Variation Exists in Rates of Admission to Intensive Care Units for Heart Failure Patients Across Hospitals in the United States

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Background—Despite increasing attention on reducing relatively costly hospital practices while maintaining the quality of care, few studies have examined how hospitals use the intensive care unit (ICU), a high-cost setting, for patients admitted with heart failure (HF). We characterized hospital patterns of ICU admission for patients with HF and determined their association with the use of ICU-level therapies and patient outcomes.

Methods and Results—We identified 166,224 HF discharges from 341 hospitals in the 2009–2010 Premier Perspective database. We excluded hospitals with <25 HF admissions, patients <18 years old, and transfers. We defined ICU as including medical ICU, coronary ICU, and surgical ICU. We calculated the percent of patients admitted directly to an ICU. We compared hospitals in the top quartile (high ICU admission) with the remaining quartiles. The median percentage of ICU admission was 10% (interquartile range, 6%–16%; range, 0%–88%). In top-quartile hospitals, treatments requiring an ICU were used less often; the percentage of ICU days receiving mechanical ventilation was 6% for the top quartile versus 15% for the others; noninvasive positive pressure ventilation, 8% versus 19%; vasopressors and/or inotropes, 9% versus 16%; vasodilators, 6% versus 12%; and any of these interventions, 26% versus 51%. Overall HF in-hospital risk-standardized mortality was similar (3.4% versus 3.5%; \( P=0.2 \)).


Key Words: heart failure ■ mortality

One in 5 patients hospitalized with heart failure (HF) in the United States is admitted to an intensive care unit (ICU), a resource-intensive setting that accounts for 20% to 35% of total hospital costs.\(^\text{1-3}\) Despite the high cost of ICU admission, there are no standard, evidence-based guidelines for ICU triage of patients with HF.\(^\text{4}\) Therefore, the decision to admit patients to an ICU may be a result of multiple factors, including the patients' clinical status, practitioner discretion, institutional policies and procedures, and hospital capacity.\(^\text{5}\) Several patient-level studies conducted more than a decade ago demonstrated that patients are frequently admitted to the ICU who never receive ICU-level therapies during their hospitalization.\(^\text{6,7}\) However, we lack information about contemporary practice for patients with HF and hospital-level variation.

Clinical Perspective on p 929

The primary aim of this study is to describe patterns of ICU use for patients with HF among a diverse group of US hospitals. Once we observed the variation in the use of ICUs, we compared groups of hospitals with distinct patterns of ICU use in terms of their management of HF within the ICU. We hypothesized that hospitals that more frequently triage patients with HF to the ICU admit, on average, lower-risk patients to the ICU and therefore provide fewer ICU-level therapies and have lower risk-adjusted mortality rates for these patients compared with hospitals that have lower rates of ICU triage. Because we did not expect higher ICU triage to be associated with better patient outcomes, we expected that overall in-hospital risk-standardized mortality rates (RSMRs)
for all patients with HF would be similar across hospitals regardless of triage patterns.

Methods

Data Source
We conducted a cross-sectional study using data from Perspective, a voluntary, fee-supported database developed by Premier, Inc for measuring quality and healthcare use. Premier is a private consortium of hospitals that pools finances and a limited set of clinical data from hundreds of US hospitals into a common database. As of 2010, Perspective contained data from >130 million cumulative hospital discharges. These inpatient discharges represent >20% of all acute care inpatient hospitalizations nationwide. In addition to the information available in the standard hospital discharge file, Perspective contains a date-stamped log of all billed items at the individual patient level, including medications and laboratory, diagnostic, and therapeutic services, as well as limited clinical data about each patient. For this study, patient data were deidentified in accordance with the Health Insurance Portability and Accountability Act, and a random hospital identifier assigned by Premier was used to identify the hospitals. The Yale University Human Investigation Committee reviewed the protocol for this study and determined that it is not considered to be human subjects research as defined by the Office of Human Research Protections.

Study Cohort
We included hospitalizations from January 1, 2009, to December 31, 2010. To qualify for inclusion in the study cohort, patients must have had a principal discharge diagnosis of HF (International Classification of Diseases, ninth revision, clinical modification code 402.01, 402.11, 402.91, 404.01, 404.03, 404.11, 404.13, 404.91, 404.93, 428.xx). This code captures the reason, in retrospect, for the admission and is determined after discharge. Patients could contribute >1 hospitalization to the study cohort. Only hospitals that participated in the Premier research program in 2009 to 2010 and had at least 25 cases of HF during that period were considered for inclusion. Hospitalizations were excluded if patients were <18 years of age at the time of admission, assigned a pediatrician as the attending physician of record, transferred in from another hospital, or received cardiac surgery during their stay. Excluded cardiac surgeries were coronary artery bypass grafting, valvular surgery, peripheral vascular surgery, ventricular assist device placement, and heart transplantation.

Outcomes
We first conducted an exploratory analysis on the variation in admission rates to the ICU across hospitals within our cohort. The primary outcome for each hospital was the proportion of its HF hospitalizations admitted to an ICU. Admission to an ICU was defined as having a room and board charge for an ICU bed on the first day of the hospitalization. ICU beds included those located in the medical ICU, coronary care unit, and surgical ICU.

We calculated the use of ICU-level therapies among patients with HF admitted to the ICU. ICU-level therapies were defined as commonly used therapies for acute decompensated HF typically available only in a critical care setting. These included mechanical ventilation, intravenous vasopressors, intravenous inotropes, intravenous vasodilators, intra-aortic balloon pumps, and/or pulmonary artery catheters. We also measured the use of noninvasive positive-pressure ventilation (NPPV), including continuous positive airway pressure and bilevel positive airway pressure, which requires an ICU setting in many institutions.

We compared hospitals in terms of in-hospital all-cause mortality for patients with HF triaged to an ICU. Finally, we compared hospitals in-hospital all-cause RSMRs for all patients admitted to the hospital with HF.

Statistical Analysis
Hospitals were divided into quartiles based on the proportion of patients admitted to the ICU, with the top quartile having the highest admission rates. The bottom 3 quartiles of hospitals had similar rates of ICU admission; the top-quartile hospitals had distinctly higher rates of ICU admission. Thus, we defined the top quartile as a group of hospitals with high ICU admission rates and compared them with the rest of the hospitals in our cohort (hospitals in the bottom 3 quartiles) for the remainder of the analysis. Hospital characteristics for the top quartile of hospitals were compared with the hospital characteristics for all other hospitals by use of χ² tests to assess statistical differences. The top-quartile hospitals were compared with all other hospitals by use of χ² tests to assess statistical differences for ICU-level therapies and ICU inhospital mortality. A value of P<0.05 was considered statistically significant in all cases. Continuous variables are reported with medians and interquartile ranges. We repeated the full analysis among large hospitals (>265 beds) and among small hospitals (<265 beds).

Next, we calculated the proportion of days in the ICU in which the patient received mechanical ventilation, NPPV, intravenous vasopressors, intravenous inotropes, and/or intravenous vasodilator drugs. Among all hospitalizations occurring at hospitals in the top quartile of ICU admission rates, we calculated the proportion of days that each therapy was given and compared this with the average among all hospitalizations occurring at other hospitals. Similarly, we calculated the frequency with which pulmonary artery catheters and intra-aortic balloon pumps were administered during each hospitalization and compared the frequency across all hospitalizations occurring at top-quartile hospitals and other hospitals. The proportion of days without any intervention (mechanical ventilation, NPPV, vasopressors and/or inotropes, vasodilators, pulmonary artery catheters, intra-aortic balloon pump, and dialysis) was also calculated and compared between top-quartile hospitals and other hospitals.

In addition, we calculated the in-hospital all-cause mortality rate for patients triaged to top-quartile hospitals and compared it with the in-hospital all-cause mortality rate at other hospitals. We calculated RSMRs for each hospital using a hierarchical logistic regression with methods that are used in the outcomes measures that are publicly reported by the Centers for Medicare & Medicaid Services. Adjustment was done for patient characteristics, including age, sex, and Elixhauser comorbidities (Table I in the online-only Data Supplement) classified with the software (versions 3.4, 3.5, and 3.6 for federal fiscal years 2009, 2010, and 2011, respectively) provided by the Healthcare Costs and Utilization Project of the Agency for Healthcare Research and Quality. The RSMRs for top-quartile hospitals were compared with RSMRs for the other hospitals by use of a Wilcoxon rank-sum test. A value of P<0.05 was considered statistically significant. All analyses were conducted with SAS version 9.2 (SAS Institute Inc, Cary, NC). Procedure GLIMMIX was used to estimate the hierarchical logistic models. The Figure was generated with R (R Development Core Team, Vienna, Austria).

Results

Hospital Characteristics
Our cohort included 166 224 patients treated at 341 hospitals from across the United States. Of these, 19 169 patients were admitted directly to the ICU and accrued a total of 59 709 ICU days. The median hospital bed size was 265 (interquartile range, 131–402), volume of patients with HF was 407 (interquartile range, 193–709), and volume of patients with HF admitted to the ICU was 34 (interquartile range, 20–69). Hospitals tended to be located in the South (41%), to serve an urban population (78%), and to be identified as nonteaching (72%; Table 1). Hospitals in the top quartile of ICU admission rates and those in other quartiles tended to have similar characteristics in terms of geographic location and population served; however, they varied in terms of bed size (P<0.0001), ICU HF volume (P<0.0001), and teaching status (P=0.0108; Table 1). We observed that hospitals in the bottom 3 quartiles
were slightly larger (31% had >400 beds), had a lower number of ICU HF patients during the study period, and were more often teaching hospitals (32% versus 17%). In addition, we examined hospital characteristics within each of the 4 quartiles of ICU admission rates (Table II in the online-only Data Supplement). We observed similar trends across the 4 quartiles, with hospitals that have higher ICU admission rates being larger, having a lower number of ICU HF patients, and being designated as teaching.

### ICU Admission Rates

Of the 341 hospitals we analyzed, 328 admitted patients with HF directly to an ICU during the study period. The Figure shows the ICU admission rate for each of the 328 hospitals, ranked from lowest to highest rate of admission. The range of ICU admission rates was from 0% to 88% (median, 10%; interquartile range, 6%–16%). Among hospitalizations at hospitals in the top quartile of ICU admissions, 32% of patients on average were admitted directly to the ICU compared with only 8% of patients at hospitals in the other quartiles ($P<0.0001$). Figure I in the online-only Data Supplement demonstrates the number of hospitals with the indicated ICU admission rates.

### ICU-Level Therapy Use

We compared the percentage of ICU days in which patients received critical care interventions between top-quartile hospitals and other hospitals (Table 2). Patients at top-quartile hospitals spent less than half as many ICU days on mechanical ventilation compared with those at other hospitals (6% versus 15%; $P<0.0001$). Similarly, vasopressors and/or inotropes, vasodilators, and NPPV were administered during a smaller percentage of ICU days at top-quartile hospitals compared with other hospitals (9% versus 16% for vasopressors and/or inotropes, $P<0.0001$; 6% versus 12% for vasodilators, $P<0.0001$; and 8% versus 19% for NPPV, $P<0.0001$). Overall, top-quartile hospitals had a lower percentage of ICU days in which any intervention was administered (26% versus 51%; $P<0.0001$). In addition, we observed similar trends when comparing all 4 quartiles of hospitals, with higher-admission quartiles having a lower percentage of ICU days in which patients received critical care interventions (Table III in the online-only Data Supplement).

Furthermore, the proportion of patients receiving critical care interventions was compared between hospitals in the top quartile of ICU admission and other hospitals (Table 3). The proportion of patients receiving mechanical ventilation (7% versus 14%), NPPV (14% versus 31%), vasopressors and/or inotropes (9% versus 18%), vasodilators (16% versus 25%), intra-aortic balloon pump (0.2% versus 0.5%), and dialysis (0.01% versus 0.1%) was lower at top-quartile hospitals compared with other hospitals (9% versus 16% for vasopressors and/or inotropes, $P<0.0001$; 6% versus 12% for vasodilators, $P<0.0001$; and 8% versus 19% for NPPV, $P<0.0001$). Overall, top-quartile hospitals had a lower percentage of ICU days in which any intervention was administered (26% versus 51%; $P<0.0001$). In addition, we observed similar trends when comparing all 4 quartiles of hospitals, with higher-admission quartiles having a lower percentage of ICU days in which patients received critical care interventions (Table IV in the online-only Data Supplement).
Discussion
In a study of >300 hospitals in the United States, we observed remarkable variation in the rates at which the hospitals triage patients with HF to the ICU. This variation in the rate of ICU admission was accompanied by variation in the use of ICU-level therapies for acute decompensated HF such as mechanical ventilation and intravenous vasopressors and inotropic medications. Patients triaged to the ICU at hospitals that admitted a high percentage of patients with HF to the ICU were less likely to have these treatments compared with those admitted to hospitals with lower rates of ICU admission. This finding suggests that the former may be admitting relatively healthier patients to their ICUs. Consistent with this hypothesis, we found that patients with HF triaged to the ICUs of hospitals with high rates of ICU admission had lower mortality compared with patients with HF in the ICUs of hospitals that less frequently triaged to the ICU. Although it is plausible that closer monitoring in the ICU without any HF-related critical care intervention may reduce ICU mortality, our data showed that overall in-hospital RSMRs for all patients admitted with HF did not differ by ICU admission rate with less frequent use of ICU-level therapies such as mechanical ventilation and intravenous vasopressors and inotropic medications. Patients triaged to the ICU at hospitals with high rates of ICU admission had lower mortality compared with patients with HF in the ICUs of hospitals that less frequently triaged to the ICU. Although it is plausible that closer monitoring in the ICU without any HF-related critical care intervention may reduce ICU mortality, our data showed that overall in-hospital RSMRs for all patients admitted with HF did not differ by ICU admission patterns. Thus, hospitals that most frequently triage patients with HF to the ICU may be engaging in a high-cost behavior that does not improve patient outcomes.

We could not directly determine whether an individual patient required ICU admission because our data source lacked acute clinical information such as patient vital signs and the results of diagnostic tests. Moreover, there are no clear standards for ICU admission. We sought, however, to characterize hospital-level patterns of ICU admission rather than to determine the appropriateness of individual triage decisions, and it is unlikely that patient case mix would account for the wide variation in admission rates among hospitals that we observed. Furthermore, the association of high ICU admission rates with less frequent use of ICU-level therapies suggests that higher admission rates were due to discretionary decisions by doctors rather than site differences in the patients they are treating.

The decision to triage to an ICU comes at a high cost to both the patient and the healthcare system. Hospitalization in
the ICU has been shown to hold inherent risks for the patient, including increased risk of medication errors, delirium, hospital-acquired infection with multidrug-resistant pathogens, and posttraumatic stress disorder.\textsuperscript{17–22} Furthermore, although ICU beds represent only 5% to 10% of total hospital capacity, ICU use accounts for as much as 20% to 35% of hospital costs.\textsuperscript{2} The average daily cost to occupy an ICU bed is approximately $2573.\textsuperscript{23–26} This amount does not include the opportunity cost of delaying or denying use of that bed to a patient with critical care needs because it is occupied by a patient who could be managed safely in another setting.

Despite these costs, there may be clinical reasons that such behavior persists among hospitals. We hypothesized that small hospitals may not have telemetry capabilities outside the ICU and may admit patients with HF to the ICU for telemetry until myocardial infarction can be ruled out. Table 1, however, demonstrates that there is not a statistically significant difference in telemetry capability in beds outside the ICU among hospitals in the top quartile compared with hospitals in other quartiles.

Another clinical reason that differences in ICU triage exist may be related to the lack of guidelines that specify clinical criteria for ICU triage. The inconsistency in ICU resource use among hospitals underscores a need for improved HF triage guidelines for practitioners and adoption of HF risk-stratification models by hospitals.\textsuperscript{4} Triage decision making, which the American Heart Association recognizes as having a “crucial bearing on resource utilization,” is not explicitly addressed in the most recent HF management guidelines.\textsuperscript{27} General critical care guidelines from the Society of Critical Care Medicine suggest that efficient ICU use requires that patients who do not immediately need intensive care treatments should be triaged to an ICU only if there is a high likelihood that they will subsequently need ICU-level therapies.\textsuperscript{28} Yet, our findings add to other studies that have demonstrated that relatively healthy patients with HF may be frequently triaged to an ICU and often never receive critical care therapies associated with HF.\textsuperscript{6,7,29} In response to this trend, several validated risk-assessment models have been developed to aid in ICU triage decision making but have yet to be widely adopted by hospitals.\textsuperscript{29–31} These models have shown significant gains in improving the appropriateness of ICU triage both in the general medical population and specifically for patients with HF. Our data imply that these efforts might lead to significant savings in resources.

In addition, hospital ICU use may be driven by economic considerations. Hospitals that frequently triage to the ICU may do so in an effort to recuperate the high fixed cost of maintaining an ICU bed. If hospitals have ICU capacity beyond patient need for ICU beds and services, they have the opportunity to reduce fixed costs by eliminating or repurposing resources. Studies have shown, however, that hospitals have been slow to address excess fixed costs.\textsuperscript{32–34} This reluctance has significant implications for healthcare expenditures in the United States because >85% of hospital costs are fixed.

Despite these drivers of ICU bed use, reports of individual hospitals in the United States championing ICU triage reform have shown that ICU use can be guided more rationally. Unnecessary ICU admissions can be reduced and the value of care provided can be increased with the commitment of hospital leadership to changing institutional policies and attitudes through locally derived data.\textsuperscript{5} For example, an 18-hospital system implemented an ICU quality and efficiency improvement initiative that resulted in a reduction of the proportion of ICU admissions deemed “low risk” from 42% to 22%. The hospitals identified inefficient triage practices by collecting data using risk-scoring models that predict hospital mortality rates and comparing them with triage destinations. The hospitals used these data to assess ICU triage policies and to win institution-wide acceptance of the need for better practices and accountability at all levels within the hospital. Their quality management team rewrote hospital triage guidelines and moved from a subjective triage culture based almost totally on the discretion of the ICU director to a collaborative, data-driven approach involving emergency physicians, critical care physicians, nurse managers, and others. Institutional policy changed from a new available bed admission strategy, in which patients were admitted to beds on the basis of availability, to one centered on patient needs. New policies received continual reinforcement by nurse and physician champions, as well as top administrators. Thus, institution-level reforms to entrenched policy and culture may successfully improve hospital ICU triage practices.

Our study should be interpreted with the following caveats. The hospital risk adjustment was limited to age, sex, race, and comorbidities because our data source lacked acute clinical information. However, risk adjustment for patients with HF based on those characteristics has been validated in other studies.\textsuperscript{35–37} Because of the lack of acute clinical data, we cannot comment on the appropriateness of ICU triage strategies. In addition, our data set does not longitudinally track patient outcomes, and we could not calculate long-term patient mortality, which could have been altered by ICU triage strategies even though in-hospital mortality was not. Moreover, although our cohort included >340 hospitals with diverse characteristics, all of them voluntarily participate in a consortium that gathers and shares data with the aim of improving hospital practices. This suggests that our cohort may be more sensitive to establishing efficient care practices than other hospitals, which may provide an underestimation of ICU triage rates nationally. Furthermore, our data set does not contain information that would allow us to characterize ICUs to better understand the type of care offered such as nursing ratios or levels of ICU care. Finally, our data set does not contain information on provider type or physician reimbursement, which may explain some of the variation in clinical triage patterns.

Identifying opportunities to improve the value of care provided to patients is especially important for hospitals and clinicians operating in an increasingly costly healthcare environment with greater resource constraints.\textsuperscript{38–40} Our findings demonstrate that a significant number of hospitals in the United States triage many more patients with HF to their ICUs relative to other hospitals without achieving better in-hospital RSMRs. Given the high price of ICU admission, it is plausible that some hospitals may be engaging in a low-value, high-cost behavior.
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Disclosures
Dr Krumholz reports that he is the recipient of a research grant from Medtronic, Inc through Yale University and is chair of a cardiac scientific advisory board for UnitedHealth. The other authors report no conflicts.

References
CLINICAL PERSPECTIVE

Increasing attention is being focused on identifying costly hospital practices that do not necessarily lead to improved patient outcomes. Intensive care units (ICUs) account for 20% to 35% of total hospital costs, yet few studies have examined hospital patterns of ICU use for patients admitted with heart failure (HF) and whether these rates are associated with improved patient outcomes. In the present observational study, we describe patterns of ICU use for patients admitted with HF among a diverse group of 341 US hospitals. Once we observed the variation in the use of ICUs, we compared groups of hospitals with distinct patterns of ICU use in terms of their management of HF within the ICU and in-hospital mortality rates. We found substantial variation in ICU admission rates across hospitals with the top quartile of hospitals admitting 32% of patients on average directly to the ICU compared with only 8% of patients at hospitals in the other quartiles ($P<0.0001$). In top-quartile hospitals, treatments requiring an ICU were used less often, including mechanical ventilation, noninvasive positive-pressure ventilation, vasopressors and/or inotropes, and vasodilators. Overall HF in-hospital risk-standardized mortality was similar (3.4% versus 3.5%; $P=0.2$). Our findings demonstrate that a substantial number of hospitals triage many more patients with HF to their ICUs relative to other hospitals without achieving better in-hospital mortality outcomes. Given the high price of ICU admission, it is plausible that some hospitals may be engaging in a low-value, high-cost behavior. Such findings indicate the potential positive impact of creating guidelines to aid practitioners in the decision of whether to use the ICU for patients admitted with HF.

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**Supplemental Table 1. Selected comorbidities.**

Valvular disease
Pulmonary circulation disease
Peripheral vascular disease
Paralysis
Other neurological disorders
Chronic pulmonary disease
Diabetes without chronic complications
Diabetes with chronic complications
Hypothyroidism
Renal failure
Liver disease
Acquired immune deficiency syndrome
Lymphoma
Metastatic cancer
Solid tumor without metastasis
Rheumatoid arthritis/collagen vascular disease
Coagulopathy
Obesity
Weight loss
Fluid and electrolyte disorders
Chronic blood loss anemia
Deficiency anemias
Alcohol abuse
Drug abuse
Psychoses
Depression
Hypertension
Disorders of lipid metabolism
Coronary atherosclerosis and other heart disease
Acute myocardial infarction
Peripheral and visceral atherosclerosis
Aortic, peripheral and visceral artery aneurysms
Aortic and peripheral arterial embolism or thrombosis
Transient cerebral ischemia
Cardiac dysrhythmias
Cardiac arrest and ventricular fibrillation
## Supplemental Table 2. Hospital cohort characteristics.

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<th>Bottom Quartile (n=86)</th>
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HF, heart failure; ICU, intensive care unit
**Supplemental Table 3. Proportion of ICU days receiving ICU-level therapy.**

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<tr>
<th>Therapy</th>
<th>Usage of therapy (Proportion of bed-days)</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Top Quartile (N=31,066)</td>
<td>Quartile 3 (N=15,396)</td>
<td>Quartile 2 (N=8,795)</td>
<td>Bottom Quartile (N=4,452)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mechanical ventilation</td>
<td>6</td>
<td>15</td>
<td>14</td>
<td>19</td>
<td>&lt;0.0001</td>
<td></td>
</tr>
<tr>
<td>NPPV</td>
<td>8</td>
<td>17</td>
<td>22</td>
<td>23</td>
<td>&lt;0.0001</td>
<td></td>
</tr>
<tr>
<td>Vasopressors and/or inotropes</td>
<td>9</td>
<td>15</td>
<td>16</td>
<td>19</td>
<td>&lt;0.0001</td>
<td></td>
</tr>
<tr>
<td>Vasodilators</td>
<td>6</td>
<td>12</td>
<td>13</td>
<td>13</td>
<td>&lt;0.0001</td>
<td></td>
</tr>
<tr>
<td>Pulmonary artery catheter</td>
<td>0.7</td>
<td>0.4</td>
<td>0.6</td>
<td>0.7</td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td>None of these interventions*</td>
<td>74</td>
<td>52</td>
<td>47</td>
<td>42</td>
<td>&lt;0.0001</td>
<td></td>
</tr>
</tbody>
</table>

*No intervention includes mechanical ventilation, NPPV, vasopressors and/or inotropes, vasodilators, pulmonary artery catheter, dialysis, and intra-aortic balloon pump.

ICU, intensive care unit; NPPV, non-invasive positive pressure ventilation.
Supplemental Table 4. Proportion of patients receiving ICU-level therapy.

<table>
<thead>
<tr>
<th>Therapy</th>
<th>Top Quartile (N=8,830)</th>
<th>Quartile 3 (N=5,273)</th>
<th>Quartile 2 (N=3,383)</th>
<th>Bottom Quartile (N=1,683)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanical ventilation</td>
<td>7</td>
<td>15</td>
<td>13</td>
<td>16</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>NPPV</td>
<td>14</td>
<td>28</td>
<td>33</td>
<td>36</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Dialysis</td>
<td>0.01</td>
<td>0.08</td>
<td>0.03</td>
<td>0.30</td>
<td>0.0006</td>
</tr>
<tr>
<td>Vasopressors and/or inotropes</td>
<td>9</td>
<td>16</td>
<td>17</td>
<td>22</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Vasodilators</td>
<td>16</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Intra-aortic balloon pump</td>
<td>0.2</td>
<td>0.3</td>
<td>0.4</td>
<td>1</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Pulmonary artery catheter</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>0.08</td>
</tr>
</tbody>
</table>

ICU, intensive care unit; NPPV, non-invasive positive pressure ventilation
## Supplemental Table 5. Patient mortality.

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Category</th>
<th>N</th>
<th>Mortality rate (%)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-hospital mortality for heart failure patients triaged to ICU</td>
<td>Top Quartile</td>
<td>8,830</td>
<td>4%</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td></td>
<td>Quartile 3</td>
<td>5,273</td>
<td>7%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Quartile 2</td>
<td>3,383</td>
<td>8%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bottom Quartile</td>
<td>1,683</td>
<td>11%</td>
<td></td>
</tr>
<tr>
<td>Risk-standardized in-hospital mortality*</td>
<td>Top Quartile</td>
<td>86</td>
<td>3.4 (3.0, 3.9)</td>
<td>0.41</td>
</tr>
<tr>
<td></td>
<td>Quartile 3</td>
<td>84</td>
<td>3.3 (3.1, 4.2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Quartile 2</td>
<td>85</td>
<td>3.4 (3.0, 4.3)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bottom Quartile</td>
<td>73</td>
<td>3.6 (3.2, 4.1)</td>
<td></td>
</tr>
</tbody>
</table>

*Includes entire patient cohort (ICU and non-ICU)
†Calculated using a 2-sided Kruskal-Wallis test
ICU, intensive care unit
Supplemental Figure 1.

Histogram of ICU Admission Rates Across Hospitals

Number of Hospitals

ICU Admission Rate (%)
Supplemental Figure Legend.

Histogram of ICU Admission Rates Across Hospitals (N=328).