Early Unplanned Readmissions after Admission to Hospital with Heart Failure

Running title: Unplanned readmissions after heart failure

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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.

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 antagonists[11] 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 care[18] 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 HF[28] 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			<0.001
2010	19.7%	18.7%	
2011	19.2%	19.1%	
2012	18.4%	18.9%	
2013	20.6%	21.0%	
2014	22.2%	22.3%	
Primary expected payer			<0.001
Medicare	73.8%	77.5%	
Medicaid	8.3%	7.6%	
Private	11.4%	10.5%	
Uninsured	3.7%	2.1%	
No charge	0.4%	0.2%	
Other	2.4%	2.1%	
Median household income (percentile)			<0.001
0-25th	31.6%	30.8%	
26-50th	25.0%	25.0%	
51-75th	23.3%	23.4%	
76-100th	20.2%	20.8%	
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			<0.001
Small	11.8%	10.8%	
Medium	26.4%	25.5%	
Large	61.9%	63.7%	
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			<0.001
Home	57.6%	47.5%	
Transfer to other hospital	18.2%	30.3%	
Care home	23.0%	21.3%	
Discharge against medical advice	1.2%	0.9%	
Court/law enforcement	<0.1%	<0.1%	
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			<0.001			<0.001
2010	19.5%	20.5%		18.7%	19.2%	
2011	19.1%	19.8%		19.0%	19.7%	
2012	18.4%	18.5%		18.9%	19.1%	
2013	20.6%	20.1%		21.1%	20.4%	
2014	22.4%	21.2%		22.4%	21.6%	
Primary expected payer			<0.001			<0.001
Medicare	73.1%	77.6%		77.1%	79.9%	
Medicaid	8.1%	9.2%		7.4%	8.2%	
Private	11.9%	8.5%		10.8%	8.4%	
Uninsured	4.0%	2.4%		2.2%	1.6%	
No charge	0.4%	0.2%		0.3%	0.2%	
Other	2.5%	2.0%		2.2%	1.7%	
Median household income (percentile)			<0.001			<0.001
0-25th	31.5%	32.5%		30.7%	31.0%	
26-50th	25.0%	24.8%		25.1%	25.0%	
51-75th	23.3%	22.9%		23.4%	23.3%	
76-100th	20.2%	19.8%		20.8%	20.6%	
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	NS	0.22	NS	0.74
2012	0.95 (0.93-0.97)	<0.001	0.97 (0.96-0.98)	<0.001
2013	0.92 (0.91-0.94)	<0.001	0.93 (0.92-0.94)	<0.001
2014	0.89 (0.88-0.91)	<0.001	0.92 (0.91-0.93)	<0.001
Primary expected payer vs Medicare				
Medicaid	1.11 (1.09-1.14)	<0.001	1.05 (1.04-1.06)	<0.001
Private	0.75 (0.74-0.77)	<0.001	0.77 (0.76-0.78)	<0.001
Uninsured	0.65 (0.63-0.68)	<0.001	0.70 (0.68-0.72)	<0.001
No charge	0.64 (0.58-0.71)	<0.001	0.77 (0.72-0.82)	<0.001
Other	0.82 (0.79-0.85)	<0.001	0.79 (0.77-0.81)	<0.001
Median household income (percentile) vs 0-25th				
26-50th	0.96 (0.94-0.97)	<0.001	NS	0.32
51-75th	0.94 (0.93-0.96)	<0.001	0.99 (0.98-0.99)	0.001
76-100th	0.93 (0.92-0.95)	<0.001	0.99 (0.98-1.00)	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	NS	0.067	1.01 (1.00-1.02)	0.035
Large	1.02 (1.00-1.03)	0.049	NS	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	1.23 (1.21-1.25)	<0.001	1.19 (1.18-1.20)	<0.001
Care home	1.21 (1.19-1.22)	<0.001	1.20 (1.19-1.21)	<0.001
Discharge against medical advice	2.29 (2.20-2.39)	<0.001	2.06 (2.01-2.12)	<0.001
Court/law enforcement	NS	-	NS	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
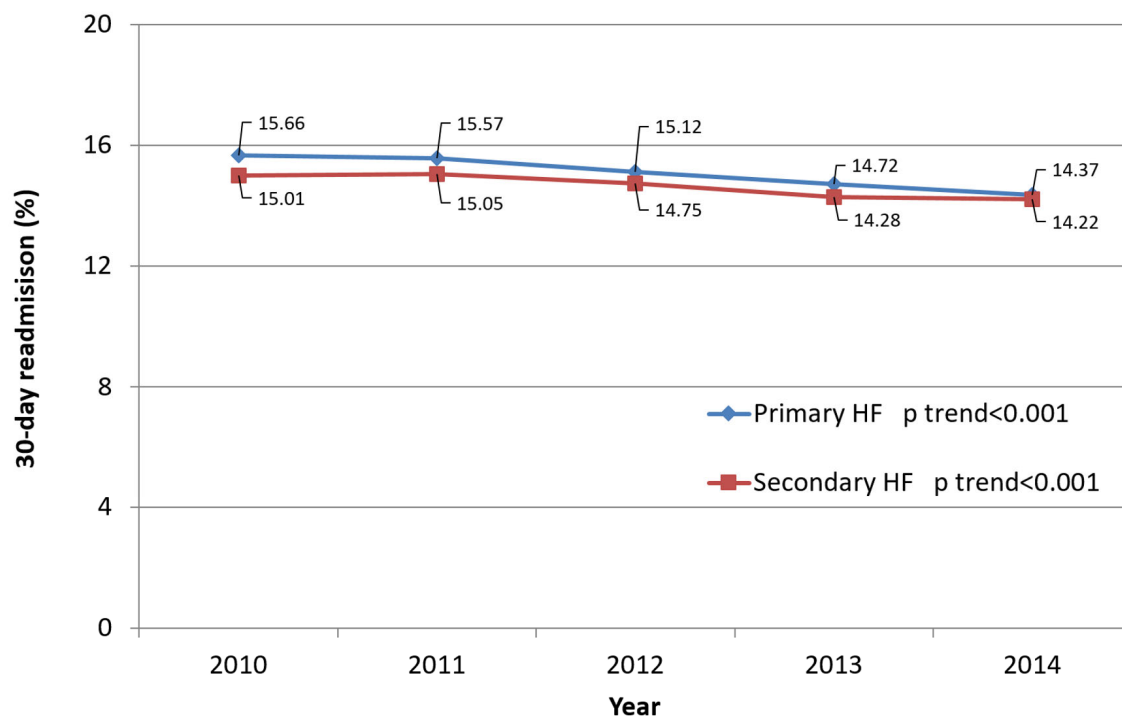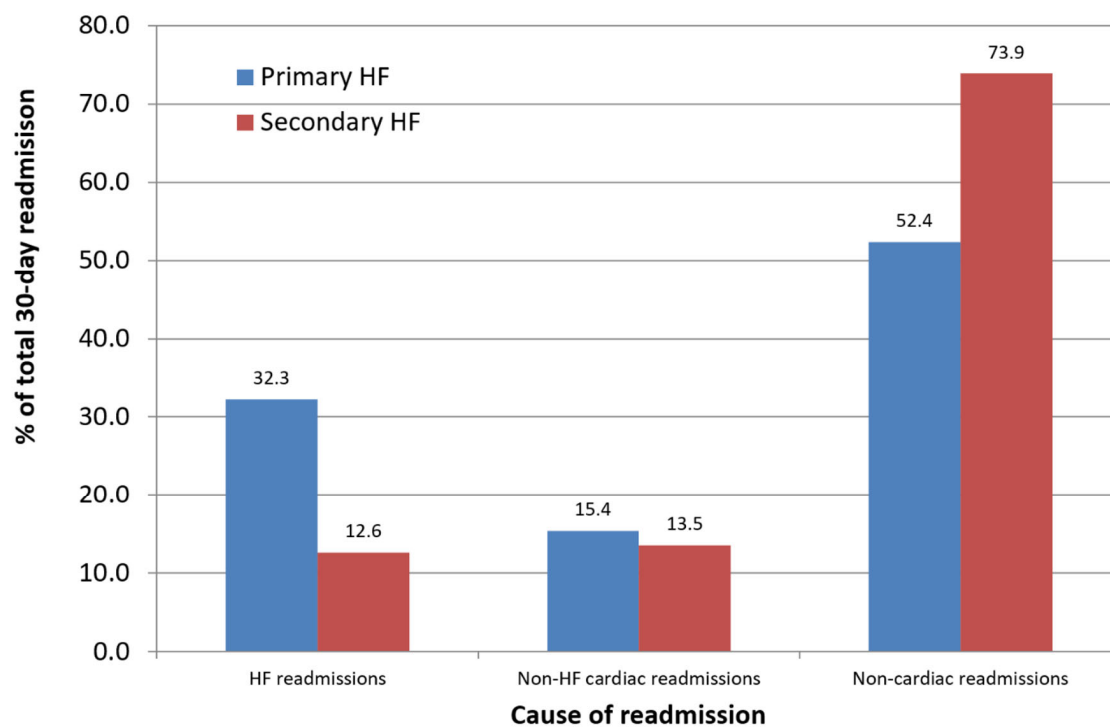
Figure 2: Causes of readmission among patients hospitalized with a primary and secondary diagnosis of heart failure
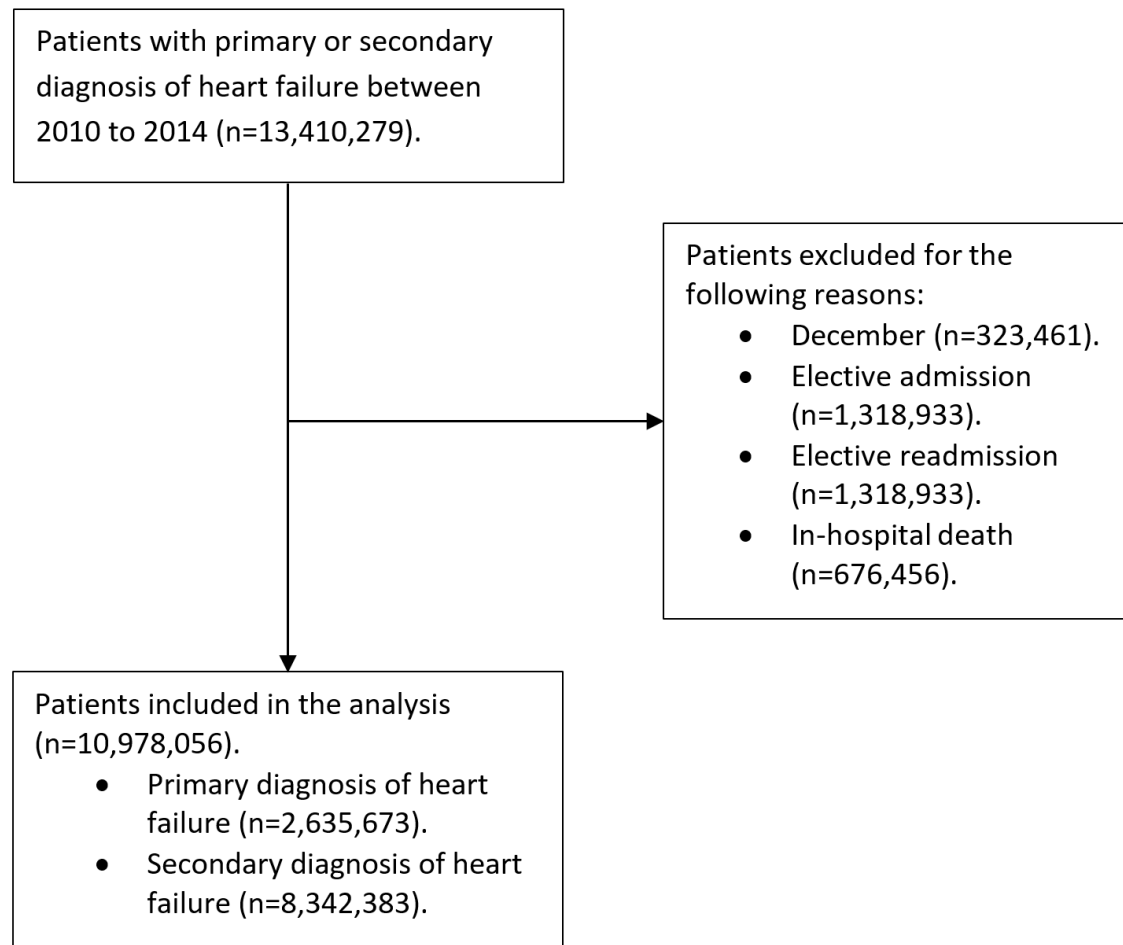
Supplementary Data

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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┌─────────────────────────────────┐
│ Patients with primary or secondary│
│ diagnosis of heart failure between│
│ 2010 to 2014 (n=13,410,279).     │
└─────────────────────────────────┘
                │
                │          ┌──────────────────────────────┐
                │          │ Patients excluded for the    │
                │          │ following reasons:           │
                ├─────────▶│   • December (n=323,461).    │
                │          │   • Elective admission       │
                │          │     (n=1,318,933).           │
                │          │   • Elective readmission     │
                │          │     (n=1,318,933).           │
                │          │   • In-hospital death        │
                │          │     (n=676,456).             │
                │          └──────────────────────────────┘
                ▼
┌─────────────────────────────────┐
│ Patients included in the analysis│
│ (n=10,978,056).                  │
│   • Primary diagnosis of heart   │
│     failure (n=2,635,673).       │
│   • Secondary diagnosis of heart │
│     failure (n=8,342,383).       │
└─────────────────────────────────┘
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Supplementary Figure 2: Detailed causes of readmission among patients hospitalized with a primary and secondary diagnosis of heart failure

A) Non-cardiac causes for readmission
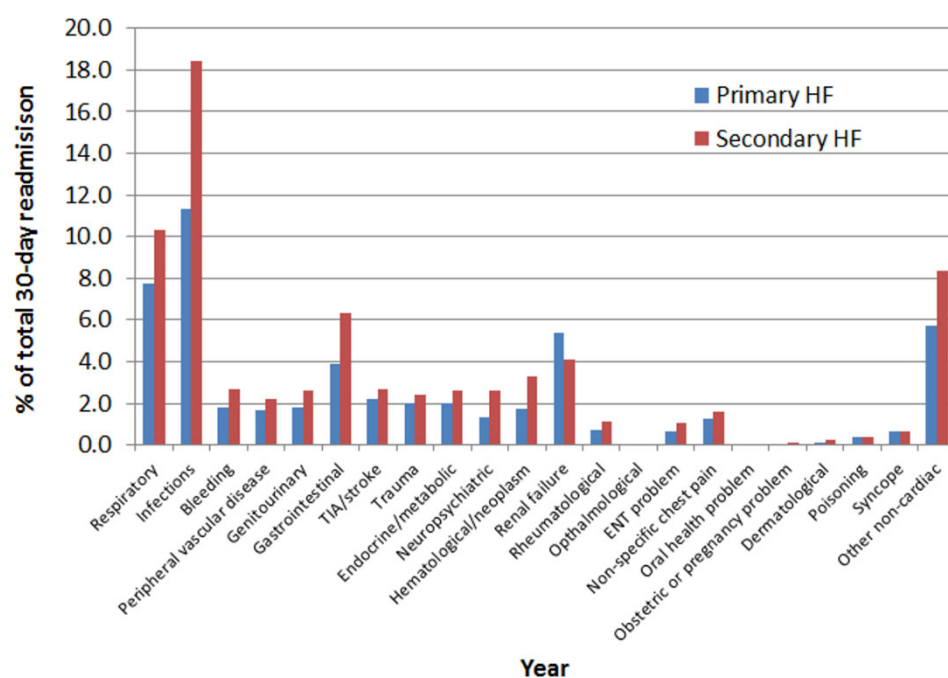
B) Cardiac causes for readmission
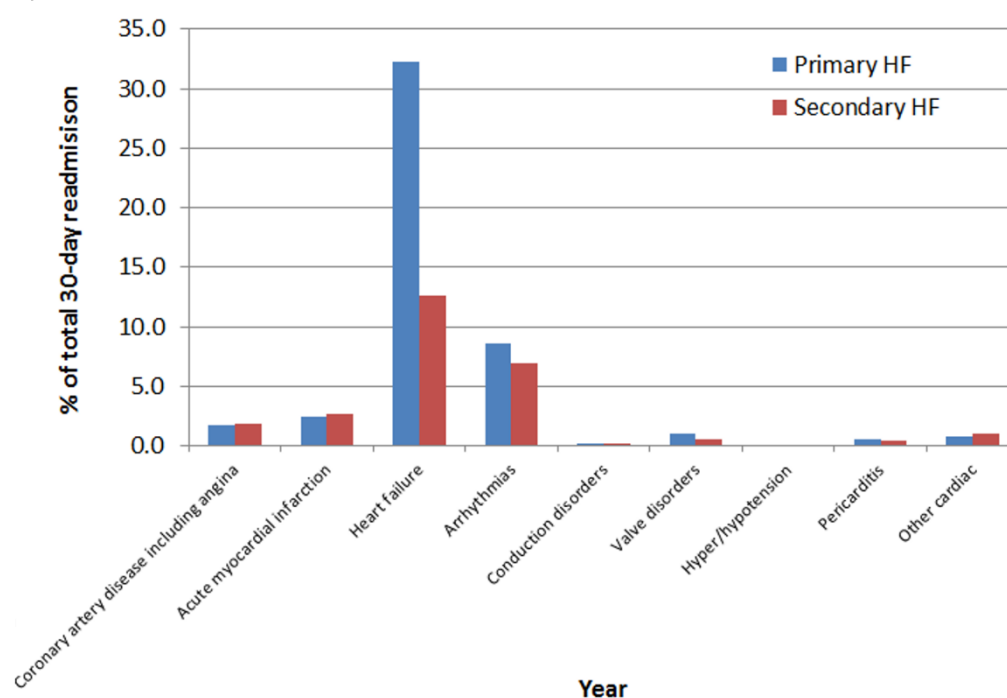
Supplementary Figure 3: Risk of 30-day readmission according to principal reason for admission among patients with secondary diagnosis of heart failure

A) Primary non-cardiac diagnosis for index admission and 30-day readmission

B) Primary cardiac diagnosis for index admission and 30-day readmission rate

Supplementary Table 1: Classification of CCS codes for Readmissions Causes

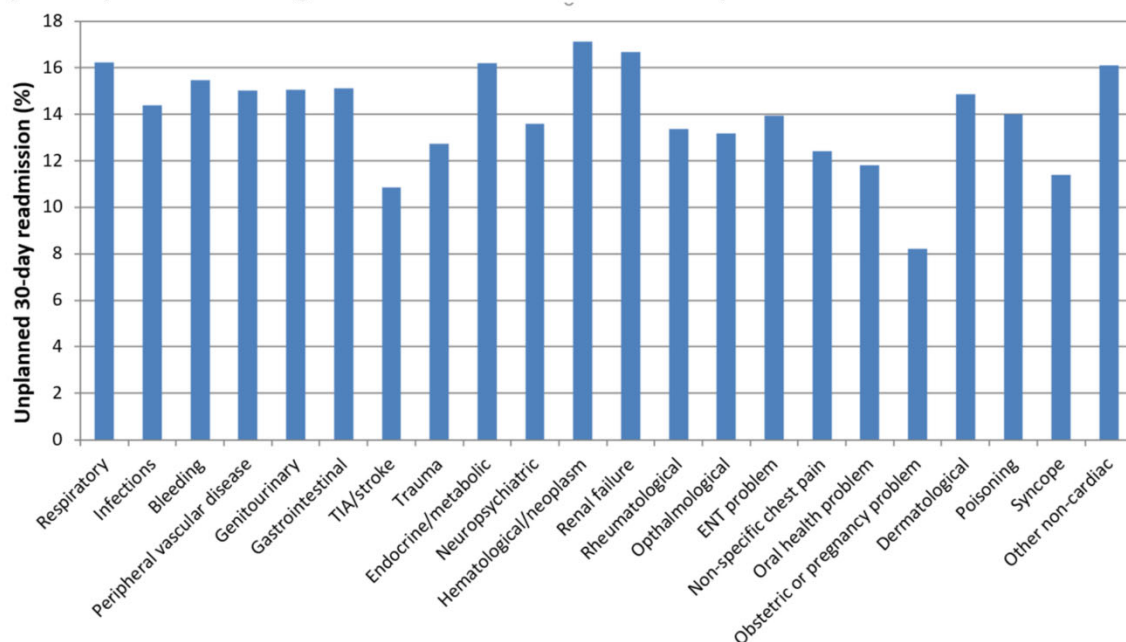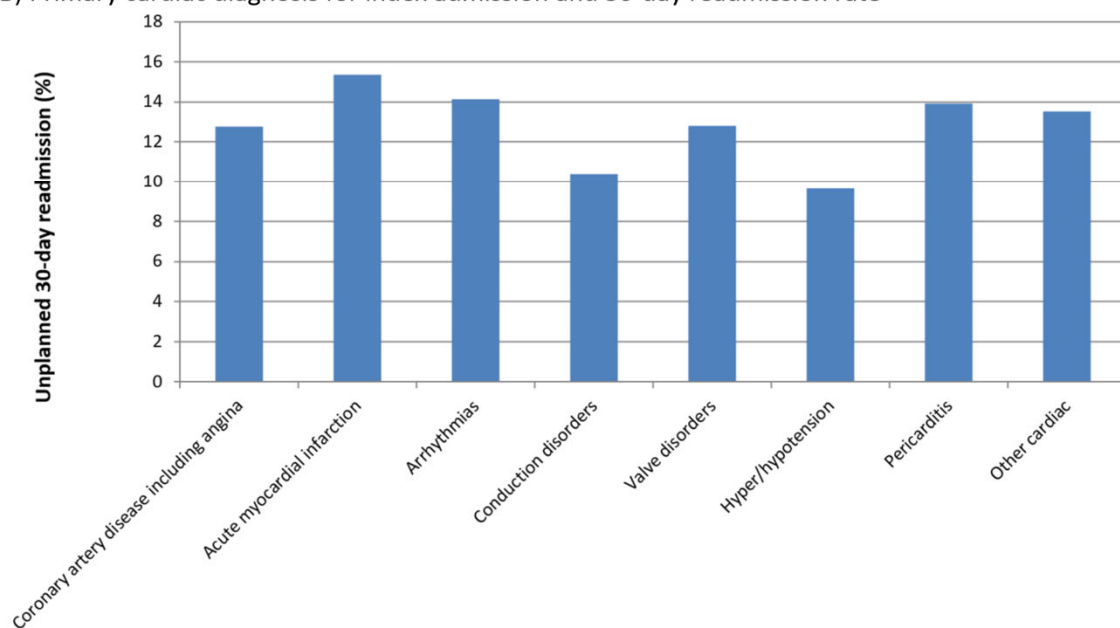| Causes of readmission	CCS code	Diagnosis
Respiratory	127	Chronic obstructive pulmonary disease and bronchietasis
	128	Asthma
	130	Pleurisy, pneumothorax, pulmonary collapse
	131	Respiratory failure, insufficiency and arrest
	132	Lung disease due to external agents
	133	Other lower respiratory disease
	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	0.79 (0.78-0.80)	<0.001
Bleeding	0.88 (0.86-0.90)	<0.001
Peripheral vascular disease	0.84 (0.82-0.86)	<0.001
Genitourinary	0.83 (0.82-0.85)	<0.001
Gastrointestinal	0.86 (0.85-0.87)	<0.001
TIA/stroke	0.60 (0.59-0.61)	<0.001
Trauma	0.69 (0.67-0.70)	<0.001
Endocrine/metabolic	0.89 (0.87-0.91)	<0.001
Neuropsychiatric	0.77 (0.75-0.79)	<0.001
Hematological	0.97 (0.85-0.99)	0.002
Renal failure	0.94 (0.93-0.96)	<0.001
Rheumatological	0.72 (0.70-0.74)	<0.001
Opthalmological	0.74 (0.63-0.87)	<0.001
ENT problem	0.75 (0.73-0.78)	<0.001
Non-specific chest pain	0.73 (0.71-0.75)	<0.001
Oral health problem	0.64 (0.56-0.74)	<0.001
Obstetric or pregnancy problem	0.48 (0.44-0.52)	<0.001
Dermatology	0.77 (0.72-0.83)	<0.001
Poisoning	0.80 (0.76-0.84)	<0.001
Syncope	0.65 (0.62-0.67)	<0.001
Other non-cardiac	0.88 (0.87-0.90)	<0.001
Coronary artery disease including angina	0.84 (0.82-0.86)	<0.001
Acute myocardial infarction	NS	0.65
Arrhythmias	0.87 (0.86-0.89)	<0.001
Conduction disorders	0.73 (0.69-0.77)	<0.001
Valve disorders	0.85 (0.82-0.88)	<0.001
Hyper/hypotension	0.56 (0.47-0.66)	<0.001
Pericarditis	0.89 (0.86-0.93)	<0.001
Other cardiac	0.82 (0.79-0.84)	<0.001