Journal of the American Heart Association

ORIGINAL RESEARCH

Temporal Trends and Sex Differences in Intensity of Healthcare at the End of Life in Adults With Heart Failure

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BACKGROUND: Patients with chronic disease prefer an adequately supported death at home, but often die in the hospital. We assessed temporal trends and sex differences in healthcare intensity and location of death among decedents with heart failure.

METHODS AND RESULTS: This was a retrospective cohort study of adults with heart failure who died between April 1, 2004 and March 31, 2017 in Ontario, Canada. We used population-based administrative databases to assess healthcare utilization during the last 6 months of life and applied multilevel multivariable logistic regression to assess whether sex was independently associated with location of death. Among 396 024 decedents with heart failure, mean (SD) age was 81.8 (10.7) years, 51.5% were women, and 53.4% had in-hospital deaths. From 2004 to 2016, there was an increase in patients receiving mechanical ventilation (15.1%–19.6%), hemodialysis (5.2%–6.8%), and cardiac revascularization (1.7%–2.3%). Relative to men, women spent fewer days in a hospital (mean, 16.4 versus 18.3; mean difference, 1.9; 95% CI, 1.7–2.0; $P<0.001$) and in an intensive care unit (mean, 2.1 versus 3.0; mean difference, 0.9; 95% CI, 0.8–0.9; $P<0.001$); and less commonly received mechanical ventilation (15.5% versus 20.8%; $P<0.001$); hemodialysis (4.8% versus 7.7%; $P<0.001$); or cardiac catheterization (2.8% versus 4.6%; $P<0.001$). Female sex was independently associated with lower odds of in-hospital death (odds ratio, 0.88; 95% CI, 0.87–0.89). Mean (SD) 6-month direct healthcare cost was greater for in-hospital ($52 349 [$55 649]) than out-of-hospital ($35 998 [$31 900]) death.

CONCLUSIONS: Among decedents with heart failure, invasive care in the last 6 months increased in prevalence over time but was less common in women, who had lower odds of dying in a hospital.

Key Words: end-of-life-care ■ healthcare intensity ■ heart failure ■ sex

Heart failure (HF) places a substantial burden on patients and is a leading cause of healthcare expenditure in high income countries.[1,2]. Approximately 70% of healthcare system costs of HF are attributed to hospitalizations,[3,4] which are concentrated in the final months of life.[5–9] While trends in clinic and hospital visits in the final year of life have been described in HF,[10] trends in the intensity of healthcare services offered to patients hospitalized with HF and near the end of life—including the use of critical care resources and invasive procedures—have not been assessed. These services likely account for a substantial proportion of the expense of hospital care in HF.

Hospital care itself may be discordant with the wishes of patients in their terminal months. Patients with many chronic diseases prefer an adequately supported death at home, but often die in the hospital.[11] The factors associated with death in the hospital versus at home have not been previously reported in HF, and the role of sex in end-of-life care has not been explored. Sex differences have been described in several aspects of HF care and outcomes,[12] and it is possible

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Supplementary Material for this article is available at https://www.ahajournals.org/doi/suppl/10.1161/JAHA.120.018495

For Sources of Funding and Disclosures, see page 12.

JAHA is available at: www.ahajournals.org/journal/jaha

CLINICAL PERSPECTIVE

What Is New?

- Among 396 024 patients who died with heart failure, invasive and intensive care during the last 6 months of life increased between 2004 and 2017, and most patients died in the hospital.
- Women received invasive and intensive care less commonly than men in the last 6 months of life,
- Healthcare costs in the last 6 months of life were substantially lower among those who died out of hospital versus those who died in hospital.

What Are the Clinical Implications?

- There are sex differences in end-of-life healthcare intensity and location of death among patients with heart failure.
- Whether this is driven by differences in clinical indications, treatment recommendations, or patient preference remains to be explored.

Nonstandard Abbreviations and Acronyms

DAD	Discharge Abstract Database
MOHLTC	Ontario Ministry of Health and Long-Term Care

that this extends to intensity of healthcare utilization at the end of life. With a view to assessing and improving the quality of care at the end of life for patients with HF, we describe the intensity of care—including sex differences—as well as temporal trends in healthcare utilization, location of death, and healthcare costs. We hypothesize that invasive and intensive care near the end of life is increasing with time, that there are sex differences in the receipt of these services, and that sex is independently associated with location of death (hospital versus home). We also hypothesize that the cost of care in the last months of life are significantly higher among patients who die in a hospital rather than community setting.

METHODS

Design and Setting

We conducted a retrospective cohort study in Ontario, Canada, a province with universal coverage for healthcare through a single-payer publicly funded health system. The use of data in this project was authorized under section 45 of Ontario's Personal Health Information Protection Act, which does not require review by a Research Ethics Board. The data set from this study is held securely in coded form at ICES. While data sharing agreements prohibit ICES from making the data set publicly available, access may be granted to those who meet pre-specified criteria for confidential access, available at www.ices.on.ca/DAS. The full data set creation plan and underlying analytic code are available from the authors upon request, understanding that the computer programs may rely upon coding templates or macros that are unique to ICES and are therefore either inaccessible or may require modification (ICES, 2020).

Inclusion Criteria and Data Sources

We identified adults (aged ≥18 years) who died between April 1, 2004 and March 31, 2017 using the Registered Persons Database and the Ontario Office of the Registrar General—Deaths file, which contains vital statistics data on all residents of Ontario, including date of death, sex, and age at death. We selected decedents with a diagnosis of HF, identified using the Ontario Congestive Heart Failure database, which uses a validated algorithm based on physician billing claims and hospital admissions.[13] This database excludes individuals aged <40 years; therefore, in order not to miss younger patients, we also identified HF if this diagnosis was documented during the last hospitalization preceding death (Data S1).

We established the cause of death using the Ontario Office of the Registrar General—Deaths file, which assigns this based on *International Classification of Diseases, Tenth Revision* (*ICD-10*) codes. To identify healthcare resource use, we linked records of decedents with population-based administrative databases, including Discharge Abstract Database (DAD) for hospital admissions; National Ambulatory Care Reporting System (NACRS) for emergency department, day surgery, and outpatient clinics; Ontario Health Insurance Plan for physician specialty, services and billing claims, and laboratory services; Ontario Drug Benefit and Assistive Devices Program for drugs/devices; Continuing Care Reporting System for long-term and complex continuing care; Home Care Database; and National Rehabilitation Reporting System for rehabilitation. These data sets were linked using unique encoded identifiers and analyzed at ICES, an independent, non-profit research institute funded by an annual grant from the Ontario Ministry of Health and Long-Term Care (MOHLTC). We established decedents' rurality and socioeconomic status (neighborhood income) by linking postal codes to Statistics Canada census data.[14]

Baseline Characteristics

We assessed demographic, socioeconomic, and clinical characteristics. We classified chronic

conditions[15] based on hospitalization records (DAD) using *ICD-10* diagnostic codes during the last hospitalization. We determined comorbidities and the Charlson comorbidity index using an *ICD-10* coding algorithm[16] applied to DAD records within the 2 years before death.

Healthcare Utilization

We examined healthcare utilization preceding death, including the number of emergency department visits; acute care hospitalizations; cardiac catheterization, coronary angiography, and coronary revascularization; receipt of mechanical ventilation, and dialysis; implantation of internal cardioverter-defibrillator, cardiac resynchronization therapy, or ventricular assist devices; and number of physician visits/consultations. The latter was defined as the total number of outpatient physician visits, classified according to physician. For decedents who were admitted to hospital within the year before death, we identified and counted the number of admissions to an intensive care unit (ICU) using special care unit code in the DAD and also measured the total inpatient and ICU days for these individuals. We established whether each decedent received palliative care in the terminal 6 months using a previously derived algorithm.[17] This algorithm uses a comprehensive list of physician billing, diagnostic, and administrative codes to identify receipt of palliative care service in the community, acute, continuing and long-term care settings. We assessed sex differences in healthcare utilization and temporal trends in healthcare utilization during the last 6 months of life.

Healthcare Costs

Healthcare expenditure was determined from the perspective of the MOHLTC, the single payer of publicly funded universal healthcare coverage for Ontario. We estimated costs using an established methodology for allocating patient-level costs for encounters across various health services using administrative data,[18] including acute care, emergency department visits, day surgeries, inpatient rehabilitation, complex continuing care, physician services, assistive device and prescription drugs. Encounter-specific cost information for sectors that have global budgets (eg, emergency department) were determined through resource intensity weights and case-mix methodology.[18–20] Sectors that have fee payments associated with each use (eg, drug cost or physician billing) had costs estimated directly. Drug costs were restricted to the costs of drugs dispensed to individuals eligible for coverage by the Ontario Drug Benefit Program (primarily individuals aged ≥65 years). Expenditures for long-term care were based on per diem costs established by the MOHLTC. Home care expenditure was calculated as actual total billing charges per patient based on services used during total length of stay in home care program from date of initiation until death (entire home care episode). In instances where the length of stay was longer than the costing period of interest, costs were prorated. Costs reimbursed to individuals for assisted devices were obtained from the Assistive Devices Program database. All costs are reported in 2016 Canadian dollars, with inflation of past costs using healthcare- specific yearly Consumer Price Index reported by before death. Total health sector cost for the population was defined as the sum of all costs among decedents captured within each respective sector.

Location of Death

We classified the location of death as in-hospital, at home, long-term care, or at another location using the Registered Persons Database. Deaths in hospital were further classified as occurring in the ICU using special care unit death codes available in the DAD.

Statistical Analysis

We used descriptive statistics to characterize patients, healthcare services, healthcare expenditures and to compare these according to the location of death (hospital versus non-hospital setting). We used means (SD) or medians (interquartile ranges for continuous variables, and counts (percentages [%]) for categorical variables. We compared continuous variables using 1-way ANOVA or Kruskal–Wallis tests as appropriate, and categorical variables using the Chi-square test. To further facilitate between group comparisons, we calculated the absolute difference (with 95% CI) in means and/or proportions (Wald Interval) for the reported outcomes. Cochran-Armitage trend tests were conducted to assess temporal trends in healthcare services use and location of death. We used generalized linear models with gamma distribution and log link to test for significant trends in total healthcare costs over the study period.

To determine factors independently associated with in-hospital death and to avoid false inferences from single-level models that ignore clustering effects, we developed a 2-level multivariable logistic regression model for the outcome of all-cause death in the hospital (yes/no), with patients (first level) nested in regions (second level). Region-level variables included existence of a quaternary care cardiac center and hospital bed capacity (total number of hospital beds/# inhabitants) in the region. Patient-level included sociodemographic (age, sex, income quintile, urban/rural area of residence) and clinical factors (comorbidities, receipt of outpatient palliative care

services, visits to the ED within 15 days of death), and year of death.

All variables were selected based on relevance. In a sensitivity analysis, we repeated the regression analysis using death from HF as the outcome. Analyses were performed using SAS Enterprise Guide version 7.12 (SAS Institute Inc., Cary, NC) and the nominal significant level for the testing was at 5%.

RESULTS

Baseline Characteristics

We identified 396 024 adults (51.5% women) with a diagnosis of HF who died between April 1, 2004 and March 31, 2017. Baseline characteristics are presented in Table 1. Approximately 53% of decedents died in a hospital, and these individuals were younger and more likely to be men.

Table 1. Baseline Characteristics of HF Decedents in Ontario April 1, 2004 to March 31, 2017

	All Decedents (n=396 024)	Deaths in Hospital (n=211 337)	Deaths Out of Hospital (n=184 687)
Age at death, mean (SD)	81.8 (10.7)	80.4 (10.6)	83.4 (10.5)
Age group, %			
18–59 y	4.0	4.5	3.3
60–64 y	3.5	3.9	3.0
65–69 y	5.5	6.3	4.6
70–74 y	8.5	9.9	6.9
75–79 y	13.1	14.9	11.1
80–84 y	19.4	20.8	17.8
≥85 y	46.0	39.7	53.3
Women, %	51.5	48.9	54.6
Rural residence at death, %	15.2	15.1	15.3
Income quintile, %			
1 (lowest)	23.4	23.9	22.8
2	21.1	22.0	20.2
3	19.7	19.4	20.0
4	18.7	18.3	19.1
5 (highest)	17.1	16.4	18.0
Charlson comorbidity index score, %			
0	7.5	2.7	13.7
1	12.6	10.7	15.1
2	15.5	15.1	16.0
≥3	64.4	71.5	55.2
Chronic conditions, %			
Congestive heart failure	46.6	48.3	44.1
Cancer	12.6	12.4	12.9
COPD	10.6	11.3	9.5
Coronary artery disease	10.3	10.6	9.7
Dementia	10.5	6.8	15.6
Renal failure	6.6	7.0	5.9
Severe liver disease	1.4	1.8	1.0
Peripheral vascular disease	1.4	1.6	1.1
Diabetes mellitus with end organ failure	0.1	0.1	0.1
Leading cause of death (top 5), %			
Ischemic heart disease	23.4	19.3	28.2
Cancer	14.4	13.9	15.0
Infection	6.5	9.0	3.5
Neurological	11.2	8.4	14.5
Injury/self-harm	3.2	4.0	2.2

COPD indicates chronic obstructive pulmonary disease.

Table 2. Sex Differences in Intensity of Healthcare in the Last 6 Months and 1 Month of Life in Patients With HF

	6 mo					1 mo				
	Women (n=204 144)	Men (n=191 880)	Total (n=396 024)	Absolute Difference (95 % CI)	*P* Value	Women (n=204 144)	Men (n=191 880)	Total (n=396 024)	Absolute Difference (95% CI)	*P* Value
Emergency department visits										
Any (%)	81.7	86.5	84.0	4.8 (4.5–5.0)	<0.001	58.7	63.6	61.1	4.9 (4.6, 5.2)	<0.001
Mean±SD*	2 .0 (1.9)	2.2 (2.2)	2.1 (2.1)	0.2 (0.2–0.2)	<0.001	0.8 (0.8)	0.9 (0.9)	0.8 (0.9)	0.1 (0.1, 0.1)	<0.001
Median (IQR)*	1 (1–3)	2 (1–3)	2 (1–3)		<0.001	1 (0–1)	1 (0–1)	1 (0–1)		<0.001
Hospital admission										
Any (%)	75.6	80.8	78.1	5.2 (5.0–5.5)	<0.001	54.9	59.7	57.2	4.8 (4.5, 5.1)	<0.001
Mean±SD*	1.4 (1.2)	1.5 (1.3)	1.5 (1.3)	0.1 (0.1–0.1)	<0.001	0.6 (0.7)	0.7 (0.7)	0.7 (0.7)	0.1 (0.1, 0.1)	<0.001
Median (IQR)*	1 (1–2)	1 (1–2)	1 (1–2)		<0.001	1 (0–1)	1 (0–1)	1 (0–1)		<0.001
Hospital, d										
Mean±SD*	16.4 (22.5)	18.3 (23.4)	17.4 (23)	1.9 (1.7–2.0)	<0.001	4.9 (7.0)	5.7 (7.6)	5.3 (7.3)	0.8 (0.7, 0.9)	<0.001
Median (IQR)*	8 (1–23)	10 (2–25)	9 (1–24)		<0.001	1 (0–8)	2 (0–9)	1 (0–9)		<0.001
ICU admission										
Any (%)	22.8	30.1	26.4	7.3 (7.0–7.5)	<0.001	15.5	20.6	18.0	5.1 (4.8, 5.3)	<0.001
Mean±SD*	0.3 (0.7)	0.4 (0.8)	0.4 (0.8)	0.1 (0.1–0.1)	<0.001	0.2 (0.5)	0.3 (0.6)	0.2 (0.5)	0.1 (0.1, 0.1)	<0.001
Median (IQR)*	0 (0–0)	0 (0–1)	0 (0–1)		<0.001	0 (0–0)	0 (0–0)	0 (0–0)		<0.001
Total ICU, d										
Mean±SD*	2.1 (7.4)	3.0 (9.0)	2.5 (8.3)	0.9 (0.8–0.9)	<0.001	0.9 (3.0)	1.3 (3.7)	1.1 (3.4)	0.4 (0.4, 0.4)	<0.001
Median (IQR)*	0 (0–0)	(0–2)	0 (0–0)		<0.001	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)	<0.001
Total highest ICU, d†										
Mean±SD*	1.6 (6.6)	2.3 (8.0)	1.9 (7.3)	0.7 (0.7–0.7)	<0.001	0.7 (2.7)	1.0 (3.2)	0.9 (2.9)	0.3 (0.3, 0.3)	<0.001
Mechanical ventilation										
Any (%)	15.5	20.8	18.1	5.3 (5.0–5.5)	<0.001	12.9	17.4	15.1	4.5 (4.3, 4.8)	<0.001
Mean±SD*	1.4 (7.2)	1.9 (8.6)	1.6 (7.9)	0.5 (0.5, 0.5)	<0.001	0.8 (3.4)	1.2 (4.0)	1.0 (3.7)		<0.001
Median (IQR)*	0 (0–0)	0 (0–0)	0 (0–0)		<0.001	0 (0–0)	0 (0–0)	0 (0–0)		<0.001
Cardiac catheterization or coronary angiogram	2.8	4.6	3.7	1.8 (1.7–1.9)	<0.001	1.2	2.1	1.6	0.8 (0.7, 0.9)	<0.001
Coronary revascularization	1.5	2.6	2.0	1.1 (1.0–1.2)	<0.001	0.8	1.3	1.0	0.5 (0.5, 0.6)	<0.001
Dialysis	4.8	7.7	6.2	2.9 (2.7–3.0)	<0.001	4.4	7.1	5.7	2.7 (2.6, 2.8)	<0.001
Palliative care (%)										
Any	45.1	45.0	45.1	0.1 (–0.2 to 0.4)	0.53	41.5	41.6	41.6	0.1 (–0.2, 0.4)	0.76
Home and community	28.3	28.7	28.5	0.5 (0.2–0.8)	<0.001	26.0	26.6	26.3	0.6 (0.3, 0.8)	<0.001

(*Continued*)

Table 2. Continued

	6 mo					1 mo				
	Women (n=204 144)	Men (n=191 880)	Total (n=396 024)	Absolute Difference (95 % CI)	*P* Value	Women (n=204 144)	Men (n=191 880)	Total (n=396 024)	Absolute Difference (95% CI)	*P* Value
Hospital/ED	38.6	39.6	39.1	0.9 (0.6–1.2)	<0.001	34.3	35.2	34.7	0.9 (0.6, 1.2)	<0.001
Saw ≥10 different physicians (%)	57.6	67.1	62.2	9.5 (9.3–9.9)	<0.001	21.8	28.1	24.9	6.3 (6.0, 6.6)	<0.001

ED indicates emergency department; ICU, intensive care unit; and IQR, interquartile range.
*Mean and median values pertain to services received per patient.
†Days spent in highest level of intensive care (medical intensive care unit, surgical intensive care unit, combined medical/surgical intensive care unit, and trauma intensive care unit).

Healthcare Utilization

Table 2 displays healthcare utilization in the last months of life. ED visits and hospitalizations were common during the last 6 months of life. During this period 84.0% of decedents visited the ED and 78.1% were admitted to the hospital. The mean length of hospital and ICU stay per patient in the last 6 months of life was 17.4 (23) and 2.5 (8.3) days, respectively.

Approximately half of these ICU admissions and days occurred during the last month of life. Decedents with HF commonly received invasive care near the end of life (Table 2). During the final 6 months of life, 18.1% received mechanical ventilation (83.4% of these in the final month), 3.7% underwent cardiac catheterization/ coronary angiography (44% of these in the final month), 2.0% underwent coronary revascularization (52.3% of these in the final month), and 6.2% received dialysis (92.6% of these in the final month).

In the terminal 6 months, only 45.1% received either outpatient or inpatient palliative care (92.2% of these in the final month). Decedents typically received care from multiple physicians: 75.4% saw ≥10 different physicians in the year before death and 62.2% saw ≥10 physicians in their terminal 6 months.

Resource Utilization in Men and Women

During the last 6 months of life, a lower proportion of women than men experienced ED visits (81.7% versus 86.5%; 4.8% difference; 95% CI, 4.5%–5.0%; *P*<0.001); hospitalizations (75.6% versus 80.8%; 5.2% difference; 95% CI, 5.0%–5.5%; *P*<0.001); ICU admissions (22.8% versus 30.1%; 7.3% difference; 95% CI, 7.0%–7.5%; *P*<0.001); mechanical ventilation (15.5% versus 20.8%; 5.3% difference; 95% CI, 5.0%–5.5%; *P*<0.001); cardiac catheterization or coronary angiogram (2.8% versus 4.6%; 1.8% difference; 95% CI, 1.7%–1.9%; *P*<0.001); coronary revascularization (1.5% versus 2.6%; 1.1% difference; 95% CI, 1.0%–1.2%; *P*<0.001); hemodialysis (4.8% versus 7.7%; 2.9% difference; 95% CI, 2.7%–3.0%; *P*<0.001); or care from ≥10 different physicians (57.6% versus 67.1%; 9.5% difference; 95% CI, 9.3%–9.9%; *P*<0.001) (Table 2). There was no difference in the proportion of women versus men receiving palliative care (45.1% versus 45.0%; 0.1% difference; 95% CI, −0.2% to 0.4%; *P*=0.53) (Table 2). In the last 6 months of life, women spent fewer mean days than men in the hospital (16.4 versus 18.3; 1.9 difference; 95% CI, 1.7–2.0; *P*<0.001) and in an ICU (2.1 versus 3.0; 0.9 difference; 95% CI, 0.8–0.9; *P*<0.001) (Table 2). After adjusting for ED visits and other clinical and hospital level factors, female sex was independently associated with lower odds of in-hospital death (odds ratio [OR], 0.88; 95% CI, 0.86–0.89).

Table 3. End-of-Life Care Among Patients With Heart Failure in Ontario, by Receipt of Palliative Care in the Home/Community in the Months Preceding Death

	6 mo		1 mo	
	No Palliative Care (n=283 145)	Palliative Care (n=112 879)	No Palliative Care (n=283 145)	Palliative Care (n=112 879)
Emergency department admission				
Any, %	82.6	87.7	63.1	56.1
Mean±SD	2.0 (2.0)	2.4 (2.1)	0.8 (0.9)	0.8 (0.9)
Median (IQR)	1 (1–3)	2 (1–3)	1 (0–1)	1 (0–1)
Hospital admission				
Any, %	75.8	83.9	58	55.2
Mean±SD	1.4 (1.2)	1.7 (1.3)	0.7 (0.7)	0.7 (0.7)
Median (IQR)	1 (1–2)	1 (1–2)	1 (0–1)	1 (0–1)
Hospital, d				
Mean±SD	15.7 (22.2)	21.5 (24.2)	5.1 (7.2)	5.8 (7.6)
Median (IQR)	8 (1–21)	14 (4–30)	1 (0–8)	2 (0–10)
ICU admission				
Any, %	29.2	19.1	21.4	9.4
Mean±SD	0.4 (0.8)	0.3 (0.7)	0.3 (0.6)	0.1 (0.4)
Median (IQR)	0 (0–1)	0 (0–0)	0 (0–0)	0 (0–0)
Total ICU, d				
Mean±SD	2.8 (8.7)	1.8 (6.8)	1.3 (3.6)	0.6 (2.4)
Median (IQR)	0 (0–2)	0 (0–0)	0 (0–0)	0 (0–0)
Total highest-intensity care, d*				
Mean±SD	2.2 (7.8)	1.3 (5.8)	1.0 (3.2)	0.4 (2.1)
Median (IQR)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)
Mechanical ventilation				
Any, %	20.8	11.1	18.1	7.3
Mean±SD	1.9 (8.5)	0.9 (5.9)	1.2 (4.0)	0.5 (2.5)
Median (IQR)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)
Cardiac catheterization/coronary angiogram	4.1	2.3	2.0	0.6
Coronary revascularization	2.4	1.0	1.4	0.3
Dialysis	6.8	4.6	6.4	4.1
≥10 different outpatient physicians	57.7	73.5	24.1	27.0

ICU indicates intensive care unit; and IQR, interquartile range.

*Days spent in units capable of the highest level of care (medical intensive care unit, surgical intensive care unit, combined medical/surgical intensive care unit, and trauma intensive care unit).

Resource Utilization Among Those Who Received Palliative Care

In the last 6 months of life, 39.9% of decedents received community palliative care (Table 3). Patients receiving community palliative care presented to the ED more commonly (87.7% versus 82.6%), were hospitalized more commonly (83.9% versus 75.8%) and had a longer mean [SD] length of stay (21.5 [24.2] versus 15.7 [22.2] days) relative to those who did not receive palliative care, possibly related to their disease severity or complexity. However, patients receiving community palliative care were less commonly admitted to the ICU (19.1% versus 29.2%) or to receive mechanical ventilation (11.1% versus 20.8%), cardiac catheterization (2.3% versus 4.1%), coronary revascularization (1.0% versus 2.4%), or dialysis (4.6% versus 6.8%) in the last 6 months of life.

Factors Associated With Location of Death

Factors independently associated with a higher odds of in-hospital death included higher Charlson score (OR, 6.95; 95% CI, 6.70–7.20 for score ≥3 relative to 0), presentation to the ED within 15 days of death (OR, 9.02; 95% CI, 8.85–9.19), and hospital bed capacity (OR, 1.08; 95% CI, 1.03–1.13 per 50 bed increase) (Table 4).

Table 4. Multi-Level Model of Factors Associated With Dying in a Hospital Versus Home Among Patients With a History of HF (n=324 188)

Characteristic	Odds Ratio (95% CI)
Sex (reference men)	
Women	0.88 (0.86–0.89)
Age (10-y increase)	0.74 (0.73–0.74)
Charlson score (reference 0)	
1	3.28 (3.15–3.42)
2	4.38 (4.21–4.56)
≥3	6.95 (6.70–7.20)
Income quintile (reference lowest quintile)	
2	1.09 (1.06–1.12)
3	0.95 (0.93–0.98)
4	0.96 (0.93–0.99)
5 (Highest)	0.91 (0.89–0.94)
Palliative care in the home/community setting within 6 mo (reference: no)	0.69 (0.67–0.70)
Emergency room visit within 15 d of death (reference no)	9.02 (8.85–9.19)
Area of residence at time of death	
Rural (reference urban)	1.00 (0.97–1.02)
LHIN bed capacity/ 100 000 population (per 50 bed increase)*	1.08 (1.03–1.13)
Quaternary cardiac center in LHIN (reference no)	1.04 (0.81–1.35)
More recent year of death (per year)	0.98 (0.98–0.98)

*LHIN, local health integration network (the regional network/boundary within which patients in the region receive healthcare services).

Table 5. Multi-Level Model of Factors Associated With Dying in a Hospital Versus Home Among Patients With Heart Failure as the Leading Cause of Death (n=3882)

Characteristic	Odds Ratio (95% CI)
Sex (reference men)	
Women	0.70 (0.58–0.84)
Age (per 10-y increase)	0.54 (0.49–0.61)
Charlson score (reference 0)	
1	1.77 (1.28–2.45)
2	2.32 (1.67–3.22)
≥3	2.63 (1.95–3.54)
Income quintile (reference lowest quintile)	
2	1.05 (0.79–1.40)
3	0.89 (0.67–1.18)
4	0.89 (0.67–1.19)
5 (Highest)	0.82 (0.62–1.09)
Palliative care in home/community setting within 6 mo (reference no)	0.34 (0.28–0.42)
Emergency room visit within 15 d of death (reference no)	9.69 (7.96–11.79)
Area of residence at time of death	
Rural (reference urban)	0.59 (0.46–0.77)
LHIN bed capacity/100 000 population (per 50 bed increase)*	1.03 (0.87–1.21)
Quaternary cardiac center in LHIN (reference no)	0.95 (0.67–1.35)
Year of death	0.98 (0.95–1.01)

*LHIN, Local Health Integrated Network (the regional network/boundary within which patients in the region receive healthcare services).

Factors independently associated with lower odds of in-hospital death included older age (OR 0.74; 95% CI, 0.73–0.74 per 10-year increment), female sex (OR, 0.88; 95% CI, 0.86–0.89), higher income (OR, 0.91; 95% CI, 0.89–0.94 for highest versus lowest quintile), ambulatory palliative care services in last 6 months of life (OR, 0.69; 95% CI, 0.67–0.70), and more recent year of death (OR, 0.98; 95% CI, 0.98–0.98 per year). Similar findings were observed for the cohort of decedents with HF as the cause of death (Table 5).

Temporal Trends

Figure 1 illustrates the temporal trends in healthcare services provided to patients during their last 6 months of life. Between 2004 and 2016, there was an increase in proportion of HF decedents receiving mechanically ventilation (15.1%–19.6%), cardiac revascularization (1.7%–2.3%), hemodialysis (5.2%–6.8%), and care from 10 or more physicians (51.6%–67.8%). Mean length of hospitalization during the last 6 months stayed stable over the 13-year span, ranging from 16.8 (in 2016) to 17.8 (in 2011) days per person.

Mean length of ICU stay ranged from 2.3 (in 2004) to 2.7 (in 2015) days.

Figure 2 displays temporal trends in the location of death among HF decedents in Ontario (2004–2016). During this period, a majority of deaths (ranging from 50.0%–55.2 %) occurred in the hospital. The proportion of deaths in hospital increased steadily from 53.7% in 2004 to 55.2% in 2008, and subsequently decreased to 50.0% in 2016. The proportion of deaths occurring in a home setting increased from 32.6% in 2004 to 38% in 2016. Deaths in long-term care facilities increased slightly from 7.5% in 2004 to 7.9% in 2016.

Healthcare Costs

Direct inpatient costs (not including physician billings) accounted for more than half of the total cost of care in the last 6 months of life. Breakdown of total costs and mean cost per patient are provided in Table S1. Overall, in the last 6 months, healthcare costs for patients who died in hospital were much greater than for patients who died outside the hospital: mean (SD) $52 349 ($55 649) for death in hospital versus $35 998 ($31 900) for death out of hospital) (Table S1

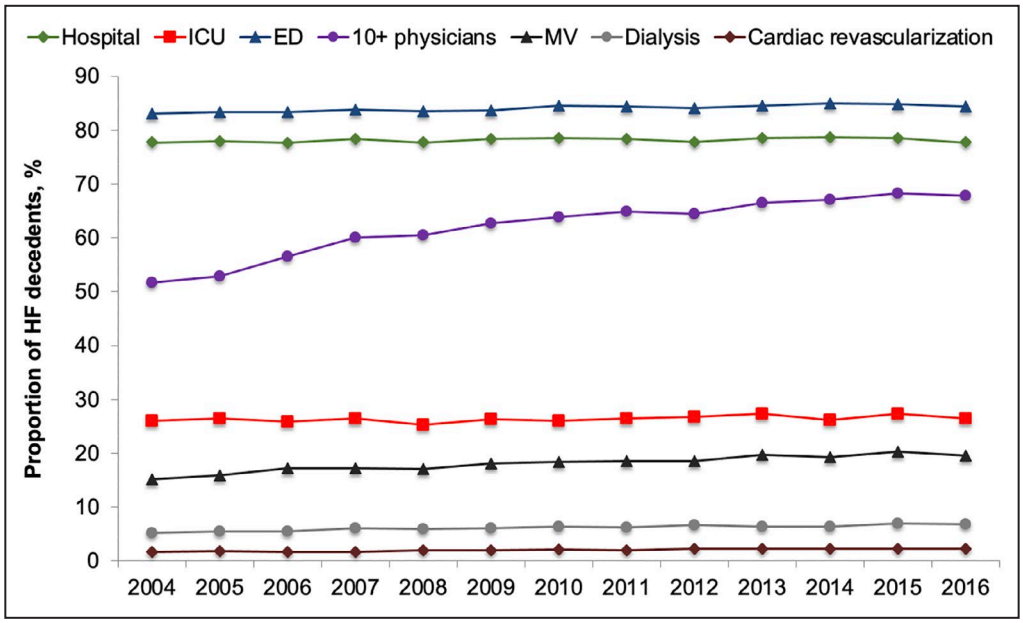

Figure 1. Temporal trends in the utilization of healthcare services in the last 6 months of life among patients with heart failure (2004–2016).
ED indicates emergency department; ICU, intensive care unit; and MV, mechanical ventilation.

and Figure 3). Similar findings were observed for costs within the last month of life. Among patients who died in hospital, healthcare costs in the last 6 months of life increased from a mean (SD) of $42 808 ($42 312) in 2004 to $54 446 ($55 317) in 2016; for these individuals, healthcare costs in the last 1 month of life increased steadily from $21 594 ($18 439) in 2004 to $27 655 ($25 612) in 2009, and remained relatively stable from 2010 to 2016, ranging from $25 064 ($23 176) to $25 979 ($24 200). Among patients who died out of hospital, healthcare costs in the last 6 months of life also demonstrated a steady, though less steep, increase from $30 085 ($27 288) in 2004 to $38 126 ($32 685) in 2016, with healthcare costs in the last

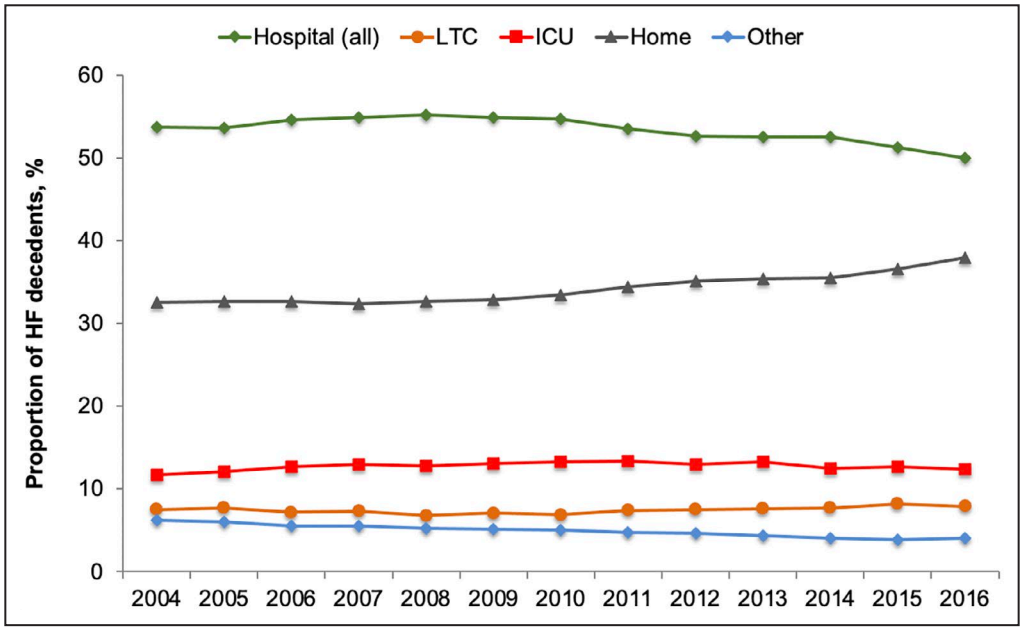

Figure 2. Temporal trends in location of death among patients with heart failure in Ontario (2004–2016).
Data points display the percentage of all deaths occurring in a given setting each year. HF indicates heart failure; ICU, intensive care unit; and LTC, long-term care.

month of life also increasing: from $7690 ($8378) in 2004 to $10 559 ($10 798) in 2016.

DISCUSSION

In this retrospective cohort study of 396 024 adults with HF between 2004 and 2017, we found that a majority of decedents were hospitalized in the last 6 months of life, spending an average of 17.4 days in the hospital. Most patients died in the hospital, although the proportion of in-hospital deaths decreased over time. Women spent fewer days than men in the hospital and in an ICU, and a significantly lower proportion of women than men received mechanical ventilation, hemodialysis, cardiac catheterization, or coronary revascularization. Female sex was independently associated with out-of-hospital death, as was older age, higher socioeconomic status, outpatient palliative care, and recent year of death. Recent ED use, higher comorbidity score, and hospital bed capacity were associated with higher odds of in-hospital death (Figure 4).

Our findings are consistent with a small cohort study of 698 HF decedents in Minnesota demonstrating that >80% of decedents have at least 1 hospitalization in the last year of life.[10] However, the Minnesota study demonstrated a lower proportion of deaths in hospital than did ours (28.4% versus 53.5%), possibly related to better access to ambulatory care supports. The Minnesota study did not assess factors associated with in-hospital death and the association between palliative care services and hospital usage in the last year of life; and there was no association found between sex and healthcare utilization at the end of life, possibly because of the small sample size.[10]

The sex-related differences in intensive care in our cohort reflect patterns seen in other chronic diseases.[21,22] For example, men with terminal cancer were more likely to receive ICU care than their female counterparts, but men who reported an end-of-life discussion had lower odds of an ICU stay.[23] While we found no difference in the proportion of men versus women receiving palliative care, it is unclear whether women with HF are more engaged in discussions about end-of-life care planning and ED avoidance. It is possible that women are less likely to present to the emergency department for hospital care as they are either adequately supported at home or less likely to be brought to the hospital by their caregivers. The observation that

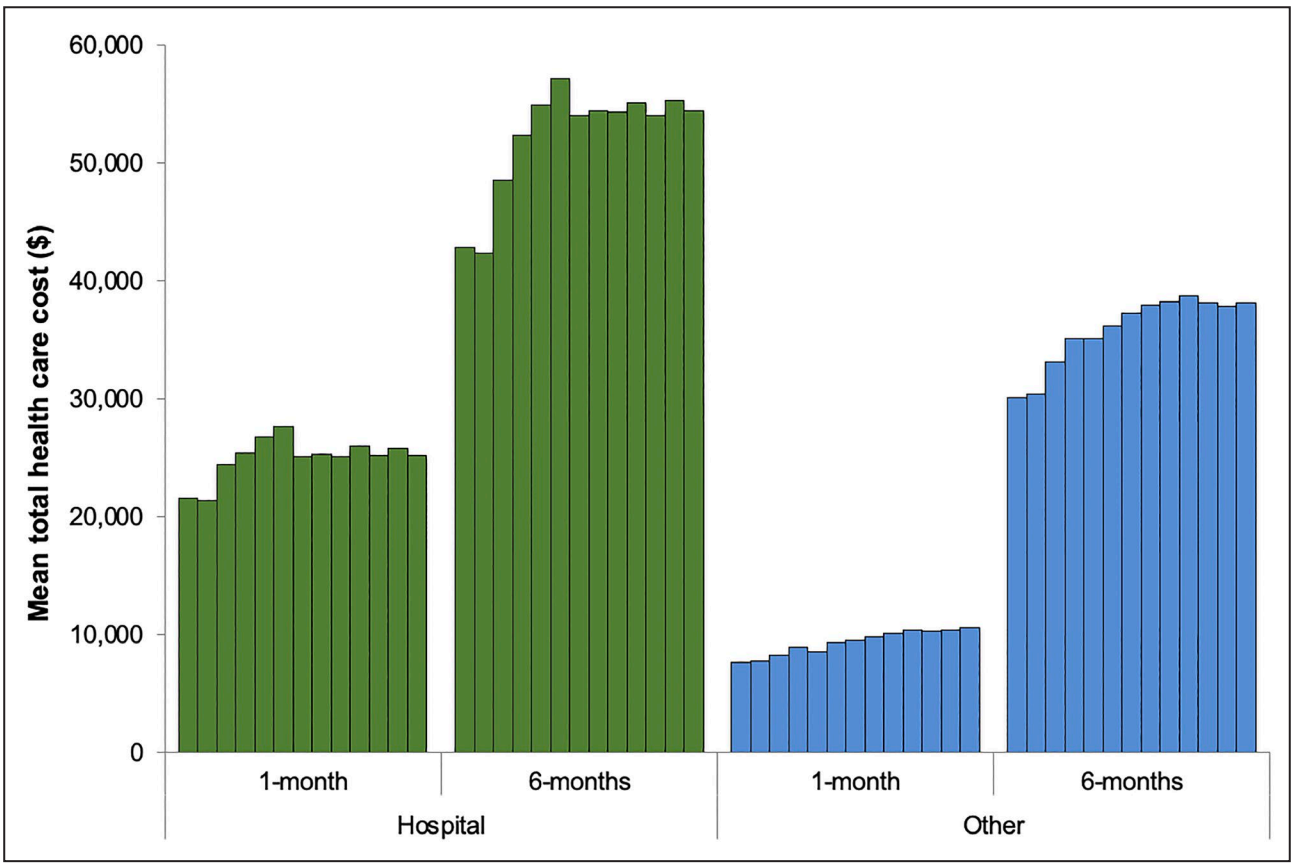

Figure 3. Temporal trends in total direct healthcare costs accrued in the last month and last 6 months of life according to location of death (in-hospital or out-of-hospital) among heart failure decedents in Ontario.
Each bar represents one year from fiscal year 2004 to 2016.

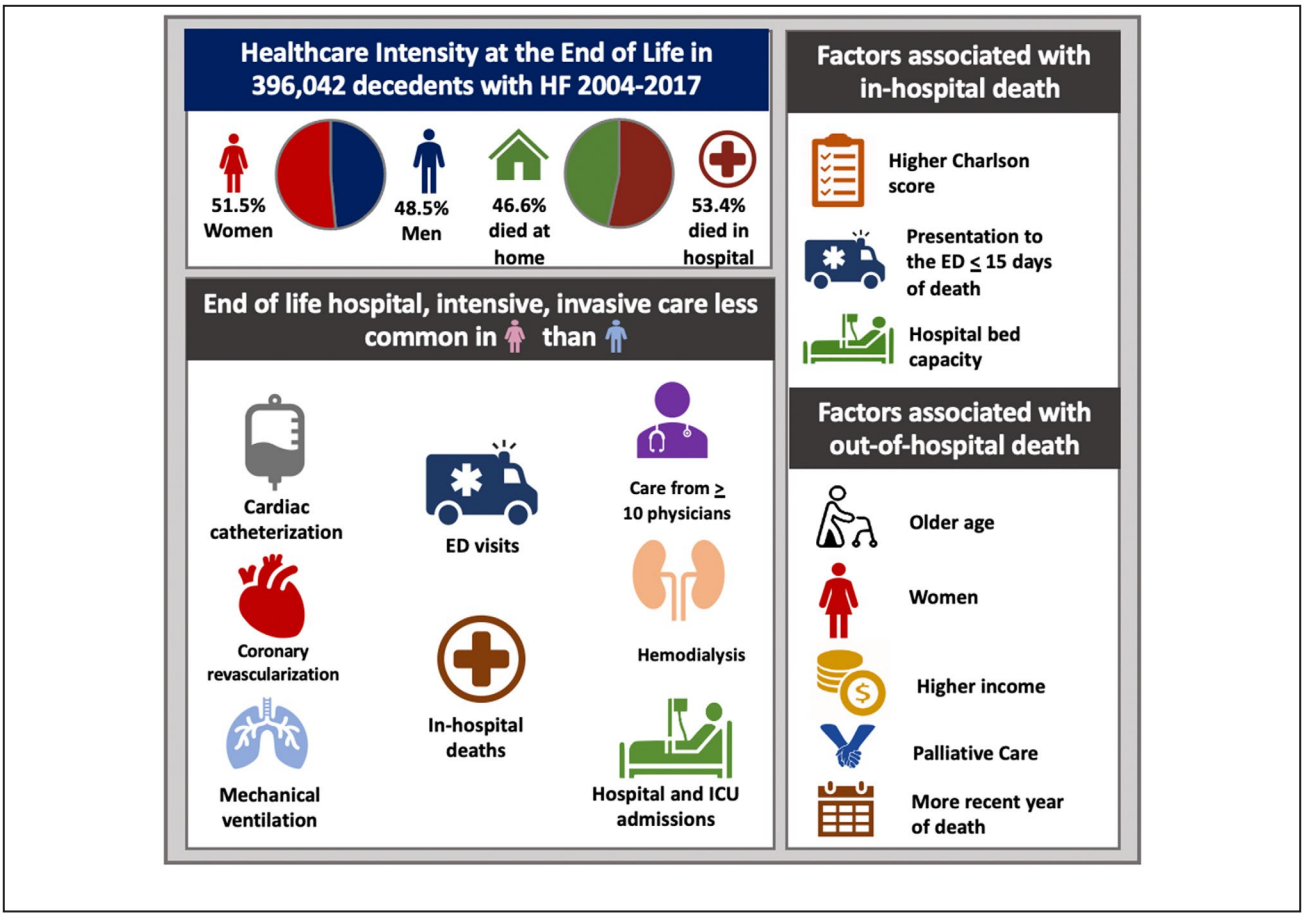

Figure 4. Central illustration.
Sex differences in healthcare intensity at the end of life in heart failure (HF).

women were less likely to be hospitalized and receive intensive or invasive care than men may represent under-treatment of women or over-treatment of men at the end of life.

We found that community palliative care was associated with fewer hospitalizations in the last month of life, less use of intensive or invasive care, and lower odds of in-hospital death. In a small RCT in Hong Kong, a transitional palliative care home visiting program decreased short-term readmissions following hospitalization for HF, although it is unknown whether this influenced location of death and unclear whether the benefit was derived from the nurse home visits or the palliative care.[24] An American study reported an increase in-hospital palliative consultations and hospice care and a decrease in hospitalization between 2003 and 2012 among patients with HF.[10] Interdisciplinary palliative care interventions in patients with advanced HF can improve quality of life, reduce anxiety and depression, and improve general well-being compared with usual care,[25] and these in turn may reduce the use of in-hospital services.

We found that healthcare costs near the end of life increased over time and that death in hospital was associated with higher average healthcare costs than death out of hospital. A large population-based cohort study among patients with general medical illnesses in Ontario, Canada reported similar findings, although the overall costs during the last 6 months of life were substantially lower[26] possibly because of the shorter length of stay and invasive procedures in general medical versus patients with HF. The finding of higher median (interquartile range) total healthcare costs in the final 6 months among those who died in-hospital was attributed to invasive, expensive end-of-life care services offered in-hospital.[26] It is possible that invasive treatments drive up the cost of care whilst offering limited utility. While our analysis of drug costs was limited to those aged >65 years, 92.5% of decedents fell into this age group; nevertheless, drug costs in the ambulatory setting are slightly underestimated in this analysis. Our findings support the need to invest in strategies that facilitate death out of rather than in hospitals.

Our study has many strengths. First, it was large and representative of real-world patients dying with HF and reported sex differences in healthcare utilization, which to our knowledge, has not been done before. Second, it included temporal trends for location of death and a breakdown of healthcare utilization and healthcare system costs at the end of life. This information can be used to guide healthcare resource allocation. Third, we conducted a sensitivity analysis to distinguish dying with HF and from HF, to establish whether associations with location of death were different depending on the primary cause of death. Fourth, the study avoided false inferences observed in single-level regression models by usizing a 2-level multivariable logistic regression model to account for clustering effects.

This study has several limitations. First, we could not assess the role of marital status, caregiver burnout, or psychosocial support in healthcare utilization. Second, we did not have access to vital signs and diagnostic results (eg, ECG, laboratory values, left ventricular ejection fraction) to assess the appropriateness of care. Third, the cost analysis of this study only included direct medical costs and did not consider indirect/overhead costs or costs borne by the patient; the latter may increase when end-of-life care is received at home rather than in hospital. Fourth, healthcare utilization—including inpatient care, ambulatory palliative care, and location of death—was assessed in a publicly funded healthcare system in Canada and may not apply to other systems.

CONCLUSIONS

Among 396 024 decedents with HF in Ontario, Canada, hospital was the most common location of death. Between 2004 and 2016, there was a temporal increase in invasive care in the last months of life. Women received intensive and invasive care less commonly and after adjusting for relevant factors, had lower odds of dying in a hospital setting than men. Community palliative care was also associated with lower odds of dying in a hospital. Healthcare costs in the last 6 months of life were greater among those who died in a hospital setting.

ARTICLE INFORMATION

Received July 21, 2020; accepted October 22, 2020.

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Acknowledgments

Parts of this report are based on Ontario Office of the Registrar General—Death information on deaths, the original source of which is Service Ontario. The views expressed therein are those of the author and do not necessarily reflect those of Ontario Registrar General or Ministry of Government Services.

Sources of Funding

This study was supported by ICES, which is funded by an annual grant from the Ontario Ministry of Health and Long-Term Care (MOHLTC). The opinions, results and conclusions reported in this paper are those of the authors and are independent from the funding sources. No endorsement by ICES or the MOHLTC is intended or should be inferred. Parts of this material are based on data and/or information compiled and provided by Canadian Institute for Health Information (CIHI). However, the analyses, conclusions, opinions and statements expressed in the material are those of the authors, and not necessarily those of CIHI. Dr Van Spall is supported by the Hamilton Health Science (HHS) Early Career Award and the Women As One Escalator Award. This study is supported by grants from the Heart and Stroke Foundation of Ontario (held by RF) and the Canadian Institutes of Health Research (CIHR) (held by HV).

Disclosures

None.

Supplementary Material

Data S1
Table S1

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SUPPLEMENTAL MATERIAL

Data S1.

Definition of Congestive Heart Failure:

Heart Failure Source	Definition	ICD-9/10 and OHIP Codes
Ontario's CHF Database	Any documented hospital admission with HF in a diagnostic field, or a physician claim/emergency room record with a HF diagnosis followed within one year by at least one additional record with a HF diagnosis from any source.	ICD-9 428 ICD-10 I500, I501, I509 OHIP fee code: Q050
Hospital Admission	Any hospitalization between 2002 and death date with a documented HF diagnosis. Only 0.5% of those identified where not included in the CHF database. Median age at death (31years (21,36) was consistent with the age exclusion criteria (< 40 years) for the CHF database.	ICD-10 I500, I501, I509

CCI codes http://www.health.gov.on.ca/en/pro/programs/ohip/bulletins/na_69/na_69_2.pdf (accessed Sept 20 2016)

http://www.cmaj.ca/content/suppl/2016/02/22/cmaj.150901.DC1/150901-res-2-at.pdf (accessed Sept 20, 2016)

Defibrillator implantation

- 1.HZ.53.GR-FS cardioverter/defibrillator (transvenous)
- 1.HZ.53.GR-FU cardiac resynchronization therapy defibrillator (Transvenous)
- 1.HZ.53.HA-FS cardioverter/defibrillator (perc)
- 1.HZ.53.LA-FS cardioverter/defibrillator (thoracotomy)
- 1.HZ.53.LA-FU cardiac resynchronization therapy defibrillator (thoracotomy)
- 1.HZ.53.SY-FS cardioverter/defibrillator (combined approach)
- 1.HZ.53.SY-FU cardiac resynchronization therapy defibrillator (combined)

CRT implantation

- 1.HZ.53.GR-FR cardiac resynchronization therapy pacemaker
- 1.HZ.53.GR-FU cardiac resynchronization therapy defibrillator

- 1.HZ.53.LA-FR cardiac resynchronization therapy pacemaker
- 1.HZ.53.SY-FR cardiac resynchronization therapy pacemaker
- 1.HZ.53.SY-FU cardiac resynchronization therapy defibrillator

VAD implantation

- 1.HP.53.GP-QP Implantation of internal device, ventricle, of ventricular assist pump using percutaneous transluminal approach [e.g. Impella]
- 1.HP.53.LA-QP Implantation of internal device, ventricle, of ventricular assist pump using open approach [e.g. HeartMate, Novacor]

Cardiac cath

- 2HZ24GPKJ, 2HZ24GPKL, 2HZ24GPKM, 2HZ24GPXJ, 2HZ28GPPL, 2HZ71GP, 3HZ30GP, 3IJ30GP

Coronary angiogram

- 3IP10

Coronary revascularization

- CCI: 1IJ26, 1IJ27, 1IJ50, 1IJ57, 1IJ76, 1IJ54GQAZ, 1IJ57GQ

Dialysis (OHIP code for dialysis with nephrologist present only, couldn't find CCI codes that would pertain to peritoneal/home dialysis)

- OHIP fee: G323, G325, G326, G330-G332, G860- G866, R849

Table S1. Total and mean cost of health care in 6 months preceding death by location of death.

	All patients		Died out of hospital (N = 184,687)		Died in hospital (N = 211,337)	
*Sector	Total $	*Mean (SD) $	Total $	*Mean (SD) $	Total $	*Mean (SD) $
Inpatient	9,207,017,617	29,416 (41,892)	2,232,276,495	21,958 (24,018)	6,974,741,122	33,003 (47,771)
Inpatient mental health	29,982,871	37,953 (42,134)	18,360,507	42,403 (45,488)	11,622,364	32,556 (37,018)
Hospital outpatient clinic	591,695,327	2,329 (3,329)	179,642,726	1,886 (2,407)	412,052,601	2,595 (3,751)
Emergency department	454,000,336	1,363 (956)	153,660,632	1,205 (916)	300,339,704	1,461 (967)
Dialysis clinics (NACRS)	386,148,509	27,199 (20,428)	143,707,569	29,185 (20,207)	242,440,940	26,145 (20,468)
Cancer clinics (NACRS)	141,020,997	5,599 (7,508)	56,906,248	5,202 (6,776)	84,114,749	5,904 (8,012)
Same day surgery	76,011,733	1,599 (2,249)	25,993,974	1,528 (2,184)	50,017,759	1,639 (2,283)
Total OHIP physician fee for service visits	1,569,117,174	4,001 (5,162)	493,121,518	2,725 (3,563)	1,075,995,656	5,094 (6,001)
OHIP lab cost	62,846,754	211 (187)	31,502,554	219 (191)	31,344,200	204 (183)
OHIP non-physician cost	48,553,935	370 (377)	31,056,275	445 (386)	17,497,660	284 (346)
Complex continuing care	1,100,734,349	25,710 (30,552)	851,207,471	24,923 (30,643)	249,526,878	28,817 (29,989)
Home care services	980,626,571	4,308 (5,867)	477,646,006	4,825 (6,776)	502,980,565	3,910 (5,021)
Long term care	1,904,987,666	16,955 (7,254)	1,404,308,590	17,601 (7,098)	500,679,076	15,373 (7,387)
ODB drug cost (all ages)	697,128,752	1,854 (2,742)	344,553,576	1,962 (2,408)	352,575,176	1,761 (3,001)

	All patients		Died out of hospital (N = 184,687)		Died in hospital (N = 211,337)	
*Sector	Total $	*Mean (SD) $	Total $	*Mean (SD) $	Total $	*Mean (SD) $
Rehabilitative services (10,852)	293,127,800	19,331 (11,228)	121,775,473	20,082 (11,731)	171,352,327	18,830
Temporary / durable Assisted Device	34,114,851	1,512 (1,396)	18,186,409	1,591 (1,341)	15,928,442	1,430 (1,445)
Total cost	17,701,522,324	44,730 (4,846)	6,638,264,499	35,998 (31,900)	11,063,257,825	52,349 (55,649)

NACRS, National Ambulatory Care Reporting System; OHIP, Ontario Health Insurance Plan; ODB, Ontario Drug Benefit Plan

*For each sector, mean costs were calculated after excluding patients with zero costs.