**Readmission and Mortality in Heart Failure patients in a Statewide Database**

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**ABSTRACT**

**OBJECTIVES** The aim of this study was to examine the temporal trends in readmission and mortality of heart failure (HF) patients in a population-based study.

**BACKGROUND** Readmission of patients with HF is common and associated with high mortality. However, the time trends of readmission, cardiovascular (CV) mortality and all-cause death have not been adequately explored.

**METHODS** This study includes 93,246 patients who were discharged alive with a first diagnosis of HF between January 1 2000 and December 31 2014. Data were obtained from the Myocardial Infarction Data Acquisition System (MIDAS), a statewide database of all hospitalizations in New Jersey. The temporal trends in the rate of HF specific and all-cause readmission and mortality up to one year were examined using multivariable logistic regression. The difference in all-cause mortality at 3 years between patients who were readmitted compared to those who were not readmitted at one year was examined.

**RESULTS**  The number of patients with HF declined between 2000 and 2006 and remained unchanged thereafter (p<0.001). Male gender, black race, comorbidities and admission to non-teaching hospitals were important predictors of HF readmission and CV mortality (p<0.001 for all). The rate of readmissions for any-cause increased during the study period (p<0.001) while the rate of HF readmissions and mortality remained relatively unchanged. Patients that had been readmitted within a year exhibited a significantly higher 3-year mortality (p<0.001).

**CONCLUSIONS** CV mortality among HF patients did not change significantly between 2000 and 2014, while rates of readmission increased. Patients who were readmitted had higher 3-year mortality than those who were not.

**Key words:** heart failure, readmissions, mortality, comorbidities,population-based study

**ABBREVIATIONS AND ACRONYMS**

HF = heart failure

MIDAS =Myocardial Infarction Data Acquisition System

ICD-CM = international classification of diseases-clinical modification

CKD = chronic kidney disease

AMI = acute myocardial infarction

PCI = percutaneous coronary intervention

CV = cardiovascular

COPD = chronic obstructive pulmonary disease

LOS = length of stay

Heart failure (HF) is the most common reason for hospital admission in adults and is associated with impaired quality of life, high mortality, financial burden and frequently repeated readmission (1). Thirty percent of patients with HF are readmitted and approximately 15% die within 30-60 days after discharge (2). American Heart Association statistics indicate that US health care expenditures on HF reached $30.7 billion between 2011-2014 (3) and this number is anticipated to increase nearly 127% to almost $70 billion by 2030 (4). Previous studies have addressed the issues of the incidence, outcomes and time-trends of HF readmissions. These reports were based on data from specific programs addressing these questions, single-center intervention trials or were review papers and meta-analyses. In addition, these publications included varying number of participants, diverse time intervals and different methodologies. Moreover, most of these papers did not include follow-up for more than 30 days and did not examine secular changes with regards to readmission and outcomes (2,5,6-16). In addition, prior studies did not report on long-term mortality of patients who were readmitted vs to those who were not readmitted.

The purpose of this study is to describe the incidence, time-trends and outcomes of HF readmissions including differences in mortality among patients who were readmitted vs patients not readmitted in an all-inclusive population-based cohort of 93,246 HF patients.

Data on patients who were discharged alive from New Jersey hospitals and time-trends from 2000 to 2014 were obtained from the Myocardial Infarction Data Acquisition System (MIDAS) (17-19)

**Methods**

**Data sources**

Data were obtained from the MIDAS database that includes the sum of the admissions to acute care non-federal hospitals in New Jersey from 2000 to 2014 for CV disease with longitudinal follow-up. Patients discharged with a principal diagnosis HF were identified using the International Classification of Diseases, Ninth Revision, Clinical Modification, (ICD-9-CM). MIDAS captures the dates of admission and discharge, demographic characteristics, insurance status (commercial, HMO, Medicare/Medicaid, self-pay), reason for admission, and comorbidities including anemia (280.0; 280.1; 280.8; 280.9; 281.0; 281.1; 281.2; 281.3; 281.4; 281.8; 281.9; 285.21; 285.29; 285.8; 285.9), chronic kidney disease (CKD, 585.1, 585.2, 585.3, 585.4, 585.6, 585.9), chronic obstructive pulmonary disease (COPD, 490; 491.0; 491.1; 491.20; 491.21; 491.22; 491.8; 491.9; 492.0; 492.8; 493.00; 493.01; 493.02; 493.10; 493.11; 493.12; 493.20; 493.21; 493.22; 493.81; 493.82; 493.90; 493.91; 493.92; 494.0; 494.1; 495.0; 495.1; 495.2; 495.3; 495.4; 495.5; 495.6; 495.7; 495.8; 495.9; 496), stroke (433.01; 433.11; 433.21; 433.31; 433.81; 433.91; 434.01; 434.11; 434.91), hypertension (401.0; 401.1; 401.9; 402.00; 402.01; 402.10; 402.11; 402.90; 402.91; 403.00; 403.01; 403.10; 403.11; 403.90; 403.91; 404.00; 404.01; 404.02; 404.03; 404.10; 404.11; 404.12; 404.13; 404.90; 404.91; 404.92; 404.93; 405.01; 405.09; 405.11; 405.19; 405.91; 405.99), diabetes (250.00; 250.01; 250.02; 250.03; 250.10; 250.11; 250.12; 250.13; 250.20; 250.21; 250.22; 250.23; 250.30; 250.31; 250.32; 250.33; 250.40; 250.41; 250.42; 250.43; 250.50; 250.51; 250.52; 250.53; 250.60; 250.61; 250.62; 250.63; 250.70; 250.71; 250.72; 250.73; 250.80; 250.81; 250.82; 250.83; 250.90; 250.91; 250.92; 250.93), atrial fibrillation 427.31 and atrial flutter (427.32), hyperlipidemia (272.0; 272.1; 272.2; 272.3; 272.4; 272.5; 272.6; 272.7; 272.8; 272.), acute myocardial infarction (410.00; 410.01; 410.02; 410.10; 410.11; 410.12; 410.20; 410.21; 410.22; 410.30; 410.31; 410.32; 410.40; 410.41; 410.42; 410.50; 410.51; 410.52; 410.60; 410.61; 410.62; 410.70; 410.71; 410.72; 410.80; 410.81; 410.82; 410.90; 410.91; 410.92), obstructive sleep apnea (327.23), Parkinson’s disease (332)*,* and transient ischemic attack (434.01; 434.11; 434.91). Hospital characteristics included hospital location (inner city, urban, rural, suburban), teaching status (teaching vs non-teaching) and availability of invasive or interventional procedures. The cause and date of death were obtained from New Jersey Death Registration files. We used “The Link King” (20),a public automated record linkage and consolidation softwarethat in a report of 500 000 linked records chosen at random and referred for blinded clerical review had a positive predictive value of 96.1% and a sensitivity of 96.7% (21).

Study patients were hospitalized for HF with ICD-9-CM primary discharge diagnosis code 428.xx. The cause of death was recorded using the ICD-10-CM codes, with ICD-10 between I00.0 and I99.9 coding for cardiovascular death, including I21.0 to I23.8 for AMI, and I60.0 to I64.9 for stroke.

The precision of MIDAS has been audited using a stratified random sample of charts. The information was correct for 98.8% for vital status at discharge, 99.7% for age, 99.3% for sex, 98.8% for race, 99.3% for length of hospital stay and 98.8% for procedures (22). In addition, hospital discharge records were matched with the information given on the death certificates. Patients with history of cancer and/or HIV were not included in this study. The study subjects were 18 years or older and were discharged alive from New Jersey non-federal hospitals, between 2000 and 2014, with a first diagnosis of HF. Of the 93,246 patients who fulfilled the criteria for inclusion, 3,353 (3.6%) were excluded from the statistical analysis because of missing values.

**Study variables**

Study variables included comorbidities, patient demographics, hospital characteristics [teaching/non-teaching, area type and facilities for percutaneous coronary intervention (PCI)], index hospitalization length of stay (LOS), and insurance type. HF patients were identified with ICD-9-CM codes as follows: 428.0; 428.1; 428.20; 428.21; 428.22; 428.23; 428.30; 428.31; 428.32; 428.33; 428.40; 428.41; 428.42; 428.43; 428.9.

**Outcomes – Statistics**

Outcomes were CV and all-cause death, readmission for HF and readmission for any-cause at 30-days, 90-days, 180-days and 1-year. Multivariable logistic regression models adjusted for demographics, hospital characteristics, LOS, and the comorbidities listed above were used for these analyses. Linear models were fit to examine the time trends of all four end points. In order to determine the effect of readmission on subsequent mortality we examined the rate of all-cause death at 3-years in HF patients who were readmitted compared to those who were not readmitted.

This study was approved byRutgers Robert Wood Johnson Medical School Institutional Review Board*.*

**Results**

**Outcomes at 30-day, 90-day, 180-day and at 1-year post discharge**

The number of patients with a first diagnosis of HF as the reason for admission who were discharged alive by year of admission ranged from 7760 to 5375 patients per year (Table 1). Breakpoint analysis of the number of readmissions per year identified the year 2006 (2006.5, 95% confidence interval [CI]: 2004.9 to 2008.1) when the number of readmissions stopped declining and plateaued thereafter. The number of HF admissions declined by 323.7 cases per year on average between 2000 and 2006 (95% CI: -410.1 to -237.4, p-value < 0.001), and remained unchanged from 2007 onward (Figure 1). All-cause readmissions showed a statistically significant positive slope by 0.665 per year (95% CI: 0.463 to 0.867, p<0,001) while for HF readmissions, all-cause mortality and CV mortality there was no statistically significant change (Figure 2). Demographics, hospital characteristics and type of health insurance are shown in Table 2. Approximately three quarters of the patients (73.7%) were Caucasian, 15.8% were black, and 8.3% defined themselves as Hispanic. Most of the patients were Medicare beneficiaries (64.3%), 28.4% of participants had commercial insurance, and 7.3% had Medicaid/self-pay/other. At one year more than one half of the patients were readmitted (53.6%) and approximately 19% died. About one half of the study patients were admitted to teaching hospitals (48.1%), while 41.1% of the patients were admitted to hospitals with PCI facilities. Almost 18% of the patients (17.7%) were admitted to hospitals located to inner city, 24.2% to hospitals in urban area, 42% in suburb locations, and 12.5% to hospital in rural areas (Table 2).

All-cause readmissions at 30, 90, 180 days and 1-year are presented in Online Table 1 and HF readmissions in Online Table 2. The all-cause readmission rates at 30-days and 1-year were 18% and more than 50% respectively (Online Table 1). Approximately 6.3% of the patients were readmitted for HF at 30-days and approximately 20% at one year (Online Table 2). The unadjusted 30-day all-cause readmission rate increased from 15.89% in the year 2000 to 20.29% in 2014 (Online Table 1). During the period of observation all-cause and CV mortality remained relatively stable, approximately 19% and 8%, respectively (Online Tables 3 and 4).

Logistic regression identified the following associations with readmission for all-cause, readmission for HF, all-cause mortality (Tables 3, 4, 5) and CV mortality (Online Table 5) among patients with HF.

Predictors of higher all-cause readmissions at 1-year were LOS (odds ratio [OR]: 1.08, 95% CI: 1.07 to 1.1), anemia (OR: 1.20, 95% CI: 1.15 to 1.25), CKD (OR: 1.33, 95% CI: 1.24 to 1.42), COPD (OR: 1.29, 95% CI: 1.24 to 1.34), diabetes (OR: 1.29, 95% CI: 1.25 to 1.34), hypertension (OR: 1.45, 95% CI: 1.40 to 1.50), hyperlipidemia (OR: 1.14, 95% CI: 1.09 to 1.18), and admission to a non-teaching hospital (OR: 1.09, 95% CI: 1.05 to 1.13, p<0.001 for all, Table 3).

Logistic regression identified male gender (OR: 1.08, 95% CI: 1.04 to 1.12), black race (OR: 1.32, 95% CI: 1.25 to 1.38), Medicare or Medicaid beneficiaries (OR: 1.16, 95% CI: 1.08 to 1.25), history of AMI (OR: 1.13, 95% CI: 1.06 to 1.20), COPD (OR: 1.09, 95% CI: 1.04 to 1.14), diabetes (OR: 1.21, 95% CI: 1.16 to 1.27), hypertension (OR: 1.12, 95% CI: 1.07 to 1.17), admission to non-teaching hospitals (OR: 1.10, 95% CI: 1.05 to 1.15), as important predictors of HF readmission for HF at 1-year, (p<0.001 for all, Table 4).

Logistic regression identified age per 10 years (OR: 1.59, 95% CI: 1.56 to 1.62), male gender (OR: 1.16, 95% CI: 1.12 to 1.21), LOS (OR: 1.49, 95% CI: 1.46 to 1.52), atrial fibrillation/flutter (OR: 1.05, 95% CI: 1.01 to 1.10), anemia (OR: 1.32, 95% CI: 1.26 to 1.38), history of AMI (OR: 1.24, 95% CI: 1.16 to 1.31), COPD (OR: 1.29, 95% CI: 1.23 to 1.35), CKD (OR: 1.38, 95% CI: 1.29 to 1.49), hypertension (OR: 1.16, 95% CI: 1.11 to 1.22), stroke (OR: 1.51, 95% CI: 1.19 to 1.93), Parkinson’s disease (OR: 1.35, 95% CI: 1.18 to 1.55), as important predictors of all-cause mortality at 1-year (p<0.001 for all, Table 5).

Logistic regression identified age per 10 years (OR: 1.51, 95% CI: 1.48 to 1.55), male gender (OR: 1.17, 95% CI: 1.11 to 1.23), LOS (OR: 1.34, 95% CI: 1.30 to 1.37), anemia (OR: 1.16, 95% CI: 1.08 to 1.23), history of AMI (OR: 1.34, 95% CI: 1.23 to 1.45), COPD (OR: 1.13, 95% CI: 1.06 to 1.20), hypertension (OR: 1.17, 95% CI: 1.10 to 1.25), stroke (OR: 1.73, 95% CI: 1.29 to 2.33), non-teaching hospital (OR: 1.11, 95% CI: 1.05 to 1.19), as important predictors of CV mortality at 1-year, (p<0.001 for all, Online Table 5).

The most common causes of readmission at 1-year, present in at least 1% of the patients (21 in total) were grouped into 13 categories and are presented in Figure 3. HF was the most common reason for readmission followed by respiratory, heart and kidney diseases. In the aggregate all reasons with rate below 1% accounted for 18.5% of readmissions (other reasons). More than 46% (46.4%) were not readmitted within a year.

All-cause readmissions increased significantly during the period of observation, on average by 0.7% per year (p<0.001), and readmissions for HF increased on average by 0.1% per year (p=0.08). There were no significant trends for all-cause and CV mortality.

Using a logistic regression model with log2 of number of days to readmission, as predictor of 1-year all-cause mortality, we estimated an odds ratio of 0.723 (95% CI: 0.717 to 0.729, p<0,001).

**All-cause mortality of patients who were readmitted compared to those who were not readmitted**

Figure 4 shows the odds ratios for all-cause mortality at 3-years from the index HF admission comparing patients readmitted vs those who were not readmitted by reason for readmission. Not being readmitted or being readmitted for the first time for heart disease, respiratory disease, arrhythmias, diabetes, general symptoms, hypertension, procedures or other reasons decreased the risk of dying within one year from the initial discharge. On the other hand, readmission for AMI, kidney disease, acute infection or cerebrovascular accidents increased the risk.

Univariate model identified all-cause 3-year mortality among HF patients discharged alive to be significantly higher in patients who were readmitted within one year from the index hospitalization (OR: 1.63, 95% CI: 1.59 to 1.68, p-value < 0.001). The 3-year all-cause mortality adjusted for all covariates remained significantly higher in patients who were readmitted vs those not readmitted (OR: 1.49, 95% CI: 1.45 to 1.54, p-value < 0.001). Figure 5 presents the adjusted 3-year mortality rates of HF patients re-hospitalized for various reasons. Logistic regression determined acute infections (OR: 1.29, 95% CI: 1.15 to 1.43, p-value < 0.001), history of AMI (OR: 1.42, 95% CI: 1.27 to 1.58, p-value < 0.001) and kidney disease (OR: 1.18, 95% CI: 1.09 to 1.28, p-value=0.007) as critical predictors of mortality within 3-years post discharge among patients with a first diagnosis of HF.

**Discussion**

This study shows that the number of patients admitted for the first time for HF as the reason of admission declined significantly during the period of observation, that half of these patients were readmitted within one year and that patients with longer LOS, anemia, CKD, COPD, diabetes, hypertension, hyperlipidemia were more likely to be readmitted. Similar data were reported by Bottle and associates who examined patient-level data from the Hospital Episodes Statistics in the United Kingdom. They concluded that HF, ischemic heart disease, cardiac dysrhythmias and diseases of the respiratory or genitourinary system were common reasons for admission (23). Congruent to our findings, JD Davis et al., in an all-payer analysis of HF hospitalization found that comorbidities similar to those reported in this paper were associated with higher rate of readmission up to 30 days (24). In a nationally representative US cohort study Gulea and associates reported that HF patients with COPD were at significantly higher risk of readmission (25). In the present study, LOS was associated with higher all-cause readmission rate and all-cause mortality. This is similar to the results from H Khan and associates who reported in a multinational cohort of hospitalized patients for HF that longer LOS was associated with higher risk of readmissions for HF and for readmissions for any-cause (26). Also, Fernande-Gasso reported that the 30-day readmission rate increased for HF and non-HF reasons (27).

Patients with respiratory disease, ischemia and arrythmias were more likely to be readmitted. Patients with ischemia and those with worsening renal function had a higher mortality at follow-up (28). Ruigomez, reporting on 3516 patients in The Health Improvement Network Primary Care Data Base also found higher mortality rates among patients readmitted for HF (29).

Khera and colleagues in agreement with our findings, reported that the announcement or implementation of the Hospital Readmission Reduction Program (HRRP) was not associated with an increase in in-hospital or post discharge mortality (30). This was attributed to the fact that physicians did not adopt strategies that specifically deferred admissions or affected mortality in the 30-day period after discharge (31). However, the results of Wadhera and associates, studying 7.9 million Medicare beneficiaries with HF, MI and pneumonia who were discharged alive reported that the HRRP announcement and implementation was associated with a significant increase of post discharge mortality at 30-days for pneumonia and HF patients (32).

In the OPTIMIZE-HF study, high systolic blood pressure was an independent predictor of morbidity and mortality similar to the findings of the present study (reference 8). Investigators from both the ADHERE and OPTIMIZE-HF registries described kidney disease to be a strong predictor of mortality. CKD was common and an important independent predictor of death and hospitalization in HF patients regardless of systolic function (33-34).

In the study of Walker et al. of 1802 patients with congestive HF, cause of death was defined over a 10.3-year follow-up period. They concluded that sepsis is a major contributor to death in people with CHF (35). A publication from Alon et al among 9355 HF patients reported increased mortality over a 10-year period (36). Similarly, results from the GREAT registry, noted higher 90-day risk of death after a hospitalization for acute infection (37). Panhwar and associates reported an association between influenza and increased inpatient morbidity and mortality (38). Gerber (39) et al. reported that HF markedly increases the risk of death after MI regardless of ejection fraction.

Samsky and coworkers in their recent study on trends in readmission and LOS for hospitalized patients with HF in Canada and U.S. reported similar results with respect to 30-day readmission rates. These authors did not report in readmission rates up to 1-year and they did not examine mortality rates (5). This limitation of the study by Samsky is emphasized by Su and associates who stated that the 30-day readmission rate is not an optimal standard for HF management (40). The effects of comorbidities and race observed by these authors are similar to our results (40). They also recommend that in the future process indicators will provide additional benefits in the evaluation and treatment of HF (41- 42).

An important limitation of this study is that confounders such as clinical and laboratory data including hemodynamic status, left ventricular function and physical findings are not included in the data set. Also, information on medications used during hospitalization or prescribed at discharge is missing. It is possible that different medication classes e.g. diuretics, b-blockers, or calcium channel blockers were associated with different rates of readmission and mortality. In addition, the present study does not include information on the HRRP that has been used throughout the US, meanwhile been associated with controversial results including decreased readmissions, cost savings and in some instances increased mortality (6,43-45).

However,our study has significant strengths including that the data are derived from a statewide data base spanning 15 years. The information in MIDAS is correct for 98.8% for vital status at discharge, 99.7% for age, 99.3% for sex, 98.8% for race, 99.3% for length of hospital stay and 98.8% for procedures (22). Also, this New Jersey statewide database represents a population of approximately 9 million residents that has characteristics similar in ethnicity, age, household mean income and education as the US a whole (46). Moreover, health insurance coverage in NJ resembles that of the United States (47). Health insurance coverage in the United States: 2014. 2015). Furthermore, the large sample size that includes every patient admitted to a NJ acute care hospital over a 15-year period for HF in an unselected, unbiased population gives additional credence to our conclusions.

In summary, this study that includes 93,246 patients who were discharged alive with a diagnosis of HF between 2000 and 2014 shows that the number of patients admitted for the first time for HF declined during the period of observation, that half of these patients were readmitted within a year and that patients who were readmitted had a notably higher all-cause mortality than those who were not readmitted.

**PERSPECTIVES**

**COMPETENCY IN MEDICAL KNOWLEDGE:** Readmission of patients with HF is common and associated with high mortality. Between 2000 and 2006 there was a continuous decrease in the number of 1st admissions for HF in NJ which remained stable thereafter. All-cause readmissions within a year increased while HF readmissions and mortality remained unchanged. Patients who were readmitted within a year had a significantly higher all-cause mortality at 3-years.

**TRANSLATIONAL OUTLOOK:** Although admissions and readmissions for HF have been stable for 15-years, all-cause mortality of those who get readmitted is high. This provides an opportunity to improve the prognosis of HF by preventing and managing comorbidities such as myocardial infarction, infections, stroke and chronic kidney disease. Attention to these factors will result in major health benefits.

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Figure 1: Number of First Heart Failure Discharges. The number of HF admissions declined between 2000 and 2006 and remained relatively stable thereafter

Figure 2: Cardiovascular Outcome Trends in Heart Failure Patients. All-cause readmissions increased significantly during the period of observation while heart failure readmissions, all-cause and CV mortality did not show a significant change.

Figure 3: Heart Failure Patient Readmissions by Reason for Readmission. The 12 most common reasons for readmission are depicted in order of frequency. Other reason includes the sum of all readmissions for reasons not included among the 12 shown.

Figure 4: Odds Ratios of 3-year All-Cause Mortality by Reason for Readmission. Readmission for AMI, kidney disease, acute infection or cerebrovascular accidents increased the risk of 3-year all-cause mortality

Figure 5: Odds Ratios of 3-year All-Cause Mortality by Number of Comorbidities.

|  |  |  |
| --- | --- | --- |
| 1 | readm1yTRUE | 1-Year All-Cause Readmission |
| 2 | hparkTRUE | Parkinson |
| 3 | decade | Age (X10) |
| 4 | hckdTRUE | CKD |
| 5 | hstrokeTRUE | Stroke |
| 6 | HISPANNon-Hispanic | Ethnisity:Non-Hispanic vs. Hispanic |
| 7 | HISPANUnknown | Ethnisity:Unknown vs. Hispanic |
| 8 | hanemiaTRUE | Anemia |
| 9 | log2(los + 1) | Length of Stay |
| 10 | hcopdTRUE | COPD |
| 11 | hhyperTRUE | Hypertension |
| 12 | SEXM | Male vs. Female |
| 13 | hamiTRUE | AMI |
| 14 | CLABNo Cath Lab | Hosp:No Cath Lab vs. Cath Lab |
| 15 | hafTRUE | AFib/AFlutter |
| 16 | AreaSuburb | Area:Suburb Area vs. Urban |
| 17 | hdiabTRUE | Diabetes |
| 18 | AreaInner city | Area:Inner City Area vs. Urban |
| 19 | AreaRural | Area:Rural Area vs. Urban |
| 20 | TeachNon-Teaching | Hosp:Non-Teaching vs. Teaching |
| 21 | DSCYR | Discharge year |
| 22 | PRIMEmedicaid/self-pay/other | Insurance:Medicaid/Self-Pay/Other vs. Medicare |
| 23 | htiaTRUE | TIA |
| 24 | hosaTRUE | Sleep Apnea |
| 25 | PRIMECOMMERCIAL | Insurance:Commercial vs. Medicare |
| 26 | RACEBlack | Race:Black vs. White |
| 27 | hlipidTRUE | Hyperlipidemia |
| 28 | RACEOther | Race:Other vs.White |

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