

Prognosis and Determinants of Survival in Patients Newly Hospitalized for Heart Failure

A Population-Based Study

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Background: The prognosis in unselected community-dwelling patients with heart failure has not been widely studied.

Objective: To determine the short- and long-term mortality of patients after first hospitalizations for heart failure and to examine how age, sex, and comorbidities influence survival.

Methods: We used the Canadian Institute for Health Information database to construct a retrospective population-based cohort of 38 702 consecutive patients with first-time admissions for heart failure from April 1994 through March 1997 in Ontario, Canada. Prognostic variables were collected from hospital discharge abstracts. Vital status at 30 days and 1 year was determined through linkage with the Ontario Registered Persons Database. Regression analyses were used to identify the relationships among survival, age, sex, and comorbidities.

Results: The crude 30-day and 1-year case-fatality rates after first admissions for heart failure were 11.6% and

33.1%, respectively. Advancing age, male sex, and the presence of comorbidities as identified by the Charlson Index were independently associated with poorer survival. The 30-day and 1-year mortality ranged from 2.3% and 7.6%, respectively, in the youngest subgroup with minimal comorbidity to 23.8% and 60.7%, respectively, in the oldest comorbidity-laden subgroup. Complex interactions among age and sex, sex and comorbidities, and age and comorbidities were observed in models of short- and long-term survival.

Conclusions: The prognosis of unselected community-dwelling patients with heart failure remains poor, despite advances in treatment, with substantial variation seen across different subgroups. Although age, sex, and comorbidities were confirmed to be independent prognostic indicators of heart failure, their complex interaction with survival should be considered in future studies.

Arch Intern Med. 2002;162:1689-1694

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ALTHOUGH DECREASING mortality rates observed in clinical trials of heart failure during the past decades suggest improved prognosis in patients with heart failure (hereafter referred to as heart failure patients) who were enrolled in those trials,¹ it is unclear whether such improvement is also seen in heart failure patients from the general population. In particular, the prognosis of unselected community-dwelling patients who are newly hospitalized for heart failure has not been well studied. This omission is not surprising, since subjects enrolled in clinical trials are often unrepresentative of heart failure patients from the community, who are likely to be older women and to have significant comorbidities.^{2,3}

To better characterize the prognosis of heart failure patients from the general population, past epidemiological studies^{4,5} have used administrative databases

to assemble cohorts of largely unselected heart failure patients in whom outcomes can be tracked over time on a population level. However, most studies⁶⁻¹¹ have not eliminated the confounding effect of disease duration when determining the prognosis of these patients by failing to select only those with newly diagnosed heart failure. Thus, an accurate description of the outcomes of this population and the factors that influence their outcomes is needed. In this study, we conducted a population-based analysis using hospital discharge abstracts to determine the short- and long-term survival of patients who have been admitted for the first time for heart failure in Ontario, Canada, a province with a population of 11 million. We hypothesized that in the era of contemporary therapy for heart failure, the case-fatality rates due to heart failure in the community remain high, and that the poor prognosis of this population bears a com-

PATIENTS AND METHODS

DATA SOURCES

The Canadian Institute for Health Information collects and collates data on all hospital discharges in Canada.¹² This database can be linked to other data sources using encrypted health card numbers to anonymously track outcomes of individuals over time. The accuracy of the Canadian Institute for Health Information data has been described previously.^{13,14} Using this database, we constructed a cohort of consecutive patients who were hospitalized for the first time for heart failure in the province of Ontario from April 1994 to March 1997. We identified all individuals (N=75 642) who were admitted with a most-responsible diagnosis of congestive heart failure (*International Classification of Diseases, Ninth Revision, Clinical Modification [ICD-9-CM]*, code 428). We excluded subjects who were younger than 20 years (n=273), those without a valid Ontario health card number (n=927), and those who were admitted to chronic care facilities (n=713). To minimize referral bias from outside our catchment area, we excluded all non-Ontario residents (n=660) and those who transferred from other acute care facilities (n=1626). We also excluded subjects for whom heart failure was coded as a hospital complication (n=493) to prevent confounding by the latter coding on survival. To avoid double counting of cases, we excluded all individuals for whom this was not the first admission for heart failure (n=23 268). We also excluded all subjects with previous admissions for heart failure or who had a diagnosis of heart failure coded during any hospital admission in the 5 years before this study (n=8980).

INDICATORS AND OUTCOMES

We used the ICD-9-CM codes recorded on the discharge abstracts of all hospitalizations, including and within 5 years before the index admission, to identify the presence of any comorbid condition. The abstract provided up to 15 fields for secondary or other diagnoses to record comorbid conditions. Comorbidities were abstracted using the adaptation of the Charlson Index for administrative databases by Deyo et al.¹⁵ The Charlson Index is a composite score of

comorbidity measures commonly used for case-mix adjustments in studies assessing longitudinal health outcomes.¹⁶ We linked our cohort to the Ontario Registered Persons Database to determine the vital status of each patient at 30 days and 1 year after the index admission. The annual emigration rate from Ontario is less than 0.01%.¹⁷ Additional deaths were also captured by searching for subsequent hospital admissions from the Canadian Institute for Health Information data that coded for in-hospital deaths.

STATISTICAL ANALYSIS

We calculated the crude 30-day and 1-year case-fatality rates and tabulated the crude case-fatality rates stratified by age, sex, and the Charlson comorbidity score. We used Cochran-Mantel-Haenszel statistics¹⁸ to test for sex differences in the case-fatality rates while controlling for the confounding effect of age. We tested the age-specific case-fatality rates for trend using the Mantel extension test¹⁹ to control for the confounding effect of sex. We used the χ^2 statistic to test the relationship between case-fatality rates and the Charlson score.

To determine the independent effects of age, sex, and comorbidities on prognosis, we constructed multivariable logistic regression models for the 30-day and 1-year mortality. All comorbidities with a prevalence of at least 1% in our cohort were considered for inclusion in our models. A univariate logistic regression model was first performed for each covariate. Only covariates that had a significance level of $P < .20$ were entered into the multivariable logistic models. A backwards elimination procedure (cutoff, $P > .10$) was then used to arrive at a final regression model for each outcome. Because the logit risk for death increased nonlinearly with age, a 4-level age group was used in the model regression. We tested model calibration by means of the Hosmer-Lemeshow²⁰ χ^2 test, and assessed model discrimination by means of the c statistic.²¹ Significance of each covariate in the final models was tested using the Wald χ^2 statistic.

We examined the interdependence among age, sex, and comorbidities on survival by adding a first-order interaction term among age group, sex, and the Charlson score in a pairwise fashion to the models. Significance of interactions was tested using the likelihood ratio tests²² for comparing different logistic models. All analyses were conducted using SAS software, Version 8.0 (SAS Institute Inc, Cary, NC).

plex relationship to age, sex, and comorbidities that has not been well described.

RESULTS

POPULATION DEMOGRAPHICS

A total of 38 702 patients were hospitalized for heart failure for the first time in Ontario during the 3-year period. More than half (51.1%) of the cohort were women. Most patients (84.6%) were 65 years or older, and 57.9% were 75 years or older.

CRUDE CASE-FATALITY RATES

The crude 30-day and 1-year case-fatality rates after first-time admissions for heart failure were 11.6% and 33.1%,

respectively (**Table 1**). In men, these rates were 11.4% and 34.0%, respectively; in women, 11.8% and 32.3%, respectively. After adjustment for age, men showed a higher 30-day mortality rate than women (odds ratio [OR], 1.09; $\chi^2 = 10.3$; $P = .001$). This difference persisted at 1 year after discharge (OR, 1.16; $\chi^2 = 101.9$; $P < .001$).

As expected, case-fatality rates rose sharply with increasing age. The 30-day case-fatality rate increased from 4.5% in those younger than 50 years to 15.1% in those 75 years or older. The effect of age on the case-fatality rate at 1 year was even more dramatic. The 1-year case-fatality rate was 13.5% in those younger than 50 years, which increased to 40.1% in those 75 years or older. Controlling for the confounding effect of sex did not diminish the powerful effect of age on 30-day ($\chi^2 = 580.9$; $P < .001$) or 1-year ($\chi^2 = 1278.0$; $P < .001$) mortality.

Table 1. Age- and Sex-Stratified Case-Fatality Rates 30 Days and 1 Year After First Hospitalization for Heart Failure

Age Group, y	Men				Women			
	No. of Patients	Mortality, %		No. of Patients	Mortality, %			
		30-Day	1-Year		30-Day	1-Year		
20-49	655	4.6	15.0	375	4.3	10.9		
50-64	3048	5.5	20.5	1892	5.4	19.5		
65-74	5923	8.6	28.8	4412	6.8	23.0		
≥75	9310	15.6	43.1	13 087	14.7	37.9		
All Ages	18 936	11.4	34.0	19 766	11.8	32.3		

The 30-day and 1-year case-fatality rates were strongly correlated to the Charlson score ($\chi^2=350.4$ and $\chi^2=1042.0$, respectively; $P<.001$ for both) (**Table 2**). Among patients with no major comorbidity (Charlson score of 0) except for heart failure, the 30-day and 1-year mortality rates were 9.3% and 26.8%, respectively; these rates increased to 18.8% and 50.6% among those with comorbidity scores of 3 or more.

Table 3 describes the 30-day and 1-year case-fatality rates observed in our cohort stratified by age, sex, and the Charlson score. The 30-day and 1-year mortality rates ranged from 2.3% and 7.6%, respectively, in the lowest-risk group to 23.8% and 60.7%, respectively, in the highest-risk group. The lowest-risk group consisted of patients younger than 50 years with minimal comorbidity except for heart failure. The highest-risk group included men 75 years or older with significant comorbidities.

INDEPENDENT EFFECTS OF AGE, SEX, AND COMORBIDITIES

Multivariate modeling confirmed the strong independent effect of age on mortality after the first hospitalization for heart failure (**Table 4**). We found a stepwise increase in the risk for death with advancing age. Patients in the highest-age bracket had ORs for death of 3.55 at 30 days and 4.24 at 1 year ($P<.001$ for both) compared with those in the lowest-age bracket. In contrast, sex exerted an independent effect on long- but not short-term survival. Compared with men, women had a significantly higher survival at 1 year (OR, 0.84; $P<.001$) but not at 30 days. Furthermore, most comorbid conditions identified by the Charlson Index were found to be significant independent predictors of 30-day and 1-year mortality. These included malignancy (ORs, 2.32 and 2.89 [for 30-day and 1-year mortality, respectively]; $P<.001$ for both), renal disease (OR, 1.97 and 2.35; $P<.001$ for both), dementia (ORs, 1.77 and 1.85; $P<.001$ for both), cerebrovascular disease (ORs, 1.57 and 1.60; $P<.001$ for both), rheumatologic disease (ORs, 1.32 and 1.47; $P=.04$ and $P<.001$), peripheral vascular disease (ORs, 1.17 and 1.42; $P=.03$ and $P<.001$), and previous myocardial infarction (ORs, 1.16 and 1.12; $P<.001$ for both). The presence of chronic pulmonary disease and diabetes mellitus with chronic complications were significant predictors of mortality at 1 year (ORs, 1.13 and 1.52; $P<.001$ for both) but not at 30 days. The Hosmer-Lemeshow tests showed no lack of fit for our 30-day and 1-year models ($\chi^2_8=10.68$ and $\chi^2_7=6.30$; $P=.22$ and $P=.51$).

Table 2. Relationship Between Comorbidities and Crude 30-Day and 1-Year Case-Fatality Rates After First Hospitalization for Heart Failure

Charlson Score	No. (%) [*]	Mortality, %	
		30-Day	1-Year
0	15 020 (38.8)	9.3	26.8
1	12 602 (32.6)	10.7	31.0
2	6 485 (16.8)	13.8	39.4
≥3	4 595 (11.9)	18.8	50.6

^{*}Prevalence rates are given in parentheses.

The *c* statistics were 0.64 and 0.65, respectively, on par with other models²³ that incorporated the Deyo adaptation of the Charlson Index in predicting survival in the population with heart failure.

INTERACTIONS AMONG AGE, SEX, AND COMORBIDITIES

The effect of sex on survival after first hospitalizations for heart failure differed across age groups (**Table 5**). We found an interaction between age group and sex that approached statistical significance in the model that predicted 30-day mortality ($\chi^2_3=6.64$; $P=.08$) and became statistically significant in the model that predicted 1-year mortality ($\chi^2_3=8.39$; $P=.04$). In particular, among patients 75 years or older, the gender gaps in the ORs for death at 30 days and 1 year were only 10.8% and 40.3%, respectively, of the gaps observed among the group younger than 50 years. Likewise, the cumulative effect of comorbidity on survival after first-time admissions for heart failure differed between the sexes. We found significant interactions between the Charlson score and sex in models that predicted 30-day and 1-year mortality ($\chi^2_1=30.34$ and $\chi^2_1=149.87$, respectively; $P<.001$ for both). The direction of the interaction in both models suggested that the sex gaps in mortality diminished with increasing comorbidities. Any survival advantage possessed by women was lost when the Charlson score was greater than 2 in our 30-day model and greater than 3 in our 1-year model. Significant interactions were also seen between age group and the Charlson score when predicting 30-day and 1-year mortality after first hospitalizations for heart failure ($\chi^2_3=140.61$ and $\chi^2_3=416.69$, respectively; $P<.001$ for both). The gap in mortality rates owing to differences per unit of the Charlson

Table 3. Impact of Age, Sex, and Comorbidities on 30-Day and 1-Year Mortality After First Hospitalization for Heart Failure

Age Group, y	Charlson Score							
	Men				Women			
	0	1	2	≥3	0	1	2	≥3
25-49								
30-day rate, %	4.5	2.3	6.5	17.2	2.7	2.8	5.1	13.3
1-year rate, %	12.9	14.0	20.8	31.0	7.6	10.3	10.3	26.7
50-64								
30-day rate, %	3.4	6.2	6.0	9.4	3.3	5.0	7.0	9.9
1-year rate, %	15.2	20.1	22.8	35.7	11.6	17.6	27.9	33.9
65-74								
30-day rate, %	5.8	7.5	10.5	15.2	4.3	6.0	9.0	13.1
1-year rate, %	21.1	25.7	34.9	45.4	16.3	20.8	28.3	41.5
≥75								
30-day rate, %	12.4	13.4	19.3	23.8	12.2	14.9	16.7	22.7
1-year rate, %	36.3	39.6	48.9	60.7	31.4	38.0	46.3	55.8

Table 4. Independent Effects of Age, Sex, and Comorbidities on 30-Day and 1-Year Mortality After First Hospitalization for Heart Failure*

Regressor	No. (%)†	Mortality			
		30-Day		1-Year‡	
		OR (95% CI)	P Value	OR (95% CI)	P Value
Female sex	19 766 (51.1)	0.95 (0.89-1.01)	.10	0.84 (0.80-0.88)	<.001
Age group, y					
50-64	4940 (12.8)	1.19 (0.86-1.64)	.29	1.56 (1.29-1.90)	<.001
65-74	10 335 (26.7)	1.71 (1.26-2.31)	<.001	2.18 (1.81-2.63)	<.001
≥75	22 397 (57.9)	3.55 (2.63-4.79)	<.001	4.24 (3.53-5.09)	<.001
Comorbidity					
Malignancy‡	1015 (2.6)	2.32 (1.99-2.70)	<.001	2.89 (2.53-3.29)	<.001
Renal disease	2501 (6.5)	1.97 (1.77-2.19)	<.001	2.35 (2.16-2.55)	<.001
Dementia	980 (2.5)	1.77 (1.52-2.07)	<.001	1.85 (1.62-2.11)	<.001
Cerebrovascular disease	2111 (5.5)	1.57 (1.39-1.76)	<.001	1.60 (1.46-1.76)	<.001
Rheumatologic disease	515 (1.3)	1.32 (1.01-1.71)	.04	1.47 (1.22-1.77)	<.001
Peripheral vascular disease	1711 (4.4)	1.17 (1.01-1.35)	.03	1.42 (1.28-1.57)	<.001
Previous myocardial infarction	5685 (14.7)	1.16 (1.07-1.27)	<.001	1.12 (1.05-1.19)	<.001
Chronic pulmonary disease	7383 (19.1)	1.08 (1.00-1.17)	.056	1.13 (1.07-1.19)	<.001
Diabetes with chronic complications§	670 (1.7)	1.14 (0.89-1.47)	.31	1.52 (1.29-1.80)	<.001

*OR indicates odds ratio; CI, confidence interval.

†Prevalence rates are given in parentheses.

‡Includes any malignancy, including leukemia and lymphoma.

§Excludes patients with diabetes without chronic complications.

score was lower among patients 75 years or older than among those in the next 2 younger age brackets. In all cases, addition of these significant interactions improved the discriminative powers of our models (*c* statistic increases, 0.003-0.013) in predicting mortality.

COMMENT

Our study has documented the high short- and long-term mortality rates after first-time admissions for heart failure in unselected patients from a large population-based sample in Ontario. We also demonstrated a substantial variation in the case-fatality rates across different patient subgroups. Only young subjects with minimal comorbidity had the low mortality rates that were typically seen in contemporary clinical trials of heart fail-

ure.¹ For most community-dwelling subjects with heart failure who were more likely to be older women with significant comorbidities, their prognosis remained poor.

The large disparity between case-fatality rates observed in our study and those reported in clinical trials is due to selection bias of the populations enrolled in these trials. Contemporary clinical trials of heart failure have largely been conducted in white, male populations with mean ages of about 60 years and a minimal number of comorbidities.¹ Although it is unclear what percentage of patients with heart failure encountered in clinical practice would not qualify for participation in these trials, studies evaluating the effect of screening on trial enrollment suggest that typically 35% to 85% of those undergoing screening were excluded from participation.²⁴ Therefore, a serious concern is raised that the evidence-based

Table 5. β Coefficients for Interaction Terms Among Age, Sex, and Comorbidities in Models for 30-Day and 1-Year Mortality After First Hospitalization for Heart Failure

Interaction	Mortality, β Coefficient			
	30-Day		1-Year	
	Female	Charlson Score*	Female	Charlson Score*
Age group, y				
50-64	+0.1188†	+0.2281	+0.3825‡	+0.3149
65-74	-0.1015†	+0.2380	+0.1793‡	+0.2955
≥ 75	+0.1148†	+0.1545	+0.2892‡	+0.2448
Female	...	+0.1086§	...	+0.1817§

* $P < .001$ for overall interaction.

† $P = .08$ for overall interaction. The β coefficient for female sex was -0.1278 .

‡ $P = .04$ for overall interaction. The β coefficient for female sex was -0.4461 .

§The β coefficients for female sex were -0.1955 for the 30-day model and -0.3899 for the 1-year model.

practice that currently exists for heart failure may only be appropriate for the limited segment of the population with heart failure included in the trials.

Our ability to track the outcomes of anonymous subjects in a large community using unique identifiers may improve on another study⁴ that used only probabilistic matching to link subjects between databases, because there is no guarantee in the latter approach that an individual from the first database corresponds to the same individual from a different database. Furthermore, because Canada uses a single-payer healthcare system, our database provides uniform information covering an entire geographic area across a broad population inclusive of all socioeconomic strata that is not readily available in the United States. By selecting only subjects with newly diagnosed heart failure, we minimized the confounding effects of disease duration on survival. Prevalence (as opposed to incidence) studies⁶⁻¹¹ that reported on survival after heart failure are prone to bias²⁵ because they may miss early fatal cases with survival not long enough to be counted.

We were aware of only 5 large-scale studies^{4,5,26-28} that provided longitudinal health data from heart failure patients on a community level in a contemporary setting. The Scottish Heart Failure Study⁴ used probabilistic linkages to track the outcomes of 66 547 patients admitted to the hospital for the first time with heart failure from 1986 to 1995 in Scotland. The crude 1-year case-fatality rate in that study was 44.5% (44.0% in men and 44.9% in women). Moreover, our study and theirs showed that chronic comorbidities independently increased the mortality rates of patients with newly diagnosed heart failure. The Framingham Heart Study²⁶ followed up 652 subjects undergoing screening from 1948 through 1988 and in whom new-onset heart failure developed. The 1-year mortality rates were 43% in men and 36% in women. As in the Scottish Heart Failure Study, the rates in the Framingham Heart Study were higher than in our own, perhaps owing to progress made in heart failure therapy since the early 1990s and to differences in the underlying population. Unlike our study, new cases of heart failure in the Framingham Heart Study were captured by interval examinations performed every 2 years rather than by hospital discharge abstracts.

In contrast, our approach is similar to a that of Swedish study⁵ in which 2461 patients from 1980 to 1987 were

followed up after their first hospitalizations for heart failure. The 1-year mortality rate was just above 20%. The lower mortality rate in that study compared with our own might be related to the younger age composition of the population with heart failure in Sweden. About half of the subjects in that study were aged 61 to 65 years, whereas more than half of our cohort were 75 years or older. The Rochester Epidemiology Project²⁸ described the prognosis of 107 and 141 patients who presented with new-onset heart failure in 1981 and 1991, respectively. The 1-year mortality rate was 28% in the first cohort and 23% in the second. The same group of investigators also followed up 216 patients from Olmstead County, Minnesota, who had a first diagnosis of heart failure in 1991.²⁷ They found a 1-year case-fatality rate of 24%. Because comorbidities were not systematically listed in either of these studies, it was unclear whether the lower observed mortality rates compared with our own were related to a lower prevalence of comorbidities in their cohorts of heart failure patients.

Although a number of studies^{5,11,27,28} have identified prognostic indicators in unselected community-dwelling heart failure patients, few studies^{4,26} have addressed how these indicators interact with each other in determining mortality. This omission is understandable because interactions between predictors in prognostic models are often difficult to quantify and interpret clinically. We demonstrated that such interactions could be readily quantifiable and that their inclusion might elucidate meaningful understanding of the competing risks among age, sex, and comorbidity in influencing survival in the population with heart failure. The Framingham Heart Study has long recognized that the mortality rate due to heart failure in men but not in women increased at more than a simple exponential rate with advancing age.²⁶ MacIntyre et al⁴ reported a significant age-sex interaction in their Scottish cohort of heart failure patients for the 30-day case-fatality rate, although the interaction did not persist at 1 year. An age-sex interaction was evident in our population and we found meaningful interactions between sex and comorbidity and between age and comorbidity. Barring statistical variations, these interactions qualitatively raise, although do not prove, the hypothesis that a common mechanism of competing risks may determine heart failure survival, ie, that the presence of one risk dimin-

ishes the gap in survival created by the presence or the absence of a second risk. The improvement in the performance of our models by the addition of these interaction terms implies a complex interdependence among age, sex, and comorbidity that should not be ignored in any future prognostic modeling of mortality due to heart failure.

There are several limitations to our study. We tracked only subjects who were hospitalized for the first time for heart failure. Thus, we omitted individuals with newly diagnosed heart failure who had not been admitted for any reason in the 5 years before our study. This omission is unlikely to alter the outcome of our study, because about 80% of the new heart failure patients are presented through hospital admissions,²⁹ and because community surveys³⁰ have shown that the remaining heart failure patients would have been hospitalized at least once within the first 2 years of identification. Also, the use of ICD-9-CM codes might result in an underenumeration of heart failure cases,³¹ although this problem is less important in Canada than in the United States. We also did not apply standardized diagnostic criteria through random chart reviews to confirm the diagnosis of heart failure in this study cohort. At the time of our study, we could not distinguish heart failure patients with normal vs reduced ejection fractions or classify the cause of the heart failure. In particular, undercoding of hypertension in discharge abstracts forbade estimation of the true prevalence of hypertension, a common cause of heart failure, in our population. We could not take into account differences between subpopulations of heart failure patients in use of drugs that would influence their survival. Some demographic variables, such as ethnicity and socioeconomic status, were missing in our database and could not be adjusted for. Although undercoding of comorbid conditions in our cohort was certainly possible, serious comorbid conditions were unlikely to be missed.

CONCLUSIONS

Our study highlights the high case-fatality rates in unselected community-dwelling patients after first-time hospitalizations for heart failure. Furthermore, the complex relationships among age, sex, and comorbidity and their relationship to survival are likely more involved than previously described and demand validation in other heart failure populations. Despite recent advances in medical treatment, we found persistent high mortality rates in our contemporary cohort of heart failure patients. This finding should be a sobering note to the medical community that much more remains to be done to improve the outcomes of this seriously ill population than is currently believed.

Accepted for publication April 8, 2002.

This study was supported by a Canadian Institute for Health Research Fellowship (Ottawa, Ontario) (Dr Jong), a Heart & Stroke Studentship Award (Dr Vowinckel), a Canada Research Chair in Health Services Research (Dr Tu), and an operating grant from the Canadian Institute of Health Research and the Heart & Stroke Foundation, Toronto, Ontario.

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REFERENCES

1. Konstam MA. Progress in heart failure management? lessons from the real world. *Circulation*. 2000;102:1076-1078.
2. Vowinckel E, Jong P, Liu P, Tu JV. Persistent high mortality in a population-based cohort of 39 710 newly diagnosed heart failure patients in Ontario, Canada [abstract]. *J Am Coll Cardiol*. 2001;37(suppl A):218A.
3. Vowinckel E, Jong P, Liu P, Tu JV. Determinants of mortality from co-morbid conditions in a population based follow-up of 39 710 newly diagnosed heart failure patients in Ontario, Canada [abstract]. *J Am Coll Cardiol*. 2001;37(suppl A):512A.
4. MacIntyre K, Capewell S, Stewart S, et al. Evidence of improving prognosis in heart failure: trends in case fatality in 66 547 patients hospitalized between 1986 and 1995. *Circulation*. 2000;102:1126-1131.
5. Andersson B, Waagstein F. Spectrum and outcome of congestive heart failure in a hospitalized population. *Am Heart J*. 1993;126:632-640.
6. McMurray J, McDonagh T, Morrison CE, Dargie HJ. Trends in hospitalization for heart failure in Scotland 1980-1990. *Eur Heart J*. 1993;14:1158-1162.
7. Haldeman GA, Croft JB, Giles WH, Rashidee A. Hospitalization of patients with heart failure: National Hospital Discharge Survey, 1985 to 1995. *Am Heart J*. 1999;137:352-360.
8. Brophy JM, Deslauriers G, Rouleau JL. Long-term prognosis of patients presenting to the emergency room with decompensated congestive heart failure. *Can J Cardiol*. 1994;10:543-547.
9. Brophy JM, Deslauriers G, Boucher B, Rouleau JL. The hospital course and short term prognosis of patients presenting to the emergency room with decompensated congestive heart failure. *Can J Cardiol*. 1993;9:219-224.
10. Schocken DD, Arrieta MI, Leaverton PE, Ross EA. Prevalence and mortality rate of congestive heart failure in the United States. *J Am Coll Cardiol*. 1992;20:301-306.
11. Clinical Quality Improvement Network Investigators. Mortality risk and patterns of practice in 4606 acute care patients with congestive heart failure: the relative importance of age, sex, and medical therapy. *Arch Intern Med*. 1996;156:1669-1673.
12. Fitzgerald C, Ogilvie L. Achieving standardization of health information in Canada by the year 2000. *Medinfo*. 1998;9(pt 1):425-428.
13. Iron K, Goel V, Williams JI. Concordance of hospital discharge abstracts and physicians claims for surgical procedures in Ontario. *ICES Working Paper*. 1995;42:1-18.
14. Ontario Hospital Association. *Executive Summary: Report of the Ontario Data Quality Reabstraction Study*. Ottawa: Ontario Ministry of Health, Hospital Medical Records Institute; 1991.
15. Deyo RA, Cherkin DC, Ciol MA. Adapting a clinical comorbidity index for use with ICD-9-CM administrative databases. *J Clin Epidemiol*. 1992;45:613-619.
16. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis*. 1987;40:373-383.
17. *1996 Census Technical Report: Mobility and Migration*. Ottawa, Ontario: Ministry of Industry, Statistics Canada; 1999.
18. Mantel N, Haenszel W. Statistical aspects of the analysis of data from retrospective studies of disease. *J Natl Cancer Inst*. 1959;22:719-748.
19. Rosner B. *Fundamentals of Biostatistics*. 5th ed. Pacific Grove, Calif: Brooks/Cole, Thomson Learning; 2000.
20. Hosmer DW, Lemeshow S. *Applied Logistic Regression*. New York, NY: John Wiley & Sons; 1989.
21. Hanley JA, McNeil BJ. The meaning and use of the area under a receiver operating characteristic (ROC) curve. *Radiology*. 1982;143:29-36.
22. Allison PD. *Logistic Regression Using the SAS System: Theory and Application*. Cary, NC: SAS Institute Inc; 1999.
23. Stukenborg GJ, Wagner DP, Connors AF Jr. Comparison of the performance of two comorbidity measures, with and without information from prior hospitalizations. *Med Care*. 2001;39:727-739.
24. Bjorn M, Brendstrup C, Karlsen S, Carlsen JE. Consecutive screening and enrollment in clinical trials: the way to representative patient samples? *J Card Fail*. 1998;4:225-230.
25. Sackett DL. Bias in analytic research. *J Chronic Dis*. 1979;32:51-63.
26. Ho KK, Anderson KM, Kannel WB, Grossman W, Levy D. Survival after the onset of congestive heart failure in Framingham Heart Study subjects. *Circulation*. 1993;88:107-115.
27. Senni M, Tribouilloy CM, Rodeheffer RJ, et al. Congestive heart failure in the community: a study of all incident cases in Olmsted County, Minnesota, in 1991. *Circulation*. 1998;98:2282-2289.
28. Senni M, Tribouilloy CM, Rodeheffer RJ, et al. Congestive heart failure in the community: trends in incidence and survival in a 10-year period. *Arch Intern Med*. 1999;159:29-34.
29. Cowie MR, Wood DA, Coats AJ, et al. Incidence and aetiology of heart failure: a population-based study. *Eur Heart J*. 1999;20:421-428.
30. Clarke KW, Gray D, Hampton JR. Evidence of inadequate investigation and treatment of patients with heart failure. *Br Heart J*. 1994;71:584-587.
31. Goff DC, Pandey DK, Chan FA, Ortiz C, Nichaman MZ. Congestive heart failure in the United States: is there more than meets the ICD code? the Corpus Christi Heart Project. *Arch Intern Med*. 2000;160:197-202.