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In-Hospital and Postdischarge Mortality Among Patients With Acute Decompensated Heart Failure Hospitalizations Ending on the Weekend Versus Weekday: The ARIC Study Community Surveillance

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Background—Hospital staffing is usually reduced on weekends, potentially impacting inpatient care and postdischarge coordination of care for patients with acute decompensated heart failure (ADHF). However, investigations of in-hospital mortality on the weekend versus weekday, and post-hospital outcomes of weekend versus weekday discharge are scarce.

Methods and Results—Hospitalizations for ADHF were sampled by stratified design from 4 US areas by the Community Surveillance component of the ARIC (Atherosclerosis Risk in Communities) study. ADHF was classified by a standardized computer algorithm and physician review of the medical records. Discharges or deaths on Saturday, Sunday, or national holidays were considered to occur on the "weekend." In-hospital mortality was compared between hospitalizations ending on a weekend versus weekday. Post-hospital (28-day) mortality was compared among patients discharged alive on a weekend versus weekday. From 2005 to 2014, 39 699 weighted ADHF hospitalizations were identified (19% terminating on a weekend). Demographics, comorbidities, length of stay, and guideline-directed therapies were similar for patients with hospitalizations ending on a weekend versus weekday. In-hospital death doubled on the weekend compared with weekday (12% versus 6%) and was not attenuated by adjustment for potential confounders (odds ratio, 2.37; 95% CI, 1.93–2.91). There was no association between weekend discharge and 28-day mortality among patients discharged alive.

Conclusions—The risk of in-hospital death among patients admitted with ADHF appears to be doubled on the weekends when hospital staffing is usually reduced. However, among patients discharged alive, hospital discharge on a weekend is not adversely associated with mortality. **(*J Am Heart Assoc.* 2019;8:e011631. DOI: 10.1161/JAHA.118.011631.)**

Key Words: acute heart failure • discharge • epidemiology • mortality

Heart failure (HF) is the third most common diagnosis for patient hospitalization, excluding maternal/neonatal stays.[1] The "weekend effect," worse patient outcomes following weekend admission, has been well-described for many admission diagnoses.[2–5] This has been attributed to a variety of causes, including decreased availability of supervising physicians and subspecialty care on weekends, reduced nurse staffing, higher illness severity among patients admitted on weekends, and delays to diagnosis and therapeutic procedures.[2,6–11] Outcomes of weekend versus weekday admission have also been described among patients admitted with acute decompensated HF (ADHF) in several large registries.[12–15]

In contrast, there are no analyses of in-hospital death on the weekend versus weekday for patients admitted for ADHF, and the existing data on post-hospital outcomes by weekend or weekday *discharge* are both minimal and conflicting.[13,16] The Centers for Medicare and Medicaid Services prioritize in-hospital mortality and 30-day mortality as outcome metrics in the Hospital Quality Initiative.[17] Examining inpatient mortality on the weekend versus weekday and post-hospital outcomes following discharge on the weekend versus weekday in a large, geographically diverse sample of patients admitted with ADHF may suggest actionable areas for intervention. To meet this objective, we analyzed ADHF hospitalizations captured by the Community Surveillance component of the ARIC (Atherosclerosis Risk in Communities) study. We expected that patients would have worse in-hospital outcomes on the weekend because of fewer available resources including diagnostic and therapeutic procedures and subspecialty care.

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Accompanying Tables S1 through S3 are available at https://www.ahajournals.org/doi/suppl/10.1161/JAHA.118.011631

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Clinical Perspective

What Is New?

- Patients admitted with acute decompensated heart failure, have twice the in-hospital mortality on weekend days compared with weekdays, but 28-day post-hospital mortality is similar, regardless of weekend versus weekday discharge.
- The heightened risk of in-hospital death on the weekend compared with weekdays is consistent for patients with heart failure who have reduced versus preserved ejection fraction or weekend versus weekday admission.

What Are the Clinical Implications?

- It is crucial for health systems to continue developing care delivery models that allow for a consistent inpatient quality of care and availability of resources irrespective of day of the week.

Further, we anticipated that patients discharged alive on the weekends would have worse post-hospital outcomes because of incomplete discharge instructions and scheduling of follow-up care. Finally, we explored the possibility that associations between weekend discharge and mortality may be modified by HF type or by synergistic interaction with weekend admission.

Methods

Study Design and Population

The ARIC study's data and materials are publicly available.[18,19] Details of the Community Surveillance component of the ARIC study have been previously described.[20] In short, admissions for ADHF from January 1, 2005, to December 31, 2014, were sampled by stratified design from 4 US communities: Washington County, Maryland; Forsyth County, North Carolina; Jackson, Mississippi; and selected suburbs of Minneapolis, Minnesota. All surveillance protocols were approved by local institutional review boards. Informed consent was not required, because all data were anonymized by redacting personal identifiers. Events from acute care hospitals for patients 55 years or older with a home address within an ARIC community were identified through discharge diagnoses and their associated *International Classification of Diseases, Ninth Revision, Clinical Modification* (*ICD-9-CM*) codes, which included the following: rheumatic heart disease (398.91), hypertensive heart disease with congestive HF (402.01, 402.11, 402.91), hypertensive heart disease and renal failure with congestive HF (404.01, 404.03, 404.11, 404.13, 409.91, 404.93), acute cor pulmonale (415), chronic pulmonary heart disease (416.9), other primary cardiomyopathies (425.4), congestive HF (428.x), acute edema of lung (518.4), and dyspnea and respiratory abnormalities (786.0x). Sampling fractions were assigned based on *ICD-9-CM* codes (428.x code, all other codes), ARIC center, sex, and race (white or black).

ADHF Classification and Final Study Population

Eligible hospitalizations were abstracted by trained abstractors if there was any evidence of ADHF, new onset of HF symptoms, or mention by a physician that HF was the reason for hospitalization. Abstracted cases were independently classified by a computer algorithm and physicians of the ARIC Mortality and Morbidity Classification Committee into 1 of 5 prespecified definitions: definite ADHF, probable ADHF, chronic stable HF, HF unlikely, or unclassifiable HF.[21] For the purposes of this analysis, hospitalizations were limited to patients classified with definite and probable ADHF. Transfers to or from another acute care hospital were excluded, as these would result in misclassification of weekend discharge status and confound length-of-stay assessments.

Weekend Classification

Discharge due to release from the hospital or death on Saturday, Sunday, or federal holidays was considered to occur on the "weekend." The US Government Office of Personnel Management classifies New Year's Day, Martin Luther King Day, President's Day, Memorial Day, Independence Day, Labor Day, Columbus Day, Veterans Day, Thanksgiving Day, and Christmas Day as federal holidays.

Demographics, Medical History, and Hospital Procedures

Demographic and clinical data were abstracted from the medical record. Demographic data included age, sex, race, health insurance status, hospital, and year of admission. Clinical characteristics included smoking history, comorbidities (chronic obstructive pulmonary disease, coronary disease, diabetes mellitus, receipt of dialysis, chronic kidney disease, stroke, previous HF admission, and previous hospitalization for ADHF), and vital signs at admission. Laboratory values during the span of the hospitalization (eg, hemoglobin, sodium, serum urea nitrogen, and creatinine) were abstracted by recording the "worst" and "last" values in the hospital record. Glomerular filtration rate was estimated using the Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) formula[22] and the "last" reported creatinine value. We defined chronic kidney disease by an estimated glomerular filtration rate <60 mL/min per 1.73 m^2, or receipt of hemodialysis.[22] Medications taken before admission or during hospitalization (eg, angiotensin-converting enzyme inhibitors, angiotensin II receptor blockers, β-blockers, digitalis, aldosterone blockers, statins, hydralazine, and nitrates), and therapies during hospitalization, such as intravenous medications (diuretics and inotropes) and diagnostic procedures (eg, right heart catheterization and coronary angiography) were also abstracted. Ejection fraction (EF) was recorded from inpatient diagnostic echocardiograms, either during the inpatient stay or within 90 days of hospitalization. We considered an EF <50% to be evidence of HF with reduced EF and EF ≥50% to be HF with preserved EF. EF data were available for 25 383 (64%) patients.

Mortality

In-hospital mortality was abstracted from the medical record. Deaths within 28 days of hospitalization were ascertained by the ARIC study by linking patient records with the National Death Index.

Statistical Analysis

All analyses were performed using SAS 9.4 Survey Procedures (SAS Institute). Analyses were weighted by the inverse of the sampling probability and accounted for the stratified sampling design.[23] Demographics, clinical characteristics, length of stay, and mortality were compared between patients with weekend versus weekday discharge. Categorical variables were compared using Rao-Scott χ^2 tests. Continuous variables were compared using the difference in least square means from weighted linear regression. Odds ratios of in-hospital mortality on the weekend versus weekday were analyzed using multivariable logistic regression. Adjusted hazards of 28-day mortality were compared using multivariable Cox regression, with analyses limited to patients discharged alive. Modeling strategies were determined a priori. First, we constructed minimally adjusted models accounting for demographics (age, race, sex, year of admission, and hospital). Next, we examined models adjusted for demographics and routinely abstracted variables shown to differ in univariate comparisons of patients with hospitalizations terminating on the weekend versus weekday. Additionally, we adjusted for length of stay and intravenous inotrope administration, considering these to be indicators of HF severity. We also explored the possibility that associations may differ by HF type or by weekend versus weekday admission. This was accomplished by constructing stratified models and by testing multiplicative interaction.

Results

Of 39 699 (8500 unweighted) hospitalizations included in this analysis, 19% ended on the weekend. A small percentage of hospitalizations (2%) terminated on a federal holiday. The mean age of patients at admission was 76 years, 48% were men, and 66% were white. The majority of patients (96%) had health insurance. As shown in Figure 1, day of admission was unequally distributed (P<0.0001), as was day of discharge (P<0.0001). Monday was the most frequent day of admission (16%), while Friday was the most frequent day of discharge (19%). Saturday and Sunday were the least common discharge days (9% and 6%, respectively).

Patient demographics, comorbidities, laboratory values, HF classification, in-hospital procedures, and receipt of intravenous inotropes, intravenous diuretics, and other evidence-based therapies were largely comparable among hospitalizations ending on a weekend versus weekday (Table 1). However, patients who were discharged on a weekend were less frequently admitted on a weekend (20% versus 28%) and were less likely to have a history of stroke (18% versus 21%). Administration of β-blockers was more common among patients discharged on the weekend (70% versus 66%), while administration of angiotensin II receptor blockers was less common (11% versus 14%). The overall mean length of stay was 8 days (11 days among patients dying in-hospital) and did not differ for hospitalizations terminating on a weekend versus weekday.

In total, there were 2816 (7%) in-hospital deaths. Demographic, diagnostic, and clinical characteristics of patients who died in-hospital on the weekend versus weekday are shown in Table S1. The incidence of in-hospital death was twice as high on the weekend (12% versus 6%; P<0.0001), with a similar pattern observed among subgroups stratified by HF type and by weekend versus weekday admission (Figure 2). However, the incidence of in-hospital death did not differ by weekend or weekday admission (7% versus 7%). After adjusting for demographics, patients had twice the odds of in-hospital death on the weekend (odds ratio, 2.37; 95% CI, 1.93–2.91) (Figure 3). Similar adjusted associations were observed in patients with HF with reduced EF and HF with preserved EF, with no suggestion of statistical interaction (P for interaction=0.4). However, there was a trend toward higher in-hospital mortality on the weekend for patients admitted on a weekend as opposed to a weekday (P for interaction=0.2). The increased odds of in-hospital death on the weekend versus weekday was consistent in models with additional adjustments for stroke, diastolic blood pressure, angiotensin II receptor blockers, β-blockers, length of stay, and intravenous inotropes (Table 2). There was no difference in the adjusted odds of in-hospital death by weekend versus weekday *admission* (Table S2).

Among patients discharged alive, a total of 1868 (5%) deaths occurred by 28 days of hospitalization. Clinical characteristics of patients discharged alive on the weekend versus weekday are shown in Table S3 and are largely comparable. As shown in Figure 4, a similar distribution of

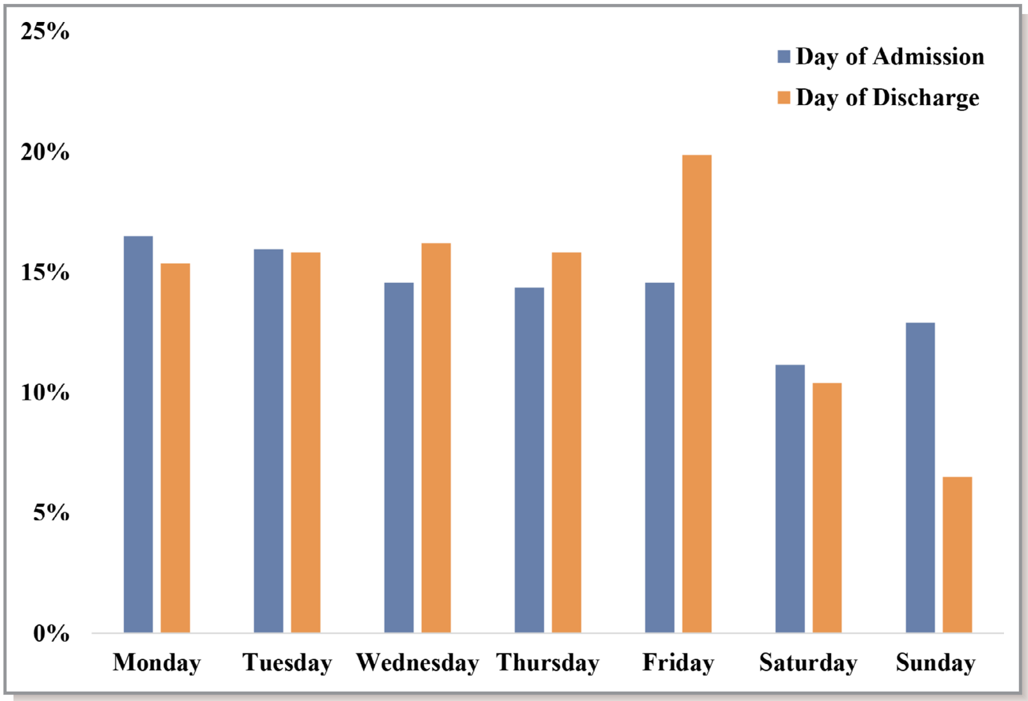

Figure 1. Frequency of admissions and discharges by day of week among patients hospitalized with acute decompensated heart failure. The Community Surveillance component of the Atherosclerosis Risk in Communities study, 2005–2014.

discharge days was observed when comparing 28-day fatalities with 28-day survivors (*P*=0.3). Sunday was the least common discharge day (6% of discharges for both groups), followed by Saturday (9% and 10%). The incidence of 28-day mortality did not differ among patients with a weekend versus weekday discharge (5% for each). After adjustment for demographics and surrogate markers for disease severity (length of stay and intravenous inotropes), no significant difference in 28-day mortality was noted among patients discharged alive on the weekend versus weekday (hazard ratio, 0.86; 95% CI, 0.62–1.19).

Discussion

We conducted this investigation to examine whether mortality differs among patients with ADHF hospitalizations ending on the weekend versus weekday. Among 39 699 hospitalizations, a greater incidence of in-hospital deaths occurred on the weekend, irrespective of HF type, with a trend toward greater in-hospital mortality among patients also admitted on the weekend. The association remained significant after adjusting for hospital- and patient-level factors. However, no difference in 28-day mortality was observed among patients discharged alive on a weekend versus weekday. To our knowledge, this is the first examination of mortality outcomes and their relation to hospitalizations ending on a weekend versus weekday in a population-based sample of patients classified with ADHF by physician validation.

Despite similar demographics, comorbidities, admission vital signs, and laboratory values, in-hospital mortality was more frequent on the weekend than on weekdays. Higher in-hospital mortality on the weekend has been reported for other conditions, such as chronic obstructive pulmonary disease and pneumonia.[24,25] A potential factor contributing to weekend in-hospital mortality may be handovers of care. Handovers of care are frequently inconsistent on the weekends, likely because of an increased number of team transitions and decreased compliance with the handover structure itself.[26] Several hospital systems have implemented quality initiatives to improve weekend handovers, leading to increased utilization and provider satisfaction with the handover tool.[27–30] Unfortunately, these interventions did not evaluate patient outcomes. Regardless, since improved handovers have been shown to reduce medical errors, focused initiatives concentrating on weekend handovers may lead to better in-hospital outcomes on the weekend.[31]

We hypothesized that patients discharged on the weekend would have worse post-hospital outcomes due to incomplete discharge instructions and scheduling of follow-up care. On the contrary, no difference in 28-day mortality was observed among patients with weekend versus weekday discharge. A possible explanation may be that patients discharged on the

Table 1. Demographics and Clinical Characteristics of Patients With ADHF Hospitalizations Ending on a Weekend vs Weekday

	Weekend* Discharge (n=7494) No. (%) or Mean±SEM	Weekday Discharge (n=32 205) No. (%) or Mean±SEM	*P* Value
Demographics			
Age, y	76±0.2	76±0.1	0.7
Women	3809 (51)	17 120 (53)	0.1
White	5150 (69)	21 063 (65)	0.02
Health insurance	7178 (96)	31 121 (97)	0.2
Year of admission	2010±0.01	2010±0.01	1.0
Weekend admission	1478 (20)	9054 (28)	<0.0001
Medical history			
Ejection fraction[†]	42%±0.6%	43%±0.3%	0.4
HFrEF (EF <50%)[†]	2559 (54)	10 984 (53)	0.5
Hypertension	6433 (86)	27 650 (86)	1.0
Atrial fibrillation/flutter	12 098 (38)	2987 (40)	0.1
Chronic kidney disease[‡]	4040 (72)	17 441 (70)	0.3
COPD/bronchitis	2673 (36)	11 294 (35)	0.7
Myocardial infarction	2036 (27)	8012 (25)	0.1
Coronary heart disease	4326 (58)	18 105 (56)	0.3
Diabetes mellitus	3525 (47)	15 508 (48)	0.5
Dialysis	524 (7)	2252 (7)	1
Stroke/transient ischemic attack	1344 (18)	6833 (21)	0.01
Prior HF hospitalization	2716 (36)	11 288 (35)	0.6
Current smoking	1001 (13)	4085 (13)	0.5
Hospital vital signs and laboratory values[§]			
Systolic BP, mm Hg[‖]	141±0.9	142±0.5	0.3
Diastolic BP, mm Hg[‖]	76±0.5	78±0.3	<0.0001
B-type natriuretic peptide, pg/dL[¶]	1320±53	1359±36	<0.0001
Hemoglobin, g/dL	10.6±0.06	10.5±0.03	0.2
Sodium, mEq/L	136±0.1	136±0.06	0.5
Serum urea nitrogen, mg/dL	41±0.7	41±0.3	0.8
Creatinine, mg/dL	2.15±0.05	2.15±0.02	1.0
Hospital procedures/intravenous medications			
Right heart catheterization	215 (3)	895 (3)	0.8
Angiography	948 (13)	3781 (12)	0.4
Intravenous inotropes	455 (6)	1876 (6)	0.7
Intravenous diuretics	5969 (80)	25 736 (80)	0.8
Medications			
ACE inhibitor	2684 (36)	11 552 (36)	1.0
Angiotensin receptor II blocker	847 (11)	4376 (14)	0.03
β-Blocker	5219 (70)	21 322 (66)	0.02
Digitalis	899 (12)	4034 (12)	0.6
Diuretics	5170 (69)	21 996 (68)	0.7
Aldosterone blocker	659 (9)	2668 (8)	0.6

Continued

Table 1. Continued

	Weekend* Discharge (n=7494) No. (%) or Mean±SEM	Weekday Discharge (n=32 205) No. (%) or Mean±SEM	*P* Value
Nitrates	2239 (30)	9247 (29)	0.4
Hydralazine	919 (12)	3767 (12)	0.6
Length of stay, d	8.1±1.5	8.1±0.2	1.0

The Community Surveillance component of the Atherosclerosis Risk in Communities Study, 2005–2014. ACE indicates angiotensin-converting enzyme; ADHF, acute decompensated heart failure; COPD, chronic obstructive pulmonary disease; HF, heart failure; HFrEF, heart failure with reduced ejection fraction; SEM, standard error of the mean.
*Weekend=Saturday, Sunday, or national holiday.
†Ejection fraction (EF) limited to 25 383 (64%) patients with available echocardiography abstractions.
‡Chronic kidney disease defined by estimated glomerular filtration rate <60 mL/min per 1.73 m^2 or receipt of hemodialysis; among 30 609 patients with available creatinine data abstractions.
§Laboratory results are the worst reported values from the hospitalization.
||Blood pressures (BPs) on admission.
¶Data not available for 50% of patients.

weekend were healthier, reflecting physician comfort with discharging lower-risk patients on the weekend. Comorbidities, admission vital signs, and length of stay were comparable among patients discharged alive on the weekend versus weekday. Based on these available data, patients discharged on the weekend did not appear to be lower risk. However, there are many factors such as social support and a relationship with a primary care physician that we were unable to account for. Friday was the most frequent day of discharge. This likely reflects provider and patient preference to discharge before the weekend. Despite this, no significant difference in 28-day mortality was observed by day of discharge or by weekend versus weekday discharge.

Previous reports of postdischarge mortality for patients with HF discharged on the weekend versus weekday have been conflicting. Consistent with our results, the OPTIMIZE-HF (Organized Program to Initiate Lifesaving Treatment in Hospitalized Patients With Heart Failure) registry observed no difference in 60- or 90-day mortality among patients discharged on the weekend versus weekday.[13] Conversely, McAlister et al[16] reported a significantly lower 30-day mortality for patients with HF discharged on a weekday, despite older age and greater comorbidities compared with patients with weekend discharges. However, this analysis was sourced from administrative claims databases with cases determined by unadjudicated *International Classification of Diseases, Ninth Revision* (*ICD-9*) codes. Further, information concerning admission vital signs, laboratory results, ejection fraction, in-hospital diagnosis, and treatment were lacking.

Providers are often hesitant to discharge patients on the weekend because of concern that coordination of follow-up care may be inadequate. However, an analysis of the California's Office of Statewide Health Planning and Development database reported no difference in readmissions among patients hospitalized with pneumonia, myocardial infarction, and HF who were discharged on the weekend versus weekday.[32] Given this and the similar 28-day mortality among weekend and weekday discharges observed in the ARIC Community Surveillance, the hesitancy to discharge patients on the weekend is perhaps unfounded.

Multiple studies have examined outcomes of weekend versus weekday *admission* for patients hospitalized with

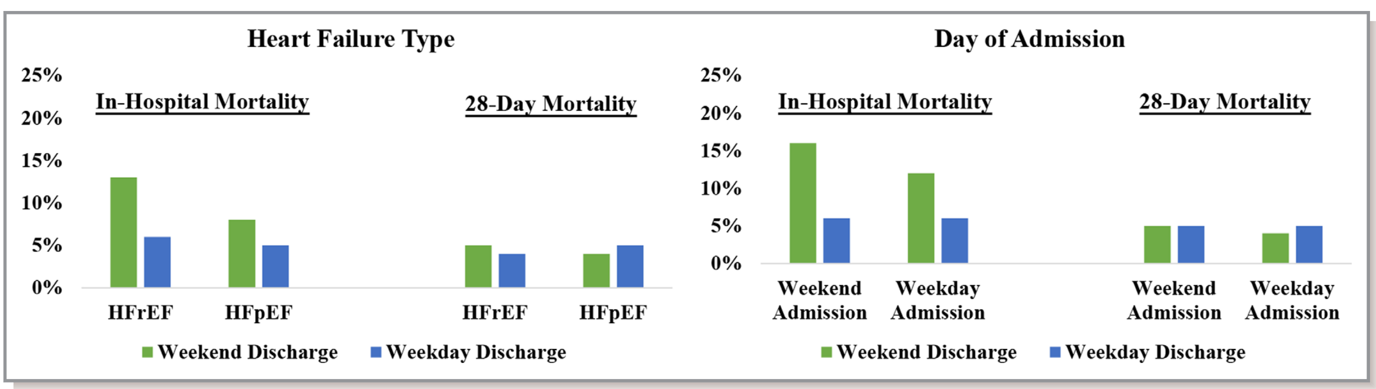

Figure 2. Incidence* of in-hospital and 28-day mortality among patients with acute decompensated heart failure hospitalizations ending on a weekday vs weekend, stratified by heart failure type and admission on a weekend vs weekday. The Community Surveillance component of the Atherosclerosis Risk in Communities study, 2005–2014. *Heart failure type limited to patients with available echocardiography, and 28-day mortality limited to patients discharged alive. HFpEF indicates heart failure with preserved ejection fraction; HFrEF, heart failure with reduced ejection fraction.

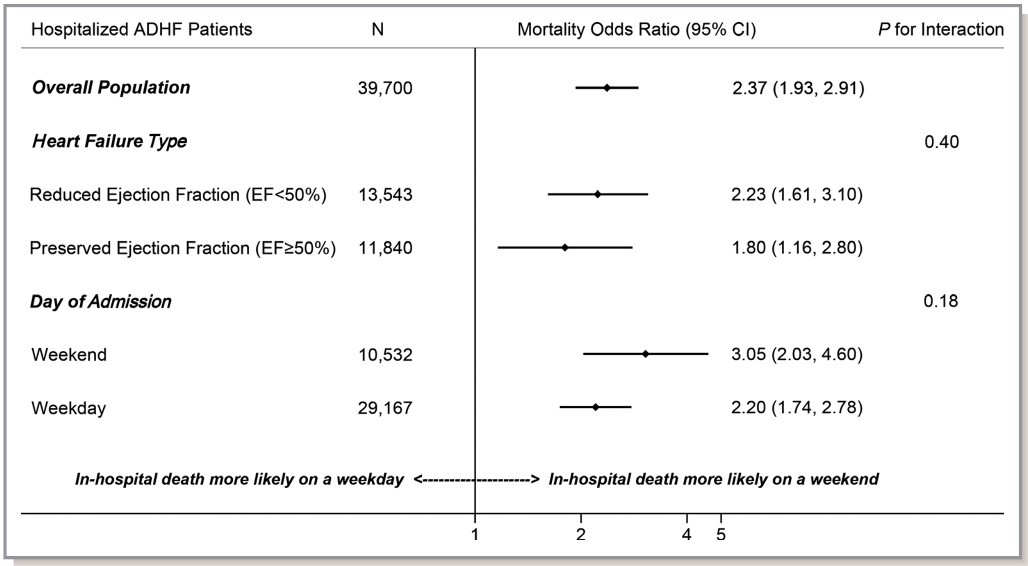

Figure 3. Adjusted odds ratios of in-hospital mortality among patients with acute decompensated heart failure (ADHF) hospitalizations ending on a weekend vs weekday. The Community Surveillance component of the Atherosclerosis Risk in Communities study, 2005–2014. Models adjusted for age, race, sex, year of admission, and hospital.

ADHF. In an analysis from the GWTG-HF (Get With the Guidelines—Heart Failure) registry, a higher incidence of in-hospital mortality was observed for patients admitted with ADHF on the weekend.[12] In support of this, a recent analysis from the Einstein Medical Center and Agency for Healthcare Research and Quality (AHRQ) Nationwide Inpatient Sample reported significantly higher in-hospital mortality for patients admitted with ADHF on the weekend.[15] Conversely, the OPTIMIZE-HF registry reported no difference in in-hospital mortality among patients admitted on the weekend compared with weekday.[13] Similar to the results from the present study showing no difference in in-hospital mortality by weekend versus weekday admission, no difference in in-hospital mortality was observed for patients with HF with reduced EF who were admitted on a weekend versus weekday in a previous analysis from ARIC Community Surveillance.[33] In these previous reports, in-hospital death did not necessarily occur on the day of admission. Should patient condition worsen after day of admission, resources present at the time of decompensation may be similarly relevant as to those available on the day of admission. Thus, it is important to examine in-hospital mortality of patients with ADHF by day of death, rather than solely by day of admission, because decreased availability of resources, including specialist and nursing availability, are known to be associated with increased weekend mortality.[2,6–11]

Table 2. Crude, Minimally Adjusted, and Fully Adjusted ORs of In-Hospital Death on a Weekend vs Weekday Among Patients Admitted With ADHF

	Model 1	Model 2	Model 3	Model 4
Subgroup	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
All patients	2.29 (1.88–2.80)	2.37 (1.93–2.91)	2.46 (1.99–3.04)	2.49 (2.0–3.10)
HFrEF* (EF <50%)	2.10 (1.53–2.89)	2.23 (1.61–3.10)	2.39 (1.69–3.38)	2.50 (1.01–1.05)
HFpEF* (EF ≥50%)	1.71 (1.10–2.64)	1.80 (1.16–2.81)	1.75 (1.11–2.74)	2.63 (2.00–2.44)
Weekend admission	3.07 (2.05–4.60)	3.05 (2.02–4.60)	3.00 (1.94–4.63)	2.84 (1.80–4.50)
Weekday admission	2.11 (1.68–2.65)	2.20 (1.74–2.78)	2.36 (1.85–3.01)	2.44 (1.90–3.13)

The Community Surveillance component of the Atherosclerosis Risk in Communities study, 2005–2014. Model 1=crude. Model 2=adjusted for demographics (age, race, sex, year of admission, and hospital code). Model 3=adjusted for demographics, history of stroke, diastolic blood pressure at admission, and receipt of angiotensin II receptor blockers and β-blockers during hospitalization. Model 4=adjusted for demographics, history of stroke, diastolic blood pressure at admission, receipt of angiotensin II receptor blockers and β-blockers during hospitalization, and disease severity as indicated by length of stay and receipt of intravenous inotropes. ADHF indicates acute decompensated heart failure; EF, ejection fraction; HFpEF, heart failure with preserved ejection fraction; HFrEF, heart failure with reduced ejection fraction; OR, odds ratio.

*Classification of heart failure type limited to 25 383 patients (64%) with available echocardiography abstractions.

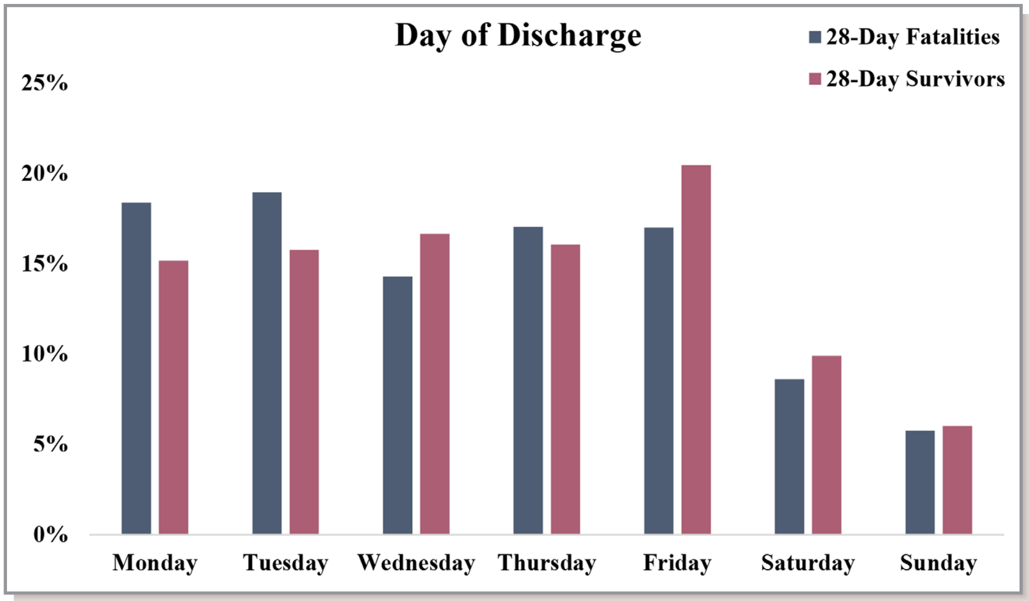

Figure 4. Distributions of discharge days among patients hospitalized with acute decompensated heart failure who were discharged alive, stratified by those who died or survived by 28 days of hospitalization. The Community Surveillance component of the Atherosclerosis Risk in Communities study, 2005–2014.

Study Limitations and Strengths

Our analysis from ARIC Community Surveillance has several limitations. This was an observational study and was based on data available in the hospital record. We were unable to consider hospital readmissions, an important postdischarge outcome, or cause-specific mortality. Federal holidays were considered to occur on the “weekend,” but observation of federal holidays may differ by hospital. However, only 2% of hospitalizations in this analysis terminated on a federal holiday. Our analysis also has several noteworthy strengths. The Community Surveillance component of the ARIC study represents 4 geographically diverse regions of the United States. Rather than relying solely on *ICD-9* codes, ADHF hospitalizations were classified by a standardized computer algorithm and physician review. Clinical data were collected by certified abstractors following standardized protocols, and mortality outcomes were ascertained by linking records with the National Death Index.

Conclusions

Patients admitted with ADHF appear to have heightened risk of in-hospital death on the weekends. Future studies should focus on in-hospital death by day of discharge instead of solely by day of admission. Further, analyses of hospital resources should be conducted across many hospitals nationally to elucidate the specific reasons for this greater in-hospital mortality on the weekends for patients admitted with ADHF.

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Disclosures

None.

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SUPPLEMENTAL MATERIAL

Table S1. **Demographics and clinical characteristics of patients admitted with acute decompensated heart failure and dying in-hospital on a weekend vs. weekday.** The Community Surveillance component of the Atherosclerosis Risk in Communities Study, 2005 – 2014.

	Weekend Death[*]	**Weekday Death**	**P-value**
	N = 934	*N* = 1,882	
	No. (%) or mean ± SEM	*No.* (%) or mean ± SEM	
Demographics			
Age (years)	79 ± 0.6	79 ± 0.4	0.8
Female	495 (53%)	976 (52%)	0.1
White	695 (74%)	1382 (73%)	0.8
Health insurance	903 (98%)	1816 (98%)	0.9
Year of admission	2010 ± 0.01	2010 ± 0.005	0.5
Weekend admission	230 (25%)	513 (27%)	<0.0001
Medical History			
Ejection Fraction[†]	41% ± 1.11	40% ± 0.75	0.6
HFrEF (EF<50%)[†]	767 (82%)	1424 (76%)	0.3
Hypertension	781 (82%)	1544 (84%)	0.6
Atrial fibrillation/flutter	390 (42%)	806 (43%)	0.8
Chronic kidney disease[‡]	1184 (82%)	554 (76%)	0.2
COPD / bronchitis	350 (37%)	691 (37%)	0.8
Myocardial infarction	175 (19%)	497 (26%)	0.05
Coronary heart disease	460 (49%)	1059 (56%)	0.1
Diabetes	403 (43%)	836 (44%)	0.8
Dialysis	59 (6%)	126 (7%)	0.8
Stroke / transient ischemic attack	225 (24%)	541 (29%)	0.2
Prior heart failure hospitalization	364 (39%)	605 (32%)	0.3
Current smoking	107 (11%)	198 (10%)	0.7
Hospital Vital Signs and Labs[§]			
Systolic blood pressure (mmHg)[‖]	125 ± 2.1	127 ± 1.7	0.001
Diastolic blood pressure (mmHg)[‖]	68 ± 1.2	69 ± 0.96	<0.0001
B-type natriuretic peptide (pg/dL)[#]	1769 ± 133	2127 ± 191	0.3
Hemoglobin (g/dL)	10 ± 0.2	9.7 ± 0.1	0.05
Sodium (mEq/L)	134 ± 0.3	134 ± 0.2	0.6
Blood urea nitrogen (mg/dL)	60 ± 1.7	59 ± 1.3	0.5
Creatinine (mg/dL)	2.6 ± 0.1	2.6 ± 0.1	1.0
Hospital Procedures / Intravenous Medications			
Right heart catheterization	19 (2%)	79 (4%)	0.1
Angiography	102 (11%)	176 (9%)	0.5
Intravenous inotropes	218 (23%)	395 (21%)	0.5
Intravenous diuretics	712 (76%)	1473 (78%)	0.6
Pre-Hospital Medications			
ACE Inhibitor	241 (26%)	607 (32%)	0.1
Angiotensin II Blocker	107 (11%)	188 (10%)	0.6
Beta Blocker	585 (63%)	1089 (58%)	0.3
Digitalis	137 (15%)	281 (15%)	0.9
Diuretics	647 (69%)	1308 (69%)	0.9
Aldosterone Blocker	118 (13%)	127 (7%)	0.01
Nitrates	195 (21%)	536 (28%)	0.04
Hydralazine	101 (11%)	137 (7%)	0.1
Length of Stay (days)	10.7 ± 0.6	10.8 ± 0.6	0.9

[*]Weekend = Saturday, Sunday or national holiday; [†] Ejection fraction limited to 25,383 (64%) patients with available echocardiography abstractions; [‡]Chronic kidney disease defined by estimated glomerular filtration rate<60 mL/min per 1.73 m^2 or receipt of hemodialysis; among 30,609 with available creatinine data abstractions; [§] Laboratory results are the worst reported values from the hospitalization; [‖] Blood pressures on

admission; [#]Data not available for 50% of patients. SEM= standard error of the mean; COPD = chronic obstructive pulmonary disease; HFrEF = heart failure with reduced ejection fraction.

Table S2. **Demographics and clinical characteristics of patients admitted with acute decompensated heart failure and discharged alive on a weekend vs. weekday.** The Community Surveillance component of the Atherosclerosis Risk in Communities Study, 2005 – 2014.

	Weekend Discharge* *N* = 6,560 *No.* (%) or mean ± SEM	**Weekday Discharge** *N* = 30,324 *No.* (%) or mean ± SEM	**P-value**
Demographics			
Age (years)	75 +/- 0.2	76 ± 0.1	0.6
Female	3315 (51%)	16144 (53%)	0.1
White	4455 (68%)	19681 (65%)	0.05
Health insurance	6274 (96%)	29305 (97%)	0.2
Year of admission	2010 ± 0.01	2010 ± 0.01	0.01
Weekend admission	1248 (19%)	8541 (28%)	<0.0001
Medical History			
Ejection Fraction†	42% ± 0.52	43% ± 0.26	0.01
HFrEF (EF<50%)†	2237 (53%)	10279 (53%)	0.8
Hypertension	5652 (86%)	26106 (86%)	1
Atrial fibrillation/flutter	2597 (40%)	11292 (37%)	0.1
Chronic kidney disease‡	3486 (71%)	16257 (69%)	0.3
COPD / bronchitis	2323 (35%)	10603 (35%)	0.8
Myocardial infarction	1861 (28%)	7515 (25%)	0.02
Coronary heart disease	3866 (59%)	17046 (56%)	0.1
Diabetes	3121 (48%)	14672 (48%)	0.6
Dialysis	465 (7%)	2126 (7%)	0.9
Stroke / transient ischemic attack	1119 (17%)	6292 (21%)	0.01
Prior heart failure hospitalization	2352 (36%)	10683 (35%)	0.7
Current smoking	3886 (13%)	894 (14%)	0.5
Hospital Vital Signs and Labs§			
Systolic blood pressure (mmHg)‖	143 ± 0.9	143 ± 0.5	0.9
Diastolic blood pressure (mmHg)‖	78 ± 0.6	78 ± 0.3	<0.0001
B-type natriuretic peptide (pg/dL)#	1262 ± 56	1317 ± 36	<0.0001
Hemoglobin (g/dL)	10.7 ± 0.06	10.6 ± 0.03	0.06
Sodium (mEq/L)	136 ± 0.1	136 ± 0.1	0.8
Blood urea nitrogen (mg/dL)	38.4 ± 0.7	40.2 ± 0.3	0.02
Creatinine (mg/dL)	2.08 ± 0.05	2.13 ± 0.02	<0.0001
Length of Stay (days)	7.8 ± 1.7	7.9 ± 0.2	0.9

*Weekend = Saturday, Sunday or national holiday; † Ejection fraction limited to patients with available echocardiography abstractions; ‡Chronic kidney disease defined by estimated glomerular filtration rate<60 mL/min per 1.73 m^2 or receipt of hemodialysis; among patients with available creatinine data abstractions; § Laboratory results are the worst reported values from the hospitalization; ‖ Blood pressures on admission; #Data not available for 50% of patients. SEM= standard error of the mean; COPD = chronic obstructive pulmonary disease; HFrEF = heart failure with reduced ejection fraction

Table S3. **Crude, minimally adjusted, and fully adjusted odds ratios of in-hospital death among patients *admitted* on the weekend and weekday with acute decompensated heart failure.** The Community Surveillance component of the Atherosclerosis Risk in Communities Study, 2005 – 2014.

Subgroup	**Model 1** *OR (95% CI)*	**Model 2** *OR (95% CI)*	**Model 3** *OR (95% CI)*	**Model 4** *OR (95% CI)*
All Patients	0.99 (0.80-1.23)	0.99 (0.80-1.23)	1.04 (0.83-1.30)	1.07 (0.86-1.34)
HFrEF* (EF<50%)	1.17 (0.85-1.61)	1.18 (0.85-1.63)	1.35 (0.96-1.89)	1.37 (0.97-1.92)
HFpEF* (EF≥50%)	0.91 (0.69-1.18)	0.90 (0.69-1.19)	0.92 (0.69-1.21)	0.96 (0.72-1.27)

Model 1 = crude
Model 2 = adjusted for demographics (age, race, sex, year of admission, and hospital code).
Model 3 = adjusted for demographics, history of stroke, diastolic blood pressure at admission, and receipt of angiotensin II receptor blockers and beta blockers during hospitalization.
Model 4 = adjusted for demographics, history of stroke, diastolic blood pressure at admission, receipt of angiotensin II receptor blockers and beta blockers during hospitalization, disease severity as indicated by length of stay and receipt of IV inotropes
*Classification of heart failure type limited to 25,383 patients (64%) with available echocardiography abstractions