CJC Open 7 (2025) 279–286

Original Article

Economic Burden of Heart Failure Hospitalizations in Canada: A Population-based Study

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ABSTRACT

Background: Heart failure (HF) is associated with significant mortality and morbidity and accounts for substantial health care resources. We examined hospitalization costs of patients with HF in Canada (excluding patients from Quebec and the Territories) between 2010/2011 and 2018/2019 and estimated future costs to 2039/2040.

Methods: We identified hospitalization records with a primary diagnosis of HF between 2010/2011 and 2018/2019. Concurrent hospitalizations were combined to identify episodes of care. Total hospitalization costs and costs per HF patient were calculated for each fiscal year of the study. All costs are presented in 2022 CAD$. Generalized linear models were used to project primary HF hospitalization episodes and costs to 2039/2040 on the basis of population projections from Statistics Canada.

Results: There were 436,160 hospitalization episodes with a primary diagnosis of HF. Between 2010/2011 and 2018/2019, HF episodes increased from 43,114 to 54,743, and number of patients increased from 34,960 to 44,567, and total hospitalization costs increased from $684.3 million to $776.0 million, resulting in a cumulative cost of $6.65 billion. Between 2019/2020 and 2039/2040, there are projected to be 1.69 million HF hospitalization episodes, costing the Canadian health care system $19.5 billion.

RÉSUMÉ

Contexte : L'insuffisance cardiaque (IC) est associée à une mortalité et à une morbidité importantes et représente une part substantielle des ressources de santé. Nous avons examiné les coûts d'hospitalisation des patients atteints d'IC au Canada (à l'exclusion des patients du Québec et des Territoires) entre 2010-2011 et 2018-2019 et procédé à l'estimation des coûts projetés jusqu'en 2039-2040.

Méthodologie : Nous avons recherché les dossiers de patients hospitalisés ayant reçu un diagnostic principal d'IC entre 2010-2011 et 2018-2019. Les hospitalisations concurrentes ont été combinées de façon à isoler les épisodes de soins. Le coût total des hospitalisations et les coûts par patient atteint d'IC ont été calculés pour chaque exercice financier au cours de l'étude. Les coûts totaux sont présentés en dollars canadiens de 2022. Un modèle linéaire généralisé (MLG) a été utilisé pour projeter le nombre et le coût des hospitalisations liées à un diagnostic principal d'IC jusqu'en 2039/2040 sur la base des projections démographiques de Statistique Canada.

Résultats : Durant cette période, on a enregistré 436 160 hospitalisations liées à un diagnostic principal d'IC. Entre 2010-2011 et 2018-2019, le nombre de ces hospitalisations est passé de 43 114 à 54 743, et le nombre de patients a augmenté de 34 960 à 44 567; le coût total des hospitalisations est passé de 684,3 à 776,0 millions de dollars, entraî-

The global prevalence of heart failure (HF) is estimated at approximately 64 million and is expected to increase over time.[1] In Canada and the United States, HF is one of the most common reasons for hospitalization.[2,3] The substantial morbidity and mortality burden, as well as significant economic burden, especially in terms of hospitalization costs associated with HF make it a major public health concern.[2,3]

Accordingly, the Heart & Stroke Foundation of Canada, the Canadian Heart Failure Society, the HeartLife

Received for publication July 10, 2024. Accepted November 20, 2024.

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See page 285 for disclosure information.

https://doi.org/10.1016/j.cjco.2024.11.019

Conclusions: HF places a substantial economic burden on the Canadian health care system, which is likely to increase in the coming decades. Health system planning and policy solutions to identify, and reduce barriers to, HF therapies that are effective in preventing hospitalizations; and improved access to community-based services are needed to mitigate future costs.

nant des coûts cumulatifs de 6,65 milliards de dollars. Entre 2019-2020 et 2039-2040, on estime à 1,69 million le nombre d'hospitalisations liées à l'IC, selon les projections, ce qui représente des coûts de 19,5 milliards de dollars pour le système de santé canadien.

Conclusions : L'IC impose un lourd fardeau économique au système de santé canadien, et il est probable que ce fardeau s'alourdira au cours des décennies à venir. Pour atténuer ces coûts à l'avenir, une planification du système de santé et des initiatives politiques visant à repérer et à contrer les obstacles au traitement de l'IC, et l'amélioration de l'accès à des services communautaires, seront nécessaires afin de prévenir ces hospitalisations.

Foundation, the Canadian Cardiovascular Society, along with other partners have launched a major initiative to create a HF strategy across Canada and implement a robust action plan. As part of the initiative, an economic analysis of HF hospitalization in Canada was undertaken to provide key information on current and future costs to raise awareness, support advocacy and policy efforts, and drive systems change.

The current study provides the results of this economic analysis. We examined hospitalization costs associated with HF in all Canadian provinces, except Quebec and the Territories (Yukon, Northwest Territories, and Nunavut), between fiscal years 2010/2011 and 2018/2019. Our primary analyses were on the basis of acute care hospitalization episodes in which HF was listed as the most responsible diagnosis. In supplementary analyses, we extended the examination to hospitalization episodes for which HF was a secondary or contributing diagnosis. We also estimated hospitalizations with HF as the most responsible diagnosis, and their costs, for the next 20 years to fiscal year 2039/2040.

Methods

Our study was a retrospective population-based cohort study; we used the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) checklist.[4]

Data and study population

Data from the Canadian Institute for Health Information (CIHI) Discharge Abstract Database (DAD) for the time period April 1, 2010 to March 31, 2019 were used for the study.[5] The DAD data were available for all Canadian provinces, except Quebec. Data from the Territories were excluded because of small cell size issues. The DAD includes an anonymous, yet unique patient identifier; data on patient age and sex; the first 3 digits of the patient's residential postal code; admission and discharge dates, provider information, and information on the province at which the hospitalization occurred. It includes information on up to 25 diagnoses, including a primary or most responsible diagnosis and 24 secondary diagnoses. Diagnoses are coded on the basis of the *International Statistical Classification of Diseases and Related Health Problems*, 10th Revision (ICD-10), Canada (ICD-10-CA) codes.[6] The DAD data are available according to fiscal years defined as April 1 of the named year to March 31 of the following calendar year.

Previously established diagnosis codes were used to identify HF hospitalization records (provided in Supplemental Table S1).[7] The primary analysis cohort consisted of hospitalization episodes with a primary diagnosis of HF. In a supplementary analysis, a second cohort consisting of hospitalization episodes with HF in the secondary diagnosis field was created. Hospitalization episodes were created by combining acute care hospital records for which the admission date was within 1 day of the discharge date, such that transfers between hospitals were not counted as distinct hospitalizations. Hospital records missing the anonymous patient identifier or with missing or "other" gender were excluded because of the lack of data on population projections. Because CIHI data from Quebec were not available to us, any hospital records for patients or hospitals in Quebec were excluded. Similarly, data from the Territories were excluded because of small sample size issues. Records where the province of service and the province of residence differed were excluded to eliminate the complexities of costing interprovincial care. The analysis was restricted to adult patients, therefore, hospitalization episodes when the patient was younger than 18 years of age were excluded.

Costing

Hospitalization costs include costs incurred by hospitals in providing acute care. These include costs of compensation for nursing and support services (but not physician services), costs associated with supplies, equipment, drugs in hospital, buildings and grounds, as well as contracted-out services. The DAD includes data on Case Mix Groups resource intensity weights, which are assigned to each hospital record by CIHI using Case Mix Groups+ methodology. The cost per hospital record was determined by multiplying a record's resource intensity weight by the corresponding province and year-specific cost of a standard hospital stay.[8] For episodes containing multiple hospital records, the cost per episode equals the sum of all hospitalization costs within the episode. All costs were inflated to 2022 CAD$ using the consumer price index.[9]

Demographic and clinical features

Study population characteristics are presented using count (%) for categorical variables, and mean (standard deviation) or median (interquartile range) for continuous variables. Age is presented as continuous and in categories (according to age groups 18-39, 40-44, 45-49, 50-54, 55-59, 60-64, 65-69, 70-74, 75-79, 80-84, 85-89, and 90 years and older). Acute

length of stay for an episode was calculated as the difference between the admission date to the first hospital and discharge date from the last hospital, incorporating any transfers.

The Charlson Comorbidity Index (CCI), a measure of comorbidity burden based on ICD-10 codes,[10,11] was calculated by examining hospitalization records for a 5-year period before the HF hospitalization episode.[12] CCI scores are presented categorically (0-2, 3, 4, $\geq$ 5), with a higher score indicating greater comorbidity burden. The Hospital Frailty Risk Score (HFRS) is a frailty measure calculated on the basis of the presence of specific ICD-10 codes in the 2 years before the HF hospitalization episode.[13] HFRS scores are presented categorically as high risk (> 15), intermediate risk (5-15), or low risk (< 5).

HF episode projection

We decided *a priori* to include the following variables in the projection models: age, sex, province, and year. These dimensions align with population projections and have performed well in the past.[14] HF episode rates from 2010/2011 to 2018/2019 were calculated by dividing the number of HF episodes for a given province, age category, sex, and year group by the corresponding Statistics Canada population estimates.[15] For each province, age category, and sex combination, a binomial generalized linear model (GLM) with identity link was fit where time trends were modelled with linear line segments to capture any shape in historical trends. The number of change points (between 0 and 4) was chosen on the basis of Akaike information criterion. Projections assume the trend in HF episode rates at the end of the observed period continues to 2039/2040. The projected HF episode counts were determined by mapping the projected HF episode rates onto the projected population counts. Specifically, the projected HF episode counts were determined by multiplying projected HF episode rates for a given province, age, sex, and year combination by the Statistics Canada M3 medium-growth projection population estimate for the corresponding group.[15] The Atlantic provinces (New Brunswick, Nova Scotia, Newfoundland, and Prince Edward Island) were grouped into 1 Atlantic category for greater statistical stability for analysis of trends. In sensitivity analyses, we used Statistics Canada low- and high-growth scenarios.

HF episode cost projection

A 2-stage model on the basis of costs observed from 2010/2011 to 2018/2019 was used to project HF episode costs for 2019/2020 to 2039/2040. In stage 1, a gamma GLM with log link was used to model the average cost per HF episode for each discrete year on the basis of a combination of province, age category, and sex. The second stage modelled the temporal trends on the basis of the year parameters from the first stage using a normal linear model for the annual percentage change in the episode costs for each age category, sex, and province combination. The predicted average HF episode costs apply the predicted increases in costs over time to the predicted age, sex, and province predicted costs. Total costs for a given province, age, sex, and fiscal year were calculated by multiplying the predicted average HF episode cost by the corresponding predicted number of HF episodes.

To capture the stochastic uncertainty in the projections, parametric prediction intervals were used. Binomial prediction intervals used the projected episode rate. Total costs were the product of the average episode cost and the number of episodes, and its variance was computed assuming costs and episodes were independent and that the episode cost distribution was gamma with mean from the estimate average cost and constant scale parameter.

This study was approved by the University of Alberta's Health Research Ethics Board (Pro00100060). All analyses were carried out using SAS 9.4 (SAS Institute Inc, Cary, NC). In compliance with CIHI's disclosure requirements for the protection of privacy, values representing < 5 patients have been suppressed, as have related values that could result in residual disclosure. We have noted when values are on the basis of denominators that are < 50 (generally in the youngest age groups in the smaller provinces), because they might be variable because of the small sample size and suggest that caution be exercised in interpreting these values.

Results

Study cohort characteristics

There were 436,160 HF episodes between April 1, 2010, and March 30, 2019 in Canada, excluding Quebec and the Territories (Fig. 1). During the study period from 2010/2011 to 2018/2019 the HF episodes increased from 43,114 to 54,743 as did the number of patients with HF from 34,960 to 44,567 (Table 1). The proportion of female and male patients remained stable (female: 49%, male: 51%) over time. Mean age remained stable (approximately 78 years), whereas the proportion of patients in the 90 years and older age group increased (2010/2011: 14.5%, 2018/2019: 18.7%), and patients 75-89 years of age decreased (2010/2011: 51.3%, 2018/2019: 46.4%) over time. The proportion of frail patients increased (2010/2011: 12.4%, 2018/2019: 15.3%), whereas CCI scores declined, with the proportion of patients with scores 0-2, indicating lower levels of comorbidity, increasing from 20.8% to 23.2% during the study period. The proportion of patients with more than 1 episode per year also remained stable across the years (approximately 17%). The percent change in the total number of observed HF episodes between 2010/2011 and 2018/2019 varied across provinces, with the smallest increase in Saskatchewan (2%) and the largest increase in Alberta (39%; Table 2).

HF episode costs

Between 2010/2011 and 2018/2019, HF episodes cost the Canadian health care system (excluding Quebec and the Territories) $6.65 billion, with the average episode costing $15,236 (Fig. 2; Supplemental Table S2). The total cost for female patients ($3.08 billion; average $14,501 per patient) was lower than for male patients ($3.57 billion; average $15,932 per patient; Supplemental Table S2). The percent change in the total cost of HF episodes between 2010/2011 and 2018/2019 varied across provinces, ranging from a 17% decrease in Newfoundland to a 44% increase in Prince Edward Island (Table 2). Total HF episode costs were highest for the 85- to 89-year-old age group ($1.09 billion; Supplemental Table S2).

Extending our examination to hospitalization episodes in which HF was listed as 1 of the 24 secondary diagnoses on the

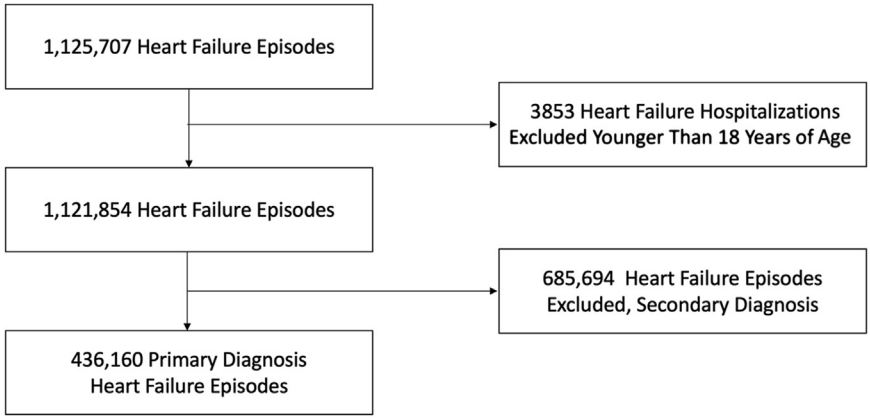

Figure 1. Study cohort exclusion diagram.

hospitalization record, and additional 685,694 episodes were identified with a cost to the Canadian health care system (excluding Quebec and the Territories) a total of $17.5 billion between 2010/2011 and 2018/2019 (Supplemental Table S3). The average cost per episode in which HF was listed as a secondary diagnosis during the study period was $25,500.

HF episode and cost projections

Between 2019/2020 and 2039/2040, there are projected to be 1.69 million HF episodes in Canada excluding Quebec and the Territories (Fig. 2; Supplemental Table S4). The projected number of HF episodes is higher for female patients (869,201 episodes) than for male patients (824,188 episodes; Supplemental Table S4). The age group of 90 years and older is projected to have the highest number of HF episodes (377,127; Supplemental Table S4). Zero knots were included in the final binomial GLM, because models with zero knots had lower Akaike information criterion values. The percent change in the total number of projected HF episodes between 2019/2020 and 2039/2040 varied across provinces, ranging from a 33% increase in Nova Scotia to a 143% increase in Alberta (Table 2).

The projected 1.69 million HF episodes between 2019/2020 and 2039/2040 are estimated to cost the Canadian health care system (excluding Quebec and the Territories) $19.5 billion (Fig. 2; Supplemental Table S5) with an average cost per episode of $16,378 (Supplemental Table S6). The projected cost between 2019/2020 and 2039/2040 for female patients ($8.85 billion) is estimated to be lower than for male patients ($10.7 billion; Supplemental Table S5). The percent change in the total cost of HF episodes between 2019/2020 and 2039/2040 is estimated to vary across provinces, ranging from a 15% decrease in Newfoundland to a 77% increase in Alberta (Table 2). Although projected HF episode costs increased for all age groups between 2019/2020 and 2039/2040, total costs are estimated to be highest for the group aged 90 years and older ($3.63 billion; Supplemental Table S5).

Sensitivity analysis

The effect of different population growth scenarios had limited effect on predicted numbers of episodes or total costs, with all scenarios within 8% of the 2039/2040 moderate-growth based values. Using the Statistics Canada low growth projection scenario population estimates resulted in approximately 63,000 fewer predicted episodes (Supplemental Table S7) and a reduction of 700 million in HF episode costs (Supplemental Table S8) from 2019/2020 to 2039/2040 compared with the medium growth scenario. Using the Statistics Canada high growth projection scenario population estimates resulted in ~66,000 more predicted episodes (Supplemental Table S9) and an increase of 600 million in HF episode costs (Supplemental Table S10) from 2019/2020 to 2039/2040 compared with the medium growth scenario.

Discussion

Between April 1, 2010 and March 31, 2019, there were 436,160 hospitalization episodes with HF as the primary diagnosis among 354,715 patients in all Canadian provinces, except Quebec, which cost the health care system a total of $6.65 billion. Extending the economic analysis to hospitalization episodes for which HF was listed as a secondary diagnosis, we identified an additional 685,694 episodes for an additional cost of approximately $17.5 billion. Annual total costs for hospitalizations episodes for which HF was listed as a primary diagnosis increased from approximately $684 million in 2010/2011 to approximately $776 million in 2018/2019, a 13% increase. If the trends observed during this time period continue, we estimate a total of 112,310 episodes with HF as the most responsible diagnosis, which will cost the health care system $1.05 billion in 2039/2040. Although these estimates are substantial, and consistent with those reported in other countries, they are likely underestimates of the true cost of HF in Canada for several reasons.[16] First, they do not include the cost of HF in Quebec or the Territories. Were we to assume that Quebec and the Territories had rates and trends similar the remainder of the country, we would estimate a total of 141,100 episodes with HF as the most responsible diagnosis costing the health care system $1.32 billion in 2039/2040. Second, the projections do not account for costs for which HF is a contributing factor. On the basis of observed data, HF as a secondary diagnosis is likely to contribute substantially to hospitalization costs in the future. Third, they do not account for physician costs or the costs of training, recruiting, and

Table 1. Baseline characteristics for Canadian (excluding Quebec and Territories) hospitalized HF patients from 2010 to 2018

	2010	2011	2012	2013	2014	2015	2016	2017	2018
Episodes, N	43,114	43,477	44,417	46,664	49,330	50,284	51,028	53,103	54,743
Patients, N	34,960	35,422	36,115	37,851	40,047	40,846	41,578	43,329	44,567
Sex, n (%)									
Female	17,140 (49.0)	17,384 (49.1)	17,561 (48.6)	18,452 (48.7)	19,662 (49.1)	20,062 (49.1)	20,262 (48.7)	21,067 (48.6)	21,780 (48.9)
Male	17,820 (51.0)	18,038 (50.9)	18,554 (51.4)	19,399 (51.3)	20,385 (50.9)	20,784 (50.9)	21,316 (51.3)	22,262 (51.4)	22,787 (51.1)
Age, y	77.4 (12.6)	77.5 (12.7)	77.7 (12.7)	77.8 (12.7)	77.8 (12.9)	77.8 (12.9)	78.0 (12.9)	77.9 (13.0)	77.8 (13.2)
Age category, years, n (%)									
18-39	328 (0.9)	377 (1.1)	353 (1.0)	351 (0.9)	439 (1.1)	450 (1.1)	428 (1.0)	491 (1.1)	563 (1.3)
40-44	245 (0.7)	273 (0.8)	252 (0.7)	269 (0.7)	307 (0.8)	301 (0.7)	283 (0.7)	317 (0.7)	370 (0.8)
45-49	513 (1.5)	496 (1.4)	470 (1.3)	477 (1.3)	498 (1.2)	542 (1.3)	523 (1.3)	529 (1.2)	581 (1.3)
50-54	868 (2.5)	900 (2.5)	886 (2.5)	950 (2.5)	942 (2.4)	999 (2.4)	955 (2.3)	995 (2.3)	1030 (2.3)
55-59	1365 (3.9)	1403 (4.0)	1419 (3.9)	1538 (4.1)	1612 (4.0)	1587 (3.9)	1643 (4.0)	1705 (3.9)	1792 (4.0)
60-64	2182 (6.2)	2052 (5.8)	2130 (5.9)	2200 (5.8)	2307 (5.8)	2414 (5.9)	2422 (5.8)	2656 (6.1)	2565 (5.8)
65-69	2816 (8.1)	2917 (8.2)	2961 (8.2)	3200 (8.5)	3385 (8.5)	3545 (8.7)	3571 (8.6)	3554 (8.2)	3650 (8.2)
70-74	3631 (10.4)	3693 (10.4)	3762 (10.4)	3749 (9.9)	4105 (10.3)	4229 (10.4)	4399 (10.6)	4734 (10.9)	4982 (11.2)
75-79	4980 (14.2)	4842 (13.7)	4880 (13.5)	4999 (13.2)	5211 (13.0)	5348 (13.1)	5368 (12.9)	5624 (13.0)	5662 (12.7)
80-84	6385 (18.3)	6520 (18.4)	6527 (18.1)	6741 (17.8)	6962 (17.4)	6772 (16.6)	6639 (16.0)	6848 (15.8)	7084 (15.9)
85-89	6581 (18.8)	6518 (18.4)	6748 (18.7)	6989 (18.5)	7389 (18.5)	7505 (18.4)	7567 (18.2)	7953 (18.4)	7955 (17.8)
≥90	5066 (14.5)	5431 (15.3)	5727 (15.9)	6388 (16.9)	6890 (17.2)	7154 (17.5)	7780 (18.7)	7923 (18.3)	8333 (18.7)
CCI score, n (%)									
0-2	7261 (20.8)	7396 (20.9)	7484 (20.7)	7908 (20.9)	8519 (21.3)	8754 (21.4)	9087 (21.9)	9818 (22.7)	10,319 (23.2)
3	2477 (7.1)	2470 (7.0)	2502 (6.9)	2562 (6.8)	2596 (6.5)	2531 (6.2)	2582 (6.2)	2510 (5.8)	2550 (5.7)
4	5433 (15.5)	5594 (15.8)	5881 (16.3)	6206 (16.4)	6521 (16.3)	6526 (16.0)	6761 (16.3)	7334 (16.9)	7679 (17.2)
≥5	19,789 (56.6)	19,962 (56.4)	20,248 (56.1)	21,175 (55.9)	22,411 (56.0)	23,035 (56.4)	23,148 (55.7)	23,667 (54.6)	24,019 (53.9)
HFRS, n (%)									
Frail	4344 (12.4)	4623 (13.1)	5002 (13.9)	5438 (14.4)	5868 (14.7)	6148 (15.1)	6460 (15.5)	6539 (15.1)	6837 (15.3)
Not frail	18,503 (52.9)	18,103 (51.1)	18,194 (50.4)	18,972 (50.1)	19,895 (49.7)	20,016 (49.0)	20,156 (48.5)	21,177 (48.9)	21,566 (48.4)
Pre-frail	12,113 (34.6)	12,696 (35.8)	12,919 (35.8)	13,441 (35.5)	14,284 (35.7)	14,682 (35.9)	14,962 (36.0)	15,613 (36.0)	16,164 (36.3)
Acute length of stay, d	10.4 (13.7)	10.3 (13.4)	10.3 (14.1)	10.2 (14.2)	10.0 (13.0)	9.9 (13.0)	9.9 (12.8)	9.7 (12.1)	9.9 (12.6)
More than 1 episode per year, %)	34,960 (17.0)	35,422 (16.8)	36,115 (17.0)	37,851 (17.1)	40,047 (17.0)	40,846 (16.9)	41,579 (16.9)	43,329 (16.7)	44,567 (16.9)

CCI, Charlson Comorbidity Index; HF, heart failure; HFRS, Hospital Frailty Risk Score.

Table 2. Observed (2010-2018) and predicted (2019-2039) percent change in Canadian (excluding Quebec and Territories) heart failure hospitalizations and costs

Province	2010 Episodes, n	2018 Episodes, n	Observed change in episodes, %	2019 Episodes, n	2039 Episodes, n	Predicted change in episodes, %	2010 Total cost*	2018 Total cost*	Observed change in total cost, %	2019 Total cost*	2039 Total cost*	Predicted change in total cost, %
BC	7006	9201	31	9454	20,007	112	109.3M	124.2M	14	126.3M	140.0M	11
AB	4922	6830	39	7275	17,680	143	110.9M	137.5M	24	154.9M	273.7M	77
SK	2390	2433	2	2498	3666	47	37.4M	36.5M	-2	38.1M	36.8M	-3
MB	2380	2645	11	2630	4285	63	44.7M	48.7M	9	49.1M	72.3M	47
ON	21,783	28,436	31	29,349	59,613	103	303.3M	349.1M	15	356.3M	459.4M	29
NB	1825	2005	10	1710	2333	36	26.7M	26.0M	-3	25.1M	22.0M	-12
NS	1512	1781	18	2084	2774	33	28.7M	32.6M	14	30.5M	26.2M	-14
NL	1047	1105	6	1095	1468	34	19.5M	16.1M	-17	16.2M	13.7M	-15
PE	249	307	23	319	484	52	3.4M	4.9M	44	4.6M	4.6M	-1
CA	43,144	54,743	27	56,414	112,310	99	684.3M	776.0M	13	801.5M	1.0B	25

AB, Alberta; B, billion; BC, British Columbia; M, million; MB, Manitoba; NB, New Brunswick; NL, Newfoundland; PEI, Prince Edward Island; SK, Saskatchewan.

*All dollars are on the basis of 2022 CAD$.

retaining highly skilled clinical teams to manage patients with HF. Fourth, they do not consider societal costs, in terms of loss of productivity of patients and their caregivers. Fifth, they do not include any ambulatory costs such as medications, investigations, and expert follow-up. Finally, these projections are on the basis of data before the pandemic, and do not incorporate the effects of COVID-19. However, they provide an important benchmark against which the effect of the pandemic on HF incidence and costs can be measured in future research.

Our estimates of the economic burden of HF hospitalizations on the basis of data from 2010/2011 to 2018/2019 are consistent with those we had previously reported, on data from 2004/2005 to 2013/2014.[14] For example, we had previously projected that the average patient hospitalized with HF would cost the Canadian health care system approximately $14,000 per year in 2030 ($16,900 in 2022 CAD$), which is very close to our current estimate of $16,279 per HF hospitalization episode, especially when we take into account that 17% of our patients had more than 1 hospitalization episode per year.

However, our current estimates of total cost of HF in 2030 ($946 million) is higher than our previously projected costs of $828 million.[14] There are several potential explanations for this increase. First, although in our previous study we used only one code (I50), in the current study we used a more comprehensive list of ICD-10-CA codes to identify hospitalizations with a primary diagnosis of HF. Second, our projections, on the basis of hospitalization episodes from 2010/2011 to 2018/2019, reflect more recent population growth rates. For example, the population growth rate for adults aged 75 years and older is increasing faster than other age groups, and older adults are at a higher risk for HF events.[17,18] These changing growth rates might also explain why the HF episode costs were highest for the 85- to 89-year-old age group between 2010/2011 and 2018/2019, with the 90 years and older age group projected to have the highest HF episode costs between 2019/2020 and 2039/2040. Third, the incidence of HF is likely increasing over time because of increased awareness toward the disease and access to diagnostic testing such as B-type natriuretic peptide. And finally, HF is often the final common pathway, and improvement in survival in other cardiovascular conditions such as myocardial infarction or valvular disease might translate into an increase in the number of patients who can potentially develop HF.

Limitations

Several limitations of our study must be noted. Data for Quebec and the Territories were not available. Our projections assume that trends in the number of HF hospitalization episodes between 2010/2011 and 2018/2019 will continue until 2039/2040. This should be interpreted as a baseline scenario with the assumption of no changes, but with the expectation that future changes in health care policies, clinical practice, and therapies will affect the trajectory presented. Our study focused only on HF hospitalization costs. Although hospitalizations are the major cost driver, the exclusion of other health system costs such as physician services, emergency department visits, outpatient care,

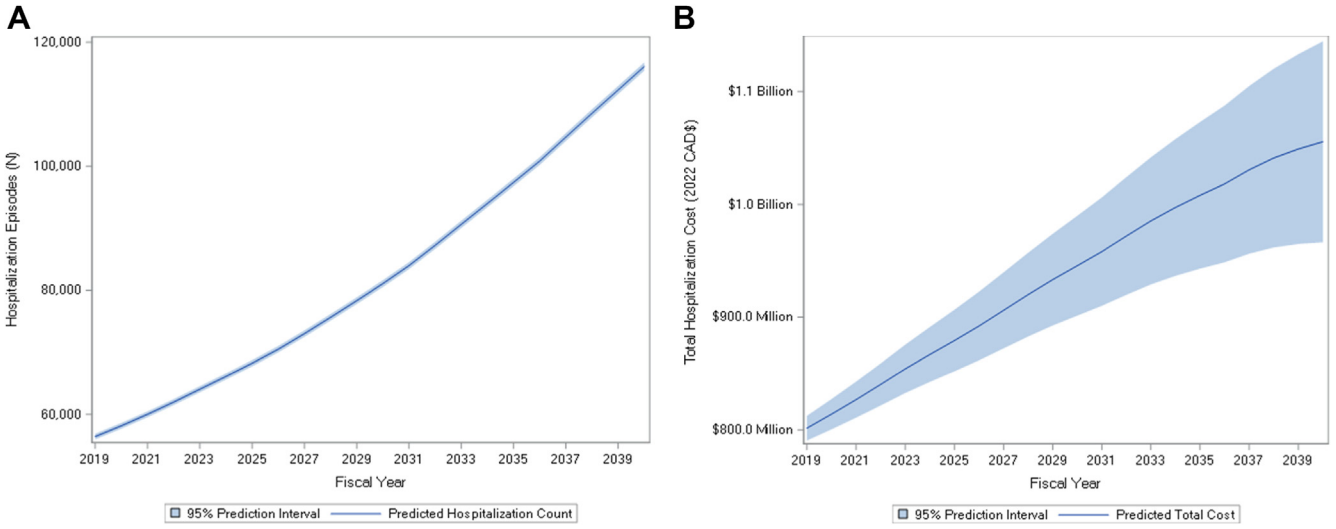

Figure 2. Canadian predicted total heart failure hospitalization episodes (**A**) and costs (**B**) over time (excluding Quebec and Territories).

medications, rehabilitation services, etc, substantially underestimate the true economic burden of HF care in Canada. Finally, data on sex, but not on gender, were available in hospitalization records and for population projections. The lack of the latter remains a limitation of our study.

Conclusion

The economic burden of HF hospitalizations on the Canadian health care system is substantial and is likely to grow significantly over time. These results should inform health systems planning to better serve patients with HF. It is necessary to prioritize early identification of patients at risk; access to early assessments and diagnoses of those who show symptoms; and to develop interventions and care pathways to manage patients in the outpatient setting and deliver more cost-efficient care.

Acknowledgements

Parts of this material are on the basis of data and information provided by the CIHI. However, the analyses, conclusions, opinions and statements expressed herein are those of the authors and not those of the CIHI. The authors acknowledge the Canadian Heart Failure Action Plan Data Governance Committee for their input and guidance at the early conceptualization stages of this research; members include Sean Virani, Anique Ducharme, M. Patrice Lindsay, Nathaniel M. Hawkins, Robert McKelvie, Stephanie Poon, Kim Anderson, Douglas Lee, Paula Henderson, Robert Schlamp, Agnes Lehman, Carolyn Doyle-Cox, and Shelley Valaire.

Ethics Statement

This study was approved by the University of Alberta Research Ethics Board (Pro00100060).

Patient Consent

The ethics panel determined that this is a retrospective database review for which subject consent for access to personally identifiable health information would not be reasonable, feasible, or practical.

Funding Sources

This economic analysis was commissioned by the Heart & Stroke Foundation of Canada through an unrestricted grant from Novartis. Dr Kaul holds a Canadian Institutes of Health Research Sex and Gender Science Chair and a Heart & Stroke Foundation Chair in Cardiovascular Research.

Disclosures

The authors have no conflicts of interest to disclose.

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Supplementary Material

To access the supplementary material accompanying this article, visit *CJC Open* at https://www.cjcopen.ca/ and at https://doi.org/10.1016/j.cjco.2024.11.019.