**Early Unplanned Readmissions after Admission to Hospital with Heart Failure**

Running title: Unplanned readmissions after heart failure

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**List of Supports/Grants Information:** The study was supported by a grant from the Research and Development Department at the Royal Stoke Hospital. This work is conducted as a part of PhD for CSK which is supported by Biosensors International.

**Acknowledgement:** We are grateful to the Healthcare Cost and Utilization Project (HCUP) and the HCUP Data Partners for providing the data used in the analysis.

**Conflicts of interest disclosures:** The authors have no conflicts of interest to declare.

**Abstract**

Hospital readmissions remain a continued challenge in the care of patients with heart failure (HF). This study aims to examine the rates, temporal trends, predictors and causes of 30-day unplanned readmissions after admission with HF. Patients hospitalized with a primary or secondary diagnosis of HF in the U.S. Nationwide Readmission Database were included. We examined the incidence, trends, predictors and causes of unplanned all-cause readmissions at 30-days. A total of 3,264,082 and 8,724,846 patients were included in the analyses for primary and secondary diagnoses of HF, respectively. The 30-day unplanned readmission rate was 15.1% for primary HF and 14.6% for secondary HF. Predictors of readmission in primary HF included renal failure (OR 1.27 (1.25-1.28)), cancer (OR 1.26 (1.22-1.29)), receipt of circulatory support (OR 2.81 (1.64-4.81)) and discharge against medical advice (OR 2.29 (2.20-2.39)). In secondary HF, the major predictors were receipt of circulatory support (OR 1.43 (1.12-1.84)) and discharge against medical advice (OR 2.01 95%CI (1.95-2.07)). In primary HF 52.4% of patients were readmitted for a non-cardiac cause while for secondary HF 73.9% were readmitted for a non-cardiac cause. For secondary HF, the strongest predictor of readmission was discharge against medical advice (OR 2.06 95%CI 2.01-2.12, p<0.001). Early unplanned readmissions are common among patients hospitalized with HF, and a majority of readmissions are due to causes other than HF. Our results highlight the need to better manage comorbidities in patients with HF.

**Keywords:** heart failure; readmissions; outcomes

**Introduction**

Hospital readmissions remain a continued challenge in the care of patients with heart failure (HF)1 as approximately 1 in 5 patients are readmitted within 30-day of hospitalization.2-5 Readmissions are considered an adverse outcome for patients which is also associated with a poor prognosis.6 They further have important health economic implications, both from a direct costs perspective as well as through the Hospital Readmission Reduction Program in the Affordable Care Act, which financially penalizes hospitals that have higher than expected risk-standardized 30-day readmission rates for HF.7 While previous studies have examined readmissions in HF they are limited because the data are derived from distinct healthcare providers (Medicare or Veterans Health Administration beneficiaries),8,9 are limited to 1 year of national data or do not consider secondary diagnosis of HF.5 In this study, we aimed to examine the rates of 30-day readmission, temporal trends in rates of 30-day readmission, predictors of 30-day readmissions, attributable causes of 30-day readmission and outcomes for both index admission and readmission among patients with primary and secondary diagnosis of HF in the Nationwide Readmission Database (NRD) in the United States.

**Methods**

The NRD is a nationally representative sample of all-age, all-payer discharges from U.S. non-federal hospitals that is produced by the Healthcare Cost and Utilization Project of the Agency for Healthcare Research and Quality.10 Readmissions were determined using a de-identified unique patient linkage number assigned to each patient, which allows for patient tracking across hospitals within a state during a given calendar year.

Individual patients in the NRD dataset are assigned up to 25 *International Classification of Disease, Ninth Revision* (ICD-9) codes (there are 30 rather than 25 for 2014) for each hospitalization. We defined patients with primary diagnosis of HF as those having at least one of the following as their first ICD-9 code of 402.01, 402.11, 402.91, 404.01, 404.03, 404.11, 404.13, 404.91, 404.93 and 428\*. HF as a secondary diagnosis was defined as any of the ICD-9 codes specifying HF as a diagnosis other than as a primary diagnosis for the hospital admission. We included the first admission for each patient with primary or secondary diagnosis of HF within a calendar year. Only patients who were not admitted to hospital with an admission that was classified as elective and alive at discharge were considered. Planned readmissions were excluded, which were defined as readmissions within 30 days that were classified as elective.

The primary outcome was the unplanned readmissions within 30 days of non-elective readmission for primary and secondary HF. We included patients with a diagnosis of HF between 2010 and 2014 with 30-days of follow up. Patients admitted in December of each year were excluded because they would not have 30-days of follow up. The cost of index hospitalization and hospital readmissions were determined by multiplying the hospital charges by the Agency for Healthcare Research and Quality’s all-payer cost-to-charge ratios for each hospital.

Data on patient demographics, comorbidities, clinical variables, procedural variables and causes of readmissions were collected as defined in Supplementary Data 1.

Statistical analysis was performed using Stata version 14.0 (StataCorp, College Station, TX, USA). Full description of statistical methods is described in Supplementary Data 1. The sample was split into patients with HF as primary and secondary diagnoses, and their unplanned 30-day all-cause and HF readmission were determined along with descriptive statistics. Multiple logistic regressions were used to identify independent predictors of 30-day readmissions and we evaluated the proportion of 30-day unplanned readmissions for secondary diagnosis of HF according to the primary cause of admission.

**Results**

A total of 10,978,056 patients were included in the analysis after the exclusion criteria were applied (Supplementary Figure 1). A total of 2,635,673 patients had a primary diagnosis of HF while 8,342,383 patients had a secondary diagnosis of HF. The rate of in-hospital mortality for the total cohort was 5.8%. The 30-day unplanned readmission rate was 15.1% for primary HF and 14.6% for secondary HF. The rates of all-cause unplanned readmissions decreased over time from 15.7% to 14.4% for primary HF and from 15.0% to 14.2% for secondary HF between 2010 to 2014 (Figure 1). A similar decrease was observed for 30-day HF readmissions. The rate of death during the unplanned readmission was 6.8% and 7.7% for primary and secondary HF respectively.

The characteristics of the patients according to primary and secondary diagnosis of HF are shown in Table 1. Large absolute differences were observed for renal failure (38.4% in primary HF, 29.3% in secondary HF), pulmonary vascular disorder (0.4% in primary HF, 7.7% in secondary HF) and fluid and electrolyte disorders (29.4% in primary HF and 37.5% in secondary HF). Patients with primary HF were more likely to be discharged home (57.6% vs 47.5%) and their length of stay for index admission was shorter (5.2 vs 7.3 days). The mean cost of hospitalization for primary HF was less than that for secondary HF ($11,213 vs $17,098). The mean time to readmission was approximately 16 days for both groups and the mean readmission length of stay and direct in-hospital costs were 6.2 days and $13,488 and 6.5 days and $13,947 for primary and secondary HF, respectively.

Table 2 shows the baseline characteristics of participants according to readmission status. Compared with non-readmitted patients, those requiring hospital readmission were more likely to have renal failure (44.9% vs 37.2% in primary HF, 34.1% vs 28.5% in secondary HF), anemia (32.6% vs 27.5% in primary HF, 31.8% vs 27.1% in secondary HF) and cancer (4.3% vs 3.4% for primary HF, 5.8% vs 4.7% in secondary HF). The most common primary cause for admission in secondary HF was infections (20.5%).

The independent predictors of readmissions in primary and secondary HF are shown in Table 3. For primary HF, diabetes (odds ratio (OR) 1.11 95% confidence interval (CI) 1.09-1.12, p<0.001), coronary artery disease (OR 1.10 95%CI 1.08-1.11, p<0.001), chronic lung disease (OR 1.16 95% CI 1.15-1.17, p<0.001), renal failure (OR 1.27 95%CI 1.25-1.28, p<0.001), liver failure (OR 1.21 95%CI 1.18-1.25, p<0.001), anemia (OR 1.13 95%CI 1.12-1.14, p<0.001) and cancer (OR 1.26 95%CI 1.22-1.29, p<0.001) were associated with greater odds of readmission. Receipt of circulatory support was associated with greater odds of readmission (OR 2.81 95%CI 1.64-4.81, p<0.001). Status or place of discharge were associated with greater odds of readmission as rates were high for patients transferred to other hospitals (OR 1.23 95%CI 1.21-1.25, p<0.001), care homes (OR 1.21 95%CI 1.19-1.22, p<0.001) and those who were discharged against medical advice (OR 2.29 95%CI 2.20-2.39, p<0.001) compared to those were discharge home. For secondary HF, the strongest predictor of readmission was discharge against medical advice (OR 2.06 95%CI 2.01-2.12, p<0.001). The impact of causes for admissions as predictors of readmission in patients with secondary HF is shown in Supplementary Table 2.

The causes of unplanned readmissions are shown in Figure 2. For primary HF, 32.3% of patients were readmitted for HF while 15.4% were readmitted for non-HF cardiac reasons and 52.4% for non-cardiac reasons. The rates of HF, non-HF cardiac and non-cardiac readmissions for secondary HF were 12.6%, 13.5% and 73.9%, respectively. For non-cardiac reasons of unplanned readmissions, the top 5 categories were infections, respiratory disorders, gastrointestinal disorders, renal failure and hematological disorders / neoplasms for both a primary or secondary diagnosis of HF during the index hospital admission (Supplementary Figure 2). For cardiac reasons of unplanned readmissions, HF was dominant followed by arrhythmias. The single most common reason for readmission was HF after admission with primary HF (32.3%) and infection for secondary HF (18.4%). Compared to primary HF, secondary HF was associated with lower rates of HF readmissions (12.6% vs 32.3%).

Supplementary Figure 3 shows rates of 30-day unplanned readmissions according to the primary cause of the readmission for patients with an index admission with secondary HF. Patients with a primary non-cardiac diagnosis that was hematological/oncological (17.1%), renal (16.7%), respiratory (16.2%) and endocrine/metabolic (16.2%) had the most readmissions. Readmissions were least among patients with obstetrical diagnoses (8.2%), TIA/stroke (10.8%) and syncope (11.4%). For cardiac causes, a secondary diagnosis of HF in the context of acute myocardial infarction (15.4%) and arrhythmia (14.1%) had the highest rates of readmission.

**Discussion**

Our results suggest that approximately 1 in 6 patients with either a primary or secondary diagnosis of HF have an unplanned readmission within 30-days of hospitalization. The important predictors of readmission after an index admission with a primary or secondary diagnosis of HF are comorbidities as well as discharge to care homes, or choosing to self-discharge against medical advice. Our evaluation of reasons for admission and rate of readmission among patients with secondary diagnosis of HF suggests that variation in readmission propensity depends on the reason(s) for the index hospital admission. While overall, causes of readmission were primarily non-cardiac (52.8% and 73.0% for primary and secondary HF, respectively), HF only accounted for 32% of unplanned readmission in patients admitted with an index primary diagnosis of HF and a significant number (13%) of patients with other causes for admissions have an unplanned readmission for HF. The findings from this study support the need for HF care to focus on the integrated patient health burden and better management of co-morbidities in HF in addition to the details of HF medications and specific follow up in HF clinics.

Our analysis is important for several reasons. First, we include all patients admitted to hospitals in the United States with diagnoses of HF. Both clinical trials and registries of HF are selective in patient inclusion. For example, the PARADIGM-HF exclude patients with hypotension, estimated glomerular filtration rate <30 and side effects to angiotensin receptor blockers or angiotensin receptor antagonists11 and in particular renal impairment in commonly observed in patients with HF especially those on diuretics. In terms of registries, the Get With The Guidelines-HF study only included a subset of hospitals in the United States which volunteer to take part and there is only linkage to Medicare inpatient data.12 For the readmissions study, there were only 130,146 patients eligible from 339 sites between 2005 and 2013 and 70% were excluded leaving 37,457 patients from 132 sites in the analysis.13 Our analysis represents complete national data which has advantages because of its size, representativeness and inclusion of all types of patients that present to hospital such as those with Medicaid, private and no health insurance. Secondly, because of the completeness of the NRD dataset across the years, we were able to examine trends over time and show that readmission rates are decreasing. Third, our analysis was able to consider primary and secondary HF separately which is important as patients with secondary HF have a greater burden of comorbidities and there are differences in causes for readmissions for these patients. For secondary diagnosis of HF, we further explored the rates of 30-day unplanned readmissions according to the primary diagnosis which is novel. We show that there is considerable variation in rates which vary from 8.2% for patients with primary diagnosis of obstetric or pregnancy problems and highest for hematological/oncological problems (17.1%) Finally, we were able to consider the financial implications of readmissions which adds an additional level of significance of readmissions. Readmissions were associated with on average more than $13,000 for both primary and secondary diagnosis of HF which was greater than the cost of the index admission for patients with a primary diagnosis of HF.

HF services should be optimally structured to prevent or reduce readmissions after hospitalizations for HF. Strategies to improve outcomes and reduce hospitalizations include optimization of medical therapy for HF and early follow up post-discharge. An important challenge in managing patients with HF is that of medication adherence as a review of 57 studies suggests that interventions to improve medication adherence reduces risk of mortality by 11% and odds of readmission by 21%.14 In addition, non-pharmacological measures may also be implemented to reduce readmissions which include programs such as Hospital-to-Home Readmission Intervention Program,15 ModelHeart,16 Patient-Centered Care Transitions,17 and other interventions such as telemedical care18 and use of grand-aides nurse extenders.19

Our finding that non-cardiac factors are the commonest reasons for unplanned readmissions in both primary and secondary HF raises the question about whether resources should be directed at management of comorbidities. Opportunities to manage comorbidities can take place during the index hospitalization or in the post-discharge period. Strategies can be employed to target the management of comorbidities such as continuous positive airway pressure for sleep disordered breathing, cardiopulmonary rehabilitation, immunization, inhalational drug therapies for chronic obstructive pulmonary disease and counselling patients on the consequences of failure to properly manage these multimorbidities may influence future hospitalization and progression of HF.20

A major concern has been raised regarding an active promotion for shortening length of hospital stay and reducing readmissions in HF that could result in increased mortality rates.21,22 It has been suggested that readmissions rates and mortality for congestive HF are inversely related.23-25 Analysis of the Get With The Guidelines-Heart Failure Registry (GWTG-HF) reported that among Medicare beneficiaries the rate of mortality in HF increased from 7.2% to 8.6% after the introduction of the Hospital Readmissions Reduction Program.26 It has been suggested that the increase in mortality may be related to hospitals attempting to delay admissions beyond day 30, increase observational stays or shift inpatient care to emergency departments.27 In the current study, mortality rates for patients with primary HF admission declined in the Medicare (3.2 % to 2.9%), and Medicaid (1.5% to 1.3%) patients but increased among uninsured patients (2.5% to 2.3%) with overall mortality rates declining over time from 3.0% to 2.7%. The divergence in findings between the Medicare cohorts and NRD may be related to generalizability of the cohort as participation in the GWTG-HF registry is voluntary whilst the NRD includes all payers and is designed to be nationally representative.

Important considerations in determining predictors of rehospitalization include patient-level non-clinical factors. Some of these factors not captured in the current dataset include the local healthcare infrastructure, patient preferences, access to care, caregiver situation, financial incentives for hospitals or physicians and medicolegal liability climate. In the current study, we were able to capture the primary expected payer, median household income, hospital bed size, teaching status, discharge location, but they are unlikely to account for the propensity to be readmitted based on the non-clinical factors. The inability of the research community to capture these non-clinical factors may be an explanation why there are difficulties in robustly predicting HF rehospitalizations.

Our study has several limitations. The NRD is also limited in its ability to explore regional differences and link outcomes across calendar years; as such, patients may appear in multiple years. In addition, in the current study we do not have information left ventricular systolic function, left ventricular diastolic function, New York Heart Association class, volume status, etiology of heart failure or prescription of pharmacological therapies such as angiotensin converting enzyme inhibitors that have been shown to reduce mortality and readmission.11,12 Furthermore, there is evidence that specialist management in hospital reduces readmissions in HF28 and the NRD does not capture data around whether patients had been managed or reviewed by HF specialists or cardiologists during their index admission. Also, once discharged there is no information regarding outpatient HF clinic follow up which has been shown to reduce 30-day readmission and mortality.29 As being inherent in any observational study, there is the risk of confounding and it would be incorrect to make causal inferences. Finally, the nature of the dataset is such that we are unable to determine deaths outside of hospital after discharge, so there is an issue of survivor bias.

In conclusion, 30-day unplanned readmission after admission with primary and secondary diagnosis is common. We report that non-cardiac causes are the most common causes of unplanned readmissions in both primary and secondary diagnoses of HF. The single most common cause for readmission in primary HF was HF whilst for secondary diagnosis of HF it was infection. Findings from this study highlight and confirm the importance of managing comorbidities, including respiratory, metabolic/endocrine disorders and renal failure, as targets to prevent readmission and warrant special attention to medical handover when discharging patients to destinations other than home.

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**Table 1:** Characteristics of participants by primary or secondary diagnosis of heart failure

|  |  |  |  |
| --- | --- | --- | --- |
| Variable | Primary heart failure (n=2,635,673) | Secondary heart failure (n=8,342,383) | p-value |
| Demographics | | | |
| Age (years) | 72.5±14.5 | 73.1±13.7 | <0.001 |
| Female | 49.5% | 52.5% | <0.001 |
| Weekend admission | 23.6% | 24.3% | <0.001 |
| Year  2010  2011  2012  2013  2014 | 19.7%  19.2%  18.4%  20.6%  22.2% | 18.7%  19.1%  18.9%  21.0%  22.3% | <0.001 |
| Primary expected payer  Medicare  Medicaid  Private  Uninsured  No charge  Other | 73.8%  8.3%  11.4%  3.7%  0.4%  2.4% | 77.5%  7.6%  10.5%  2.1%  0.2%  2.1% | <0.001 |
| Median household income (percentile)  0-25th  26-50th  51-75th  76-100th | 31.6%  25.0%  23.3%  20.2% | 30.8%  25.0%  23.4%  20.8% | <0.001 |
| Cardiovascular comorbidities | | | |
| Hypertension | 70.5% | 71.3% | <0.001 |
| Coronary artery disease | 44.5% | 44.9% | <0.001 |
| Previous myocardial infarction | 12.6% | 12.1% | <0.001 |
| Previous PCI | 9.9% | 9.4% | <0.001 |
| Previous CABG | 14.5% | 11.4% | <0.001 |
| Previous heart failure | 1.5% | 75.7% | <0.001 |
| Atrial fibrillation | 36.8% | 35.8% | <0.001 |
| Valvular heart disease | 0.4% | 11.8% | <0.001 |
| Previous stroke or TIA | 10.7% | 13.1% | <0.001 |
| Peripheral vascular disease | 11.5% | 12.5% | <0.001 |
| Pulmonary circulatory disorder | 0.4% | 7.7% | <0.001 |
| Non-cardiovascular comorbidities | | | |
| Smoker | 27.3% | 26.6% | <0.001 |
| Alcohol misuse | 3.4% | 3.5% | <0.001 |
| Dyslipidemia | 45.0% | 43.7% | <0.001 |
| Obesity | 19.1% | 16.8% | <0.001 |
| Diabetes mellitus | 43.1% | 40.4% | <0.001 |
| Chronic lung disease | 33.9% | 31.0% | <0.001 |
| Hypothyroidism | 15.9% | 16.6% | <0.001 |
| Renal failure | 38.4% | 29.3% | <0.001 |
| Liver disease | 2.7% | 3.1% | <0.001 |
| Fluid and electrolyte disorders | 29.4% | 37.5% | <0.001 |
| Peptic ulcer disease | 0.03% | 0.04% | <0.001 |
| Anemia | 28.3% | 27.8% | <0.001 |
| Bleeding | 0.7% | 2.8% | <0.001 |
| Cancer | 3.6% | 4.8% | <0.001 |
| Depression | 8.6% | 11.2% | <0.001 |
| Dementia | 9.2% | 13.5% | <0.001 |
| Charlson Comorbidity Index | 2.2±1.7 | 2.9±1.8 | <0.001 |
| Hospital characteristics | | | |
| Bed size  Small  Medium  Large | 11.8%  26.4%  61.9% | 10.8%  25.5%  63.7% | <0.001 |
| Teaching hospital | 55.6% | 56.7% | <0.001 |
| Urban hospital | 89.8% | 90.3% | <0.001 |
| In-hospital outcomes and treatment | | | |
| Cardiogenic shock | 0.8% | 1.3% | <0.001 |
| Cardiac arrest | 0.3% | 0.9% | <0.001 |
| Ventilation | 1.4% | 6.8% | <0.001 |
| Circulatory support | 0.3% | 0.8% | <0.001 |
| Intra-aortic balloon pump | 0.2% | 0.8% | <0.001 |
| Vasopressor | 0.3% | 0.6% | <0.001 |
| Coronary angiogram | 8.9% | 10.6% | <0.001 |
| Current admission PCI | 1.1% | 3.9% | <0.001 |
| Current CABG | 0.3% | 1.7% | <0.001 |
| Pacemaker or ICD implantation | 1.5% | 2.1% | <0.001 |
| Cardiac resynchronization therapy | 0.9% | 0.4% | <0.001 |
| Left ventricular assist device | 0.14% | 0.09% | <0.001 |
| Heart transplant | 0.08% | 0.02% | <0.001 |
| Discharge disposition  Home  Transfer to other hospital  Care home  Discharge against medical advice  Court/law enforcement | 57.6%  18.2%  23.0%  1.2%  <0.1% | 47.5%  30.3%  21.3%  0.9%  <0.1% | <0.001 |
| Length of stay (days) | 5.2±6.1 | 7.3±9.0 | <0.001 |
| Cost (USD) | $11,213±19,499 | $17,098±25,287 | <0.001 |
| Time to readmission | 16.3±7.6 | 16.6±7.5 | <0.001 |
| Readmission length of stay (days) | 6.2±7.2 | 6.5±7.5 | <0.001 |
| Death during readmission | 6.8% | 7.7% | <0.001 |
| Cost of readmission (USD) | $13,488±22,758 | $13,947±20,125 | <0.001 |

PCI=percutaneous coronary intervention, CABG=coronary artery bypass graft, TIA=transient ischemic attack, ICD=implantable defibrillator device

**Table 2:** Characteristics of participants by 30-day unplanned readmission and primary or secondary diagnosis of heart failure

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Variable | Primary heart failure (n=2,635,673) | | | Secondary heart failure (n=8,342,383) | | |
| Not readmitted | Readmitted | p-value | Not readmitted | Readmitted | p-value |
| Demographics | | | | | | |
| Age (years) | 72.3±14.5 | 73.1±14.1 | <0.001 | 73.1±13.7 | 73.1±13.6 | 0.15 |
| Female | 49.5% | 49.7% | 0.12 | 52.5% | 52.3% | 0.006 |
| Weekend admission | 23.5% | 24.1% | <0.001 | 24.3% | 24.6% | <0.001 |
| Year  2010  2011  2012  2013  2014 | 19.5%  19.1%  18.4%  20.6%  22.4% | 20.5%  19.8%  18.5%  20.1%  21.2% | <0.001 | 18.7%  19.0%  18.9%  21.1%  22.4% | 19.2%  19.7%  19.1%  20.4%  21.6% | <0.001 |
| Primary expected payer  Medicare  Medicaid  Private  Uninsured  No charge  Other | 73.1%  8.1% 11.9%  4.0%  0.4% 2.5% | 77.6%  9.2%  8.5%  2.4%  0.2%  2.0% | <0.001 | 77.1%  7.4%  10.8%  2.2%  0.3%  2.2% | 79.9%  8.2%  8.4%  1.6%  0.2%  1.7% | <0.001 |
| Median household income (percentile)  0-25th  26-50th  51-75th  76-100th | 31.5%  25.0%  23.3%  20.2% | 32.5%  24.8%  22.9%  19.8% | <0.001 | 30.7%  25.1%  23.4%  20.8% | 31.0%  25.0%  23.3%  20.6% | <0.001 |
| Cardiovascular comorbidities | | | | | | |
| Hypertension | 70.4% | 71.0% | <0.001 | 71.4% | 71.2% | 0.001 |
| Coronary artery disease | 44.0% | 46.9% | <0.001 | 44.7% | 46.4% | <0.001 |
| Previous myocardial infarction | 12.5% | 13.2% | <0.001 | 12.0% | 12.4% | <0.001 |
| Previous PCI | 9.8% | 10.5% | <0.001 | 9.3% | 9.7% | <0.001 |
| Previous CABG | 14.3% | 15.4% | <0.001 | 11.4% | 12.0% | <0.001 |
| Previous heart failure | 1.6% | 1.3% | <0.001 | 75.5% | 76.9% | <0.001 |
| Atrial fibrillation | 36.6% | 38.4% | <0.001 | 35.6% | 36.7% | <0.001 |
| Valvular heart disease | 0.5% | 0.4% | 0.001 | 11.8% | 12.2% | <0.001 |
| Previous stroke or TIA | 10.5% | 11.6% | <0.001 | 13.0% | 13.4% | <0.001 |
| Peripheral vascular disease | 11.2% | 12.9% | <0.001 | 12.3% | 13.8% | <0.001 |
| Pulmonary circulatory disorder | 0.4% | 0.3% | 0.001 | 7.7% | 8.0% | <0.001 |
| Non-cardiovascular comorbidities | | | | | | |
| Smoker | 27.4% | 26.6% | <0.001 | 26.5% | 26.8% | <0.001 |
| Alcohol misuse | 3.5% | 3.1% | <0.001 | 3.6% | 3.5% | 0.076 |
| Dyslipidemia | 45.1% | 44.1% | <0.001 | 43.9% | 42.5% | <0.001 |
| Obesity | 19.5% | 16.9% | <0.001 | 17.0% | 15.7% | <0.001 |
| Diabetes mellitus | 42.7% | 45.9% | <0.001 | 39.9% | 43.0% | <0.001 |
| Chronic lung disease | 33.3% | 37.2% | <0.001 | 30.6% | 33.4% | <0.001 |
| Hypothyroidism | 15.7% | 16.8% | <0.001 | 16.5% | 16.8% | <0.001 |
| Renal failure | 37.2% | 44.9% | <0.001 | 28.5% | 34.1% | <0.001 |
| Liver disease | 2.6% | 3.3% | <0.001 | 2.9% | 3.7% | <0.001 |
| Fluid and electrolyte disorders | 29.0% | 31.5% | <0.001 | 37.2% | 39.0% | <0.001 |
| Peptic ulcer disease | 0.03% | 0.04% | 0.003 | 0.04% | 0.04% | 0.59 |
| Anemia | 27.5% | 32.6% | <0.001 | 27.1% | 31.8% | <0.001 |
| Bleeding | 0.7% | 0.8% | <0.001 | 2.8% | 2.7% | 0.18 |
| Cancer | 3.4% | 4.3% | <0.001 | 4.7% | 5.8% | <0.001 |
| Depression | 8.5% | 9.4% | <0.001 | 11.1% | 11.7% | <0.001 |
| Dementia | 9.1% | 9.8% | <0.001 | 13.5% | 13.4% | 0.011 |
| Charlson Comorbidity Index | 2.2±1.6 | 2.5±1.7 | <0.001 | 2.9±1.8 | 3.1±1.8 | <0.001 |
| Hospital characteristics | | | | | | |
| Bed size  Small  Medium  Large | 11.8%  26.4%  61.8% | 11.5%  26.6%  62.0% | <0.001 | 10.8%  25.5%  63.8% | 10.7%  25.8%  63.5% | <0.001 |
| Teaching hospital | 55.9% | 54.1% | <0.001 | 56.9% | 55.6% | <0.001 |
| Urban hospital | 89.7% | 90.0% | <0.001 | 90.2% | 90.9% | <0.001 |
| In-hospital outcomes and treatments | | | | | | |
| Cardiogenic shock | 0.9% | 0.7% | <0.001 | 1.4% | 1.0% | <0.001 |
| Cardiac arrest | 0.3% | 0.2% | <0.001 | 1.0% | 0.6% | <0.001 |
| Ventilation | 1.5% | 1.0% | <0.001 | 7.0% | 5.5% | <0.001 |
| Circulatory support | 0.3% | 0.1% | <0.001 | 0.9% | 0.7% | <0.001 |
| Intra-aortic balloon pump | 0.3% | 0.1% | <0.001 | 0.8% | 0.6% | <0.001 |
| Vasopressor | 0.3% | 0.2% | 0.027 | 0.6% | 0.5% | <0.001 |
| Coronary angiogram | 9.3% | 6.4% | <0.001 | 10.8% | 9.2% | <0.001 |
| Current admission PCI | 1.1% | 1.0% | 0.002 | 4.0% | 3.7% | <0.001 |
| Current CABG | 0.3% | 0.2% | <0.001 | 1.7% | 1.2% | <0.001 |
| Pacemaker or ICD implantation | 1.5% | 1.1% | <0.001 | 2.1% | 1.6% | <0.001 |
| Cardiac resynchronization therapy | 1.0% | 0.7% | <0.001 | 0.4% | 0.3% | <0.001 |
| Left ventricular assist device | 0.16% | 0.03% | <0.001 | 0.09% | 0.05% | <0.001 |
| Heart transplant | 0.09% | 0.02% | <0.001 | 0.02% | 0.01% | <0.001 |
| Discharge location  Home  Transfer to other hospital  Care home  Discharge against medical advice  Court/law enforcement | 58.6%  17.8%  22.6%  1.0%  <0.1% | 51.9%  20.5%  25.5%  2.1%  <0.1% | <0.001 | 48.1%  30.2%  21.0%  0.8%  <0.1% | 43.9%  31.4%  23.2%  1.6%  <0.1% | <0.001 |
| Length of stay (days) | 5.3±6.5 | 5.0±3.7 | <0.001 | 7.4±9.6 | 6.2±4.7 | <0.001 |
| Cost (USD) | $11,410±20,707 | $10,105±10,274 | <0.001 | $17,561±26,666 | $14,394±14,579 | <0.001 |
| Time to readmission | - | 16.3±7.5 | - | - | 16.6±7.5 | - |
| Readmission length of stay (days) | - | 6.2±7.2 | - | - | 6.5±7.5 | - |
| Death during readmission | - | 6.8% | - | - | 7.7% | - |
| Cost of readmission (USD) | - | $13,488±22,758 | - | - | $13,947±20,124 | - |

NS=non-significant, PCI=percutaneous coronary intervention, CABG=coronary artery bypass graft, TIA=transient ischemic attack, ICD=implantable defibrillator device

**Table 3:** Predictors of readmission with primary heart failure and secondary heart failure

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Variable | Primary heart failure | | Secondary heart failure\* | |
| Odds ratio (95% CI) | p-value | Odds ratio (95% CI) | p-value |
| Age (per year) | 0.99 (0.99-0.99) | <0.001 | 0.99 (0.99-0.99) | <0.001 |
| Female | NS | 0.063 | NS | 0.28 |
| Weekend admission | 1.02 (1.01-1.04) | <0.001 | 1.02 (1.01-1.03) | <0.001 |
| Year vs 2010  2011  2012  2013  2014 | NS  0.95 (0.93-0.97)  0.92 (0.91-0.94)  0.89 (0.88-0.91) | 0.22  <0.001  <0.001  <0.001 | NS  0.97 (0.96-0.98)  0.93 (0.92-0.94)  0.92 (0.91-0.93) | 0.74  <0.001  <0.001  <0.001 |
| Primary expected payer vs Medicare  Medicaid  Private  Uninsured  No charge  Other | 1.11 (1.09-1.14)  0.75 (0.74-0.77)  0.65 (0.63-0.68)  0.64 (0.58-0.71)  0.82 (0.79-0.85) | <0.001  <0.001  <0.001  <0.001  <0.001 | 1.05 (1.04-1.06)  0.77 (0.76-0.78)  0.70 (0.68-0.72)  0.77 (0.72-0.82)  0.79 (0.77-0.81) | <0.001  <0.001  <0.001  <0.001  <0.001 |
| Median household income (percentile) vs 0-25th  26-50th  51-75th  76-100th | 0.96 (0.94-0.97)  0.94 (0.93-0.96)  0.93 (0.92-0.95) | <0.001  <0.001  <0.001 | NS  0.99 (0.98-0.99)  0.99 (0.98-1.00) | 0.32  0.001  0.003 |
| Hypertension | NS | 0.066 | 0.97 (0.96-0.98) | <0.001 |
| Dyslipidemia | 0.93 (0.92-0.94) | <0.001 | 0.93 (0.93-0.94) | <0.001 |
| Obesity | 0.83 (0.82-0.84) | <0.001 | 0.88 (0.87-0.89) | <0.001 |
| Diabetes mellitus | 1.11 (1.09-1.12) | <0.001 | 1.10 (1.10-1.11) | <0.001 |
| Smoker | 0.96 (0.95-0.98) | <0.001 | 0.99 (0.99-1.00) | 0.048 |
| Alcohol misuse | 0.95 (0.92-0.98) | 0.002 | NS | 0.87 |
| Coronary artery disease | 1.10 (1.08-1.11) | <0.001 | 1.08 (1.07-1.08) | <0.001 |
| Previous myocardial infarction | NS | 0.12 | 1.01 (1.00-1.02) | 0.048 |
| Previous PCI | 1.03 (1.01-1.05) | 0.003 | 1.03 (1.01-1.04) | <0.001 |
| Previous CABG | NS | 0.38 | NS | 0.52 |
| Previous heart failure | 0.72 (0.69-0.76) | <0.001 | NS | 0.27 |
| Atrial fibrillation | 1.08 (1.07-1.09) | <0.001 | 1.08 (1.08-1.09) | <0.001 |
| Valvular heart disease | NS | 0.50 | 1.01 (1.00-1.02) | <0.001 |
| Previous stroke or TIA | 1.05 (1.03-1.07) | <0.001 | 1.03 (1.02-1.04) | <0.001 |
| Peripheral vascular disease | 1.07 (1.06-1.09) | <0.001 | 1.07 (1.06-1.08) | <0.001 |
| Pulmonary circulatory disorder | NS | 0.72 | NS | 0.29 |
| Chronic lung disease | 1.16 (1.15-1.17) | <0.001 | 1.14 (1.13-1.14) | <0.001 |
| Hypothyroidism | 1.04 (1.03-1.06) | <0.001 | NS | 0.14 |
| Renal failure | 1.27 (1.25-1.28) | <0.001 | 1.24 (1.23-1.25) | <0.001 |
| Liver disease | 1.21 (1.18-1.25) | <0.001 | 1.20 (1.18-1.22) | <0.001 |
| Fluid and electrolyte disorders | 1.08 (1.07-1.09) | <0.001 | 1.04 (1.03-1.05) | <0.001 |
| Peptic ulcer disease | 1.46 (1.11-1.92) | 0.007 | NS | 0.89 |
| Anaemia | 1.13 (1.12-1.14) | <0.001 | 1.15 (1.15-1.16) | <0.001 |
| Bleeding | NS | 0.25 | 0.97 (0.96-0.99) | 0.12 |
| Cancer | 1.26 (1.22-1.29) | <0.001 | 1.22 (1.20-1.24) | <0.001 |
| Depression | 1.08 (1.07-1.11) | <0.001 | 1.04 (1.03-1.05) | <0.001 |
| Dementia | NS | 0.15 | 0.97 (0.96-0.98) | <0.001 |
| Bed size vs small  Medium  Large | NS  1.02 (1.00-1.03) | 0.067  0.049 | 1.01 (1.00-1.02)  NS | 0.035  0.81 |
| Teaching hospital | 0.96 (0.95-0.97) | <0.001 | 0.98 (0.98-0.99) | <0.001 |
| Urban hospital | 1.03 (1.01-1.05) | 0.001 | 1.09 (1.08-1.10) | <0.001 |
| Cardiogenic shock | NS | 0.071 | 0.88 (0.85-0.91) | <0.001 |
| Cardiac arrest | 0.83 (0.73-0.94) | 0.004 | 0.84 (0.81-0.87) | <0.001 |
| Ventilation | 0.74 (0.70-0.78) | <0.001 | 0.72 (0.71-0.73) | <0.001 |
| Circulatory support | 2.81 (1.64-4.81) | <0.001 | NS | 0.46 |
| Intra-aortic balloon pump | 0.30 (0.18-0.52) | <0.001 | NS | 0.73 |
| Vasopressor | NS | 0.86 | 0.94 (0.90-0.98) | 0.003 |
| Coronary angiogram | 0.74 (0.72-0.75) | <0.001 | 0.84 (0.83-0.86) | <0.001 |
| Current admission PCI | 1.26 (1.19-1.33) | <0.001 | 1.08 (1.05-1.10) | <0.001 |
| Current CABG | NS | 0.55 | 0.74 (0.72-0.76) | <0.001 |
| Pacemaker or ICD implantation | 0.84 (0.80-0.88) | <0.001 | 0.82 (0.80-0.84) | <0.001 |
| Cardiac resynchronization therapy | 0.77 (0.73-0.82) | <0.001 | 0.82 (0.68-0.76) | <0.001 |
| Left ventricular assist device | 0.18 (0.12-0.25) | <0.001 | 0.60 (0.49-0.74) | <0.001 |
| Heart transplant | 0.34 (0.24-0.48) | <0.001 | 0.32 (0.22-0.47) | <0.001 |
| Discharge location vs home  Transfer to other hospital  Care home  Discharge against medical advice  Court/law enforcement | 1.23 (1.21-1.25)  1.21 (1.19-1.22)  2.29 (2.20-2.39)  NS | <0.001  <0.001  <0.001  - | 1.19 (1.18-1.20)  1.20 (1.19-1.21)  2.06 (2.01-2.12)  NS | <0.001  <0.001  <0.001  0.51 |

\*Also adjusted for causes of admission but shown in detail in Supplementary Table 2

NS=not significant where p>0.05.

**Figure 1:** Trends in 30-day all-cause readmissions over time among patients hospitalized with a primary or secondary diagnosis of heart failure

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**Figure 2:** Causes of readmission among patients hospitalized with a primary and secondary diagnosis of heart failure



**Supplementary Data**

**Supplementary Data 1:** Additional description of methods

At index admission, demographic such as age, gender, primary expected payer, median household income, and institutional characteristics such as hospital bed size, teaching hospital status, urban hospital classification and discharge location were available in the NRD dataset. We used ICD-9 codes at index admission to define clinical variables including smoking status, dyslipidaemia, coronary artery disease, previous myocardial infarction, previous percutaneous coronary intervention (PCI), previous coronary artery bypass grafting (CABG), previous stroke or transient ischemic attack (TIA), atrial fibrillation, dementia, and receipt of circulatory support (ICD-9 codes 37.61, 37.68 and 39.65). Other variables analysed were Elixhauser comorbidities, which included alcohol misuse, chronic lung disease, heart failure (as a previous diagnosis), diabetes mellitus, valvular heart disease, peptic ulcer disease, hypertension, renal failure, obesity, cancer, fluid and electrolyte disorders, depression, peripheral vascular disease, hypothyroidism, liver disease, anaemia, and coagulopathy. The Charlson Comorbidity Index was defined according to a previously reported method.1 Procedural ICD-9 codes were used to define circulatory support, vasopressor use, intra-aortic balloon pump use, coronary angiogram, percutaneous coronary intervention, coronary artery bypass graft (CABG), pacemaker or implantable cardioverter defibrillator, cardiac resynchronization therapy, left ventricular assist device and heart transplant. The causes of readmission were determined by the first diagnosis based on the Clinical Classification codes which are presented in detail in Supplementary Table 1.

Statistical analysis was performed using Stata version 14.0 (StataCorp, College Station, TX, USA). The survey estimation commands were used to estimate the sample size as recommended by the Agency of Healthcare Research and Quality. The sample was split into patients with heart failure as primary and secondary diagnoses, and their unplanned 30-day all-cause and heart failure readmission were determined. For both groups, descriptive statistics were presented according to 30-day readmission status. The statistical differences for continuous and categorical variables were compared using the t test and chi-square test, respectively. Multiple logistic regressions were used to identify independent predictors of 30-day readmissions for both primary and secondary diagnosis of heart failure. For the analysis of secondary heart failure, we included the primary condition for admission in the model. Furthermore, we evaluated the proportion of 30-day unplanned readmissions for secondary diagnosis of heart failure according to the primary cause of admission.

**Reference**

1. Kwok CS, Martinez SC, Pancholy S, Ahmed W, Al-Shaibi K, Potts J, Mohamed M, Kontopantelis E, Curzen N, Mamas MA. Effect of comorbidity on unplanned readmissions after percutaneous coronary intervention (From the Nationwide Readmission Database). Sci Rep 2018;8:11156.

**Supplementary Figure 1:** Flow diagram of patient inclusion

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**Supplementary Figure 2:** Detailed causes of readmission among patients hospitalized with a primary and secondary diagnosis of heart failure



**Supplementary Figure 3:** Risk of 30-day readmission according to principal reason for admission among patients with secondary diagnosis of heart failure



**Supplementary Table 1:** Classification of CCS codes for Readmissions Causes

|  |  |  |
| --- | --- | --- |
| Causes of readmission | CCS code | Diagnosis |
| Respiratory | 127 | Chronic obstructive pulmonary disease and bronchietasis |
| 128 | Asthma |
| 130 | Pleurisy, pneumothorax, pulmonary collapse |
| 131 | Respiratory failure, insufficiency and arrest |
| 132 | Lung disease due to external agents |
| 133 | Other lower respiratory disease |
| 134 | Other upper respiratory disease |
| 221 | Respiratory distress syndrome |
| Infection | 1 | Tuberculosis |
| 2 | Septicemia |
| 3 | Bacterial infection |
| 4 | Mycoses |
| 5 | HIV infection |
| 6 | Hepatitis |
| 7 | Viral infection |
| 8 | Other infection |
| 9 | Sexually transmitted infection |
| 76 | Meningitis |
| 77 | Encephalitis |
| 78 | Other CNS infection and poliomyelitis |
| 90 | Inflammation or infection of eye |
| 122 | Pneumonia |
| 123 | Influenza |
| 124 | Acute and chronic tonsillitis |
| 125 | Acute bronchitis |
| 126 | Other upper respiratory infections |
| 129 | Aspiration pneumonitis |
| 135 | Intestinal infection |
| 197 | Skin and subcutaneous tissue infections |
| 201 | Infective arthritis and osteomyelitis (except that caused by tuberculosis or sexually transmitted disease) |
| Bleeding | 60 | Acute posthaemorrhagic anemia |
| 153 | Gastrointestinal hemorrhage |
| 182 | Hemorrhage during pregnancy; abrutio placenta; placenta previa |
| Peripheral vascular disease | 114 | Peripheral and visceral atherosclerosis |
| 115 | Aortic, peripheral and visceral artery aneurysms |
| 116 | Aortic and peripheral arterial embolism or thrombosis |
| 117 | Other circulatory disease |
| 118 | Phlebitis, thrombophlebitis and thromboembolism |
| 119 | Varicose veins of lower extremities |
| Genitourinary | 159 | Urinary tract infection |
| 160 | Calculus of the urinary tract |
| 161 | Other diseases of kidney and ureters |
| 162 | Other diseases of bladder and urethra |
| 163 | Genitourinary symptoms and ill-defined conditions |
| 164 | Hyperplasia of prostate |
| 165 | Inflammatory conditions of the male genital organs |
| 166 | Other male genital disorders |
| 170 | Prolapse of female genital organs |
| 175 | Other female genital disorders |
| 215 | Genitourinary congenital anomalies |
| Renal disease | 156 | Nephritis; nephrosis; renal sclerosis |
| 157 | Acute and unspecified renal failure |
| 158 | Chronic kidney disease |
| Gastrointestinal | 138 | Esophageal disorders |
| 139 | Gastroduodenal ulcer (except hemorrhage) |
| 140 | Gastritis and duodenitis |
| 141 | Other disorders of stomach and duodenum |
| 142 | Appendicitis and other appendiceal conditions |
| 143 | Abdominal hernia |
| 144 | Regional enteritis and ulcerative colitis |
| 145 | Intestinal obstruction without hernia |
| 146 | Diverticulosis and diverticulitis |
| 147 | Anal and rectal conditions |
| 148 | Peritonitis and intestinal abscess |
| 149 | Biliary tract disease |
| 150 | Liver disease; alcohol-related |
| 151 | Other liver diseases |
| 152 | Pancreatic disorders (not diabetes) |
| 154 | Noninfectious gastroenteritis |
| 155 | Other gastrointestinal disorders |
| 214 | Digestive congenital anomalies |
| 222 | Hemolytic jaundice and perinatal jaundice |
| 250 | Nausea and vomiting |
| 251 | Abdominal pain |
| TIA/stroke | 109 | Acute cerebrovascular disease |
| 110 | Occlusion of stenosis of precerebral arteries |
| 111 | Other and ill-defined cerebrovascular disease |
| 112 | Transient cerebral ischemia |
| 113 | Late effects of cerebrovascular disease |
| Trauma | 207 | Pathological fracture |
| 225 | Joint disorders and dislocations; trauma-related |
| 226 | Fracture of neck of femur (hip) |
| 227 | Spinal cord injury |
| 228 | Skull and face fractures |
| 229 | Fracture of upper limb |
| 230 | Fracture of lower limb |
| 231 | Other fractures |
| 232 | Sprains and strains |
| 233 | Intracranial injury |
| 234 | Crushing injury or internal injury |
| 235 | Open wounds of head; neck; and trunk |
| 236 | Open wounds of extremities |
| 239 | Superficial injury; contusion |
| 244 | Other injuries and conditions due to external causes |
| 260 | All (external causes of injury and poisoning) |
| Endocrine/metabolic | 48 | Thyroid disorders |
| 49 | Diabetes mellitus without complication |
| 50 | Diabetes mellitus with complication |
| 51 | Other endocrine disorders |
| 53 | Disorders of lipid metabolism |
| 58 | Other nutritional and endocrine/metabolic disorders |
| 186 | Diabetes or abnormal glucose tolerance complicating pregnancy; childbirth; or the puerperium |
| Neuropsychiatric | 650 | Adjustment disorders |
| 651 | Anxiety disorders |
| 652 | Attention-deficit, conduct, and disruptive behavior disorders |
| 653 | Delirium, dementia, and amnestic and other cognitive disorders |
| 654 | Developmental disorders |
| 655 | Disorders usually diagnosed in infancy and childhood or adolescence |
| 656 | Impulse control disorders, NEC |
| 657 | Mood disorders |
| 658 | Personality disorders |
| 659 | Schizophrenia and other psychotic disorders |
| 660 | Alcohol-related disorders |
| 661 | Substance-related disorders |
| 662 | Suicide and intentional self-inflicted injury |
| 663 | Screening and history of mental health and substance abuse codes |
| 670 | Miscellaneous mental health disorders |
| 79 | Parkinson's disease |
| 80 | Multiple sclerosis |
| 81 | Other hereditary and degenerative nervous system conditions |
| 82 | Paralysis |
| 83 | Epilepsy, convulsions |
| 84 | Headache including migraine |
| 85 | Coma, stupor and brain damage |
| 95 | Other nervous system disorders |
| 216 | Nervous system congenital anomalies |
| 650 | Adjustment disorders |
| 651 | Anxiety disorders |
| 652 | Attention-deficit, conduct, and disruptive behavior disorders |
| 653 | Delirium, dementia, and amnestic and other cognitive disorders |
| 654 | Developmental disorders |
| 655 | Disorders usually diagnosed in infancy and childhood or adolescence |
| 656 | Impulse control disorders, NEC |
| 657 | Mood disorders |
| 658 | Personality disorders |
| 659 | Schizophrenia and other psychotic disorders |
| 660 | Alcohol-related disorders |
| 661 | Substance-related disorders |
| 662 | Suicide and intentional self-inflicted injury |
| 663 | Screening and history of mental health and substance abuse codes |
| 670 | Miscellaneous mental health disorders |
| Hematological/neoplastic | 11 | Cancer of head and neck |
| 12 | Cancer of esophagus |
| 13 | Cancer of stomach |
| 14 | Cancer of colon |
| 15 | Cancer of rectum and anus |
| 16 | Cancer of liver and intrahepatic bile ducts |
| 17 | Cancer of pancreas |
| 18 | Cancer of other GI organs, peritoneum |
| 19 | Cancer of bronchus, lung |
| 20 | Cancer of other respiratory and intrathoracic |
| 21 | Cancer of bone and connective tissue |
| 22 | Melanoma of skin |
| 23 | Other non-epithelial cancer of skin |
| 24 | Cancer of breast |
| 25 | Cancer of uterus |
| 26 | Cancer of cervix |
| 27 | Cancer of ovary |
| 28 | Cancer of other female genital organs |
| 29 | Cancer of prostate |
| 30 | Cancer of testis |
| 31 | Cancer of other male genital organs |
| 32 | Cancer of bladder |
| 33 | Cancer of kidney and renal pelvis |
| 34 | Cancer of other urinary organs |
| 35 | Cancer of brain and nervous system |
| 36 | Cancer of thyroid |
| 37 | Hodgkin's disease |
| 38 | Non-Hodgkin's lymphoma |
| 39 | Leukaemias |
| 40 | Multiple myeloma |
| 41 | Cancer, other and unspecified primary |
| 42 | Secondary malignancies |
| 43 | Malignant neoplasm without specification of site |
| 44 | Neoplasm of unspecified nature or uncertain behaviour |
| 46 | Benign neoplasm of uterus |
| 47 | Other and unspecified benign neoplasm |
| 59 | Deficiency and other anemias |
| 61 | Sickle cell anemia |
| 62 | Coagulation and hemorrhagic disorders |
| 63 | Disease of white blood cells |
| 64 | Other hematologic conditions |
| Rheumatology problem | 54 | Gout and other crystal arthropathies |
| Opthalmology problem | 86 | Cataract |
| 87 | Retinal detachment defects, vascular occlusion and retinopathy |
| 88 | Glaucoma |
| 89 | Blindness and vision defects |
| 91 | Other eye disorders |
| ENT problem | 92 | Otitis media and related conditions |
| 93 | Conditions associate with dizziness or vertigo |
| 94 | Other ear and sense organ disorder |
| Non-specific chest pain | 102 | Non-specific chest pain |
| Oral health problem | 136 | Disorders of teeth and jaw |
| 137 | Diseases of mouth; excluding dental |
| Obstetric admission including pregnancy | 174 | Female infertility |
| 176 | Contraceptive and procreative management |
| 177 | Spontaneous abortion |
| 178 | Induced abortion |
| 179 | Postabortion complication |
| 180 | Ectopic pregnancy |
| 181 | Other complications of pregnancy |
| 184 | Early or threatened labor |
| 185 | Prolonged pregnancy |
| 187 | Malposition; malpresentation |
| 188 | Fetopelvic disproportion; obstruction |
| 189 | Previous C-section |
| 190 | Fetal distress and abnormal forces of labor |
| 191 | Polyhydramnios and other problems of amniotic cavity |
| 192 | Umbilical cord complication |
| 193 | OB-related trauma to perineum and vulva |
| 194 | Forceps delivery |
| 195 | Other complications of birth; puerperium affecting management of mother |
| 196 | Other pregnancy and deliver including normal |
| 218 | Liveborn |
| 219 | Short gestation; low birth weight; and fetal growth retardation |
| 220 | Intrauterine hypoxia and birth asphyxia |
| 223 | Birth trauma |
| 224 | Other perinatal conditions |
| Dermatology problem | 198 | Other inflammatory condition of skin |
| 199 | Chronic ulcer of skin |
| 200 | Other skin disorders |
| Poisoning | 241 | Poisoning by psychotrophic agents |
| 242 | Poisoning by other medication and drugs |
| 243 | Poisoning by nonmedical substances |
| Syncope | 245 | Syncope |
| Other non-cardiac | 10 | Immunization and screening for infectious disease |
| 45 | Maintenance chemotherapy, radiotherapy |
| 52 | Nutritional deficiencies |
| 55 | Fluid and electrolyte disorders |
| 56 | Cystic fibrosis |
| 57 | Immunity disorder |
| 120 | Hemorrhoids |
| 121 | Other diseases of veins and lymphatics |
| 167 | Nonmalignant breast conditions |
| 168 | Inflammatory disease of female pelvic organs |
| 169 | Endometriosis |
| 172 | Ovarian cyst |
| 173 | Menopausal disorders |
| 202 | Rheumatoid arthritis and related disease |
| 203 | Osteoarthritis |
| 204 | Other non-traumatic joint disorders |
| 205 | Spondylosis; intervertebral disc disorders; other back problems |
| 206 | Osteoporosis |
| 208 | Acquired foot deformities |
| 209 | Other acquired deformities |
| 210 | Systemic lupus erythematosus and connective tissue disorders |
| 211 | Other connective tissue disease |
| 212 | Other bone disease and musculoskeletal deformities |
| 217 | Other congenital anomalies |
| 237 | Complication of device; implant or graft |
| 238 | Complications of surgical procedure or medical care |
| 240 | Burns |
| 246 | Fever of unknown origin |
| 247 | Lymphadenitis |
| 248 | Gangrene |
| 252 | Malaise and fatigue |
| 253 | Allergic reactions |
| 254 | Rehabilitation care; fitting of prostheses; and adjustment of devices |
| 255 | Administrative/social admission |
| 256 | Medical examination/evaluation |
| 257 | Other aftercare |
| 258 | Other screening for suspected conditions (not mental disorders or infectious disease) |
| 259 | Residual codes; unclassified |
| Heart failure | 108 | Congestive heart failure non-hypertensive |
| Arrhythmia | 106 | Cardiac dysrhythmias |
| 107 | Cardiac arrest and ventricular fibrillation |
| Conduction disorder | 105 | Conduction disorders |
| Valve disorders | 96 | Heart valve disorder |
| Hyper/hypotension | 98 | Essential hypertension |
| 99 | Hypertension with complications and secondary hypertension |
| 183 | Hypertension complicating pregnancy; childbirth and the puerperium |
| 249 | Shock |
| Pericarditis | 97 | Peri-, endo- and myocarditis, cardiomyopathy |
| Coronary artery disease including angina | 101 | Coronary atherosclerosis and other heart disease |
| Acute myocardial infarction | 100 | Acute myocardial infarction |
| Others (cardiac) | 103 | Pulmonary heart disease |
| 104 | Other and ill-defined heart disease |
| 213 | Cardiac and circulatory congenital anomalies |

**Supplementary Table 2:** Causes of admission as a predictors of readmission in patients with secondary diagnosis of heart failure

|  |  |  |
| --- | --- | --- |
| Cause of admission vs respiratory cause | Odds ratio (95% CI) | p-value |
| Infections  Bleeding  Peripheral vascular disease  Genitourinary  Gastrointestinal  TIA/stroke  Trauma  Endocrine/metabolic  Neuropsychiatric  Hematological  Renal failure  Rheumatological  Opthalmological  ENT problem  Non-specific chest pain  Oral health problem  Obstetric or pregnancy problem  Dermatology  Poisoning  Syncope  Other non-cardiac  Coronary artery disease including angina  Acute myocardial infarction  Arrhythmias  Conduction disorders  Valve disorders  Hyper/hypotension  Pericarditis  Other cardiac | 0.79 (0.78-0.80)  0.88 (0.86-0.90)  0.84 (0.82-0.86)  0.83 (0.82-0.85)  0.86 (0.85-0.87)  0.60 (0.59-0.61)  0.69 (0.67-0.70)  0.89 (0.87-0.91)  0.77 (0.75-0.79)  0.97 (0.85-0.99)  0.94 (0.93-0.96)  0.72 (0.70-0.74)  0.74 (0.63-0.87)  0.75 (0.73-0.78)  0.73 (0.71-0.75)  0.64 (0.56-0.74)  0.48 (0.44-0.52)  0.77 (0.72-0.83)  0.80 (0.76-0.84)  0.65 (0.62-0.67)  0.88 (0.87-0.90)  0.84 (0.82-0.86)  NS  0.87 (0.86-0.89)  0.73 (0.69-0.77)  0.85 (0.82-0.88)  0.56 (0.47-0.66)  0.89 (0.86-0.93)  0.82 (0.79-0.84) | <0.001  <0.001  <0.001  <0.001  <0.001  <0.001  <0.001  <0.001  <0.001  0.002  <0.001  <0.001  <0.001  <0.001  <0.001  <0.001  <0.001  <0.001  <0.001  <0.001  <0.001  <0.001  0.65  <0.001  <0.001  <0.001  <0.001  <0.001  <0.001 |