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

Michail Giakoumis, MD, PhD, John B. Kostis, MD, Davit Sargsyan, MS, Javier Cabrera, PhD, William J. Kostis, PhD, MD

Cardiovascular Institute, Rutgers Robert Wood Johnson Medical School

Total Word Count: XXX

Brief Title: Heart failure readmissions and long-term outcomes

Address for correspondence: Michail Giakoumis, MD, PhD

Cardiovascular Institute, Rutgers Robert Wood Johnson Medical School

125 Paterson Street, CAB-4180

New Brunswick, NJ. 08901

Phone: 732-235-7685

Fax: 732-235-7039

giakoumis@rwjms.rutgers.edu

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

**Clinical perspectives**

**Cover letter**

Dear Dr Christopher M. O’Connor,

I submit a manuscript entitled “Readmission and Mortality in Heart Failure patients in a Statewide Database” by John B. Kostis, MD, Davit Sargsyan, MS, Javier Cabrera, PhD, William J. Kostis, PhD, MD and myself for possible publication in JACC Heart Failure. The information included is derived from a statewide database in the state of New Jersey and includes data and 15-year time trends on readmissions, profile of patients who were readmitted compared to those not readmitted, rate of readmission and mortality up to one year, as well as, the higher all-cause mortality among heart failure patients who were readmitted.

I hope that this manuscript may be acceptable for publication in JACC Heart Failure.

Sincerely,

Michail Giakoumis, MD, Ph.D

Cardiovascular Institute, Rutgers Robert Wood Johnson Medical School

**Manuscript may not exceed 4500 words including intro, text, refs, figure legends**

**ABSTRACT**

**OBJECTIVES**

To describe the profile of heart failure patients who were readmitted and to determine the rates, time-trends and predictors of readmission and mortality among patients discharged alive with a first diagnosis of heart failure.

**BACKGROUND**

Readmission of patients who are discharged alive with a diagnosis of heart failure is common and associated with high mortality and financial burden.

**METHODS**

This study includes 89,738 patients who were discharged alive with a diagnosis of heart failure included in New Jersey statewide database Myocardial Infarction Data Acquisition System, a statewide database of all hospitalizations for cardiovascular diseases with longitudinal follow-up for more than 20 years. The temporal trends in the rate of heart failure and all-cause readmission as well as cardiovascular and all-cause mortality at 30-days, 90-days, 180-days and 1-year were examined using multivariable logistic regression models.

**RESULTS**

Admission to a non-teaching hospital without cardiac catheterization laboratory, located in inner city, Medicare or Medicaid, black race, male gender, and patients with comorbidities were predictors of readmission for heart failure. Age, male gender, length of stay, history of myocardial infarction, anemia, chronic obstructive pulmonary disease, hypertension, stroke, and hospitalization in non-teaching hospital were associated with cardiovascular mortality (p<0.001 for all). The rate of readmission increased during the study period (p<0.001) while the rate of cardiovascular mortality remained relatively unchanged.

**CONCLUSIONS**

The number of patients admitted for heart failure declined significantly during the period of observation, half of them were readmitted within a year and those readmitted had higher all-cause mortality.

**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

TIA = transient ischemic attack

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 (hines). Thirty percent of patients with HF are readmitted and approximately 15% die within 30-60 days after discharge (Gheorgiadhe). American Heart Association statistics indicate that US health care expenditures on HF reached $30.7 billion between 2011-2014 (benjamin) and this number is projected to increase nearly 127% to almost $70 billion by 2030 (heidenreich). 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. These publications included varying number of participants, diverse time intervals and different methodologies. However, 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 (gupta, gheorghiade + vaduganathan, Huffman, national center for health statistics, gheorghiade+Abraham, , maggioni, adams, Nieminen, sato, fudim, Atherton, Braunstein,). In addition, prior studies did not report on mortality of patients who are readmitted vs those who are not.

The purpose of this study is to describe the incidence, time-trends and outcomes of HF readmissions including differences in mortality between patients who were readmitted vs patients not readmitted in an all-inclusive population-based cohort of more than 93000 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) (Kostis circulation 1994, Kostis NEJM 2007, wellings).

**METHODS**

**DATA SOURCES.** Data were obtained from the MIDAS database that includes all of the admissions to acute care non-federal hospitals in New Jersey from 2000 to 2014 for cardiovascular 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 includes 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 (585.1, 585.2, 585.3, 585.4, 585.6, 585.9, CKD), chronic obstructive pulmonary disease (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 to 405.99), diabetes (250.00 to 250.93), atrial fibrillation 427.31 and atrial flutter 427.32, hyperlipidemia (272 to 272.9), AMI (410.00 to 410.92), obstructive sleep apnea code 327.23, Parkinson’s disease code 332*,* and Transient Ischemic Attack (TIA) (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” (Campbell),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% (GANDHI + Kostis NEJM 2007=REFERENCE 17).

Study patients were hospitalized for HF with ICD‐9‐CM primary discharge diagnosis code 428. The cause of death was recorded using the ICD‐10‐CM codes between I21.0 and I23.8 for AMI as a cause of death, ICD‐10‐CM codes between I60.0 and I64.9 for stroke while for death due to CV events ICD‐10‐CM codes between I00.0 and I99.9.

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 (Al Falluji). 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 93246 remaining patients, 3353 (3.6%) patients were omitted from the logistic regression due to missing information on variables used in the analysis.

**STUDY VARIABLES.** Study variables included comorbidities, patient demographics, hospital characteristics (inner city vs rural) and facility with percutaneous coronary intervention (PCI), index hospitalization length of stay 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 all-cause death, readmission for HF and readmission for any-cause at 30-days, 90-days, 180-days and 1-year as well as all-cause death at 1-year in patients who were readmitted compared to those who were not readmitted. Multivariable logistic regression models adjusted for demographics, hospital characteristics, length of stay (LOS), and the comorbidities listed above were used for these analyses. Linear models were fit to examine the time trends of all end points i.e. all-cause readmission, readmission for HF, CV death and all-cause death.

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

**RESULTS**

**Admissions and Readmissions for HF patients**

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 and decreased by approximately 150 cases per year throughout the period of observation (Table 1, Figure 1, p<0.001). 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 study participants were Medicare/Medicaid beneficiaries (64.2%) of the total whereas 28.4% participants used commercial insurance. About half of the study patients were admitted to teaching hospitals and half to non-teaching hospitals (48.1% vs 48.3% respectively). Forty-four percent of the patients were admitted to hospitals with PCI facility and 17.7% were admitted to hospitals located to inner city, 24.2% hospitals in urban area, 42% in suburb locations, and 12.5% in hospital in rural areas (Table.2).

Readmissions for any-cause and for HF at 30-day, 90-day, 180-day and 1-year follow-up are presented in Table 3a. Approximately 18% of the patients were admitted for any-cause at 30-days and more than 50% at one year (Table 3a). Approximately 6.3% of the patients were readmitted for HF at 30-days and approximately 20% at one year (Table 3b). The unadjusted 30-day all-cause readmission rate increased from 15.98% in the year 2000 to 20.29% in 2014 (Table 3b). During the period of observation all-cause and CV mortality remained relatively stable, approximately 19% and 8%, respectively (Tables 3c and 3d).

Logistic regression identified the following associations with readmission for any-cause, readmission for HF, all-cause mortality and CV mortality among patients with HF (tables 4a-4d).

Predictors of higher all-cause readmissions at 1-year were length of stay (odds ratio [OR] 1.01, 95% confidence interval [CI] 1.01 to 1.01), anemia (OR 1.20, 95% CI 1.16 to 1.26), CKD (OR 1.34, 95% CI 1.26 to 1.43), COPD (OR 1.29, 95% CI 1.24 to 1.34), diabetes (OR 1.30, 95% CI 1.25 to 1.35), hypertension (OR 1.44, 95% CI 1.40 to 1.50), hyperlipidemia (OR 1.13, 95% CI 1.09 to 1.17), and admission to a non-teaching hospital (OR 1.10, 95% CI 1.06 to 1.34, p<0.001 for all, table 4a).

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 1.24), history of AMI (OR 1.12, 95% CI 1.06 to 1.19), COPD (OR 1.10, 95% CI 1.05 to 1.15), diabetes (OR 1.22, 95% CI 1.17 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 4b).

Logistic regression identified age per 10 years (OR 1.61, 95% CI 1.58 to 1.63), male gender (OR 1.16, 95% CI 1.12 to 1.21), LOS (OR 1.054, 95% CI 1.051 to 1.057), atrial fibrillation/flutter (OR 1.05, 95% CI 1.01 to 1.10), anemia (OR 1.32, 95% CI 1.26 to 1.39), history of AMI (OR 1.22, 95% CI 1.15 to 1.30), COPD (OR 1.30, 95% CI 1.24 to 1.36), CKD (OR 1.40, 95% CI 1.30 to 1.51), hypertension (OR 1.16, 95% CI 1.11 to 1.22), stroke (OR 1.52, 95% CI 1.20 to 1.34), Parkinson’s disease (OR 1.37, 95% CI 1.20 to 1.57), as important predictors of all-cause mortality at 1-year (p<0.001 for all, table 4c).

Logistic regression identified age per 10 years (OR 1.53, 95% CI 1.49 to 1.57), male gender (OR 1.17, 95% CI 1.11 to 1.23), LOS (OR 1.029, 95% CI 1.026 to 1.033), anemia (OR 1.16, 95% CI 1.09 to 1.24), history of AMI (OR 1.32, 95% CI 1.22 to 1.44), COPD (OR 1.14, 95% CI 1.07 to 1.22), hypertension (OR 1.17, 95% CI 1.10 to 1.24), stroke (OR 1.75, 95% CI 1.31 to 2.35), non-teaching hospital (OR 1.12, 95% CI 1.05 to 1.19), as important predictors of CV mortality at 1-year, (p<0.001 for all, Table 4d).

The most common causes of readmission at 1-year, with a frequency of more than 1%, are listed in Table. 5). These readmissions were aggregated clinically into ten categories (Table. 6).

The rate of first admissions for HF decreased significantly by XX% (about 150 cases) per year and 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 by 0.1% per year on average (p=0.08). There was no significant trend for all-cause and CV death.

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

Characteristics of patients readmitted compared to those not readmitted are shown in Table 7 (Davit to produce). All-cause mortality of patients who were readmitted compared to those who were not readmitted are shown in table 8 (Davit to produce). Table 9 shows (Davit to produce) the results of the differences in all-cause mortality using logistic regression adjusting for the confounders listed above.

**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 a year and that patients with longer length of stay, anemia, CKD, COPD, diabetes, hypertension, hyperlipidemia were more likely to be readmitted. The findings of Blecker and associates that patients with heart failure are often hospitalized for other causes have higher readmission rates and that risk adjusted readmission rates started declining after passage of the Affordable Care Act are in agreement with our results (Blecker 2019). Bottle and associated reported that HF, ischemic heart disease, cardiac dysrhythmias and diseases of the respiratory or genitourinary system were common reasons for admission as was described in this paper.

There was no significant change in 1-year all-cause mortality during the period of observation. However, patients who were readmitted had higher all-cause mortality than those who were not readmitted. Ruigomez, reporting on 3516 patients in The Health Improvement Network Primary Care Data Base also found higher mortality rates among patients readmitted for heart failure (Ruigomez 2016).

Wadhera and associates studying 7.9 million Medicare beneficiaries with heart failure, MI and pneumonia who were discharged alive found that readmission was associated with a significant increase of post discharge mortality at 30 days (Wadhera JAMA 2018). In comparison, the present study that examined data on all adults reported increased mortality up to two years. 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 (JD Davis 2016).

In the present study LOS was associated with higher readmission for any-cause 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 heart failure that longer LOS was associated with higher risk of readmissions for HF and for readmissions for any-cause (H Khan 2015). Also, Fernande-Gasso reported that the 30-day readmission rate increased for HF and non-HF reasons (Fernande-Gasso 2016).

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. In addition the present study does not include information on hospital readmission reduction programs that have been used throughout the US and have been associated with mixed results including decreased readmissions, cost savings and in some instances increased mortality (Bradley 201?, Bilchick 2019, Van Spall 2019, Gupta 2018)

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 (Al Falluji). Also, this New Jersey statewide data base represents a population of approximately 9 million residents that has characteristics similar in ethnicity, age, household mean income and education as a whole (XYZ). Moreover, health insurance coverage in NJ resembles that of the United States (Smith JC, Medalia C). Health insurance coverage in the United States: 2014. 2015). Moreover, 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 unlike registries gives additional credence to our conclusions.

In summary, this study that includes 89,738 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 meaningfully during the period of observation, that half of these patients were readmitted within a year and that patients who were readmitted had higher all-cause mortality than those who were not readmitted.

**PERSPECTIVES**

**COMPETENCY IN MEDICAL KNOWLEDGE:**

**TRANSLATIONAL OUTLOOK:**

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**FIGURE LEGENDS**

Figure 1: Title

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