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Economic burden of cardiomyopathy in Canada 2018 to 2021: opportunity for cost avoidance through pharmaceutical innovation.

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ABSTRACT

This study estimated the economic burden of illness associated with cardiomyopathy (CM), by hospital cost, productivity loss, mortality cost, and pharmaceutical costs over 4 years from 2018-2021, using data from the Canadian Institute for Health Information (CIHI) and Patented Medicine Prices Review Board (PMPRB). CM encompasses a group of genetic degenerative cardiac disorders, with limited preventative options. Pharmaceuticals are often first line treatments for CM including ACE inhibitors, beta-blockers, calcium channel blockers, antiarrhythmic drugs, anticoagulants, digoxin, and a new drug class known as cardiac myosin inhibitors. If pharmacological therapy is ineffective, surgical options include septal myectomy (SM) and alcohol septal ablation (ASA), and often CM patients are eligible for cardiac implantable electronic devices (CIED). CM can be associated with cardiac co-morbidities that may require other surgical interventions including coronary artery bypass graft (CABG). In 2021 CM-related costs ranged from $3.2 billion to $5.1 billion. The total economic burden of illness associated with CM over the 4 years ranged from $11.2 billion to $18.1 billion. Mortality accounted for 88% to 90% of the total cost. While hospital cost accounted for 6.8% to 7.1%, pharmaceuticals cost from 3.8% to 2.4%, and productivity losses from 1% to 2.4%. Patented innovative medicines accounted for less than 1% of the total estimated CM related economic cost. As a first line outpatient therapy, pharmaceuticals offer an opportunity for treating CM and reducing downstream hospital utilization, productivity losses, and mortalities. The magnitude of the economic burden suggests that any pharmaceutical innovation leading to improved CM patient outcomes, has the potential to achieve significant cost avoidance. Facilitating development and early adoption of new medicines should be a policy priority.

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INTRODUCTION

Cardiovascular disease

Cardiovascular (or heart) disease (CVD) is the second leading cause of death in Canada, accounting for 53,704 of the 307,205 fatalities reported in 2020.[1] According to 2017–2018 data from the Canadian Chronic Disease Surveillance System (CCDSS) about 1 in 12 (or 2.6 million) Canadian adults aged 20 and over live with diagnosed heart disease. According to one recent study, heart diseases accounted for 271,072 hospitalizations in Canada in 2016.[2]

Heart disease includes several conditions of varying severity including angina, atrial fibrillation, arrhythmia, atherosclerosis, cardiac arrest, cardiomyopathy, congenital heart disease, coronary artery disease, enlarged heart, heart attack, heart block, heart failure, infective (bacterial) endocarditis, inherited rhythm disorders, long Q-T syndrome, Marfan syndrome, pericarditis, rheumatic heart disease, spontaneous coronary artery dissection, and valvular heart disease.

For most patients with heart disease, symptoms are manageable using pharmacological therapies including ACE inhibitors, aldosterone antagonists, angiotensin receptor blockers (ARB), antiarrhythmics, anticoagulants, antiplatelets, beta-blockers, calcium channel blockers, cholesterol absorption inhibitors, digoxin, diuretics, fibrates, ivabradine, niacin, nitrates, resins, statins, and warfarin. Pharmaceuticals are often first line treatments, but if pharmacological therapy is ineffective, surgery and/or other procedures are often performed. Pharmaceutical therapy often accompanies surgical treatment. Surgeries to treat heart disease include ablation, angioplasty, atherectomy, coronary artery bypass graft (CABG), heart transplant, heart valve repair or replacement, percutaneous coronary intervention, and ventricular resection. Other types of surgical interventions include procedures using cardiac implantable electronic devices (CIED) such as cardiac resynchronization therapy (CRT), implantable cardioverter defibrillators (ICD), implantable pacemakers, and mechanical assist devices.[3]

Cardiomyopathy

This study focused on the cardiomyopathy (CM) subtype of CVD. CM encompasses a group of genetic degenerative cardiac disorders, with limited preventative options. Types include hypertrophic cardiomyopathy (HCM), obstructive hypertrophic cardiomyopathy (OHCM), dilated cardiomyopathy (DCM), peripartum cardiomyopathy (PPCM), restrictive cardiomyopathy (RCM), transthyretin amyloid cardiomyopathy (ATTR-CM), and arrhythmogenic right ventricular dysplasia (ARVD).

HCM is characterized by the thickening of the left ventricle, which reduces blood flow, causing ventricular and supraventricular arrhythmias, atrial fibrillation, non-sustained ventricular tachycardia, heart failure, stroke, and rarely sudden cardiac death. Estimates of the prevalence of HCM range from 1:500 (0.2%) to 1:200 (0.5%). From 70–75% of HCM patients are diagnosed with the more severe form OHCM. Recent research comparing mortality rates between HCM and non-HCM patients, found that the HCM group had higher all-cause (8.3% versus 5.3%), HCM-related (1.6% versus 0.6%), and other cardiovascular mortalities (0.8% versus 0.5%). DCM is characterized by malfunction of ventricles, causing arrhythmias and heart failure with an estimated prevalence of 1:2500. PPCM is a rare cause of cardiomyopathy that occurs during late pregnancy or in the early postpartum period and is characterized by significant left ventricular dysfunction and heart failure. RCM is characterized by diastolic dysfunction, and accounts for approximately 5% of all cases of cardiomyopathy. ATTR-CM is a rare but severe cause of restrictive cardiomyopathy, associated with heart failure or conduction system disease. ARVD is characterized by impaired systolic function and its prevalence ranges from 1:1000 to 1:5000.[4,5,6,7,8,9,10,11]

Pharmaceutical treatments for CM include ACE inhibitors, beta-blockers, calcium channel blockers, antiarrhythmic drugs, anticoagulants, digoxin, and a new drug class known as cardiac myosin inhibitors.[12] If pharmacological therapy is ineffective, surgical options include septal myectomy (SM) and alcohol septal ablation (ASA). Septal myectomy is a highly specialized cardiac operation regarded as the most effective treatment for patients with OHCM and drug-refractory symptoms. In the mid-1990s, percutaneous (catheter-based, less invasive) alcohol septal ablation was introduced as an alternative to SM in patients with OHCM. ASA requires a shorter hospital and recovery time than other surgeries and is associated with less postoperative disability. However, both these procedures are invasive and require surgeons with high volume experience as they are associated with high risk of morbidity and mortality, particularly in low-volume surgical centers. [13] CM can be associated with other cardiac co-morbidities that may require other surgical interventions including coronary artery bypass graft (CABG). Often CM patients are eligible for cardiac implantable electric devices (CIED).[14,15]

Policy issue

According to the most recent research, the economic burden of illness associated with cardiovascular disease in Canada was estimated to be $21.2 billion in 2004.[16] Adjusting for changes in the Consumer Price Index since 2004, the cost in 2022 was $28.7 billion.

As a first line outpatient therapy, pharmaceuticals offer an opportunity to avoid some of the downstream economic costs associated with CVD. Previous innovation in pharmaceutical therapies has improved CVD health outcomes reducing the need for expensive surgical interventions. A 2009 study of 1100 cardiovascular drugs in 20 OECD countries found that pharmaceutical innovation was associated with a 70% reduction of per capita expenditure on cardiovascular hospital stays during 1995-2004.[17] Other research has shown that in the United States, the introduction of statins led to an 11% reduction in total cardiovascular disease related healthcare costs.[18]

However, innovation in the treatment of heart disease has slowed in recent years with declining trends in the development of new pharmaceutical therapies.[19] The trend might be turning with the emergence of cardiac myosin inhibitors.[20], [21] Unfortunately, federal and provincial publicly funded drug insurance programs are reluctant to cover new medicines as soon as they are available, and sometimes not at all.[22] Facilitating the development and early adoption of new medicines should be a policy priority. Barriers to utilization of innovative pharmaceutical treatments are likely to result in significant opportunity costs, i.e. lost savings that would have otherwise accrued from reduced hospital utilization, productivity loss, and mortality costs.

In the field of research on the economic burden of illness, cardiomyopathy is a relatively understudied subtype of CVD. To demonstrate the magnitude of the potential for cost avoidance through pharmaceutical innovation, this study estimated the hospital expenditure, drugs cost, productivity loss, and mortality related cost associated with reported CM cases. To the author's knowledge, this study represents the first attempt to estimate the economic burden of illness associated with cardiomyopathy in Canada.

UTILIZATION STATISTICS

The analysis used anonymized aggregate data purchased from CIHI's Discharge Abstract Database (DAD) and National Ambulatory Care Reporting System (NACRS), which included case counts of hospital discharges (hospitalizations) for CM diagnoses (primary or secondary) and the associated average resource intensity weight (RIW), average length of stay (LOS in days or hours which were converted to days), average patient age, number of in-hospital deaths, and the number of surgical procedures performed for ASA, SM, CIED, and CABG for each of the fiscal years 2018-19 to 2021-22. The data were requested separately for each CM diagnoses type, but while CIHI collects such data, it would only supply the data grouped across all CM types. **TABLE 1** shows the relevant ICD-10-CA diagnostic and CCI procedure codes verified by CIHI to correspond to the data requested, with descriptions provided by CIHI.

TABLE 1. Diagnosis and Intervention Codes.

ICD-10-CA Codes	Descriptions
I42.1	Obstructive hypertrophic cardiomyopathy (OHCM)
I42.2	Hypertrophic Cardiomyopathy (HCM)
I42.0	Dilated Cardiomyopathy (DCM)
O90.3 OR (O99.4 + I42.- appearing on the same record)	Peripartum Cardiomyopathy (PPCM)
I42.5	Restrictive Cardiomyopathy
E85.4 + I43.1 appearing on the same record	Transthyretin Amyloid Cardiomyopathy (ATTR-CM)
I42.8	Arrhythmogenic Right Ventricular Dysplasia (ARVD - included in category Other Cardiomyopathies in ICD-10-CA)
CCI Codes	**Descriptions**
1.HP.78	Repair by decreasing size, ventricle
1.HN.87	Partial Excision of Intra-atrial Septum
1.HZ.53^^	CIEDs – Implantation of Internal Devices – Cardiac
1.HD.53^^	
1.HB.53^^	
1.HP.53^^	
1.IJ.76^^	CABG – Coronary Artery Bypass Graft

Data were requested separately for acute inpatient (AI) care patients, day surgery (DS) cases, and emergency department cases however, CIHI grouped emergency department cases with cardiac catheterization (EDCC) clinic patients.

Data were requested by province separately, but were only available in some of the 10 provinces:

- AI/DS/EDCC: excluded Quebec because the province doesn't report to CIHI.
- DS: excluded Quebec and Prince Edward Island.
- EDCC: excluded Quebec, British Columbia (2019), Manitoba, New Brunswick, and Newfoundland.
- CIHI combined the records from British Columbia with the Territories because the province restricts public access to data. For simplicity the study treated the combined data as BC.

Much of the data that was requested was not made available to this study because CIHI suppresses data when small case counts (1- 4) are reported and substitutes with "N/R" (not reportable) citing the organization's privacy policies as the reason for the restriction. It was unclear how reporting this anonymized data could compromise privacy and CIHI provided no further explanation.

The hospital utilization data for cardiomyopathy cases from 2018 to 2021, which were supplied by CIHI are shown in the **Appendix TABLES A, B, and C**. Summaries of these data are presented in **TABLES 2a, 2b, and 2c**, which show aggregate numbers across the four years from 2018 to 2021 separately for each of three hospital admission categories: AI - Acute inpatient, DS – Day surgery ambulatory, and EDCC – emergency dept / cardiac catheterization clinic.

TABLE 2a. Cardiomyopathy related hospital utilization, total AI, 2018 to 2021.

	HOSPS	RIW	LOS (days)	MORTS	AGE	ASA	SM	CIED	CABG
AB	4450	3.9357	14	270	58	7	0	489	19
BC	5035	2.8074	11	315	64	55	0	408	36
MB	1063	3.4056	13	97	60	0	0	104	12
NB	1297	1.8798	8	84	64	0	0	124	6
NL	535	2.2228	11	55	62	0	0	52	0
NS	1458	2.9913	12	125	62	0	0	84	0
ON	17599	2.9252	11	1252	64	33	0	1340	106
PE	119	1.4229	7	0	63	0	0	0	0
SK	1340	2.1420	9	88	61	0	0	103	0
Total/ Average	32896	2.6370	11	2286	62	95	0	2704	179

TABLE 2b. Cardiomyopathy related hospital utilization, total DS, 2018 to 2021.

	HOSPS	RIW	LOS (hours)	MORTS	AGE	ASA	SM	CIED	CABG
AB	362	2.1724	0.3	0	62	0	0	255	0
BC	2250	0.7654	0.3	0	65	0	0	373	0
MB	366	0.7566	0.3	0	63	0	0	63	0
NB	527	0.9133	0.4	0	63	0	0	104	0
NL	402	1.0250	0.2	0	63	0	0	139	0
NS	40	0.3529	0.2	0	59	0	0	0	0
ON	835	2.0729	0.3	0	64	0	0	548	0
SK	475	0.8098	0.4	0	62	0	0	105	0
Total/ Average	5257	1.1085	0.3	0	63	0	0	1587	0

TABLE 2c. Cardiomyopathy related hospital utilization, total EDCC, 2018 to 2021.

	HOSPS	RIW	LOS (hours)	MORTS	AGE	ASA	SM	CIED	CABG
AB	1949	0.3602	0.3	0	57	27	0	105	0
BC	5	0.0646	0.2	0	58	0	0	0	0
NS	372	0.9025	0.4	0	60	0	0	95	0
ON	7992	0.6131	0.4	33	62	7	0	1067	0
PE	26	0.0864	0.5	0	59	0	0	0	0
SK	162	0.0782	0.4	0	52	0	0	0	0
Total/ Average	10506	0.4239	0.4	33	58	34	0	1267	0

The data included HOSPS - hospitalizations, MORTS – in-hospital mortalities, RIW – average resource intensity weight, LOS – average length of stay, AGE - average age, ASA - alcohol septal ablation, SM - septal myectomy, CIED - cardiac implantable electronic device, CABG – coronary artery bypass graft. Results are shown separately by province.

The results for acute inpatient cases are displayed separately in **TABLE 2a** and represent the experience of the nine provinces for which data were available (Alberta, British Columbia, Manitoba, New Brunswick, Newfoundland and Labrador, Nova Scotia, Ontario, Prince Edward Island, and Saskatchewan). There were 32,896 hospitalizations for cardiomyopathy diagnosis. The average length of stay in

hospital was 11 days and the average age of patients was 62 years. There were 2978 surgical procedures performed on cardiomyopathy patients, and 2,286 deaths recorded.

The data for acute inpatient hospitalizations was far more complete than the data for day surgeries and emergency department/ cardiac catheterization cases. The results shown in **TABLE 2b and 2c** reflect only the experience of provinces with sufficient data. Corresponding results for day surgery cases indicate the following: 5,257 hospitalizations, average LOS < 1-day, average age 63, and 1587 surgical procedures, zero mortalities. For emergency department and cardiac catheterization cases there were 10,506 hospitalizations, average LOS < 1-day, average age 58, 1,301 surgical procedures and 33 mortalities.

TABLE 2d shows aggregate results for AI, DS, and EDCC over the four years from 2018 to 2021 including all nine provinces studied, were 48,654 total acute inpatient, day surgery, and emergency department/ cardiac catheterization clinic hospitalizations for cardiomyopathy cases. The average length of stay in hospital was 5 days. The average age of patients was 60 years. There were 5,985 surgeries and 2,319 in-hospital deaths recorded.

TABLE 3 shows the total volume of cardiomyopathy related surgical procedures reported over the four years from 2018 to 2021, stated as a percentage of the group total across the four selected surgical types: ASA – alcohol septal ablation, SM - septal myectomy, CIED – cardiac implantable electronic device, and CABG – coronary artery bypass graft. The results are displayed by admission type and organized by province.

The data indicate that CIED accounted for almost 95% of the total volume of cardiomyopathy related surgical procedures across the four types compared over the four-year timeframe of the study. Only very small percentages were reported for CABG and ASA surgical procedures. Zero surgical procedures were reported for SM.

TABLE 2d. Summary presentation of cardiomyopathy related hospital utilization, by province, across acute inpatient, day surgery, emergency/ cardiac catheterization, 2018 to 2021.

	AB	BC	MB	NB	NL	NS	ON	PE	SK	Total
2018										
n HOSPS	1,809	1,822	397	451	243	502	6,398	32	517	12,171
n CM SURG	208	216	60	47	57	46	822	32	44	1,532
Average LOS (Days)	4	5	6	4	7	4	4	4	3	5
n MORTS	66	78	22	22	9	31	278	0	27	533
Average AGE	59	64	60	63	60	60	63	32	57	58
Average RIW	1.7946	1.6505	1.8917	1.5482	1.8867	1.4110	1.8538	0.8922	0.9492	1.5347
2019										
n HOSPS	1,754	1,752	399	446	260	509	6,370	24	447	11,961
n CM SURG	223	219	58	55	50	48	765	24	48	1,490
Average LOS (Days)	5	6	7	4	5	4	4	2	4	4
n MORTS	68	69	28	24	17	35	318	0	22	581
Average AGE	59	64	62	65	63	61	62	32	58	59
Average RIW	2.1376	1.8820	2.2374	1.3282	1.5203	1.3895	1.9399	0.4172	0.9566	1.5473
2020										
n HOSPS	1,524	1,809	346	442	231	431	6,323	44	500	11,650
n CM SURG	259	220	31	55	44	51	741	37	47	1,485
Average LOS (Days)	5	6	7	5	5	5	4	6	3	5
n MORTS	61	72	29	23	9	28	315	0	21	558
Average AGE	58	64	62	63	62	59	65	58	59	61
Average RIW	2.3502	1.8292	2.2665	1.3926	1.5312	1.6354	1.8944	1.1030	1.0703	1.6862
2021										
n HOSPS	1,674	1,902	287	485	203	428	7,335	45	513	12,872
n CM SURG	212	217	30	77	40	34	773	26	69	1,478
Average LOS (Days)	5	6	7	4	5	4	4	3	3	4
n MORTS	75	96	18	15	20	31	374	0	18	647
Average AGE	60	65	61	64	66	61	64	63	59	62
Average RIW	2.3421	1.7839	1.9289	1.3172	1.5573	1.2263	1.7936	0.5197	1.0638	1.5223
2018-2021										
n HOSPS	6,761	7,285	1,429	1,824	937	1,870	26,426	145	1,977	48,654
n CM SURG	902	872	179	234	191	179	3,101	119	208	5,985
Average LOS (Days)	5	6	7	4	5	4	4	4	3	5
n MORTS	270	315	97	84	55	125	1,285	0	88	2,319
Average AGE	59	64	62	64	63	60	63	46	58	60
Average RIW	2.1561	1.7864	2.0811	1.3965	1.6239	1.4155	1.8704	0.7330	1.0100	1.5726

The distribution of cardiomyopathy related surgical procedures reported by CIHI is contradicted by other research indicating that there are significant numbers of cases where the SM procedure is performed. According to a study conducted by researchers at the University of Toronto and University health network, 150 isolated septal myectomy surgeries were performed for hypertrophic cardiomyopathy over the period January 2012 to August 2016.[23]

This study was also aware of anecdotal reports from cardiologists that ASA is performed in larger numbers than the data published by CIHI indicates. The same can be said of CABG. In its 2022 report on wait times CIHI indicated that more than 5,000 CABG surgical procedures were performed annually across 8 provinces in each of the years 2018 to 2021. **[TABLE 6]** It is unknown what percentage of these numbers is attributable to cardiomyopathy.

TABLE 3. Surgical procedures performed on cardiomyopathy patients, by surgical type, by province and by hospital admission category, 2018 to 2021, stated as a percentage of group total: ASA + SM + CIED + CABG.

	ASA%	SM%	CIED%	CABG%
AB				
AI	1.4%	0.0%	95.0%	3.7%
DS	0.0%	0.0%	100.0%	0.0%
EDCC	20.5%	0.0%	79.5%	0.0%
TOTAL	**3.8%**	**0.0%**	**94.1%**	**2.1%**
BC				
AI	11.0%	0.0%	81.8%	7.2%
DS	0.0%	0.0%	100.0%	0.0%
EDCC				
TOTAL	**6.3%**	**0.0%**	**89.6%**	**4.1%**
MB				
AI	0.0%	0.0%	89.7%	10.3%
DS	0.0%	0.0%	100.0%	0.0%
TOTAL	**0.0%**	**0.0%**	**93.3%**	**6.7%**
NB				
AI	0.0%	0.0%	95.4%	4.6%
DS	0.0%	0.0%	100.0%	0.0%
TOTAL	**0.0%**	**0.0%**	**97.4%**	**2.6%**
NL				
AI	0.0%	0.0%	100.0%	0.0%
DS	0.0%	0.0%	100.0%	0.0%
TOTAL	**0.0%**	**0.0%**	**100.0%**	**0.0%**
NS				
AI	0.0%	0.0%	100.0%	0.0%
DS				
EDCC	0.0%	0.0%	100.0%	0.0%
TOTAL	**0.0%**	**0.0%**	**100.0%**	**0.0%**
ON				
AI	2.2%	0.0%	90.6%	7.2%
DS	0.0%	0.0%	100.0%	0.0%
EDCC	0.7%	0.0%	99.3%	0.0%
TOTAL	**1.3%**	**0.0%**	**95.3%**	**3.4%**
PE				
AI				
EDCC				
TOTAL				
SK				
AI	0.0%	0.0%	100.0%	0.0%
DS	0.0%	0.0%	100.0%	0.0%
EDCC				
TOTAL	**0.0%**	**0.0%**	**100.0%**	**0.0%**
Grand Total	**2.2%**	**0.0%**	**94.7%**	**3.1%**

HOSPITAL COSTS

Two methods were used to estimate the total hospital related expenditure on CM patient cases. The first required a calculation of the resource intensity weighted cost per CM patient case. According to CIHI, resource intensity weights are "a relative value measuring total patient resource use compared with average typical acute inpatients."[24] CIHI's Cost of a Standard Hospital Stay (CSHS) indicator provides the average cost for a hypothetical patient with a Resource Intensity Weight (RIW) of 1.0000. Calculating the CSHS is stated as: total inpatient costs divided by total weighted cases, excluding day procedures.[25] The RIW includes average cost per patient case for all hospitalizations and all diagnoses, total hospital operational and capital expenditures on equipment, excluding amortized expenses for land, buildings, and facilities.

The CSHS was multiplied by the average RIW reported in the CIHI data for CM patient cases to produce the resource intensity weighted cost per CM patient case, which was then multiplied by the number of CM discharges to produce the total expenditure on CM patient cases. 2021 data on the cost of a standard hospital stay were unavailable. Numbers for 2021 were forecasted based on the annual average growth rate for hospital expenditures in 2021 published by CIHI in its NHEX Data tables. An example of the calculation is shown in **Appendix TABLE D**.

The second method used CIHI's Patient Cost Estimator (PCE) online tool to estimate the average cost per patient across cardiac Case-Mix Groups (CMGs). Selected CMGs are listed in **Appendix TABLE E.**

Appendix TABLE F summarizes the total hospital cost associated with cardiomyopathy showing the results by province, and for each of the four years from 2018 to 2021. **TABLE 4** summarizes total hospital cost associated with cardiomyopathy cases across the provinces with available data, across AI, DS, and EDCC cases, and over the 4 years from 2018 to 2021. Using the RIW method produced an estimated total cost of $763 million, while the PCE tool produced an estimated total cost of nearly $1.3 billion. The results are significant in magnitude even though Quebec (22% of the population of Canada) was excluded. The estimate is conservative also because the CIHI calculation of the cost of a standard hospital stay does not account for capital amortization expenses relating to land,

buildings and facilities, which if included could increase the estimate up to 15% based on the ratio of capital spending to hospital spending reported by CIHI in its national health expenditures data tables.[26]

TABLE 4. Estimates of cardiomyopathy related hospital cost: acute inpatient, day surgery, emergency department and cardiac catheterization clinic hospitalizations 2018 to 2021f. Resource Intensity Weighted (RIW) versus Patient Cost Estimator (PCE) average cost per patient.

PROV	RIW TOTAL HOSPEX	PCE: Cardiac CMGs TOTAL HOSPEX
AB	$164.3	$221.4
BC	$120.4	$151.2
MB	$27.3	$26.3
NB	$18.2	$26.3
NL	$11.0	$21.3
NS	$32.0	$30.2
ON	$361.5	$761.9
PE	$1.4	$1.1
SK	$26.5	$38.2
Grand Total	$762.7	$1,278.0

DRUGS COST

Data were not available for cardiomyopathy related pharmaceutical costs. However, the Organization for Economic Cooperation and Development (OECD) publishes data on national pharmaceutical sales for the cardiovascular therapeutic class that report numbers for Canada spanning the study period.[27] The CM share of CVD drugs sales was estimated assuming that it would approximate the share of hospitalization attributable to CM, which could be calculated from the data obtained from CIHI for this study and the data obtained from the OECD **[Appendix TABLES G and H]**. The observed number of CM hospitalizations was divided by the forecasted number of CVD hospitalizations to obtain the CM proportion, which was then used to estimate the CM share of CVD drugs sales from 2018 to 2021.

Cardiomyopathy related drugs cost was roughly estimated to be about $431 million over the four years **[TABLE 5]**. Annual results were nearly $105 million in 2018, $98 million in 2019, $112 million in 2020, and $117 million in 2021.

TABLE 5. Estimate of cardiomyopathy related pharmaceutical expenditures (RXEX), Stated in millions of current Canadian dollars.

	2018	2019	2020	2021	2018-2021
Est. CVD hospitalizations	266,208	265,211	235,253	248,518	1,015,190
CM hospitalizations	8,221	8,217	7,909	8,549	32,896
CM % CVD	3.1%	3.1%	3.4%	3.4%	
CVD pharmaceuticals	$3,386.8	$3,162.5	$3,318.3	$3,394.2	$13,261.8
Est. CM pharmaceuticals	$104.6	$98.0	$111.6	$116.8	$430.9
CVD patented medicines	$635.9	$560.5	$553.4	$384.4	$2,134.2
Est. CM patented medicines	$19.6	$17.4	$18.6	$13.2	$68.8

This study also attempted to identify the CM related cost associated with innovative or patented pharmaceuticals. The share of innovative patented drugs costs attributable to cardiomyopathy patients was unknown due to lack of data on sales of therapeutic products specifically sold to CM patients. Data were available from the Patented Medicine Prices Review Board (PMPRB) indicating that in 2018 total national expenditure on patented drugs in the cardiovascular therapeutic class was $635.9 million and declined steadily to $384.4 million by 2021 **[see TABLE 5]**.[28] The PMPRB reports this data as sales at manufacturer list prices excluding confidential rebates, and all downstream supply chain or otherwise related cost. These data made it possible to produce a rough estimate using a calculation derived from applying the proportion of cardiovascular disease hospitalizations attributable to cardiomyopathy to total sales of patented CVD medicines assuming that the CM share would be a similar proportion.

Cardiomyopathy related patented drugs cost was roughly estimated to be about $69 million over the four years. Annual spending on patented CM drugs in 2018, 2019, 2020, and 2021 was about $20 million, $17 million, $19 million, and $13 million respectively.

PRODUCTIVITY LOSS

Waits for access to necessary medical services are associated with potential economic productivity losses, especially for conditions with debilitating symptoms that prevent or impede paid work. To estimate productivity losses required data on the number of CM patients receiving surgical treatment, the average wait times experienced by CM patients, the average length of stay in hospital, the average recovery time for return to work, and the average daily income. The data purchased for the study included the number of surgical procedures performed which represents the number of patients who would have received surgical treatment and experienced the reported wait times, assuming one procedure per patient. The study used the only available wait times data published for cardiac conditions (CABG) as a proxy, assuming the wait times experienced for CABG surgical services could be extrapolated to represent wait times experienced by CM patients for the four types of surgical services examined. Data for the length of stay were purchased for the study from CIHI.

The Canadian Institute for Health Information publishes data on wait times for only 14 common surgical procedures including 5 types of cancer surgery (bladder, breast, colorectal, lung, and prostate), 4 types of joint surgery (3 hip, 1 knee), 2 types of diagnostic imaging (CT, MRI), cataract surgery, radiation therapy, and only 1 type of cardiac surgery (CABG: coronary artery bypass graft).[29] Data on wait times for access to surgical procedures for the treatment of cardiomyopathy were not publicly available from CIHI, and no other source of such data could be identified. This necessitated a proxy analysis using other published data from CIHI on wait times affecting CABG, which is the only cardiac surgical procedure represented in their analysis of wait times (CIHI's Wait Times for Priority Procedures in Canada — Data Tables). CABG was used as a proxy to estimate potential wait times affecting all other surgical treatments for CM. The data included estimated wait times in days at the 50th and 90th percentiles of the patient population (50% or 90% of patients waiting less than the number of days reported), and volume of cases, by province for the years 2018 to 2021.

CIHI data on wait times for CABG surgery across all patients receiving the procedure, for the years 2018 to 2021, are shown in **TABLE 6**. The data for CABG shows that across the eight provinces studied, on average from 2018 to 2021, 90% of patients who eventually received treatment, experienced maximum wait times ranging from 54 days (or less) in Manitoba, up to 148 days in New Brunswick, and 84 days in both Alberta and Ontario. Across 8 provinces (PE data not reported by CIHI), and across all four years, the average wait time at the 90th percentile was 81 days, which means that 10% of patients experienced wait times that were longer than this. Looking at each province and year individually, at the 90th percentile average wait times were as low as 17 days in Saskatchewan and as high as 245 days in Newfoundland and Labrador.

TABLE 6. Wait times for CABG by province, 2018 to 2021, maximum number of days spent waiting for 90% of the population of patients.

	2018	2019	2020	2021
Alberta				
Max. wait 90th percentile	98	63	118	58
CABG surgeries performed	533	549	419	474
British Columbia				
Max. wait 90th percentile	62	42	56	64
CABG surgeries performed	1060	1072	907	922
Manitoba				
Max. wait 90th percentile	34	76	41	65
CABG surgeries performed	182	205	165	149
New Brunswick				
Max. wait 90th percentile	141	148	183	118
CABG surgeries performed	234	215	216	198
Newfoundland and Labrador				
Max. wait 90th percentile	103	149	42	245
CABG surgeries performed	175	182	116	192
Nova Scotia				
Max. wait 90th percentile	27	43	94	84
CABG surgeries performed	148	131	138	160
Ontario				
Max. wait 90th percentile	43	48	58	64
CABG surgeries performed	3533	3622	2823	3011
Saskatchewan				
Max. wait 90th percentile	17	35	94	84
CABG surgeries performed	191	177	120	109

However, the data significantly underestimate total wait times because of the way CIHI defined the waiting period. CIHI uses the following definition for bypass surgery wait times: "The number of days a patient waited, between the date when the patient and the appropriate physician agreed to a coronary artery bypass graft (CABG) and the patient was ready to receive it, and the date the patient received a planned CABG."[30] This definition excludes important segments of the actual wait time experienced by patients, which should include the time spent waiting for a consultation with a general practitioner or family physician, and the subsequent time spent waiting for an appointment with a specialist following referral from the general practitioner.

CIHI's definition contains another exclusion that leads to an underestimation of wait times. The hospital utilization data presented earlier in this paper indicates a low volume of surgical procedures received by CM patients, which could mean that many patients simply go without these services. Incidentally this means that they are not captured in wait times data because waits are defined as the time between the patient and physician agreeing to schedule a surgical procedure and when the patient received a service. Patients not receiving any services are not counted in the wait times data published by CIHI. Significant unreported backlogs probably exist. In fact, the Ontario Medical Association published an estimate of the backlog for CABG in October 2021 suggesting the wait time was 14 months or 420 days.[31] This is almost 7 times longer than the wait times reported by CIHI for Ontario in the same year. A February 2022 recent report from the OMA cited survey data that the backlog of patients waiting for CABG in Ontario reached 4,296 and wait times grew to 16 months or 480 days.[32]

The estimated average recovery time at home before returning to work was obtained from an Internet search of reputable sources (e.g. The UK NHS, the American Heart Association, etc.) for published recommendations. Medical recommendations vary widely for home recovery time following alcohol septal ablation, septal myectomy, CIED, and CABG surgery. The most common recommendation was up to eight weeks home recovery time before return to work, and longer if the patient's occupation involves strenuous physical activity. Research suggests that the actual return to work could exceed 8 weeks. A 2016 study of over 11, 000 patients in Denmark

found that only 68% returned to the workforce following cardiac hospitalization, and of those who did, 75% returned to work by 6 months.[33] For this study eight weeks was used for the calculation.

The average income data were obtained from Statistics Canada, which represented the average for the 55 to 64 age group which corresponds to the average age of 60 years for the population of hospitalized cardiomyopathy patients in the study data.[34]

The calculation summed the three time-based metrics: initial wait time (assuming that patients who are waiting for cardiac surgical services are off work due to the diagnosis), length of stay in hospital, and recovery time before returning to work. The result was measured in days. This was then multiplied by the average daily employment income (annual employment income divided by 365). The total was calculated by multiplying this result by the number of CM surgeries performed. The calculation is shown in **Appendix TABLE D.**

TABLE 7. CM related productivity loss, millions current Canadian dollars.

	2018	2019	2020	2021	2018-2021
AB	$5.4	$4.9	$7.3	$4.2	$21.8
BC	$3.8	$3.2	$3.3	$3.7	$14.0
MB	$0.9	$1.2	$0.4	$0.5	$3.1
NB	$1.2	$1.4	$1.6	$1.6	$5.8
NL	$1.2	$1.4	$0.5	$1.5	$4.5
NS	$0.5	$0.6	$1.0	$0.6	$2.8
ON	$13.1	$12.5	$13.4	$14.6	$53.5
PE	$0.2	$0.2	$0.3	$0.2	$0.8
SK	$0.5	$0.7	$1.0	$1.4	$3.6
TOTAL	$26.8	$26.0	$28.7	$28.4	$110.0

TABLE 7 shows the results for an estimation of total productivity loss associated with wait times for access to the four types of surgical procedures studied, the length of stay in hospital, and the time spent in recovery waiting to return to work for AI/DS/EDCC cardiomyopathy cases in 9 provinces from 2018 to 2021. Annual productivity losses totaled almost $27 million in 2018, over $28 million in 2021, and the total over the four years from 2018 to 2021 was almost $110 million in productivity losses.

HOSPITAL MORTALITY COSTS

Cardiomyopathy related in-hospital mortality rates were compared to the corresponding rate for the whole population of inpatient hospitalizations. Data on hospital deaths and discharges for cardiomyopathy patients were available from the data purchased from CIHI for the four years from 2018 to 2021. Data were also available from published reports from CIHI including 2018 to 2021 for total hospital discharges across all diagnoses.[35] Data were available from Statistics Canada's Vital Statistics – Deaths database which included in-hospital mortality however, the most recent data for total hospital deaths were available for only three years 2018 to 2020.[36] 2021 was estimated by forecasting the average over 2018 to 2020.

TABLE 8 shows data for total deaths in hospital stated as a percentage of total hospitalizations from 2018 to 2021f for cardiomyopathy patients versus all diagnoses, including acute inpatient cases only due to the absence of comparable data for day surgery and emergency department/ cardiac catheterization clinic cases. The data exclude Quebec and Prince Edward Island (missing mortality data).

The mortality risks for cardiomyopathy patients are notably higher than the general inpatient population. From 2018 to 2021 and across the 8 provinces with available data there were 2,286 in-hospital deaths among 32,777 cardiomyopathy patients, counting inpatient cases only to maintain comparability. Corresponding numbers over the general inpatient population were 450,113 in-hospital mortalities among 8,976,790 hospitalizations. Representing a 7.0% mortality rate for cardiomyopathy patients versus 5.0% for the general inpatient population.

It was possible to estimate the economic cost of mortality associated with cardiomyopathy patients, using the data purchased for the study, plus data from the life-year tables published by Statistics Canada, and the value of a statistical life (VSL) and its derivative the value of a statistical life-year (VSLY). The life-year tables provide estimates of life expectancy at birth for use in calculating potential life years lost following premature death.[37] The VSLY was obtained from the Government of Canada's published Cost Benefit Analysis Guide for Regulatory Submissions, which defines the value of a statistical life-year as an estimate of, *"the life-years that*

TABLE 8. Cardiomyopathy related mortality: acute inpatient cases, in-hospital mortalities, across eight provinces

	2018	2019	2020	2021	2018-2021
CM MORTS	523	570	546	647	2,286
CM HOSPS	8,189	8,193	7,872	8,523	32,777
CM MORTS % CM HOSPS	6.4%	7.0%	6.9%	7.6%	7.0%
MORTS all	114,500	113,554	109,958	112,101	450,113
HOSPS all	2,330,687	2,336,323	2,095,097	2,214,683	8,976,790
MORTS all % HOSPS all	4.9%	4.9%	5.2%	5.1%	5.0%

would be lost if an individual were to die prematurely. In its simplest form, the method derives estimates of the value of a statistical life-year from the value of a statistical life. The underlying premise is that a value of a statistical life is the aggregation of a stream of constant annual values for the remaining expected years of life of an individual. In this interpretation the estimate of the value of a statistical life-year depends on three factors: the underlying estimate of the value of a statistical life, a discount rate, and the number of years of life remaining. It has been suggested that many wage-risk studies are based on individuals with an average life expectancy of an additional 35 years. Using the 35-year life expectancy and an estimate of $5 million as the value of a statistical life, this approach yields an estimate of $143,000 per life-year given a zero discount rate. If a discount rate of 5% is used, then the $5 million value of a statistical life translates into a value of a statistical life-year of $305,000…" [37] The Guide cited research which, "*found the average VSL to be $6.5 million in 2007 Canadian dollars"* and advised that *"Departments and agencies are expected to use this value as the VSL in their cost-benefit analysis. Departments and agencies can convert this VSL to their chosen price year using the Statistics Canada Consumer price index."* [38]

Upper and lower range estimates of the mortality cost associated with cardiomyopathy were calculated by subtracting the average age of the hospitalized CM patient population in each province from the average life expectancy at birth associated with each province from 2018 to 2021f, which produced the average potential life years lost (PLYL). The PLYL was multiplied by the VSLY published by the Government of Canada. Two separate calculations were performed representing lower and upper bounds. The lower bound was estimated by using the $6.5 million (2007) VSL, which at a 0% discount rate produced a VSLY of $186,000 (2007). This VSLY was adjusted to account for annual inflation based on changes in the Consumer Price Index (CPI) since 2007, and the updated current dollar values were applied to the calculation in each of the four years studied.[39] After multiplying the PLYL and the VSLY, the result was multiplied by the total number of deaths in hospital for cardiomyopathy patients. The upper bound was estimated the same way, except that the $305,000 (2007, $5m, 5%dr) VSLY calculated by the Government of Canada was taken as given and simply inflated into current dollar values. This was done to preserve the conservative approach of the estimate.

The summary results of the estimate of economic cost related to mortality are shown in the **TABLE 9**. Annual totals for the societal cost of in-hospital mortality associated with acute inpatient cardiomyopathy cases, across 8 provinces studied are displayed for each year from 2018 to 2021f. Upper and lower estimates are shown for each province in each year, stated in millions current Canadian dollars. The total annual in-hospital mortality cost, calculated across 8 provinces, ranged from $2.3 billion to $3.8 billion in 2018; $2.5 billion to $4.0 billion in 2019; $2.4 billion to $3.9 billion in 2020; and $2.8 billion to $4.6 billion in 2021. The estimate over the four years from 2018 to 2021 produced a total cost for cardiomyopathy related mortality ranging from $9.9 billion to $16.3 billion.

TABLE 9. Cardiomyopathy related mortality cost: acute inpatient cases, In-hospital mortalities, upper and lower cost estimates based on low and high values for a statistical life year, 2018 to 2021.

		2018	2019	2020	2021	2018-2021
	VSLY-1	$222,533	$226,870	$228,538	$236,212	
MORT COST Millions	AB	$352	$365	$332	$391	$1,440
	BC	$328	$300	$314	$415	$1,357
	MB	$103	$115	$132	$87	$436
	NB	$81	$84	$95	$63	$324
	NL	$40	$72	$36	$64	$212
	NS	$126	$135	$129	$134	$525
	ON	$1,157	$1,294	$1,249	$1,568	$5,268
	SK	$113	$93	$89	$79	$374
	LOWER TOTAL	$2,301	$2,459	$2,376	$2,799	$9,936
	VSLY-2	$364,906	$372,018	$374,753	$387,336	
MORT COST millions	AB	$577	$599	$544	$641	$2,361
	BC	$538	$492	$514	$680	$2,225
	MB	$168	$189	$217	$142	$716
	NB	$134	$138	$156	$104	$531
	NL	$66	$117	$59	$104	$347
	NS	$207	$222	$212	$220	$860
	ON	$1,897	$2,123	$2,048	$2,571	$8,639
	SK	$185	$153	$147	$129	$614
	UPPER TOTAL	$3,773	$4,033	$3,897	$4,591	$16,293

TOTAL COSTS

TABLE 10 summarizes the total cardiomyopathy related economic cost over the four years from 2018 to 2021. Annually total costs related to cardiomyopathy ranged from $2.6 billion to $4.2 billion in 2018; $2.8 billion to $4.4 billion in 2019; $2.7 billion to $4.4 billion in 2020; and $3.2 billion to $5.1 billion in 2021. Over the four years from 2018 to 2021 the grand total including hospital cost, pharmaceutical cost, productivity losses, and mortality cost ranged from $11.2 billion at the lower end, to $18.1 billion at the upper end. Mortality cost accounted for 88% to 90% of the total cost. While hospital cost accounted for 6.8% to 7.1%, pharmaceuticals cost from 3.8% to 2.4%, and productivity losses from 1% to 2.4%.

TABLE 10. Lower and upper estimates of total cardiomyopathy related economic cost, millions current Canadian dollars.

LOWER ESTIMATE

	2018	2019	2020	2021	2018-2021	% TOTAL
Hospital cost: Resource intensity weighted	$167.7	$178.2	$200.5	$216.3	$762.7	6.8%
Pharmaceuticals cost	$104.6	$98.0	$111.6	$116.8	$430.9	3.8%
Productivity loss	$26.8	$26.0	$28.7	$28.4	$110.0	1.0%
Mortality cost: VSLY-1	$2,301	$2,459	$2,376	$2,799	$9,936	88.4%
Total cardiomyopathy related economic cost	$2,600.2	$2,761.4	$2,717.2	$3,160.9	$11,239.7	100.0%

UPPER ESTIMATE

	2018	2019	2020	2021	2018-2021	% TOTAL
Hospital cost: Patient cost estimator	$283.2	$297.5	$312.9	$384.4	$1,278.0	7.1%
Pharmaceuticals cost	$104.6	$98.0	$111.6	$116.8	$430.9	2.4%
Productivity loss	$26.8	$26.0	$28.7	$28.4	$110.0	0.6%
Mortality cost: VSLY-2	$3,773	$4,033	$3,897	$4,591	$16,293	90.0%
Total cardiomyopathy related economic cost	$4,187.9	$4,454.0	$4,350.0	$5,120.1	$18,112.0	100.0%

CONCLUSION

This study demonstrated that the economic cost of cardiomyopathy in Canada is significant. The findings suggest that any pharmaceutical innovation that reduces cardiomyopathy related demand for hospital-based surgical procedures, has the potential to achieve significant cost avoidance. As a first line outpatient therapy, pharmaceuticals offer the most cost-effective means of avoiding the economic costs estimated in this study.

Over the four years from 2018 to 2021, CM related pharmaceutical cost ($431m) accounted for 3.8% of the total CM related economic costs estimated at the lower bound ($11.2b), and 2.4% at the upper bound ($18.1b) [**TABLE 10**]. The cost of patented innovative drugs for CM ($69m) was estimated to be less than 1% (0.61%) of the total CM related economic costs estimated at the lower bound, and less than half of 1 percent (0.38%) at the upper bound.

Facilitating the development and early adoption of new medicines should be a policy priority. When new therapies demonstrate either incremental, or breakthrough improvements for patient health, they should be quickly added to public drug plan formularies. Innovative medicines can be technological substitutes (replacing less efficient or less effective therapeutic modes), or complements (making another technology more efficient or more effective). Barriers to the utilization of improved pharmaceutical therapies cause opportunity costs: lost savings that would otherwise accrue from reduced mortality, less demand for surgical services and lower productivity losses.

CAUTIONS AND LIMITATIONS

- CIHI data purchased for this study were mostly complete for acute inpatient cases, but partly incomplete for day surgery cases, and largely incomplete for emergency department/ cardiac catheterization clinic cases.
- Data on the number of surgical procedures was inconsistent with external sources, indicating significant under reporting or administrative misclassification.
- Quebec (22% of pop.) was excluded from the study because the jurisdiction does not report data to CIHI's discharge abstract database or national ambulatory care reporting system.
- Much of the data requested for this study was marked as "N/R" "not reported" which according to CIHI represents, not only unreported numbers, but also includes suppressed data for small case counts (1 to 4 cases).
- No cases of the surgical procedure septal myectomy were reported by any of the provinces. Yet a study conducted by researchers at the University of Toronto and University Health Network, reported 150 isolated septal myectomy surgeries were performed for hypertrophic cardiomyopathy over the period January 2012 to August 2016.
- Data for British Columbia was combined with the Yukon Territory, Northwest Territories, and Nunavut. CIHI supplies the data this way to comply with the provinces policies on disclosure of health information.
- For the estimate of wait times, this study was limited to using proxy data, which may not accurately reflect the experience of cardiomyopathy patients.
- This study applied the maximum proxy surgical waits at the 90th percentile to all cases of hospitalization. This over counts the number of days waited because actual waits decrease at lower percentiles (by statistical definition) and over counts the number of people actually waiting because not all hospitalizations result in surgery and wait times would vary between types of surgery.
- CIHI defines the waiting period narrowly and therefore truncates much of the time spent by patients actually waiting, the wait times reported are under counts.
- For the estimate of productivity loss, this study assumed that everyone waiting for a cardiac related surgical procedure would not be working. This might have the effect of overestimating the associated cost.
- The estimate of productivity losses is based on the average number of days spent waiting at the 90th percentile, which means 10% of the patients receiving surgical treatment waited longer than the average 81 days reported for the other 90%.
- Wait times data are defined to exclude patients who are waiting but have not yet received surgical services.
- Time spent in recovery waiting to return to work could be longer than the eight weeks average used by this analysis.
- For the estimate of mortality cost this study assumed that all in-hospital mortalities were potentially avoidable.
- Ideally, the calculation of both the upper and lower estimates of mortality costs should have used the average age of the population represented by deaths in hospital, but such specific data were not available, so the average age of the entire hospitalized CM patient population was used by proxy. This could have the effect of overestimating the calculated difference between age and life expectancy because deaths might occur more frequently among older patients.
- The estimate of cardiomyopathy related pharmaceutical cost relied on proxy data and extrapolated results. This might affect the accuracy of the estimate. Pharmaceutical costs were measured at the national level for Canada which will overstate drugs expenditure in comparisons with other components of economic cost related to cardiomyopathy, which are based on only 9 provinces.
- The CIHI calculation of the cost of a standard hospital stay does not account for capital amortization expenses relating to land, buildings and facilities, which if included could increase the estimate up to 15% based on the ratio of capital spending to hospital spending reported by CIHI in its national health expenditures data tables.

APPENDIX

TABLE A. Data purchased from CIHI: Acute Inpatient – cardiomyopathy cases.

YEAR	PROV	HOSPS	RIW	LOS (days)	MORTS	AGE	ASA	SM	CIED	CABG
2018	AB	1233	3.3711	12.7	66	57	0	N/R	162	8
2018	BC+TERR	1237	2.6188	10.6	78	63	18	N/R	112	9
2018	MB	291	3.1491	10.8	22	59	0	0	42	5
2018	NB	338	1.7855	8.3	22	64	0	0	34	N/R
2018	NL	134	2.7045	13.4	9	60	0	0	17	N/R
2018	NS	384	3.2320	12.0	31	62	0	0	23	N/R
2018	ON	4208	2.9452	10.7	268	63	13	N/R	351	29
2018	PE	32	1.7845	8.5	N/R	63	0	0	0	0
2018	SK	364	1.9485	8.4	27	61	0	0	20	0
2019	AB	1154	3.8190	13.5	68	58	N/R	N/R	124	5
2019	BC+TERR	1193	3.0323	11.8	69	63	14	N/R	105	9
2019	MB	291	3.7612	13.0	28	62	0	0	33	7
2019	NB	325	1.9585	8.3	24	65	0	0	31	6
2019	NL	150	2.0008	9.8	17	61	0	0	12	0
2019	NS	400	2.5279	11.2	35	63	0	N/R	23	N/R
2019	ON	4354	3.1014	10.7	307	64	8	N/R	360	30
2019	PE	24	0.8344	4.8	N/R	64	0	0	N/R	0
2019	SK	326	2.0790	10.3	22	61	0	0	31	N/R
2020	AB	973	4.1773	15.0	61	58	7	N/R	103	6
2020	BC+TERR	1270	2.7973	10.7	72	63	9	N/R	94	8
2020	MB	264	3.8280	14.5	29	60	N/R	N/R	18	0
2020	NB	333	2.0070	8.9	23	63	0	0	32	N/R
2020	NL	135	2.1063	10.2	9	62	0	0	14	0
2020	NS	332	3.5542	13.6	28	60	0	0	22	N/R
2020	ON	4241	2.8615	10.3	303	64	N/R	N/R	308	26
2020	PE	37	2.1218	11.6	N/R	64	0	0	0	0
2020	SK	324	2.3115	9.4	21	61	0	0	21	N/R
2021	AB	1090	4.3754	14.8	75	59	N/R	0	100	N/R
2021	BC+TERR	1335	2.7811	11.1	96	64	14	N/R	97	10
2021	MB	217	2.8843	13.8	18	60	0	0	11	N/R
2021	NB	301	1.7681	7.6	15	63	0	0	27	N/R
2021	NL	116	2.0796	9.7	20	66	0	0	9	N/R
2021	NS	342	2.6509	10.8	31	62	N/R	0	16	N/R
2021	ON	4796	2.7926	10.7	374	65	12	N/R	321	21
2021	PE	26	0.9507	4.5	0	61	0	0	0	0
2021	SK	326	2.2290	9.5	18	62	0	0	31	N/R

Source: Data purchased from CIHI. Notes: YEAR – fiscal year, PROV – Province, AI - Acute inpatient, DS – Day surgery ambulatory, EDCC – emergency dept / cardiac catheterization clinic, HOSPS - Hospitalizations, MORTS – in-hospital mortalities, RIW – average resource intensity weight, CSHS - cost of a standard hospital stay, LOS – average length of stay, AGE - average age, ASA - alcohol septal ablation, SM - septal myectomy, CIED - cardiac implantable electronic device, CABG – coronary artery bypass graft, N/R – data not reported.. Quebec data unavailable. To comply w/ CIHI's Privacy and Confidentiality Policies, small cells (counts of 1-4) were suppressed and represented w/ "N/R". Cells w/ counts of zero were represented w/ "0". BC data grouped by CIHI to prevent disclosure of evaluative data, in compliance w/ BC government policy.

TABLE B. Data purchased from CIHI: Day Surgery – cardiomyopathy cases.

YEAR	PROV	HOSPS	RIW	LOS (hours)	MORTS	AGE	ASA	SM	CIED	CABG
2018	AB	67	1.7775	7.0	0	63	0	0	33	0
2018	BC + TERR	585	0.6822	7.7	0	64	N/R	0	77	0
2018	MB	106	0.6343	5.7	N/R	62	0	0	13	0
2018	NB	113	1.3108	10.3	0	62	0	0	13	0
2018	NL	109	1.0689	5.4	0	61	0	0	40	0
2018	NS	10	0.1443	4.2	0	60	0	0	0	0
2018	ON	271	2.0146	7.7	0	64	0	0	167	0
2018	SK	114	0.8265	8.6	0	62	0	0	24	0
2019	AB	93	2.2922	6.9	0	62	0	0	71	0
2019	BC + TERR	559	0.7316	7.4	0	65	0	0	91	0
2019	MB	108	0.7135	7.4	0	63	0	0	18	0
2019	NB	121	0.6979	10.2	0	64	0	0	18	0
2019	NL	110	1.0398	5.7	0	64	0	0	38	0
2019	NS	8	0.7350	4.9	0	58	0	0	N/R	0
2019	ON	193	2.1275	7.2	0	62	0	0	132	0
2019	SK	94	0.7261	8.9	0	62	0	0	17	0
2020	AB	101	2.3483	7.2	0	61	0	0	80	0
2020	BC + TERR	539	0.8611	7.6	0	64	0	0	109	0
2020	MB	82	0.7049	7.0	0	65	0	0	13	0
2020	NB	109	0.7783	9.7	0	62	0	0	23	0
2020	NL	96	0.9562	5.1	0	63	N/R	0	30	0
2020	NS	9	0.2832	3.7	0	56	0	0	0	0
2020	ON	201	2.1770	7.5	0	67	0	0	140	0
2020	SK	138	0.8223	10.0	0	62	0	0	26	0
2021	AB	101	2.2715	7.6	0	61	0	0	71	0
2021	BC + TERR	567	0.7867	7.8	0	65	0	0	96	0
2021	MB	70	0.9736	6.8	0	63	0	0	19	0
2021	NB	184	0.8663	9.8	0	64	0	0	50	0
2021	NL	87	1.0351	4.8	0	66	0	0	31	0
2021	NS	13	0.2491	4.6	0	60	0	0	0	0
2021	ON	170	1.9727	7.0	0	65	N/R	0	109	0
2021	SK	129	0.8641	10.6	0	61	0	0	38	0

Source: Data purchased from CIHI. Notes: YEAR – fiscal year, PROV – Province, AI - Acute inpatient, DS – Day surgery ambulatory, EDCC – emergency dept / cardiac catheterization clinic, HOSPS - Hospitalizations, MORTS – in-hospital mortalities, RIW – average resource intensity weight, CSHS - cost of a standard hospital stay, LOS – average length of stay, AGE - average age, ASA - alcohol septal ablation, SM - septal myectomy, CIED - cardiac implantable electronic device, CABG – coronary artery bypass graft, N/R – data not reported.. Quebec data unavailable. To comply w/ CIHI's Privacy and Confidentiality Policies, small cells (counts of 1-4) were suppressed and represented w/ "N/R". Cells w/ counts of zero were represented w/ "0". BC data grouped by CIHI to prevent disclosure of evaluative data, in compliance w/ BC government policy.

TABLE C. Data purchased from CIHI: Emergency Department / Cardiac Catheterization – cardiomyopathy cases.

YEAR	PROV	HOSPS	RIW	LOS (hours)	MORTS	AGE	ASA	SM	CIED	CABG
2018	AB	509	0.2351	7.9	N/R	56.24	N/R	0	5	0
2018	BC+TERR	N/R	N/R	N/R	0	N/R	0	0	0	0
2018	NS	108	0.8568	10.3	0	58.15	0	0	23	0
2018	ON	1919	0.6016	9.1	10	61.51	0	0	262	0
2018	PE	N/R	N/R	N/R	0	N/R	0	0	0	0
2018	SK	39	0.0725	9.9	0	48.74	0	0	0	0
2019	AB	507	0.3016	9.0	N/R	57.19	8	0	15	0
2019	NS	101	0.9056	9.1	0	61.48	0	0	25	0
2019	ON	1823	0.5909	8.5	11	61.29	7	0	228	0
2019	PE	N/R	N/R	N/R	0	N/R	0	0	0	0
2019	SK	27	0.0646	11.1	0	52.26	0	0	0	0
2020	AB	450	0.5249	7.6	0	56.72	8	0	55	0
2020	BC+TERR	5	0.0646	7.3	0	58.40	0	0	0	0
2020	NS	90	1.0688	8.6	0	59.18	0	0	29	0
2020	ON	1881	0.6445	8.6	12	62.32	N/R	0	267	0
2020	PE	7	0.0841	8.0	0	52.86	0	0	0	0
2020	SK	38	0.0772	7.9	0	52.66	0	0	0	0
2021	AB	483	0.3793	8.3	N/R	58.54	11	0	30	0
2021	BC+TERR	N/R	N/R	N/R	0	N/R	0	0	0	0
2021	NS	73	0.7788	14.3	0	60.75	0	0	18	0
2021	ON	2369	0.6154	9.2	N/R	62.39	N/R	0	310	0
2021	PE	19	0.0886	17.1	0	65.00	0	0	0	0
2021	SK	58	0.0984	9.2	0	54.10	0	0	0	0

Source: Data purchased from CIHI. Notes: YEAR – fiscal year, PROV – Province, AI - Acute inpatient, DS – Day surgery ambulatory, EDCC – emergency dept / cardiac catheterization clinic, HOSPS - Hospitalizations, MORTS – in-hospital mortalities, RIW – average resource intensity weight, CSHS - cost of a standard hospital stay, LOS – average length of stay, AGE - average age, ASA - alcohol septal ablation, SM - septal myectomy, CIED - cardiac implantable electronic device, CABG – coronary artery bypass graft, N/R – data not reported.. Quebec data unavailable. To comply w/ CIHI's Privacy and Confidentiality Policies, small cells (counts of 1-4) were suppressed and represented w/ "N/R". Cells w/ counts of zero were represented w/ "0". BC data grouped by CIHI to prevent disclosure of evaluative data, in compliance w/ BC government policy.

TABLE D. Example calculations: cardiomyopathy related societal economic costs: Hospital, Productivity, Mortality.
HOSPITAL COST
RIW Method: HOSPEX = (RIW) X ($CSHS) X (nCM HOSPS)
PCE Method: HOSPEX = ($PCE) X (nCM HOSPS)
Hospital expenditure (HOSPEX), cardiomyopathy hospitalizations (CMHOSPS), resource intensity weight (RIW), cost of a standard hospital stay (CSHS), case mix group (CMG), patient cost estimator (PCE).
PRODUCTIVITY LOSS
PLOSS = n days(WAIT + LOS + HOME) X ($INC) X (nCM SURG)
Productivity loss (PLOSS), waiting time pre-surgery (WAIT), length of stay in hospital (LOS), recovery time at home before returning to work (HOME), average employment income (INC), cardiomyopathy related surgeries (CM SURG).
MORTALITY COST
Upper estimate: $MORT COST = (nCM MORTS) X (nPLYL) X ($VSLY)
Lower estimate: $MORT COST = (nCM EXCESS MORTS) X (nPLYL) X ($VSLY).
Mortality cost (MORT COST), cardiomyopathy related mortalities (CM MORTS), potential life years lost (PLYL), value of a statistical life year (VSLY), cardiomyopathy related excess mortalities (CM EXCESS MORTS).

TABLE E. Case-mix Groups (CMG) selected for the patient cost estimator.
Angina (except Unstable)/Chest Pain with Coronary Angiogram
Angina (except Unstable)/Chest Pain without Coronary Angiogram
Arrhythmia with Coronary Angiogram
Arrhythmia without Coronary Angiogram
Cardiac Conduction System Intervention
Cardiac Valve Disease, except Endocarditis
Cardiac Valve Repair except Percutaneous Transluminal Approach
Cardiac Valve Replacement
Coronary Artery Bypass Graft with Coronary Angiogram with MI/Shock/Arrest with Pump
Coronary Artery Bypass Graft with Coronary Angiogram with MI/Shock/Arrest without Pump
Coronary Artery Bypass Graft with Coronary Angiogram without MI/Shock/Arrest with Pump
Coronary Artery Bypass Graft with Coronary Angiogram without MI/Shock/Arrest without Pump
Coronary Artery Bypass Graft without Coronary Angiogram with MI/Shock/Arrest with Pump
Coronary Artery Bypass Graft without Coronary Angiogram with MI/Shock/Arrest without Pump
Coronary Artery Bypass Graft without Coronary Angiogram without MI/Shock/Arrest with/without Pump
Heart Failure with Coronary Angiogram
Heart Failure without Coronary Angiogram
Implantation of Cardioverter/Defibrillator
Major Cardiothoracic Intervention with Pump
Major Cardiothoracic Intervention without Pump
Management/Removal of Pacemaker/Defibrillator/Leads
Myocardial Infarction/Shock/Arrest with Coronary Angiogram
Myocardial Infarction/Shock/Arrest without Coronary Angiogram
Pacemaker Implantation
Percutaneous Coronary Intervention with MI/Shock/Arrest/Heart Failure
Percutaneous Coronary Intervention without MI/Shock/Arrest/Heart Failure
Percutaneous Transluminal Cardiothoracic Intervention except Percutaneous Coronary Intervention
Unstable Angina/Atherosclerotic Heart Disease with Coronary Angiogram
Unstable Angina/Atherosclerotic Heart Disease without Coronary Angiogram
Ventricular Assist Device Implantation

TABLE F. Estimates of cardiomyopathy related hospital cost: acute inpatient, day surgery, emergency department and cardiac catheterization clinic hospitalizations 2018 to 2021f. Resource Intensity Weighted (RIW) versus Patient Cost Estimator (PCE) average cost per patient, millions of current Canadian dollars.

		2018	2019	2020**	2021**	2018-2021
AB						
	RIW	$36.0	$38.2	$41.5	$48.5	$164.3
	PCE	$55.4	$56.2	$51.1	$58.7	$221.4
BC						
	RIW	$23.5	$27.1	$33.9	$36.0	$120.4
	PCE	$37.0	$36.1	$37.9	$40.2	$151.2
MB						
	RIW	$6.3	$7.6	$8.1	$5.2	$27.3
	PCE	$12.7	$7.7	$4.0	$2.0	$26.3
NB						
	RIW	$4.5	$4.2	$5.0	$4.6	$18.2
	PCE	$7.0	$6.6	$6.2	$6.5	$26.3
NL*						
	RIW	$3.0	$2.6	$2.8	$2.5	$11.0
	PCE	$4.2	$5.4	$5.7	$6.0	$21.3
NS*						
	RIW	$8.5	$7.1	$9.3	$7.2	$32.0
	PCE	$9.3	$8.5	$6.5	$5.8	$30.2
ON						
	RIW	$79.6	$85.7	$91.8	$104.4	$361.5
	PCE	$147.3	$168.2	$191.5	$254.9	$761.9
PE*						
	RIW	$0.4	$0.1	$0.7	$0.2	$1.4
	PCE	$0.2	$0.2	$0.3	$0.4	$1.1
SK						
	RIW	$6.0	$5.6	$7.5	$7.5	$26.5
	PCE	$10.0	$8.6	$9.6	$9.9	$38.2
9 PROVINCES						
	RIW	$167.7	$178.2	$200.5	$216.3	$762.7
	PCE	$283.2	$297.5	$312.9	$384.4	$1,278.0

* Missing 2018 and 2019 data for total: estimated using the average ratio of total costs to hospital costs for the 6 other provinces. ** Data not yet published for 2020 and 2021: estimate based on previous year-over-year percentage change.

TABLE G. Hospitalizations for cardiovascular disease by type, Canada.					
	2018	2019	2020	2021	2018-2021
Hypertensive diseases	6,792	6,723	6,373	6,570	26,458
Angina pectoris	17,471	16,161	13,794	15,246	62,672
Acute myocardial infarction	71,237	71,462	64,339	67,454	274,492
Other ischaemic heart disease	32,699	32,293	26,455	28,981	120,428
Pulmonary heart disease and diseases of Pulmonary circulation	12,365	12,600	13,258	12,779	51,002
Conduction disorders and cardiac arrhythmias	54,382	54,674	48,210	50,946	208,212
Heart failure	71,262	71,298	62,824	66,543	271,927
Total CVD	266,208	265,211	235,253	248,518	1,015,190

TABLE H. Cardiovascular system therapeutic classes pharmaceuticals expenditures, Canada, millions of current Canadian dollars.					
	2018	2019	2020	2021	2018-2021
C01A-Cardiac glycosides	$16.4	$16.0	$16.8	$15.3	$64.5
C01B-Antiarrhythmics, Class I and III	$25.4	$23.7	$25.2	$22.8	$97.1
C02-Antihypertensives	$107.2	$116.5	$125.2	$127.2	$476.1
C03-Diuretics	$258.9	$265.8	$298.5	$342.8	$1,166.0
C07-Beta blocking agents	$299.6	$288.8	$291.7	$281.6	$1,161.7
C08-Calcium channel blockers	$472.0	$427.3	$422.5	$414.4	$1,736.2
C09-Agents acting on the Renin-Angiotensin system	$1,051.8	$946.4	$994.0	$971.5	$3,963.7
C10-Lipid modifying agents	$978.8	$912.4	$958.7	$1,014.6	$3,864.5
Other CVD	$176.7	$165.6	$185.7	$204.0	$732.0
C-Cardiovascular system	$3,386.8	$3,162.5	$3,318.3	$3,394.2	$13,261.8

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