

The Current and Future Burden of Heart Failure Hospitalization Costs in Canada

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Abstract

Background: We examined heart failure (HF) hospitalization costs between fiscal years (FY) 2004 and 2013 in Canada and modeled the future hospitalization costs until 2030.

Methods: Canadian Institutes for Health Information (CIHI) Discharge Abstract Database was used to identify hospitalizations with HF as the primary diagnosis between FY 2004-2013. Multiple linear regression models were used to calculate the trend in prevalence and extrapolate these to 2030. CIHI patient cost estimates were used to identify HF hospitalization costs. Generalized linear models were used to estimate average annual hospitalization costs per HF patient. We conducted a sensitivity analysis including all hospitalizations with HF in any diagnostic field.

Results: In 2013, 45,600 (95% CI: 43,800 to 47,200) patients were hospitalized with HF as the primary diagnosis, accounting for \$482 (95% CI: \$464 to \$500) million. By 2030, we estimate 54,000 (95% CI: 49,000 to 60,000) patients and hospitalization costs of \$722 million (95% CI: \$650 to \$801 million), with the very elderly (age \geq 80 years) accounting for 52% of costs. Including hospitalizations where HF was a secondary diagnosis would increase the total HF hospitalization cost to \$2,800 (95% CI: \$2,600 to \$3,000) million in 2030.

Interpretation: As with other developed countries, hospital costs related to HF are on the rise in Canada. The elderly are the main consumers of HF hospital services.

Strategies to improve outpatient care to reduce HF hospitalization rates are needed.

Introduction

Heart Failure (HF) is a costly health condition and a major public health problem. It is estimated that 2-3% of the population in developed countries has HF and the prevalence increases to 8% among those aged more than 75 years [1]. HF is the single most common reason for hospital admission [2, 3]. In the United States, it was projected that there would be 8.5 million people (3% of the U.S. population) with HF in 2030, which would cost the U.S. health system \$53 billion [4].

It has been hypothesized that a combination of improved survival in HF patients [5-7] and population ageing [8] is expected to increase the burden of HF in Canada.

However, little is known on the current and future cost burden of HF on the Canadian health care system. Accordingly, the objectives of our study were to examine HF hospitalization costs between fiscal years (FY) 2004 and 2013 in Canada, and based on these, model the future prevalence and hospitalization costs until 2030.

Methods

Annual volume of HF patients from FY 2004 - 2013

The Canadian Institute for Health Information (CIHI) Hospital Discharge Abstract Dataset (DAD) from FY 2004 to 2013 for all Canadian provinces and territories except Quebec was used to identify hospitalizations with a primary diagnosis of HF (10th revision International Classification of Disease code of I50).

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3 Canadian population estimates from Statistics Canada Tables CANSIM-051-0001 for
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5 FY 2004 to 2013 [9] (minus Quebec) were used as denominators to calculate annual HF
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7 hospitalization prevalence rates per 100,000 population for each of the following groups
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9 of males and females: age less than 60 years, 60-69 years, 70-79 years, and 80 years
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11 or greater. Patients with multiple HF hospitalizations during the same year were counted
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13 only once.
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18 As previously mentioned, HF hospitalization data for the province of Quebec were not
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20 available. To estimate the burden of HF for the entire country, we assumed the HF
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22 hospitalization prevalence rates in Quebec to be the average across all other provinces
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24 and territories for which data were available. In order to do this, we first used Joinpoint
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26 regression to detect significant changes in annual hospitalization prevalence rates
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28 between FY 2004 - 2013 [5, 10, 11]. Significance testing was performed using Monte
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30 Carlo permutation method with 4,500 permutations [12]. Significant turning points at
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32 $\alpha=0.05$ were recorded and used as a knot in a multiple linear regression (MLR) model to
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34 predict hospitalization prevalence rates for the entire country except Quebec. The MLR
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36 model's outcome variable was the natural logarithm of HF hospitalization prevalence
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38 rate and predictors were FY, patient sex, age group, the knot, and the interaction
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40 between sex and age. Model assumptions (homoscedasticity, normality of residuals,
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42 and the linearity of relationships between the outcome and FY as a continuous
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44 predictor) were checked and explored for unusual and influential observations by
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46 examining residuals and leverage values. The estimated number of HF patients, along
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48 with 95% confidence intervals (CI), was derived by multiplying the estimated HF
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3 hospitalization prevalence rate from the MLR model with the Canadian population
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5 (including Quebec) for each age/sex group for each year.
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8 9 ***Annual hospitalization costs per HF patient from FY 2004 - 2013***

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12 The cost of each HF hospitalization was obtained from the CIHI patient cost estimates
13 (PCE). The CIHI PCE uses an algorithm, taking case mixed groups (CMG), resource
14 intensity weight, cost per weighted case, and length of stay into consideration [13]. PCE
15 for each FY, CMG and age group combination were only available for FY 2009 to 2012.
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17 If the cost for a certain CMG grouper was not available in the CIHI PCE, we used the
18 cost in FY 2010 for that grouper in the Cost Analysis Tool of the Ontario Case Costing
19 Initiative [14]. All costs were then converted to 2014 dollar using Bank of Canada
20 inflation calculator [15]. Annual in-patient costs for a HF patient were derived by
21 summing up costs of individual hospital admissions of the same patient in the same
22 year. We then fitted a generalized linear model (GLM) with gamma distribution and log
23 link to estimate average annual hospitalization costs per HF patient for the entire study
24 period (FY 2004- 2013). The variables included in the model were FY, patient sex, and
25 age group as other patient factors were already incorporated into the CIHI PCE
26 algorithm (described above).
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47 The annual total HF hospitalization costs in Canada from FY 2004 to 2013 were derived
48 by multiplying the estimated number of HF patients hospitalized with the annual hospital
49 cost per HF patient.
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55 ***Projection of HF prevalence and costs from FY 2014 to 2030***

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3 We assumed that the trend of HF hospitalizations observed during FY 2004- 2013
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5 would continue. The coefficients from the MLR and GLM models described above were
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7 used to predict expected HF hospitalization prevalence rates and hospitalization costs
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9 per HF patient for each year for the FY 2014- 2030 period, respectively. We used
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11 Canadian population estimates (medium population growth- M5) from 2014 to 2030 [8]
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13 to calculate expected number of HF patients for each year. The annual total HF
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15 hospitalization costs for the 2014- 2030 period were derived by multiplying expected
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17 number of HF patients hospitalized with the annual hospitalization cost per patient.
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23 ***Sensitivity analysis***

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27 We conducted three sensitivity analyses. First, we examined the uncertainty around our
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29 annual HF hospitalization cost estimates by varying the estimated average annual
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31 hospitalization cost per patient within its 95% CI. Second, we added low and high
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33 population growth scenarios [8] into projections of HF hospitalization prevalence and
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35 costs from 2014 to 2030. Third, and most important, we re-calculated prevalence and
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37 cost estimates based on hospitalizations in which HF was coded as either primary or
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39 secondary diagnosis. Our primary analysis is based on hospitalizations where HF was
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41 coded as the primary diagnosis. However, HF has been shown to be associated with
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43 other conditions such as acute coronary syndromes and renal disease. It is therefore
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45 possible that when HF is present as a secondary diagnosis, it could contribute to
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47 hospital costs.
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Results

Characteristics of studied population

Between FY 2004 and 2013, there were 421,121 hospitalizations with a primary diagnosis of HF in Canada, excluding Quebec (Table 1). Average expected length of stay for an admission increased from 7.5 days in FY 2004 to 8.3 days in FY 2013. However, the median acute length of stay remained stable at 6 days. The numbers of hospitalizations and patients both reached the lowest point in 2007 and then increased. Females outnumbered males in the first 3 years. Patient average age increased overtime, as did the proportion of patients over the age of 80 years. Diabetes, chronic obstructive pulmonary and renal diseases were the most common comorbidities among HF patients. The largest increase in comorbidity rate was for diabetes, which increased from 29.3% in 2004 to 45.7% in 2013. Proportion of patients with more than one hospitalization with HF as the primary diagnosis per year increased from 17.9% in 2004 to 18.8% in 2013.

Annual volume of HF patients from FY 2004 - 2013

The results of the MLR model to estimate the hospitalization prevalence rate of HF overtime for each age and sex group are shown in Appendix 1. The HF hospitalization prevalence rates declined overtime in all groups (Figure 1). The prevalence rates were more than 100 times higher in the oldest compared to the youngest groups in both sexes. HF hospitalizations were more prevalent in males in all age groups.

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3 In contrast to the declining trend of the hospitalization prevalence rates, the absolute
4 number of HF patients hospitalized increased over time. There were 34,311 patients
5 hospitalized with HF in 2004 and this number increased to 36,142 in 2013 (Table 1).
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8 Extrapolating to include Quebec, we estimated 44,400 patients (95% CI: 42,500 to
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Annual hospitalization costs per HF patient from FY 2004 - 2013

Results of the GLM model to estimate annual HF hospitalization cost per patient are presented in the Appendix 1. Hospitalization costs for a HF patient increased by 1.4% annually. Annual hospitalization costs were higher for men and for younger patients. The average hospitalization costs for a HF patient in 2004 and 2013 were estimated at \$9,700 and \$11,000, respectively (Table 2).

Total HF hospitalization costs from 2004 to 2013 increased gradually (Figure 2). Using \$2014 values, the total cost was \$415 million (95% CI: \$397 to \$432 million) in 2004 and \$482 million (95% CI: \$464 to \$500 million) in 2013. In 2013, the very elderly (age \geq 80 years) accounted for 48.1% of costs while patients aged 70-79 years, 60-69 years, and < 60 years accounted for 27%, 16.2% and 8.7% of total HF costs, respectively.

Projection of HF prevalence and costs from FY 2014 to 2030

Results of HF hospitalization cost projection until 2030 are presented in Appendix 2. We estimated 48,000 (95% CI: 45,000 to 51,000 patients) and 54,000 HF patients (95% CI:

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3 49,000 to 60,000 patients) in 2020 and 2030, respectively. Annual hospitalization costs
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5 per HF patient were projected to increase to \$12,000 and \$14,000 in 2020 and 2030,
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7 respectively. Total HF hospitalization costs were projected to increase to \$722 million
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9 (95% CI: \$650 to \$801 million) in 2030 (Figure 2). This reflects a 49.8% increase from
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11 2013 to 2030. The very elderly (age \geq 80 years) was projected to account for 52% of
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13 total costs in 2030.
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16 17 18 **Sensitivity analyses** 19

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21 Varying annual hospitalization cost per HF patient within its 95% CI led to a maximum
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23 deviation of 1% of total HF hospitalization costs in 2013. The deviation increased to
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25 5.8% in 2030. This translated to a range of total HF hospitalization costs from \$477 to
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27 \$487 million and from \$681 to \$764 million in 2013 and 2030, respectively.
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31 Compared to medium population growth, low population growth resulted in 1,500 fewer
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33 HF patients and high population growth scenario resulted in an additional 2,500 HF
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35 patients in 2030. Consequently, the low population growth scenario would be
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37 associated with a \$22 million reduction and the high population growth scenario would
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39 be associated with an additional \$33 million in HF hospitalization costs.
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46 Results of prevalence and cost estimates based on hospitalizations with HF as either
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48 the primary or secondary diagnosis are provided in Appendix 3. Extending the analyses
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50 to include hospitalizations with HF in a secondary diagnosis field more than tripled
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52 (n=175,000 (95% CI: 164,000 to 187,000)) the estimate of patients hospitalized with HF
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3 in the year 2030. Consequently, total HF associated hospitalization costs were
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5 projected to be \$2,800 (95% CI: \$2,600 to \$3,000) million in 2030.
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8 9 **Interpretation**

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13 Patients who were hospitalized with a primary diagnosis of HF cost the Canadian health
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15 care system \$415 million in 2004 and \$482 million in 2013. HF hospitalizations
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17 therefore accounted for 0.8% of hospital spending in 2013 [16]. We estimate that cost of
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19 hospitalizations with HF as the primary diagnosis will increase substantially by 2030 to
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21 approximately \$720 million (50% increase from 2013), assuming the current patterns
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23 continues. The very elderly (age > 80 years) are the largest consumers of HF hospital
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25 services. Including hospitalizations where HF is a secondary diagnosis increased the
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27 cost estimate to 2.8 billion by 2030.
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34 Although there is a declining trend in the in-patient prevalence rates in both sexes, the
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36 absolute number of HF patients hospitalized is increasing. This is largely due to the
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38 change in population demographics. Statistics Canada has projected marked increases
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40 in the oldest age groups where HF is most prevalent: the proportion of people aged 80
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42 years and over is expected to rise by 73% in the next 15 years from 1.1 million people
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44 (4.1% of total population) in 2015 to 1.9 million (6.1% of total population) in 2030 [8].
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48 Our estimate of the increasing trend in the absolute hospitalized HF patient count is
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50 more conservative than that reported previously [17]. This is probably because we
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52 focused on hospitalizations with a primary diagnosis of HF. Extending the analysis to
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54 include hospitalization to include hospitalizations where HF was coded as a secondary
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3 diagnosis more than tripled our estimates of the number of patients hospitalized with
4 HF. Furthermore, we used more recent data (of 10 consecutive years up to 2013) and
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6 thus were able to take into account the slightly decreasing trends in hospitalization
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8 prevalence in all age groups, while the previous study by Johansen et al. used only a
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10 single data point of FY 1996/1997 [17].
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16 We projected that a patients hospitalized with a primary diagnosis of HF would cost the
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18 health care system \$14,000 per year in 2030. This is higher than the average cost of
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20 \$8,200 in the United States (converted to 2014 Canadian dollar assuming
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22 hospitalization accounts for 80% of medical costs [4] and 80% of patients with HF are
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24 hospitalized [18]). This could be explained by the fact that we used CMG, which takes
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26 comorbidities into consideration, while the U.S. study modeled medical costs
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28 attributable to HF only. Furthermore, patterns of care may also account for the
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30 difference in cost estimates in the two countries. We have previously shown that HF
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32 patients in Canada have lengths of stays that are longer than their U.S. counterparts
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34 [19].
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41 Some limitations of our study should be mentioned. We assumed that the trend in HF
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43 hospitalization patterns observed during FY 2004- 2013 would continue. Long-term HF
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45 prevalence and costs in Canada may change as a result of new therapies or changes in
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47 HF management strategies. However, forecasts based on current trends can serve as
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49 useful benchmarks to examine the impact of future innovations on health care costs.
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51 Second, we did not have hospitalization data from Quebec and assumed HF
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53 hospitalization prevalence rates in the province to be the average across all other
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3 provinces and territories. Finally, this study solely evaluated HF hospitalization costs
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5 and did not include physician, outpatient and drug costs, which are of increasing
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7 importance [20]. However, approximately 80% of total HF medical costs can be
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9 attributed to hospitalization costs [4, 21].
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14 As with other developed countries, the hospital resources related to HF care are on the
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16 rise in Canada. Hospitalizations where HF is the primary diagnosis cost the nation \$482
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18 million in 2013 and these costs will increase to \$720 million by 2030. Including costs
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20 where HF is the secondary diagnosis in our estimates increased the total cost to a
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22 sobering 2.8 billion by 2030. The elderly are the main consumers of HF hospital
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24 services. Strategies to improve outpatient care to reduce HF hospitalization rates are
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26 needed, as are innovations that provide seamless, cost-effective and evidence-based
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28 interventions from the emergency department through discharge.
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Figure legends

Figure 1: HF hospitalization prevalence rates in Canada, 2004-2013

Figure 2: HF hospitalization cost estimates and projection in Canada from 2004-2013 and 2014-2030 with 95% confidence intervals (in 2014 \$-values)

Confidential

Table 1: Statistics of HF patients hospitalized from 2004- 2013 (excluding Quebec)

Variable N (%)	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Hospitalizations	43,102	42,039	41,033	40,390	40,899	41,084	41,585	42,298	43,163	45,528
Average ELOS (SD)	7.5 (4.1)	7.5 (4.1)	7.7 (4.4)	7.8 (4.7)	7.9 (4.8)	8.0 (5.0)	8.1 (5.1)	8.3 (5.1)	8.4 (5.3)	8.3 (5.3)
Median aLOS (IQR)	6 (3-11)	6 (3-11)	6 (3-11)	6 (3-11)	6 (3-11)	6 (3-11)	6 (3-11)	6 (3-11)	6 (3-11)	6 (3-11)
Patients	34,311	33,600	32,876	32,542	33,004	32,995	33,144	33,753	34,365	36,142
Male/female ratio	0.96	0.98	0.98	1.00	1.02	1.01	1.01	1.01	1.03	1.04
Average age (SD)	76.8 (12.1)	76.9 (12.4)	77.1 (12.3)	77.1 (12.5)	77.2 (12.5)	77.1 (12.7)	77.6 (12.4)	77.6 (12.5)	77.8 (12.6)	77.9 (12.7)
Patient proportion by age group (%) **										
<60 years	8.8	9.2	8.8	9.0	9.2	9.0	8.4	8.6	8.5	8.6
60-69 years	13.5	13.7	13.5	13.8	13.7	14.5	14.0	13.8	13.7	14.0
70-79 years	29.8	28.7	27.8	27.1	27.0	26.2	25.7	25.1	24.6	23.8
>=80 years	47.8	48.4	50.0	50.1	50.2	50.3	51.9	52.5	53.2	53.6
Patient comorbidity (%)										
AMI	11.7	11.7	12.0	11.9	12.7	11.6	11.6	11.1	10.5	9.6
COPD	19.5	19.4	20.1	19.7	20.5	20.2	21.0	21.1	20.7	20.2
Dementia	5.2	5.1	5.4	5.2	5.5	5.3	5.9	6.0	5.9	5.9
Diabetes	29.3	30.4	40.0	40.9	40.6	45.0	44.7	44.9	45.5	45.7
Renal	19.0	20.0	18.6	18.0	18.8	14.6	14.4	14.2	13.9	14.3
Patient with >1 hospitalization (%)	17.9	17.7	17.8	17.4	17.4	17.6	18.2	18.4	18.6	18.8

*ELOS is expected length of stay, which is a number of days in hospital assigned to each admission based on CIHI grouping methodology.

aLOS: acute length of stay

**Total percentage may not be exactly 100% because of rounding

AMI: Acute Myocardial Infarction

COPD: Chronic Obstructive Pulmonary Diseases

Table 2: Annual hospitalization cost for HF patients hospitalized (in 2014 \$-values)

Group	2004	2007	2010	2013
Average cost per patient	9,679	10,092	10,522	10,970
Female				
All ages	9,543	9,950	10,374	10,816
<60 years	10,044	10,472	10,918	11,383
60- 69 years	9,917	10,339	10,780	11,239
70- 79 years	9,498	9,903	10,325	10,765
>=80 years	8,714	9,085	9,472	9,876
Male				
All ages	9,816	10,234	10,670	11,125
<60 years	10,331	10,771	11,230	11,709
60- 69 years	10,200	10,635	11,088	11,560
70- 79 years	9,770	10,186	10,620	11,073
>=80 years	8,963	9,345	9,743	10,158

Appendix 1: Detailed Results of HF Hospitalization Cost Evaluation in Canada, FY 2004- 2013

Annual volume of HF patients from FY 2004- 2013

We could only examine one turning point in each of the 8 studied groups by Joinpoint regression because of limited number of observations. Five knots were statistically significant at $\alpha=0.05$ at 2006 for female/70-79 and male/70-79, 2008 for female/60-69 and female/ ≥ 80 , and at 2010 for male/ ≥ 80 groups. Results of the MLR model to predict hospitalized prevalence rates are summarized in Table S1.1. Hospitalization prevalence rate from 2004 to 2013 are shown in detail in Table S1.2. In-patient HF population estimates from 2004 to 2013 are presented in detail in Table S1.3.

Table S1.1: Results of the MLR model to predict HF patient hospitalized prevalence rates

Variable	Parameter estimate	95% CI	p-value
Fiscal year	-0.033	-0.043, -0.022	<0.001
Sex			
Male	0.194	0.147, 0.241	<0.001
Female (ref)	--	--	--
Age group			
<60 years	-5.061	-5.108, -5.015	<0.001
60-69 years	-2.427	-2.472, -2.382	<0.001
70-79 years	-1.215	-1.261, -1.170	<0.001
≥ 80 years (ref)	--	--	--
Knot	0.012	-0.001, 0.025	0.079
Interaction			
Sex/<60 years	0.347	0.283, 0.412	<0.001
Sex/60-69 years	0.327	0.258, 0.396	<0.001
Sex/70-79 years	0.183	0.118, 0.248	<0.001
Adjusted R-square=0.999; Intercept= 49.720; Model assumptions' check satisfied.			

Table S1.2: HF hospitalization prevalence rate per 100,000 populations by sex and age in Canada, 2004- 2013

Fiscal Year	Female				Male			
	<60	60-69	70-79	>=80	<60	60-69	70-79	>=80
2004	12	168	551	1,902	20	270	803	2,363
2005	11	163	533	1,841	19	264	778	2,287
2006	11	157	516	1,782	19	259	753	2,214
2007	11	152	506	1,725	19	253	737	2,142
2008	11	147	495	1,669	18	248	721	2,073
2009	10	144	485	1,634	18	243	706	2,007
2010	10	141	475	1,600	17	238	692	1,942
2011	10	138	465	1,567	17	233	677	1,902
2012	10	135	455	1,534	17	228	663	1,862
2013	10	133	445	1,502	16	223	649	1,823

Table S1.3: In-patient HF population estimates in Canada, 2004- 2013

Fiscal Year	Number of HF patients hospitalized		
	Estimated average	95% CI lower bound	95% CI upper bound
2004	44,355	42,446	46,235
2005	44,184	42,492	45,827
2006	44,147	42,583	45,653
2007	44,095	42,618	45,509
2008	44,065	42,582	45,485
2009	44,196	42,709	45,620
2010	44,404	42,859	45,889
2011	44,718	43,141	46,235
2012	45,140	43,499	46,725
2013	45,562	43,830	47,244

Annual hospitalization costs per HF patient from FY 2004 - 2013

168,130 HF hospitalizations representing 134,257 patients from 2009 to 2012 were matched with CIHI PCE data. Costs of 2% of hospitalizations (n=3,042, containing 7 CMGs) with no matching PCE data were derived from the Ontario Cost Analysis Tool. Results of the GLM model to predict annual hospitalization costs per a HF patient are summarized in Table S1.4. Annual hospitalization costs per a HF patient are shown in detail in Table S1.5. Total HF hospitalization cost estimates are presented in detail in Table S1.6.

Table S1.4: Results of the GLM model to predict annual costs per HF patient hospitalized

Variable	Parameter estimate	95% CI	p-value
Fiscal year	0.014	0.011, 0.017	<0.001
Sex			
Male	0.028	0.022, 0.035	<0.001
Female (ref)	--	--	--
Age group			
<60 years (ref)	--	--	--
60-69 years	-0.013	-0.032, -0.006	0.190
70-79 years	-0.056	-0.074, -0.038	<0.001
>=80 years	-0.142	-0.159, -0.125	<0.001
Intercept= -18.662; gamma distribution and log link were used.			

Table S1.5: Annual hospitalization cost per a HF patient by sex and age in Canada (in 2014 \$-values), 2004- 2013

Fiscal Year	Patient average	Female				Male			
		<60	60-69	70-79	>=80	<60	60-69	70-79	>=80
2004	9,679	10,044	9,917	9,498	8,714	10,331	10,200	9,770	8,963
2005	9,815	10,185	10,055	9,631	8,836	10,476	10,343	9,907	9,088
2006	9,952	10,327	10,196	9,766	8,959	10,622	10,488	10,045	9,215
2007	10,092	10,472	10,339	9,903	9,085	10,771	10,635	10,186	9,345
2008	10,233	10,619	10,484	10,042	9,212	10,922	10,784	10,329	9,475
2009	10,377	10,767	10,631	10,182	9,341	11,075	10,935	10,473	9,608
2010	10,522	10,918	10,780	10,325	9,472	11,230	11,088	10,620	9,743
2011	10,669	11,071	10,931	10,470	9,605	11,387	11,243	10,769	9,879
2012	10,819	11,226	11,084	10,616	9,739	11,547	11,401	10,920	10,018
2013	10,970	11,383	11,239	10,765	9,876	11,709	11,560	11,073	10,158

Table S1.6: Annual HF hospitalization cost estimates in Canada (in million, 2014 \$-values), 2004- 2013

Fiscal Year	Total HF hospitalization costs		
	Estimated average	95% CI lower bound	95% CI upper bound
2004	415	397	432
2005	419	403	434
2006	424	409	438
2007	429	415	443
2008	435	421	449
2009	443	428	457
2010	451	435	466
2011	460	444	476
2012	471	454	488
2013	482	464	500

Appendix 2: Detailed Results of HF Hospitalization Cost Projection in Canada, FY 2014- 2030

Projection of annual volume of HF patients from FY 2014- 2030

Expected HF hospitalization prevalence rate from 2014 to 2030 are shown in detail in Table S2.1. Annual in-patient HF population projections from 2014 to 2030 are presented in detail in Table S2.2

Table S2.1: HF hospitalization prevalence rate per 100,000 populations by sex and age in Canada, 2014- 2030

Fiscal Year	Female				Male			
	<60	60-69	70-79	>=80	<60	60-69	70-79	>=80
2014	9	130	436	1,471	16	219	636	1,785
2015	9	127	427	1,440	16	214	623	1,748
2016	9	125	418	1,410	15	210	610	1,711
2017	9	122	409	1,381	15	205	597	1,676
2018	9	119	401	1,352	15	201	584	1,641
2019	8	117	393	1,324	14	197	572	1,607
2020	8	114	384	1,296	14	193	560	1,573
2021	8	112	376	1,269	14	189	549	1,540
2022	8	110	369	1,243	14	185	537	1,508
2023	8	107	361	1,217	13	181	526	1,477
2024	8	105	353	1,191	13	177	515	1,446
2025	7	103	346	1,167	13	173	504	1,416
2026	7	101	339	1,142	12	170	494	1,386
2027	7	99	332	1,118	12	166	483	1,357
2028	7	97	325	1,095	12	163	473	1,329
2029	7	95	318	1,072	12	159	464	1,301
2030	7	93	311	1,050	11	156	454	1,274

Table S2.2: In-patient HF population projection in Canada, 2014- 2030

Fiscal Year	Number of HF patients hospitalized		
	Expected	95% CI lower bound	95% CI upper bound
2014	45,834	43,992	47,633
2015	46,137	44,164	48,078
2016	46,472	44,347	48,576
2017	46,922	44,625	49,213
2018	47,367	44,884	49,861
2019	47,789	45,111	50,499
2020	48,203	45,320	51,140
2021	48,671	45,572	51,850
2022	49,130	45,808	52,561
2023	49,683	46,125	53,382
2024	50,270	46,466	54,250
2025	50,836	46,782	55,104
2026	51,435	47,122	56,003
2027	52,269	47,672	57,165
2028	52,998	48,120	58,226
2029	53,622	48,465	59,180
2030	54,196	48,759	60,089

Projection of annual hospitalization costs per HF patient from FY 2014- 2030

Annual hospitalization costs per a HF patient are shown in detail in Table S2.3. Total HF annual hospitalization costs are presented in detail in Table S2.4.

Table S2.3: Annual hospitalization cost per HF patient by sex and age in Canada (in 2014 \$-values), 2014- 2030

Fiscal Year	Patient average	Female				Male			
		<60	60-69	70-79	>=80	<60	60-69	70-79	>=80
2014	11,124	11,543	11,397	10,916	10,014	11,873	11,722	11,228	10,300
2015	11,280	11,705	11,556	11,069	10,154	12,039	11,886	11,385	10,445
2016	11,438	11,869	11,718	11,224	10,297	12,208	12,053	11,545	10,591
2017	11,598	12,035	11,882	11,381	10,441	12,379	12,222	11,706	10,739
2018	11,761	12,203	12,049	11,540	10,587	12,552	12,393	11,870	10,890
2019	11,925	12,374	12,217	11,702	10,735	12,728	12,567	12,036	11,042
2020	12,092	12,548	12,389	11,866	10,886	12,906	12,743	12,205	11,197
2021	12,262	12,723	12,562	12,032	11,038	13,087	12,921	12,376	11,354
2022	12,433	12,902	12,738	12,201	11,193	13,270	13,102	12,549	11,513
2023	12,608	13,082	12,917	12,372	11,350	13,456	13,286	12,725	11,674
2024	12,784	13,266	13,097	12,545	11,509	13,645	13,472	12,903	11,837
2025	12,963	13,451	13,281	12,721	11,670	13,836	13,660	13,084	12,003
2026	13,145	13,640	13,467	12,899	11,833	14,030	13,852	13,267	12,171
2027	13,329	13,831	13,656	13,080	11,999	14,226	14,046	13,453	12,342
2028	13,516	14,025	13,847	13,263	12,167	14,425	14,243	13,642	12,515
2029	13,705	14,221	14,041	13,449	12,338	14,628	14,442	13,833	12,690
2030	13,897	14,420	14,238	13,637	12,510	14,832	14,644	14,027	12,868

Table S2.4: HF hospitalization cost projection in Canada (in million, 2014 \$-values), 2014-2030

Fiscal Year	Total HF hospitalization cost		
	Expected	95% CI lower bound	95% CI upper bound
2014	492	472	511
2015	502	481	523
2016	513	490	536
2017	525	500	551
2018	538	510	566
2019	550	519	582
2020	563	529	597
2021	576	540	614
2022	590	550	631
2023	605	561	650
2024	620	573	669
2025	635	585	689
2026	651	597	709
2027	670	611	733
2028	688	625	757
2029	706	638	779
2030	722	650	801

Appendix 3: Detailed Results of Estimates and Projection of HF Associated Hospitalization Costs in Canada, FY 2004- 2030

Estimates and projection of annual volume of patients with HF from FY 2004- 2030

We could only examine one turning point in each of the 8 studied groups by Joinpoint regression because of limited number of observations. Seven knots were statistically significant at $\alpha=0.05$ at 2006 for male/ ≤ 60 ; at 2007 for female/ ≥ 80 and male/ ≥ 80 ; at 2009 for female/60-69, female/70-79, and male/70-79; and at 2010 for male/60-69 groups. Results of the MLR model to predict hospitalized prevalence rates are summarized in Table S3.1. Hospitalization prevalence rate from 2004 to 2030 are shown in detail in Table S3.2. In-patient HF population estimates and projection from 2004 to 2030 are presented in detail in Table S3.3.

Table S3.1: Results of the MLR model to predict hospitalized prevalence rates

Variable	Parameter estimate	95% CI	p-value
Fiscal year	-0.047	-0.051, -0.043	<0.001
Sex			
Male	0.202	0.179, 0.224	<0.001
Female (ref)	--		--
Age group			
<60 years	-4.914	-4.937, -4.891	<0.001
60-69 years	-2.394	-2.417, -2.370	<0.001
70-79 years	-1.208	-1.231, -1.184	<0.001
≥ 80 years (ref)	--	--	--
Knot	0.038	0.032, 0.044	<0.001
Interaction			
Sex/<60 years	0.223	0.191, 0.255	<0.001
Sex/60-69 years	0.213	0.181, 0.245	<0.001
Sex/70-79 years	0.125	0.093, 0.157	0.002
Adjusted R-square=0.999; Intercept= 26.351; Model assumptions' check satisfied.			

Table S3.2: HF associated hospitalization prevalence rate per 100,000 populations by sex and age in Canada, 2004- 2030

Fiscal Year	Female				Male			
	<60	60-69	70-79	>=80	<60	60-69	70-79	>=80
2004	32	475	1,554	4,820	52	747	2,156	5,897
2005	31	453	1,483	4,599	50	712	2,057	5,627
2006	31	432	1,415	4,388	47	680	1,962	5,369
2007	31	412	1,350	4,187	47	649	1,872	5,123
2008	30	394	1,288	4,150	47	619	1,787	5,077
2009	30	376	1,229	4,113	46	591	1,705	5,032
2010	30	372	1,218	4,076	46	563	1,690	4,987
2011	30	369	1,207	4,040	45	558	1,674	4,942
2012	29	366	1,197	4,004	45	553	1,659	4,898
2013	29	362	1,186	3,968	45	549	1,645	4,854
2014	29	359	1,175	3,932	44	544	1,630	4,811
2015	29	356	1,165	3,897	44	539	1,615	4,768
2016	28	353	1,154	3,862	43	534	1,601	4,725
2017	28	350	1,144	3,828	43	529	1,587	4,683
2018	28	346	1,134	3,794	43	524	1,572	4,641
2019	28	343	1,124	3,760	42	520	1,558	4,600
2020	27	340	1,114	3,726	42	515	1,545	4,559
2021	27	337	1,104	3,693	41	511	1,531	4,518
2022	27	334	1,094	3,660	41	506	1,517	4,478
2023	27	331	1,084	3,627	41	501	1,503	4,438
2024	26	328	1,075	3,595	40	497	1,490	4,398
2025	26	325	1,065	3,563	40	493	1,477	4,359
2026	26	322	1,055	3,531	40	488	1,464	4,320
2027	26	320	1,046	3,499	39	484	1,450	4,281
2028	25	317	1,037	3,468	39	479	1,438	4,243
2029	25	314	1,027	3,437	39	475	1,425	4,205
2030	25	311	1,018	3,406	38	471	1,412	4,168

Table S3.3: In-patient HF population estimates and projection in Canada, 2004- 2030

Fiscal Year	Number of patients hospitalized with HF		
	Expected	95% CI lower bound	95% CI upper bound
2004	116,773	114,443	119,076
2005	114,542	112,455	116,594
2006	112,700	110,749	114,613
2007	110,776	108,871	112,642
2008	110,985	109,133	112,798
2009	111,196	109,318	113,036
2010	112,971	111,064	114,837
2011	115,132	113,155	117,069
2012	117,613	115,497	119,693
2013	120,134	117,818	122,417
2014	122,293	119,734	124,827
2015	124,569	121,722	127,402
2016	126,968	123,792	130,143
2017	129,718	126,173	133,278
2018	132,506	128,561	136,486
2019	135,282	130,911	139,710
2020	138,083	133,261	142,989
2021	141,094	135,791	146,513
2022	144,139	138,330	150,098
2023	147,518	141,166	154,058
2024	151,065	144,141	158,222
2025	154,616	147,097	162,417
2026	158,346	150,198	166,830
2027	162,894	154,048	172,140
2028	167,202	157,644	177,227
2029	171,245	160,967	182,065
2030	175,201	164,185	186,838

Estimates and projection of annual hospitalization costs per patient with HF from FY 2004- 2030

Results of the GLM model to predict annual hospitalization costs per patient with HF are summarized in Table S3.4. Annual hospitalization costs per patient with HF are shown in Table S3.5. Total HF associated hospitalization cost estimates and projection are presented in Table S3.6.

Table S3.4: Results of the GLM model to predict annual costs per patient with HF hospitalized

Variable	Parameter estimate	95% CI	p-value
Fiscal year	0.013	0.010, 0.015	<0.001
Sex			
Male	0.069	0.063, 0.075	<0.001
Female (ref)			--
Age group			
<60 years (ref)	--	--	--
60-69 years	-0.024	-0.039, -0.009	0.002
70-79 years	-0.079	-0.093, -0.065	<0.001
>=80 years	-0.209	-0.222, -0.196	<0.001
Intercept= -16.017; gamma distribution and log link were used.			

Table S3.5: Annual hospitalization cost per patient with HF by sex and age in Canada (in 2014 \$-values), 2004- 2030

Fiscal Year	Patient average	Female				Male			
		<60	60-69	70-79	>=80	<60	60-69	70-79	>=80
2004	12,302	12,800	12,498	11,824	10,388	13,714	13,391	12,668	11,130
2005	12,459	12,963	12,658	11,975	10,521	13,889	13,563	12,831	11,272
2006	12,618	13,129	12,820	12,128	10,655	14,067	13,736	12,995	11,416
2007	12,780	13,297	12,984	12,284	10,792	14,247	13,912	13,161	11,562
2008	12,943	13,467	13,150	12,441	10,930	14,429	14,090	13,329	11,710
2009	13,109	13,640	13,319	12,600	11,069	14,614	14,270	13,500	11,860
2010	13,277	13,814	13,489	12,761	11,211	14,801	14,453	13,673	12,012
2011	13,446	13,991	13,662	12,924	11,355	14,990	14,637	13,847	12,166
2012	13,618	14,170	13,836	13,090	11,500	15,182	14,825	14,025	12,321
2013	13,793	14,351	14,013	13,257	11,647	15,376	15,014	14,204	12,479
2014	13,969	14,535	14,193	13,427	11,796	15,573	15,206	14,386	12,638
2015	14,148	14,721	14,374	13,598	11,947	15,772	15,401	14,570	12,800
2016	14,329	14,909	14,558	13,772	12,100	15,974	15,598	14,756	12,964
2017	14,512	15,100	14,744	13,949	12,254	16,178	15,797	14,945	13,130
2018	14,698	15,293	14,933	14,127	12,411	16,385	16,000	15,136	13,298
2019	14,886	15,488	15,124	14,308	12,570	16,595	16,204	15,330	13,468
2020	15,076	15,687	15,317	14,491	12,731	16,807	16,412	15,526	13,640
2021	15,269	15,887	15,513	14,676	12,894	17,022	16,622	15,724	13,815
2022	15,464	16,090	15,712	14,864	13,059	17,240	16,834	15,926	13,991
2023	15,662	16,296	15,913	15,054	13,226	17,460	17,050	16,129	14,170
2024	15,863	16,505	16,116	15,247	13,395	17,684	17,268	16,336	14,352
2025	16,066	16,716	16,323	15,442	13,566	17,910	17,489	16,545	14,535
2026	16,271	16,930	16,531	15,639	13,740	18,139	17,712	16,756	14,721
2027	16,479	17,146	16,743	15,839	13,916	18,371	17,939	16,971	14,909
2028	16,690	17,366	16,957	16,042	14,094	18,606	18,168	17,188	15,100
2029	16,904	17,588	17,174	16,247	14,274	18,844	18,401	17,408	15,293
2030	17,120	17,813	17,394	16,455	14,456	19,085	18,636	17,630	15,489

Table S3.6: HF associated hospitalization cost estimates and projection in Canada (in million, 2014 \$-values), 2004- 2030

Fiscal Year	Total HF associated hospitalization costs		
	Expected	95% CI lower bound	95% CI upper bound
2004	1,370	1,342	1,397
2005	1,360	1,335	1,384
2006	1,354	1,331	1,377
2007	1,348	1,325	1,371
2008	1,367	1,344	1,389
2009	1,385	1,361	1,408
2010	1,424	1,400	1,448
2011	1,469	1,444	1,494
2012	1,520	1,493	1,547
2013	1,572	1,542	1,602
2014	1,622	1,588	1,655
2015	1,673	1,635	1,711
2016	1,728	1,685	1,771
2017	1,789	1,740	1,838
2018	1,851	1,796	1,907
2019	1,914	1,853	1,977
2020	1,979	1,910	2,049
2021	2,048	1,971	2,126
2022	2,118	2,033	2,206
2023	2,195	2,100	2,292
2024	2,275	2,171	2,382
2025	2,356	2,242	2,475
2026	2,441	2,316	2,572
2027	2,539	2,401	2,683
2028	2,635	2,485	2,793
2029	2,729	2,566	2,901
2030	2,824	2,647	3,011