impact 2012 to 2042		
	Direct Costs	Indirect Burden
Future Value (millions)	\$1,027,872	\$687,670
Present Value (millions)	\$571,195	\$375,309

Discount Rate of 3% assumed for present value costs

The cumulative indirect economic burden of COPD in Canada, due to lost productivity in the labour force, amounts to \$687 billion in future value terms.

2.1.3 ASTHMA

Based on the simulation results, the prevalence of asthma is expected to reach over 5.9 million people. The increase is a reflection of the aging population by 2042. Over the next 30 years, the number of people living with asthma is expected to increase from 4.4 million Canadians in 2012 to 5.9 million in 2042. Figure 3 and Table 5 show the current and projected prevalence structure by age-group and sex of the total population in Canada. A higher proportion of females are expected to be living with asthma compared to males, with an average ratio of approximately 1.20 throughout the simulation period. Note that there are no risk factors for the incidence of asthma included in the model. However, smoking and second hand smoke exposure increase the health care utilization of people with asthma.

Figure 3 Number of people with asthma by age group and sex from 2012 to 2042

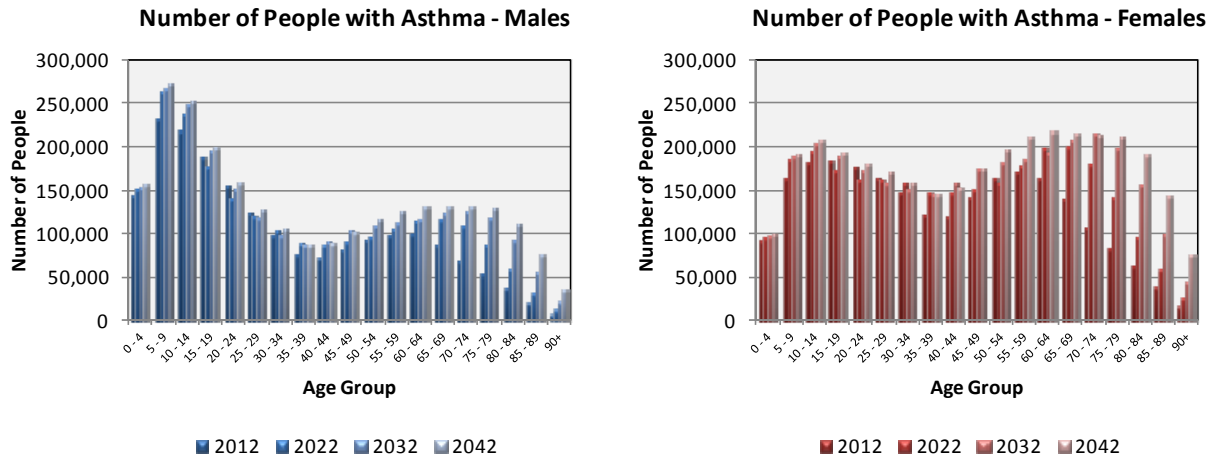


Table 5 Number of people, and percentage of the population, by age group and sex with asthma from 2012 to 2042

		Asthma Prevalence											
		Male				Female				Total			
		0-19	20-39	40-64	65+	0-19	20-39	40-64	65+	0-19	20-39	40-64	65+
2012	Number	779,232	449,986	439,447	269,966	621,804	609,152	758,205	445,994	1,401,036	1,059,137	1,197,653	715,960
	Percent	19.4%	9.5%	7.3%	11.8%	16.3%	13.2%	12.4%	15.9%	17.9%	11.3%	9.9%	14.0%
2022	Number	828,116	450,318	490,221	410,624	650,782	626,582	832,948	699,031	1,478,898	1,076,900	1,323,169	1,109,655
	Percent	19.7%	9.4%	7.9%	12.4%	16.3%	13.5%	13.4%	18.1%	18.1%	11.5%	10.7%	15.5%
2032	Number	862,964	450,977	531,542	533,210	681,575	623,453	894,045	923,322	1,544,539	1,074,430	1,425,587	1,456,532
	Percent	19.8%	9.5%	8.5%	12.3%	16.5%	13.6%	14.4%	18.6%	18.1%	11.5%	11.4%	15.7%
2042	Number	878,779	474,502	560,745	611,110	694,116	651,768	953,257	1,048,429	1,572,894	1,126,270	1,514,001	1,659,539
	Percent	19.7%	9.6%	8.8%	12.4%	16.4%	13.6%	15.1%	18.9%	18.1%	11.6%	12.0%	15.9%

The cumulative direct economic burden of asthma in Canada from 2012 to 2042 (shown in Table 6) amounts to over \$387 billion dollars, in future value terms. Note that the direct economic costs include:

- Hospitalizations, emergency visits, physician visits, pediatrician visits, respiratory specialist visits (Ungar et al. (2001) and Ungar et al. (1998) for costs; and the ICES InTool for utilization)
- Dispensing fees, prescription medications, peak flow meter, spacers and spirometry (Unger et al. (2001) and Ungar et al. (1998)) for utilization and costs

Table 6 Cumulative direct health costs indirect economic burden in the labour force from 2012 to 2042 due to asthma

Asthma: Cumulative Economic Impact 2012 to 2042		
	Direct Costs	Indirect Burden
Future Value (millions)	\$387,325	\$106,904
Present Value (millions)	\$218,910	\$59,866
Discount Rate of 3% assumed for present value costs		

The cumulative indirect economic burden of asthma in Canada, due to lost productivity in the labour force, amounts to over \$106 billion dollars in future terms.

2.1.4 IMPROVED SMOKING CESSATION

The comprehensive smoking cessation intervention aims to provide access to medications and behavioural counselling to all Canadians who want to quit smoking. The impact of this intervention was based on values from the US Clinical Practice Guidelines (Fiore *et al.* 2008) and expert panel recommendations.

- **Low effectiveness:** Cessation rate increase of 1.9;
- **Moderate effectiveness:** Cessation rate increase of 2.8; and
- **High effectiveness:** Cessation rate increase of 3.6.

Figure 4 shows that by 2042, based on the effectiveness of smoking cessation interventions,

- A high impact intervention resulted in a 7% decrease in the average smoking rates;
- A medium impact intervention resulted in 6.6% decrease in the average smoking rates; and
- A low impact intervention resulted in a 5 % decrease in the average smoking rates.

Figure 4 Average smoking rate (all ages, both male and female) with no intervention, and if cessation medication in conjunction with counseling had a low, moderate or high impact.

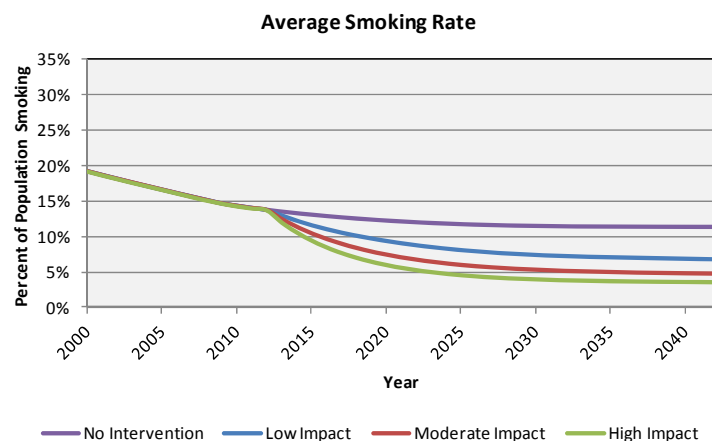


Figure 5 Reduction in the incidence of (left) and mortality due to (right) lung cancer under the various cessation effectiveness levels

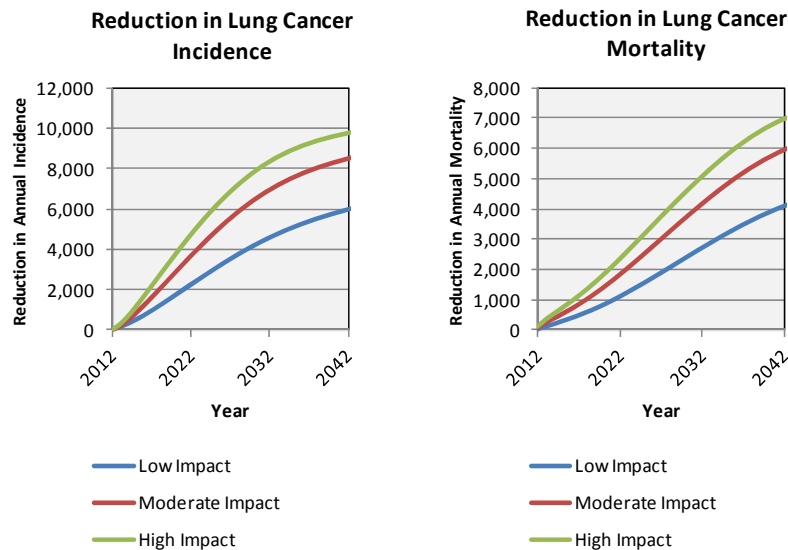


Figure 5 shows that by 2042, based on the level of the smoking cessation intervention, a reduction ranging from 5,500 to 10,000 in the annual incidence of lung cancer could be expected. Over the 30 year period, a total of between 113,000 to 207,000 would be avoided. Additionally, a reduction in annual mortalities ranging from 3,900 to 6,900 could be expected for a cumulative total of between 68,900 to 128,000 lung cancer mortalities prevented. Table 7 and Table 8 highlight the key cumulative effect of smoking cessation interventions on lung cancer and its costs.

Figure 6 shows that based on the impact level of the smoking cessation intervention, a reduction in annual incidence of COPD ranging from 11,000 to over 16,000 could be expected. Cumulatively, over the next 30 year, a total of between 290,000 and 510,000 new cases of COPD could be prevented resulting in between 117,000 and 201,000 fewer people living with the illness by 2042. Additionally, a reduction ranging from 5,300 to 8,800 in the annual mortalities (all cause) of COPD patients could be expected.

Figure 6 Reduction in the incidence of (left), mortality with (middle) and prevalence of COPD under the various cessation effectiveness levels

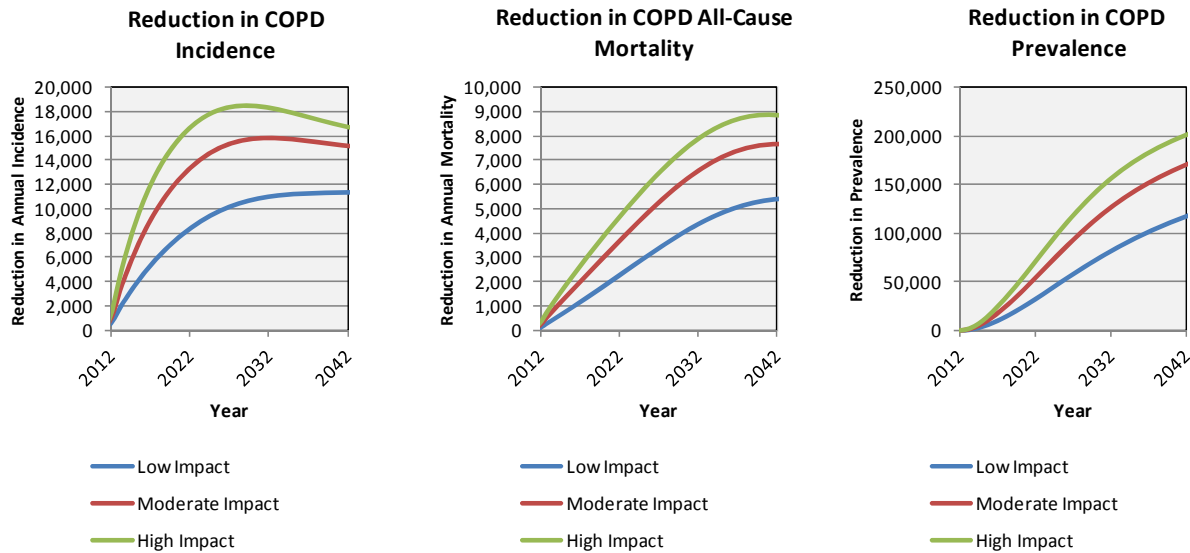


Table 7 Cumulative health and direct economic consequences of lung disease from 2012 to 2042

		Cumulative Impacts from 2012 to 2042			
		No Intervention	Low Impact	Moderate Impact	High Impact
Lung Cancer	Incidence	937,717	824,076	765,864	730,496
	Mortality	751,783	682,829	646,415	623,663
	Direct Costs (FV, millions)	\$44,044	\$37,584	\$34,446	\$32,625
	Direct Costs (PV, millions)	\$25,048	\$21,787	\$20,148	\$19,169
COPD	Incidence	6,480,642	6,190,675	6,051,238	5,970,623
	Mortality (All Cause)	4,159,853	4,051,996	3,996,720	3,962,892
	Prevalence by 2042	3,461,691	3,345,121	3,290,857	3,260,846
	Direct Costs (FV, millions)	\$1,027,872	\$995,582	\$979,318	\$969,605
	Direct Costs (PV, millions)	\$571,195	\$555,005	\$546,608	\$541,465
Asthma	Direct Costs (FV, millions)	\$387,325	\$381,621	\$378,791	\$377,124
	Direct Costs (PV, millions)	\$218,910	\$215,905	\$214,361	\$213,424

Discount Rate of 3% assumed for present value (PV) costs; Future values (FV) include inflation and real cost increases

Depending on the impact level of the smoking cessation intervention, the cumulative economic impact from 2012 to 2042 in future value terms of a smoking cessation intervention on the lung diseases is expected to yield a reduction between \$44 billion and \$80 billion as shown in Table 8. The present value of such an intervention is worth between \$22 billion and \$41 billion.

Table 8 Impact of smoking cessation medication on the cumulative health and direct economic consequences of lung disease from 2012 to 2042

		Cumulative Reduction From 2012 to 2042			
		No Intervention	Low Impact	Moderate Impact	High Impact
Lung Cancer	Incidence	-	113,641	171,853	207,221
	Mortality	-	68,953	105,367	128,120
	Direct Costs (FV, millions)	-	\$6,460	\$9,598	\$11,419
	Direct Costs (PV, millions)	-	\$3,261	\$4,899	\$5,878
COPD	Incidence	-	289,967	429,404	510,019
	Mortality (All Cause)	-	107,856	163,133	196,961
	Prevalence by 2042	-	116,570	170,834	200,846
	Direct Costs (FV, millions)	-	\$32,291	\$48,554	\$58,268
	Direct Costs (PV, millions)	-	\$16,190	\$24,587	\$29,730
Asthma	Direct Costs (FV, millions)	-	\$5,704	\$8,534	\$10,201
	Direct Costs (PV, millions)	-	\$3,005	\$4,549	\$5,486

Discount Rate of 3% assumed for present value (PV) costs; Future values (FV) include inflation and real cost increases

Table 9 Cumulative indirect economic benefits of increased smoking cessation

Cumulative Indirect Benefits of Smoking Cessation Intervention from 2012 to 2042			
	Low Impact	Moderate Impact	High Impact
Future Value (millions)	\$111,899	\$170,667	\$206,985
Present Value (millions)	\$53,227	\$81,792	\$99,764

Discount Rate of 3% assumed for present value costs

Depending on the impact level of the intervention, the cumulative indirect benefits, Table 9, of smoking cessation intervention range from \$112 billion to \$207 billion in future value terms.

2.2 IMPROVED PAIN MANAGEMENT: OSTEOARTHRITIS

RiskAnalytica's Life at Risk platform was used to examine the incidence, prevalence and mortality of osteoarthritis in Canada over the next 30 years, and assess the impact of arthritic care interventions on reducing this burden. For full details on the analysis and methodology used in this study refer to Smetanin *et al.* 2001.

2.2.1 OSTEOARTHRITIS

Figure 7 and Table 10 show the current and projected prevalence structure of the Canadian population, broken down by age and sex. Within the next 30 years, over 10.7 million people are expected to be living with osteoarthritis, with 59% of all cases occurring in females.

Figure 7 Number of people with osteoarthritis by age group and sex from 2012 to 2042

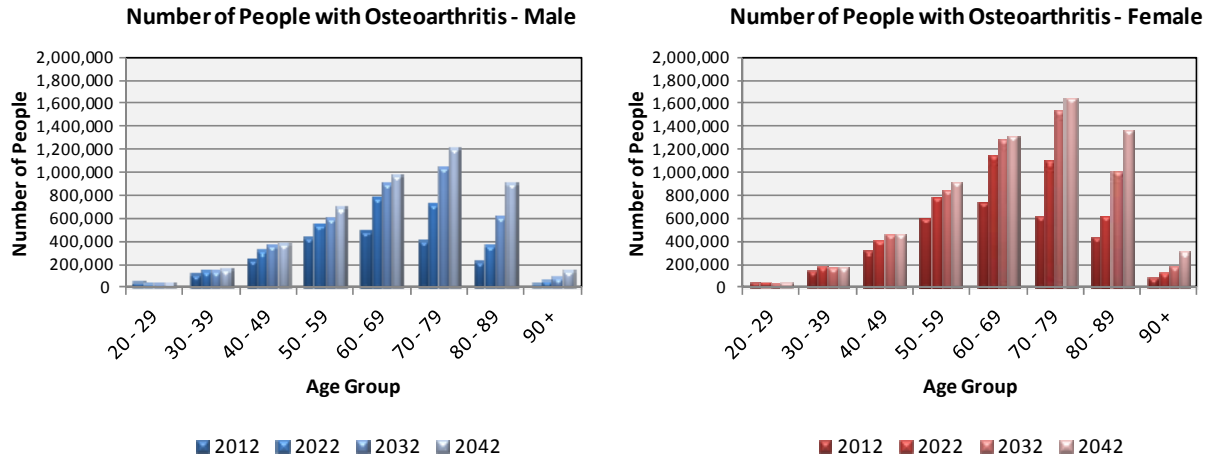


Table 10 Number of people and percentage of population with osteoarthritis by age group and sex from 2012 to 2042

		Prevalence of Osteoarthritis															
		Male								Female							
		20 - 29	30 - 39	40 - 49	50 - 59	60 - 69	70 - 79	80 - 89	90 +	20 - 29	30 - 39	40 - 49	50 - 59	60 - 69	70 - 79	80 - 89	90 +
2012	Number	37,382	117,084	251,085	430,050	489,312	396,629	230,218	29,349	44,806	138,541	314,269	609,202	732,782	612,522	430,557	86,990
	Percent	1.6%	4.9%	10.0%	17.1%	27.3%	40.4%	50.1%	56.2%	2.0%	6.0%	12.6%	23.8%	38.8%	53.8%	62.5%	65.7%
2022	Number	29,083	147,899	311,556	549,858	773,071	718,508	360,151	52,191	35,222	179,437	401,824	772,317	1,142,933	1,093,547	618,502	125,779
	Percent	1.3%	5.8%	12.7%	22.1%	33.1%	48.3%	59.9%	67.6%	1.6%	7.3%	16.6%	30.8%	46.7%	64.7%	75.2%	79.2%
2032	Number	29,827	145,835	365,301	611,105	906,925	1,056,423	623,664	85,489	34,649	172,508	458,652	831,601	1,278,611	1,530,829	1,008,654	184,859
	Percent	1.3%	6.0%	14.0%	25.0%	38.2%	53.9%	65.8%	74.0%	1.6%	7.2%	18.0%	34.0%	52.2%	70.0%	81.0%	85.9%
2042	Number	34,474	154,962	377,700	696,337	982,632	1,208,945	903,916	150,141	37,792	174,337	456,143	904,305	1,317,326	1,648,242	1,372,781	302,116
	Percent	1.4%	6.2%	14.8%	27.0%	41.3%	58.7%	70.7%	78.4%	1.6%	7.2%	18.3%	35.4%	54.4%	73.5%	84.2%	89.0%

		Prevalence of Osteoarthritis								
		Total								
		20 - 29	30 - 39	40 - 49	50 - 59	60 - 69	70 - 79	80 - 89	90 +	20+
2012	Number	82,188	255,624	565,354	1,039,253	1,222,094	1,009,150	660,775	116,340	4,950,779
	Percent	1.8%	5.4%	11.3%	20.5%	33.2%	47.6%	57.5%	63.0%	18.6%
2022	Number	64,304	327,336	713,380	1,322,175	1,916,004	1,812,054	978,653	177,971	7,311,876
	Percent	1.5%	6.5%	14.6%	26.5%	40.1%	57.0%	68.7%	75.4%	25.3%
2032	Number	64,476	318,343	823,952	1,442,707	2,185,536	2,587,252	1,632,317	270,348	9,324,931
	Percent	1.4%	6.6%	16.0%	29.5%	45.3%	62.4%	74.5%	81.7%	30.2%
2042	Number	72,266	329,299	833,843	1,600,642	2,299,958	2,857,187	2,276,696	452,257	10,722,149
	Percent	1.5%	6.7%	16.5%	31.2%	47.9%	66.4%	78.3%	85.2%	33.1%

The cumulative direct economic burden of osteoarthritis in Canada from 2012 to 2042 (shown in Table 11) amounts to over \$1.2 trillion, in future value terms. Note that the direct economic costs include: drugs, health professionals, separately ordered tests, hospitalizations, primary surgery, and surgery revisions. Estimates of the health costs were obtained from Maetzel *et al.* (2004)

Table 11 Cumulative economic burden of osteoarthritis from 2012 to 2042

	Cumulative Economic Burden of Osteoarthritis from 2012 to 2042	
	Direct Costs	Indirect Burden
Future Value (millions)	\$1,226,633	\$2,746,903
Present Value (millions)	\$563,929	\$1,613,081

The cumulative indirect economic burden of osteoarthritis in Canada over the next 30 years, due to lost productivity in the labour force, amounts to over \$2 trillion in future terms.

2.2.2 IMPROVED PAIN MANAGEMENT

The improved pain management intervention aims to reduce direct health costs and disability associated with osteoarthritis through medication. Three impact levels were tested against the base model to evaluate their potential benefit. The impact levels are based on hypothetical scenarios that were determined through consensus from an expert panel consisting of leading epidemiologists and researchers. For more information on the development of the hypothetical scenarios, refer to Smetanin *et al.* (2010).

Figure 8 Annual direct cost savings (left) and indirect economic benefits (right) of improved pain management for osteoarthritis

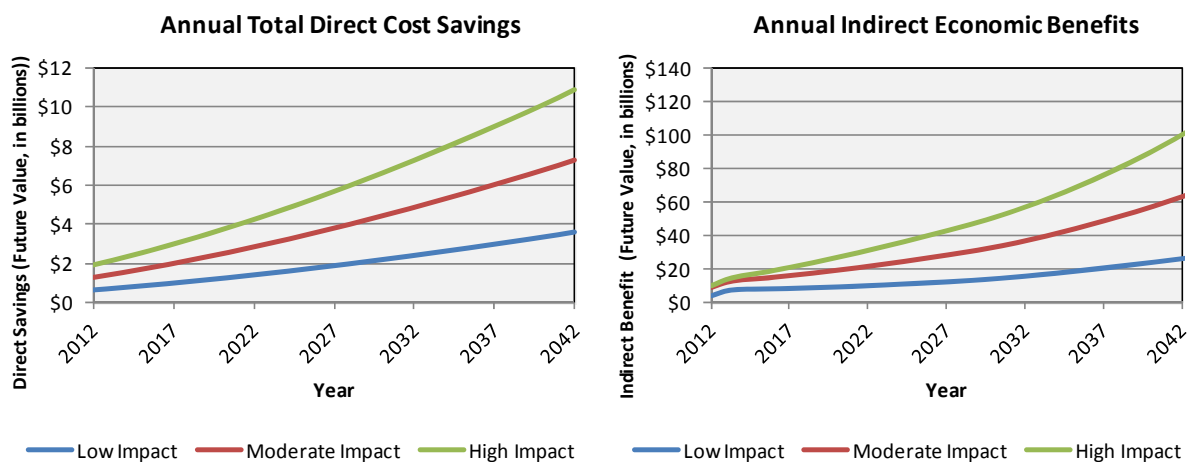


Table 12 Cumulative economic direct cost savings, and indirect economic benefits from 2012 to 2042 through improved pain management of osteoarthritis

	Cumulative Economic Benefits from 2012 to 2042					
	Low Impact		Moderate Impact		High Impact	
	Direct Savings	Indirect Benefit	Direct Savings	Indirect Benefit	Direct Savings	Indirect Benefit
Future Value (millions)	\$61,283	\$426,983	\$122,565	\$977,848	\$183,848	\$1,582,090
Present Value (millions)	\$451,756	\$254,430	\$903,512	\$570,938	\$1,355,268	\$848,658

Discount rate of 3% assumed for present values

As shown in Table 12 relative to the base model, the impacts of pain management interventions are expected to result in:

- A cumulative savings (in future value terms) ranging from \$61 billion to \$184 billion of direct health costs, based on the level of impact; and
- A cumulative indirect economic benefit (in future value terms) ranging from \$425 billion to \$1.6 trillion based on the impact level.

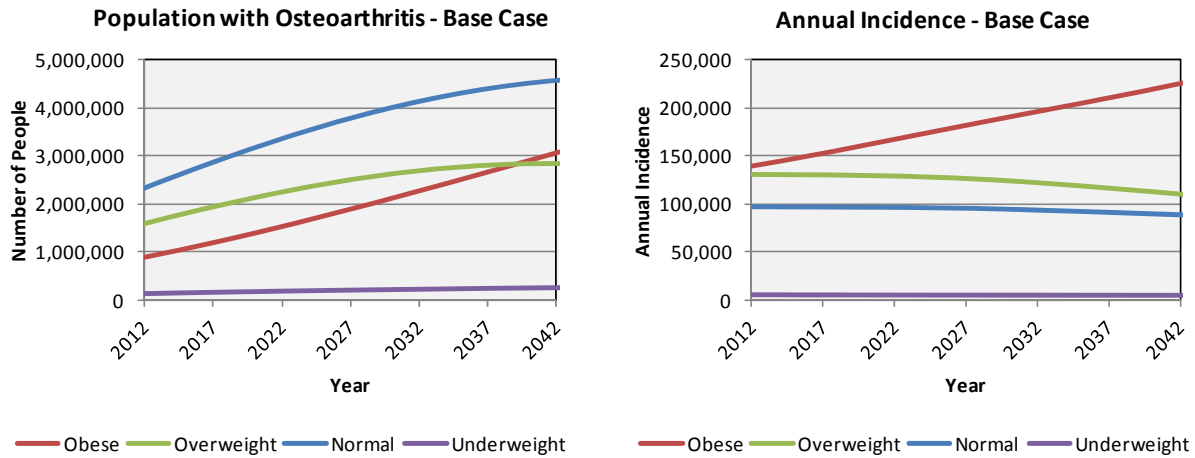
2.3 WEIGHT LOSS MEDICATION: OSTEOARTHRITIS

The osteoarthritis model used in the weight loss medication analysis is the same as that used for the pain management scenario. Refer Section 2.2 for model details.

2.3.1 OSTEOARTHRITIS AND BODY MASS INDEX

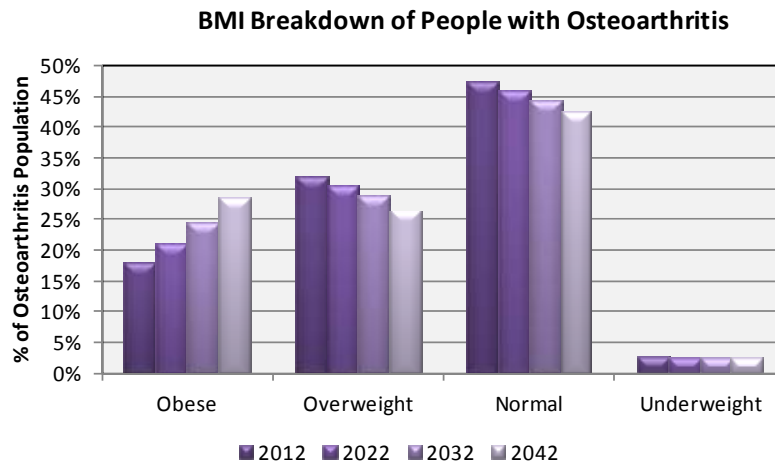
Figure 9 shows the current and projected prevalence and incidence for osteoarthritis in Canada over the next 30 years by body mass index (BMI) category. As the population with high BMI increases, the number of new cases of osteoarthritis in individuals with a high BMI increases as well. The excess risk of osteoarthritis incidence for those with high BMI provides an additional motivation to maintain healthy weights in the population.

Figure 9 The population with (left), and annual incidence of (right), osteoarthritis by BMI



Among the osteoarthritis population, the percentage of people who are obese is expected to increase from 18% in 2012 to over 28% in 2042, as shown in Figure 10.

Figure 10 Distribution of body mass index for people with osteoarthritis from 2012 to 2042



2.3.2 WEIGHT LOSS MEDICATION

Over the next ten years, weight loss medication is assumed to help reduce the obese (BMI > 30) population relative to what it would be without the intervention. This is a hypothetical intervention indicating the potential benefits that could be realized.

- **Low Impact Scenario:** By 2022, there would be 10% fewer obese people relative to the base
- **Moderate Impact Scenario:** By 2022, there would be 25% fewer obese people relative to the base
- **High Impact Scenario:** By 2022, there would be 50% fewer obese people relative to the base

Figure 11 and Table 13 show that, relative to the base model, the impacts of a 10%, 25% or 50% reduction in BMI levels over the next 10 years are expected to yield the following results:

- Between 212,000 and 1,100,000 new cases of osteoarthritis would be averted.
- Between 160,000 and 870,000 fewer Canadians would suffer from osteoarthritis

Figure 11 Reduction in prevalence (left) and annual incidence (right) if the obese population is reduced by 10%, 25% and 50% over the next 10 years.

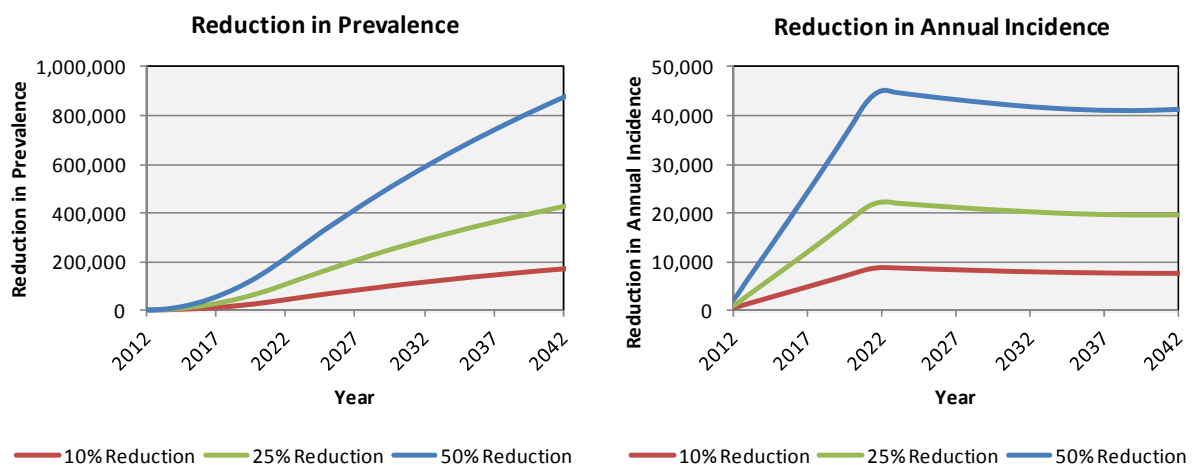


Table 13 The health impact of reducing the obese population by 10%, 25%, and 50% over the next 10 years

Cumulative impact of BMI reduction from 2012 to 2042		
	Cumulative Cases Prevented	Reduction in Prevalence
10% Reduction	212,994	168,187
25% Reduction	540,210	426,048
50% Reduction	1,107,063	871,313

As shown in Table 14, the cumulative economic benefits of reducing the obese population by 10%, 25% or 50% result in a direct savings ranging from \$24 billion to \$123 billion in future value terms. The cumulative indirect economic benefits from 2012 to 2042 of reducing the obese population due to a reduction in lost workplace productivity will range from \$88 billion to \$480 billion in future value terms.

Table 14 The cumulative economic benefits from 2012 to 2042 of reducing the obese population by 10%, 25%, and 50% by 2022

	Cumulative Economic Benefits from 2012 to 2042					
	10% Reduction		25% Reduction		50% Reduction	
	Direct Savings	Indirect Benefit	Direct Savings	Indirect Benefit	Direct Savings	Indirect Benefit
Future Value (millions)	\$24,090	\$88,906	\$60,787	\$222,149	\$123,498	\$489,883
Present Value (millions)	\$9,384	\$45,477	\$23,660	\$113,629	\$48,009	\$225,862

Discount rate of 3% assumed for present values

2.4 IMPROVED MENTAL ILLNESS REMISSION

The Mental Illness Model examines the incidence, prevalence and remission of major mental illnesses in Canada. The mental illnesses modelled include:

- Mood disorders,
- Anxiety disorders,
- Schizophrenia,
- Substance use disorders,
- Cognitive impairment including dementia,
- Attention deficit hyperactivity disorder (for those less than 20 years old)
- Conduct disorders (for those less than 20 years old), and
- Oppositional defiant disorder (for those less than 20 years old)

In addition, heart disease and type II diabetes were included in the model as there are two way risk factors between those chronic conditions and several mental illnesses. The model structure and data sources were determined in conjunction with over 30 subject matter experts both from Canada and internationally. Canadian data were used whenever possible. The details of the model implementation and data sources can be found in Smetanin *et al.* (2011b) and Smetanin *et al.* (2012). All mental illnesses and chronic diseases are modelled simultaneously in the platform which allows for correct comorbidities between conditions. The results presented in the following sections consider the aggregate of all mental illnesses.

2.4.1 MENTAL ILLNESS IN CANADA

Over the next 30 years, the total number of people living with mental illness is expected to grow significantly. This is primarily driven by population growth. However, as shown in Figure 12 and Table 15 the greatest increase will be in older age groups as the population ages. Over the next 30 years,

- The number of people living with mental illnesses will increase from 6.8 million to 8.9 million.
- The crude prevalence in the total population will increase from 21.9% to 22.7% primarily due to the increase in the older populations with dementia.

Figure 12 Number of people in Canada with a mental illness (12-month prevalence) by age and sex from 2012 to 2042

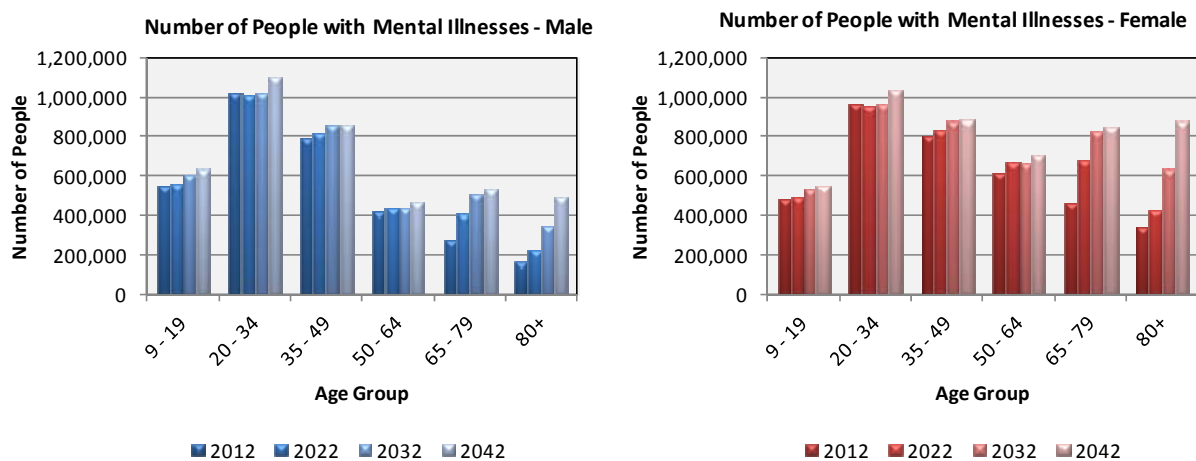


Table 15 Number and percent of people in Canada with a mental illness (12-month prevalence) by age and sex from 2012 to 2042

		Prevalence of Mental Illness from 2012 to 2042													
		Male							Female						
		9 - 19	20 - 34	35 - 49	50 - 64	65 - 79	80+	Total	9 - 19	20 - 34	35 - 49	50 - 64	65 - 79	80+	Total
2012	Number	545,783	1,020,857	789,150	414,366	273,328	158,905	3,202,389	479,108	958,739	800,508	618,581	459,342	336,343	3,652,621
	Percent	24.2%	28.5%	21.2%	11.8%	15.5%	29.3%	20.8%	22.3%	27.5%	21.7%	17.1%	23.3%	38.0%	23.1%
2022	Number	554,264	1,008,760	820,336	434,682	403,082	221,677	3,442,802	486,174	950,868	836,033	663,144	671,100	426,487	4,033,806
	Percent	23.5%	28.6%	21.3%	11.5%	15.6%	29.7%	20.4%	21.7%	27.5%	21.9%	17.3%	23.5%	38.5%	23.3%
2032	Number	606,443	1,018,122	854,898	434,663	505,653	346,524	3,766,302	530,509	961,024	877,878	661,235	826,557	632,303	4,489,507
	Percent	23.6%	28.6%	21.2%	11.5%	16.0%	29.8%	20.6%	21.8%	27.5%	21.9%	17.4%	24.0%	38.6%	23.9%
2042	Number	629,201	1,101,713	854,547	461,864	531,912	491,756	4,070,994	550,505	1,037,486	881,242	702,314	852,221	876,493	4,900,262
	Percent	23.6%	28.6%	21.2%	11.5%	16.1%	30.0%	20.9%	21.8%	27.5%	21.9%	17.5%	24.3%	38.8%	24.4%

The cumulative direct economic burden of mental illnesses in Canada from 2012 to 2042, shown in Table 16, amounts to over \$4.3 trillion in future value terms, or an average annual cost of \$145 billion dollars. Note that the direct economic costs included in-patient and physician costs, community and social costs,

pharmaceuticals, and income support. Other costs, such as those to the justice system for example, were not included due to a lack of reliable data.

Table 16 Cumulative economic burden of mental illness from 2012 to 2042

Cumulative Economic Burden of Mental Illness from 2012 to 2042		
	Cumulative Direct Costs	Cumulative Indirect Burden
Future Value (millions)	\$4,339,408	\$278,441
Present Value (millions)	\$2,486,176	\$159,678

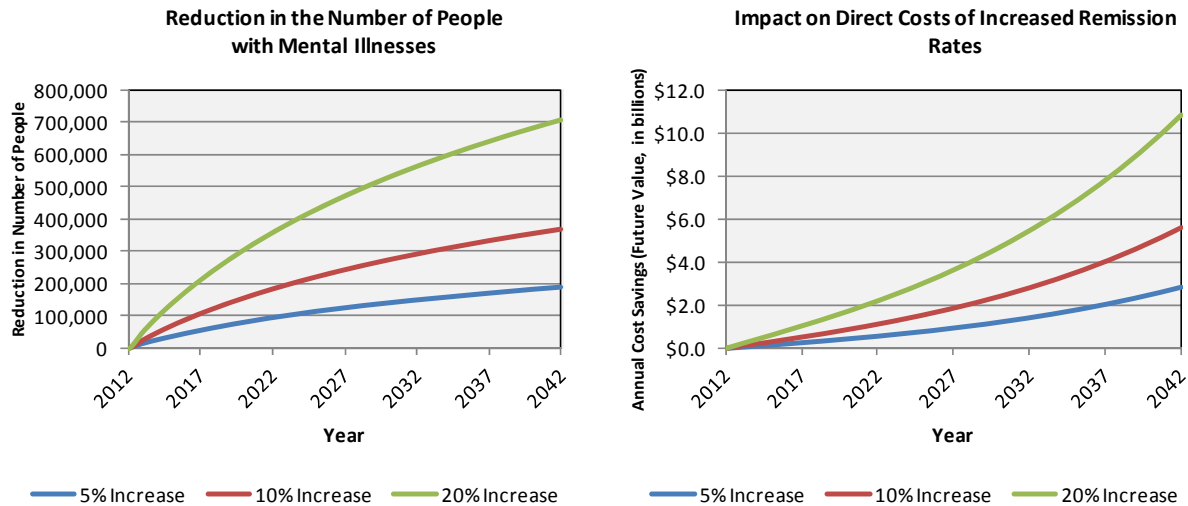
Present value assumes a 3% discount rate

The cumulative indirect economic burden of mental illnesses in Canada, due to lost productivity in the labour force, amounts to \$278 billion in future value terms. Note that the indirect burden due to informal caregiving is not included in this estimate.

2.4.2 MANAGEMENT AND REMISSION WITH MEDICATION

Proper management of symptoms or remission of the mental illness through medication can significantly reduce the health and economic burden of mental illnesses in Canada. As shown in Figure 13, if the symptom remission rate were increased by 5% over the next 30 years, by 2042, there would be almost 200,000 fewer people living with the consequences of mental illness. If the remission rates were to be increased by 20%, over 700,000 fewer people would be living with the symptoms of mental illness by 2042.

Figure 13 Reduction in the number of people with mental illness (12-month prevalence) (left) and the associated direct cost savings (right)



The reduction in prevalence results in a reduction in both the direct costs of mental illness (Figure 13, right) and indirect economic benefits through improved productivity and employability in the labour force. The cumulative direct savings, Table 17, over the next 30 years range from \$34 billion for the 5% increase in reduction rate to over \$132 billion in the 20% reduction case. The cumulative indirect benefits would amount to over \$9 billion in the 5% increase case to over \$34 billion if remission rates could be increased by 20%.

Table 17 Summary of the cumulative direct and indirect economic benefits by 2042 of increasing remission rates

Cumulative Economic Impact of Increasing Remission Rates form 2012 to 2042						
	5% Increase		10% Increase		20% Increase	
	Direct Savings	Indirect Benefits	Direct Savings	Indirect Benefits	Direct Savings	Indirect Benefits
Future Value (millions)	\$34,803	\$9,326	\$68,420	\$18,083	\$132,325	\$34,734
Present Value (millions)	\$18,805	\$4,526	\$36,996	\$8,786	\$71,649	\$16,898

Present value assumes a 3% discount rate

Note that since dementia has no remission rate, it is not affected in this scenario. A separate analysis of dementia, with a different intervention, follows in the next section.

2.5 DELAY ONSET OF DEMENTIA

As the population ages, illnesses such as dementia including vascular dementia and Alzheimer's disease, which primarily affect the older population will become more significant. Based upon data from the Canadian Study of Health and Aging, the Dementia Model estimates the incidence and prevalence of all dementias, vascular dementia, and Alzheimer's disease in Canada over a 30 year period. The complete details of the methodology and data sources can be found in Smetanin *et al.* (2009).

2.5.1 DEMENTIA

As the population ages, the number of people living with dementia will increase much faster than the general population. Figure 14 shows how the number of people with dementia is expected to increase over the next 30 years, particularly among older females. In total, the number of males with dementia is expected to increase from 161,000 in 2012 to 431,000 in 2042. For females, it is expected to increase from 276,000 to 650,000 over the same period.

Figure 14 Number of people in Canada with any form of dementia by age group and sex from 2012 to 2042

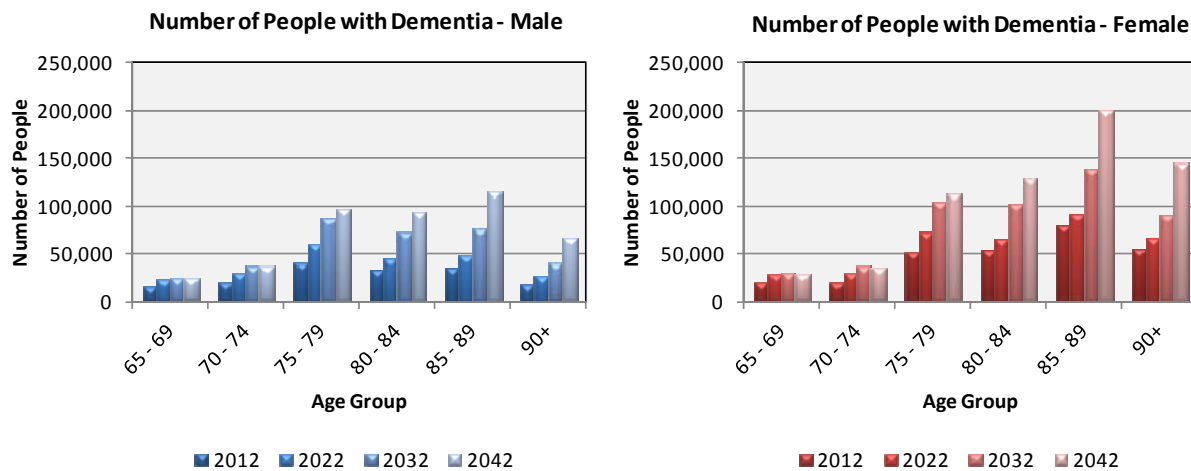


Table 18 Number and percentage of people in Canada with any form of dementia by age group and sex from 2012 to 2042

		Prevalence of All Dementias - Male						Prevalence of All Dementias - Female					
		65 - 69	70 - 74	75 - 79	80 - 84	85 - 89	90+	65 - 69	70 - 74	75 - 79	80 - 84	85 - 89	90+
2012	Number	15,779	18,855	39,749	33,970	35,746	17,506	19,579	18,991	50,589	53,243	78,960	54,705
	Percent	2.0%	3.3%	9.5%	11.5%	21.7%	33.5%	2.3%	3.0%	10.0%	13.1%	28.0%	41.3%
2022	Number	22,441	29,515	58,998	44,798	47,459	26,333	27,894	29,342	72,611	65,747	90,934	66,260
	Percent	2.0%	3.4%	9.5%	11.5%	21.9%	34.0%	2.4%	3.0%	9.9%	13.1%	28.1%	41.6%
2032	Number	24,827	37,322	85,329	71,442	76,082	39,703	30,255	36,304	103,288	101,761	138,067	90,072
	Percent	2.1%	3.4%	9.6%	11.6%	21.9%	34.0%	2.4%	3.0%	10.0%	13.1%	28.1%	41.5%
2042	Number	23,933	37,195	96,401	92,750	113,977	67,263	28,632	35,295	113,378	128,068	200,537	144,912
	Percent	2.1%	3.4%	9.7%	11.7%	22.2%	34.4%	2.4%	3.0%	10.1%	13.2%	28.4%	41.8%

The majority of dementias are Alzheimer's disease. As shown in Figure 15 and Table 19 over two thirds of all cases of dementia are Alzheimer's disease. In women, this percentage exceeds 75%.

Figure 15 Total number of people in Canada with vascular dementia, Alzheimer's disease, or any dementia from 2012 to 2042

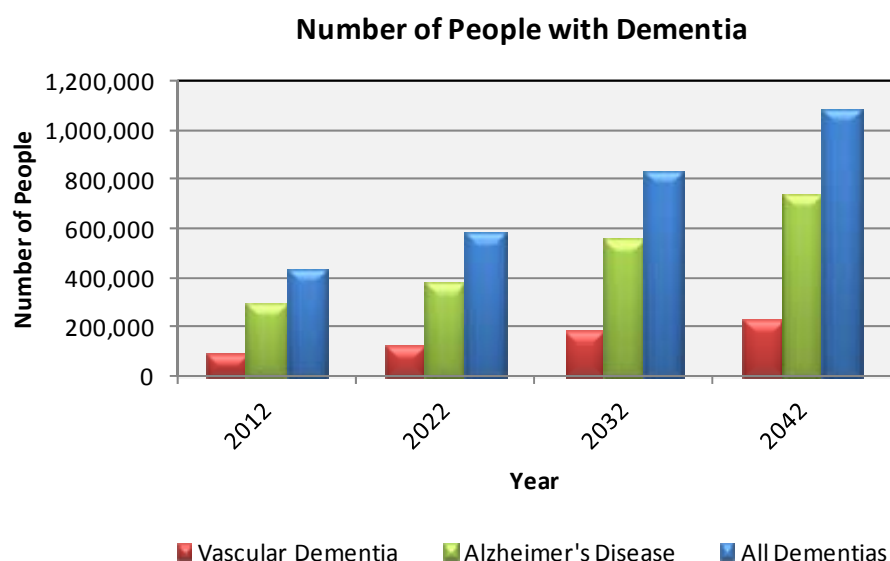


Table 19 Number and percentage of the population aged 65+ with vascular dementia, Alzheimer's disease, or any dementia from 2012 to 2042

		Male			Female			Total		
		All Dementias	Vascular Dementia	Alzheimer's Disease	All Dementias	Vascular Dementia	Alzheimer's Disease	All Dementias	Vascular Dementia	Alzheimer's Disease
2012	Number (65+)	161,605	47,664	87,156	276,066	46,377	206,144	437,672	94,041	293,300
	Percent of 65+	7.1%	2.1%	3.8%	9.9%	1.7%	7.4%	8.6%	1.8%	5.8%
2022	Number (65+)	229,545	67,941	121,824	352,786	59,885	259,049	582,331	127,825	380,872
	Percent of 65+	7.0%	2.1%	3.7%	9.1%	1.5%	6.7%	8.1%	1.8%	5.3%
2032	Number (65+)	334,706	97,294	184,574	499,747	85,300	371,978	834,453	182,594	556,552
	Percent of 65+	7.8%	2.3%	4.3%	10.0%	1.7%	7.5%	9.0%	2.0%	6.0%
2042	Number (65+)	431,519	119,891	250,759	650,821	108,503	495,454	1,082,340	228,394	746,213
	Percent of 65+	9.1%	2.5%	5.3%	11.8%	2.0%	9.0%	10.6%	2.2%	7.3%

Informal caregiving, the unpaid care of patients by family or friends, carries a significant burden due to dementia. The lost opportunity wages for caregivers due to the inability to work due to caregiving activities would exceed \$6 billion annually by 2042 in future value terms.

Table 20 Annual informal caregiving impact and formal care requirements by 2042

	Lost Caregiver Wages (future value, in millions)	Number in Long Term Care	Number in Community Care
No Intervention	\$6,333	547,020	479,464

The cumulative direct costs of dementia from 2012 to 2042, Table 21, amount to over \$1.2 trillion. This includes direct care costs and the lost caregiver wages. The indirect productivity impact due to lost productivity in the labour force as a result of disease and caregiver absenteeism amounts to over \$89 billion over the same period.

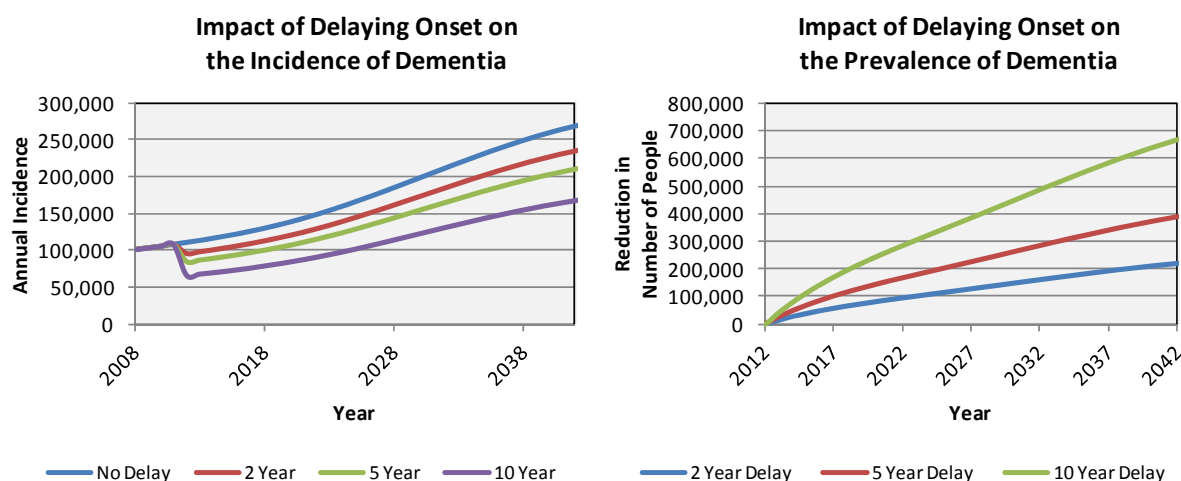
Table 21 Cumulative economic burden of dementia from 2012 to 2042

Cumulative Economic Burden from 2012 to 2042		
	Direct Costs	Indirect Burden
Future Value (millions)	\$1,296,046	\$89,088
Present Value (millions)	\$725,974	\$51,708

2.5.2 DELAY OF ONSET THROUGH MEDICATION

There is currently little known about how to delay the onset of dementia. However, if medication existed to do so, significant health and economic benefits would result. Figure 16 highlights the change in annual incidence (left) and the resulting decrease in prevalence (right) if dementia could be delayed by 2 years, 5 years, or 10 years.

Figure 16 The impact on incidence (left) and prevalence (right) of delaying the onset of dementia by 2 years, 5 years, or 10 years



If dementia were delayed by 10 years, a total of 2.3 million cases would be avoided and over 660,000 fewer people would be living with the illness by 2042. Almost \$4 billion in opportunity wages would be available to those who would be informal caregivers otherwise, and there would be 335,000 fewer people in long term care and 294,000 fewer people in community care.

Table 22 Impact of delaying the onset of dementia by 2042. Wages are in future value terms.

Impact of Delaying Onset of Dementia by 2042					
	Cumulative Cases Prevented	Reduction in Prevalence	Reduction in Lost Caregiver Wages (millions)	Reduction in Number in Long Term Care	Reduction in Number in Community Care
2 Year Delay	773,612	219,281	\$1,222	110,100	96,706
5 Year Delay	1,364,686	385,714	\$2,178	193,771	170,091
10 Year Delay	2,371,029	666,946	\$3,828	335,357	294,065

In future value terms, the cumulative total direct savings would range from \$237 billion if dementia onset were delayed by 2 years to over \$720 billion for a 10 year delay. The cumulative indirect economic benefits due to increased labour force productivity and participation would result in a cumulative benefit of \$15 billion for a 2 year delay up to \$47 billion if dementia onset were delayed 10 years.

Table 23 Cumulative economic benefits of delaying dementia from 2012 to 2042

Cumulative Economic Benefits of Delaying Dementia from 2012 to 2042						
	2 Year Delay		5 Year Delay		10 Year Delay	
	Direct Savings	Indirect Benefit	Direct Savings	Indirect Benefit	Direct Savings	Indirect Benefit
Future Value (millions)	\$237,285	\$15,317	\$417,081	\$27,491	\$720,299	\$47,672
Present Value (millions)	\$127,344	\$7,772	\$223,784	\$13,840	\$386,331	\$23,741

2.6 TYPE 1 DIABETES

While the prevalence of Type 1 diabetes in Canada is relatively small compared to other chronic diseases, the disability that patients face can be large. In particular, a key challenge associated with Type 1 diabetes is the impact of secondary complications that can result in significant disability. Based on international studies, the Type 1 Diabetes Model estimates the prevalence and economic consequences of Type 1 diabetes in Canada. The full details of the study and data sources can be found in Smetanin and Kobak (2008).

2.6.1 BURDEN OF TYPE 1 DIABETES

Over the next 30 years, the number of people living with Type 1 diabetes is expected to increase both due to population growth, and a changing age distribution of prevalence. As shown in Figure 17 and Table 24, the increase in prevalence is expected to be most significant for people between 20 and 49.

Figure 17 The number of people with Type 1 diabetes by age and sex from 2012 to 2042

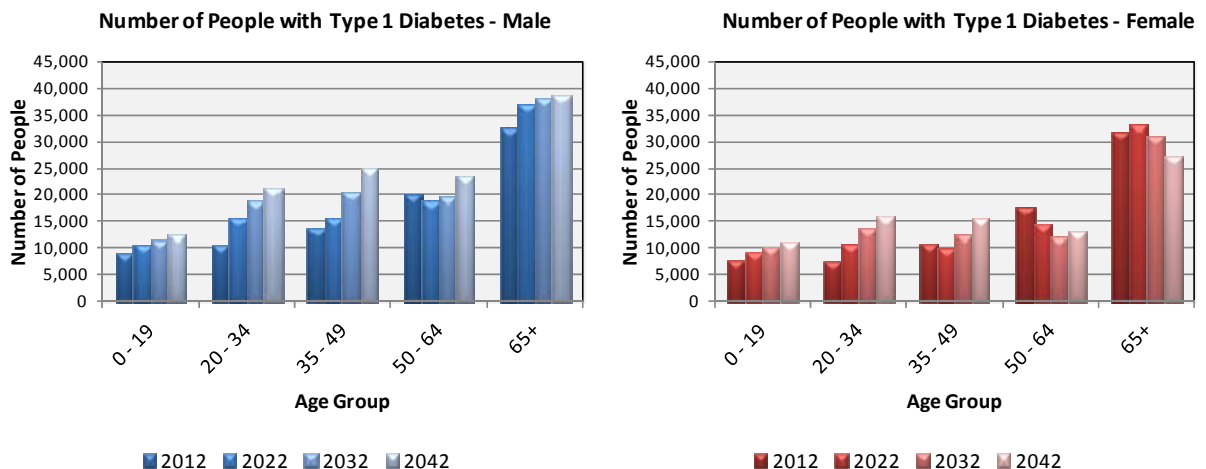


Table 24 Number and percentage of the population with Type 1 diabetes by age and sex from 2012 to 2042

		Number of People with Type 1 Diabetes by Age and Sex									
		Male					Female				
		0 - 19	20 - 34	35 - 49	50 - 64	65+	0 - 19	20 - 34	35 - 49	50 - 64	65+
2012	Number	8,954	10,526	13,565	20,076	32,567	7,645	7,304	10,832	17,768	32,049
	Percent	0.23%	0.31%	0.37%	0.58%	1.39%	0.21%	0.22%	0.30%	0.50%	1.16%
2022	Number	10,668	15,566	15,688	18,749	36,994	9,346	11,001	10,023	14,239	33,330
	Percent	0.28%	0.45%	0.42%	0.50%	1.11%	0.26%	0.33%	0.27%	0.37%	0.92%
2032	Number	11,645	18,899	20,418	19,631	38,162	10,284	13,818	12,490	12,242	31,000
	Percent	0.31%	0.54%	0.53%	0.50%	0.90%	0.28%	0.41%	0.33%	0.31%	0.70%
2042	Number	12,534	21,230	25,057	23,392	38,735	11,119	15,764	15,698	13,146	27,143
	Percent	0.33%	0.59%	0.62%	0.57%	0.80%	0.30%	0.45%	0.39%	0.32%	0.56%

Over the next 30 years, Type 1 diabetes is expected to cost a cumulative total of over \$52 billion in direct health care costs. However, as shown in Table 25, the indirect economic burden arising from disability in the labour force is even greater at \$68 billion. Interventions that can reduce the economic disability could yield significant benefits.

Table 25 Cumulative direct and indirect economic burden of Type 1 Diabetes from 2012 to 2042

Cumulative Economic Burden of Type 1 Diabetes from 2012 to 2042		
	Direct Costs	Indirect Burden
Future Value (millions)	\$52,365	\$68,591
Present Value (millions)	\$31,820	\$39,991

Present value assumes a 3% discount rate

2.6.2 IMPACT OF REDUCING SECONDARY DISABILITY

If medication were able to successfully improve the management of blood sugar levels, significant disabilities that arise from complications such as eye or nerve diseases could be reduced or avoided. Based on the results from the US Diabetes Control and Complications Trial, three scenarios were constructed that looked at the impact of reducing such complications. The scenarios were:

- **Low Reduction:** The risk of eye, kidney and nerve diseases were reduced by 64%, 25%, and 40% respectively;
- **Moderate Reduction:** The risk of eye, kidney and nerve diseases were reduced by 76%, 50%, and 60% respectively;
- **High Reduction:** The risk of eye, kidney and nerve diseases were reduced by 88%, 75%, and 80% respectively

Over the next 30 years, as shown in Table 26, such interventions could result in between \$6 billion and \$16 billion of indirect economic benefits due to increased productivity in the labour force.

Table 26 Cumulative indirect economic benefits of reducing disability arising from secondary complications from 2012 to 2042

Cumulative Indirect Economic Benefits of Reduced Disability from 2012 to 2042			
	Low Reduction	Moderate Reduction	High Reduction
Future Value (millions)	\$6,382	\$11,801	\$16,463
Present Value (millions)	\$3,582	\$6,631	\$9,260

2.7 VACCINATION AND ANTIVIRALS FOR PANDEMIC INFLUENZA

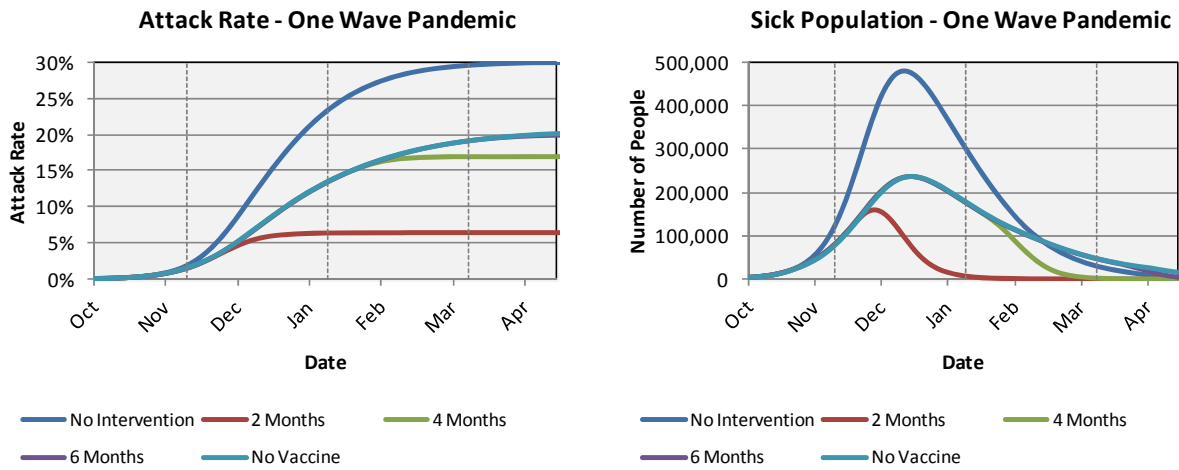
Infectious diseases, such as influenza, pose a significant health risk in the case of a widespread outbreak or pandemic. The Infectious Disease Model simulates the spread of pandemic influenza across Canada accounting for the geographic spread of the population, age-dependent contact rates between individuals and the effect of antivirals and vaccination. In addition, the infection rate can be modulated seasonally to create multi-wave pandemics to reproduce historically observed features. The complete details of the model can be found in Smetanin *et al.* (2010b).

Vaccines are the most effective way to prevent the spread of an infectious disease. However, when a novel virus is identified, appropriate vaccines are not widely available immediately. The following two sections examine the impact of timing of vaccine availability on a single wave pandemic (Section 2.7.1) and a two wave pandemic (Section 2.7.2).

2.7.1 SINGLE WAVE PANDEMIC

A moderate pandemic in which 30% of the population becomes infected by the end of the single wave outbreak when no interventions are applied is used as the base case for the single wave analysis. At the peak of the pandemic, over 450,000 people in Canada would be sick at the same time. Figure 18 shows the cumulative attack rate (left) and number of people sick (right) with no intervention, and 3 different vaccine start times combined with antiviral used, and 1 scenario with antiviral use only. The scenarios are labelled by the delay between virus identification and widespread vaccine availability.

Figure 18 Attack rate (left) and number of people sick (right) in a single wave pandemic with no interventions, and various vaccine availability delays. The dashed vertical lines indicate the time of vaccine available at 2 months, 4 months and 6 months from left to right



As shown in Figure 18 and Table 27, earlier vaccine availability can significantly mitigate the impact of a pandemic with many fewer infections, hospitalizations and deaths. However, in a single wave pandemic, a 6 month timeframe for vaccine availability is too late to have a large impact as the pandemic has largely passed. Nonetheless, antiviral use (the 'no vaccine' scenario) does result in the prevention of a substantial number of infections, hospitalizations, and mortalities.

Table 27 Total number (left columns), and number prevented (right columns) of infections, hospitalizations, and mortalities in a single wave pandemic

	One Wave Pandemic					
	Total Number Infections	Total Number Hospitalizations	Total Number Mortalities	Number Prevented Infections	Number Prevented Hospitalizations	Number Prevented Mortalities
No Intervention	10,035,380	93,677	19,656	-	-	-
2 Months	2,165,472	16,067	2,239	7,869,908	77,610	17,417
4 Months	5,654,756	46,646	6,923	4,380,624	47,031	12,733
6 Months	6,654,192	56,134	8,444	3,381,189	37,543	11,212
No Vaccine	6,807,167	57,382	8,654	3,228,214	36,295	11,002

Table 28 and Table 29 highlight the total direct costs and direct cost savings respectively. If vaccines were available 2 months after the pandemic began, direct costs could be reduced by 86%. Widespread use of antivirals for treatment and very limited use of prophylaxis could still reduce costs by 51%. However, the total costs are still in the hundreds of millions.

Table 28 The total direct costs for a single wave pandemic

	One Wave Pandemic			
	GP Visits	Office Vists	Hospizalitaions	Total
No Intervention	\$102,200,000	\$39,446,000	\$653,116,000	\$794,761,000
2 Months	\$17,528,000	\$6,765,000	\$84,012,000	\$108,305,000
4 Months	\$50,890,000	\$19,642,000	\$243,913,000	\$314,445,000
6 Months	\$61,241,000	\$23,637,000	\$293,525,000	\$378,403,000
No Vaccine	\$62,602,000	\$24,162,000	\$300,049,000	\$386,814,000

Table 29 The savings in total direct costs for a single wave pandemic

	One Wave Pandemic				
	Reduction in GP Visits	Reduction in Office Vists	Reduction in Hospizalitaions	Reduction in Total	% Reduction in Costs
2 Months	\$84,672,000	\$32,681,000	\$569,104,000	\$686,456,000	86.4%
4 Months	\$51,310,000	\$19,804,000	\$409,203,000	\$480,316,000	60.4%
6 Months	\$40,959,000	\$15,809,000	\$359,591,000	\$416,358,000	52.4%
No Vaccine	\$39,598,000	\$15,284,000	\$353,067,000	\$407,947,000	51.3%

In addition to the direct health care costs, pandemics also have a significant indirect economic impact due to workplace absenteeism and lost productivity. As shown in Table 30, with no intervention, a pandemic can result in over 0.27% loss to Canada's annual GDP. Early availability of vaccines can reduce this significantly.

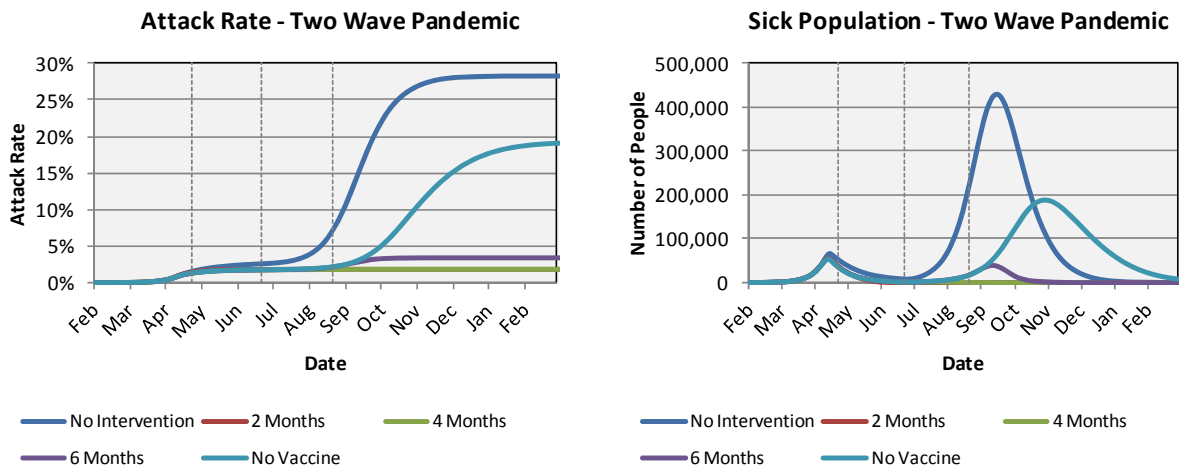
Table 30 The indirect economic impact of a single wave pandemic

	One Wave Pandemic	
	GDP Impact	% of GDP Lost
No Intervention	\$4,972,012,000	0.274%
2 Months	\$862,121,000	0.048%
4 Months	\$2,374,855,000	0.131%
6 Months	\$2,831,406,000	0.156%
No Vaccine	\$2,897,010,000	0.160%

2.7.2 TWO WAVE PANDEMIC

A two wave pandemic, such as what was observed in Canada during the 2009 H1N1 pandemic, provide a greater opportunity for interventions due to its longer total duration. As in the single wave case, the base pandemic with no intervention was chosen to have an attack rate close to 30%. Figure 19 illustrates the cumulative attack rate (left) and the two peak infection curve (right) of the two wave pandemic. The same interventions are applied to this scenario as to the single wave pandemic.

Figure 19 Attack rate (left) and number of people sick (right) in a two wave pandemic with no interventions, and various vaccine available delays. The dashed vertical lines indicate the time of vaccine available at 2 months, 4 months and 6 months from left to right.



The most significant impact is the almost total elimination of infections, hospitalizations, and mortalities if vaccines are available early. Even when the vaccines are available 6 months after the pandemic begins, the majority of deaths are prevented when antivirals are used to delay the outbreak.

Table 31 Total number (left columns), and number prevented (right columns) of infections, hospitalizations, and mortalities in a two wave pandemic

	Two Wave Pandemic					
	Infections	Total Number Hospitalizations	Mortalities	Infections	Number Prevented Hospitalizations	Mortalities
No Intervention	9,463,181	87,963	18,462	-	-	-
2 Months	555,136	4,455	657	8,908,045	83,508	17,805
4 Months	614,503	4,954	733	8,848,678	83,010	17,729
6 Months	1,151,991	8,732	1,253	8,311,190	79,232	17,209
No Vaccine	6,423,592	53,920	8,131	3,039,588	34,044	10,331

As the attack rate in the two wave pandemic with no intervention is similar to that of the one wave pandemic with no intervention, the total direct costs in both cases are similar. However, the potential cost savings are much greater in the two wave case due to vaccines becoming available earlier relative to the progression of the pandemic. Table 32 and Table 33 show the direct health care costs, and the reduction in health care costs respectively.

Table 32 The total direct costs for a two wave pandemic

	Two Wave Pandemic			
	GP Visits	Office Vists	Hospizalitaions	Total
No Intervention	\$95,966,000	\$37,040,000	\$613,281,000	\$746,286,000
2 Months	\$4,860,000	\$1,876,000	\$23,296,000	\$30,033,000
4 Months	\$5,404,000	\$2,086,000	\$25,903,000	\$33,394,000
6 Months	\$9,526,000	\$3,677,000	\$45,658,000	\$58,861,000
No Vaccine	\$58,825,000	\$22,704,000	\$281,946,000	\$363,475,000

Table 33 The savings in total direct costs for a two wave pandemic

	Two Wave Pandemic				
	Reduction in GP Visits	Reduction in Office Vists	Reduction in Hospizalitaions	Reduction in Total	% Reduction in Costs
2 Months	\$91,106,000	\$35,164,000	\$589,985,000	\$716,253,000	96.0%
4 Months	\$90,562,000	\$34,954,000	\$587,378,000	\$712,892,000	95.5%
6 Months	\$86,440,000	\$33,363,000	\$567,623,000	\$687,425,000	92.1%
No Vaccine	\$37,141,000	\$14,336,000	\$331,335,000	\$382,811,000	51.3%

The indirect economic impact of the two wave pandemic is slightly larger than the single wave pandemic due to the longer pandemic duration resulting in greater workplace absenteeism. However, the greater window for effective vaccination results in large reductions of the indirect impact.

Table 34 The indirect economic impact of a two wave pandemic

	Two Wave Pandemic	
	GDP Impact	% of GDP Lost
No Intervention	\$5,823,841,000	0.321%
2 Months	\$289,777,000	0.016%
4 Months	\$322,349,000	0.018%
6 Months	\$585,512,000	0.032%
No Vaccine	\$3,006,059,000	0.166%

3 CASE STUDIES

Two case studies examining COPD and rheumatoid arthritis have been selected that will examine in greater detail the potential impact of pharmaceutical interventions.

3.1 PREVENTION OF COPD EXACERBATIONS

COPD is one of the most prevalent lung diseases in Canada. The impact of the disease results from both the ongoing maintenance of the individual's health, as well as short term costly exacerbations. The ability to target interventions at particular aspects of an illness is one of the key capabilities of numerical modelling. The COPD model used in the case study is the same Lung Disease Model as presented in Section 2.1.

3.1.1 MAINTAINING THE STATUS QUO

Figure 20 and Table 35 shows the projected prevalence of COPD by age and sex. There is a comparable increasing trend among males and females throughout the entire simulation period. The number of people living with COPD is expected to increase by over 1.2 million cases in the next 30 years, reaching over 3 million prevalent cases. Over 2.5 million of these people are expected to be over the age of 65.

Figure 20 Number of Canadians with COPD by age and sex from 2012 to 2042

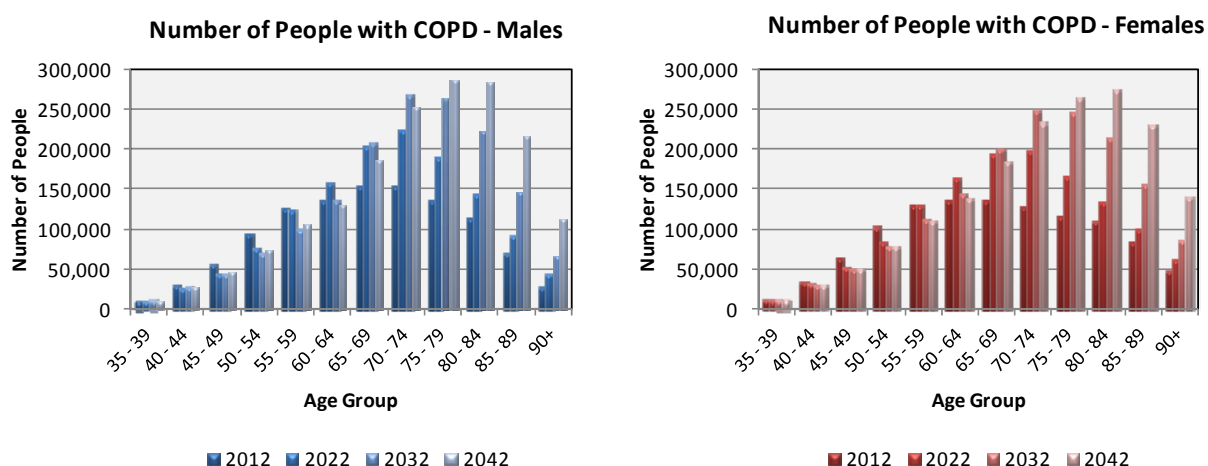
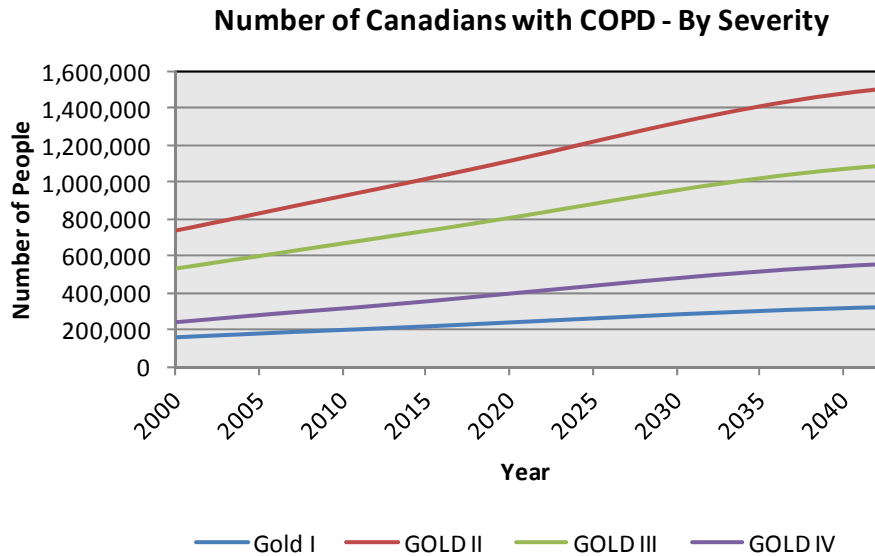


Table 35 Number and percentage of people in Canada with COPD by age and sex

Prevalence of COPD by age and sex from 2012 to 2042													
Male													
		35 - 40	40 - 45	45 - 50	50 - 55	55 - 60	60 - 65	65 - 70	70 - 75	75 - 80	80 - 85	85 - 90	90 - 100
2012	Number	10,206	29,708	55,453	94,958	125,326	136,129	154,323	153,938	135,372	112,096	69,290	27,648
	Percent	0.9%	2.5%	4.2%	7.1%	10.6%	13.5%	19.6%	27.2%	32.4%	38.1%	42.5%	42.5%
2022	Number	10,251	26,171	42,045	75,309	122,844	158,309	203,720	223,297	189,567	142,796	91,346	43,316
	Percent	0.8%	2.1%	3.5%	6.2%	9.7%	12.7%	18.6%	25.4%	30.1%	36.5%	42.4%	43.6%
2032	Number	10,867	28,316	43,101	68,603	100,994	135,485	206,818	268,461	264,445	222,439	144,906	65,438
	Percent	0.9%	2.2%	3.3%	5.5%	8.4%	11.3%	17.3%	24.3%	29.3%	35.4%	41.1%	43.1%
2042	Number	10,429	28,029	45,324	74,101	105,259	129,580	185,248	251,405	285,892	284,569	216,363	110,433
	Percent	0.8%	2.2%	3.5%	5.7%	8.2%	10.5%	15.8%	22.6%	28.0%	34.7%	40.9%	43.0%
Female													
		35 - 40	40 - 45	45 - 50	50 - 55	55 - 60	60 - 65	65 - 70	70 - 75	75 - 80	80 - 85	85 - 90	90 - 100
2012	Number	12,323	35,053	64,025	101,754	128,775	134,629	134,762	127,320	115,645	107,651	84,767	47,422
	Percent	1.1%	2.9%	4.9%	7.6%	10.6%	12.8%	16.1%	20.1%	22.8%	26.5%	30.3%	32.0%
2022	Number	11,648	31,328	51,503	84,130	128,366	163,351	192,870	197,740	167,172	134,395	100,743	61,840
	Percent	0.9%	2.6%	4.3%	6.9%	9.9%	12.6%	16.6%	20.4%	22.9%	26.7%	31.3%	33.8%
2032	Number	11,235	30,660	49,802	77,591	110,693	144,595	199,353	246,396	244,432	213,921	155,434	85,761
	Percent	0.9%	2.4%	3.9%	6.3%	9.1%	11.8%	16.0%	20.7%	24.0%	27.8%	31.8%	34.3%
2042	Number	10,909	29,380	48,434	76,803	109,285	137,836	182,079	232,416	263,402	273,653	231,327	139,537
	Percent	0.9%	2.4%	3.8%	6.0%	8.6%	11.1%	15.1%	19.8%	23.6%	28.4%	33.1%	35.5%

Figure 21 Number of Canadians with COPD by severity



GOLD is an international standard criterion for COPD, adopted by the Canadian Thoracic Society guidelines (2008), which is based on the severity of the disease and can also be classified by considering lung function impairment. As shown in Figure 21, the majority of COPD cases in Canada fall under the GOLD II (moderate) and GOLD III (severe) categories. Figure 22 shows the simulation results of the direct costs associated with COPD by severity and cause. In particular,

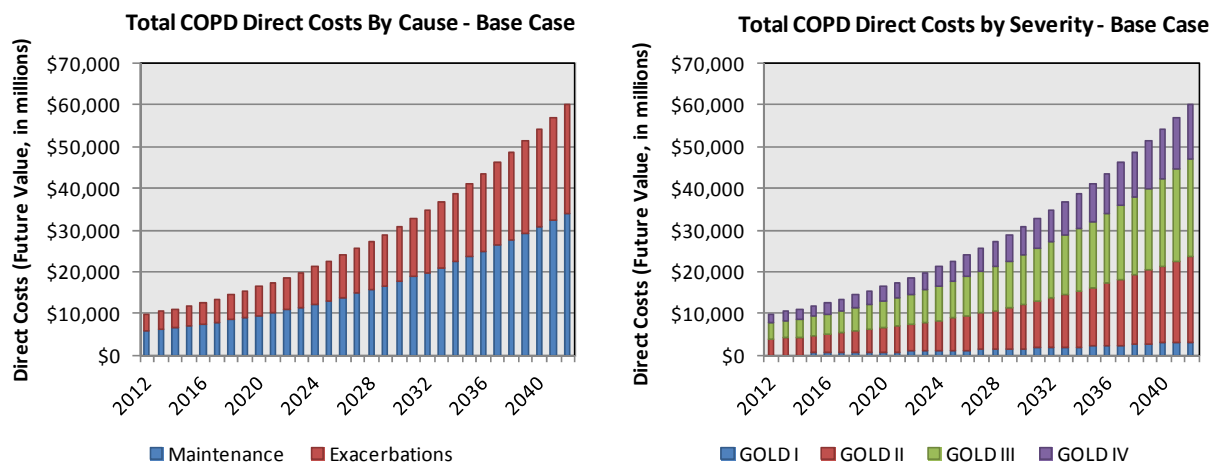
- There are over 300,000 people suffering from very severe COPD (GOLD Stage 4). Those suffering from very severe COPD may be at risk of respiratory failure or at risk of requiring oxygen. By 2042, this number is expected to increase to over 550,000 people.
- In 2012, over 200,000 were estimated to be living with mild COPD (Stage 1). By 2042, this number is expected to increase to approximately 325,000.

The direct health care costs of COPD can be divided into two primary categories:

- **Maintenance costs:** The costs associated with controlling or maintaining the disease, and
- **Exacerbation costs:** The costs that are incurred when a COPD patient has an event which triggers a significant increase in symptoms.

In addition, the average costs per patient tend to increase with COPD severity. Figure 22 shows the breakdown of the annual COPD costs by cause (left) and COPD severity (right). A significant portion of the costs are due to exacerbations, many of which may be preventable, and among the more severe cases of COPD.

Figure 22 Annual direct COPD health care costs by cause in future value dollars by cause (left) and severity (right)



The maintenance and exacerbations costs can be further divided to determine the main cost drivers for each category. As shown in Figure 23, the profiles of each category are significantly different with medication forming the bulk of the maintenance costs and hospitalizations forming almost 90% of the exacerbation costs.

Figure 23 Components of COPD direct health care costs due to maintenance (left) and exacerbations (right)

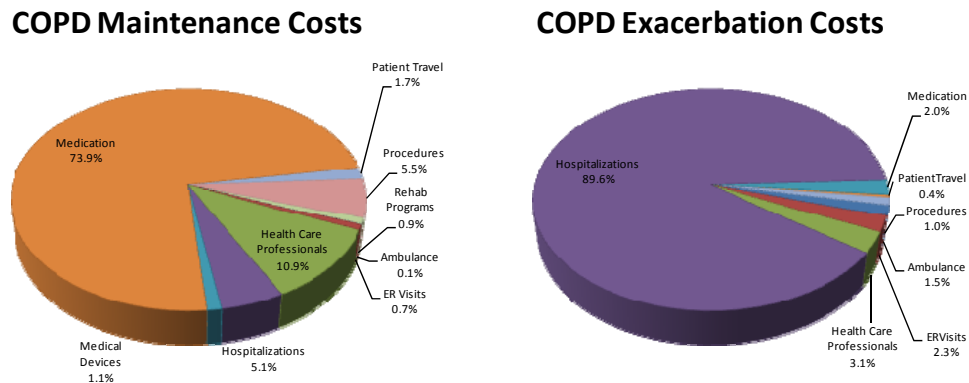


Table 36 describes the direct health costs and indirect burden associated with maintenance of COPD and exacerbations of COPD.

- By 2042, the annual direct cost (future value) associated with COPD is expected to increase to \$60 billion from \$9 billion in 2012
- The cumulative direct costs from 2012 to 2042 could amount to \$898 billion in future value terms which is worth \$520 billion in cumulative present value terms.
- By 2042, the cumulative indirect burden associated with COPD in the labour force amount to \$573 billion in future value terms, or \$331 billion in cumulative present value terms.

Table 36 Direct costs and indirect economic burden of COPD from 2012 to 2042 in future value, cumulative future value, and present value terms

	Direct Costs and Indirect Burden of COPD from 2012 to 2042					
	Direct Costs			Indirect Burden		
	Annual Future Value (millions)	Cumulative Future Value (millions)	Cumulative Present Value (millions)	Annual Future Value (millions)	Cumulative Future Value (millions)	Cumulative Present Value (millions)
2012	\$9,892	\$9,892	\$9,892	\$1,735	\$1,735	\$1,735
2022	\$18,750	\$153,041	\$130,121	\$14,058	\$91,075	\$75,347
2032	\$34,647	\$421,008	\$297,696	\$22,921	\$279,965	\$193,877
2042	\$60,019	\$898,155	\$520,084	\$35,280	\$572,780	\$330,716

3.1.2 IMPACT OF MEDICATION TO REDUCE EXACERBATIONS

If medication were to be able to successfully reduce the maintenance cost of COPD, significant costs that arise from COPD and the severities of COPD could be reduced. Three hypothetical scenarios were

constructed (based on SME consensus) that looked at the impact of reducing such costs. The scenarios constructed as follows:

- **Low Reduction:** 10% reduction of COPD maintenance costs
- **Moderate Reduction:** 20% reduction of COPD maintenance costs
- **High Reduction:** 50% reduction of COPD maintenance costs

Figure 24 highlight the results of the impact of the hypothetical scenarios if 50% of the COPD population received the intervention. As the effectiveness of the intervention increases, exacerbation costs could be reduced from the current level of 43.3% of total costs to 36.5%.

Figure 24 Reduction in COPD maintenance cost under a 10% reduction (left), 20% reduction (middle), and 50% reduction (right) in the number of exacerbations if half of the COPD population received the intervention.

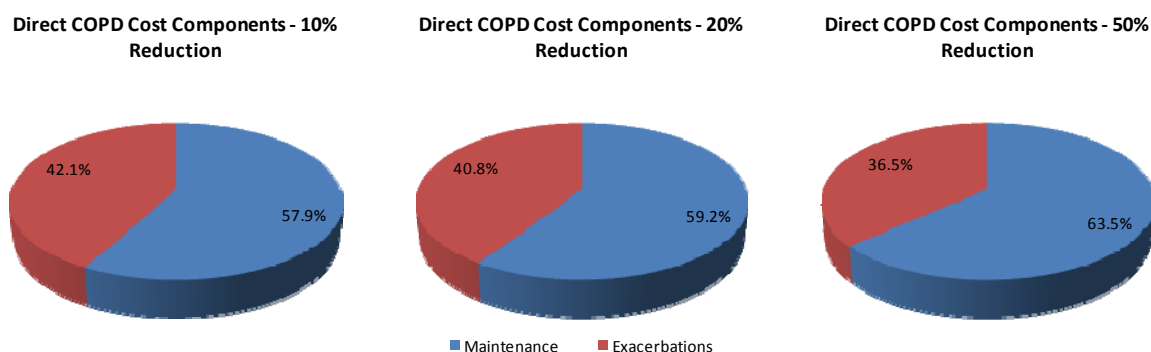


Table 37 Summary of annual direct health cost savings from 2012 to 2024 in future value terms

Annual Direct Health Cost Savings (future value, in millions)			
	10% Reduction	20% Reduction	50% Reduction
2012	\$198	\$397	\$992
2022	\$386	\$773	\$1,932
2032	\$733	\$1,465	\$3,663
2042	\$1,301	\$2,602	\$6,504

As shown in Table 37, the immediate impact would be between a \$198 million and \$992 million in savings annually. By 2042, this could grow to between a \$1.3 billion and \$6.5 billion savings annually, in future value terms.

Figure 25 Annual direct COPD cost savings (future value) if medication could reduce exacerbations by 20% for half of the COPD population

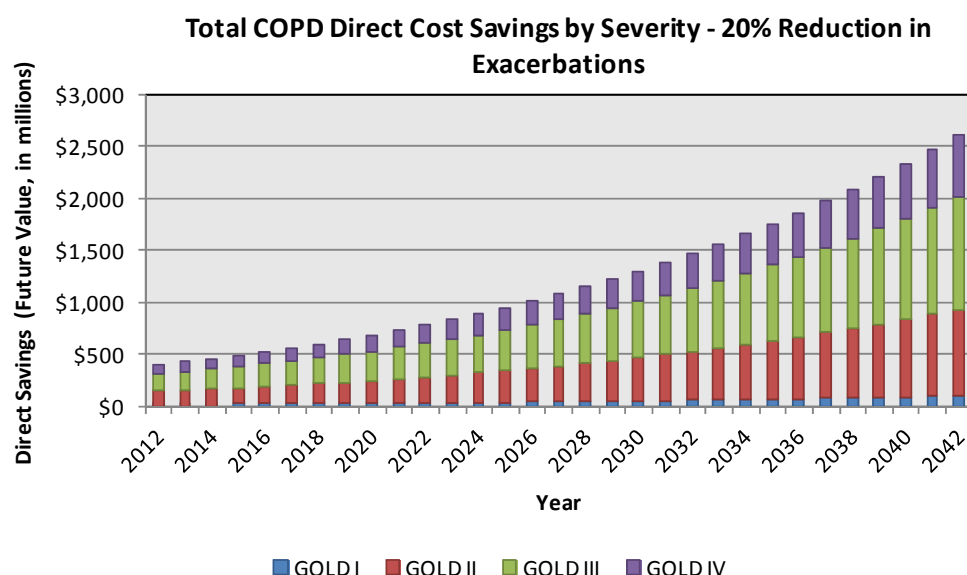


Figure 25 provides a breakdown of cost savings by COPD severity that can be achieved with a reduction of exacerbations, through medication.

- Relative to the base model, the cumulative short term impact (from 2012 to 2022) of a 20% reduction in exacerbation would result in a direct cost savings of \$228 million for GOLD I, \$2 billion for GOLD II, \$2.5 billion for GOLD III and \$1.3 billion for GOLD IV.
- Relative to the base model, the cumulative long term impact (from 2012 to 2042) of a 20% reduction in exacerbation would result in a direct cost savings of \$1.3 billion for GOLD I, \$12 billion for GOLD II, \$ 15 billion for GOLD III and \$8 billion for GOLD IV.

The indirect economic impact, through increased labour force productivity of COPD patients, is summarized in Table 38. The cumulative indirect economic benefit in future value terms over the next 30 years could amount to between \$40 billion and \$186 billion depending on the reduction in exacerbations.

Table 38 Indirect economic benefits of reduction COPD exacerbations from 2012 to 2042 in future value and present value terms

	Indirect Economic Benefits from 2012 to 2042								
	10% Reduction			20% Reduction			50% Reduction		
	Annual Future Value (millions)	Cumulative Future Value (millions)	Cumulative Present Value (millions)	Annual Future Value (millions)	Cumulative Future Value (millions)	Cumulative Present Value (millions)	Annual Future Value (millions)	Cumulative Future Value (millions)	Cumulative Present Value (millions)
2012	\$594	\$594	\$594	\$997	\$997	\$997	\$1,546	\$1,546	\$1,546
2022	\$818	\$7,420	\$6,363	\$1,546	\$13,349	\$11,405	\$3,610	\$27,596	\$23,315
2032	\$1,511	\$19,075	\$13,649	\$2,976	\$36,032	\$25,574	\$7,358	\$82,885	\$57,813
2042	\$2,640	\$39,971	\$23,386	\$5,261	\$77,525	\$44,903	\$13,140	\$186,194	\$105,928

3.2 INCREASED USE OF DMARDS AND BIOLOGICS FOR RHEUMATOID ARTHRITIS

RiskAnalytica's life at Risk Simulation model was used to provide measurements of incidence, prevalence and mortality using input data on rheumatoid arthritis, the most common form of inflammatory arthritis. The impact of early treatment and access to disease-modifying anti-rheumatic drugs (DMARDs) and biologics on rheumatoid arthritis disability and arthritis-attributable costs were assessed within this model. Figure 26 and Table 39 provide a breakdown of the results by age, sex and year. The prevalence is consistently higher among women than men. While rheumatoid arthritis is most prevalent among those older than 60, 41% of all prevalent cases are for those between 15 and 59. Due to the large disability associated with rheumatoid arthritis, this results in a large economic impact.

Figure 26 Number of people in Canada with rheumatoid arthritis by age and sex from 2012 to 2042

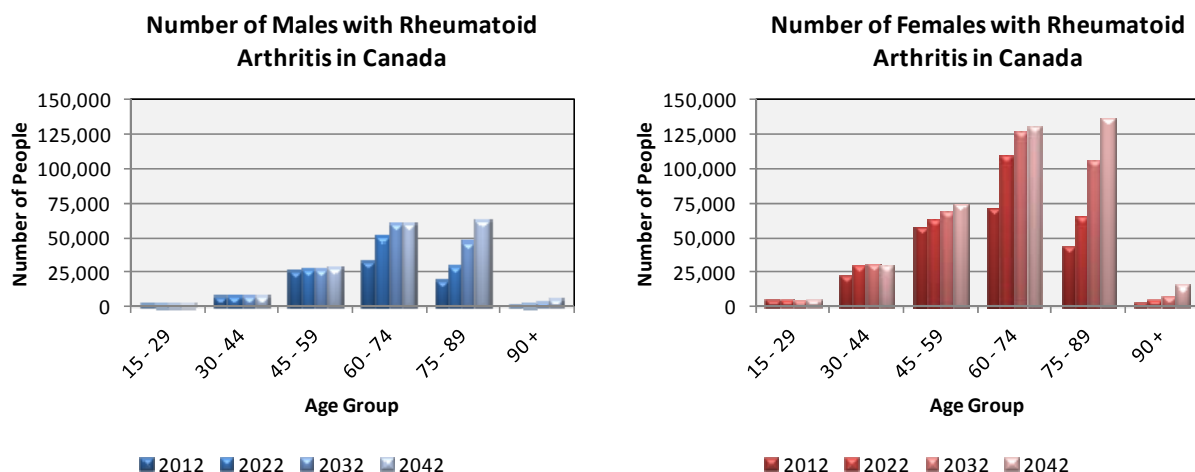
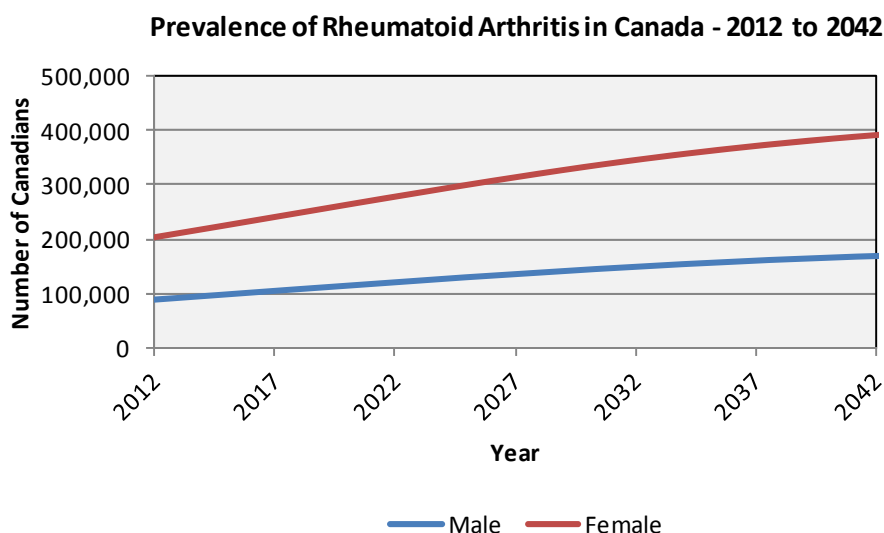


Table 39 Number and percentage of people in Canada with rheumatoid arthritis by age and sex

Prevalence of Rheumatoid Arthritis in Canada by Age Group and Sex from 2012 to 2042													
		Male						Female					
		15 - 29	30 - 44	45 - 59	60 - 74	75 - 89	90 +	15 - 29	30 - 44	45 - 59	60 - 74	75 - 89	90 +
2012	Number	2,302	7,685	25,509	32,631	19,224	1,098	6,101	21,879	57,638	72,014	43,609	3,705
	Percent	0.07%	0.22%	0.67%	1.38%	2.19%	2.10%	0.18%	0.62%	1.49%	2.85%	3.65%	2.80%
2022	Number	1,926	8,450	27,073	51,346	29,244	2,028	5,336	29,361	62,894	110,054	66,139	5,433
	Percent	0.06%	0.22%	0.73%	1.60%	2.40%	2.63%	0.17%	0.80%	1.70%	3.23%	4.27%	3.42%
2032	Number	1,831	8,519	26,823	60,246	47,868	3,253	4,984	30,668	68,698	126,969	106,259	8,521
	Percent	0.05%	0.23%	0.72%	1.74%	2.63%	2.81%	0.15%	0.84%	1.85%	3.50%	4.71%	3.96%
2042	Number	1,935	8,084	28,088	60,564	63,397	5,810	5,281	29,483	74,572	130,724	136,817	14,811
	Percent	0.05%	0.21%	0.73%	1.75%	2.81%	3.03%	0.15%	0.80%	1.96%	3.66%	5.02%	4.36%

Figure 27 highlights the significant difference in prevalence of rheumatoid arthritis between males and females. As a large number of rheumatoid arthritis cases are below 60 years old, this difference is not entirely an artifact of the slightly longer life expectancy of women as may be the case for illness which strike only the elderly, but a significant difference in the risk of rheumatoid arthritis depending upon sex.

Figure 27 Total number of people in Canada with rheumatoid arthritis by sex from 2012 to 2042



Rheumatoid arthritis patients interact with the health system through several channels. As shown in Figure 28, drugs are the majority of the direct health costs with almost 60% of the total. Table 40 describes the annual direct costs associated with rheumatoid arthritis, stratified by the cost components. By 2042 rheumatoid arthritis will cost approximately the Canadian society approximately \$11 billion annually (future value), an increase from \$2.7 billion in 2012.

Figure 28 Current components to direct health care cost for people with rheumatoid arthritis

Components of Direct Health Care Costs - Base Case

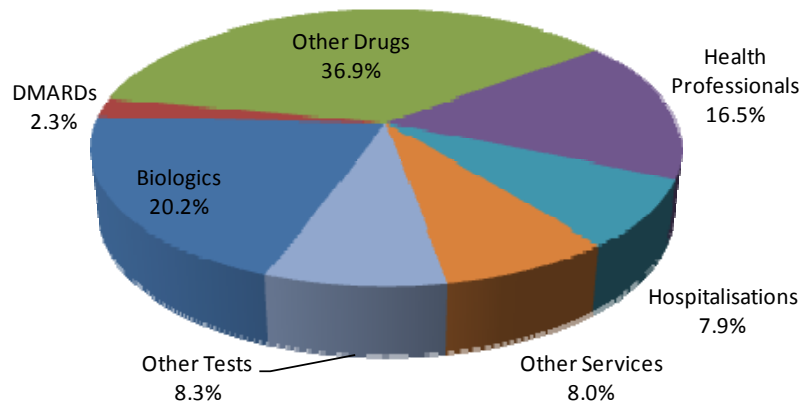


Table 40 Annual direct cost components (future values) for rheumatoid arthritis in the base case from 2012 to 2042

Annual Direct Costs in the Base Case (Future Value, in millions)								
	Health							
	Biologics	DMARDs	Other Drugs	Professionals	Hospitalisations	Other Services	Other Tests	Total
2012	\$554	\$68	\$998	\$447	\$213	\$216	\$224	\$2,720
2022	\$997	\$116	\$1,812	\$812	\$387	\$393	\$407	\$4,923
2032	\$1,564	\$177	\$2,853	\$1,278	\$609	\$618	\$641	\$7,740
2042	\$2,232	\$249	\$4,078	\$1,827	\$870	\$884	\$920	\$11,059

Cumulatively over the next 30 years, rheumatoid arthritis could incur over \$200 billion in direct health costs (future values) with a cumulative indirect economic productivity burden of \$359 billion. Due to the significant disability associated with rheumatoid arthritis and the relatively high prevalence of patients of working age, the indirect economic impact is quite large.

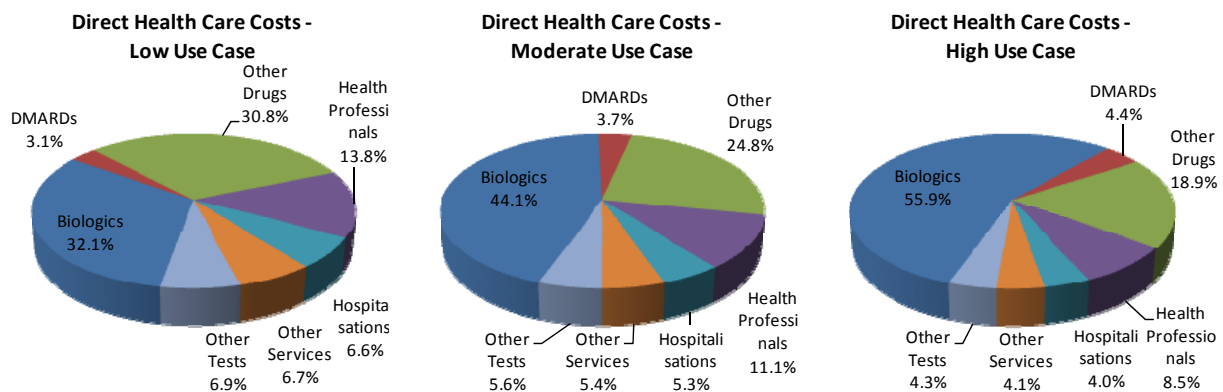
Table 41 Total direct costs and indirect economic burden of rheumatoid arthritis in future value, cumulative future value, and cumulative present value terms from 2012 to 2042

Direct and Indirect Economic Costs from 2012 to 2042						
	Annual Future Value (millions)	Direct Costs		Indirect Burden		
		Cumulative Future Value (millions)	Cumulative Present Value (millions)	Annual Future Value (millions)	Cumulative Future Value (millions)	Cumulative Present Value (millions)
2012	\$2,720	\$2,720	\$2,720	\$3,863	\$3,863	\$3,863
2022	\$4,923	\$41,502	\$35,338	\$86,568	\$86,568	\$73,527
2032	\$7,740	\$105,771	\$75,691	\$16,815	\$202,754	\$146,844
2042	\$11,059	\$200,650	\$120,125	\$24,115	\$359,278	\$220,159

3.2.1 INCREASED USE OF BIOLOGICS AND DMARDS

To investigate the impact of increasing the use of biologics and DMARDs, three base case models were generated to test the model against a low use case, moderate use case and a high use case scenario for HAQ response change for early and late rheumatoid arthritis. Figure 29 looks at the impact of increase use of DMARDs and biologics on the direct cost components.

Figure 29 Figure 29 Impact of increasing the use of biologics and DMARDs on the direct cost components



While the fraction of the total cost spent on biologics and DMARDs increases in each of the scenarios, the net result is a significant decline in the total cost. As summarized in Table 42, by increasing the use of DMARDs and biologics we can expect

- A cumulative direct costs savings between \$3 billion and \$ 11 billion (depending on the use) in the short-term (from 2012 to 2022);
- A cumulative direct cost savings between \$24 billion and \$74 billion (depending on the use) in the long term (from 2012 to 2042);

Table 42 Summary of direct cost savings due to increased use of biologics and DMARDs from 2012 to 2042

	Direct Cost Savings								
	Low Use			Moderate Use			High Use		
	Annual Future Value (millions)	Cumulative Future Value (millions)	Present Value (millions)	Annual Future Value (millions)	Cumulative Future Value (millions)	Present Value (millions)	Annual Future Value (millions)	Cumulative Future Value (millions)	Present Value (millions)
2012	\$39	\$39	\$39	\$77	\$77	\$77	\$160	\$160	\$160
2022	\$89	\$683	\$578	\$111	\$1,034	\$886	\$174	\$1,857	\$1,605
2032	\$153	\$1,913	\$1,348	\$143	\$2,320	\$1,697	\$166	\$3,559	\$2,687
2042	\$230	\$3,845	\$2,252	\$171	\$3,883	\$2,432	\$148	\$5,092	\$3,413

Depending upon the level of the intervention, future time dependence of the economic benefit can vary. As shown in Figure 30, for the high use scenario, the immediate direct cost savings in 2012 are much greater than for the low use scenario. However, by 2042, the low use scenario yields the greatest annual cost savings. This is due to the progression of rheumatoid arthritis disability. However, cumulatively over the 30 year period, the high use scenario does yield the greatest total benefit. In addition, the annual indirect economic benefits driven by reduced disability in the labour force is always greater in the high use scenario than the lower use cases.

Figure 30 Annual impact of total direct costs (left) and indirect economic benefits (right) of increasing the use biologics and DMARDs from 2012 to 2042

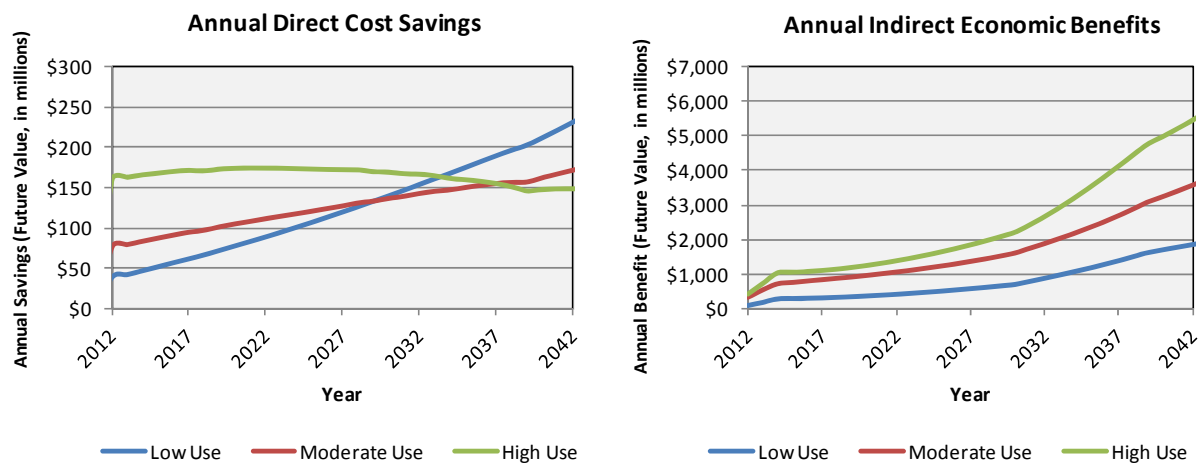


Table 43 Summary of indirect economic benefits due to increased use of biologics and DMARDs from 2012 to 2042

	Indirect Economic Benefits								
	Low Use			Moderate Use			High Use		
	Annual Future Value (millions)	Cumulative Future Value (millions)	Cumulative Present Value (millions)	Annual Future Value (millions)	Cumulative Future Value (millions)	Cumulative Present Value (millions)	Annual Future Value (millions)	Cumulative Future Value (millions)	Cumulative Present Value (millions)
2012	\$104	\$104	\$104	\$319	\$319	\$319	\$445	\$445	\$445
2022	\$425	\$3,416	\$2,888	\$1,048	\$8,704	\$7,370	\$1,407	\$11,908	\$10,107
2032	\$886	\$9,689	\$6,800	\$1,874	\$22,983	\$16,306	\$2,680	\$31,649	\$22,443
2042	\$1,857	\$24,079	\$13,480	\$3,570	\$50,872	\$29,276	\$5,465	\$74,219	\$42,218

Based on the results from Table 42 and Table 43, relative to the base model and depending on the use of biologic and DMARDs we can expect the following results:

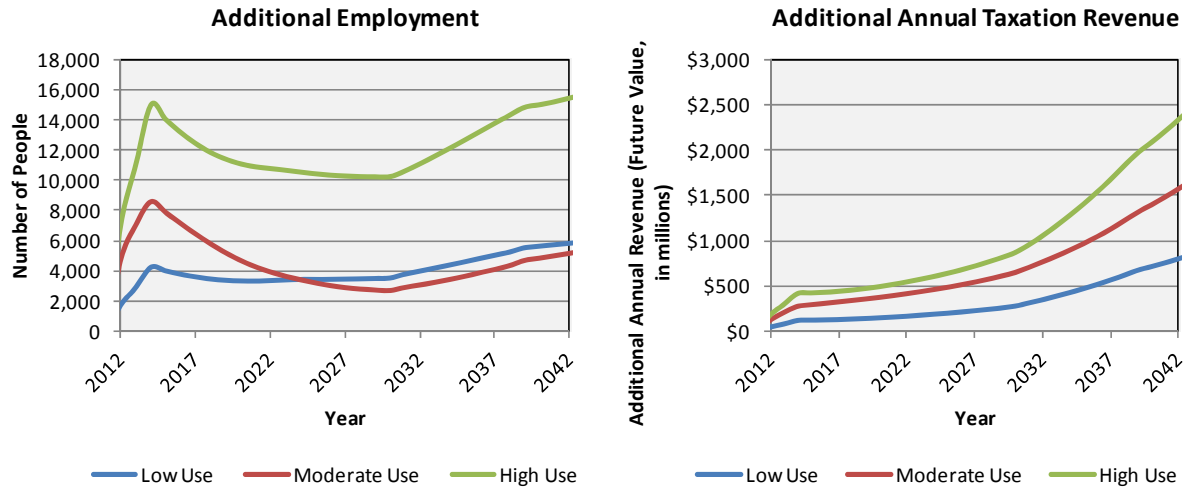
- The short term impacts of early treatment and access to DMARDs and biologics are expected to result in a direct cost savings that range from \$39 million dollars to \$160 million dollars in cumulative future value.
- The long term impacts of early treatment and access to DMARDs and biologics are expected to result in a direct cost savings that range from \$3 billion dollars to \$5 billion dollars in cumulative future values
- The short term impacts of early treatment and access to DMARDs and biologics are expected to result in an indirect economic benefit that ranges from \$3.4 billion dollars to \$11.9 billion dollars in cumulative future value.
- The long term impacts of early treatment and access to DMARDs and biologics are expected to result in indirect economic benefits that range from \$24.1 billion dollars to \$42.2 billion dollars in cumulative future values

It is important to note that though we see an increase in the health costs related to the increase use of DMARDs and biologics, the benefits that are achieved through a decrease in other cost associated with rheumatoid arthritis, and a decrease in lost workplace productivity as a result of rheumatoid arthritis, outweigh the costs in the long run. In addition to direct health costs, changes in employment and taxation revenue can also be estimated. Figure 31 describes the additional number of people who will now have the ability to work due to a decrease in the effects of RA. Based on the use of the medication, we can expect

- By 2022, an additional number of employees between 3,300 and 10,000 annually will be participating in the workforce;
- By 2042, an additional number of employees between 5,000 and 15,000 annually will be participating in the workforce;

- Additional taxation revenue collected by the government of about 600 billion annually by 2022 ;
- Additional taxation revenue collected by the government, of about 2 trillion annually by 2042;

Figure 31 Impact of employment (left) and annual taxation revenue (right) from 2012 to 2042



4 CONCLUSIONS

Over the next thirty years the major illnesses are expected to place a significant burden on Canadian society. Chronic diseases and the risk factors associated with infectious diseases were shown to have large direct health costs as well as significant impact on the productivity of the labour force. As the Canadian population increases and ages, there will be an increase in the prevalence of chronic diseases as well as the costs attributed to disease. In addition, as individuals stay in the labour force longer, the economic disability due to illnesses will become more significant. Effective pharmaceutical products have the potential to significantly improve the quality of life of individuals and contribute to significant reductions in health care costs and improved economic productivity.

Over the next 30 years, pharmaceutical-related interventions have the opportunity to:

- Prevent up to 700,000 fewer new cases of lung disease, reduce cumulative direct health costs by up to \$79 billion⁵, and improve economic productivity by up to an average of \$6.8 billion⁶ annually through increased smoking cessation rates;
- Improve pain management for osteoarthritis patients resulting in a total of up to an average of \$52.7 billion annually in economic productivity benefits due to the disease's prevalence in the population and \$183 billion in direct health costs;
- Prevent up to 870,000 new cases of osteoarthritis through improved weight management and weight loss;
- Reduce the prevalence of debilitating mental illness in the population by 700,000 individuals by 2042 resulting in up to a total of \$132 billion direct cost savings and over an average of \$1.1 billion annually in indirect economic productivity benefits;
- Reduce the dementia-related informal caregiving burden of relatives and friends by up to a cumulative total of \$3.8 billion through delaying the onset of the disease;
- Reduce the disability of people with type 1 diabetes through the prevention complications resulting in up to an average of \$549 million in indirect economic productivity benefits; and
- Provide widespread vaccination more quickly in an infectious disease outbreak reducing infections and direct health costs by almost 95%.

⁵ All costs are in the conclusion are cumulative future value totals from 2012 to 2042. Present value costs are included in the analysis sections.

⁶ All indirect economic productivity benefits are the annual average impact in future value terms for the period from 2012 to 2042

The detailed analysis of the cost drivers of patients with COPD highlighted the differences between the various causes of care and among the different disease severities. Exacerbations are the dominant reason for hospitalization costs and more severe cases of COPD were shown to drive a greater proportion of the costs than less severe cases. It was estimated that treatments that prevent exacerbations could produce up to a cumulative direct savings of \$94 billion and average improved productivity gains of over \$6.2 billion annually by 2042.

As illustrated in the detailed case study which examined the potential benefits of increasing the use of biologics and DMARDs, the benefits extend well beyond the direct health of the patients and include greater employment in the population and increased taxation revenues. In addition, by including all of the components of direct costs, the analysis revealed that the net direct health care costs could be reduced despite the increase in use of higher cost medication.

4.1 LIMITATIONS AND FUTURE RESEARCH

The majorities of the interventions in this study were based on expert opinion and are hypothetical in nature. Nonetheless, they demonstrate the significant potential if the assumed interventions were to occur. More robust estimates of the impact of specific interventions are possible with the use of clinical trial data or other evidence-based data.

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