Incidence- and prevalence-based cost of illness after first hospitalization for heart failure, Nova Scotia, Canada

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ABSTRACT

OBJECTIVES: The objective here was, among persons aged 50 years and older in Nova Scotia discharged alive after a first hospitalization for heart failure, to estimate mean age- and sex-specific prevalence- (2013-15) and incidence-based (2009-15) direct medical costs.

BACKGROUND: While it has been known that treating Canadians with heart failure makes it among the costliest of medical conditions, there is remarkable paucity of reliable information on direct medical costs of treatment.

METHODS: A retrospective cohort study was conducted using population-based administrative health databases in Nova Scotia. The cohort comprised adults with an incident hospitalization for heart failure between fiscal years 2009 and 2012 and followed until 2015. Costs were estimated using a bottom-up approach that included hospitalizations, physician visits, and cardiac medications (for those aged 65 years and older).

RESULTS: The cohort included 3,327 persons aged 50 years and older. The annual prevalence-based costs were approximately CDN2018 $6,200 for both sexes. Hospitalizations formed the biggest component of costs and were about six times greater than medication and physician costs combined. Direct medical costs were highest in the year after hospital discharge, decreased to a relatively stable level, and increased in the last year of life.

CONCLUSIONS: Mean annual costs of heart failure in Nova Scotia were lower than values reported from the United States and comparable to European countries. These cost estimates for heart failure may be used to highlight areas of inefficiency, identify temporal changes, underscore areas of inequitable allocation of resources, and serve as inputs for economic analyses.

INTRODUCTION

According to the Canadian Institute for Health Information, heart failure is the third most common reason for hospitalization in Canada[1], has the highest rates rehospitalization[2], and is the second most costly cause of hospitalization[3]. Treating people with heart failure thus imposes enormous economic burdens on all developed countries, accounting for between 1% and 2%[4, 5], and possibly as high as 3.2%[6], of total annual direct health care costs. This occurs because heart failure is common and increases rapidly after middle age and requires high intensity care including regular hospitalizations. As such, it is considered among the most impactful and expensive conditions in Canada.[7, 8]

Despite these startling figures, there exists scant reliable information on resource use and costs on which to base strategies and policies for managing Canadians diagnosed with heart failure. For example, one systematic review of cost-of-illness studies published between 2004 and 2016 yielded no Canadian studies on the topic[9] and another on studies published between 2003 and 2015[10] yielded only one Canadian study examining costs in the first year post-discharge.[11]

Studies from other jurisdictions can provide benchmarks and knowledge applicable to Canada. Mean annual cost-of-illness range from $868 in 2014 South Korea[12] to $25,532 in 2002 Germany (standardized to 2014 US dollars).[13] Investigators have shown that: the largest component of direct medical costs - over 50% - is hospitalization followed by medications[9]; that newly diagnosed patients have higher costs than those later in the course of disease; and that direct medical costs are increased during the last months of life[14-16].

Reliable estimates of the costs of failure are required for important evaluative and research purposes. First, costs of illness can be used to identify differences in distributions of costs between demographic groups or jurisdictions that can be used to generate hypotheses about reducing costs, by highlighting areas where practice variations occur and identifying inefficient use resources. These hypotheses can, in turn, help determine research and funding priorities.[17, 18] Second, costs of illness studies are needed to quantify changes that may arise through new management approaches or public policies.[16] Third, from a public health perspective, the

distributions can be used to identify potential areas of inequitable allocation of resources.[17] Fourth, they can provide more reliable inputs for lifetime cost-effectiveness models which are often based on information from randomized trials or other sources that may not reflect actual practice.

Two approaches to costing of illness exist: incidence- and prevalence-based approaches. The incidence-based approach involves calculating the costs of treatment for an individual in each year after diagnosis until death (or resolution) and the prevalence-based approach estimates the total cost to a population living with a disease incurred in a given calendar year.[18] There are no published Canadian estimates using either approach for heart failure. The primary objective here was, among persons aged 50 years and older in Nova Scotia discharged alive after a first hospitalization for heart failure, to estimate mean overall and age- and sex-specific prevalence-based (2013-15) and incidence-based direct medical costs (2009-15). We also report direct medical costs in the two years prior to death.

METHODS

A retrospective, population-based design was conducted using Nova Scotian administrative health databases of hospital discharge abstracts, physician billing, prescription claims (for persons aged 65 years and older), and death certificates. Linked using anonymized identifiers,[19] these data include records for medical and hospital services of all provincial health plan registrants in Nova Scotia (over 98% of 923,598 residents (183,820 aged 65 years and older)) in 2016. The study population consisted of all registered Nova Scotians aged 50 years and older who had a "most responsible diagnosis" code of heart failure (International Classification of Disease, Tenth revision (ICD10) code 150.x.) between 2009 and 2012, after removing those with a hospital discharge abstract including any heart failure coded in 2007 or 2008. This algorithm generally yields higher specificity and lower sensitivity, indicating high confidence that the subjects in the sample were likely to have suffered acute decompensated heart failure[20] while excluding some subjects.[21, 22] There is no *a priori* reason to think that patients with heart failure coded with a different discharge diagnosis were systematically different than included subjects.

Incidence rates per 100,000 were calculated using age- and sex-specific population denominators.[23] Duration of survival was calculated using the date of admission for the index hospitalization and the date of death on the death certificate. All-cause mortality was illustrated using Kaplan-Meier curves.

Resource Use and Costs

Costing was done using a bottom-up ("person-based") rather than a top-down ("population-based") approach.[24] Medical resources included hospitalizations, physician visits, and, for persons aged 65 years and older, cardiac medications. Costs were stratified by sex and age (50 to <65, 65-80, and >80 years) on the admission date of the date of admission for the index hospitalization. Costs were attributed to the year of follow-up after hospital discharge with subjects censored on the date of death, end of enrolment, or March 31, 2016.

To facilitate future comparisons with other jurisdictions, rather than use resource-intensity-weights[25], we estimated mean annual costs of hospitalization by multiplying the mean length of stay by a per-diem cost. The per-diem costs of hospital stays were tabulated separately for medical wards and intensive care units/coronary care units based on Canadian means from the Canadian Institute for Health Information,[26] inflated to 2018 using the consumer price index,[27] yielding values of $1,105 for a day on a general ward and $3,856 for a day in the intensive care unit. Hospital costs were attributed to the year in which the admission date discharge fell. Physician costs were obtained from the Nova Scotia physician fee schedule.[28]

The costs of cardiovascular medications was based on Anatomical Therapeutic Chemical (ATC) Classification of Drugs (codes C09AA, C09B, C09CA, C09D, C02, C07, C08, C01DA, C10, C03, C03DA) obtained from the Nova Scotia Pharmacare Drug Formulary.[29] Daily medication costs were multiplied by the number of days supplied to obtain the total cost. Dispensing fees were excluded.

Cost of illness analysis

Following conventional principles of cost of illness analysis,[24] we estimated both incidence- and prevalence-based costs of heart failure in Nova Scotia. These analyses differ from cost-effectiveness studies in that they are do not include an intervention, comparator groups, or clinical outcomes. For the incidence-based costs, subjects were followed for up to seven years (2009 to 2015) after diagnosis, with a two-year washout period applied in 2007 and 2008. For the prevalence-based approach, annual mean costs were based on the three most recent years available (2013 to 15). We tabulated the costs in the two years prior to death, accounting for left-censoring for those who survived less than two years. Rather than medians, we report mean (and standard deviation) values as they provide more accurate estimates of total budgets and are thus more useful for policy-making.[30, 31] Costs were reported in 2018 Canadian dollars and we did not apply discounting.

This study was approved by the Dalhousie University Health Sciences Research Ethics Board.

RESULTS

A total of 3,327 persons aged 50 years and older were discharged from hospital with the most responsible diagnosis for heart failure between 2009 and 2012. The mean age was 77.6 years and 48.2% were women. Incidence rates increased by an order of magnitude in each age stratum, were higher among men than women in all three age strata, and declined in both sexes and all age strata and between 2009 and 2012 (Table 1).

Mortality after heart failure diagnosis was high, with 20% of individuals dead within two months and a median survival of less than three years (Figure 1). Survival was slightly higher among men than women over seven years. Approximately 20% of individuals were alive seven years the initial diagnosis.

Between 2013 and 2015, the mean annual prevalence-based costs for all patients was approximately $6,200 for both men and women (Table 2). Approximately 85% of these costs were for hospitalizations, 10% for medications, and 5% for physician services. Mean annual prevalence-based costs declined over age stratum for both men and women; they were higher

for women than for men in age-sex stratum, however, because of different distributions of age, the weighted means of both sexes were similar. These mean costs had standard deviations greater than the means for each age-sex stratum, indicating that some subjects had very high costs. Among all subjects, hospitalizations formed the biggest cost driver, being about six times greater ($5,874) than the medication ($706) and physician ($283) costs combined.

For both sexes, mean incidence-based costs were highest in the first year after hospitalization for heart failure, ranging from approximately $63,000 among men aged 50 to 64 years to almost $160,000 among men over age 80 years and from $90,000 among women aged 50 to 64 years to almost $140,000 among women over age 80 years (Table 3). For those who survived until the second year after discharge, costs declined approximately 80% over the subsequent years, and then increased in the last year of life. Direct medical costs in the year before death were slightly higher for men than women and between five and eight times higher than the second year before death. However, the costs in the year before death were still substantially lower than the first year after diagnosis (Table 3).

DISCUSSION

We observed that, for patients for hospitalized for heart failure in In Nova Scotia, costs were highest in the first year after hospitalization, then decreased to a relatively stable and lower level, and increased again toward the end of life. While Canadian investigators have reported increased costs at the end of life,[11] the pattern of costs after diagnosis until death has not been described. Selecting subjects based on the most responsible diagnosis led to an estimated annual mean prevalence-based costs in Nova Scotia of approximately $6,200. This approach likely depicts a conservative estimate, termed “heart failure in isolation”,[6] and can appropriately represent the lower bound of the costs of illness. Including the costs of conditions that are comorbid with heart failure, such as hypertension, coronary artery disease, renal insufficiency, diabetes, chronic obstructive pulmonary disease[32] or other conditions,[4] termed “heart failure syndrome”, can appropriately represent the upper bound of the costs of illness.

Comparing the mean annual cost of $6,200 to estimates from other countries is fraught with conceptual and methodological challenges[9] (including selection of patients focusing on heart failure in isolation versus heart failure syndrome; choice of ICD codes; top down versus bottom up costing (and if the latter, the categories included); perspective (e.g. payer or societal); and others). Given those caveats, investigators have shown that the annual cost-of-illness ranges from $868 in 2014 South Korea (2014 US dollars)[12] through $20,245[6] (2012 US dollars) and $20,618[33] (2008 US dollars) in the United States, to $25,532 in 2002 Germany (2014 US dollars).[13]

This study was subject to important limitations. First, follow-up commenced for subjects after their first hospitalization, meaning that costs attributable to heart failure prior to this event were excluded, leading to an underestimation of the actual costs of illness. One key piece of information typically absent in administrative health data is the severity of illness, which, for heart failure, is often measured using the New York Heart Association (NYHA) four level categorization.[34] The first hospitalization for heart failure corresponds roughly to NYHA class III when disease severity increases and patients become more susceptible to breathlessness that requires hospitalization. In Poland, costs in NHYA class I and II were between 2/3 and 3/4 the costs in NYHA III.[35] Given the potentially larger number of individuals with less severe disease, the total costs could be substantial. One advantage of using the algorithm we used was that it corresponds to that used by other Canadian investigators.[11, 21, 36] Second, one challenge with bottom-up costing studies is external validity.[16] By using disaggregated values for length of stay and per diem costs, future investigators can compare values they observe to those in Nova Scotia. However, given the similarity between Canadian provinces and territories in the organization of care, use of common national clinical practice guidelines, similar financing mechanisms, and availability of administrative health data, lessens concerns that results are not applicable to other Canadian jurisdictions. Third, no information on emergency department and other outpatient clinic costs was included because the database in which these resources are curated, the National Ambulatory Care Reporting System, is incomplete in Nova Scotia. Fourth, as the perspective was that of a provincial health payer, we excluded the costs for informal care givers and lost productivity. One study showed these costs to be greater than the direct medical

costs of heart faiulure[37]. A similar phenomenon may exist in Nova Scotia where a deterioration of health care facilities may increase the burden on home care.[38] Fourth, given the complexity of costing medications for heart failure,[39] we simplified attribution of costs by including ATC codes for cardiovascular medications only. Similarly, for physician visits, we attributed to heart failure all billings from family physicians, cardiologists, general internists, and cardiac surgeons. While both these assumptions led to misclassification, it is unclear the direction of the combined effect of these on the costs of illness.

At least two findings regarding the epidemiology of heart failure in Nova Scotia bear greater scrutiny. First, the prevalence, incidence, and mortality in Nova Scotia were similar to other Canadian provinces (using the same algorithm of the most responsible diagnosis as that used here).[21] However, there seemed to be a trend of declining rates of hospital discharge for heart failure between 2009 and 2012. Such a finding, if confirmed elsewhere in Canada, would be of considerable interest and would parallel the decline observed in the United Kingdom. Using the same algorithm to select subjects as the one used here, in Canada, hospital costs were projected to increase from $482 million (95% confidence interval (CI): $464 to $500 million) in 2013 to $722 million (95% CI: $650-801) in 2030 (these costs standardized to 2014 Canadian dollars).[36] If the incidence is declining, these estimates may be shifted downwards. Second, the survival in Nova Scotia may be lower than reported the literature.[40]

The authors of “The Need for Heart Failure Advocacy in Canada” highlight the limited awareness about the “heart failure epidemic, the natural history of the disease, and the potential benefits of available therapies”.[8] Those authors call for action from all stakeholders that “outlines key targets for health care system redesign and policy initiatives that must be championed to affect meaningful change toward an optimal future for this disease state”.[8] Like elsewhere,[9] hospitalizations comprised the biggest component of costs in Nova Scotia. The finding of increased costs in the first year is also consistent with findings from other jurisdictions.[2;31] Taken together, these findings suggest that interventions designed to reduce hospitalizations, particularly in the year after the first hospitalization for heart failure, holds promise as a potentially useful starting point to evaluate policies and interventions such as

improved medication adherence,[41] pre-symptom identification,[42] telemedicine,[43] improved care coordination,[44] transfer to alternate levels of care,[45] clinical pathways,[46] or others[47] designed to avoid acute exacerbations and hospitalizations among heart failure patients.

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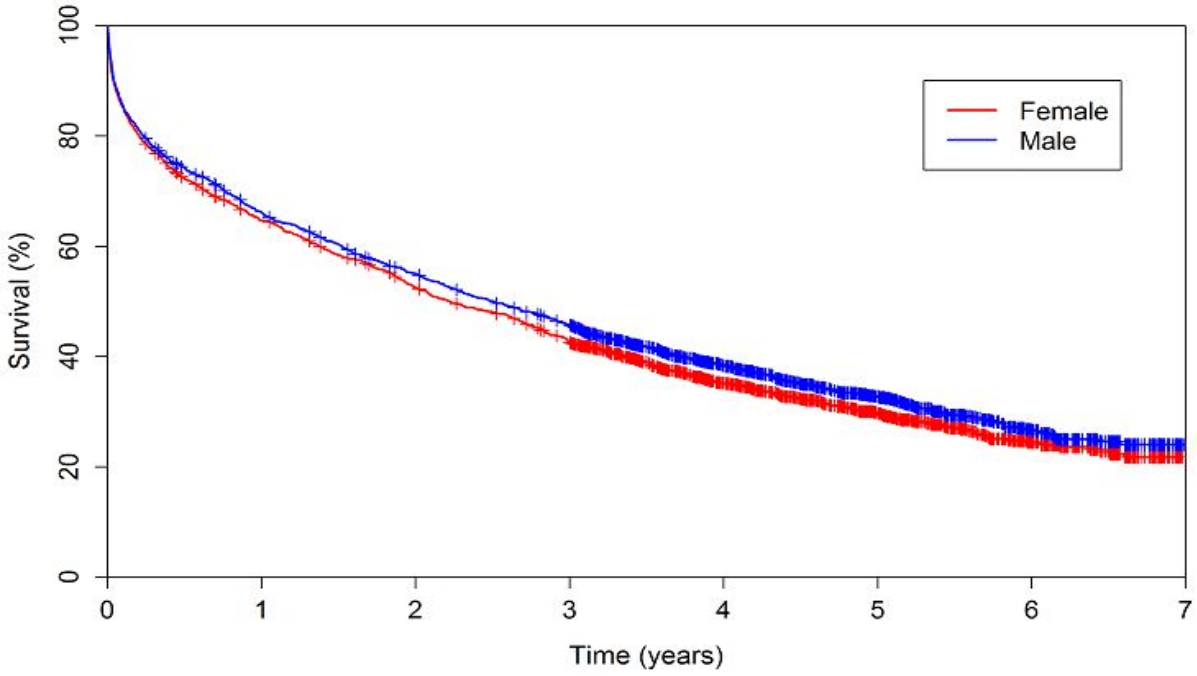

Age (years)	2009	2010	2011	2012
Men				
50 – 64	83 (84)	91 (94)	81 (85)	67 (71)
65 – 80	414 (216)	368 (198)	322 (180)	294 (173)
> 80	1,505 (178)	1,159 (141)	1,307 (161)	1,109 (141)
All men ≥ 50	289 (478)	256 (433)	246 (426)	217 (385)
Women				
50 – 64	44 (46)	39 (42)	35 (39)	30 (33)
65 – 80	292 (173)	221 (134)	226 (141)	213 (139)
> 80	925 (213)	987 (229)	991 (231)	779 (185)
All women ≥ 50	230 (432)	211 (405)	210 (411)	178 (357)
Both Men and Women				
Age-adjusted	258 (910)	232 (838)	227 (837)	196 (742)

*Based on a most responsible diagnosis of International Classification of Disease, Tenth revision code 150.x.

	Hospitalizations		Outpatient Physician visits		Outpatient cardiovascular medications†		Total‡
Age (y)	Length of stay (days)	Cost§	Visits	Cost	Dispensations	Cost	Cost
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
	Men						
50 – 64	5.4 (12.8)	7,522 (17,106)	17.1 (24.3)	433 (768)	NA	NA	7,956 (17,439)
65 – 80	5.3 (14.0)	6,701 (16,909)	14.1 (26.0)	354 (783)	26.4 (43.4)	830 (978)	7,886 (17,370)
> 80	3.3 (13.0)	3,981 (15,304)	8.7 (19.7)	188 (506)	13.3 (33.6)	409 (783)	4,577 (15,689)
All men	4.6 (13.4)	5,880 (16,444)	12.7 (23.8)	309 (699)	20.5 (39.8)	642 (920)	6,189 (16,827)
	Women						
50 – 64	7.0 (17.3)	10,491 (36,257)	16.5 (25.7)	404 (787)	NA	NA	10,895 (36,731)
65 – 80	5.9 (15.1)	7,188 (17,769)	14.8 (23.2)	336 (659)	34.4 (52.7)	927 (1,312)	8,452 (18,253)
> 80	3.3 (11.9)	4,102 (16,621)	8.2 (18.8)	170 (447)	20.3 (39.3)	658 (743)	4,930 (16,989)
All women	4.6 (13.8)	5,868 (19,943)	11.4 (21.6)	254 (579)	26.0 (45.7)	767 (1,022)	6,122 (20,295)
	Both Men and Women						
All subjects	4.6 (13.6)	5,874 (18,213)	12.1 (22.7)	283 (644)	23.3 (43.0)	706 (975)	6,157 (18,578)

NA: not available

† ATCs for cardiovascular medications: C09AA, C09B, C09CA, C09D, C02, C07, C08, C01DA, C10, C03, C03DA.

‡ Includes only costs of hospitalizations and physician visits for rows subjects under 65 y and additionally includes cardiovascular medications for sujects 65-80 y and >80 y.

§ Per-diem costs of general ward: $1,105 and ICU: $3,856.

	Year after diagnosis						
Age (y)	**1**	**2**	**3**	**4**	**5**	**6**	**7**
	Men						
50 – 64*	62,701 (148,268)	16,592 (46,630)	17,675 (55,711)	15,957 (48,843)	17,258 (78,985)	13,005 (49,298)	7,529 (26,088)
65 – 80†	106,701 (200,283)	22,723 (65,958)	24,506 (57,294)	18,249 (47,557)	18,087 (53,094)	15,512 (61,669)	5,059 (10,568)
> 80†	159,164 (215,536)	22,376 (48,152)	27,580 (64,700)	16,753 (45,100)	9,295 (17,657)	22,159 (48,409)	20,341 (39,897)
All men*	116,558 (200,390)	20,549 (56,949)	22,830 (58,749)	16,834 (47,434)	15,845 (59,371)	15,384 (55,234)	8,972 (25,648)
	Women						
50 – 64*	90,440 (201,567)	25,292 (88,160)	13,422 (26,240)	22,783 (56,948)	11,772 (35,858)	16,442 (40,347)	1,474 (3,705)
65 – 80†	103,845 (191,736)	20,369 (47,390)	19,409 (48,489)	17,869 (45,367)	16,194 (51,668)	13,312 (35,428)	14,368 (41,594)
> 80†	139,518 (179,936)	21,878 (48,755)	18,613 (48,338)	14,702 (39,266)	9,715 (36,254)	10,746 (29,286)	12,691 (37,052)
All women*	120,874 187,658)	20,982 (54,750)	17,633 (45,956)	16,884 (45,206)	12,653 (44,263)	12,650 (34,519)	11,131 (36,491)
	All						
All subjects *	118,640 (194,335)	20,756 (55,899)	20,390 (53,177)	16,857 (46,393)	14,369 (52,921)	14,138 (46,924)	9,982 (31,134)

* Includes costs of hospitalizations and physician visits.

† Includes costs of hospitalizations, physician visits, and outpatient cardiovascular medications