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SHORT REPORT
Heart failure

Outcomes of heart failure hospitalizations at urban teaching vs. Non-Teaching Hospitals: A Nationwide Propensity Score Matched Analysis in the United States

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Aims

Heart failure (HF) continues to be a major cause of morbidity and mortality worldwide, placing a significant burden on healthcare systems. Differences in the outcomes of HF hospitalizations for adults in teaching vs. non-teaching hospitals in urban settings are uncertain. We evaluated outcomes of HF hospitalizations in patients hospitalized in urban teaching vs. non-teaching hospitals in the United States.

Methods and results

HF hospitalizations were abstracted from the 2016 through 2022 Nationwide Readmissions Database and stratified into urban teaching vs. urban non-teaching hospital settings. Propensity-score matching was used to control for baseline differences between teaching and non-teaching hospital cohorts. Logistic regression and lognormal models were estimated to assess differences in inpatient mortality, length of stay (LOS), total costs, complications, and 30-day and 90-day all-cause readmissions. A total of 7 558 299 weighted HF hospitalizations were included in the analysis, of which 76.3% involved urban teaching hospitalizations. Compared to urban non-teaching, HF hospitalizations in urban teaching hospitals were associated with significantly higher odds of inpatient mortality (OR 1.19, 95% confidence interval [CI]: 1.16–1.22), complications including cardiogenic shock, cardiac arrest, Intra-aortic balloon pump, cardiopulmonary resuscitation, extracorporeal membrane oxygenation and mechanical ventilation use as well as more extended hospital LOS, higher total costs, palliative care consultation and readmissions rates (all $P < 0.001$). 30-day and 90-day all-cause readmission rates were also statistically higher in teaching hospitals, though the difference was clinically non-significant.

Conclusion

HF hospitalizations in urban teaching hospitals were associated with higher inpatient mortality, complication rates, resource utilization, and palliative care consult rates than urban non-teaching hospitals.

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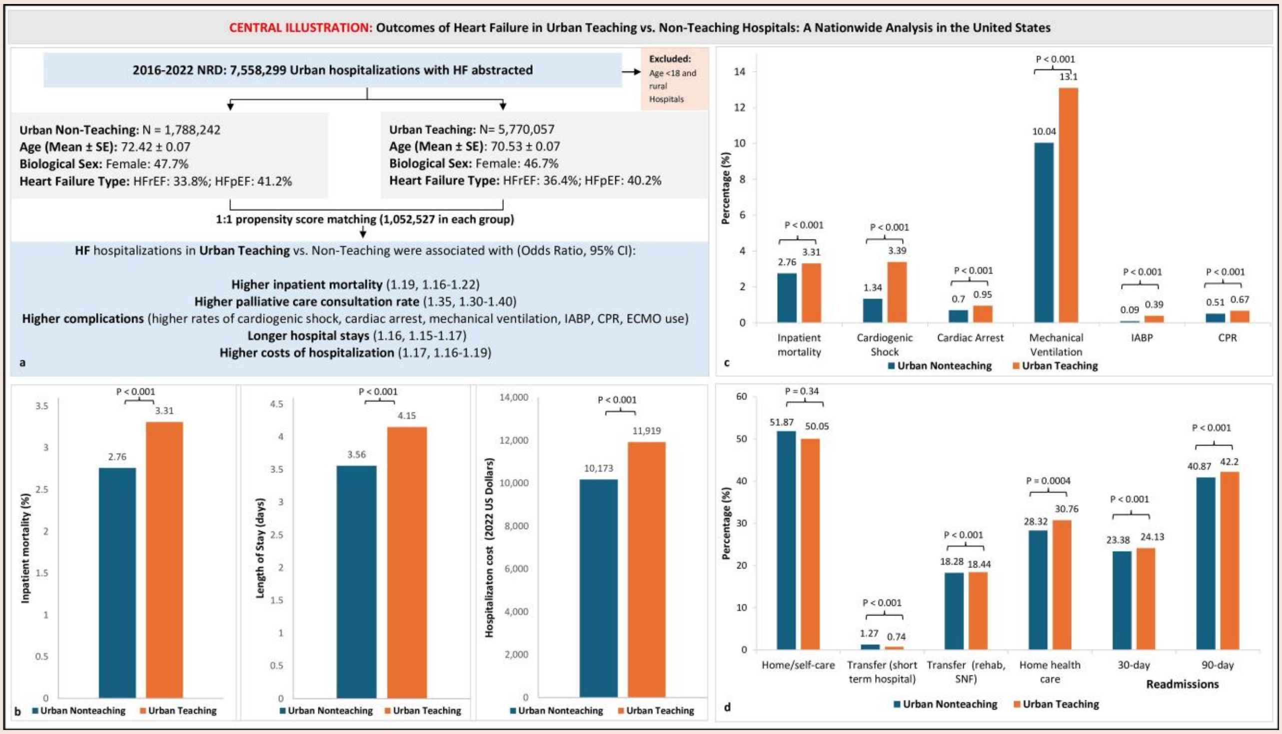
Graphical abstract



Keywords Healthcare outcomes • Heart Failure • Hospitalizations • United States • Urban • Teaching

Introduction

Heart failure (HF) is a major cause of morbidity and mortality worldwide. An estimated 1.27 million HF hospitalizations were reported in 2018, and $18.5 billion in HF hospitalization costs were reported in 2021 in the United States.[1,2] Teaching hospitals are often better equipped with advanced resources and specialized teams than non-teaching hospitals. Several studies have evaluated differences in outcomes between all-cause hospitalizations at teaching vs. non-teaching hospitals. According to data from the National Hospital Discharge Survey, approximately 61.2% of hospitals in the United States are located in urban areas, with 33.8% being teaching hospitals and 66.2% being non-teaching hospitals.[3] For a hospital to qualify as a teaching hospital in the United States, it needs one of the following: Have ≥1 residency program accredited by the Accreditation Council for Graduate Medical Education (ACGME), be affiliated with the Council of Teaching Hospitals (COTH), or maintain a full-time equivalent ratio of interns and residents to beds of ≥0.25.[4] Differences in outcomes of HF hospitalizations between urban teaching and non-teaching hospitals in the United States have not been reported.

Methods

Hospitalization discharge data 2016–2022 were abstracted from the Nationwide Readmission Database (NRD) of the Healthcare Cost and Utilization Project (HCUP), sponsored by the Agency for Healthcare Research and Quality (AHRQ). These data are deidentified, HIPPAA-compliant, publicly available, and when weighted, represent approximately 35 million annual discharges within the United States.[5]

Index hospitalizations of adults (≥18 years of age) that included a primary discharge diagnosis of HF (ICD-10-CM: I09.81, I11.0, I13.0, I13.2, I50.–) were identified using ICD-10 clinical modification (CM) codes (*Table 1*); hospitalizations in non-metropolitan areas were excluded. The Creighton University Institutional Review Board acknowledged this study as 'not human subjects research' (InfoEd record 2005559). The primary study outcome was all-cause inpatient mortality. Secondary outcomes included total cost (inflation-adjusted to 2022 US dollars), hospital length of stay (LOS), 30– and 90-day readmissions, and inpatient complications [cardiogenic shock, cardiac arrest, Intra-aortic balloon pump (IABP), cardiopulmonary resuscitation (CPR), extracorporeal membrane oxygenation (ECMO), mechanical ventilation, blood transfusion, and discharge disposition]). Patient baseline characteristics were stratified by hospital type (urban teaching vs. urban non-teaching). Patients were propensity score matched 1:1 using a greedy algorithm (caliper size set to 0.05) without replacement. For outcomes excluding our identified inpatient complications, PSMATCH covariates included demographic variables (age, sex, primary payer, zip-code-based income quartile, hospital bed size), type of HF, i.e. heart failure with reduced ejection fraction (HFrEF) and heart failure with preserved ejection fraction (HFpEF), Palliative care consult, and clinical comorbidities listed in *Table 2*. Secondary inpatient complication outcomes, including cardiogenic shock, acute respiratory failure, mechanical ventilation, vasopressors, use of an Intra-Aortic balloon pump (IABP), Extracorporeal Membrane Oxygenation (ECMO), Acute dialysis, cardiopulmonary resuscitation (CPR), blood transfusion, MI, Stroke were used as surrogates for the severity of HF for analysis of non-complication outcomes. These were matched using similar methods but excluded from the analysis model for inpatient complication outcomes. *Table 3* shows standardized mean differences for the two models. Logistic regression models assessed differences in outcomes. Lognormal regression models were used to evaluate differences in resource utilization.

Results

From 2016 through 2022, an estimated weighted total of 7 558 299 urban hospitalizations with a primary discharge diagnosis of HF occurred in the United States, comprised of 1 788 242 (23.7%) urban non-teaching and 5 770 057 (76.3%) urban teaching hospitalizations. Among HF hospitalizations, 41% and 36% were HFpEF and HFrEF, respectively. Pre-match demographic and clinical characteristics are presented in *Table 2*. Urban teaching hospitals had a greater proportion of patients with Medicaid as their primary payer and a smaller proportion of patients with Medicare as their primary payer. Urban teaching hospitals also had a higher proportion of patients with incomes in the lowest quartile and a higher baseline cumulative comorbidity burden (*Table 2*).

All non-teaching hospitalizations were successfully matched (unweighted 1 052 527 non-teaching with 1 052 527 teaching). Compared to urban non-teaching, HF hospitalizations in urban teaching hospitals were associated with 19% higher odds of in-hospital mortality [2.76% vs. 3.31%; OR 1.19, 95% confidence interval (CI) 1.16–1.22]; had higher complications, including cardiogenic shock (1.34% vs. 3.39%: OR 2.51, 95% CI 2.39–2.63), cardiac arrest (0.70% vs. 0.95%: OR 1.34, 95% CI 1.29–1.39), CPR (0.51% vs. 0.67%: OR 1.29, 95% CI, 1.23–1.35), and use of ECMO (<0.01% vs. 0.08%: OR 20.31, 95% CI 13.1–31.4), IABP (0.09% vs. 0.39%: OR 4.38, 95% CI 3.84–5.00) and mechanical ventilation (10.04% vs. 13.10%: OR 1.32, 95% CI 1.27–1.37) and higher hospitalization cost ($10 173 vs. $11 919: ratio 1.17, 95% CI 1.16–1.19), longer LOS (3.56 days vs. 4.15 days: OR 1.16, 95% CI 1.15–1.17) and a greater palliative care consultation rate (ratio 1.35 (95% CI 1.30–1.40) (all $P < 0.001$) (*Graphical abstract*). The 30-day and 90-day readmissions and home discharges were similar for teaching and non-teaching hospitals. Subgroup analyses for HFrEF (2.84% vs. 3.36%; OR 1.15, 95% CI 1.11–1.19) and HFpEF (2.54% vs. 2.91%; OR 1.26, 95% CI 1.22–1.30) showed consistent findings with higher inpatient mortality in urban teaching hospitals than in urban non-teaching hospitals.

Table 1 Diagnostic and procedural codes used to identify inclusion criteria, clinical characteristics, and complications

Diagnoses	ICD-10-CM
Heart failure	I09.81, I11.0, I13.0, I13.2, I50.x
Heart failure with preserved ejection fraction	I50.3
Heart failure with reduced ejection fraction	I50.2
Obstructive Sleep apnea	G47.33
COVID-19	U07.1, U00, U49
Dyslipidemia	E78.-
Tobacco use	F17.2, Z72.0, Z87.891
Prior ICD	Z95.810
Previous cerebrovascular disease	Z86.73, I69.-
Previous CABG	Z95.1, I25.7, I25.810, I25.812
Previous PCI	Z98.61, Z95.5
Prior cardiac arrest	Z86.74
Palliative care consultation	Z51.5
Cardiogenic shock	R57.0
Cardiac arrest	I46.-
Acute kidney injury	N99.0, N17.9
Procedures	ICD-10-PCS
IABP	5A02210
CPR	5A12012
ECMO	5A15223, 5A1522F, 5A1522G
Mechanical ventilation	5A1945Z, 5A1955Z, 5A1935Z, 5A09357, 5A09457, 5A09557
Blood transfusion	30243N0, 30243N1, 30243P0, 30243P1, 30243H0, 30243H1, 30240N0, 30240N1, 30240P0, 30240P1, 30240H0, 30240H1, 30230H0, 30230H1, 30230N0, 30230N1, 30230P0, 30230P1, 30233N0, 30233N1, 30233P0, 30233P

ICD-10-CM = International Classification of Diseases, Tenth Revision, Clinical Modification, Coding System.
ICD-10-PCS = International Classification of Diseases, Tenth Revision, Procedural Coding System.

Discussion

Our study revealed that HF hospitalizations in urban teaching hospitals are associated with higher inpatient mortality, inpatient complications, hospitalization costs, longer hospital stays, and higher palliative care consult rates compared to non-teaching hospitals. However, readmissions and home discharges were similar for teaching and non-teaching hospitals. That urban teaching hospitals had higher inpatient HF mortality than urban non-teaching hospitals contradicts previous all-cause hospitalization data. One study using data from the Centers for Medicare & Medicaid Services (CMS) Virtual Research Data Center (VRDC) reported lower 30-day mortality in teaching hospitals compared to non-teaching hospitals (10.7% vs. 12%).[6] Similarly, data from Medicare Provider Analysis and Review files reported an adjusted 30-day post-discharge mortality rate that was 11.55% lower in teaching hospitals.[7]

Despite propensity matching, higher mortality rates observed in teaching hospitals may reflect referral bias for critically ill patients referred to teaching hospitals for advanced and specialized care.[8] The present study revealed higher rates of cardiogenic shock, cardiac arrest, and CPR, IABP, ECMO, mechanical ventilation, and blood transfusion in urban teaching hospitals. Although ECMO and IABP can provide hemodynamic support, they are associated with an increased risk of complications, including bleeding, infection, and limb ischemia.[9] These advanced therapies are predominantly available in teaching hospitals, with more resources and specialized expertise. Teaching hospitals treat more advanced HF, with a higher risk of developing cardiogenic shock, contributing to higher mortality in this group. Additionally, most rural hospitals are non-teaching,

Table 2 Pre-match demographic and clinical characteristics

Characteristics	Urban Nonteaching	Urban Teaching
Hospitalizations for HF (%)	23.7	76.3
Age (mean, SE)	72.42 (0.07)	70.53 (0.07)
Female (%)	501983 (47.7)	1479512 (48.0)
Primary payer (%)		
Medicare	796932 (75.7)	2290315 (72.3)
Medicaid	110534 (10.0)	401952 (12.3)
Private Insurance	96978 (9.4)	335291 (10.8)
Other	52464 (5.0)	140378 (4.4)
Hospital bed size (%)		
Small	164738 (15.7)	623891 (20.3)
Medium	324104 (30.8)	915236 (27.8)
Large	563685 (53.6)	1632895 (51.9)
Income		
0–25th	275025 (26.1)	963147 (32.1)
26th—50th	310202 (29.5)	786210 (25.5)
50th—75th	269445 (25.6)	761200 (23.4)
75th—100th	184350 (17.5)	627040 (18.0)
Clinical characteristic		
Type of HF (%)		
Heart failure with reduced ejection fraction	355979 (33.8)	1155491 (36.4)
Heart failure with preserved ejection fraction	433411 (41.2)	1275070 (40.2)
Comorbid conditions (%)		
History of cerebrovascular disease	138450 (13.2)	425065 (13.4)
History of myocardial infarction	149972 (14.2)	461664 (14.6)
Obstructive sleep apnea	153078 (14.5)	534457 (16.8)
COVID-19	5331 (0.5)	24604 (0.8)
Dyslipidemia	585615 (55.6)	1785546 (56.3)
Tobacco	442158 (42)	1333833 (42)
History of implantable cardioverter-defibrillator	89050 (8.5)	300185 (9.5)
History of percutaneous coronary intervention	139550 (13.3)	413279 (13)
History of coronary artery bypass grafting	149497 (14.2)	411043 (13)
History of cardiac arrest	5715 (0.5)	24224 (0.8)
Charlson comorbidity index (mean ± SE)	4.22 ± 0.01	4.38 ± 0.01
Congestive heart failure	1052519 (100)	3171998 (100)
Peripheral vascular disease	188422 (17.9)	616356 (19.4)
Stroke	24209 (2.3)	76988 (2.4)
Dementia	100108 (9.5)	276545 (8.7)
Chronic obstructive pulmonary disease	434682 (41.3)	1212895 (38.2)
Rheumatic diseases	32004 (3)	103203 (3.3)
Peptic ulcer disease	7488 (0.7)	24126 (0.8)
Liver disease (mild)	40130 (3.8)	146600 (4.6)
Diabetes without clinical complications	181309 (17.2)	488386 (15.4)
Renal disease (mild)	465025 (44.2)	1449177 (45.7)
Diabetes with clinical complications	329156 (31.3)	1080498 (34.1)
Paralysis	4378 (0.4)	15620 (0.5)
Malignancy	33479 (3.2)	112063 (3.5)
Liver disease (severe)	9173 (0.9)	35363 (1.1)
Renal disease (severe)	98601 (9.4)	337263 (10.6)
Metastatic tumor	10838 (1)	37158 (1.2)
Acquired immunodeficiency syndrome	99012 (9.4)	310216 (9.8)

Table 3 Standardized mean differences before and after the match for match quality: baseline and post-match descriptives (matching covariates) by teaching status of the hospital in urban setting

Standardized mean differences (treated—control)	Model 1 Baseline	Matched	Model 2 Baseline	Matched
Age	−0.12	−0.06	−0.12	−0.05
Female	−0.02	−0.07	−0.02	−0.08
Medicare	−0.08	−0.05	−0.08	−0.08
Medicaid	0.07	−0.01	0.07	0.01
Private insurance	0.05	0.04	0.05	0.07
Other insurance	0.00	0.05	0.00	0.05
Zip code income quartile 1	0.09	−0.04	0.09	−0.05
Zip code income quartile 2	−0.11	0.04	−0.11	0.03
Zip code income quartile 3	−0.04	0.01	−0.04	0.02
Zip code income quartile 4	0.06	−0.02	0.06	−0.01
Hospital bed size (small)	0.11	0.00	0.11	−0.01
Hospital bed size (medium)	−0.04	0.04	−0.04	0.03
Hospital bed size (large)	−0.04	−0.04	−0.04	−0.02
Acute respiratory failure	−0.03	0.09	−0.03	0.06
Vasopressors	0.04	0.01	0.04	0.01
Acute dialysis	0.03	0.07	0.03	0.07
Palliative care consult	0.04	0.06	0.04	0.06
Heart failure with reduced ejection fraction	0.06	0.02	0.06	0.00
Heart failure with preserved ejection fraction	−0.02	−0.07	−0.02	−0.08
COVID	0.03	0.02	0.03	0.02
Myocardial infarction	0.03	0.10	0.03	0.13
Stroke	0.01	0.07	0.01	0.07
History of implantable cardioverter-defibrillator placement	0.04	0.08	0.04	0.07
History of coronary artery bypass graft	−0.04	0.12	−0.04	0.13
History of cardiac arrest	0.03	0.03	0.03	0.03
History of percutaneous coronary intervention	−0.01	0.09	−0.01	0.12
Renal disease (severe)	0.04	0.08	0.04	0.09
Liver disease (severe)	0.02	0.03	0.02	0.04
Dementia	−0.03	0.06	−0.03	0.06
Chronic obstructive pulmonary disease	−0.06	0.08	−0.06	0.07
Obstructive sleep apnea	0.06	0.08	0.06	0.06
Metastatic cancer	0.01	0.04	0.01	0.05
Malignancy	0.02	0.06	0.02	0.08
Diabetes with complications	0.06	0.10	0.06	0.06
Renal disease (Mild)	0.03	0.03	0.03	0.01
Liver disease (Mild)	0.04	0.05	0.04	0.07
Peripheral vascular disease	0.04	0.12	0.04	0.11
Acquired immunodeficiency syndrome	0.01	0.10	0.01	0.13
Cardiogenic shock	0.12	0.01	—	—
Cardiac arrest	0.02	0.03	—	—
Mechanical vent	0.05	0.09	—	—
Intra-aortic balloon pump	0.06	0.00	—	—
Extracorporeal Membrane Oxygenation	0.04	0.00	—	—
Cardiopulmonary resuscitation	0.01	0.03	—	—
Blood transfusion	0.01	0.08	—	—

Model 1 was used for inpatient mortality, length of stay, hospitalization cost, discharge disposition, and readmission. Model 2 was used for complication outcomes.

potentially contributing to a higher mortality rate in non-teaching hospitals within these studies due to socioeconomic factors and reduced access to care.[10] Teaching hospitals also typically have more robust palliative care infrastructure. This may contribute to higher inpatient mortality by facilitating an in-patient transition to comfort care. The present findings of greater LOS and costs in urban teaching hospitals are consistent with all-cause hospitalization data from CMS VRDC.[6] Teaching and non-teaching hospitals had an equal proportion of discharges to home and subsequent readmissions, aligning with prior all-cause hospitalization literature.[6,7] Teaching hospitals may have more robust discharge planning resources to reduce readmissions and achieve specific quality metrics, which counteract the effect of their sicker patient cohort.

The present study is admittedly limited by its retrospective nature and the limitations of the NRD's design. One hypothesized reason for higher acute HF mortality in urban teaching hospitals is that, in many US communities, these institutions serve as safety-net hospitals. This unique role exposes them to patient populations with significantly higher baseline risk and adverse social determinants of health. Despite propensity score matching on all available demographic and clinical factors, residual and unmeasured confounding factors may remain and influence our results. It is worth emphasizing that the lack of availability of inpatient acuity variables, admission vital signs, and admission blood test data to account for the severity of illness at the time of hospital admission, which can significantly impact outcomes, limits the interpretation of our findings. Moreover, NRD lacks data on the duration of HF or the time since the first HF hospitalization, as well as on drug use, which could provide essential insights into the distinctness of patient profiles and clinical care across the two different settings and further adds to the limitations. Our study is hypothesis-generating and calls for further evaluation using more robust, granular data. Given these limitations, our findings reflect case-mix differences (i.e. sicker patients treated at teaching hospitals) rather than intrinsic quality gaps between teaching and non-teaching hospitals.

Conclusion

HF hospitalizations in urban teaching hospitals were associated with higher inpatient mortality, complication rates, resource utilization, and palliative care consult rates than urban non-teaching hospitals. These findings likely reflect case-mix differences rather than quality-of-care gaps, and further research is needed to address this gap.

Data availability

All data from the National Readmission Database are available for purchase through HCUP at https://hcup-us.ahrq.gov/nrdoverview.jsp.

Author contribution

Ali Bin Abdul Jabbar (Conceptualization [lead], Methodology [equal], Validation [equal], Visualization [lead], Writing—original draft [lead], Writing—review & editing [lead]), Muhammad Abdullah Javed (Methodology, Writing—original draft [equal], Writing—review & editing [equal]), Alexander Hall (Data curation [lead], Formal analysis [lead], Methodology [equal], Software [lead], Validation [equal], Writing—Original Draft, Writing—Review & Editing, Visualization), Mahmoud Ismayl (Supervision [equal], Writing—original draft [equal], Writing—review & editing [equal]), Andrew M. Goldsweig (Supervision [equal], Writing—original draft [equal], Writing—review & editing [equal]), and Ahmed Aboeata (Supervision [equal], Writing—original draft [equal], Writing—review & editing [equal])

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