

Lifetime Costs of Medical Care After Heart Failure Diagnosis

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Background—Heart failure (HF) care constitutes an increasing economic burden on the health care system, and has become a key focus in the health care debate. However, there are limited data on the lifetime health care costs for individuals with HF after initial diagnosis.

Methods and Results—Olmsted County residents with incident HF from 1987 to 2006 were identified. Direct medical costs incurred from the time of HF diagnosis until death or last follow-up were obtained using population-based administrative data through 2007. Costs were inflated to 2008 US dollars using the general Consumer Price Index. Inpatient, outpatient, and total costs were estimated using a 2-part model with adjustment for right censoring of data. Predictors of total costs were examined using a similar model. A total of 1054 incident HF patients were identified (mean age, 76.8 years; 46.1% men). After a mean follow-up of 4.6 years, 765 (72.6%) patients had died. The estimated total lifetime costs were \$109 541 (95% confidence interval, \$100 335 to 118 946) per person, with the majority accumulated during hospitalizations (mean, \$83 980 per person). After adjustment for age, year of diagnosis, and comorbidity, diabetes mellitus and preserved ejection fraction ($\geq 50\%$) were associated with 24.8% ($P=0.003$) and 23.6% ($P=0.041$) higher lifetime costs, respectively. Higher costs were observed at initial HF diagnosis and in the months immediately before death in those surviving >12 months after diagnosis.

Conclusions—HF imposes a significant economic burden, primarily related to hospitalizations. Variations in cost over a lifetime can help identify strategies for efficient management of patients, particularly at the end of life. (*Circ Cardiovasc Qual Outcomes*. 2011;4:68-75.)

Key Words: community ■ cost ■ heart failure ■ epidemiology ■ health services research

Heart failure (HF) imposes a staggering economic burden on the health care system. In developed countries, the cost of HF care constitutes 1% to 2% of overall health care spending.¹ In the United States, HF consumes more Medicare dollars than any other diagnosis,² and total costs for HF care were estimated at \$34.8 billion dollars in 2008.³ HF costs have risen over time, and may continue to rise because of an aging population and rise in the prevalence of HF due to improved survival after diagnosis.⁴ However, little is known about lifetime medical costs among individual patients with HF and how these costs are accrued from the time of diagnosis until death.

Published cost studies in HF have primarily included hospitalized patients or trial participants, have used prevalent HF cases that were not validated, or followed patients for a very brief period of time. To the best of our knowledge, there have been no studies examining costs among incident HF patients because these data are often difficult to obtain. Because HF is a disease characterized by periodic exacerbations,⁵ it is likely that accrual of costs varies over the course of

a lifetime. Although studies have estimated that hospitalization costs are responsible for 65% to 70% of total HF costs,^{1,6} far less is known about the costs associated with outpatient care. Finally, little is known about clinical characteristics associated with higher or lower lifetime costs. These data would be particularly informative to guide interventions and public health approaches to lower health care–related costs in HF.

HF imposes a major economic burden in the United States, but there is insufficient data on the lifetime costs of HF care from the time of initial diagnosis, the temporal distribution of costs and resource use, and the patient characteristics predictive of high or low costs. Accordingly, we aimed to examine these questions by evaluating the cumulative direct medical costs of care from the time of HF diagnosis among a community HF cohort.

Methods

Study Design

This is a cohort study conducted in Olmsted County, Minnesota. The population in the county was estimated at 137 521, according

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to the 2005 US Census, 50% of which is female, and 90% of which is white. Population-based research is possible in Olmsted County as the county is relatively isolated from other urban centers, and there are few providers, the largest of which is the Mayo Clinic. Medical records from all sources of care for county residents are extensively indexed and linked via the Rochester Epidemiology Project, a centralized system. Billing data for outpatient visit, hospitalization, and surgery have been collected and organized through the Olmsted County Healthcare Expenditure and Utilization Database for each person living in the county.⁷ This extensive framework allows patients to be followed passively using their medical record information and billing data, provided they have provided Minnesota Research Authorization when moving into the county. Historically, more than 97% of persons have given Minnesota Research Authorization. Thus, the population-based data presented herein are representative of the Olmsted County population.

WHAT IS KNOWN

- The cost of heart failure care is 1% to 2% of overall health care spending in developed countries.
- In the United States, heart failure consumes more Medicare dollars than any other diagnosis.

WHAT THE STUDY ADDS

- In total, 77% of lifetime costs are accrued during hospitalizations.
- Diabetes mellitus and preserved ejection fraction are independent predictors of higher lifetime costs.
- Costs are accrued more rapidly at the time of initial heart failure diagnosis and in the final months of life.

Patient Identification

Olmsted County residents with a potential HF diagnosis from 1987 to 2006 were identified by *International Classification of Diseases, Ninth Revision (ICD9)* code 428 (HF). Codes are assigned on the basis of physician diagnoses during outpatient visits or at hospital discharge. From all patients with *ICD9* code 428, a random subset was selected to undergo case validation and data abstraction. The index date for HF was defined as the first evidence of HF in the medical record. Patients with a first diagnosis of HF before the study period or before moving to Olmsted County were excluded. Cases were validated using methods previously described.⁴ Experienced nurse abstractors reviewed records to ensure that each met Framingham criteria and had a physician's diagnosis of HF present. When this method was used previously, the interabstractor agreement was 100%,⁴ indicating these methods of classification are highly reproducible. In total, 80% of *ICD9* code 428's met criteria for Framingham heart failure, and 90% had a physician's diagnosis of HF present. During the design of the cohort, other *ICD9* codes for HF were investigated but were found to be very low yield so were not included in the study.

Patient Baseline Characteristics

Baseline patient characteristics were abstracted from the medical record. Physician's diagnosis was used to define hyperlipidemia, chronic obstructive pulmonary disease, and peripheral vascular disease. Cerebrovascular disease was defined by physician's diagnosis. A random sample of 50 patients with diagnoses of cerebrovascular disease was investigated with manual abstraction to determine the nature of the cerebrovascular disease. Smoking status was classified as "current," "prior," or "never." Hypertension was defined by a physician diagnosis of hypertension in the medical record or systolic blood pressure >140 mm Hg or diastolic blood pressure >90 mm Hg. Diabetes mellitus was defined by fasting blood glucose

levels or use of insulin and/or oral hypoglycemic medications. Myocardial infarction was defined using standard epidemiological criteria.⁸ Body mass index was calculated using the weight and height at HF diagnosis. Ejection fraction (EF) closest to the time of HF diagnosis (and within 1 year) was collected from available imaging. Laboratory values closest to the time of HF diagnosis (and within 1 year in all cases) including hemoglobin and creatinine were obtained from the medical record. Anemia was defined as hemoglobin <12 mg/dL in women and <13 mg/dL in men. Creatinine clearance was estimated using the Modification of Diet in Renal Disease equation.⁹

Patient-Level Cost Data

Each time a patient presents for a medical encounter, billing data are generated, reflecting the direct medical costs of care. These costs for county residents have been organized since 1987 through the Olmsted County Healthcare Expenditure and Utilization Database.⁷ This unique database provides a standardized inflation-adjusted estimate of the costs of each service given at providers within the community. The value of each unit of service has been adjusted to national cost norms by use of accepted valuation techniques.¹⁰ Physician services are valued using Medicare reimbursement rates. All other resource utilization adjusts billed charges by using hospital cost-to-charge ratios and wages indices. The medical costs from all health care encounters within the county on persons in the cohort were obtained from the time of HF diagnosis through 2007 (censored at the time of death or last follow-up). All costs, including physician costs, accrued during a hospital admission were categorized as inpatient costs; other costs were considered outpatient. Observed outpatient costs were categorized according to the American Medical Association's Current Procedural Terminology codes. Costs that were unable to be classified were categorized separately. The costs of outpatient prescription medications and nursing home care were not captured.

Statistical Analysis

Patient baseline characteristics are presented as means with standard deviations or frequencies and percentages. Cumulative costs for the cohort (n=1054) during the study period are presented as the mean cost per patient and interquartile range.

Lifetime costs were estimated on all patients using the methods of Tian and Huang.¹¹ This method uses a flexible 2-part model to analyze lifetime medical costs, which are often highly skewed with some zero costs. Inverse probability weighting was used to account for informative right-censoring for those alive at study end. The first part of the model is a logistic regression model that estimates the probability of having positive costs; the second part of the model uses generalized linear methods to model the lifetime costs given the occurrence of positive cost. Inpatient and outpatient costs were estimated separately, based on fitted 2-part models. Confidence intervals of estimated costs were generated by bootstrapping method.^{12,13}

Similarly, a 2-part model was used to evaluate the independent predictors of lifetime costs. Clinical variables of interest were entered into a model predicting inpatient, outpatient, and total costs. For each variable, an estimate of the percentage change in costs associated with each clinical characteristic is generated. Each of the models was estimated using a generalized linear model with a γ distribution and a log link. The γ distribution was determined using the modified Park test.¹⁴

Missing data were minimal (<2%), with the exception of EF (26% missing within 1 year of HF diagnosis). Multiple imputation was used to input the EF values for patients with missing values. Specifically, 5 data sets with imputed values of EF were created and analyzed, and the results were combined using Rubin rules.¹⁵ Analysis was performed using SAS Version 9.3.1 (Cary, NC), Splus version 8 (TIBCO Software Inc, Palo Alto, Calif), and R (2008, R Foundation for Statistical Computing, Vienna, Austria). A probability value <0.05 was used as the level of significance.

Table 1. Baseline Patient Characteristics (n=1054)

	Number Missing	Overall (n=1054)
Age, y	...	76.8 (12.7)
Male	...	486 (46.1)
EF (%)	277	46.1 (17.5)
Year of HF diagnosis		
1987–1991	...	223 (21.2)
1992–1996	...	276 (26.2)
1997–2001	...	275 (26.1)
2002–2006	...	280 (26.6)
Risk factors and comorbidities		
Hypertension	...	784 (74.4)
Current smoker	12	148 (14.2)
Hyperlipidemia	...	464 (44.0)
Diabetes mellitus	2	221 (21.0)
Body mass index, kg/m ²	16	29.0 (7.7)
Prior MI	4	211 (20.1)
Chronic obstructive pulmonary disease	...	250 (23.7)
Cerebrovascular disease	1	262 (24.9)
Peripheral vascular disease	...	234 (22.2)
Laboratory data		
Anemia	14	454 (43.7)
Creatinine clearance, mL/min	10	58.3 (21.5)

Results are shown as n (%) or mean (standard deviation).

Results

Study Population

A total of 1054 incident HF patients were randomly sampled from 1987 to 2006, distributed evenly throughout the study period. The baseline characteristics of the study population are shown in Table 1. They were elderly (mean age, 76.8 years), and 46.1% were men. After a mean follow-up of 4.6 years (median, 3.7 years; range, 0 to 20.8 years), 765 (72.6%) patients had died.

Longitudinal Medical Costs After HF Diagnosis

The total costs for the cohort during the study period were \$100 967 086, and the distribution of inpatient and outpatient costs are shown in Table 2. The majority of costs were due to hospitalizations (77.0%), with an average of \$73 762 per person. The highest proportion of inpatient costs were due to room and board (mean, \$31 516 per person), procedures (mean, \$9097 per person), and evaluation and management (mean, \$7542 per person). The total outpatient costs were \$23 221 517, an average of \$22 032 per person. The highest proportion of outpatient costs was due to evaluation and management (mean, \$5541 per person) and procedures (mean, \$7406 per person). Among evaluation and management, the majority of costs were due to office visits. Dialysis accounted for the highest proportion of procedural costs, though these costs were accumulated by only 31 patients. Among imaging studies, computed tomography and MRI/angiography scanning accounted for 29.6% of imaging costs, followed by echocardiography (20.8%). Internal cardiac de-

Table 2. Longitudinal Direct Medical Costs for 1054 Heart Failure Patients

	Mean Cost per Patient (2008 USD)	Interquartile Range (2008 USD)	% of Total Costs
Inpatient	73 762	19 226, 96 150	77.0
Evaluation and management	7542	2032, 9604	7.9
Procedures	9097	621, 13 482	9.5
Imaging	5063	1109, 7098	5.3
Echocardiography	783	0, 1082	0.8
Other	4280	750, 5884	4.5
Testing	9540	2182, 12 733	10.0
Laboratory	7137	1667, 9555	7.5
Other	2402	321, 2695	2.5
Pharmacy/facility/other	41 326	9929, 54 357	43.1
Pharmacy	4864	866, 6221	5.1
Room and board	31 516	7862, 41 784	32.9
Other	4945	341, 6528	5.2
Unclassified	1196	0, 469	1.2
Outpatient	22 032	4202, 23 988	23.0
Evaluation and management	5541	1645, 6870	5.8
Office visits	3055	612, 4086	3.2
Emergency room visits	844	0, 1094	0.9
Other	1643	171, 1852	1.7
Procedures	7406	176, 5720	7.7
Dialysis	3419	0, 0	3.6
Facility costs	1581	0, 2137	1.7
Ambulatory and minor procedures	919	0, 999	1.0
Eye procedures	353	0, 0	0.4
Anesthesia	464	0, 670	0.5
Other	670	0, 506	0.7
Imaging	2778	394, 3651	2.9
Echocardiography	578	0, 699	0.6
Computed tomography/computed tomographic angiography	575	0, 741	0.6
MRI/MR angiography	247	0, 0	0.3
Standard chest	249	47, 356	0.3
Ultrasound, other	241	0, 272	0.3
Other	887	34, 1049	0.9
Testing	3333	729, 4226	3.5
Laboratory	2445	541, 3044	2.6
Other	888	57, 1008	0.9
Medical equipment/other	2631	6, 1656	2.7
Unable to classify	343	0, 285	0.4

Mean follow-up was 4.6 years, over which 73% of patients died.

fibrillator costs were minimal at only 2% of total costs in this population (97 of 1054 patients, 9.2% affected), probably reflecting that this is a newer technology unavailable for much of the study period. In addition, many in the population had preserved EF and would not qualify for use for primary prevention of sudden cardiac death.

Table 3. Estimated Lifetime Costs From Time of Heart Failure Diagnosis Until Death Among 1054 Patients

	Overall Mean (95% CI),* 2008 USD	Year of HF Diagnosis, Mean (95% CI), 2008 USD*			
		1987 to 1991	1992 to 1996	1997 to 2001	2002 to 2006
Total costs	109 541 (100 335–118 946)	116 774 (96 040–122 942)	105 925 (89 617–130 187)	114 305 (87 609–130 934)	102 340 (90 257–128 546)
Inpatient†	83 980 (77 104–91 050)	87 870 (73 943–94 093)	82 813 (69 133–99 348)	87 787 (67 663–99 998)	78 318 (69 420–98 360)
Outpatient	25 560 (21 811–29 316)	29 037 (20 082–30 858)	22 851 (17 327–34 006)	26 256 (16 653–34 254)	23 931 (17 773–33 246)

*Lifetime costs were estimated from a model to adjust for right censoring and year of diagnosis.

†Inpatient costs included all costs associated with a hospital stay including physician costs.

Estimated Lifetime Costs From HF Diagnosis Until Death

Lifetime costs were estimated for all patients using available costs and are shown in Table 3. The estimated total lifetime costs were \$109 541 (95% confidence interval, \$100 335 to \$118 946) per person. The majority of costs were accumulated during hospitalizations (mean, \$83 980 per person), with fewer costs accrued in the outpatient setting (mean, \$25 560).

In an ancillary analysis, we examined the lifetime medical costs after HF diagnosis among those who died during follow-up (n=765) and thus had their entire lifetime costs captured. Their mean total lifetime costs were \$94 847 per person. As expected, mean total costs were lower than those estimated for the entire cohort because the duration of follow-up was shorter if we included only those that died. The majority of costs were accumulated during hospitalizations (mean, \$75 817 per person), with fewer costs accrued in the outpatient setting (mean, \$19 030 per person).

Predictors of Lifetime Costs

The multivariable predictors of lifetime costs are shown in Table 4. Diabetes mellitus was associated with a 32% increase in inpatient and 25% increase in total costs, whereas preserved EF ($\geq 50\%$) was associated with a 21% increase in inpatient and 24% increase in total costs compared with reduced EF, though survival was similar in patients with preserved and reduced EF ($P=0.213$). Cerebrovascular disease was associated with decreases in inpatient (17%), outpatient (37%), and total costs (22%). Among a random sample of 50 patients with a diagnosis of cerebrovascular disease, 25 (50%) had a prior stroke (80% ischemic, 20% hemorrhagic), 20 (40%) had prior transient ischemic attack, and 7 (14%) had prior carotid endarterectomy (5 occurred after stroke or transient ischemic attack). In 3 of the 50 cases (6%) there was no prior stroke, transient ischemic attack, or carotid endarterectomy documented in the medical record. Sixteen of the 25 (64%) patients with prior stroke had a residual neurological deficit. Inpatient, outpatient, and total costs were lower when patients were older at HF diagnosis. A creatinine clearance <30 mL/min was associated with 87% higher outpatient costs, which probably reflects the use of dialysis in some patients in this population. Hypertension was associated with 23% lower outpatient costs but similar inpatient and total costs. This was only significant when adjusting for creatinine clearance, reflecting the relationship between hypertension, renal dysfunction, and dialysis. Being diagnosed with HF from 2002 to 2006 was associated with lower total costs compared with previous time periods.

However, though the model used attempts to adjust for incomplete follow-up, it may simply be that lower adjusted costs estimated in these patients are the result of inadequate adjustment for right censoring, because a larger proportion of patients diagnosed in this time period were alive at study end (and therefore adjusted by the model) compared with other periods.

Distribution of Costs Over the Remainder of Life After HF Diagnosis

The distribution of costs from the time of HF diagnosis until death by month for those surviving 36 to 48 months is shown in the Figure, A. This Figure demonstrates that costs are high at the time of initial diagnosis, likely reflecting that 56% of community patients are diagnosed with HF while hospitalized.¹⁶ Then, costs decrease and remain relatively low until the end of life, where costs again increase. A similar distribution in costs was observed for those surviving from 12 to 36 and 48 to 72 months after diagnosis. HF patients surviving <12 months also exhibited high initial costs but maintained a higher level of costs for the remainder of their lifetime, without a significant rise at the end (Figure, B).

To assess the impact of the HF diagnosis on costs, we compared the costs in the year before HF diagnosis (ending 3 months before HF diagnosis) with the year beginning with HF diagnosis. Markedly higher costs were accrued after HF diagnosis, with mean total costs per person of \$8219 in the year prior versus \$34 372 in the year after HF diagnosis ($P<0.001$).

Discussion

The United States spent an estimated \$2.6 trillion on health care in 2009, representing more than 17.6% of our gross domestic product.¹⁷ HF care constitutes a large portion of this growing economic burden, as it consumes more Medicare dollars than any other diagnosis² and cost an estimated \$37 billion in 2009.¹⁸ Reduction of costs is a major priority, and HF will thus continue to be a central target given its high associated costs. However, limited data exist to inform interventions and policy on the distribution and predictors of health care costs over the lifetime of patients diagnosed with HF. Herein, among a population-based community cohort with incident HF followed longitudinally, we have shown that the lifetime costs of HF care are high and are primarily related to hospitalizations. Diabetes and preserved EF are independently associated with higher total costs. Costs are accrued unevenly over time, with high-cost periods at the time of initial HF diagnosis and in the final months of life.

Table 4. Multivariable Predictors of Lifetime Costs

Predictor	Inpatient Costs		Outpatient Costs		Total Costs	
	Predicted Change in Cost, %	P Value	Predicted Change in Cost, %	P Value	Predicted Change in Cost, %	P Value
Age, y						
<55 (referent)	...	...	...	...	...	...
55–64	–16.4	0.436	–41.3	0.123	–22.6	0.276
65–74	–30.7	0.124	–61.7	0.018	–33.6	0.091
75–84	–63.8	0.001	–104	<0.001	–71.3	<0.001
≥85	–113.9	<0.001	–180.5	<0.001	–130.1	<0.001
Male	7.8	0.307	2.5	0.812	6.8	0.375
EF ≥50%	20.7	0.041	33.4	0.064	23.6	0.041
Hypertension	11.0	0.165	–22.7	0.028	1.4	0.862
Smoking status						
Never-smoker (referent)	...	...	...	...	...	...
Current smoker	14.3	0.078	5.6	0.590	12.6	0.116
Former smoker	–10.2	0.382	–24.6	0.104	–9.1	0.436
Hyperlipidemia	1.6	0.836	18.5	0.061	9.8	0.193
Diabetes mellitus	32.0	<0.001	–2.9	0.787	24.8	0.003
Body mass index ≥25	5.6	0.445	–3.0	0.748	3.3	0.642
Prior myocardial infarction	5.6	0.507	16.7	0.133	7.0	0.411
Chronic obstructive pulmonary disease	–2.8	0.731	–8.7	0.425	–4.6	0.576
Cerebrovascular disease	–16.5	0.032	–36.8	<0.001	–22.2	0.003
Peripheral vascular disease	6.8	0.411	2.9	0.784	5.9	0.469
Anemia	10.1	0.139	2.4	0.789	10.2	0.131
Creatinine clearance, mL/min						
>60 (referent)	...	...	...	...	...	...
30–60	–11.8	0.097	2.9	0.754	–7.1	0.314
<30	–11.2	0.397	86.8	<0.001	11.9	0.363
Year of HF diagnosis						
1987–1991 (referent)	...	...	...	...	...	...
1992–1996	6.2	0.459	10	0.356	6.9	0.405
1997–2001	–10.5	0.285	1.2	0.924	–12.4	0.199
2002–2006	–25.9	0.0246	–35.3	0.0159	–32.7	0.004

Although the annual costs of caring for the HF population in the United States are estimated to be high, little is known about the cumulative costs of caring for HF patients after diagnosis. Russo et al¹⁹ examined costs in the final 2 years of life among 47 advanced HF patients with low EF enrolled in the Randomized Evaluation of Mechanical Assistance for the Treatment of Congestive Heart Failure trial and reported a mean cost of \$156 168, of which >50% were accumulated in the last 6 months of life. Notably, these data pertained to a limited number of trial participants with low EF, who do not represent the general HF population.²⁰ Among 343 patients with prevalent HF enrolled in the Cardiovascular Health Study, 10-year medical costs were estimated at \$54 704, with an average cost per year alive of \$10 832.²¹ Participants with HF incurred greater costs than study participants without HF. However, the use of prevalent cases precluded the examination of costs from the time of diagnosis. Herein, we quantified the direct medical costs of care in a large, community-based

cohort of HF patients followed longitudinally from the time of diagnosis. Among the >70% of the cohort who died during the study period, total lifetime costs were high, at a mean of nearly \$100 000 per person accumulated over an average of 4 years from diagnosis until death. It is important to note that health care delivery in this setting is largely integrated so that information is readily available to providers of multiple different disciplines. This may allow improved coordination of care and result in minimization of redundancy in testing and evaluation. Thus, care in this type of environment may reflect lower costs than would be incurred in some systems in which care of patients may be more fragmented. Although absolute numbers may differ, there is no reason to believe that the pattern of expenditures would differ in other settings.

Hospitalizations have been estimated to account for at least two-thirds of HF costs.^{1,6,22} Our data reveal that, on average, a staggering 79% of lifetime costs of HF care are accumulated during hospitalization. Similarly, among all 1054 HF patients

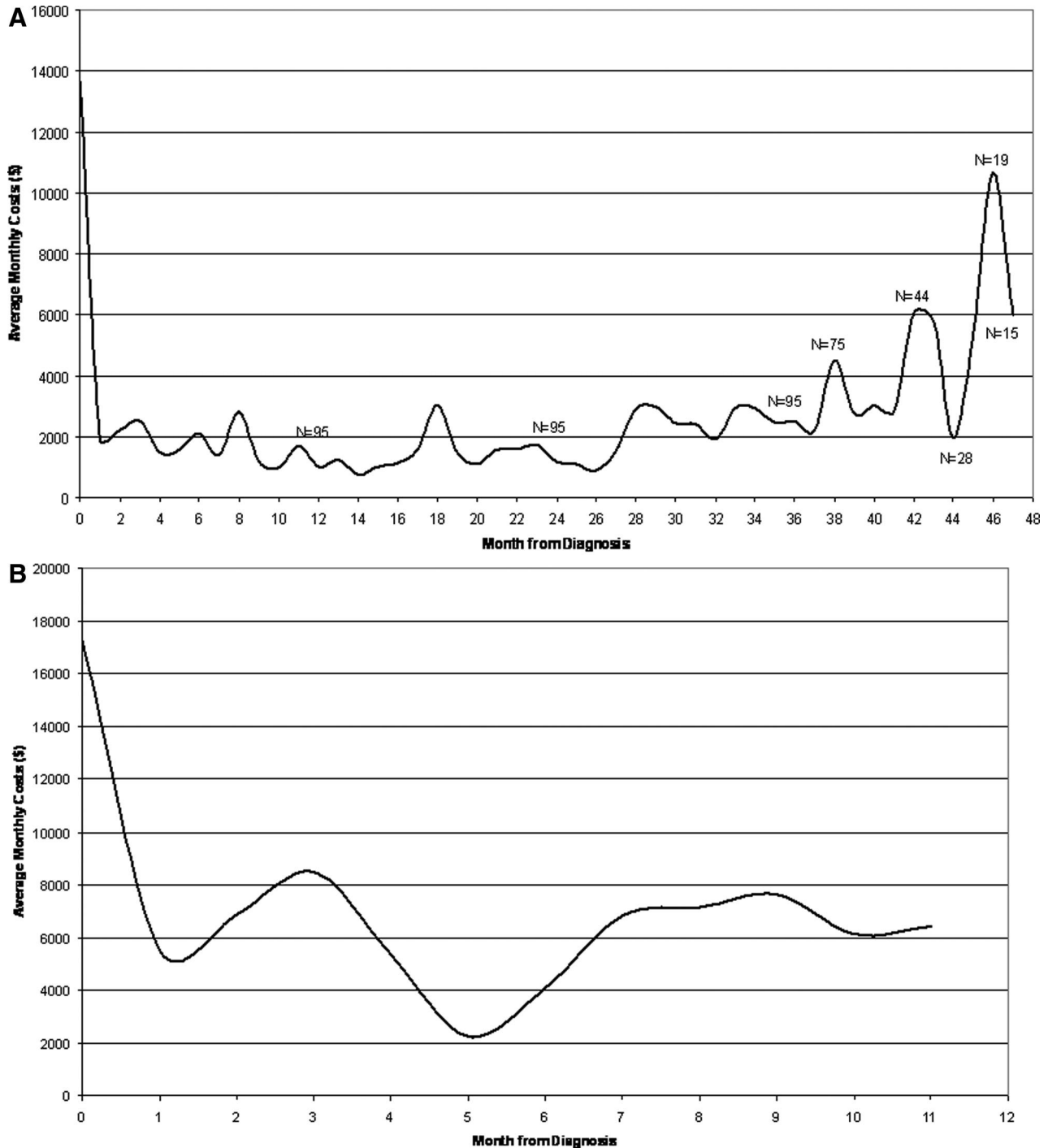


Figure. Distribution of costs over a lifetime. A representative distribution of the distribution of medical costs from the time of HF diagnosis until death by month is shown for those surviving 36 to 48 months after diagnosis (A, n=95). A similar distribution in costs over time was observed for those surviving from 12 to 36 and 48 to 96 months. Costs for those surviving <12 months (n=166) followed a different pattern (B).

followed over the course of the study, representing nearly 5000 person-years of follow-up, \$77.7 of \$101.0 million (77%) were due to hospitalizations. Although room and board was the greatest contributor to inpatient costs (43% of inpatient costs), consistent with prior studies,²³ procedures, imaging and laboratory testing accounted for an additional 32% of inpatient costs for the cohort, thereby constituting opportunities for cost-saving when clinically appropriate. The high economic burden that

hospitalizations impose on the health care system in the United States has been an area of recent focus, in particular because of the high rate of readmissions observed among HF patients.^{24,25} Although more than 50% of admissions among HF patients may be preventable,²⁶ currently hospitalizations among HF patients remain frequent and costly.

Identifying patient factors associated with higher costs may be helpful to target those patients for cost-saving interven-

tions. We recently reported on the predictors of lifetime hospitalizations among HF patient in Olmsted County¹⁶ and found that male sex, chronic obstructive pulmonary disease, diabetes mellitus, anemia, and renal insufficiency were each associated with an increased risk of hospitalization. When examining clinical variables for their association with lifetime costs herein, diabetes mellitus and preserved EF were critical factors associated with higher lifetime costs, with each having an estimated increase of 25% and 24%, respectively. The clinical characteristics associated with risk of hospitalization and lifetime costs may differ because comorbidities conveying adverse prognosis could have variable impact on lifetime costs even though they increase the risk of hospitalization. This certainly could explain, for example, why renal insufficiency was associated with higher hospitalization risk previously¹⁶ but not higher lifetime total costs herein, as it conveys worse prognosis and thus a shorter lifespan by which to accumulate costs. With diabetes, the increase in total costs was due to an increase in hospitalization costs, which is consistent with our prior work demonstrating that diabetes was associated with a 53% increase in hospitalization risk.¹⁶ However, preserved EF was also predictive of increased total costs, with a significant 21% increase in inpatient and insignificant 33% increase in outpatient costs. Liao et al²⁷ reported that among 881 elderly HF patients, 5-year costs were similar for patients with reduced and preserved EF after adjusting for other factors. Patients with preserved EF have an increased frequency of many comorbidities, which could result in longer hospital length of stay and increased total costs, though this remains to be established. The presence of cerebrovascular disease at the time of HF diagnosis was associated with lower cumulative resource utilization including lower inpatient (17%), outpatient (37%), and total (22%) lifetime costs after adjusting for age and other comorbidities. Approximately half of these patients had prior stroke, a large proportion with residual neurological deficits. Perhaps these patients underwent less extensive medical evaluation because of their neurological status and/or wishes. Further work is needed to understand this unexpected finding.

Although it has previously been recognized that the costs of caring for selected HF patients at the end of life are high,¹⁹ to the best of our knowledge, no studies have assessed costs from the time of initial HF diagnosis to identify a pattern of cost accrual over the lifetime after diagnosis. Herein, patients surviving >12 months after initial diagnosis accumulate higher costs at the time of initial diagnosis and in the months immediately before death, with lower costs accrued in the interim. However, patients surviving <12 months after diagnosis follow an alternate pattern, with high initial costs of care, followed by a steady level of cost accrual for the remainder of life that appears higher than those surviving longer periods of time. The costs of HF care appear to be particularly high in the immediate months before death, a time that has been associated with increased hospitalizations and resource use.^{16,19} Discussions between patients and clinicians regarding prognosis and the appropriateness of therapies and wishes for end of life care are of particular

importance and could result in cost-saving as the result of improved resource allocation.

Some limitations should be acknowledged in interpreting these data. This study included only direct medical costs and did not include outpatient medication costs or indirect costs of care. Costs may have been underestimated for some patients if they received medical care outside of the community, either due to emigration or to care during periods of travel. However, when residency status was examined during the study period using the resources of the Rochester Epidemiology Project,²⁸ <2% of the sample moved away from Olmsted County and the surrounding communities, reflecting a negligible degree of emigration. Although we acknowledge that the results pertain to one single geographical area and that geographical variations in care exist, the ability to examine lifetime costs of care in a stable population provides insights of clinical and societal relevance. We did not compare lifetime costs of care with a control group of patients without HF to accurately determine whether HF alone accounted for the increase in costs. However, the costs of care post-HF diagnosis were markedly higher in the same patients compared with before diagnosis. An accurate control group for cost comparison is difficult because the impact of other comorbidities and life expectancy would also need to be taken into account. After adjustment for comorbidities, those patients diagnosed with HF from 2002 to 2006 had significantly lower costs compared with other years. This may be in part due to incomplete adjustment for right-censoring of data despite our use of rigorous methodology, as a much higher proportion of patients diagnosed with HF from 2002 to 2006 were alive at study end compared with other time periods. This is further exacerbated by the fact that a large proportion of them have not experienced the high-cost end of life period. Finally, the study population is primarily White, and further studies are needed in communities where the racial and ethnic composition may differ. However, there are several strengths including the use of a validated incident population of HF patients followed longitudinally and the inclusion of both inpatient and outpatient cost data in our analysis.

The implications of these data are 3-fold. First, the longitudinal cost of caring for HF patients is high and primarily driven by inpatient care. This suggests that preventing hospitalizations and reducing the cost of hospitalizations are keys to reducing the total costs of care HF patients. Second, diabetes mellitus and preserved EF were each associated with a large increase in lifetime costs, even after adjusting for other factors. Diabetic persons, in particular, represent a segment of the HF population who are at greater risk for hospitalization and resource use and may be a target population for further investigation and intervention. Third, the costs of caring for patients with HF are highest at the time of initial diagnosis and at the end of life. Judicious allocation of resources at the end of life based on patient wishes and needs are required to decrease costs.

In summary, the costs of caring for HF patients in the community is high and primarily because of hospitalizations. Costs are higher at diagnosis and end of life. Cost-saving measures targeted at reducing hospitalizations, particularly in

patients with diabetes and preserved EF, and reducing end-of-life costs, may have the greatest impact.

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Disclosures

None.

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