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Short communication

Heart failure: Same-hospital vs. different-hospital readmission outcomes

Sopan Lahewala [a,1], Shilpkumar Arora [b,*,1], Byomesh Tripathi [b], Sidakpal Panaich [c], Varun Kumar [b], Nirali Patel [d], Sejal Savani [b], Mihir Dave [g], Yash Varma [h], Apurva Badheka [e], Abhishek Deshmukh [f], Umesh Gidwani [g], Radha Gopalan [i], Alexandros Briasoulis [c]

[a] Department of Medicine, Robert Wood Johnson – Barnabas Health, Jersey City, NJ, United States of America
[b] Department of Cardiology, Mount Sinai St Luke's Roosevelt Hospital, New York, NY, United States of America
[c] Department of Interventional Cardiology/Structural Heart Disease, University of Iowa, United States of America
[d] Department of Cardiology, University of Southern California, California, LA, United States of America
[e] Department of Cardiology, The Everett Clinic, Everett, WA, United States of America
[f] Department of Cardiology, Mayo Clinic, Rochester, MN, United States of America
[g] Department of Cardiology, Icahn School of Medicine at Mount Sinai, New York, NY, United States of America
[h] Department of Medicine, Guthrie Hospital, Sayre, PA, United States of America
[i] Department of Cardiology, University of Arizona College of Medicine, Phoenix, AZ, United States of America

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ABSTRACT

Background: Heart Failure (HF) is a major driver of the readmissions/penalties in the US. Although extensive literature on rehospitalization attributed to HF, studies to compare outcomes for same-hospital vs. different-hospital readmissions are sparse.
Methods: Nationwide Readmission Database from 2010 to 14 utilized for HF-related hospitalization using appropriate ICD-9-CM diagnostic codes. 30-day readmissions were classified into two groups: same-hospital and different-hospital. A comparative analysis was conducted focusing on: in-hospital mortality, length of stay (LOS) and hospitalization cost. Hierarchical two-level modeling and propensity score matching utilized to adjust confounders.
Results: 715,993 HF readmissions were identified, of which 21.3% were readmitted to different-hospital. Elderly, females, patients with higher co-morbidities and higher median household income were less likely to be readmitted to different-hospital. Index hospitalizations in a teaching hospital and/or larger hospital were associated with reduced different-hospital readmissions. Readmissions to the different hospital were associated with higher in-hospital mortality (7.7% vs. 6.6%, $p < 0.001$), higher resource utilization (LOS:7.5 days vs. 6.1 days, $p < 0.001$ and Cost: $22,602 vs. $13,740, $p < 0.001$) after adjusting for propensity score match. Similar results were observed with propensity score matching of multiple high-risk subgroups.
Conclusion: Resources should be directed towards minimizing different-hospital HF readmissions to improve patient outcomes by identifying the vulnerable subgroup and further tailoring in-hospital and post-discharge care.

1. Introduction

Unplanned readmissions over a 30-day period after the index hospitalization for heart failure (HF) occur in around 20% of patients, accruing significant health care costs besides poorer outcomes [1–3]. By the year 2030 Heidenreich et al. projected 3 million increase (~25%) in prevalence and about $70 billion increase (~120%) in healthcare expenditure of HF [4]. Vidic et al. [5] also showed that HF is a major driver of the readmissions penalty. Furthermore, ER policies in the US require patients to be taken to the nearest ER, even if the patient has recently been hospitalized somewhere else [6]. Therefore initiatives to reduce readmission would be most effective with the focus on HF. Although extensive literature on rehospitalization attributed to HF [1,5], limited research available addressing the issue involving outcome for same-hospital vs. different-hospital readmissions [2,3]. Analogously, the objectives of our study were to compare same-hospital vs. different-hospital readmission outcomes and discover the subgroups with higher different-hospital readmissions.

2. Methods

We queried HCUP's Nationwide Readmissions Database (NRD) of 2010–14 (details available online [7]) using the ICD-9-CM diagnosis codes for HF (402.01, 402.11, 402.91, 404.01, 404.03, 404.11, 404.13, 404.91, 404.93 and 428) in primary diagnosis field. We

* Corresponding author at: Mount Sinai St Luke's - Roosevelt Hospital, 1111 Amsterdam Ave, New York, NY 10025, United States of America.
E-mail address: dr.shilparora@yahoo.com (S. Arora).
[1] Authors share equal contribution to this manuscript.

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excluded patients with age < 18 years, with missing data for age, gender or mortality. Only the first readmission due to any cause within 30-days of index HF admission was included in the study and further classified into two groups: same-hospital and different-hospital readmissions.

The primary outcome was in-hospital mortality and secondary outcomes were the length of stay (LOS) and cost of care of 30-day readmission. NRD variables were used to identify patients' demographics, hospital characteristics, discharge disposition, LOS and in-hospital mortality as mentioned in Table 1a and 1b. Co-morbidities were described in Supplementary Table 1. The severity of co-morbid conditions was defined using Deyo modification of Charlson co-morbidity index (CCI) (Supplementary Table 2) [8].

SAS 9.4 (SAS Institute Inc., Cary, NC) was used for analyses. Differences between categorical variables were tested using the chi-square test and continuous variables using the

Table 1a
Baseline characteristics of same-hospital vs. different-hospital readmission cohort.

Index HF admissions: 4,104,252				
	Readmissions			
	Overall	Same-hospital	Different-hospital	p-Value
Readmitted HF patients	715,993	563,653 (78.7%)	152,340 (21.3%)	
Age (Years) (%)				<0.001
18–49	6.7	6.2	8.4	
50–64	19.8	19.0	22.9	
65–79	34.7	34.3	35.9	
≥80	38.9	40.5	32.8	
Gender (%)				<0.001
Male	50.0	49.3	52.9	
Female	50.0	50.7	47.1	
Charlson co-morbidity index [‖] (%)				<0.001
1	15.1	14.8	16.4	
2	20.9	20.5	22.1	
≥3	64.0	64.7	61.5	
Co-morbidities (%)				
Obesity[§]	17.4	17.1	18.4	<0.001
Hypertension[§]	69.8	70.0	69.1	<0.001
Diabetes[§]	46.9	46.8	47.1	0.086
Chronic Pulmonary Disease[§]	39.6	40.0	38.3	<0.001
Peripheral vascular disease[§]	13.6	13.9	12.6	<0.001
CKD stage 3 or more[@]	31.0	31.8	28.1	<0.001
Anemia[§]	33.6	34.0	32.3	<0.001
Depression, psychosis or substance abuse[§]	15.6	15.4	16.3	<0.001
Atrial fibrillation[@]	40.1	40.9	37.1	<0.001
Ventricular arrhythmia[@]	5.0	5.0	5.0	0.561
h/o CAD, PCI or CABG[@]	49.3	49.5	48.6	<0.001
Smoking [@]	10.1	9.8	11.2	<0.001
Median household income category for patient's zip code [#] (%)				<0.001
1. 0-25th percentile	35.1	34.5	37.5	
2. 26-50th percentile	25.4	25.4	25.3	
3. 51-75th percentile	21.8	22.1	20.6	
4. 76-100th percentile	17.8	18.1	16.6	
Primary payer (%)				<0.001
Medicare/Medicaid	87.1	87.5	85.4	
Private including HMO [x]	8.8	8.6	9.7	
Self-pay/no charge/other	3.9	3.7	4.7	
Index hospitalization characteristics				
Hospital characteristics				
Hospital bed size [£] (%)				<0.001
Small	13.8	12.1	19.9	
Medium	24.3	23.9	25.9	
Large	61.9	64.0	54.2	
Hospital teaching status[$] (%)				<0.001
Non-Teaching	54.0	52.7	58.7	
Teaching	46.0	47.3	41.3	
Admission type (%)				<0.001
Non-elective	93.7	94.0	92.7	
Elective	6.3	6.0	7.3	
Admission day (%)				<0.001
Weekdays	76.7	76.7	77.0	
Weekend	23.3	23.3	23.0	
Disposition (%)				<0.001
Home	74.9	75.5	72.7	
Facility/others	23.5	23.3	24.3	
Readmission variables				
Admission day (%)				<0.001
Weekdays	76.8	76.4	78.3	
Weekend	23.2	23.6	21.7	
Index admissions				
Length of stay (Mean ± Std Err)	6.0 ± 0.01	6.0 ± 0.01	5.89 ± 0.03	<0.001
Readmission				
In-hospital mortality (%)	7	6.8	7.7	<0.001
Length of stay (Mean ± Std Err)	6.43 ± 0.01	6.15 ± 0.01	7.45 ± 0.04	<0.001
Cost of care (Mean ± Std Err)	1,5810 ± 50	1,3916 ± 47	2,2622 ± 151	<0.001

Student *t*-test. Hierarchical 2-level logistic model with hospital ID as a random effect was used to evaluate predictors of different-hospital readmissions. All multivariate models included hospital-level variables during index hospitalization such as bed-size and teaching status; patient-level variables such as age, gender, admission type and day of both index hospitalization and readmission, median household income, primary payer and all the co-morbidities mentioned in Table 1a and 1b.

2 to 1 propensity score-match by Greedy's method without replacement was used to adjust for confounders [9]. The propensity score was obtained using simple multivariate logistic regression, with the type of readmission as a dependent variable and all variables mentioned above for multivariate model as independent variables. We identified 61,243 match pairs by 2 to 1 propensity score-match: 122,486 same-hospital and 61,243 different-hospital readmissions. Similar propensity match algorithms were utilized for all high-risk subgroups mentioned in Table 2. Simple logistic and linear regressions were used to generate odds ratio and parameter estimate for propensity score match cohort respectively.

3. Results

In total 4,104,252 Index HF admissions were identified from year 2010–14. Of which 715,993 were readmitted (50% female, 73.6% age ≥ 65, 87.1% primary payer-Medicare/Medicaid) (Table 1a). A large proportion of the patients who were readmitted had significant baseline burden of co-morbidities with CCI ≥ 3 (64%). Hypertension (69.8%), h/o CAD (49.3%), diabetes (46.9%), chronic pulmonary disease (39.6%), and CKD stage-3 or more (31%) were the most common co-morbidities. The majority index hospitalizations of readmitted patients were non-elective (93.7%), at large-bed size (61.9%) and nonteaching (54%) hospitals, and on weekdays (76.7%).

152,340 (21.3%) were readmitted to different-hospital (47.1% female, 68.7% age ≥ 65 & 85.4% primary payer-Medicare/Medicaid). The predictors of decreased different-hospital readmission were older age, higher median household income, female gender (OR: 95%-CI, p-value) (0.89, 0.87–0.91, $p < 0.001$), CCI ≥ 3 (0.94, 0.91–0.97, $p < 0.001$), co-morbidities such as diabetes (0.97, 0.95–0.99, $p = 0.003$), chronic pulmonary disease (0.91, 0.89–0.92, $p < 0.001$), peripheral vascular disease (0.94, 0.92–0.97, $p < 0.001$) and CKD stage-3 or more (0.90, 0.88–0.93, $p < 0.001$). While the predictors of higher different-hospital readmission were history of CAD (1.04, 1.02–1.06, $p < 0.001$), private insurance (1.05, 1.01–1.08, $p = 0.007$), index elective hospitalizations (1.16, 1.11–1.21, $p < 0.001$) and discharge to facility (1.28, 1.25–1.31, $p < 0.001$). Whereas, index hospitalizations to teaching and/or larger hospital were associated with reduced different-hospital readmissions (Table 1b).

In propensity score match analysis, different-hospital readmissions were associated with higher in-hospital mortality (7.7% vs. 6.6%, $p < 0.001$) (OR: 1.19, 95% CI: 1.14–1.23, $p < 0.001$), higher LOS (7.5 days vs. 6.1 days, $p < 0.001$) (Days: +1.44, 95% CI: +1.36 − +1.51, $p < 0.001$), higher cost of care of readmission (USD: +8862, 95% CI: +8577 − +9147, $p < 0.001$) compared to same-hospital readmission (Table 2). Propensity score matching of multiple high-risk subgroups including older age group (≥80 years), patients with co-morbidities such as anemia, CKD stage-3 or more, chronic pulmonary disease, atrial fibrillation, h/o CAD showed similar results (Table 2).

4. Discussion

Emergency Medicine policies in the US require patients to be taken to the nearest ER, even if the patient has recently been hospitalized anywhere else [6]. This is beneficial in acute-time sensitive conditions such as MI or CVA where delays in initial treatment are associated with poorer outcomes. Whereas HF is chronic condition and continuity of care seems to be more important [2,3,10,11]. Accordingly, we report largest contemporary all-player data in the US from NRD on outcomes for same-hospital vs. different-hospital readmissions after the index hospitalization for HF. The important findings of our study were: **1)** approximately 1 in 5 HF readmissions tends to be in different-hospitals then index hospitalization, **2)** age, female gender, higher median household income, teaching hospitals, CCI ≥ 3 were the predictors of decreased readmissions to the different-hospitals, whereas index elective hospitalizations, discharge to the facility and private insurance were predictors of higher readmissions to the different-hospitals; **3)** different-hospital readmissions were associated with higher in-hospital mortality, LOS, and cost of care.

We noted comparable readmission rate of 21% to different-hospitals in the HF population [1–3]. Similarly, different-hospital readmissions were noted to occur less likely in the female, older population, and patients with higher co-morbidity burden (CCI ≥ 3) and median household income. Whereas index elective hospitalizations, discharge to the facility and private insurance were the predictors of higher readmission to different hospital [2,3]. These predictors of readmission to different-hospitals in HF might assist in identifying this vulnerable subgroup of patients who might have fewer incentives for same-hospital readmission and/or coordinated care; and further benefit from tailored in-hospital as well as post-discharge care.

Our study adds to the literature by demonstrating higher in-hospital mortality with different-hospital readmissions similar to previous Californian studies on HF readmission [3]. Also, previous ED study [11] showed, follow-up with any physician post-ED visit was associated with reduced risk of repeat ED visit, but only follow-up with a familiar physician was associated with significantly lower risk of subsequent death or hospitalization. This pattern was evident within the first month and persisted up to 12 months [11]. The same study also showed a significantly higher use of β-blockers, ACE-Is, and diuretics among patients following up with familiar physicians [11], hypothetically physician familiarity may be associated with lower in-hospital mortality and better outcomes in our study during same-hospital readmissions.

Furthermore, we found different-hospital readmissions to be associated with longer LOS, which was in contrary to Californian study [3] that showed no significant difference. Similar to recent studies [3,12], different-hospital readmissions found to be associated with higher cost of care, however, Kind et al. [12] included only Medicare database and was not focused merely on HF cohort. Also, in contrary to Californian study [3], our study represented the nationwide sample and the cost

Notes to Table 1:
*=These variables were not included in the multivariate analysis of different hospitalization vs same hospital.
§: Variables are AHRQ co-morbidity measures.
||: Charlson/Deyo Co-morbidity index (CCI) was calculated as per Deyo classification.
#: Represents a quartile classification of the estimated median household income of residents in the patients' ZIP Code, derived from ZIP Code-demographic data obtained from Claritas. The quartiles are identified by values of 1 to 4, indicating the poorest to wealthiest populations. Because these estimates are updated annually, the value ranges vary by year. https://www.hcup-us.ahrq.gov/db/vars/zipinc_qrtl/nrdnote.jsp
@: Co-morbidities were identified by appropriate ICD 9 CM diagnosis codes in the secondary diagnosis field (Supplementary Table 1).
£: The bed size cutoff points divided into small, medium, and large have been done so that approximately one-third of the hospitals in a given region, location, and teaching status combination would fall within each bed size category. https://www.hcup-us.ahrq.gov/db/vars/hosp_bedsize/nrdnote.jsp
$: A hospital is considered to be a teaching hospital if it has an AMA-approved residency program, is a member of the Council of Teaching Hospitals (COTH) or has a ratio of full-time equivalent interns and residents to beds of 0.25 or higher. https://www.hcup-us.ahrq.gov/db/vars/hosp_ur_teach/nrdnote.jsp
x: HMO: Health Maintenance Organization.
y: Cost was calculated after adjusting for inflation and merging with cost to charge ratio provided by HCUP.

Table 1b
Multivariate analysis of different-hospital readmission vs. same-hospital readmission.

Overall readmitted HF patients	OR	LL	UL	p-Value
Age (Years)				
18–49	Referent	Referent	Referent	
50–64	0.91	0.87	0.95	<0.001
65–79	0.78	0.75	0.82	<0.001
≥80	0.58	0.55	0.6	<0.001
Gender				
Male	Referent	Referent	Referent	
Female	0.89	0.87	0.91	<0.001
Charlson co-morbidity index [ll]				
1	Referent	Referent	Referent	
2	0.99	0.96	1.03	0.704
≥3	0.94	0.91	0.97	<0.001
Co-morbidities				
Obesity[§]	1.01	0.99	1.04	0.374
Hypertension[§]	1	0.98	1.02	0.854
Diabetes[§]	0.97	0.95	0.99	0.003
Chronic Pulmonary Disease[§]	0.91	0.89	0.92	<0.001
Peripheral vascular disease[§]	0.94	0.92	0.97	<0.001
CKD stage 3 or more[@]	0.9	0.88	0.93	<0.001
Anemia[§]	0.96	0.94	0.98	<0.001
Depression, psychosis or substance abuse[§]	1.01	0.98	1.03	0.525
Atrial fibrillation[@]	0.94	0.92	0.96	<0.001
Ventricular arrhythmia[@]	1.02	0.98	1.07	0.330
h/o CAD, PCI or CABG[@]	1.04	1.02	1.06	<0.001
Smoking [@]	1.01	0.98	1.05	0.362
Median household income category for patient's zip code [#]				
1. 0-25th percentile	Referent	Referent	Referent	
2. 26-50th percentile	0.93	0.9	0.95	<0.001
3. 51-75th percentile	0.89	0.87	0.92	<0.001
4. 76-100th percentile	0.88	0.85	0.91	<0.001
Primary payer (%)				
Medicare/Medicaid	Referent	Referent	Referent	
Private including HMO [x]	1.05	1.01	1.08	0.007
Self-pay/no charge/other	1.04	0.99	1.09	0.128
Index hospitalization characteristics				
Hospital characteristics				
Hospital bed size [£]				
Small	Referent	Referent	Referent	
Medium	0.65	0.63	0.68	<0.001
Large	0.49	0.47	0.51	<0.001
Hospital teaching status[$]				
Non-Teaching	Referent	Referent	Referent	
Teaching	0.76	0.74	0.79	<0.001
Admission type				
Non-elective	Referent	Referent	Referent	
Elective	1.16	1.11	1.21	<0.001
Admission day				
Weekdays	Referent	Referent	Referent	
Weekend	1	0.98	1.02	0.797
Disposition				
Home	Referent	Referent	Referent	
Facility/others	1.28	1.25	1.31	<0.001
Readmission variables				
Admission day				
Weekdays	Referent	Referent	Referent	
Weekend	0.89	0.88	0.91	<0.001
Index admissions				
Length of stay (Mean ± Std Err)	1.00	0.99	1.01	0.138

*, §, ||, #, @, £, $, x, y: Same As Table 1a.

difference associated with different-hospital readmissions was significantly higher. This difference in resource utilization was likely explained by fragmentation of care associated with new/unfamiliar physicians, more diagnostic testing and procedures, unknown severity of co-morbidities and prior medication reconciliation than readmissions to the same-hospital [12]. Similarly prior studies on HF and other morbidities and hospitalization [2,3,10,11,13] showed a direct relationship between physician familiarity and favorable outcomes after hospital discharges or ER visits.

Though our study originates from well-designed nationalized retrospective database, there remain few limitations. Being an administrative database coding error can lead to under-coding, but not other way around. Understandably, there are few other factors that may have affected patients' prognosis after hospital discharge such as echocardiographic findings or other clinical parameters that would have provided insight into prognosis of HF such as management strategies (β-blockers, ACE-I, diuretics, diet, education, etc.), outpatient follow-up (HF programs and/or telemonitoring) and compliance data. Furthermore, the studied cohort was limited to US patients only, so it is uncertain to what extent the data will reflect the worldwide population. Nevertheless, in contrast to previous studies restricted by small sample size or selective population cohorts [2,3], ours is the largest available study

Table 2
Propensity score match subgroup analysis of outcomes.

In-hospital mortality during readmission								
Propensity score match groups	Match pairs (2:1)	Readmission		p-Value	OR	LL	UL	p-Value
		Same-hospital	Different-hospital					
Overall	61,243	6.58	7.7	<0.001	1.19	1.14	1.23	<0.001
Age ≥ 80 years	20,881	9.48	10.7	<0.001	1.14	1.08	1.21	<0.001
Anemia[§]	20,702	7.18	8.2	<0.001	1.16	1.09	1.23	<0.001
Charlson co-morbidity index [‖] ≥ 3	77,484	7.1	8.36	<0.001	1.19	1.14	1.25	<0.001
CKD stage 3 or more[@]	18,117	6.87	8.51	<0.001	1.26	1.18	1.35	<0.001
Atrial fibrillation[@]	23,213	7.86	9.62	<0.001	1.25	1.18	1.32	<0.001
h/o CAD, PCI, CABG[@]	30,096	6.58	7.71	<0.001	1.19	1.12	1.25	<0.001
Index emergent admission	57,716	6.69	7.72	<0.001	1.17	1.12	1.21	<0.001
Length of stay of readmission								
Propensity score match groups	Match pairs (2:1)	Readmission		p-Value	Days	LL	UL	p-Value
		Same-hospital	Different-hospital					
Overall	61,243	6.1 ± 0.02	7.54 ± 0.04	<0.001	1.44	1.36	1.51	<0.001
Age ≥ 80 years	20,881	5.83 ± 0.03	6.87 ± 0.05	<0.001	1.14	1.03	1.24	<0.001
Anemia[§]	20,702	6.41 ± 0.04	7.83 ± 0.07	<0.001	1.35	1.21	1.48	<0.001
Charlson co-morbidity index [‖] ≥ 3	77,484	6.35 ± 0.03	7.71 ± 0.05	<0.001	1.36	1.26	1.46	<0.001
CKD stage 3 or more[@]	18,117	6.42 ± 0.04	7.84 ± 0.08	<0.001	1.41	1.26	1.56	<0.001
Atrial fibrillation[@]	23,213	6.38 ± 0.03	7.75 ± 0.06	<0.001	1.36	1.24	1.49	<0.001
h/o CAD, PCI, CABG[@]	30,096	6.1 ± 0.03	7.40 ± 0.05	<0.001	1.29	1.18	1.39	<0.001
Index emergent admission	57,716	6.06 ± 0.02	7.53 ± 0.04	<0.001	1.48	1.40	1.55	<0.001
Cost of care of readmission								
Propensity score match groups	Match pairs (2:1)	Readmission		p-Value	Cost	LL	UL	p-Value
		Same-hospital	Different-hospital					
Overall	61,243	13,740 ± 65	22,602 ± 158	<0.001	8862	8577	9147	<0.001
Age ≥ 80 years	20,881	11,535 ± 70	19,147 ± 203	<0.001	7611	7268	7955	<0.001
Anemia[§]	20,702	14,156 ± 108	21,864 ± 242	<0.001	7709	7257	8160	<0.001
Charlson co-morbidity index [‖] ≥ 3	77,484	14,160 ± 84	22,307 ± 191	<0.001	8148	7794	8501	<0.001
CKD stage 3 or more[@]	18,117	14,318 ± 126	22,099 ± 282	<0.001	7780	7255	8305	<0.001
Atrial fibrillation[@]	23,213	14,131 ± 114	22,473 ± 260	<0.001	8342	7863	8822	<0.001
h/o CAD, PCI, CABG[@]	30,096	13,874 ± 91	22,158 ± 213	<0.001	8284	7895	8672	<0.001
Index emergent admission	57,716	13,457 ± 63	22,557 ± 162	<0.001	9100	8817	9384	<0.001
Fit statistics								
Propensity score match groups		C-index[#]			Hosmer and Lemeshow Goodness-of-Fit Test[#]			
Overall		0.59			(chi sq.:218, p < 0.001)			
Age ≥ 80 years		0.57			(chi sq.:9.5, p = 0.296)			
Anemia[§]		0.59			(chi sq.:48, p < 0.001)			
Charlson co-morbidity index [‖] ≥ 3		0.59			(chi sq.:68, p < 0.001)			
CKD stage 3 or more[@]		0.59			(chi sq.:38, p < 0.001)			
Atrial fibrillation[@]		0.58			(chi sq.:50, p < 0.001)			
h/o CAD, PCI, CABG[@]		0.59			(chi sq.:90, p < 0.001)			
Index emergent admission		0.59			(chi sq.:206, p < 0.001)			

§, @, ‖: Same As Table 1b.
#: c-index and the Fit test are the measures of how well variables in the model were able to predict the readmission to the different hospital.

on nationally representative sample in the US on the current topic representing all-payer, nationwide hospitalized patients with HF, and allowed us to evaluate some meaningful outcome results for increasingly relevant quality parameters. Similarly obtained NIS Data has been extensively used in the past for studying various clinically relevant outcomes.

5. Conclusion

We found readmissions to same-hospitals to be associated with better outcomes and improved quality of care in HF cohort. Physician familiarity results in reduced resource utilization by reducing diagnostic testing/procedures, and timely diagnoses or managements further support for the importance of continuity in health care. Resources should be directed towards minimizing different-hospital HF readmissions by identifying the vulnerable subgroup with fewer incentives and/or coordinated care for same hospital readmission and further tailoring in-hospital and post-discharge care.

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Appendix A. Supplementary data

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