Costs to Canada's Health Care System of Climate Change Impacts on Health (Annex A)

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1 Introduction

1.1 Objectives and Scope

1.1.1 Objectives

The objective of this work is to provide additional information on the public sector health care costs of morbidity estimates in *"Costing Climate Impacts and Adaptation: A Canadian Study on Human Health",* so as to express the estimated ozone related, climate change-induced morbidity cases as a cost to the Canadian public health care system.

1.1.2 Scope

Health care cost estimates are generated for the four cities (Toronto, Montreal, Calgary, Vancouver), over the three time slices (2020s, 2050s, 2080s) and combinations of scenarios (LS, WM; A2, B1) of the original study.

The morbidity cases included are[1]:

- acute respiratory symptom days (ARSD),
- asthma symptom days (ASD),
- minor restricted activity days (MRAD),
- respiratory emergency room visits (RERV), and
- respiratory hospital admissions (RHA).

Public sector health care costs are estimated based on the previously estimated number of physical impacts in the original study *"Costing Climate Impacts and Adaptation: A Canadian Study on Human Health"* and the health care cost per morbidity case estimates, calculated using the approach outlined in Section 2.

1.2 Health Impacts, Economic Value, and Health Care Costs

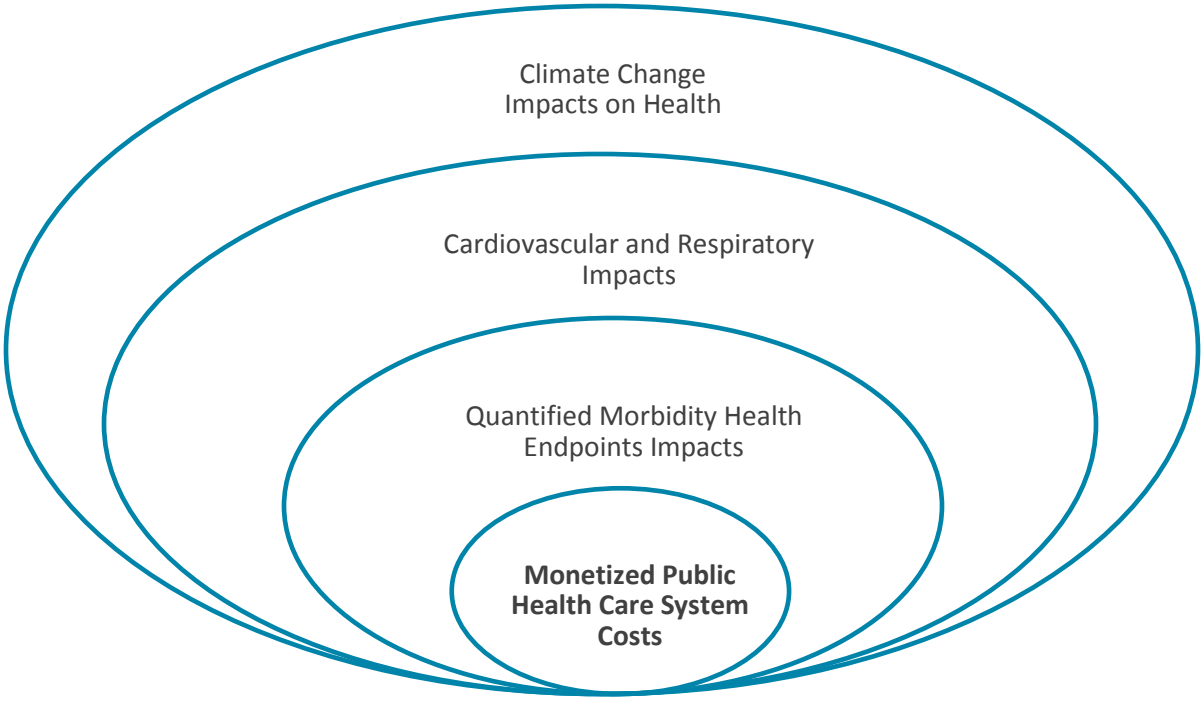
Increased temperatures associated with climate change may increase ground-level ozone concentrations.[2] Ground-level ozone has been linked to cardiovascular and respiratory impacts for individuals. The human health sector is directly and indirectly affected by a changing climate. The economic value of these health impacts can be most appropriately measured using the welfare economics framework and the measure of willingness-to-pay (WTP). The societal WTP to avoid health impacts is generally made up of three main components[3]:

- Health care-related expenditures;
- Value of lost productivity; and
- Pain and suffering[4].

[1] The health care costs relating to mortality impacts are not included in this report.
[2] See the main report for more information.
[3] An individual's WTP may differ from society's WTP if health care costs are not borne by the individual, or if sick pay compensates the individual for lost productivity. Both of these conditions are true in Canada.
[4] This third component has also been defined more broadly to include "inconvenience, restrictions and reduced enjoyment of leisure activities, anxiety about the future, and concern and inconvenience to family members and others" (Stieb et al., 2000).

In this study, we are exclusively concerned with the health care-related expenditures associated with the previously quantified increase in the five morbidity health endpoints. However, it should be stated that climate change may have additional impacts on Canadian's health, and therefore the health care system, beyond those estimated in this study. In fact, the cost estimates derived in this study should be interpreted as a subset of the total health care system costs associated with climate change. Exhibit 1 provides a schematic that contextualizes the costs estimated in this report (the monetized public sector health care system costs), in relation to the full spectrum of health care system costs that could be associated with climate change.

Exhibit 1 Schematic of full spectrum of health care system costs of climate change



In general, health care costs are reported at the aggregate level, either at the hospital, regional or provincial level. The Canadian Institute for Health Information (CIHI) provides the most comprehensive information on the costs of Canada's health system, and the health of Canadians more generally.[5] Because health care costs are generally provided at the aggregate level, the majority of studies use a top-down approach when estimating the economic burden of illnesses on Canada's health care system.[6] For the purposes of this study however, health care costs on a per health endpoint basis are required. Therefore, we rely on a bottom-up approach to estimate the health care costs of those health endpoints associated with climate change. As such, health care cost data may require manipulation to get from more general metrics (i.e. dollars spent by hospitals) to specific costs per health endpoint (i.e. $/hospital visit).

[5] www.cihi.ca
[6] For example, see the *Economic Burden of Illness in Canada* series (Health Canada, 2002).

2 Approach

This section describes our approach to deriving the cost to the Canadian public health care system of the climate change-induced health impacts in the original study, *"Costing Climate Impacts and Adaptation: A Canadian Study on Human Health".* It is divided into four sub-sections, outlining:

1. The approach to estimating the per health endpoint costs of the five health endpoints;
2. The three proposed comparators;
3. The approach to assessing each city's current burden on provincial health care budgets; and,
4. The approach to estimating health care costs into the future.

2.1 Approach to Estimating Health Care Costs per Endpoint

This section describes the approach to estimating the per health endpoint costs of climate change on Canada's health care system based on the five morbidity health endpoints. This approach was developed based on a review of three main sources: the EPA's *The Cost of Illness Handbook*[7], the Illness Cost of Air Pollution (ICAP) model[8] and information included in CIHI's reports and CIHI's Patient Cost Estimator (PCE)[9].

The first step of the approach is mapping the five morbidity health endpoints to specific cost categories of the health care system. Surveying the literature, there are four main interactions that have been quantified between the five morbidity health endpoints and the health care system:

1. hospital admissions;
2. emergency room visits;
3. medication consumption; and
4. doctor's office visits.

Two of the health endpoints, RHA and RERV, have a direct relationship with the health care system, as these health endpoints themselves involve direct interaction with the health care system. The other three health endpoints relating to symptom days and minor restricted activity days (ARSD, ASD, and MRAD) have a more indirect relationship to the health care system, and therefore indirect costs.

Besides hospital admissions and emergency room visits, two other relevant forms of air pollution related health care costs are: 1) expenditures on medication consumption and 2) visits to the doctor's office. As the number of symptom days associated with poor air quality increases, it can be hypothesized that medication consumption and doctor office visits will also increase. The link between elevated levels of air pollution and increased medication consumption has been quantitatively proven in epidemiological studies (Menichini and Mudu, 2010; Zeghnoun et al., 1999). However, the quantitative relationship between air pollution and increased doctor's visits, or patients with reparatory illnesses that require a doctor's visit, is more uncertain (Ontario Medical Association, 2000).

[7] http://www.epa.gov/oppt/coi/
[8] http://www.cma.ca/index.php/ci_id/86830/la_id/1.htm
[9] http://www.cihi.ca/CIHI-ext-portal/internet/en/document/spending+and+health+workforce/spending/spending+by+category/pce#

It is important to reiterate that, as shown in Exhibit 1, there will be other health care costs associated with the five morbidity health endpoints that are not included in this study. These include both public sector costs that could not be quantified such as respiratory therapists, and private sector drug expenditures that are purposely excluded because we are only interested in costs accruing to the public sector.

Exhibit 2 provides an outline of the interaction between health endpoints and the health care system.

Exhibit 2 Interactions between Health Endpoints and Health Care System Components

Health Care System Cost Components	Health Endpoints				
	RHA	RERV	ARSD	ASD	MRAD
Hospital Admission	X				
Emergency Room Visit		X			
Medication Consumption	X	X	X	X	X
Doctor's Office Visit			X	X	
Respiratory Therapists	X[a]	X[a]	X[a]	X[a]	X[a]
Other Health Care System Services	X[a]	X[a]	X[a]	X[a]	X[a]

Notes: [a] These interactions are not monetized

The rest of this section outlines the approach to estimating the cost of each of the specific health care system cost components in Exhibit 2 above.

2.1.1 Hospital Admissions

The costs of respiratory hospital admissions have been estimated using a cost of treatment model and with case cost estimates.

Stieb et al. (2002) use a cost of treatment model to estimate the Canadian health-care related costs associated with the RHA and RERV health endpoints. Empirical data from 1,772 individuals visiting the emergency departments for cardiorespiratory conditions in Saint John, Canada was gathered through the use of a follow-up survey to estimate costs on a per patient basis (Stieb et al., 2000). The parameter estimates of the cost of treatment model were derived using stepwise ordinary least squares regression. For reference, the cost of treatment model is presented in Appendix B.

Steib et al. (2002) use the cost of treatment model to estimate the health-care related expenditures associated with RHA at $2,800 ($1997). The advantage of this approach is that the model uses respiratory illness-specific data. The disadvantage of the approach is that the cost estimates derived from relatively old data (1997) and come from only one province (New Brunswick).

Hospital reported cost data can be used to estimate illness-specific costs on a per case basis. There have been several Canadian specific applications of this approach, including Alberta's

Case Cost Reports (ACCR)[10], the Ontario Case Cost Initiative (OCCI)[11], the ICAP model and CIHI's PCE. All of these applications share a common source of data, the CIHI.

For 2008-2009 (the most recent year of data availability), CIHI's PCE provides the inputs for determining average illness-specific hospital admission costs for all of the provinces, except for Quebec. Consequently, we developed an alternative approach to estimating the costs of an RHA for Montreal, as explained later.

For the RHA costs in Toronto, Calgary and Vancouver, we follow the four general steps below (note: CIHI's PCE computes Steps 2 and 3, but we include an explanation of these two steps for context):

1. Identify respiratory hospital admission patient groupings.

Hospitals track patients using distinct patient groupings based on illness condition. These distinct patient groupings, named Case Mix Group (CMG), provide useful information on the resources used in treatment as well as the patient's expected length of stay, two important cost factors in hospital admissions. In this step, the RHA health endpoint is linked with specific CMGs.

To determine which CMGs are associated with RHA, we can use published results from Stieb et al. (2002) and Stieb et al. (2000). Stieb et al. (2002) report that approximately 60% of RHA's are either asthma cases (CMG code = 147) or chronic obstructive pulmonary disease (COPD) cases (CMG code = 139) with the remaining 40% of cases being respiratory infections (CMG code = 141). The empirical evidence presented in Stieb et al. (2000) show that asthma cases represent 47% of the combined asthma/COPD hospital admission cases. Therefore, we assign a proportion of 28% and 32% of total RHA to asthma and COPD cases respectively.[12] We now know the distribution of RHA broken down by CMG code.

2. Determine average daily hospital admission costs at the provincial level.

This step is achieved by dividing the total inpatient hospital expenditures by the total number of inpatient days for hospital admissions. For example, if a hospital had total inpatient expenditures of $1,000,000 and a total of 400 inpatient days, then the average daily cost of hospital admission would be $2,500. This is calculated in CIHI's PCE.

3. Adjust average daily hospital admission costs by relevant CMG code-specific costs.

As noted above, health care costs can be expected to vary by medical condition type. Therefore, it is pertinent to adjust the average hospital admission costs determined in Step 2 by relevant CMG codes found in Step 1 to account for these varying medical costs. The outcome of this step is average hospital admissions costs that are specific to respiratory medical conditions.

As mentioned, the two main factors influencing patient costs are intensity of hospital resource use and expected length of stay. The CIHI develops resource intensity weights (RIW) for each CMG which represent the average cost for each unique CMG relative to the overall average costs for a hospital admission (CIHI, 2008). If a CMG has a below-average cost, then the RIW will

[10] These annual case reports can be accessed from http://www.health.alberta.ca/newsroom/pub-annual-reports.html
[11] http://www.occp.com/
[12] These percentages were calculated as 47% *x* 60% = 28% for asthma and 53% *x* 60% = 32% for COPD.

be less than one, and vice versa for CMGs with above-average costs. Therefore, RIWs are easy to use metrics of the relative costs of varying patient medical conditions in terms of hospital resources. CMG-specific expected length of stay estimates are reported by CIHI for province and age groupings (CIHI, 2008). The RIW metrics and the expected length of stay estimates are frequently revised to reflect changing health circumstances and costs.

Using the RIW metrics and expected length of stay, the average daily cost of hospital admission can be adjusted to yield an average cost of a hospital admission, by illness, at the provincial level. This is calculated by CIHI's PCE. The raw provincial cost estimates are presented in Appendix C by age group and CMG code. Because physical morbidity estimates are not age specific, we use the estimated average cost of all age groups.[13]

Using the distribution of RHAs by CMG-code from Step 1, we can use the costs estimated by CIHI's PCE (Appendix C) to estimate the costs of a RHA at the provincial level.

4. Adjust provincial estimates by regional health authority cost ratios.

CIHI also reports the average (across all illnesses) cost per weighted case at the regional health authority level in addition to the provincial level (CIHI, 2010f). Using the ratio of average regional health authority inpatient costs to average provincial inpatient costs, we adjust the provincial level, CMG code-specific inpatient cost estimates calculated above to derive a regional estimate. Exhibit 3 provides the adjustment ratios for Toronto, Calgary and Vancouver. In all three cities, the average regional health authority inpatient costs are higher than the provincial average.

Exhibit 3 Provincial-Regional Health Authority Adjustment Ratios

	Provincial Average Inpatient Cost	Regional Health Authority Inpatient Cost	Adjustment Ratio
Toronto	$5,519	$5,928	1.074
Calgary	$6,273	$6,315	1.007
Vancouver	$5,166	$5,714	1.106

It should be noted that these average inpatient estimates reflect the costs incurred by the hospital in providing services only, and do not include physician fees, as physicians are usually paid by the province or health jurisdiction and not by the hospital directly. Therefore, these cost estimates should be interpreted as an underestimate of the total costs of hospital admissions.[14]

Montreal

As noted above, CIHI does not provide Quebec-specific hospital patient costs. Despite the fact that Quebec does submit some data to CIHI, there is not enough specific financial data available that is needed in order to calculate average costs in the PCE for Quebec. However, the ICAP

[13] The impacts of air pollution are generally believed to fall disproportionally on the older population. In addition, as shown in Appendix C, elderly patients tend to have higher hospital admission costs. Consequently, because we use estimated average cost of all age groups, the estimated RHA costs in this report may be an underestimation of the actual RHA costs.

[14] We attempted to fill this informational gap but were unsuccessful mainly due to the difficulty in connecting physician costs to specific hospitals and the unreliability of FTE physician data. As shown later, because the number of increased hospital admissions is relatively low, even if physician costs were a large portion of hospital costs, our final results will not change to a large extent.

model does provide estimates of provincial daily hospital costs for respiratory illnesses using data from 2005-2006 for Quebec and the rest of the provinces.

It is prudent to update the ICAP model's Quebec estimates to account for changing health care costs over time. We adjust these older Quebec estimates by multiplying the Quebec specific estimates in ICAP by the ratio of CIHI's PCE estimated costs for Ontario to the ICAP model's estimated cost for Ontario. Therefore, we assume that Quebec's RHA costs have increased at the same rate as Ontario's RHA costs from 2006 to 2008-2009. In addition, this lack of data does not allow for Montreal specific RHA cost estimates to be made. Instead, provincial estimates are used in this analysis.

2.1.2 Emergency Room Visits

The costs of an emergency room visit have been estimated by Steib et al. (2002) and by CIHI (2010g). Using the same cost of treatment model outlined above (and provided in Appendix B), Steib et al. (2002) estimate the health-care related expenditures associated with a RERV at $930 ($1997).

CIHI (2010g) provides information on the average cost of emergency room visits in Ontario in 2008. It is estimated that seniors' emergency room visit costs for COPD and asthma conditions are $550 and $400, respectively. Using the known relative percentages of COPD and asthma cases for hospital admissions, we can derive an average cost for seniors of an RERV of $480. As our quantified health endpoint is not age specific, we derive an average RERV for the whole population. For all age groups, the average cost of emergency room visits is $260, while the average cost of seniors' emergency room visits is $386. Using this ratio ($260/386), we adjust the senior-specific value of $480 to yield an average RERV for all-age groups of $323. We use this cost of an RERV for Ontario, and information on the relative RHA costs between provinces to provide province-specific costs for the other three provinces.[15] These costs are presented in Exhibit 4 for each of the four provinces.

Exhibit 4 Provincial Emergency Room Visit Costs for Respiratory Illnesses

	Provincial Emergency Room Visit Costs for Respiratory Illnesses ($2008/visit)
Ontario	$323
Quebec	$243
Alberta	$346
British Columbia	$313

2.1.3 Medication Consumption

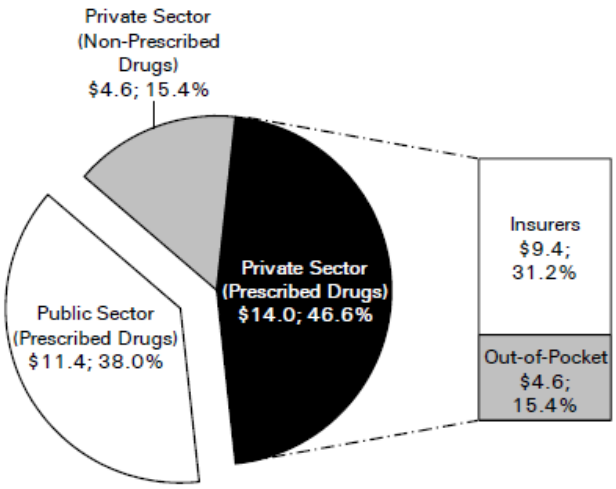
In 2009, medication consumption represented over 16% of total health expenditure in Canada (CIHI, 2010a). Increases in respiratory health endpoints have been found to increase medication consumption (Menichini and Mudu, 2010). For this assessment, public sector medication consumption costs on a per-health endpoint basis are estimated.

[15] For example, the cost of a REV for Quebec is determined as $323*($3,409/$4,541) = $243.

Medication consumption costs are financed by the public sector, individuals and private insurers. Non-prescribed drugs are typically financed out-of-pocket by individuals while prescribed drugs are financed by all three types of payers. In this analysis, because we are estimating the costs to the public health care system, we want to estimate the medication consumption costs that can be attributed to the public sector.

Exhibit 5 summarizes the total amount and distribution of drug costs by type of payer. Overall, the public sector funds 38% of all drug costs while individuals and private insurers fund the remaining 62%.

Exhibit 5 Total Drug Expenditures in Canada by Source of Finance and Type, 2009 ($ billions)



(Source: CIHI, 2010a)

Exhibit 5 presents the total distribution of drug costs by type of payer, but for this study we are interested in the drug costs specific to the quantified morbidity health endpoints. A study of asthma patients' costs in south central Ontario provides information on the total (public and private sector) medication costs incurred by asthma patients (Ungar et al., 1998). These patient-level costs have been manipulated by the Ontario Medical Association (2000) to yield per-illness episode medication costs for use in their ICAP model. In the ICAP model, cost factors were used to scale the average total medication consumption per health endpoint to account for the increased severity and duration of major health end-points (hospital admissions and emergency room visits). The total medication costs attributed to these major health endpoints were then subtracted from the total medication consumption costs. The remaining medication costs were divided by the number of total estimated minor illness cases (restricted activity days + asthma symptom days) to yield the average medication costs of a minor illness. Total medication consumption costs for minor restricted activity days were approximated as half of the amount for minor illnesses. All of the medication consumption costs have been updated in the most recent version of ICAP (Canadian Medical Association, 2008).

Exhibit 6 presents the average total medication costs for the health endpoints included in ICAP.

Exhibit 6: Average Total Medication costs per Health Endpoint from ICAP

($2006)	Hospital Admission	Emergency Room Visit	Minor Illness[a]	Minor Restricted Activity Day	Overall Average
Cost Factor	20	5			
Average Cost/Incident	$546	$136	$17	$8	$27

Notes:
[a] Minor Illness includes restricted activity days and asthma symptom days.
Source: Canadian Medical Association (2008).

ARSDs are an important category of health impacts and contribute to approximately 80% of the total incidence of health endpoints as calculated in the previous report *"Costing Climate Impacts and Adaptation: A Canadian Study on Human Health"*. However, ARSDs are not included in ICAP and therefore, the medication consumption costs were not estimated in ICAP for this health endpoint. Nevertheless, ARSDs have associated medication consumption. Steib et al. (2002) map ARSDs to typical health symptoms and show that approximately 70% of ARSDs are associated with upper respiratory symptoms and 30% with eye irritations. Upper respiratory symptoms include dry cough, cough with phlegm, shortness of breath, chest cold, croup, asthma, bronchitis, flu or pneumonia (Ostro et al, 1993). Medication used to treat acute respiratory symptoms includes eye drops, analgesics (painkillers such as aspirin, ibuprofen, etc), throat lozenges, nose drops and dry skin lotion (United States Environmental Protection Agency, n.d.).

To account for the medication consumption costs of ARSDs, but also to ensure the results are defensible, we use one half of the value of an ASD, $8 per incidence ($2006), as a proxy value for the medication consumption costs of ARSDs. This is consistent with the values used by AQBAT for estimating the WTP. The central WTP to avoid an ARSD is approximately half of the central WTP to avoid an ASD ($16 versus $35). Empirical evidence suggests that for respiratory and cardiovascular illnesses, the value of cost of illness estimates is approximately one half of the WTP estimates to avoid morbidity health endpoints (EPA, 2000). In fact, this may be an underestimate of the true total medication costs. For example, the severity of impacts, in terms of activity levels, is the same for both ARSDs and ASDs. For both of these health endpoints, 90% of cases result in mild limitations and the remaining 10% of cases result in individuals being housebound (Steib et al., 2002).

Now that we have total medication costs per health endpoint, we need to update these values to 2008 Canadian dollars and determine the share of this total medication expenditure that is financed by the public sector. These average medication costs were derived from a 1998 study from Ontario but updated to 2006 dollars. These costs need to be adjusted to account for drug price changes between 2006 and 2008. We use Statistics Canada's consumer price index for medicinal and pharmaceutical products to update the values in Exhibit 6 to 2008 Canadian dollars.

In addition, we want to estimate the public sector's share of the total respiratory medication consumption costs. Therefore, we need to subtract the costs to the private sector from the total respiratory medication consumption costs. The Canadian study by Ungar et al. (1998) considers three perspectives in determining their costs for respiratory medication: societal (total medication consumption costs), Ministry of Health (direct medication costs paid for by the provincially administered health insurance program), and patient (noninsured health

services and out-of-pocket expenses). Ungar et al. (1998) show that the public sector's (Ministry of Health) share of the total respiratory medication consumption costs are 22.3%.[16] We use this percentage to scale the total medication consumption costs to public sector medication consumption costs. [17]

Exhibit 7 presents the total and public sector medication costs per health endpoint, updated to 2008 Canadian dollars. The public sector medication costs in Exhibit 7 are used for all four provinces.

Exhibit 7 Total and Public Sector Medication Costs per Health Endpoint

	Medication Consumption Costs ($2008)	
Health Endpoint	Total	Public Sector
Respiratory Hospital Admissions	$548.14	$122.41
Respiratory Emergency Room Visits	$136.53	$30.49
Acute Respiratory Symptom Days	$8.03	$1.79
Asthma Symptom Days	$17.07	$3.81
Minor Restricted Activity Days	$8.03	$1.79

2.1.4 Doctor's Office Visits

As stated earlier, the relationship between higher levels of air pollution and increased doctor's visits is relatively uncertain (Ontario Medical Association, 2000). The initial version of ICAP did not include estimates of the costs of air pollution on the health endpoints in terms of doctor's office visits because of this lack of information. However, it has been noted that doctor's office visits are an important source of health care costs for cardiorespiratory illnesses, especially for minor illnesses (Canadian Medical Association, 2008).

The inclusion of doctor's office visits was debated during the expert opinion elicitation process undertaken by the Canadian Medical Association (CMA) as part of the continued revision of the ICAP model (Canadian Medical Association, 2008). It was concluded that including this cost category would increase the relevance of the health care cost results. In their technical report, the CMA uses the risk coefficients for acute exposure to air pollution for premature mortality as proxies for the risk coefficients for cardiovascular and respiratory-related causes for doctor's visits. However, the necessary base incidence rate was only collected for Ontario and the lack of a centralized database of doctor's office visits has limited the inclusion of the other provinces. Therefore, the newer version of ICAP has the ability to include the health care costs associated with doctor's office visits in Ontario, but not the other provinces (Canadian Medical Association, 2008).

[16] It is interesting to note that the public share of total medication costs for respiratory drugs is lower than the overall share of total drug expenditures financed by the public sector (shown in Exhibit 5). This suggests that for the respiratory symptoms relating to the health endpoints, the private sector covers a larger percentage of the medication consumption costs relative to all medication consumption costs.

[17] Ungar et al. (1998) present the overall proportion of respiratory medication costs paid by the public sector and they do not show the breakdown of the costs by health endpoint. It is probable that the public sector's share of drug costs would vary across health endpoint. For example, the public sector may pay 50% of the drug costs associated with a RHA, but only 10% of drug costs associated with an ASD. In the absence of more refined data, we use the same proportion of public sector costs, 22.3% of overall medication costs, across all five health endpoints.

To include this important source of health care costs, we used existing information on doctor's office visit rates and costs for Ontario to extrapolate data for the other provinces. In 2008, it is estimated that 260,000 visits to Ontario doctor office visits are associated with air pollution exposure and there were approximately 10,383,000 Ontario cases of respiratory minor illnesses (Canadian Medical Association, 2008). Therefore, on average, for every case 1,000 cases of minor respiratory illnesses, there are approximately 25 doctor's office visits.

We use the ratio between doctor's office visits caused by air pollution to cases of respiratory minor illnesses as reported for Ontario. This ratio is assumed to be the same for the other provinces.

The costs of doctor's office visits for respiratory symptoms have been estimated for Ontario (Ontario Medical Association, 2000). These costs were estimated using physician billing code data in Ontario for 1998-1999 and correspond to the ICD-9 codes relating to respiratory illnesses.[18] For its central estimate, ICAP uses only fee codes that represent the majority of physician's billings for an ICD-9 and assume that each doctor's visit is comprised of only one service. Their calculations result in an average cost per doctor's office visit of $16.56 ($2006) for asthma symptoms and $43.59 ($2006) for acute respiratory symptoms.[19] As they note, these cost estimates excludes multiple-service visits and are therefore likely an underestimation (Ontario Medical Association, 2000).

We adjust these costs to account for increases in doctor's payments by the provincial government over time (between 2006 and 2008) in Ontario. The other three provinces are adjusted based on the average relative cost per service in that province compared to Ontario. For example, in 2009, if the average cost per service in Ontario was $50 a visit and the cost was $45 a visit in British Columbia, we would adjust the figures above by a factor of 90% ($45/$50). Information on physician fees is taken from CIHI data (CIHI, 2010b).

Exhibit 8 presents the provincial costs of a doctor's office visit as well as the costs of doctor's office visits on a per health endpoint basis. We use the latter metric multiplied by the climate-induced increases in ARSD and ASD to determine the incremental costs to the health care system of increased visits to the doctor's office.

Exhibit 8 Provincial Costs of a Doctor's Office Visit

	Costs per Doctor's Office Visit		Costs per Health Endpoint	
	ARSD	ASD	ARSD	ASD
Ontario	$46.78	$17.77	$1.17	$0.44
Quebec	$50.10	$19.03	$1.25	$0.48
Alberta	$62.08	$23.58	$1.55	$0.59
British Columbia	$55.98	$21.27	$1.40	$0.53

Notes: The costs per health endpoint are derived by multiplying the cost per doctor's office visit by the incidence rate of 25 visits per 1,000 minor illnesses

[18] ICD-9 codes are diagnostic code descriptions developed by the International Classification of Diseases and Related Health Problems.

[19] The relatively low costs associated with the average cost of a doctor's office visit for asthma symptoms can be explained by the fact that the vast majority of cases are for renewing prescriptions (Ontario Medical Association, 2000).

2.2 Proposed Comparators

In consultation with the NRTEE, the following two comparators were selected to illustrate the monetary impacts to the health care system:

- Number of full-time equivalent (FTE) family medicine physicians: The cost of the average FTE family medicine physicians is calculated as the average total physician clinical payment per FTE family medicine physician, and
- Number of general duty registered nurses: The cost of the average general duty registered nurse is calculated as the average annual income of a general duty registered nurse.

Exhibit 9 presents the province specific unit costs of the two comparators. All values are reported in 2008 dollars.

Exhibit 9 Province-specific Unit Costs of the Two Comparators

$2008	Total clinical costs per FTE family medicine physician	Average annual income of a general duty registered nurse*
Ontario	$395,430	$69,102
Quebec	$277,314	$50,276
Alberta	$362,037	$71,715
British Columbia	$295,505	$64,777

*Calculated as the average of the minimum and maximum annual incomes of nurses from the four provincial nurse unions.
Source: Family Medicine Physician: CIHI (2010b); General Duty Registered Nurse: Canadian Federation of Nurses Unions (2010).

Using these comparators, one can make statements such as "*the estimated public sector health care costs of climate change on the five morbidity endpoints is equivalent to X number of annual full-time equivalent family medicine physicians, or Y number of general duty registered nurses each year*", something which the general public can identify with.

2.3 Approach to Assessing each City's Current Burden on Provincial Health Care Budget

The exact burden that a Canadian city has on the provincial health care budget is difficult to determine, largely due to number of jurisdictions and payment systems that make up Canada's health care system. While health care cost information is available at the regional health authority level, these expenditures do not cover all public-sector health expenditures directly paid by the provincial government, such as physician fees and those costs incurred by municipal governments.

To provide an estimate of the four cities burden on their respective provincial health care budget, we rely on provincial level estimates of per capita public-sector health expenditures as reported by CIHI (2010e). We multiply per-capita costs by the population of the city to derive the city's expected health care burden. Exhibit 10 shows the per capita public-sector health expenditures, as well as each of the four cities estimated health care burdens. These values are presented to provide context for the health care estimates presented in Section 3.

Exhibit 10 Current City Burdens on the Provincial Health Care Budgets (2008)

$2008	Public-Sector Health Expenditures, per capita	2008 Population (thousands)	Current City Heath Care Burden ($ millions)	Total Provincial Public Heath Care Spending ($ millions)
Toronto	$3,549	5,054	$17,937	$45,888
Montreal	$3,285	3,407	$11,189	$25,459
Calgary	$4,141	1,077	$4,458	$14,847
Vancouver	$3,569	2,081	$7,427	$15,641

Source: CIHI (2010e)

2.4 Escalation of Health Care Costs over Time

Health care costs are increasing in Canada, in real terms and as a percentage of GDP. In 1975, health care costs represented 7.0% of Canada's GDP. By 2009, this percentage had increased to 11.9% (CIHI, 2010e). Therefore, health care costs have experienced an annual increase, as a percentage of GDP, of 0.14% per year over the last 35 years. In the last 10 years, the rate of growth in health care costs, as a percentage of GDP, has accelerated to 0.31% per year.

Although total health care costs are increasing, the direction of change in per health endpoint costs (in real terms) is not clear. On the one hand, real increases in wages and higher costs of newly developed medication and equipment may increase the per health endpoint costs. On the other hand, new technologies and innovations may reduce the costs of providing existing services and care to patients.

There is some empirical evidence on the dynamic nature of per patient costs in Canada that suggests the per health endpoint costs increase in real terms. Time-series data, from 2004-2005 to 2008-2009, on provincial hospital admission costs per patient is available from CIHI (2010f). Using a simple population weighted average for all the provinces (except Quebec), the average cost per weighted case in Canada has increased (in real terms) by 3.4% a year. This percentage increase compares with the average annual increase in Canada's real GDP in the last ten years of 2.1%. Therefore, per patient costs in Canadian hospitals have increased at a rate that is approximately 162% times that of the rate of real GDP growth.

Information at the regional level reveals that the health regions covering the major cities tend to have a lower growth in patient costs relative to the provincial average. For example, the Toronto Central District Health Council per patient cost increased 0.9% per year versus 3.3% for Ontario, the Calgary Health Region the per patient cost increased 4.2% per year versus 4.9% for Alberta, and the Vancouver Coastal Health Authority per patient cost increased 0.6% per year versus 2.5% for British Columbia.

In this report, it is assumed that per health endpoint health care costs increase at the same rate as the real GDP growth rate. Therefore, costs will be higher under the high growth scenario (World Market) relative to the low growth scenario (Local Stewardship). Exhibit 11 shows the percentage increase in real GDP relative to 2008 for the three time-periods.

Exhibit 11 Increase in Real GDP for the Local Stewardship and World Market Scenarios, relative to 2008

	Increase in Real GDP relative to 2008	
	LS	**WM**
2010-2040	7%	49%
2040-2070	44%	212%
2070-2100	78%	548%

3 Health Care Costs Estimates

This section presents the health care cost estimates to the Canadian public health care system, based on the methodology described in Section 2 of this report, and the number of climate change-induced morbidity health impacts in the original study, *"Costing Climate Impacts and Adaptation: A Canadian Study on Human Health".* This section is divided into three sub-sections, including:

1. The unit health care costs in 2008
2. The unit health care costs in the various time-slices (2020s, 2050s and 2080s) and socio-economic (World Markets, Local Stewardship) scenarios.
3. The annual health care cost estimates by morbidity health endpoint and by health care system component for the four cities, three time periods, and two socio-economic and two climate scenarios.

3.1 Unit Health Care Costs in 2008

Exhibit 12 and Exhibit 13 present the unit health care costs in 2008 for Toronto, Montreal, Calgary and Vancouver. As shown, RHAs have the highest unit health care costs, followed by RERVs.

Exhibit 12 Unit Health Care Costs in 2008 for Toronto and Montreal

	Toronto					Montreal				
	RHA	RERV	ARSD	ASD	MRAD	RHA	RERV	ARSD	ASD	MRAD
Hospital Admission	$4,541	-	-	-	-	$3,409	-	-	-	-
Emergency Room Visit	-	$323	-	-	-	-	$243	-	-	-
Medication Consumption	$122	$30	$1.79	$3.81	$1.79	$122	$30	$1.79	$3.81	$1.79
Doctor's Office Visit	-	-	$1.17	$0.44	-	-	-	$1.25	$0.48	-
Total	**$4,664**	**$354**	**$2.96**	**$4.26**	**$1.79**	**$3,532**	**$273**	**$3.05**	**$4.29**	**$1.79**

Exhibit 13 Unit Health Care Costs in 2008 for Calgary and Vancouver

	Calgary					Vancouver				
	RHA	RERV	ARSD	ASD	MRAD	RHA	RERV	ARSD	ASD	MRAD
Hospital Admission	$4,862	-	-	-	-	$4,403	-	-	-	-
Emergency Room Visit	-	$346	-	-	-	-	$313	-	-	-
Medication Consumption	$122	$30	$1.79	$3.81	$1.79	$122	$30	$1.79	$3.81	$1.79
Doctor's Office Visit	-	-	$1.55	$0.59	-	-	-	$1.40	$0.53	-
Total	**$4,984**	**$377**	**$3.35**	**$4.40**	**$1.79**	**$4,525**	**$344**	**$3.19**	**$4.34**	**$1.79**

3.2 Unit Health Care Costs in the 2020s, 2050s and 2080s

Exhibit 14, Exhibit 15, Exhibit 16, Exhibit 17 present the unit health care costs in the 2020s, 2050s and 2080s for Toronto, Montreal, Calgary and Vancouver and for both socio-economic scenarios (Local Stewardship and World Market). Unit health care costs increase in real terms throughout the three time periods. Because of the differences in real GDP increases, the unit health care costs are higher under the WM scenario relative to the LS scenario.

Exhibit 14 Unit Health Care Costs in 2020s, 2050s and 2080s for Toronto

Unit Health Care System Cost Components ($2008)	Toronto							
	2008		2020s		2050s		2080s	
	LS	WM	LS	WM	LS	WM	LS	WM
Acute Respiratory Symptom Days	$2.96	$2.96	$3.16	$4.43	$4.27	$9.26	$5.27	$19.21
Asthma Symptom Days	$4.26	$4.26	$4.53	$6.36	$6.13	$13.30	$7.57	$27.59
Minor Restricted Activity Days	$1.79	$1.79	$1.91	$2.68	$2.59	$5.60	$3.19	$11.63
Respiratory Emergency Room Visits	$354	$354	$377	$529	$510	$1,105	$629	$2,294
Respiratory Hospital Admissions	$4,664	$4,664	$4,967	$6,968	$6,722	$14,571	$8,293	$30,232

Exhibit 15 Unit Health Care Costs in 2020s, 2050s and 2080s for Montreal

Unit Health Care System Cost Components ($2008)	Montreal							
	2008		2020s		2050s		2080s	
	LS	LS	LS	LS	LS	LS	LS	LS
Acute Respiratory Symptom Days	$3.05	$3.05	$3.24	$4.55	$4.39	$9.52	$5.42	$19.75
Asthma Symptom Days	$4.29	$4.29	$4.57	$6.41	$6.18	$13.39	$7.62	$27.79
Minor Restricted Activity Days	$1.79	$1.79	$1.91	$2.68	$2.59	$5.60	$3.19	$11.63
Respiratory Emergency Room Visits	$273	$273	$291	$408	$394	$854	$486	$1,771
Respiratory Hospital Admissions	$3,532	$3,532	$3,762	$5,277	$5,091	$11,035	$6,280	$22,894

Exhibit 16 Unit Health Care Costs in 2020s, 2050s and 2080s for Calgary

Unit Health Care System Cost Components ($2008)	Calgary							
	2008		2020s		2050s		2080s	
	LS	WM	LS	WM	LS	WM	LS	WM
Acute Respiratory Symptom Days	$3.35	$3.35	$3.56	$5.00	$4.82	$10.45	$5.95	$21.69
Asthma Symptom Days	$4.40	$4.40	$4.69	$6.58	$6.34	$13.75	$7.83	$28.53
Minor Restricted Activity Days	$1.79	$1.79	$1.91	$2.68	$2.59	$5.60	$3.19	$11.63
Respiratory Emergency Room Visits	$377	$377	$401	$563	$543	$1,177	$670	$2,441
Respiratory Hospital Admissions	$4,984	$4,984	$5,309	$7,447	$7,184	$15,572	$8,862	$32,309

Exhibit 17 Unit Health Care Costs in 2020s, 2050s and 2080s for Vancouver

Unit Health Care System Cost Components ($2008)	Vancouver							
	2008		2020s		2050s		2080s	
	LS	WM	LS	WM	LS	WM	LS	WM
Acute Respiratory Symptom Days	$3.19	$3.19	$3.40	$4.77	$4.60	$9.98	$5.68	$20.70
Asthma Symptom Days	$4.34	$4.34	$4.63	$6.49	$6.26	$13.57	$7.72	$28.15
Minor Restricted Activity Days	$1.79	$1.79	$1.91	$2.68	$2.59	$5.60	$3.19	$11.63
Respiratory Emergency Room Visits	$344	$344	$366	$514	$496	$1,075	$612	$2,230
Respiratory Hospital Admissions	$4,525	$4,525	$4,820	$6,761	$6,522	$14,138	$8,046	$29,334

3.3 Annual Health Care Cost Estimates

Using the results summarized in Section 3.2 and the physical morbidity estimates from Exhibit 20 in the original report (presented in Appendix D), we estimate each city's annual health care cost estimates for each of the 30 year time periods (2020s, 2050s, 2080s), socio-economic scenarios (Local Stewardship, World Markets) and climate scenarios (A2, B1).

Exhibit 18 presents the annual health care system cost by health endpoint. For all cities, time periods and socio-economic and climate scenarios, ARSDs are associated with approximately 70% of the total public sector health care costs. Although the per health endpoint health care costs are low relative to the other health endpoints, as noted earlier, ARSDs represent approximately 80% of the total incidence of quantified morbidity health endpoints. Therefore, it is not surprising that this health endpoint constitutes the majority of public sector health care costs. ASDs and RHAs are the second and third largest contributors to public sector health care costs, respectively, followed by MRADs and RERVs.

Exhibit 19 presented these annual costs by health care system component. Medication consumption comprises approximately 55 to 60% of the total public health care system cost, depending on the city, time period and scenario. The next largest contributor to public sector health care costs is doctor's office visits, followed by hospital admissions and then emergency room visits. The main reason medication consumption costs represent such a large proportion of total public health care costs is the costs associated with ARSDs. As noted in the previous paragraph, ARSDs make up 70% of total public health care costs and medication costs cover 60% of ARSD costs.

Exhibit 18 Health Care Cost Estimates by Morbidity Health Endpoint

Annual Health Care Costs 2020s ($000s)	Toronto				Montreal				Calgary				Vancouver			
	A2		B1		A2		B1		A2		B1		A2		B1	
	LS	WM	LS	WM	LS	WM	LS	WM	LS	WM	LS	WM	LS	WM	LS	WM
Acute Respiratory Symptom Days	$1,023	$1,483	$886	$1,285	$780	$1,131	$662	$959	$220	$319	$220	$319	$673	$976	$673	$976
Asthma Symptom Days	$217	$314	$188	$272	$162	$235	$137	$199	$43	$62	$43	$62	$135	$196	$135	$196
Minor Restricted Activity Days	$57	$83	$49	$72	$42	$61	$36	$52	$11	$16	$11	$16	$35	$51	$35	$51
Respiratory Emergency Room Visits	$38	$56	$34	$49	$24	$34	$20	$29	$7	$10	$7	$10	$24	$34	$24	$34
Respiratory Hospital Admissions	$169	$244	$144	$209	$102	$148	$87	$121	$32	$45	$32	$45	$101	$149	$101	$149
Total	**$1,504**	**$2,179**	**$1,301**	**$1,886**	**$1,110**	**$1,609**	**$942**	**$1,361**	**$312**	**$451**	**$312**	**$451**	**$969**	**$1,406**	**$969**	**$1,406**

Annual Health Care Costs 2050s ($000s)	Toronto				Montreal				Calgary				Vancouver			
	A2		B1		A2		B1		A2		B1		A2		B1	
	LS	WM	LS	WM	LS	WM	LS	WM	LS	WM	LS	WM	LS	WM	LS	WM
Acute Respiratory Symptom Days	$3,121	$7,565	$2,147	$5,203	$2,419	$5,864	$1,702	$4,125	$638	$1,546	$459	$1,112	$1,600	$3,878	$1,319	$3,198
Asthma Symptom Days	$663	$1,608	$456	$1,104	$504	$1,222	$354	$858	$124	$301	$89	$216	$322	$782	$266	$644
Minor Restricted Activity Days	$174	$422	$120	$290	$131	$318	$92	$224	$32	$76	$23	$55	$83	$201	$68	$166
Respiratory Emergency Room Visits	$118	$287	$82	$198	$74	$178	$52	$125	$21	$51	$15	$36	$57	$136	$46	$113
Respiratory Hospital Admissions	$511	$1,239	$350	$845	$311	$761	$219	$530	$93	$218	$65	$156	$241	$594	$202	$481
Total	**$4,588**	**$11,121**	**$3,153**	**$7,641**	**$3,439**	**$8,343**	**$2,419**	**$5,862**	**$907**	**$2,192**	**$650**	**$1,575**	**$2,303**	**$5,591**	**$1,901**	**$4,600**

Annual Health Care Costs 2080s ($000s)	Toronto				Montreal				Calgary				Vancouver			
	A2		B1		A2		B1		A2		B1		A2		B1	
	LS	WM	LS	WM	LS	WM	LS	WM	LS	WM	LS	WM	LS	WM	LS	WM
Acute Respiratory Symptom Days	$7,555	$30,621	$4,036	$16,359	$5,872	$23,800	$3,124	$12,660	$1,420	$5,753	$818	$3,314	$3,382	$13,709	$2,179	$8,832
Asthma Symptom Days	$1,612	$6,533	$857	$3,475	$1,229	$4,980	$650	$2,636	$277	$1,123	$159	$645	$684	$2,771	$439	$1,779
Minor Restricted Activity Days	$422	$1,711	$225	$913	$319	$1,294	$170	$687	$70	$285	$40	$164	$175	$711	$113	$458
Respiratory Emergency Room Visits	$288	$1,163	$153	$619	$178	$724	$95	$384	$46	$188	$27	$110	$119	$484	$76	$310
Respiratory Hospital Admissions	$1,236	$5,018	$663	$2,691	$760	$3,068	$402	$1,626	$204	$808	$115	$452	$515	$2,083	$330	$1,349
Total	**$11,113**	**$45,047**	**$5,935**	**$24,057**	**$8,358**	**$33,866**	**$4,440**	**$17,993**	**$2,017**	**$8,157**	**$1,159**	**$4,685**	**$4,876**	**$19,758**	**$3,137**	**$12,728**

Exhibit 19 Health Care Cost Estimates by Health Care System Component

Annual Health Care Costs 2020s ($000s)	Toronto				Montreal				Calgary				Vancouver			
	A2		B1		A2		B1		A2		B1		A2		B1	
	LS	WM	LS	WM	LS	WM	LS	WM	LS	WM	LS	WM	LS	WM	LS	WM
Hospital Admission	$164	$237	$140	$204	$98	$143	$84	$117	$31	$44	$31	$44	$98	$145	$98	$145
Emergency Room Visit	$35	$51	$31	$44	$21	$30	$18	$26	$7	$9	$7	$9	$22	$31	$22	$31
Medication Consumption	$878	$1,273	$761	$1,103	$652	$945	$553	$801	$167	$242	$167	$242	$537	$778	$537	$778
Doctor's Office Visit	$426	$618	$369	$535	$339	$491	$287	$417	$108	$156	$108	$156	$312	$452	$312	$452
Total	**$1,504**	**$2,179**	**$1,301**	**$1,886**	**$1,110**	**$1,609**	**$942**	**$1,361**	**$312**	**$451**	**$312**	**$451**	**$969**	**$1,406**	**$969**	**$1,406**

Annual Health Care Costs 2050s ($000s)	Toronto				Montreal				Calgary				Vancouver			
	A2		B1		A2		B1		A2		B1		A2		B1	
	LS	WM	LS	WM	LS	WM	LS	WM	LS	WM	LS	WM	LS	WM	LS	WM
Hospital Admission	$497	$1,206	$340	$823	$300	$735	$211	$511	$91	$213	$63	$152	$235	$578	$197	$468
Emergency Room Visit	$108	$263	$75	$181	$65	$158	$46	$111	$19	$47	$13	$34	$52	$124	$42	$103
Medication Consumption	$2,681	$6,499	$1,843	$4,468	$2,023	$4,904	$1,423	$3,448	$485	$1,175	$349	$845	$1,276	$3,094	$1,052	$2,549
Doctor's Office Visit	$1,301	$3,154	$895	$2,169	$1,051	$2,547	$739	$1,791	$312	$757	$225	$545	$741	$1,796	$611	$1,480
Total	**$4,588**	**$11,121**	**$3,153**	**$7,641**	**$3,439**	**$8,343**	**$2,419**	**$5,862**	**$907**	**$2,192**	**$650**	**$1,575**	**$2,303**	**$5,591**	**$1,901**	**$4,600**

Annual Health Care Costs 2080s ($000s)	Toronto				Montreal				Calgary				Vancouver			
	A2		B1		A2		B1		A2		B1		A2		B1	
	LS	WM	LS	WM	LS	WM	LS	WM	LS	WM	LS	WM	LS	WM	LS	WM
Hospital Admission	$1,203	$4,887	$646	$2,620	$734	$2,962	$388	$1,569	$199	$788	$112	$441	$501	$2,026	$321	$1,313
Emergency Room Visit	$263	$1,063	$140	$566	$158	$644	$84	$341	$42	$173	$25	$101	$109	$441	$70	$282
Medication Consumption	$6,497	$26,330	$3,467	$14,051	$4,916	$19,922	$2,612	$10,584	$1,080	$4,377	$622	$2,519	$2,700	$10,943	$1,738	$7,044
Doctor's Office Visit	$3,150	$12,768	$1,683	$6,819	$2,551	$10,339	$1,357	$5,498	$696	$2,819	$401	$1,624	$1,566	$6,348	$1,009	$4,089
Total	**$11,113**	**$45,047**	**$5,935**	**$24,057**	**$8,358**	**$33,866**	**$4,440**	**$17,993**	**$2,017**	**$8,157**	**$1,159**	**$4,685**	**$4,876**	**$19,758**	**$3,137**	**$12,728**

4 Summary, Limitations and Assumptions

The objective of this annex was to estimate the public sector health care costs associated with the previously quantified climate-induced increase in morbidity health endpoints associated with increased ozone concentration levels. The results estimated in this report suggest that climate change impacts will increase the public sector health care costs associated with the five respiratory and cardiovascular morbidity health endpoints.[20] In addition, the results suggest that the majority of total public sector health care costs are caused by the large number of symptom days, even though the per incidence cost is low. This is in comparison to the relatively small number of incidences of the much more costly health endpoints such as RERVs and RHAs.
There are several limitations of this report. First, there are burdens that the quantified health endpoints have on the health care system (such as respiratory therapists) that were not monetized in this report due to lack of data. Second, physician costs associated with hospital admissions and emergency room visits were not included in the cost estimates (due to lack of data). Both of these limitations cause the cost results to likely be underestimations of the actual costs to the public health care system. Third, the estimates for medication consumption costs, although updated to 2008 Canadian dollars, come from a primary study conducted in Ontario in the mid 1990s. Because medication consumption costs are such a large portion of overall public sector costs, using more recent medication consumption data sources (from all of the provinces considered in this report) would provide more up-to-date and geographically representative cost estimates.

Two of the most significant assumptions are made in regards to 1) medication consumption costs for ARSDs and 2) the escalation of costs over time. The assumption regarding the medication consumption costs of ARSDs, although conservative, is uncertain. While more primary research is needed to yield a more precise drug cost estimate of ARSDs, the values used in this report are the most defensible estimate given the available information. The second assumption, regarding how the health care costs change into the future, is also uncertain and has a large impact on the results, especially for the 2050s and 2080s results. If real unit health care costs increase faster than the increase in real GDP, and there is some evidence to support this (as presented in Section 2.4), then the public sector health care costs estimated in this report will be an underestimate. Clearly, the opposite is true if real unit health care costs increase at a rate less than the increase in real GDP. Most likely, there will probably be periods where real unit health care costs rise faster than the increase in real GDP and periods where they rise slower as the factors influencing unit health care costs may not change at constant rates (due to such things as technology, real wages of health care professionals, government funding etc).

[20] It is worth stating again that the cost estimates exclude and health care costs associated with ozone-related mortality.

Appendix A References

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Appendix B Cost of Treatment Model (Steib et al., 2002)

Steib et al. (2002) provide information on variable description and the model.

Variable Name	Variable Description	Parameter Estimate ($)	Standard Error ($)
$V_{COT} = \alpha + \beta_{AS}AS + \beta_{CHF}CHF + \beta_{D}D + \beta_{CC}CC + \beta_{NCC}NCC + \beta_{AS*D}AS*D + \beta_{RI*D}RI*D + \beta_{MIA*D}MIA*D + \beta_{RI*CC}RI*CC + \beta_{DYS*CC}DYS*CC$			
Intercept	Intercept term	348.58	90.71
AS	Dummy variable for diagnosis of asthma (0,1)	440.33	125.97
CHF	Dummy variable for diagnosis of congestive heart failure (0,1)	1680.09	406.92
D	Total duration of disease episode (days)	31.70	7.85
CC	Dummy variable for admission to hospital in critical care unit (0,1)	4530.36	176.20
NCC	Dummy variable for admission to hospital in non-critical care unit (0,1)	1977.94	163.67
AS*D	Interaction term (see variable definitions above)	-27.71	9.17
RI*D	Interaction term where RI is a dummy variable for diagnosis of respiratory infection (0,1)	-29.02	8.07
MIA*D	Interaction term where MIA is a dummy variable for diagnosis of myocardial infarction/angina (0,1)	-30.54	14.50
RI*CC	Interaction term (see variable definitions above)	-1544.58	538.12
DYS*CC	Interaction term where DYS is a dummy variable for diagnosis of dysrhythmia (0,1)	-2402.73	906.97
AS*NCC	Interaction term (see variable definitions above)	-431.01	272.89
MIA*NCC	Interaction term (see variable definitions above)	1180.79	301.74
CHF*NCC	Interaction term (see variable definitions above)	-2158.82	539.88

Appendix C Patient Cost Estimator Estimates

Exhibit 20 Patient Cost Estimator Results for Ontario for Three Respiratory Illnesses (2008-2009, CIHI (2010c))

Case Mix Group (CMG)		Age Group Metrics	Estimated Average Cost	Estimated Average Cost (all Age Groups)	Average Acute LOS	Volume
139	Chronic Obstructive Pulmonary Disease	29-364 Days (Paediatric)	$3,792	$6,561	2.3	**
		1-7 Years (Paediatric)	$3,914	$6,561	4.0	**
		8-17 Years (Paediatric)	$3,716	$6,561	5.0	**
		18-59 Years (Adult)	$6,317	$6,561	5.5	2,561
		60-79 Years (Adult)	$6,305	$6,561	6.4	10,813
		80+ Years (Adult)	$7,097	$6,561	7.0	6,350
141	Upper/Lower Respiratory Infection	29-364 Days (Paediatric)	$3,552	$3,592	2.7	1,947
		1-7 Years (Paediatric)	$3,028	$3,592	2.1	827
		8-17 Years (Paediatric)	$3,734	$3,592	2.7	27
		18-59 Years (Adult)	$3,956	$3,592	3.6	145
		60-79 Years (Adult)	$4,338	$3,592	4.2	233
		80+ Years (Adult)	$4,877	$3,592	5.4	244
147	Asthma	29-364 Days (Paediatric)	$2,250	$2,470	2.0	281
		1-7 Years (Paediatric)	$1,996	$2,470	1.7	2,448
		8-17 Years (Paediatric)	$2,094	$2,470	2.0	521
		18-59 Years (Adult)	$2,837	$2,470	3.0	1,350
		60-79 Years (Adult)	$3,660	$2,470	4.3	476

Source: CIHI (2010c)

Exhibit 21 Patient Cost Estimator Results for Alberta for Three Respiratory Illnesses (2008-2009)

Case Mix Group (CMG)		Age Group Metrics	Estimated Average Cost	Estimated Average Cost (all Age Groups)	Average Acute LOS	Volume
139	Chronic Obstructive Pulmonary Disease	1-7 Years (Paediatric)	$5,323	$6,934	2.0	**
		8-17 Years (Paediatric)	$10,369	$6,934	6.0	**
		18-59 Years (Adult)	$6,304	$6,934	6.2	719
		60-79 Years (Adult)	$6,897	$6,934	7.2	2,742
		80+ Years (Adult)	$7,305	$6,934	7.9	1,464
141	Upper/Lower Respiratory Infection	29-364 Days (Paediatric)	$5,030	$4,551	3.3	1,045
		1-7 Years (Paediatric)	$3,423	$4,551	2.5	409
		8-17 Years (Paediatric)	$4,497	$4,551	2.3	26
		18-59 Years (Adult)	$3,652	$4,551	3.5	98
		60-79 Years (Adult)	$4,693	$4,551	4.5	85
		80+ Years (Adult)	$5,060	$4,551	5.6	76
147	Asthma	29-364 Days (Paediatric)	$2,490	$2,821	2.1	44

Case Mix Group (CMG)	Age Group Metrics	Estimated Average Cost	Estimated Average Cost (all Age Groups)	Average Acute LOS	Volume
	1-7 Years (Paediatric)	$2,274	$2,821	1.8	544
	8-17 Years (Paediatric)	$2,526	$2,821	2.3	172
	18-59 Years (Adult)	$3,388	$2,821	3.4	343
	60-79 Years (Adult)	$4,232	$2,821	5.2	69
	80+ Years (Adult)	$4,982	$2,821	6.8	33

Source: CIHI (2010c)

Exhibit 22 Patient Cost Estimator Results for British Columbia for Three Respiratory Illnesses
(2008-2009)

Case Mix Group (CMG)		Age Group Metrics	Estimated Average Cost	Estimated Average Cost (all Age Groups)	Average Acute LOS	Volume
139	Chronic Obstructive Pulmonary Disease	1-7 Years (Paediatric)	$3,844	$5,960	2.5	**
		8-17 Years (Paediatric)	$3,479	$5,960	1.0	**
		18-59 Years (Adult)	$5,177	$5,960	5.4	903
		60-79 Years (Adult)	$5,968	$5,960	6.7	3,622
		80+ Years (Adult)	$6,278	$5,960	7.6	2,154
141	Upper/Lower Respiratory Infection	29-364 Days (Paediatric)	$3,527	$3,498	2.8	772
		1-7 Years (Paediatric)	$3,015	$3,498	2.5	311
		8-17 Years (Paediatric)	$2,817	$3,498	1.8	11
		18-59 Years (Adult)	$3,023	$3,498	3.7	76
		60-79 Years (Adult)	$4,059	$3,498	4.7	109
		80+ Years (Adult)	$4,602	$3,498	6.2	100
147	Asthma	29-364 Days (Paediatric)	$2,044	$2,407	2.2	74
		1-7 Years (Paediatric)	$1,821	$2,407	1.7	540
		8-17 Years (Paediatric)	$1,952	$2,407	2.1	100
		18-59 Years (Adult)	$2,785	$2,407	2.8	398
		60-79 Years (Adult)	$3,408	$2,407	4.1	164
		80+ Years (Adult)	$3,918	$2,407	5.4	49

Source: CIHI (2010c)

Appendix D Annual Cardiovascular and Respiratory Morbidity Impacts due to Climate-Induced Increases in Ozone Concentrations

Exhibit 23 Annual Cardiovascular and Respiratory Morbidity Impacts due to Climate-Induced Increases in Ozone Concentrations

Annual cases 2020s	Toronto				Montreal				Calgary				Vancouver			
	A2		B1		A2		B1		A2		B1*		A2		B1*	
	LS	WM	LS	WM	LS	WM	LS	WM	LS	WM	LS	WM	LS	WM	LS	WM
Acute Respiratory Symptom Days	324,089	334,892	280,810	290,170	240,456	248,471	203,961	210,759	61,699	63,756	61,699	63,756	197,978	204,577	197,978	204,577
Asthma Symptom Days	47,826	49,420	41,424	42,805	35,494	36,677	30,093	31,096	9,103	9,406	9,103	9,406	29,256	30,231	29,256	30,231
Minor Restricted Activity Days	29,858	30,853	25,867	26,730	22,155	22,893	18,789	19,416	5,684	5,873	5,684	5,873	18,247	18,855	18,247	18,855
Respiratory Emergency Room Visits**	102	106	89	92	81	83	69	72	18	18	18	18	65	67	65	67
Respiratory Hospital Admissions	34	35	29	30	27	28	23	23	6	6	6	6	21	22	21	22

* For these scenarios, the B1 temperature signals indicated higher temperature changes than the associated A2 temperature signals. This was due to unusually high mean temperatures for winter months in the GCM model output data. As it was considered not intuitively likely that SRES B1 scenario have faster warming than the SRES A2 scenario, B1 temperature changes were considered equal to those of the A2 temperature changes, for this time period only. These anomalies were not observed in future time periods.

** In the original report, Respiratory Hospital Admissions were included in the total of Respiratory Emergency Room Visits. For our purposes, we need to net out the Respiratory Hospital Admissions from Respiratory Emergency Room Visits.

Annual cases 2050s	Toronto				Montreal				Calgary				Vancouver			
	A2		B1		A2		B1		A2		B1		A2		B1	
	LS	WM	LS	WM	LS	WM	LS	WM	LS	WM	LS	WM	LS	WM	LS	WM
Acute Respiratory Symptom Days	730,786	817,151	502,656	562,061	551,003	616,121	387,643	433,456	132,266	147,898	95,155	106,400	347,683	388,773	286,638	320,513
Asthma Symptom Days	108,161	120,944	74,263	83,040	81,594	91,237	57,297	64,068	19,569	21,881	14,057	15,718	51,513	57,601	42,418	47,431
Minor Restricted Activity Days	67,389	75,353	46,326	51,800	50,819	56,824	35,731	39,954	12,195	13,637	8,769	9,806	32,072	35,862	26,431	29,554
Respiratory Emergency Room Visits**	232	260	160	179	187	208	131	147	38	43	27	31	114	127	93	105
Respiratory Hospital Admissions	76	85	52	58	61	69	43	48	13	14	9	10	37	42	31	34

Annual cases 2080s	Toronto				Montreal				Calgary				Vancouver			
	A2		B1		A2		B1		A2		B1		A2		B1	
	LS	WM	LS	WM	LS	WM	LS	WM	LS	WM	LS	WM	LS	WM	LS	WM
Acute Respiratory Symptom Days	1,434,069	1,594,283	766,124	851,715	1,084,196	1,205,322	576,714	641,144	238,640	265,301	137,459	152,816	595,772	662,332	383,819	426,699
Asthma Symptom Days	213,042	236,843	113,313	125,972	161,200	179,209	85,334	94,867	35,412	39,368	20,326	22,596	88,542	98,433	56,842	63,192
Minor Restricted Activity Days	132,398	147,189	70,632	78,523	100,123	111,309	53,177	59,117	22,024	24,485	12,672	14,088	55,010	61,156	35,400	39,355
Respiratory Emergency Room Visits**	457	507	243	270	367	409	195	217	69	77	40	45	195	217	125	139
Respiratory Hospital Admissions	149	166	80	89	121	134	64	71	23	25	13	14	64	71	41	46

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