Short-Term Outcomes and Factors Associated With Adverse Events Among Adults Discharged From the Emergency Department After Treatment for Acute Heart Failure

See Editorial by Pang and Weaver

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BACKGROUND: Although 80% of patients with heart failure seen in the emergency department (ED) are admitted, less is known about short-term outcomes and demand for services among discharged patients.

METHODS AND RESULTS: We examined adult members of a large integrated delivery system who visited an ED for acute heart failure and were discharged from January 1, 2013, through September 30, 2014. The primary outcome was a composite of repeat ED visit, hospital admission, or death within 7 days of discharge. We identified multivariable baseline patient-, provider-, and facility-level factors associated with adverse outcomes within 7 days of ED discharge using logistic regression. Among 7614 patients, mean age was 77.2 years, 51.9% were women, and 28.4% were people of color. Within 7 days of discharge, 75% had outpatient follow-up (clinic, telephone, or e-mail), 7.1% had an ED revisit, 4.7% were hospitalized, and 1.2% died. Patients who met the primary outcome were more likely to be older, smokers, have a history of hemorrhagic stroke, hypothyroidism, and dementia, and less likely to be treated in a facility with an observation unit. In multivariable analysis, higher comorbidity scores and history of smoking were associated with a higher odds of the primary outcome, whereas treatment in a facility with an observation unit and presence of outpatient follow-up within 7 days were associated with a lower odds.

CONCLUSIONS: We identified selected hospital and patient characteristics associated with short-term adverse outcomes. Further understanding of these factors may optimize safe outpatient management in ED-treated patients with heart failure.

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WHAT IS NEW?

- This observational, retrospective cohort study describes the natural history of >7000 patients in a large, integrated delivery system who are treated and discharged directly from the emergency department (ED) after a heart failure ED encounter.
- Although most heart failure research relates to hospitalized patients with heart failure, by focusing on the ED population, this study provides novel and important information that will be helpful to improve heart failure care and outcomes across settings.
- We also assess patient-, provider-, and facility-level factors associated with acute care encounters and death within 7 days of ED discharge and identify factors associated with adverse events.

WHAT ARE THE CLINICAL IMPLICATIONS?

- Compared with the general population, there were high rates of acute care utilization within 7 days of ED discharge.
- Higher comorbidity scores and history of smoking were associated with higher odds of an adverse event, whereas treatment in a facility with an observation unit and close outpatient follow-up (either in clinic or by telephone or e-mail) were associated with lower odds.
- This information provides valuable insights on an understudied population and will be useful for future efforts targeting risk stratification, outcomes, and resource utilization in this population.

The population burden of disease from heart failure (HF) is tremendous and is continuing to rise.[1] There are >1 million hospital admissions annually for HF,[2] and ≈1 quarter of discharged patients are readmitted within 30 days.[3–5] Total annual costs for HF are estimated to reach $70 billion by 2030, 80% of which will be because of hospitals.[2,6] Although HF is a chronic disease, it is marked by acute exacerbations that often trigger emergency department (ED) visits. EDs play a critical role in acute HF care through symptom management, coordination of care, and risk stratification to identify sicker patients needing admission. ED visits account for ≈20% of HF-specific ambulatory care each year,[7] and >80% of patients presenting with acute HF to the ED are admitted to the hospital.[7,8]

With shifting payment and delivery models that aim to tie payment to value, hospital systems have aimed to reduce discretionary and short-stay admissions and readmissions.[9,10] Although a major focus of research and policy has been on improving outcomes, risk prediction,[11,12] and readmission rates[3–5] among hospitalized patients with HF, the specific role of EDs in these processes has been less well studied. The major HF registries have included only hospitalized patients, thereby limiting understanding of acute HF care in the ED and among patients discharged after stabilization in the ED.[12,13] The few studies of HF patients discharged from the ED have included small sample sizes[14] or were conducted outside the United States.[15–17]

Given the limited data available in this area and the potential promise of reducing discretionary admissions with cost savings,[18] we examined short-term (3, 7, and 30 days) outcomes and associated patient-, provider-, and facility-related characteristics among a diverse community-based population of patients discharged from the ED after treatment for acute HF in a large integrated healthcare delivery system.

METHODS

Source Population

Kaiser Permanente Northern California (KPNC) is large integrated healthcare delivery system currently providing comprehensive inpatient, ED, and ambulatory care for 4 million people in Northern California. KPNC is a prepaid healthcare system consisting of 3 entities: a health plan that bears insurance risk, a medical group of physicians, and a hospital system. The system promotes coordination of work by primary care providers, specialists, hospitals, pharmacies, and laboratories and because of shared incentives, is accountable, both clinically and financially, for the outcomes of its members.

The KPNC membership is highly representative of the local surrounding and statewide population.[19] KPNC includes 21 medical centers and associated EDs with >1 million ED visits annually.

The study was approved by the KPNC Institutional Review Board; no informed consent was required. The data, analytic methods, and study materials have not been made available to other researchers for purposes of reproducing the results.

Cohort Assembly

We identified all health plan members aged ≥18 years with known sex who were discharged from the ED after treatment for HF between January 1, 2013, and September 30, 2014. We initially searched for possible HF as a reason for the ED visit based on the following *International Classification of Diseases, Ninth Revision* (*ICD-9*) codes listed at the time of discharge from the ED in any coding position: 398.91, 402.01, 402.11, 402.91, 404.01, 404.03, 404.11, 404.13, 404.91, 404.93, 428.0, 428.1, 428.20, 428.21, 428.22, 428.23, 428.30, 428.31, 428.32, 428.33, 428.40, 428.41, 428.42, 428.43, and 428.9. Previous studies have shown a positive predictive value of >95% for hospital admissions with a primary discharge diagnosis of HF based on these codes when compared against chart review using the Framingham clinical criteria.[20–22]

However, after completing manual review of a random sample of 200 ED visits with one of these HF codes and using the Framingham Heart Study clinical criteria, we found that these codes were only accurate in the primary coded

diagnosis (positive predictive value of 87%) or when the code 428.0 was in an unspecified position (positive predictive value of 80%), so we restricted our sample using this approach. We repeated a chart review of an additional 100 charts after this classification scheme was revised to confirm the validity of our approach. We excluded patients if they met any of the following criteria: left against medical advice, eloped before discharge, died during the ED visit, admitted to the hospital within 1 day of their ED visit, no laboratory tests during the ED visit, <12 months of continuous health plan membership or pharmacy benefit before the index ED visit, no evidence of clinical follow-up after ED discharge, or history of organ transplant before index date. Patients who did not have membership or pharmacy coverage after ED discharge were excluded because they would not have clinical follow-up information within our healthcare system. We used the first qualifying ED visit during the study period as the patient's index date.

Follow-Up and Outcomes

Eligible patient encounters were included in the study if the ED visit occurred between January 1, 2013, and September 30, 2014, which was the latest date that complete information on outcomes were available at the time of analysis. The primary outcome of interest included all-cause repeat ED visit, all-cause hospital admission, or death within 7 days of the index date. Each patient could contribute only once to the outcome (even if they had a repeat ED visit, hospitalization, or death). Repeat ED visits and hospital admissions were systematically identified from health plan electronic medical records. Deaths from any cause were identified from hospital and billing claims databases, administrative health plan databases, state death certificate registries, and social security administration files as available at each site. These approaches have yielded >97% vital status information in prior studies.[19,20]

We selected a 7-day time frame as the primary outcome based on its policy implications, use in prior studies describing adverse events after ED discharge, and the likelihood that longer time frames were likely to include an increasing proportion of events unrelated to the index ED visit.[23–25] We evaluated 2 secondary time periods. First, outcomes within 3 days of the index date were examined because these outcomes may be most related to care provided in the ED. Second, outcomes within 30 days of the index date were also examined because of the Center for Medicare and Medicaid Services focus on 30-day readmission rates.[9] We also examined the distribution of the frequency of the primary outcome by day of follow-up during the first 30 days after discharge from the index ED visit. Finally, we tracked outpatient follow-up (primary care or cardiology) within 30 days of the index ED visit.

Covariates

We collected patient demographic information, including age, sex, self-reported race/ethnicity, and socioeconomic status from administrative databases and residential block US census data. We ascertained information on coexisting illnesses based on diagnoses or procedures using relevant *ICD-9* codes, laboratory results, and outpatient prescriptions from health plan hospitalization discharge, ambulatory visit, laboratory, and pharmacy databases, as well as regional diabetes mellitus and cancer registries.[20] We collected baseline information on the following conditions based on data ≤5 years before the index ED date: coronary heart disease, prior HF, ischemic stroke, intracranial hemorrhage, peripheral artery disease, hypertension, diabetes mellitus, chronic liver disease, chronic lung disease, hyperthyroidism, hypothyroidism, systemic cancer, diagnosed dementia, and diagnosed depression based on relevant *ICD-9* codes and Current Procedures Terminology procedure codes (codes available on request). Smoking status (current, former,

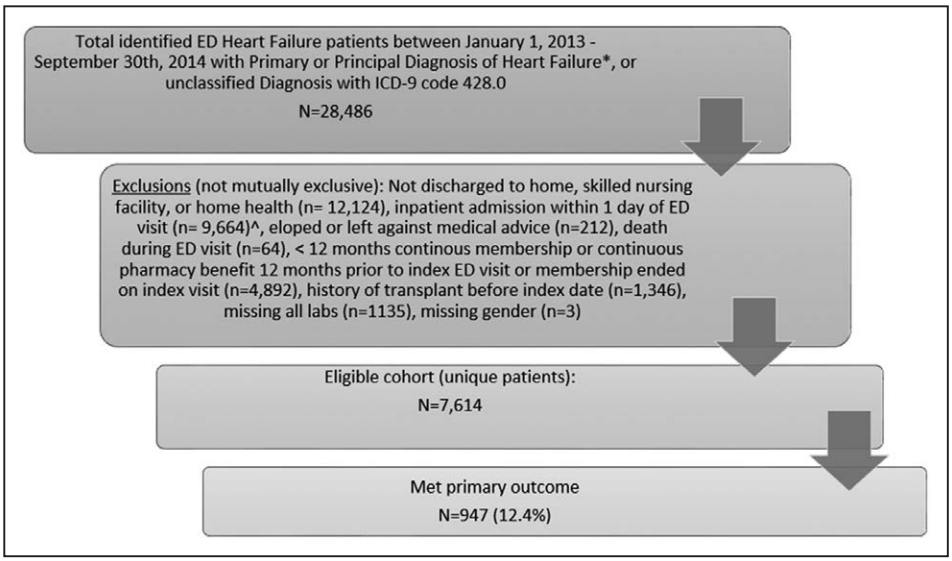

Figure 1. Cohort assembly of 7614 Kaiser Permanente Northern California adult patients discharged from the emergency department (ED) after treatment for acute heart failure.
*Any of the following *International Classification of Diseases, Ninth Revision* (*ICD-9*) codes: 398.91, 402.01, 402.11, 402.91, 404.01, 404.03, 404.11, 404.13, 404.91, 404.93, 428.0, 428.1, 428.20, 428.21, 428.22, 428.23, 428.30, 428.31, 428.32, 428.33, 428.40, 428.41, 428.42, 428.43, and 428.9. ^Because the time between ED and hospitalization was within 1 d, we assumed the hospitalization was related to the ED visit.

Table 1. Baseline Characteristics of Adults Treated for HF During the ED Visit Between January 1, 2013, and September 30, 2014, Overall and Stratified by Outcomes Within 7 Days, With Cohen *d* Value as Measure of Effect Size

Characteristics	Overall N=7614	Death, ED Visit, or Any Hospitalization N=947	No ED Visit, Readmission, or Death N=6667	*d* Value
Age, y, mean (SD)	77.2 (12.6)	78.3 (12.3)	77.0 (12.6)	0.10
Women, n (%)	3952 (51.9)	490 (51.7)	3462 (51.9)	0.00
Race, n (%)				0.02
White/European	5451 (71.6)	691 (73.0)	4760 (71.4)	
Black/African American	1046 (13.7)	119 (12.6)	927 (13.9)	
Asian/Pacific Islander	758 (10.0)	96 (10.1)	662 (9.9)	
American Indian/Alaska Native	66 (0.9)	7 (0.7)	59 (0.9)	
Hispanic ethnicity, n (%)	1007 (13.2)	117 (12.4)	890 (13.3)	0.03
Current or former smoker, n (%)	4531 (59.5)	597 (63.0)	3934 (59.0)	0.10
Residential block-level socioeconomic status				
Median household income				0.02
≥$35 000	6966 (91.5)	862 (91.0)	6104 (91.6)	
<$35 000	636 (8.4)	83 (8.8)	553 (8.3)	
Highest level of educational attainment				0.02
High-school graduate or higher	6260 (82.2)	786 (83.0)	5474 (82.1)	
Less than high school	1342 (17.6)	159 (16.8)	1183 (17.7)	
Acute illness severity scores				
COPS2 score, median (IQR)	74.0 (49.0–106.0)	81.0 (56.0–117.0)	72.0 (48.0–105.0)	0.21
LAPS2 score, median (IQR)	63.0 (45.0–82.0)	70.0 (50.0–91.0)	62.0 (44.0–81.0)	0.28
Cardiovascular history, n (%)				
HF	5988 (78.6)	740 (78.1)	5248 (78.7)	0.02
Coronary heart disease	982 (12.9)	129 (13.6)	853 (12.8)	0.04
Ischemic stroke	414 (5.4)	57 (6.0)	357 (5.4)	0.08
Intracranial hemorrhage	211 (2.8)	30 (3.2)	181 (2.7)	0.10
Peripheral artery disease	35 (0.5)	4 (0.4)	31 (0.5)	0.06
Medical history, n (%)				
Diabetes mellitus	3493 (45.9)	454 (47.9)	3039 (45.6)	0.06
Hypertension	6926 (91.0)	869 (91.8)	6057 (90.9)	0.07
Chronic liver disease	375 (4.9)	49 (5.2)	326 (4.9)	0.04
Chronic lung disease	3380 (44.4)	440 (46.5)	2940 (44.1)	0.06
Hyperthyroidism	431 (5.7)	49 (5.2)	382 (5.7)	0.07
Hypothyroidism	1951 (25.6)	270 (28.5)	1681 (25.2)	0.10
Systemic cancer	1658 (21.8)	209 (22.1)	1449 (21.7)	0.01
Diagnosed dementia	918 (12.1)	133 (14.0)	785 (11.8)	0.12
Diagnosed depression	1963 (25.8)	240 (25.3)	1723 (25.8)	0.02
Baseline outpatient vital signs*				
Systolic blood pressure, mm Hg, mean (SD)	125.2 (19.9)	124.2 (20.4)	125.3 (19.8)	0.06
Diastolic blood pressure, mm Hg, mean (SD)	67.4 (12.3)	66.9 (12.6)	67.5 (12.3)	0.04
Heart rate, beats per minute, mean (SD)	76.4 (16.5)	78.0 (17.0)	76.2 (16.5)	0.11
Baseline medication use, n (%)				
Angiotensin-converting enzyme inhibitors/angiotensin II receptor blockers	4094 (53.8)	467 (49.3)	3627 (54.4)	0.12

(*Continued*)

Table 1. Continued

Characteristics	Overall N=7614	Death, ED Visit, or Any Hospitalization N=947	No ED Visit, Readmission, or Death N=6667	*d* Value
Aldosterone receptor agonist	505 (6.6)	57 (6.0)	448 (6.7)	0.07
β-Blocker	5014 (65.9)	603 (63.7)	4411 (66.2)	0.07
Calcium channel blocker	1624 (21.3)	190 (20.1)	1434 (21.5)	0.05
Digoxin	809 (10.6)	94 (9.9)	715 (10.7)	0.05
Diuretics (loop)	4328 (56.8)	541 (57.1)	3787 (56.8)	0.01
Diuretics (thiazide)	780 (10.2)	96 (10.1)	684 (10.3)	0.01
Nitrates	1375 (18.1)	179 (18.9)	1196 (17.9)	0.04
Hydralazine	943 (12.4)	117 (12.4)	826 (12.4)	0.00
Statin	4827 (63.4)	590 (62.3)	4237 (63.6)	0.03
Anticoagulant	2039 (26.8)	256 (27.0)	1783 (26.7)	0.01
Initial emergency visit vital signs*				
Systolic blood pressure, mm Hg, mean (SD)	136.1 (22.2)	133.9 (22.8)	136.4 (22.1)	0.11
Diastolic blood pressure, mm Hg, mean (SD)	70.2 (14.7)	70.4 (15.0)	70.2 (14.6)	0.01
Heart rate, beats per minute, mean (SD)	76.5 (14.4)	78.5 (15.1)	76.3 (14.2)	0.15
Oxygen saturation, %, mean (SD)	96.6 (3.3)	96.3 (4.5)	96.6 (3.1)	0.11
Respiratory rate, breaths per minute, mean (SD)	18.3 (2.9)	18.5 (3.1)	18.3 (2.9)	0.07
Initial emergency visit laboratories*				
Creatinine, mg/dL, mean (SD)	1.2 (0.6)	1.3 (0.7)	1.2 (0.6)	0.11
Hemoglobin, g/L, mean (SD)	12.1 (1.9)	11.8 (1.9)	12.1 (1.9)	0.19
Sodium, mg/dL, mean (SD)	139.1 (4.1)	138.4 (4.5)	139.2 (4.0)	0.18
Potassium, mg/dL, mean (SD)	4.3 (0.5)	4.3 (0.6)	4.3 (0.5)	0.07
Blood urea nitrogen, mg/dL, mean (SD)	27.9 (16.3)	30.6 (18.3)	27.5 (15.9)	0.19
Troponin I, ng/mL, mean (SD)	0.1 (0.3)	0.1 (0.2)	0.0 (0.3)	0.05
BNP, pg/mL, mean (SD)	663.7 (724.5)	765.8 (765.4)	649.8 (717.8)	0.16
ED HF evaluation and treatment processes				
Chest radiograph	5656 (74.3)	720 (76.0)	4936 (74.0)	0.06
Medications given in ED				
ACE inhibitor	67 (0.9)	10 (1.1)	57 (0.9)	0.13
Diuretics (loop)	2806 (36.9)	327 (34.5)	2479 (37.2)	0.07
Nitrates	489 (6.4)	49 (5.2)	440 (6.6)	0.16
ED-level characteristics and care coordination practices				
ED consult made to specialist during index ED visit	481 (6.3)	56 (5.9)	425 (6.4)	0.05
Outpatient referral to cardiology department	321 (4.2)	25 (2.6)	296 (4.4)	0.33
Outpatient orders for diagnostic tests made, n (%)				
Holter monitor	22 (0.3)	3 (0.3)	19 (0.2)	0.07
Echocardiography	146 (1.9)	13 (1.4)	133 (2.0)	0.23
Discharge destination				0.04
Home	7406 (97.3)	918 (96.9)	6488 (97.3)	
Skilled nursing facility	191 (2.5)	28 (3.0)	163 (2.4)	
ED length of stay, h, mean (SD)	6.6 (6.1)	6.5 (5.7)	6.6 (6.1)	0.01
Outpatient follow-up within 1 wk after index visit‡				
Outpatient noncardiology	3394 (44.6)	450 (47.5)	2944 (44.2)	0.08
Outpatient cardiology	747 (9.8)	109 (11.5)	638 (9.6)	0.13

(*Continued*)

Table 1. Continued

Characteristics	Overall N=7614	Death, ED Visit, or Any Hospitalization N=947	No ED Visit, Readmission, or Death N=6667	*d* Value
E-mail or phone follow-up	4097 (53.8)	543 (57.3)	3554 (53.3)	0.10
Part of HF care management team				0.02
≤1 y before index date	560 (7.4)	63 (6.7)	497 (7.5)	
Index date and during first 30 d of follow-up	148 (1.9)	22 (2.3)	126 (1.9)	
ED physician characteristics				
Age, mean (SD)	43.4 (8.9)	43.5 (8.9)	43.4 (8.9)	0.01
Sex, women (%)	2416 (31.7)	294 (31.0)	2122 (31.8)	0.02
Years since training, mean (SD)	14.8 (8.9)	14.8 (8.9)	14.8 (8.9)	0.00
Hospital characteristics, n (%)				
Facility has OU	665 (8.7)	61 (6.4)	604 (9.1)	0.22

ACE indicates angiotensin-converting enzyme; BNP, brain natriuretic peptide; COPS2, comorbidity point score; ED, emergency department; HF, heart failure; IQR, interquartile range; LAPS2, laboratory-based acute physiology score; and OU, observation unit.

*Missing values: for baseline outpatient vital signs, 2.3% were missing; for ED vital sings, <1% were missing, and for laboratory values, the percent missing ranged from <5% for white blood cell count, hemoglobin, and serum chemistries to 44% for serum troponin, and 43% for BNP.

‡Total patients who received outpatient follow-up and e-mail/telephone follow-up, 2117 (27.8%); total patients with outpatient follow-up only, 1598 (21.0%); total patients with e-mail/telephone follow-up only, 1980 (26.0%); total patients with at least 1 outpatient, telephone, or e-mail follow-up, 5695 (74.8%).

or nonsmoker) was identified from health plan electronic medical records. On chart review, we found ejection fraction was reliably retrievable from the electronic medical record in <50% of cases, so this was not included as a predictor variable.

We also collected filled prescriptions within 30 days before the index date for ACE (angiotensin-converting enzyme) inhibitors, angiotensin II receptor blockers, aldosterone receptor agonists, anticoagulants, nonsteroidal anti-inflammatory drugs, β-blockers, calcium channel blockers, digoxin, diuretics (loop and thiazides), nitrates, hydralazine, statins, and other lipid-lowering therapies from electronic medical records.

Relevant laboratory results were obtained from health plan outpatient and inpatient laboratory databases, and ED-level characteristics from the index ED visit were ascertained from health plan administrative databases and electronic medical records. We collected the following ED laboratory results and vital signs (initial, or triage, vital signs taken within minutes of ED registration): creatinine, hemoglobin, serum sodium, natriuretic peptides, serum potassium, blood urea nitrogen, troponin I, white blood cell count, systolic blood pressure, heart rate, and oxygen saturation. For each patient, we calculated validated acute severity of illness scores based on demographics, laboratory data, vital signs, neurological score (laboratory-based acute physiology score), and comorbidity data (comorbidity point score).[26]

We collected the following care coordination and facility-level characteristics: specialty consultation during the ED visit (hospitalist or cardiologist), outpatient referral to the cardiology department, outpatient orders for future diagnostic tests, ED length of stay, outpatient follow-up within 1 week (e-mail, telephone, primary care, or cardiology clinic visit), patient participation in a HF care management team, HF evaluation and treatment processes during the ED visit, discharge destination, and presence of an observation unit (OU) at the facility where the visit occurred. Of note, patients admitted to an OU were included in the analysis because the OUs are ED-based in our system, and OU admission is not considered a hospital admission. Physician-level characteristics included age, sex, and years since completing training.

Analysis Approach

All analyses were conducted using SAS statistical software, version 9.3 (Cary, NC). We calculated the risk of 7-day outcomes, overall and for each individual outcome, with associated 95% confidence limits. We next compared baseline characteristics by outcome status using ANOVA or the relevant nonparametric test for continuous variables and χ^2 tests for categorical variables. Because of our large sample size, we calculated *d* values from the standardized mean difference to compare baseline characteristics between the groups of interest.[27–29] We considered a value of $D \geq 0.10$ to be statistically significant.[29]

We performed multivariable logistic regression to evaluate the independent association of each candidate factor and the composite outcome of death, hospitalization, or ED visit within 7 days. We also conducted multivariable logistic regression models for each component of the composite outcome for the same candidate variables. For all models, we used generalized estimating equations to account for potential cluster effects based on treating ED.

RESULTS

Between January 2013 and September 2014, we identified 7614 eligible adults who were treated for acute HF in the ED (Figure 1) and discharged home. The cohort was elderly (mean age, 77), 28% were nonwhite, and there were high rates (current or former) of smoking (59%), high-risk comorbid illnesses, and cardiovascular medication use at baseline (Table 1).

There were high rates of timely outpatient follow-up in our study population: ≈75% of patients had an outpatient appointment, telephone appointment, or e-mail follow-up within 7 days. Approximately 18% of follow-up visits within the first 7 days were to a cardiologist, the remaining 82% were to a primary care physician. In addition, 54% had an e-mail or telephone follow-up within 7 days.

During the first 7 days after the index ED visit, 12.4% (n=947) of patients met the primary outcome: 7.1% of patients had an ED revisit, 4.7% were hospitalized, and 1.2% died (Figure 2). Patients who met the primary outcome in general had similar demographic characteristics compared with those who did not, although they were more likely to be older and have higher rates of smoking, prior hemorrhagic stroke, hypothyroidism, and dementia (Table 1). Baseline use of ACE inhibitors/angiotensin II receptor blockers was higher among those who did not experience an event. All other baseline medication use was similar between the 2 groups. Patients who met the primary outcome had worse mean initial ED vital signs (heart rate, blood pressure, and oxygen saturation) and laboratory values than those who did not experience outcomes of interest. Patients treated in facilities with OUs and those who had timely outpatient follow-up (in clinic or via e-mail) were also less likely to meet the primary outcome.

Two secondary time periods were also analyzed: outcomes at 3 and 30 days after the index ED visit. Within 3 days, 5.3% of patients experienced an adverse outcome; at 30 days, the adverse outcome rate was 37.2%. We further delineated the temporal pattern of the primary outcome during the first 30 days after the index ED visit and observed a peak at 2 days after the index ED visit followed by a gradual decrease over time (Figure 3). This temporal pattern was seen for outpatient follow-up, repeat ED visits, and hospitalizations, whereas there was no clear pattern for death from any cause (Figure 4).

In multivariable analyses, current or former smoking and higher laboratory-based acute physiology score (≥100) and hemoglobin <12 g/L were independently associated with higher odds for the composite primary

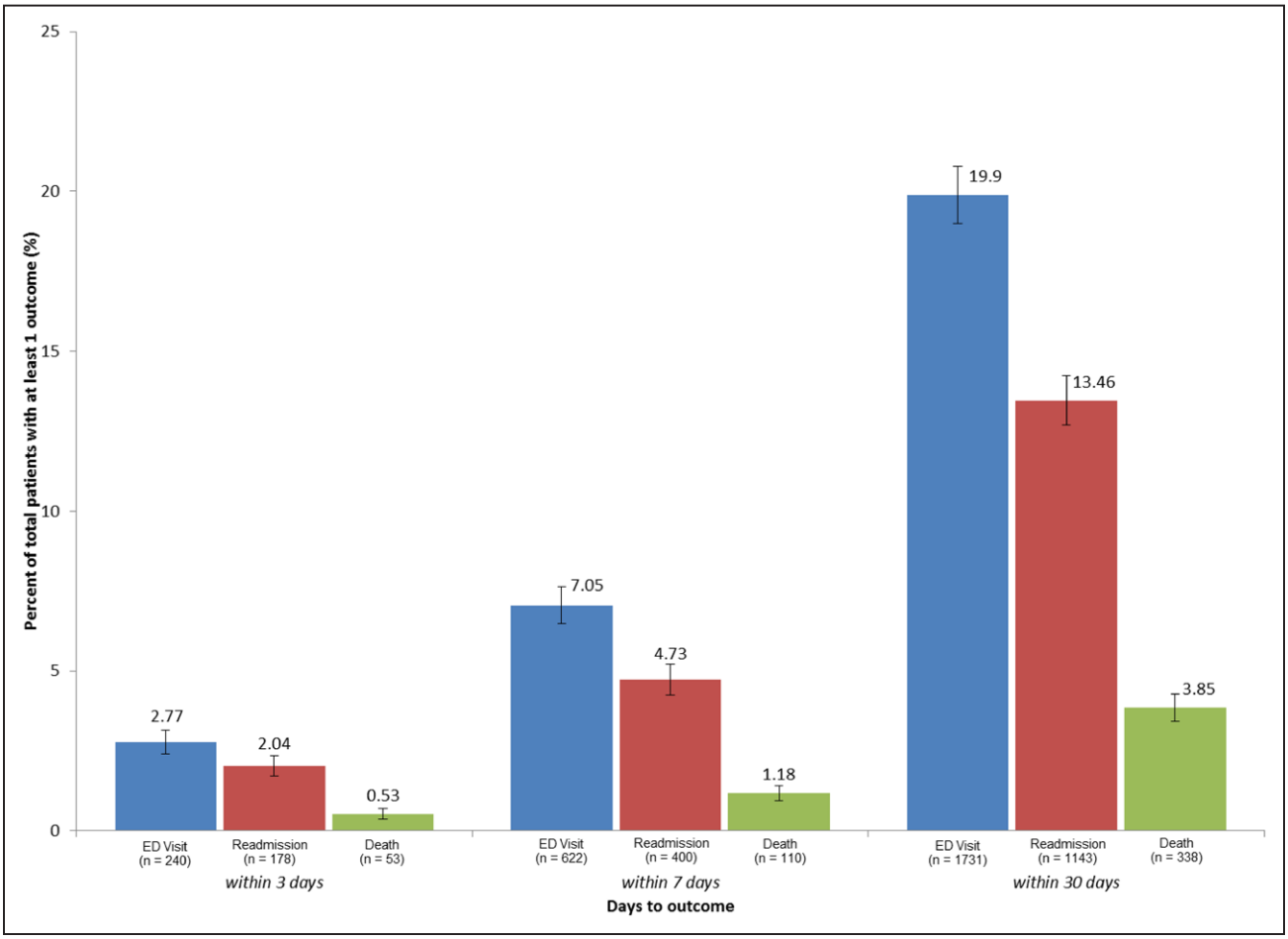

Figure 2. Frequency of events within 3, 7, and 30 d from index date among 7614 adults treated for heart failure in the emergency department (ED), and then discharged, between January 1, 2013, and September 30, 2014.
Table 1 contains exclusive counts—only 1 event per patient, whereas Figure 2 shows overlapping outcomes and depicts how many times each of the outcomes occurred separately within 3, 7, or 30 d.

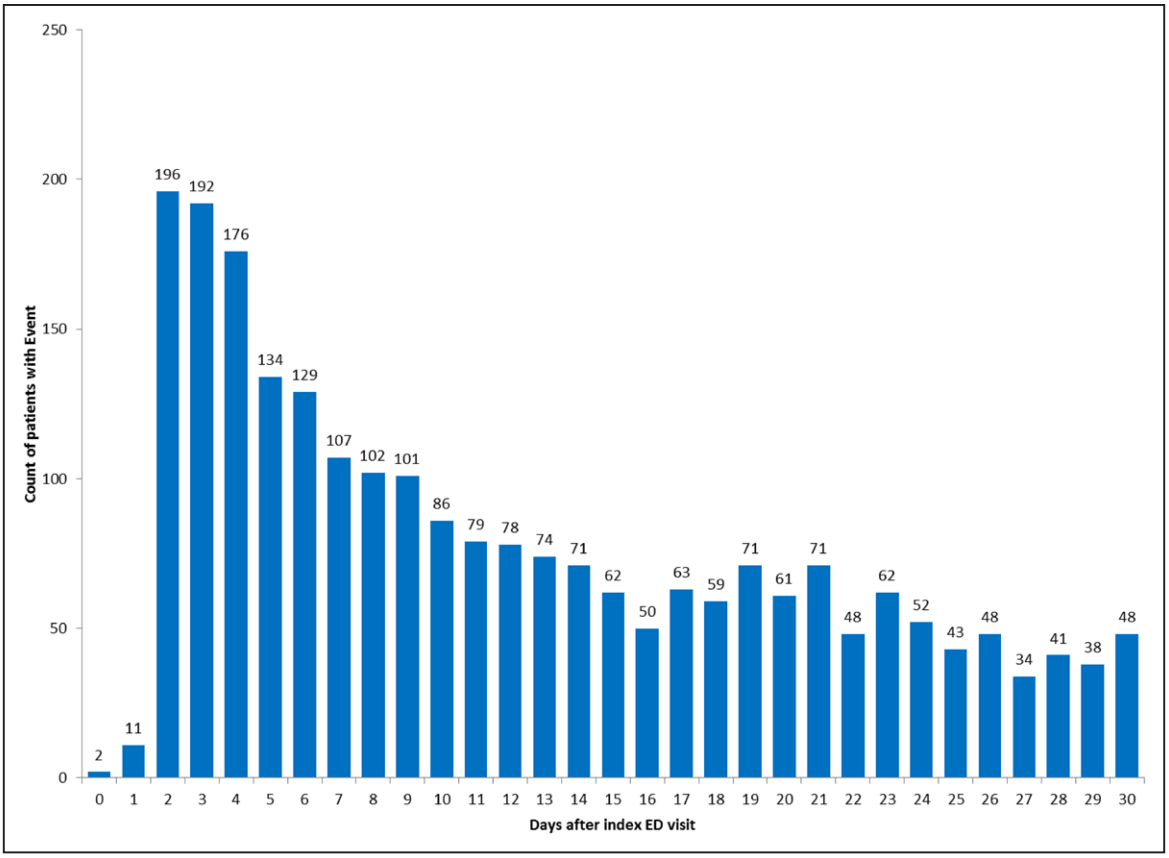

Figure 3. Distribution of time to first outcome of death, hospitalization, or emergency department (ED) visit within 30 d after index ED visit (2389 events).

outcome (Table 2). In contrast, a history of HF was associated with lower adjusted odds of the composite outcome. We also evaluated characteristics associated with each component of the composite outcome. For death within 7 days, these included age ≥80 years, hypothyroidism, higher laboratory-based acute physiology score, baseline systolic blood pressure <100 mm Hg, low and higher initial heart rate, low initial oxygen saturation, and serum potassium >5.5 mg/dL in the ED. Multivariable factors associated with an ED revisit within 7 days included a median household income <$35 000 and anemia; for hospitalization within 7 days, high acute severity of illness scores were associated with higher adjusted odds, whereas female sex and serum sodium 140 to 149 mg/dL were associated with lower adjusted odds (Table 2).

When considering facility-level characteristics, patients who received an outpatient follow-up or telephone or e-mail follow-up visit within 1 week after index ED visit experienced better outcomes even after adjustment for patient characteristics. In addition, patients treated in facilities with OUs were significantly less likely to experience the composite outcome and specifically having an ED visit within 7 days. There were no provider-level characteristics significantly associated with an adverse outcome (Table 2).

DISCUSSION

The goal of our study was to examine the natural history of a diverse population of patients discharged from the ED after evaluation and treatment for acute HF in a large integrated healthcare delivery system. Specifically, we examined contemporary rates of, and time to, various events of clinical and policy-oriented importance after ED discharge, including subsequent repeat ED visits, hospitalization, and death, as well as outpatient follow-up. Although we focused on patients with HF who were considered by treating providers to be clinically stable for discharge from the ED, the study population still experienced a high comorbidity burden, which likely contributed to high rates of adverse events early after ED discharge. Overall, ≈1 in 8 patients in our study met the primary outcome of repeat ED visit, hospitalization, or death within 7 days after ED discharge, and >1 in 3 experienced an adverse outcome within the first 30 days. Furthermore, we also identified several multivariable patient- and facility-level characteristics associated with adverse events after ED discharge.

This study provides a descriptive analysis of the understudied population of patients presenting with acute HF who are deemed stable for discharge after evaluation and treatment directly from the ED. It also

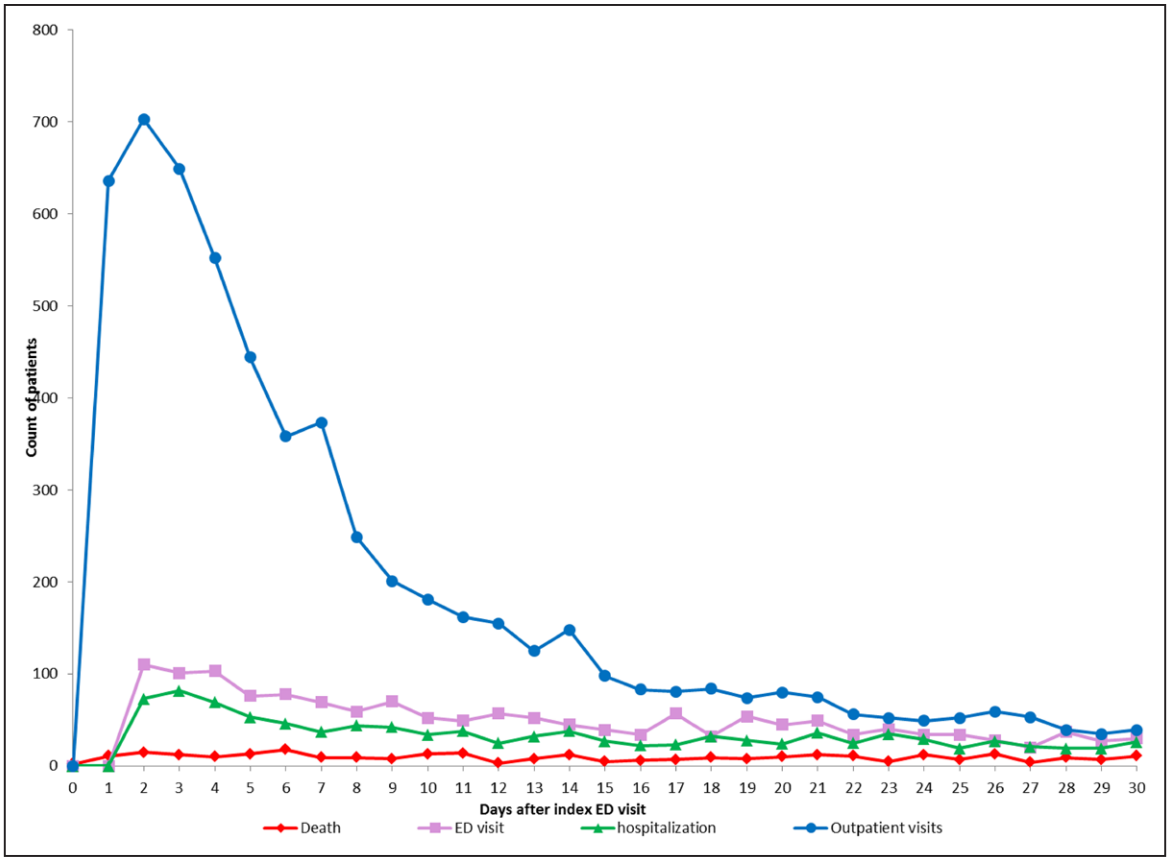

Figure 4. Distribution of time to death, first emergency department (ED) visit, first hospitalization, and first outpatient visit within 30 d after index ED visit.

provides the largest analysis of a multicenter, US-based population managed for acute HF in the ED and outlines short-term outcomes and characteristics associated with adverse events in this population. The study adds significantly to existing literature describing this population by adjusting for physiological and laboratory data, as well as several facility-level variables, which have been shown to be predictors of adverse events among admitted patients with acute HF.[11]

In multivariable analyses, higher illness severity scores and smoking history were associated with an increased risk of the primary outcome, whereas a history of HF, outpatient follow-up, and treatment in a facility with an OU were associated with a significantly lower risk. The exact reasons for why a history of HF was associated with lower adjusted odds of the primary outcome are challenging to tease out given the currently available data. It is possible that patients with previously known HF are more likely to be activated for earlier outpatient follow-up and have more providers involved in coordinating more timely post-ED visit care and intervention.

Existing studies suggest that most patients admitted with HF do not receive invasive procedures or require inotropic or mechanical circulatory support, and the vast majority receive intravenous or oral diuretics until symptoms improve.[12,30] This suggests that some patients may not need immediate hospital admission but may benefit from prolonged symptom management and further risk stratification, which may be best accomplished through OUs.[31–33] Unfortunately, coding for admission into an OU at the patient level was inconsistent within our healthcare system during this study period. Despite this limitation, the significantly reduced odds of an adverse outcome among patients treated in facilities with OUs suggest they may be potentially useful in the low-risk HF population.

Two recent HF risk prediction scores have been proposed to predict serious adverse events after an ED visit for HF.[16,34] Stiell et al[16] found that certain comorbidities, ED vital signs, electrocardiographic findings, laboratory tests, and performance on a walk test predicted a serious event (including intubation or noninvasive ventilation, myocardial infarction, major procedure, death, or hospital admission) within 14 days; the baseline admission rate in this cohort was 38%. Collins et al[30] found that age, body mass index, laboratory tests, ED vital signs, and EKG findings predicted a serious event (including acute coronary syndrome, major procedure, intubation, resuscitation, or death) at 30 days. Our study builds on these and other previous studies by focusing specifically on discharged ED patients and by providing information on factors associated with early adverse events within 7 days after discharge.

Table 2. Multivariable Factors Associated With Adverse Outcomes Among 7614 Adults Diagnosed With HF in the ED Visit Between January 1, 2013, and September 30, 2014

	Outcomes within 7 days of Index Emergency Department Values			
	Any Outcome Within 7 d	Death Within 7 d	ED Visit Within 7 d	Hospitalization Within 7 d
	Odds Ratio (95% CI)*	Odds Ratio (95% CI)†	Odds Ratio (95% CI)‡	Odds Ratio (95% CI)§
Women	0.93 (0.80–1.09)	0.97 (0.61–1.54)	1.05 (0.86–1.27)	0.79 (0.64–0.98)
Current or former smoker	1.15 (1.00–1.33)	1.62 (0.97–2.70)	1.15 (0.96–1.36)	1.02 (0.83–1.24)
Residential block-level socioeconomic status				
Median household income				
≥$35 000	Reference	Not applicable	Reference	Reference
<$35 000	1.02 (0.79–1.30)	Not applicable	1.34 (1.05–1.70)	0.69 (0.43–1.10)
Missing	1.00 (1.00–1.00)	Not applicable	1.00 (1.00–1.00)	1.00 (1.00–1.00)
Acute illness severity score				
COPS2 score				
0–39	0.81 (0.65–1.00)	0.66 (0.28–1.53)	0.74 (0.54–1.00)	0.94 (0.64–1.37)
40–59	0.80 (0.64–0.99)	0.36 (0.16–0.83)	0.79 (0.60–1.04)	0.87 (0.67–1.13)
60–79	Reference	Reference	Reference	Reference
80–99	0.98 (0.77–1.24)	0.54 (0.22–1.31)	0.84 (0.64–1.10)	1.31 (0.84–2.04)
100–119	0.94 (0.72–1.23)	1.17 (0.51–2.70)	0.84 (0.60–1.17)	1.18 (0.75–1.84)
≥120	1.15 (0.95–1.39)	1.46 (0.67–3.20)	0.93 (0.71–1.23)	1.54 (1.07–2.20)
LAPS2 score				
0–49	Reference	Reference	Reference	Reference
50–74	1.07 (0.84–1.35)	2.39 (1.04–5.48)	1.00 (0.76–1.31)	1.39 (0.91–2.13)
75–99	1.23 (0.94–1.60)	3.27 (1.31–8.18)	0.86 (0.61–1.22)	2.32 (1.64–3.29)
100–124	1.54 (1.10–2.15)	8.08 (3.06–21.33)	1.04 (0.70–1.55)	2.65 (1.62–4.33)
≥125	1.96 (1.45–2.64)	32.31 (14.09–74.08)	0.80 (0.49–1.32)	1.28 (0.63–2.60)
Cardiovascular history				
HF	0.80 (0.71–0.91)	0.67 (0.43–1.03)	0.87 (0.70–1.08)	0.82 (0.64–1.05)
Coronary heart disease	0.92 (0.69–1.23)	0.55 (0.27–1.15)	0.88 (0.71–1.08)	1.08 (0.73–1.6)
Hospitalized ischemic stroke	0.98 (0.76–1.27)	0.63 (0.20–1.97)	1.12 (0.72–1.73)	0.8 (0.48–1.35)
Intracranial hemorrhage	1.07 (0.64–1.81)	0.68 (0.18–2.58)	1.52 (0.88–2.62)	0.66 (0.32–1.33)
Peripheral artery disease	0.74 (0.32–1.73)	2.04 (0.22–18.89	0.72 (0.21–2.49)	0.45 (0.05–4.48)
Medical history				
Diabetes mellitus	1.06 (0.92–1.24)	1.41 (0.95–2.08)	1.07 (0.91–1.26)	0.91 (0.72–1.16)
Hypertension	1.05 (0.88–1.25)	0.62 (0.37–1.02)	1.12 (0.88–1.44)	1.11 (0.73–1.70)
Chronic liver disease	1.02 (0.76–1.37)	1.06 (0.40–2.82)	0.88 (0.55–1.39)	1.33 (0.85–2.08)
Chronic lung disease	1.02 (0.91–1.15)	0.74 (0.52–1.06)	1.07 (0.92–1.23)	1.08 (0.89–1.32)
Hyperthyroidism	0.80 (0.59–1.10)	1.37 (0.51–3.67)	0.82 (0.55–1.23)	0.72 (0.43–1.21)
Hypothyroidism	1.15 (0.97–1.37)	1.51 (1.03–2.22)	1.06 (0.81–1.37)	1.17 (0.92–1.50)
Systemic cancer	0.96 (0.79–1.16)	1.49 (0.77–2.86)	0.91 (0.76–1.11)	0.93 (0.69–1.24)
Diagnosed dementia	1.05 (0.88–1.24)	1.50 (0.95–2.38)	1.00 (0.73–1.36)	1.01 (0.71–1.44)
Diagnosed depression	0.96 (0.85–1.10)	1.16 (0.78–1.72)	0.97 (0.76–1.23)	0.93 (0.70–1.24)
Medication was prescribed/used before index event	0.93 (0.71–1.21)	2.1 (0.55–8.07)	0.80 (0.63–1.02)	1.05 (0.70–1.57)
Care coordination and facility characteristics				
Outpatient referral (eConsult) made by emergency physician to cardiology or card laboratory services	0.91 (0.63–1.32)	0.74 (0.12–4.52)	1.07 (0.60–1.91)	0.76 (0.36–1.63)

(*Continued*)

Table 2. Continued

	Outcomes within 7 days of Index Emergency Department Values			
	Any Outcome Within 7 d	Death Within 7 d	ED Visit Within 7 d	Hospitalization Within 7 d
	Odds Ratio (95% CI)*	Odds Ratio (95% CI)†	Odds Ratio (95% CI)‡	Odds Ratio (95% CI)§
Outpatient orders for echo made by EP	1.17 (0.55–2.50)	Not applicable	1.43 (0.57–3.58)	0.96 (0.39–2.32)
ED length of stay, h	1.00 (0.98–1.02)	0.99 (0.95–1.02)	1.00 (0.98–1.03)	0.98 (0.96–1.00)
Outpatient follow-up within 1 wk after index visit				
Outpatient	0.36 (0.30–0.42)	0.17 (0.09–0.32)	0.41 (0.34–0.50)	0.38 (0.30–0.47)
E-mail or phone follow-up	0.61 (0.51–0.72)	0.48 (0.28–0.82)	0.63 (0.51–0.78)	0.67 (0.54–0.83)
HF care/case management team				
≤1 y before index date	1.02 (0.82–1.26)	0.54 (0.17–1.71)¶	1.15 (0.83–1.59)	1.00 (0.72–1.40)
Index date and during follow-up	3.74 (1.48–9.43)	Not applicable	3.04 (0.80–11.55)	5.7 (1.23–26.47)
Not participating as of censor date	Reference	Not applicable	Reference	
Discharge destination				
Home	Reference	Reference	Reference	Reference
Home health	0.30 (0.04–2.34)	Not applicable	0.86 (0.11–6.88)	Not applicable
Skilled nursing facility	0.73 (0.53–1.01)	Not applicable	0.73 (0.43–1.24)	Not applicable
Facility has OU	0.62 (0.42–0.92)	0.87 (0.38–1.98)	0.51 (0.33–0.77)	0.84 (0.46–1.52)

CI indicates confidence interval; COPS2, comorbidity point score; ED, emergency department; HF, heart failure; LAPS2, laboratory-based acute physiology score; and OU, observation unit.

*Model also adjusted for age, race, known Hispanic ethnicity, current or former smoking, level of education, hospitalized ischemic stroke, intracranial hemorrhage, peripheral artery disease, diabetes mellitus, chronic liver disease, chronic lung disease, hyperthyroidism, systemic cancer, diagnosed dementia, diagnosed depression, baseline heart rate, baseline systolic blood pressure, heart rate, oxygen saturation, and respiratory rate measured during index ED visit, serum creatinine, hemoglobin, serum sodium, and serum potassium measured during index ED visit, medications prescribed before index date, eConsult referral made, outpatient echocardiography test ordered, ED length of stay, medications given during index ED visit, and discharge destination. Covariates not included in model: systolic blood pressure measured during index ED visit.

†Model also adjusted for age, race, known Hispanic ethnicity, current or former smoking, level of education, hospitalized ischemic stroke, intracranial hemorrhage, peripheral artery disease, diabetes mellitus, chronic liver disease, chronic lung disease, hyperthyroidism, systemic cancer, diagnosed dementia, diagnosed depression, baseline heart rate, baseline systolic blood pressure, heart rate, and oxygen saturation measured during index ED visit, medications prescribed before index date, Serum creatinine, hemoglobin, serum sodium, and serum potassium measured during index ED visit, eConsult referral made, ED length of stay, and medications given during index ED visit. Covariates excluded from modeling death within 7 d: systolic blood pressure and respiratory rate measured during index ED visit, echocardiography tests, education level, median household income, and discharge destination.

‡Model also adjusted for age, race, known Hispanic ethnicity, current or former smoking, level of education, hospitalized ischemic stroke, intracranial hemorrhage, peripheral artery disease, diabetes mellitus, chronic liver disease, chronic lung disease, hyperthyroidism, systemic cancer, diagnosed dementia, diagnosed depression, baseline heart rate, baseline systolic blood pressure, heart rate, oxygen saturation, and respiratory rate measured during index ED visit, Serum creatinine, hemoglobin, serum sodium, and serum potassium measured during index ED visit, medications prescribed before index date, eConsult referral made, outpatient echocardiography test ordered, ED length of stay, medications given during index ED visit, and discharge destination. Covariates excluded: systolic blood pressure measured during index ED visit.

§Model also adjusted for race, known Hispanic ethnicity, current or former smoking, level of education, hospitalized ischemic stroke, intracranial hemorrhage, peripheral artery disease, diabetes mellitus, chronic liver disease, chronic lung disease, hyperthyroidism, systemic cancer, diagnosed dementia, diagnosed depression, baseline heart rate, baseline systolic blood pressure, medications prescribed before index date, Serum creatinine, hemoglobin, serum sodium, and serum potassium measured during index ED visit, eConsult referral made, outpatient echocardiography test ordered, ED length of stay, and medications given during index ED visit. Covariates excluded from modeling hospitalization within 7 d: systolic blood pressure, heart rate, respiratory rate, and oxygen saturation measured during index ED visit.

¶HF care/case management team for death model only indicates for before index date.

Overall, compared with the general population, our study population had high utilization of acute care services (ED, inpatient, and outpatient care) after discharge from the ED, although hospital admission rates after ED discharge were lower than in previous studies. For example, in our sample, 4.6% and 13.1% of our patients were admitted within 7 and 30 days, respectively, after ED discharge. Prior studies of patients with less comorbidity burden than in our sample had hospitalization rates of 11% and 19% within 7 and 30 days, respectively.[15,35] Repeat ED visits in our study at 7 and 30 days were 7% and 20%, which were lower than in other studies (9%[14] and 40%, respectively).[15]

Although the exact reasons for our observed lower subsequent utilization rates are not known, it is likely explained, at least in part, to our patients receiving care within an integrated healthcare system where patients can be monitored and followed across time and care settings. In our study, 75% of patients had outpatient follow-up (in-person, telephone, or e-mail) within 7 days, and close outpatient follow-up was significantly associated with decreased odds (odds ratio, 0.36) of the primary outcome. This ability to readily continue care in the outpatient setting likely leads to lower rates of subsequent ED visits and hospital admissions[36] and may also be associated with lower mortality.[37] Given

this is a modifiable variable, it represents a possible target for future implementation studies to improve outcomes among this population.

Although subsequent ED and inpatient utilization rates were lower than reported previously, short-term mortality rates in our population were similar to those observed in other studies.[8,14,15,30] We found that 1.3% and 3.9% of patients died within 7 and 30 days, respectively, after discharge from the index ED visit. Although these patients were selected as overall lower risk and appropriate for ED discharge, this population had a high burden of comorbidity, including diabetes mellitus, hypertension, lung disease, thyroid disease, and cancer, and 60% were current or former smokers. This relatively high short-term mortality rate highlights the poor prognosis for patients with HF. It also implies the need for further study on appropriate identification of truly low-risk patients, improvement in disease management, and development of patient-specific long-term care plans in this population.

Like prior studies,[38–40] we found that most return visits occurred within days of the initial ED discharge. We observed that the time to a repeat ED visit or hospital admission peaked within the first 3 days after ED discharge and then gradually decreased over the subsequent 27 days. We focused on the first 7 days for our primary outcome measure, and 35% of all events occurred within this time frame.

There are several strengths to this study, specifically the use of a large, contemporary, diverse, multicenter population with comprehensive pre- and post-ED visit data. To our knowledge, this is the largest US-based study of patients with HF treated in the ED and is the only study to include outpatient follow-up after ED discharge. Also, our system's comprehensive, shared electronic medical records allowed for linkage of demographic, healthcare utilization, pharmacy, laboratory, and mortality data, providing a significant advantage over use of administrative databases. Last, we focused on an understudied population, namely the segment of patients presenting with acute HF who ED providers felt were safe for direct ED discharge. An understanding of short-term outcomes in this population provides important epidemiological data that may be used to predict adverse outcomes to help optimize the potential for outpatient management. The findings also have important policy implications with regards to understanding demand for acute care services in the immediate window after ED discharge.

Our study also had several limitations. Use of *ICD-9* diagnosis codes for HF in the ED setting likely led to modest misclassification; we had an estimated positive predictive value of 85% using our algorithm. We note, however, that prior HF studies have also relied on *ICD-9* coding[15] and have found similar positive predictive values.[41–43] Our study was conducted within an insured population with readily available access to early outpatient follow-up, suggesting that our results may not fully translate to the uninsured or to all other types of practice settings. Although our subsequent ED and inpatient utilization were lower than in other studies, the similar rates of short-term mortality,[13,14,35,36] and overall higher rates of reported comorbid illness compared with other studies,[13,14] support the generalizability of our findings. Lastly, there may be other patient, hospital, and provider variables (eg, patient social support networks, use of care management services, and HF volume by site) that may affect short-term outcomes that we were unable to examine.

CONCLUSIONS

This study provides important data on short-term outcomes of patients with HF discharged from the ED, with ≈1 in 8 patients meeting the primary outcome within 7 days of ED discharge. We found that selected patient- and facility-level characteristics were independently associated with early adverse events after ED discharge. Future studies are needed to delineate potential targets to improve outcomes and optimize resource use in the subset of patients with HF at highest risk for poor outcomes after being treated in the ED.

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DISCLOSURES

None.

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FOOTNOTES

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