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Acute but not chronic heart failure is associated with higher mortality among patients hospitalized with pneumonia: An analysis of a nationwide database☆

Essa Hariri[a],

Niti G. Patel[b],

Elias Bassil[a],

Milad Matta[a],

Pei-Chun Yu[c],

Quinn R. Pack[d],

Michael B. Rothberg[c,*]

[a]Department of Internal Medicine, Cleveland Clinic, Cleveland, Ohio, United States

[b]Department of Medicine, Northwestern Medicine, Chicago, ILChicago

[c]Center for Value-Based Care Research, Cleveland Clinic, Cleveland, Ohio, United States

[d]Division of Cardiovascular Medicine, Baystate Medical Center, Springfield, MA, United States

Abstract

Background: Among patients admitted for pneumonia, heart failure (HF) is associated with worse outcomes. It is unclear whether this association is due to acute HF exacerbations, complex medical management, or chronic co-morbid conditions.

Methods: This is a retrospective cohort study of patients admitted between July 2010 and June 2015 at 651 US hospitals with a principal diagnosis of either pneumonia or secondary diagnosis of pneumonia with a primary diagnosis of respiratory failure or sepsis. Comorbidities were identified by ICD-9 codes and medical management by daily charge codes. Patients were categorized according to the presence and acuity of admission diagnosis of HF. In-hospital mortality was the primary outcome. Secondary outcomes included length of stay, hospital cost, ICU admission, use of mechanical ventilation, vasopressors and inotropes. Logistic regression was used to study the association of outcomes with presence and acuity of HF.

Results: Of 783,702 patients who met inclusion criteria, 212,203 (27%) had a diagnosis of HF. Of these, 56,306 (26.5%) had acute while 48,188 (22.7%) had chronic HF on admission; 51% had a diagnosis of unspecified HF. In multivariable-adjusted models, having any HF was associated with increased mortality (OR 1.35 [1.33 – 1.38]) compared to those without HF;

*Corresponding author. rothbem@ccf.org (M.B. Rothberg).

☆All authors contributed significantly and had a role in writing the manuscript.

Supplementary materials

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increased mortality was associated with acute HF (OR 1.19 [1.15 – 1.22]) but not chronic HF (OR 0.92 [0.89 – 0.96]).

Conclusion: The worse outcomes for pneumonia patients with HF appear due to acute HF exacerbations. Adjustment for HF without accounting for chronicity could lead to biased prognostic and billing estimates.

Introduction

Pneumonia is the leading cause of hospital admission and infectious disease-related death in the United States.[1] About 1 million adults in the US are hospitalized due to pneumonia every year, and 50,000 of them die.[2,3] Moreover, pneumonia is responsible for a great loss of disability-adjusted life years and is a major economic burden,[1] with total annual costs of approximately $8.5 billion dollars.[4, 5]

With an increase in the proportion of people aged 65 years or older in the US, the prevalence of chronic conditions such as heart failure (HF) is expected to increase. Thus, understanding the impact of HF on patient care is increasingly important. Among patients hospitalized for pneumonia, more than one in three has HF.[6, 7] Both conditions are intertwined and exacerbate each other; HF is a major predisposing factor for pneumonia,[8] and one of the most common cause of acute HF exacerbation is acute respiratory illness.[9] Those with pneumonia and HF concurrently have a higher mortality than those without HF.[10, 11] Furthermore, pneumonia-associated healthcare costs are the highest among patients with heart failure.[5]

Exactly how HF worsens outcomes in pneumonia is not known. It is possible that acute exacerbations of HF compromise respiratory functioning, leading to respiratory failure and death. It is also possible that HF is simply a marker of comorbid disease, as patients with HF tend to be older and have multiple comorbidities. Lastly, underlying cardiac dysfunction may contribute to hypoperfusion and organ failure or predispose patients to fatal arrhythmias. Careful adjustment for comorbid conditions, as well as an appreciation for the difference between acute and chronic HF could help to differentiate among these possibilities. However, studies investigating the impact of comorbidities on pneumonia outcomes have considered HF as a single condition and may have been limited in their ability to adjust for co-morbid conditions.

Because HF is known to be associated with mortality, pneumonia pay-for-performance models often adjust for HF as a comorbid condition.[12, 13] However, these models do not differentiate between acute and chronic HF and thus can over- or underestimate the importance of this factor if chronicity has an impact on outcomes. Understanding the contribution of acute versus chronic HF could allow for more accurate adjustment in these models.

Using a database of patients from 651 US hospitals, we describe the prevalence, characteristics, treatment, cost, and in-hospital outcomes of patients admitted for pneumonia with or without HF and compare the difference in outcomes between those who have acute

HF versus and chronic HF to understand the independent contribution of each to outcomes of pneumonia.

Methods

Design, setting, and subjects

We conducted a retrospective cohort study of patients admitted with pneumonia between July 1, 2010, and June 30, 2015, to a geographically and structurally diverse group of 651 US hospitals that contributed data to the Premier Database, a voluntary all-payer inpatient database. Along with the standard hospital discharge abstract (i.e.UB-04), the database contains logs of items and services charged including: medications, laboratory and radiologic tests, and services such as respiratory and physical therapy. Physician charges are not included. Three-fourth of hospitals report actual hospital costs derived from internal cost-accounting systems. The remainder estimate cost using Medicare cost-to-charge ratios. Data collected electronically from participating sites is audited regularly to ensure validity. The database encompasses approximately 25% of all annual US hospital admissions[14] and has been used extensively in clinical epidemiologic and outcomes research.[6, 15, 16]

We identified all adult (age ≥ 18) patients admitted with pneumonia. Cases were identified by an ICD-9-CM principal diagnosis code of pneumonia (481–488 or 507.0) present on admission or a secondary diagnosis code of pneumonia present on admission paired with a principal diagnosis of respiratory failure (518.81 and 518.84), acute respiratory distress syndrome (769), respiratory arrest (799.1), sepsis (995.91, 995.92) or influenza (487, 488). Each patient also had a chest radiograph and received antimicrobials for at least the first 3 hospital days or until death or discharge. We excluded patients transferred from or to other acute care facilities as neither their treatment nor outcomes could be assessed. Other exclusion criteria included a length of stay <2 days, cystic fibrosis, ventilator-associated pneumonia, and a Medicare Severity Diagnosis-Related Group inconsistent with pneumonia. Details of inclusion and exclusion criteria appear in Fig. 1. Because the Premier database does not contain identifiable patient information, the Institutional Review Board at the Cleveland Clinic determined that this study did not constitute human subjects research.

Data extraction for HF

We defined HF as a secondary diagnosis and based on the following ICD −9 codes: 428.xx and 402.01, 402.11, 402.91, 404.01, 404.03, 404.11, 404.13, 404.9; and categorized it as acute (ICD-9 code: 428.21, 428.23, 428.31, 428.33, 428.41, 428.43) or chronic (ICD-9 code: 428.22, 428.32, 428.42) HF (Table 1). In order to avoid uncertainties in ICD-9 codes given to patients with acute or chronic HF and established a specified chronicity to the study groups, we excluded subjects with a diagnosis code of congestive HF (not otherwise specified) or unspecified HF from the analysis comparing acute and chronic HF. This was done after comparing the baseline characteristics and management of patients with those excluded subjects to subjects with a diagnosis code of chronic HF, which did not show any major differences (supplementary table 1). We also excluded patients whose first episode of HF developed in the hospital as we have a not-present-admission indicator for all HF diagnoses.

Patient and hospital information

Patients' age, sex, race, primary insurance coverage, marital status, and admitting physician's specialty were recorded. In addition, we considered 30 unique co-morbidities that were present on admission. Some co-morbidities were identified directly using ICD-9 codes, while other comorbidities were assigned using the Elixhauser Comorbidity Software, which has been used to predict in-hospital cost and mortality.[11, 17] Hospital characteristics included number of beds, teaching status, geographic region and urban/rural location.

Study outcomes

We assessed inpatient mortality as the primary outcome. The secondary outcomes include length of stay, median cost, need for intensive care unit (ICU), acute kidney injury (AKI), use of invasive mechanical ventilation (IMV), vasopressors or inotropes at any time during hospitalization. Cost was inflation-adjusted to 2015 dollars using the medical care component of consumer price index.

Statistical analyses

We used summary statistics to compare patients with and without heart failure and between patients with acute versus chronic heart failure. Frequencies and proportions were used for categorical data and medians and interquartile ranges for continuous variables, and comparisons of proportions were made using Pearson's chi-square. We did not apply weighted propensity matching weights to the data. Mixed logistic regression analyses were used to examine the association between the presence and type of HF with the primary and secondary outcomes (AKI, IMV and need for vasopressor, or inotropes) as well as the association of acute versus chronic HF with the study outcomes. Log-linked gamma general linear mixed models were used for length of stay and cost. All models were adjusted for baseline demographic, co-morbidities, insurance status, Elixhauser comorbidities, and hospital characteristics. We did not report p-values when comparing crude differences between the study groups given their limited utility with the large sample size of the analyses. All analyses were performed using the Statistical Analysis System, version 9.4 (SAS Institute Inc).

Results

Patient characteristics

Baseline demographic, hospital and medical characteristics of the study patients are summarized in Table 2. Of 783,702 patients who met our inclusion criteria, 212,203(27.1%) had a secondary diagnosis of HF. Among patients who had HF, 56,133 (26.5%) had acute HF, 48,160 (22.7%) had chronic HF, and 51% had unspecified HF. The median age of the included patients was 72 [interquartile range (IQR): 59 – 83], and the majority were white (74.5%) and females (51.5%).

Compared to patients without HF, those with HF were older (78 [IQR: 56 – 81] vs 70 [IQR: 68 – 86] years) and sicker, with a higher median comorbidity score (5 [IQR: 1 – 4] vs. 2 [IQR: 4 – 7] $p<0.001$). Specifically, they were more likely to be diagnosed with chronic conditions including hypertension (76.2 vs 59.7%), valvular disease (20.6 vs 5.7%), diabetes

(18.8 vs 12.0%), obesity (17.4 vs. 11.4%), obstructive sleep apnea (12.6 vs. 6.7%), chronic pulmonary disease (52.5 vs 42.3%), chronic kidney disease (20.8 vs. 9.4%), atrial fibrillation (40.2 vs 14.7%), coronary artery disease (18.1 vs 5.4%), peripheral vascular disease (13.4 vs 6.6%) and anemia (37 vs 26.3%) ($p < 0.001$ for all comparisons).

Patients with acute and chronic HF generally had similar demographics with similar median age (79 [IQR: 68 – 86] vs 78 [68 – 86]), percent female (52.3 vs 50.4%) and race (77.6 vs 77.0% of white race) as well as prevalence of chronic comorbidities. Yet, patients with acute HF had a higher prevalence of vascular diseases (26.8 vs 19.8%) including mitral (9.9 vs 6.5%), acute coronary syndrome (10.2 vs. 4.2%), and pulmonary circulation disease (20.6 vs 16.5%) compared to those with chronic HF ($p < 0.001$ for all comparisons).

Medical management

Table 3 shows the medical management with commonly used HF medications among the patients admitted with pneumonia. Patients with HF were more likely to receive anti-hypertensive medications including beta blockers (67.1 vs 37.1%), angiotensin converting enzyme inhibitors (ACEi)/angiotensin receptor blockers (ARB) (38.8 vs 26.6%), thiazide (4.0 vs 0.92%) and loop diuretics (76.6 vs 29.4%), mineralocorticoid receptor antagonists (7.6 vs 1.9%), anti-arrhythmic medications (13.8 vs 5.9%), and blood thinners during admission compared to patients without HF ($p<0.001$ for all comparisons). Additionally, patients with HF were less likely to receive isotonic fluids. Patients with acute and chronic HF had similar use of antihypertensive medications and intravenous fluid therapy (63.1 vs 55.7%; $p < 0.001$); however, there was no difference in receipt of intravenous fluids among patients with acute and chronic HF. P with acute HF received more ACEi/ARB (44.3 vs 39.0), beta blockers (76.2 vs 67.9%), digoxin (20.8 vs 16.3%), hydralazine (16.8 vs 13.2%), thiazide (92.8 vs 69.4%) and loop diuretics (6.3 vs 3.1%) compared to those with chronic HF ($p<0.001$ for all comparisons).

Patient outcomes

Compared to patients without HF, those with HF had higher inpatient mortality (13.2 vs. 8.1%), longer length of stay (6 vs. 5 days), higher hospital costs (11,709 vs. $8,175) and higher rates of AKI (34.1 vs 21%), ICU stays (41.3 vs 27.7%), vasopressor use (18.2 vs 12%), inotrope or vasodilator use (7.1 vs. 2.1%) and mechanical ventilation (21.4 vs. 12.9%) ($p<0.001$ for all comparisons) (Table 4). These findings persisted after adjusting for patient demographics, comorbidities, and hospital characteristics (Fig. 2/Supplementary table 3).

In multivariable-adjusted logistic regression, only patients with acute HF had increased in-hospital mortality compared to patients with no HF (OR 1.19, 95% CI: 1.15–1.22; $p<0.001$). On the contrary, chronic HF was associated with lower hospital mortality than no HF (OR 0.92, 95% CI: 0.89–0.96; $p <0.001$). All other study outcomes, except vasopressor use, were significantly increased with both acute HF and chronic HF compared to no HF, and acute HF had higher odds of having AKI, requiring ICU stay with use of IMV, vasopressors and inotropes/vasodilators, having longer length of stay and higher hospital cost (Fig. 2/ Supplementary table 3).

Discussion

In this observational study of more than three-quarters of a million diverse patients admitted with pneumonia to 651 US hospitals, we found that 27% of patients had a concomitant diagnosis of HF, but of those with specified chronicity, 54% represented an acute exacerbation. Expectedly, patients with HF were older and had substantially more comorbidities than those without HF. HF patients were also treated differently. They received more cardiac medications, including diuretics, and less intravenous fluids compared to patients without HF. Finally, patients with HF had outcomes that were substantially worse than those of patients without HF, including higher mortality, more treatment in ICU, longer lengths of stay and higher costs. These outcomes were not simply due to co-morbid illness, because they persisted after adjustment for demographics and co-morbidities. However, the mortality difference was limited to patients with acute exacerbations of their HF, which likely represents a direct influence of HF on mortality.

Several prior studies have examined the impact of HF on pneumonia outcomes, but most were not contemporary or reflective of current management of HF.[10,18,19,20–22] Reported odds of mortality for HF in prior studies was approximately 2.4 (95% CI: 2.1 – 2.6).[18] There are no contemporary reports on the effect of HF on pneumonia outcomes in hospitalized patients to the best of our knowledge. Also, most studies considered the prognostic impact of HF as part of a broader investigation of risk factors of pneumonia mortality rather than specifically studying patients with concomitant HF and pneumonia. Our finding that patients with HF had a 35% increased adjusted odds for mortality is lower than what has been previously reported.[10, 23, 24] Further, our analyses add to these studies in two ways. First, we examined a number of additional outcomes, including AKI, ICU admission, mechanical ventilation, use of vasopressors or inotropes, length of stay, and costs, which have not been previously reported. Specifically, close to 50% of patients with acute HF required ICU admission during their hospitalization, and more than a quarter of them were mechanically ventilated. We found that HF was associated with important increases in all of these, including an additional hospital day and an extra $1800 in adjusted costs per admission. As HF becomes more common, the complexity of pneumonia care and its cost can be expected to rise.

Our study further elucidates this relationship by examining differences in outcomes according to HF acuity. While all of our secondary outcomes were consistently worse in patients with HF, only acute HF was associated with in-hospital mortality. This finding can easily be explained. Cardiogenic pulmonary edema and respiratory distress are common manifestations of acute HF. Increased pulmonary vasculature pressures cause fluid to leak into the alveoli,[25] impairing normal gas exchange and exacerbating concurrent pulmonary conditions including pneumonia. Conversely, pneumonia may induce or worsen cardiogenic pulmonary edema in the setting of HF as cardiac output fails to meet the needs during severe infection.[26] Given the increased morbidity and mortality associated with acute HF, it is therefore crucial to identify those at risk of acute HF exacerbation and to avoid excessive fluid or other inciting factors. We found that more than 40% of patients with chronic HF received IV fluids, while only 30% received a loop diuretic. Although our data do not allow

for comparisons of treatment effectiveness, such findings are interesting and warrant further investigation.

Interestingly, chronic HF alone was associated with lower mortality than not having HF. This was an unexpected finding, especially because the risk of other serious complications and escalation of care was increased. One possible explanation is that patients with chronic HF and pneumonia were more likely to require ICU level of care compared to less severe cases of pneumonia without HF, and with closer monitoring and management of both conditions (with antibiotics and aggressive diuresis), patients may have a better chance at survival. Moreover, some non-HF patients might actually have undiagnosed HF which goes untreated during their hospital stay, leading to worse outcomes. Alternatively, higher mortality patients with chronic HF may have been more likely coded as unspecified HF, and as such the remaining chronic HF patients would then appear to have lower mortality.

Moreover, there was no difference in the use of vasopressors between patients without HF and those with chronic HF, so it seems likely that higher ICU admission was for reasons other than septic shock, one of the major drivers of mortality of pneumonia. A related alternative is that physicians send patients with HF to the ICU for closer observation and hemodynamic assessment, even if they are not yet in respiratory failure.

Given that the incidence of HF and HF-related hospitalizations is expected to increase as the population ages,[27] it is crucial to better our understanding on the impact of HF on patient care. Given its profound impact on healthcare cost and outcomes, pneumonia has been the target of quality improvement initiatives for more than 2 decades.[28, 29] Pneumonia mortality models are used to determine quality and payment at the hospital level, and these models all include HF diagnosis. Beginning in October 2012, the Centers for Medicare and Medicaid Services (CMS) adopted Pay-for-Performance (P4P) for the Medicare program nationwide, and most privately insured patients have been covered by health plans using P4P since 2006.[30] These programs reward or penalize hospitals based on their performance on multiple domains of care, including patient experience, cost efficiency and outcomes, including 30-day mortality for pneumonia.[31]

In order to assure a level playing field, hospitals' performance is adjusted to reflect their case mix, including HF. In the pneumonia mortality model developed by CMS, having a diagnosis code of congestive HF (condition code - CC 85) is assigned an OR for 30-day mortality ranging between 1.13 to 1.15 depending on the year studied (2017 to 2019).[12] However, the models used by CMS and others adjust for HF generally but do not distinguish between acute and chronic HF.[12, 13] Based on our results, this practice may overestimate the mortality risk in patients with chronic HF while underestimating risk in those with acute exacerbations. Given the relatively tight distribution around pneumonia mortality rates, these differences could be important, and general hospital policies encourage specifying chronicity of HF when coding the diagnosis of HF. Moreover, it is important to further describe patients labeled with a diagnosis code of unspecified HF or congestive HF, as it is important to recognize the acuity of HF presentation both for prognostic and billing purposes. Future research related to development of pneumonia mortality models for quality improvement and performance monitoring should account for type and chronicity of HF

This study has several strengths. To our knowledge, this is the largest study examining detailed clinical characteristics and outcomes of HF patients admitted for pneumonia. The inclusion of almost 800,000 patients at more than 600 hospitals supports the generalizability and reliability of the findings and increases the external validity. It also allowed us to adjust for many comorbid conditions and investigate a multitude of outcomes that characterize the severity of patients' hospital course (AKI, ICU stay with use of inotropes, vasopressors, mechanical ventilation). This is also the first study to differentiate acute versus chronic HF and assess their differential impact on outcomes among patients admitted to the hospital with pneumonia. Our findings should be considered in light of several limitations. First, this was a retrospective study based on billing data. Relying on ICD-9 CM codes for outcome definition and excluding unspecified HF could undermine the validity of our findings. We used ICD-9 CM codes to identify cases of HF and other comorbidities, so our results are susceptible to ascertainment bias due to inaccurate coding, particularly because we had to exclude a substantial number of subjects whose diagnosis codes did not clearly specify chronicity of HF. Thus, our estimate of acute versus chronic HF could change if these proportions are not the same among patients with unspecified chronicity. Yet, we decided to include patients with a clear and more reliable diagnosis of acute or chronic HF and not risk further ascertainment bias by including those with congestive or unspecified HF. There is also the possibility of having residual (unmeasured) confounders that we could not capture in our database. We were also unable to assess the severity of HF in terms of grade of systolic or diastolic dysfunction, echocardiographic parameters of HF such as ejection fraction, and New York Heart Association Functional Classification. However, the use of ICD-9 codes to conduct clinical studies has been validated in multiple studies of heart failure.[32] Additionally, our data are from 2011–2015, and may not reflect contemporary HF management.

In conclusion, patients with HF admitted for pneumonia are significantly sicker and have a worse prognosis and higher cost that those without HF. This is especially true among those with acute HF and this subgroup appears responsible for the worse outcomes observed, including increased mortality. In light of the above findings, it is important to specify acuity of HF when accounting for this disease in pneumonia risk models. Further studies are needed to understand the paradoxical finding of lower adjusted mortality among patients with chronic HF only.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Disclosures

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Abbreviations:

ACEi	Angiotensin converting enzyme inhibitor

ARB	angiotensin receptor blocker
AKI	acute kidney injury
ICU	intensive care unit
IMV	invasive mechanical ventilation
HF	heart failure
POA	present on admission.

References

1. Heron MP. Deaths: leading causes for 2010. 2013.
2. Vos T, Lim SS, Abbafati C, Abbas KM, Abbasi M, Abbasifard M, Abbasi-Kangevari M, Abbastabar H, Abd-Allah F, Abdelalim A. Global burden of 369 diseases and injuries in 204 countries and territories, 1990–2019: a systematic analysis for the global burden of disease study 2019. Lancet. 2020;396:1204–1222. [PubMed: 33069326]
3. Welte T, Torres A, Nathwani D. Clinical and economic burden of community-acquired pneumonia among adults in Europe. Thorax. 2012;67:71–79. [PubMed: 20729232]
4. Bonafede MM, Suaya JA, Wilson KL, Mannino DM, Polsky D. Incidence and cost of CAP in a large working-age population. Am J Manag Care. 2012;18:380–387. [PubMed: 22823532]
5. Polsky D, Bonafede M, Suaya JA. Comorbidities as a driver of the excess costs of community-acquired pneumonia in US commercially-insured working age adults. BMC Health Serv Res. 2012;12:379. [PubMed: 23113880]
6. Rothberg MB, Haessler S, Lagu T, Lindenauer PK, Pekow PS, Priya A, Skiest D, Zilber-berg MD. Outcomes of patients with healthcare-associated pneumonia: worse disease or sicker patients? Infect Control Hosp Epidemiol. 2014;35:S107–S115. [PubMed: 25222889]
7. Koivula I, Sten M, Makela PH. Risk factors for pneumonia in the elderly. Am J Med. 1994;96:313–320. [PubMed: 8166149]
8. Jackson ML, Neuzil KM, Thompson WW, Shay DK, Yu O, Hanson CA, Jackson LA. The burden of community-acquired pneumonia in seniors: results of a population-based study. Clin Infect Dis. 2004;39:1642–1650. [PubMed: 15578365]
9. Michalsen A, König G, Thimme W. Preventable causative factors leading to hospital admission with decompensated heart failure. Heart. 1998;80:437–441. [PubMed: 9930040]
10. Kaplan V, Angus DC, Griffin MF, Clermont G, Scott Watson R, Linde-Zwirble WT. Hospitalized community-acquired pneumonia in the elderly: age- and sex-related patterns of care and outcome in the United States. Am J Respir Crit Care Med. 2002;165:766–772. [PubMed: 11897642]
11. Thompson NR, Fan Y, Dalton JE, Jehi L, Rosenbaum BP, Vadera S, Griffith SD. A new elixhauser-based comorbidity summary measure to predict in-hospital mortality. Med Care. 2015;53:374–379. [PubMed: 25769057]
12. Centers for Medicare Medicaid Services. Mortality measures methodology. https://qualitynet.cms.gov/files/5d0d3908764be766b0103031?filename=YaleCMS_PN_Report,0.pdf. 2021.
13. Bratzler DW, Normand S-LT, Wang Y, O'Donnell WJ, Metersky M, Han LF, Rapp MT, Krumholz HM. An administrative claims model for profiling hospital 30-day mortality rates for pneumonia patients. PLoS One. 2011;6:e17401. [PubMed: 21532758]
14. Premier Applied Sciences. Premier applied sciences: premier healthcare database: data that informs and performs. https://learn.premierinc.com/white-papers/premier-healthcare-database-whitepaper. Accessed August 7, 2020;August 7.
15. Lindenauer PK, Stefan MS, Johnson KG, Priya A, Pekow PS, Rothberg MB. Prevalence, treatment, and outcomes associated with OSA among patients hospitalized with pneumonia. Chest. 2014;145:1032–1038. [PubMed: 24371839]

16. Lindenauer PK, Pekow PS, Lahti MC, Lee Y, Benjamin EM, Rothberg MB. Association of corticosteroid dose and route of administration with risk of treatment failure in acute exacerbation of chronic obstructive pulmonary disease. JAMA. 2010;303:2359–2367. [PubMed: 20551406]
17. Elixhauser A, Steiner C, Harris DR, Coffey RM. Comorbidity measures for use with administrative data. Med Care. 1998:8–27. [PubMed: 9431328]
18. Fine MJ, Smith MA, Carson CA, Mutha SS, Sankey SS, Weissfeld LA, Kapoor WN. Prognosis and outcomes of patients with community-acquired pneumonia: a meta–analysis. JAMA. 1996;275:134–141. [PubMed: 8531309]
19. Kalin M, Örtqvist Å, Almela M, Aufwerber E, Dwyer R, Henriques B, Jorup C, Julander I, Marrie TJ, Mufson MA. Prospective study of prognostic factors in community-acquired bacteremic pneumococcal disease in 5 countries. J Infect Dis. 2000;182:840–847. [PubMed: 10950779]
20. SOLVD InvestigatorsEffect of enalapril on survival in patients with reduced left ventricular ejection fractions and congestive heart failure. N Engl J Med. 1991;325:293–302. [PubMed: 2057034]
21. Heidenreich PA, Lee TT, Massie BM. Effect of beta-blockade on mortality in patients with heart failure: a meta-analysis of randomized clinical trials. J Am Coll Cardiol. 1997;30:27–34. [PubMed: 9207617]
22. Pitt B, Zannad F, Remme WJ, Cody R, Castaigne A, Perez A, Palensky J, Wittes J. The effect of spironolactone on morbidity and mortality in patients with severe heart failure. N Engl J Med. 1999;341:709–717. [PubMed: 10471456]
23. Thomsen RW, Kasatpibal N, Riis A, Nørgaard M, Sørensen HT. The impact of pre-existing heart failure on pneumonia prognosis: population-based cohort study. J Gen Intern Med. 2008;23:1407. [PubMed: 18574639]
24. Thomsen RW, Kasatpibal N, Riis A, Nørgaard M, Sørensen HT. The impact of pre-existing heart failure on pneumonia prognosis: population-based cohort study. J Gen Intern Med. 2008;23:1407–1413. [PubMed: 18574639]
25. Cotter G, Felker GM, Adams KF, Milo-Cotter O, O'Connor CM. The pathophysiology of acute heart failure–is it all about fluid accumulation? Am Heart J. 2008;155:9–18. [PubMed: 18082483]
26. Ware LB, Matthay MA. Clinical practice. Acute pulmonary edema. N Engl J Med. 2005;353:2788–2796. [PubMed: 16382065]
27. Heidenreich PA, Albert NM, Allen LA, Bluemke DA, Butler J, Fonarow GC, Ikonomidis JS, Khavjou O, Konstam MA, Maddox TM. Forecasting the impact of heart failure in the United States: a policy statement from the American heart association. Circ Heart Fail. 2013;6:606–619. [PubMed: 23616602]
28. Niederman M, Bass J Jr, Campbell GD, Fein A, Grossman R, Mandell L, Marrie T, Sarosi G, Torres A, Yu V. Guidelines for the initial management of adults with community-acquired pneumonia: diagnosis, assessment of severity, and initial antimicrobial therapy. American thoracic society. medical section of the American lung association. Am Rev Respir Dis. 1993;148:1418–1426. [PubMed: 8239186]
29. Meehan TP, Weingarten SR, Holmboe ES, Mathur D, Wang Y, Petrillo MK, Tu GS, Fine JM. A statewide initiative to improve the care of hospitalized pneumonia patients: the connecticut pneumonia pathway project. Am J Med. 2001;111:203–210. [PubMed: 11530031]
30. Rosenthal MB, Landon BE, Normand S-LT, Frank RG, Epstein AM. Pay for performance in commercial HMOs. N Engl J Med. 2006;355:1895–1902. [PubMed: 17079763]
31. Centers for Medicare Medicaid Services. Hospital value-based purchasing. CMS.gov. https://www.cms.gov/Medicare/Quality-Initiatives-Patient-Assessment-Instruments/Value-Based-Programs/HVBP/Hospital-Value-Based-Purchasing. Accessed April 18, 2021.
32. Cozzolino F, Montedori A, Abraha I, Eusebi P, Grisci C, Heymann AJ, Lombardo G, Mengoni A, Orso M, Ambrosio G. A diagnostic accuracy study validating cardiovascular ICD-9-CM codes in healthcare administrative databases. The umbria data-value project. PLoS One. 2019;14:e0218919.

Clinical significance

- Heart failure (HF) is common in patients with pneumonia associated with worse outcomes.
- Pneumonia mortality models by CMS adjust for HF without differentiating its chronicity.
- This is the largest study to study how HF and its subtypes affect cost and outcomes.
- We show that patients with acute but not chronic HF diagnosis had higher mortality.
- It is important to specify acuity of HF in multivariable-adjusted pneumonia risk models.

1,454,843	Adult admissions[1] discharged between July 2010 to June 2015 with principal diagnosis present on admission (POA) in pneumonia (480-486, 487.0, 488.01, 488.11, 488.81 , 507.0) or principal diagnosis of sepsis (785.52, 790.7, 995.91, 995.92, 038.x)/respiratory failure (518.81, 518.82, 518.84, 799.1)/principal diagnosis of POA influenza (487.1, 487.8, 488.0, 488.02, 488.09, 488.1, 488.12, 488.19, 488.82, 488.89) plus secondary diagnosis POA pneumonia

3	Missing medical record key
394	Missing patient's cost
25	Gender unknown
142,932	Transfer from acute care or admission source unknown
22,214	Still patients or transfer to acute care or discharged status unknown
1,718	DX in cystic fibrosis (277.0x, x = 0, 1, 2, 3, 9)
59,793	Length of stay < 2 days (unless died in hospital)
12,399	Ineligible Medicare severity diagnosis related group
2,070	Ineligible attending physician's' specialty
466	Ventilator associated pneumonia (present on admission)
19,507	Tracheostomy charged on day 0/1
7,042	SDX codes in Respirator depend status and mechanical ventilator charged on first hospital day
93,239	No chest x-ray or CT charged on day 0/1
163,923	Ineligible antimicrobial treatments[1]
549,647	Total exclusion

929,118	Eligible pneumonia admission

For patients with multiple admissions, using simple random selection to choose 1 admission

783,702	Pneumonia patients

[1] included patients who received antibiotics /oseltamivir on day 0/1 for at least 3 days or discharged. (except for dialysis patients, included them if they received antibiotics /oseltamivir every other day in first 3 days)

Fig. 1.
Patient flowchart

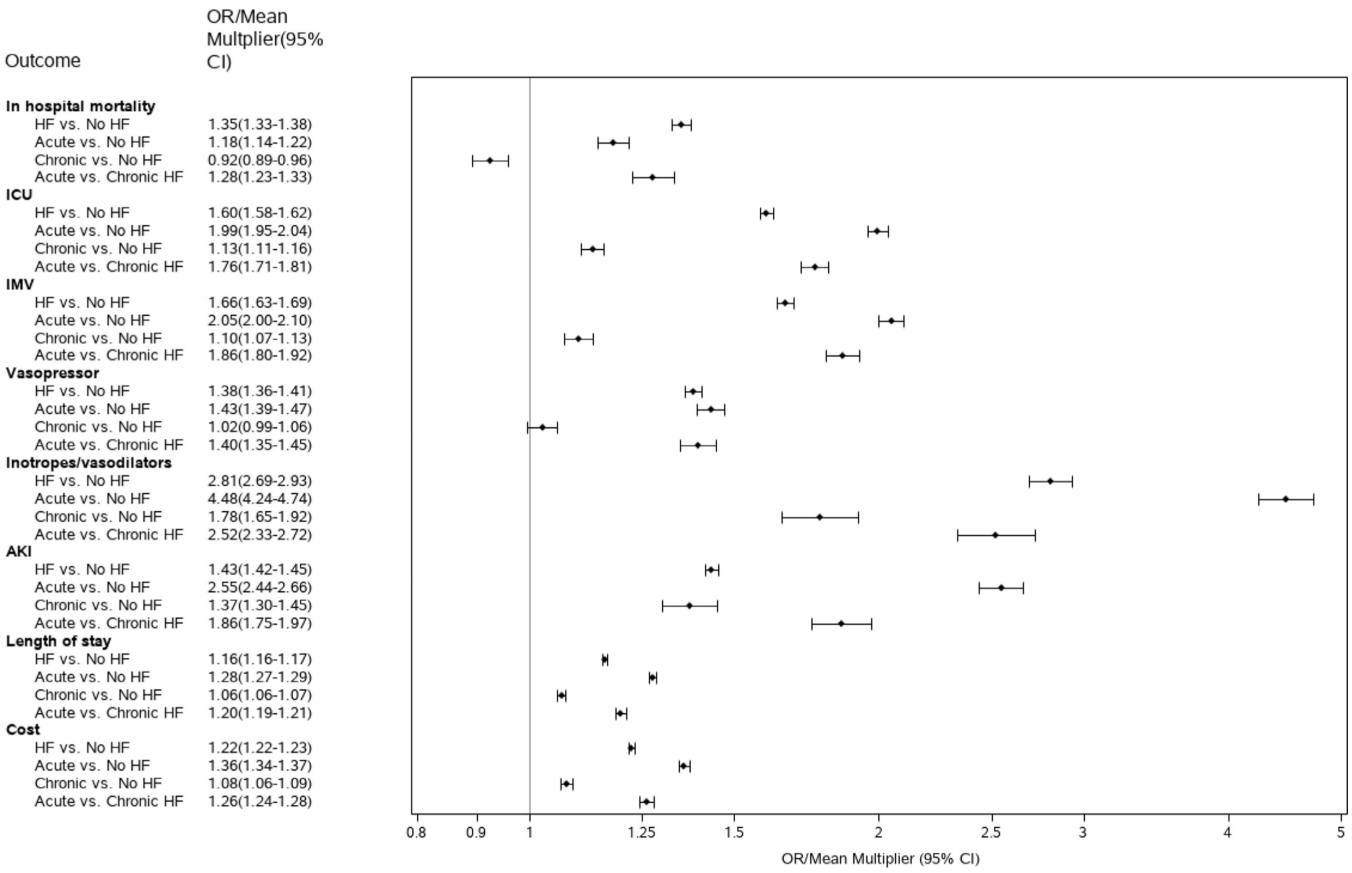

Fig. 2.

Forest plot for multivariable adjusted logistic regression for the study's outcome according to different types of HF

Odds ratios and confidence intervals for all comparisons are calculated using a multivariable mixed logistic regression model, adjusted for baseline demographic (age, sex, race) and clinical (all co-morbidities) characteristics as well as insurance status, Elixhauser comorbidities, and hospital characteristics. Log-linked gamma general linear mixed models were used for length of stay and cost.

P for all comparisons were < 0.001 (except for chronic HF vs no HF and use of inotropes/vasodilators, p > 0.05)

ICU, intensive care unit

IMV, invasive mechanical ventilation

POA, present on admission

Table 1

Distribution of patients according to the ICD-9 coded diagnosis and type of HF

All HF and ICD-9 codes	Total (N=783,702)
Acute HF (present on admission), No. (%)	**56,133(7.2)**
428.21: Acute systolic heart failure, No. (%)	5,144(0.66)
428.23: Acute on chronic systolic heart failure, No. (%)	15,547(2.0)
428.31: Acute diastolic heart failure, No. (%)	7,251(0.93)
428.33: Acute on chronic diastolic heart failure, No. (%)	21,418(2.7)
428.41: Acute combined systolic and diastolic heart failure, No. (%)	1,039(0.13)
428.43: Acute on chronic combined systolic and diastolic heart failure, No. (%)	5,835(0.74)
Chronic HF (present on admission), No. (%)	**48,160(6.2)**
428.22: Chronic systolic heart failure, No. (%)	16,084(2.1)
428.32: Chronic diastolic heart failure, No. (%)	28,046(3.6)
428.42: Chronic combined systolic and diastolic heart failure, No. (%)	4,030(0.51)
428.0: Congestive heart failure, unspecified (present on admission), No. (%)	**203,104(25.9)**
428.9: Unspecified HF (present on admission), No. (%)	**27,395(3.5)**
402.01: Malignant hypertensive heart disease with heart failure, No. (%)	184(0.02)
402.11: Benign hypertensive heart disease with heart failure, No. (%)	160(0.02)
402.91: Unspecified hypertensive heart disease with heart failure, No. (%)	2,985(0.38)
404.01: Malignant hypertensive heart and renal disease with heart failure, No. (%)	176(0.02)
404.03: Malignant hypertensive heart and renal disease with heart failure and renal failure, No. (%)	92(0.01)
404.11: Benign hypertensive heart and renal disease with heart failure, No. (%)	201(0.03)
404.13: Benign hypertensive heart and renal disease with heart failure and renal failure, No. (%)	51(0.01)
404.91: Hypertensive heart & CKD, unspecified, w heart failure & CKD stage V or end stage renal, No. (%)	3,406(0.43)
428.1: Left heart failure, No. (%)	884(0.11)
428.9: Heart failure unspecified, No. (%)	252(0.03)
428.20: Unspecified systolic heart failure, No. (%)	742(0.09)
428.30: Unspecified diastolic heart failure, No. (%)	4,400(0.56)
428.40: Unspecified combined systolic and diastolic heart failure, No. (%)	13,731(1.8)
404.90: Hypertensive heart and CKD, unspecified, with heart failure and w CKD stage I to IV, or unspecified, No. (%)	1,131(0.14)

Table 2

Baseline characteristics of the study population according to presence and acuity of HF

Factor	Total(N=783,702)	Heart Failure No(N=571,499)	Yes(N=212,203)	Acute HF(N=56,133)	Chronic HF(N=48,160)
Age, Median [Q1, Q3] †	72 [59,83]	70 [56,81]	78 [68,86]	79 [68,86]	78 [68,86]
Sex, No. (%)					
Females	403,360(51.5)	292,758(51.2)	110,602(52.1)	29,349(52.3)	24,281(50.4)
Males	380,342(48.5)	278,741(48.8)	101,601(47.9)	26,784(47.7)	23,879(49.6)
Race, No. (%)					
White	583,482(74.5)	422,715(74.0)	160,767(75.8)	43,545(77.6)	37,104(77.0)
Black	85,124(10.9)	62,552(10.9)	22,572(10.6)	5,301(9.4)	5,298(11.0)
Hispanic	5,443(0.69)	4,167(0.73)	1,276(0.60)	243(0.43)	148(0.31)
Others	109,096(13.9)	81,653(14.3)	27,443(12.9)	7,006(12.5)	5,578(11.6)
Unknown	557(0.07)	412(0.07)	145(0.07)	38(0.07)	32(0.07)
Insurance status, No. (%)					
Medicare	558,362(71.2)	380,182(66.5)	178,180(84.0)	47,386(84.4)	41,221(85.6)
Medicaid	68,626(8.8)	56,680(9.9)	11,946(5.6)	2,893(5.2)	2,562(5.3)
Managed Care	85,825(11.0)	74,055(13.0)	11,770(5.5)	3,046(5.4)	2,412(5.0)
Commercial Indemnity	22,414(2.9)	18,598(3.3)	3,816(1.8)	975(1.7)	766(1.6)
Others	48,475(6.2)	41,984(7.3)	6,491(3.1)	1,833(3.3)	1,199(2.5)
Marital status, No. (%)					
Married	295,195(37.7)	219,720(38.4)	75,475(35.6)	20,512(36.5)	17,133(35.6)
Single	406,405(51.9)	292,324(51.2)	114,081(53.8)	29,985(53.4)	25,667(53.3)
Other	80,957(10.3)	58,561(10.2)	22,396(10.6)	5,557(9.9)	5,298(11.0)
Unknown	1,145(0.15)	894(0.16)	251(0.12)	79(0.14)	62(0.13)
Attending physician, No. (%)					
Critical care	8,101(1.0)	5,374(0.94)	2,727(1.3)	888(1.6)	667(1.4)
Pulmonary diseases	31,210(4.0)	22,503(3.9)	8,707(4.1)	2,283(4.1)	1,707(3.5)
Internal medicine	338,321(43.2)	246,621(43.2)	91,700(43.2)	23,245(41.4)	20,231(42.0)
Cardiovascular diseases	6,329(0.81)	3,542(0.62)	2,787(1.3)	894(1.6)	542(1.1)
Family practice	88,010(11.2)	63,861(11.2)	24,149(11.4)	5,635(10.0)	4,712(9.8)
Others	311,731(39.8)	229,598(40.2)	82,133(38.7)	23,188(41.3)	20,301(42.2)

Factor	Total(N=783,702)	Heart Failure No(N=571,499)	Yes(N=212,203)	Acute HF(N=56,133)	Chronic HF(N=48,160)
Hospital characteristics, No. (%)					
Bed size					
≤ 200 Beds	189,119(24.1)	140,795(24.6)	48,324(22.8)	12,713(22.6)	10,047(20.9)
201 – 400 Beds	310,914(39.7)	228,053(39.9)	82,861(39.0)	20,835(37.1)	17,438(36.2)
≥401 Beds	283,669(36.2)	202,651(35.5)	81,018(38.2)	22,585(40.2)	20,675(42.9)
Urban/Rural					
Rural	125,315(16.0)	91,424(16.0)	33,891(16.0)	9,178(16.4)	6,894(14.3)
Urban	658,387(84.0)	480,075(84.0)	178,312(84.0)	46,955(83.6)	41,266(85.7)
Teaching hospital	277,626(35.4)	198,831(34.8)	78,795(37.1)	21,263(37.9)	20,888(43.4)
Region					
Midwest	153,139(19.5)	108,530(19.0)	44,609(21.0)	12,051(21.5)	10,184(21.1)
Northeast	122,816(15.7)	88,293(15.4)	34,523(16.3)	8,956(16.0)	8,828(18.3)
South	377,677(48.2)	277,634(48.6)	100,043(47.1)	25,953(46.2)	21,893(45.5)
West	130,070(16.6)	97,042(17.0)	33,028(15.6)	9,173(16.3)	7,255(15.1)
Comorbidities / diagnosis, No. (%)					
Combined comorbidity scores, Median [Q1, Q3]	3.0[1.00,5.0]	2.0[1.00,4.0]	5.0[4.0,7.0]	5.0[4.0,7.0]	5.0[4.0,7.0]
Alcohol use disorder[*,**]	30,149(3.8)	24,273(4.2)	5,876(2.8)	1,755(3.1)	1,194(2.5)
Anemia	229,125(29.2)	150,568(26.3)	78,557(37.0)	21,136(37.7)	17,774(36.9)
Rheumatoid arthritis	34,877(4.5)	25,165(4.4)	9,712(4.6)	2,463(4.4)	2,353(4.9)
Chronic pulmonary disease[†,‡]	353,312(45.1)	241,999(42.3)	111,313(52.5)	28,942(51.6)	26,080(54.2)
Coagulopathy[*,**]	60,539(7.7)	41,743(7.3)	18,796(8.9)	5,071(9.0)	4,052(8.4)
Depression[**]	113,945(14.5)	82,472(14.4)	31,473(14.8)	7,672(13.7)	7,430(15.4)
Diabetes[†]	108,482(13.8)	68,491(12.0)	39,991(18.8)	10,326(18.4)	9,303(19.3)
Drug abuse[†]	26,352(3.4)	21,946(3.8)	4,406(2.1)	1,161(2.1)	1,063(2.2)
Hypertension[†]	502,879(64.2)	341,141(59.7)	161,738(76.2)	42,986(76.6)	37,046(76.9)
Hypothyroidism[*]	36,835(4.7)	24,908(4.4)	11,927(5.6)	3,040(5.4)	2,711(5.6)
Liver disease	24,513(3.1)	18,314(3.2)	6,199(2.9)	1,558(2.8)	1,367(2.8)
Lymphoma	3,877(0.49)	2,913(0.51)	964(0.45)	231(0.41)	223(0.46)
Solid tumor without metastasis	6,171(0.79)	4,808(0.84)	1,363(0.64)	316(0.56)	298(0.62)

Factor	Total(N=783,702)	Heart Failure No(N=571,499)	Yes(N=212,203)	Acute HF(N=56,133)	Chronic HF(N=48,160)
Metastatic cancer†	29,183(3.7)	24,624(4.3)	4,559(2.1)	918(1.6)	970(2.0)
Fluid and electrolyte disorders*	290,705(37.1)	206,612(36.2)	84,093(39.6)	22,391(39.9)	18,511(38.4)
Other neurological disorders	126,314(16.1)	94,252(16.5)	32,062(15.1)	7,287(13.0)	7,021(14.6)
Obesity*,**	102,023(13.0)	65,199(11.4)	36,824(17.4)	10,356(18.4)	8,318(17.3)
Paralysis	36,317(4.6)	27,601(4.8)	8,716(4.1)	2,043(3.6)	1,893(3.9)
Peripheral vascular disease†	66,317(8.5)	37,815(6.6)	28,502(13.4)	7,871(14.0)	6,780(14.1)
Psychoses*,**	43,988(5.6)	34,123(6.0)	9,865(4.6)	2,152(3.8)	2,337(4.9)
Pulmonary circulation disease†,‡	62,371(8.0)	26,797(4.7)	35,574(16.8)	11,570(20.6)	7,938(16.5)
Valvular disease†,‡	75,349(9.6)	32,133(5.6)	43,216(20.4)	14,866(26.5)	9,316(19.3)
Weight loss	63,213(8.1)	45,204(7.9)	18,009(8.5)	4,694(8.4)	4,179(8.7)
Chronic kidney disease†	97,683(12.5)	53,561(9.4)	44,122(20.8)	10,904(19.4)	9,554(19.8)
Chronic liver disease	8,412(1.1)	5,737(1.0)	2,675(1.3)	621(1.1)	631(1.3)
Cardiac dysrhythmia	1,460(0.19)	955(0.17)	505(0.24)	111(0.20)	89(0.18)
Atrial fibrillation†,‡	169,522(21.6)	84,248(14.7)	85,274(40.2)	25,044(44.6)	19,829(41.2)
Coronary artery disease†	69,344(8.8)	30,919(5.4)	38,425(18.1)	11,855(21.1)	9,631(20.0)
Acute coronary syndrome†,‡	24,344(3.1)	10,700(1.9)	13,644(6.4)	5,723(10.2)	2,025(4.2)
Thyrotoxicosis	2,852(0.36)	1,912(0.33)	940(0.44)	261(0.46)	210(0.44)
Mitral stenosis or insuffciency†,‡	25,622(3.3)	10,564(1.8)	15,058(7.1)	5,573(9.9)	3,154(6.5)
Aortic stenosis or insuffciency†,‡	22,202(2.8)	9,566(1.7)	12,636(6.0)	4,268(7.6)	2,755(5.7)
Urinary tract infection†	112,137(14.3)	76,370(13.4)	35,767(16.9)	9,002(16.0)	7,543(15.7)
Obstructive sleep apnea†,‡	65,125(8.3)	38,378(6.7)	26,747(12.6)	7,414(13.2)	6,766(14.0)
Antiplatelet (V codes)†,‡	157,297(20.1)	94,727(16.6)	62,570(29.5)	17,253(30.7)	16,056(33.3)
Long-term (current) use of anticoagulants	*66,391(8.5)*	*35,778(6.3)*	*30,613(14.4)*	8,602(15.3)	7,869(16.3)
Long-term (current) use of antiplatelets	*19,856(2.5)*	*11,549(2.0)*	*8,307(3.9)*	2,321(4.1)	2,139(4.4)
Long-term (current) use of aspirin	*92,556(11.8)*	*58,335(10.2)*	*34,221(16.1)*	9,408(16.8)	8,927(18.5)

*Denotes significant differences ($p < 0.05$) between HF and no HF

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[†]Denotes significant difference ($p < 0.01$) between HF and no HF

[**]Denotes significant differences ($p < 0.01$) between acute and chronic HF

[‡]Denotes significant differences ($p < 0.01$) between acute and chronic HFComparisons for differences in baseline characteristics of HF and no HF and acute and chronic HF were made using Pearson's chi-square methods (except for age, where Mann-Whitney test was used).POA, present on admission

Table 3

Medical management on admission during hospital stay of patients admitted with pneumonia according to the presence and acuity of heart failure

Factor	Total(N=783,702)	Heart Failure No(N=571,499)	Yes(N=212,203)	Acute HF(N=56,133)	Chronic HF† (N=48,160)
Treatment (any day), No. (%)					
ACEi / ARB	234,035(29.9)	151,777(26.6)	82,258(38.8)	24,868(44.3)	18,768(39.0)
Mineralocorticoid receptor antagonists	27,128(3.5)	10,952(1.9)	16,176(7.6)	5,955(10.6)	3,672(7.6)
Loop diuretics	330,692(42.2)	168,197(29.4)	162,495(76.6)	52,077(92.8)	33,419(69.4)
Thiazide diuretics	13,709(1.7)	5,267(0.92)	8,442(4.0)	3,519(6.3)	1,472(3.1)
Calcium channel blocker	234,169(29.9)	155,195(27.2)	78,974(37.2)	22,458(40.0)	16,842(35.0)
Beta blocker	354,944 (45.2)	212,358 (37.1)	142,586 (67.1)	42,826 (76.2)	32,712 (67.9)
Isosorbide dinitrate	39,188(5.0)	17,089(3.0)	22,099(10.4)	7,147(12.7)	5,462(11.3)
Hydralazine	74,862(9.6)	45,073(7.9)	29,789(14.0)	9,439(16.8)	6,334(13.2)
Digoxin	71,522(9.1)	33,718(5.9)	37,804(17.8)	11,662(20.8)	7,870(16.3)
Antiarrhythmics	57,924(7.4)	28,703(5.0)	29,221(13.8)	9,473(16.9)	6,338(13.2)
Antiplatelets	326,678(41.7)	206,942(36.2)	119,736(56.4)	35,228(62.8)	28,163(58.5)
Anticoagulants	304,090(38.8)	216,300(37.8)	87,790(41.4)	24,776(44.1)	20,545(42.7)
Fluids	478,933(61.1)	360,794(63.1)	118,139(55.7)	30,465(54.3)	25,956(53.9)
Isotonic fluids	478,933(61.1)	360,794(63.1)	118,139(55.7)	30,465(54.3)	25,956(53.9)
Hypertonic fluids	757(0.10)	528(0.09)	229(0.11)	79(0.14)	40(0.08)
Hypotonic fluids	128,544(16.4)	94,163(16.5)	34,381(16.2)	8,367(14.9)	6,870(14.3)

Comparisons for differences in baseline characteristics of HF and no HF and acute and chronic HF were made using Pearson's chi-square methods (except for age, where Mann-Whitney test was used).

†With the except of hypotonic fluids, p-values for all comparisons of HF and no HF as well as acute and chronic HF were < 0.01. P-values were calculated using chi-squarePOA, present on admission; ACEi, angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blocker

Table 4

Prevalence of study outcomes among patients admitted for pneumonia, according to the presence and acuity of HF

Heart Failure Factor, No. (%)	Total (N=783,702)	No (N=571,499)	Yes (N=212,203)	Acute HF (N=56,306)	Chronic HF (N=48,188)
In hospital mortality	74,255 (9.5)	46,292 (8.1)	27,963(13.2)	7,261 (12.9)	4,588 (9.5)
Length of stay, Median[Q1, Q3]	5.0 [3.0,8.0]	5.0 [3.0,7.0]	6.0[4.0,10.0]	7.0 [4.0,11.0]	5.0 [3.0,9.0]
Cost, Median[Q1, Q3]	9003.1[5,473,16,183]	8174[5107,14423]	11708[6,992,20,816]	13893[8420, 23,934]	10130[6291,17511]
Intensive care unit	246,136 (31.4)	158,348 (27.7)	87,788(41.3)	27,298 (48.5)	16,317 (33.9)
Mechanical ventilation	119,195 (15.2)	73,739 (12.9)	45,456 (21.4)	14,730 (26.2)	7,508 (15.6)
Vasopressor	107,051 (13.7)	68,366 (12.0)	38,685 (18.2)	11,527 (20.5)	6,774 (14.1)
Inotropes / vasodilators	23,672/ 615,114(3.9)	12,918/464,391(2.8)	10,754 / 150,723(7.1)	3,744 / 37,870(9.9)	1,912 / 34,782(5.5)
Acute kidney injury	192,390 (24.5)	120,067 (21.0)	72,323 (34.1)	22,046 (39.3)	15,303 (31.8)

*P values for all outcome comparisons between HF versus no HF were < 0.001

†P-values for all comparisons between acute versus chronic HF were < 0.001 All comparisons were made using Person's chi-square test.