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Association of 30-day All-cause Readmission with Long-term Outcomes in Hospitalized Older Medicare Beneficiaries with Heart Failure

Cherinne Arundel, MD[#1], **Phillip H. Lam, MD**[#2], **Rahul Khosla, MD**[1], **Marc R. Blackman, MD**[1], **Gregg C. Fonarow, MD**[3], **Charity Morgan, PhD**[4], **Qing Zeng, PhD**[5], **Ross D. Fletcher, MD**[1], **Javed Butler, MD**[6], **Wen-Chih Wu, MD**[7], **Prakash Deedwania, MD**[8], **Thomas E. Love, PhD**[9], **Michel White, MD**[10], **Wilbert S. Aronow, MD**[11], **Stefan D. Anker, MD, PhD**[12], **Richard M. Allman, MD**[13], and **Ali Ahmed, MD, MPH**[1,4,*]

[1]Veterans Affairs Medical Center, Washington, DC

[2]Georgetown University Hospital/Washington Hospital Center, Washington, DC

[3]University of California, Los Angeles, CA

[4]University of Alabama at Birmingham, Birmingham, AL

[5]George Washington University, Washington, DC

[6]State University of New York, Stony Brook, NY

[7]Veterans Affairs Medical Center, Providence, RI

[8]University of California San Francisco, CA

[9]Case Western Reserve University, Cleveland, OH

[10]Montreal Heart Institute, Montreal, Canada

[11]New York Medical College, Valhalla, NY

[12]University of Göttingen, Göttingen, Germany

[13]Department of Veterans Affairs, Geriatrics and Extended Care Services, Washington, DC

[#] These authors contributed equally to this work.

Abstract

BACKGROUND—Heart failure is the leading cause for 30-day all-cause readmission. We examined the impact of 30-day all-cause readmission on long-term outcomes and cost in a propensity score matched study of hospitalized patients with heart failure.

[*]**Correspondence:** Ali Ahmed, MD, MPH, Center for Health and Aging, Washington DC VA Medical Center, 50 Irving St. NW, Washington, DC 20422; Telephone: 1-202-745-8386; aliahmedmdmph@gmail.com.

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METHODS—Of the 7578 Medicare beneficiaries discharged with a primary diagnosis of heart failure from 106 Alabama hospitals (1998–2001) and alive at 30-day post-discharge, 1519 had 30-day all-cause readmissions. Using propensity scores for 30-day all-cause readmission, we assembled a matched cohort of 1516 pairs of patients with and without 30-day all-cause readmissions, balanced on 34 baseline characteristics (mean age 75 years, 56% women, 24% African American).

RESULTS—During 2-12 months of follow-up after discharge from index hospitalization, all-cause mortality occurred in 41% and 27% of matched patients with and without 30-day all-cause readmission, respectively (hazard ratio {HR}, 1.68; 95% confidence interval {CI}, 1.48–1.90; p<0.001). This harmful association of 30-day all-cause readmission with mortality persisted during an average follow-up of 3.1 (maximum, 8.7) years (HR, 1.33; 95% CI, 1.22–1.45; p<0.001). Patients with a 30-day all-cause readmission had higher cumulative all-cause readmissions (mean, 6.9 vs. 5.1; p<0.001), a longer cumulative length of stay (mean, 51 vs. 43 days; p<0.001) and a higher cumulative cost (mean, $38,972 vs. $34,025; p=0.001) during 8.7 years of follow-up.

CONCLUSIONS—Among Medicare beneficiaries hospitalized for heart failure, 30-day all-cause readmission was associated with a higher risk of subsequent all-cause mortality, higher number of cumulative all-cause and heart failure readmissions, longer cumulative length of stay and higher cumulative cost.

Keywords

30-Day All-Cause Readmission; Medicare Beneficiaries; Heart Failure; All-cause Mortality; Cost

Heart failure is the leading cause for hospital admission and readmissions in the United States among adults 65 years of age and older, creating a significant healthcare burden.[1] Greater than 1 million Medicare beneficiaries are hospitalized annually with heart failure as their primary discharge diagnosis and about one in four of these patients are readmitted within 30 days of hospital discharge. Such numbers in part contribute to the nearly $17 billion of total Medicare expenditure, prompting the need to reduce this cost with a focus on readmission reduction.[2] Under the Affordable Care Act, hospitals with above-average 30-day all-cause readmission rates are subject to financial penalties with a projected loss of over $7 billion in Medicare payments over the next 10 years.[3] Among ambulatory patients with heart failure, hospitalization is associated with a higher risk of post-discharge mortality.[4, 5] However, little is known about the association of 30-day all-cause readmission with subsequent all-cause mortality and other outcomes. Moreover, this issue has not been investigated in a large cohort of patients using propensity score matching. In the current study, we examined the association of 30-day all-cause readmission with subsequent all-cause mortality and cumulative hospitalizations, lengths of stay and costs in a propensity-matched cohort of hospitalized heart failure patients.

MATERIALS AND METHODS

Data Source and Study Population

The Alabama Heart Failure Project is a quality improvement registry of hospitalized heart failure patients, the details of which have been presented elsewhere.[6] Briefly, extensive data on baseline characteristics, past medical history, admission and discharge medications, in-hospital events, hospital care characteristics and laboratory values were collected on 8555 Medicare beneficiaries discharged from 106 Alabama hospitals with a principal discharge diagnosis of heart failure between July 1, 1998 and October 31, 2001.[6-9] A diagnosis of heart failure was ascertained using International Classification of Diseases, Ninth Revision, Clinical Modification codes. Medical records of these patients were centrally abstracted and then linked to Medicare outcomes data. Of the 8555 Medicare beneficiaries with heart failure, 8049 were discharged alive.

Exposure Variable: 30-Day All-Cause Readmission

Data on hospitalization and time of hospitalization through April 2, 2007 obtained from the Medicare Provider Analysis and Review File were used to ascertain 30-day all-cause readmission. [6-9] The Medicare Provider Analysis and Review File contains inpatient hospital final action stay records that summarize all services rendered to a beneficiary from the time of admission to a Medicare certified inpatient hospital through discharge.[6] Patients admitted to out-of-state hospitals and those who did not have Medicare pay for their hospitalizations were not included. Although data on hospitalization was originally collected as an outcome variable, in the current analysis, 30-day all-cause hospitalization was the exposure variable and was defined as first hospitalization due to any cause within 30 days from index hospital discharge. Of the 7578 Medicare beneficiaries that were alive at 30 days post-discharge, 1519 had a 30-day all-cause readmission.

Outcomes Data

Data on death and time of death through April 2, 2007 obtained from the Centers for Medicare & Medicaid Services Denominator File were used to ascertain all-cause mortality.[6-9] The Denominator File contains data on dates of birth and death for each Medicare beneficiary enrolled in Medicare during a calendar year.[6] The primary outcome of our study was all-cause mortality during post-discharge months 2 to 12. Because our primary exposure of all-cause readmission occurred during the first 30 days after index discharge, the first month post-discharge was excluded from outcomes follow-up. Data on total number of subsequent all-cause and heart failure-related hospital readmission, length of stay, charges and payments were also collected.

Assembly of a Balanced Study Cohort

To reduce bias due to imbalances in baseline characteristics between patients with and without a 30-day all-cause readmission, we used propensity scores for 30-day all-cause readmission to assemble a matched cohort in which those with and without 30-day all-cause readmission would be balanced on key measured baseline characteristics.[10, 11] We used a non-parsimonious multivariable logistic regression model using 34 key baseline

characteristics (**Figure 1**) to estimate propensity scores or predicted probability for 30-day all-cause readmissions for each of the 7578 patients.[12, 13] We then used a greedy matching protocol to match patients based on their propensity scores, thus assembling a cohort of 1516 pairs of patients with vs. without a 30 day all-cause readmission (**Table 1** and **Figure 1**).[7-9]

Statistical Analyses

Descriptive pre- and post-match analyses comparing between-group differences in baseline characteristics for those with and without a 30-day all-cause readmission were conducted using Pearson chi-square and Wilcoxon rank sum tests as appropriate. Cox regression models were used to examine the association of 30-day all-cause readmission with the primary outcome of all-cause mortality among matched patients during 2 to 12 months of follow-up. Although matched patients with vs. without a 30-day all-cause readmission were balanced on 34 baseline characteristics, bias due to an unmeasured covariate is possible. Therefore, we conducted formal sensitivity analyses to quantify the degree of a hidden bias that may potentially explain away a significant association in the matched data.[14] For mortality beyond the first year of follow-up, we used a single Cox model in which those who survived during the first 8 years were censored. Because the proportional hazards assumptions held for these models, the constant hazard ratio over the entire 8.7-year time frame is a viable assumption. Thus, we did not fit separate Cox models for events at 2, 4 and 8.7 years post-discharge. We also examined the primary association of 30-day all-cause readmission with all-cause mortality at one year and during 8.7 years of follow-up among 7578 pre-match patients using 3 different models: unadjusted, multivariable-adjusted (34 baseline covariates) and adjusted for propensity scores (based on 34 covariates). We then examined the association of 30-day all-cause readmission with 2–12 month all-cause mortality in several clinically important subgroups of patients including those based on left ventricular ejection fraction cutoff of 45%. Finally, we used student T-test to compare total number of subsequent all-cause and heart failure-related hospital readmissions, cumulative lengths of stay, charges and payments associated with those readmissions in the matched cohort. Finally, to examine the impact of a longer-term readmission, we examined the association of 90-day all-cause readmission with subsequent all-cause mortality. All statistical analyses were two-tailed and p values <0.05 were considered significant. All data analyses were performed using SPSS Statistics for Windows, Version 23.0. (International Business Machines Corporation; 2012: Armonk, NY).

RESULTS

Baseline Characteristics

After matching, patients (n=3032) had a mean age of 75 years, 56% were women, and 24% were African American. Before matching, baseline characteristics of heart failure patients with vs. without a 30-day all-cause readmission were generally similar. However, those with a 30-day all-cause readmission were younger, likely to be sicker with a higher prevalence of pre-existing heart failure, coronary artery disease, diabetes mellitus, chronic obstructive lung disease, chronic kidney disease, cancer, and clinical factors such as pulmonary edema, pneumonia and pressure ulcer (**Table 1**). Those with a 30-day all-cause readmission also had

longer length of stay and intensive care use. Before matching, fewer patients in the group with a 30-day all-cause readmission were discharged on angiotensin-converting enzyme (ACE) inhibitors or angiotensin receptor blockers (ARBs) and loop diuretics. However, all these variables were balanced after matching as is evident from post-match absolute standardized differences of <10% for all 34 baseline characteristics, suggesting that the balance achieved was substantial and any residual bias would be inconsequential (**Figure 1**).

30-day All-cause Readmission and Subsequent All-cause Mortality

During the 2–12 months of post-discharge follow-up, all-cause mortality occurred in 41% and 27% of matched patients with and without 30-day all-cause readmission, respectively (hazard ratio {HR}, 1.68; 95% confidence interval {CI}, 1.48–1.90; p<0.001; **Table 2** and **Figure 2**). Findings from our sensitivity analysis demonstrated that of the 857 patients who clearly outlived their matched counterparts during the first year of follow-up, 542 were from the group without a 30-day all-cause hospitalization and 315 were from the group with a 30-day all-cause hospitalization. In the absence of a hidden bias, a sign-score test for matched data with censoring provides strong evidence (p <0.001) that 30-day readmission was associated with significantly higher risk of death during 2–12 months post-discharge follow-up. There was no evidence of heterogeneity in the association between a 30-day all-cause readmission and 2–12 months all-cause mortality.

The harmful association of 30-day all-cause readmission with subsequent mortality persisted during 8.7 (mean, 3.1) years of follow-up (HR, 1.33; 95% CI, 1.22–1.45; p<0.001; **Table 2** and **Figure 2**). Of the 1376 clear survivors within matched pairs, 822 and 554 were from the groups without and with a 30-day all-cause hospitalization, respectively (sign-score test p < 0.001). Unadjusted and adjusted associations among pre-match patients are displayed in **Table 2**.

30-Day All-cause Readmission and Other Outcomes

During 8.7 (mean, 3.1) years of follow-up, patients with a 30-day all-cause readmission (vs. without) had higher cumulative readmissions (mean, 6.9 vs. 5.1; p<0.001) and also had longer cumulative lengths of stay (mean, 51 vs. 43 days; p<0.001), higher charges (mean, $129,175 vs. $114,787; p=0.012), and payments (mean, $38,972 vs. $34,025; p=0.001) associated with those readmissions (**Table 3**). Among patients with a 30-day all-cause readmission, there were also higher cumulative heart failure readmissions (mean, 2.4 vs. 1.7; p<0.001), longer cumulative length of stay (mean, 24 vs. 20 days; p<0.001), and higher cumulative charges (mean, $59,609 vs. $51,358; p=0.036), and payments (mean, $17,748 vs. $15,123; p=0.008) compared to those who were not readmitted (**Table 3**).

90-Day All-cause Readmission and Subsequent Mortality

Among the 2437 pairs of matched patients with and without a 90-day all-cause readmission, all-cause mortality occurred in 30% and 19% of those with and without a 90-day all-cause readmission, respectively (HR, 1.70; 95% CI, 1.51–1.91; p<0.001) during the 4-12 months of post-discharge follow-up. This association persisted during 8.7 years of follow-up (HR, 1.29; 95% CI, 1.20–1.38; p<0.001).

DISCUSSION

The findings of the current study demonstrate that among Medicare beneficiaries hospitalized for heart failure, a 30-day all-cause readmission was associated with a significantly higher risk of mortality during the first year after post-readmission discharge, which persisted during longer follow-up. A similar harmful association was observed between 90-day all-cause readmission and subsequent mortality. Patients with a 30-day all-cause readmission also had higher numbers of subsequent all-cause and heart failure readmissions, longer cumulative length of stay and higher costs associated with those readmissions. Previous studies have demonstrated a significant association between hospital admission and subsequent mortality in ambulatory patients with chronic heart failure.[4, 5] However, to the best of our knowledge, this is the first study to examine the associations of 30-day all-cause readmission with long-term mortality, cumulative readmission, length of stay, and cost in a propensity matched, balanced cohort of real-world hospitalized heart failure patients.

There are several potential explanations for the observed higher mortality rates among heart failure patients with a 30-day all-cause readmission. Heart failure is associated with neurohormonal activation and cardiac remodeling that worsens with disease progression, which may be adversely affected by hospitalization, likely due to abnormal hemodynamics and an enhanced neurohormonal activation that underlie acute decompensation.[15-18] It is possible that the pathophysiologic processes underlying hospitalization also underlie re-hospitalization and may be further enhanced during readmission. The higher mortality among those in the 30-day all-cause readmission group may also be explained by the higher prevalence of baseline co-morbidities such as coronary artery disease, diabetes and in-hospital events such as acute myocardial infarction and pneumonia, all of which may be associated with poor outcomes in patients with acute and chronic heart failure.[19-21] Although the prevalence of these conditions were balanced in our matched cohort, it is possible that these conditions were of higher severity or longer duration among those with a 30-day all-cause readmission.

Similarly, the prevalence of new-onset heart failure was lower among those with a 30-day all-cause readmission, suggesting more prolonged and advanced heart failure in that group. The mode of death in patients with heart failure is known to change from predominantly sudden cardiac death to relatively predominant pump failure death, which is likely to be preceded by higher symptom burden and readmission rates, leading to subsequent higher mortality.[22, 23] Although the prevalence of new-onset heart failure was balanced after matching, it is possible that those with a 30-day all-cause readmission had more advanced disease progression.

Additionally, before matching, fewer patients with a 30-day all-cause readmission were receiving ACE inhibitors or ARBs, likely due to the higher prevalence of hypotension and renal insufficiency in that group. Although, after matching, both the use of ACE inhibitors or ARBs and the prevalence of hypotension and renal insufficiency were balanced, we were not able to balance for the severity of pump failure and cardiorenal syndrome, which may have underlain the higher prevalence of baseline hypotension and renal insufficiency in the

readmission group. Finally, hospitalization due to medical conditions is often associated with a decline in physical function and mobility, which in turn, may adversely affect subsequent outcomes.[24]

Previous studies have demonstrated an association between hospitalizations and higher subsequent mortality in ambulatory patients with heart failure.[4, 5] Previous studies have also examined cross sectional associations between readmission and mortality in hospitalized patients with heart failure.[25, 26] However, our study is distinguished by its focus on the association between 30-day all-cause readmission and long-term mortality, readmission, cumulative length of stay, and cost, using propensity scores matching design to assemble a balanced cohort of real-world hospitalized heart failure patients.

Affordable Care Act provision for financial penalties for hospitals with above-average 30-day all-cause readmissions has brought the important outcome of hospital readmission to the forefront of academic and policy discourse. Despite the limitations of the cost-driven metric of 30-day all-cause readmission, the rate for heart failure readmission remains unacceptably high. In 2011, heart failure accounted for 134,500 30-day all-cause readmissions (24.5% of all heart failure admissions) for a total cost of $1.7 billion.[27] In contrast, acute myocardial infarction accounted for 51,300 30-day all-cause readmissions (19.8% of all AMI admissions) for a total cost of $0.69 billion and stroke accounted for 45,800 30-day all-cause readmissions (14.5% of all stroke admissions) for a total cost of $0.57 billion.[27] Findings from our study suggest that heart failure is not only associated with a higher 30-day all-cause readmission and cost, but also associated with a higher downstream cumulative readmissions and costs. Furthermore, findings from our study also highlight the impact of 30-day all-cause readmission on patients as these patients had more cumulative readmissions, a longer cumulative length of stay, and a higher mortality.

Findings from our study suggest that a higher 30-day all-cause readmission is not only a risk factor for higher subsequent mortality but also for cumulative cost. Additionally, findings from our study also highlight the cost for the patients with index 30-day all-cause readmission who had more readmissions and longer cumulative length of stay and higher mortality than those without readmission. Future research needs to develop and test interventions that can reduce the risk of admission among ambulatory heart failure patients and the risk of readmission among those who are hospitalized.

Our study has several limitations. Although we used propensity scores to assemble a matched cohort balanced on key measured baseline characteristics, bias due to imbalances in unmeasured characteristics is possible. However, findings from our sensitivity analysis suggest that the primary harmful association between a 30-day all-cause readmission and 2-12 month all-cause mortality observed in our study is fairly insensitive to a hidden bias. For a hidden covariate to explain away our primary association, it would need to be a near-perfect predictor of 2-12 month all-cause mortality and would also need to increase the odds of having a 30-day all-cause readmission by 50%, which is unlikely. Our analysis was restricted to fee-for-service Medicare beneficiaries from a single state in an earlier era of heart failure management and may not be generalizable to a more contemporary population.

CONCLUSIONS

Among hospitalized older Medicare beneficiaries with heart failure, 30-day all-cause readmission is associated with a higher risk of long-term all-cause mortality. It is also associated with a higher number of all-cause and heart failure readmissions, a longer cumulative length of stay and a higher cumulative cost. Future studies need to develop and test outpatient interventions to prevent heart failure admissions and subsequent readmissions.

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- Nearly one in four heart failure patients are readmitted within a month of hospital discharge, the reduction of which is a priority under the Affordable Care Act.
- Among older heart failure patients a 30-day all-cause readmission is associated with a higher risk of subsequent all-cause mortality, cumulative higher readmissions, cost and longer length of stay.

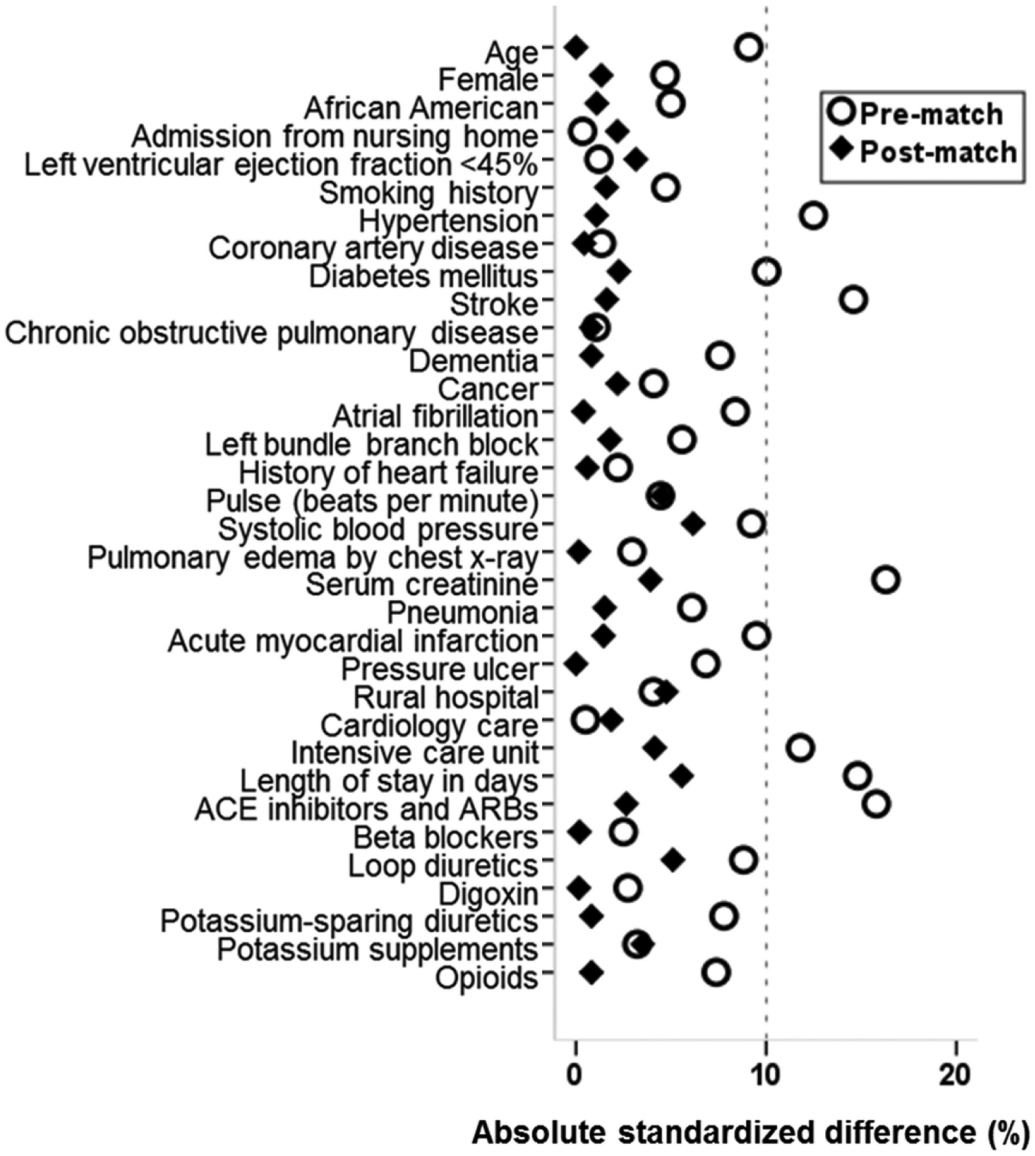

Figure 1.

Love plot displaying absolute standardized differences comparing 34 baseline characteristics between heart failure patients with and without 30 day all-cause readmission before and after propensity score matching (ACE= angiotensin converting enzyme; ARB=angiotensin receptor blockers)

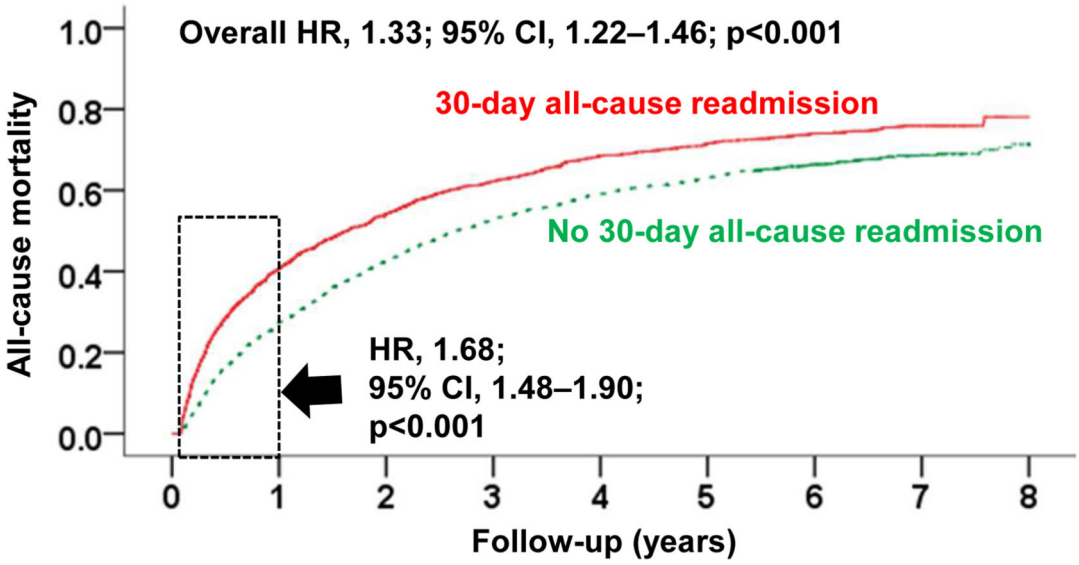

Figure 2.

Kaplan Meier plot for all-cause mortality in a propensity-matched cohort of older heart failure patients with and without a 30-day all-cause readmission (HR=hazard ratio; CI=confidence interval)

Table 1

Baseline Patient Characteristics of Heart Failure Patients with a 30-Day All-Cause Readmission

n (%) or mean (±SD)	Before propensity score matching			After propensity score matching		
	30-day all-cause readmission (n=7578)			30-day all-cause readmission (n=3032)		
	No (n=6059)	Yes (n=1519)	P value	No (n=1516)	Yes (n=1516)	P value
Age (years)	76 (±11)	75 (±11)	0.009	75 (±11)	75 (±11)	0.967
Female	3531 (58)	850 (56)	0.102	840 (55)	850 (56)	0.715
African American	1550 (26)	356 (23)	0.085	349 (23)	356 (24)	0.763
Admission from nursing home	372 (6)	92 (6)	0.904	100 (52)	92 (48)	0.763
Left ventricular ejection fraction						
<45%	2321 (38)	573 (38)		550 (36)	573 (38)	
≥45%	1852 (31)	454 (30)	0.635	465 (31)	451 (30)	0.682
Unknown	1886 (31)	492 (32)		501 (33)	492 (33)	
Past medical history						
Smoking history	681 (11)	194 (13)	0.095	185 (12)	193 (13)	0.660
Hypertension	4267 (70)	1079 (71)	0.641	1080 (71)	1077 (71)	0.904
Coronary artery disease	3221 (53)	917 (60)	<0.001	902 (60)	914 (60)	0.657
Diabetes mellitus	2594 (43)	726 (48)	<0.001	708 (47)	725 (48)	0.536
Stroke	1290 (20)	330 (22)	0.125	325 (21)	330 (22)	0.825
Chronic obstructive pulmonary disease	2097 (35)	581 (38)	0.008	572 (38)	578 (38)	0.822
Dementia	539 (9)	118 (8)	0.163	127 (8)	118 (8)	0.549
Cancer	103 (2)	45 (3)	0.001	43 (3)	44 (3)	0.913
Atrial fibrillation	1542 (25)	424 (28)	0.050	412 (27)	424 (28)	0.626
Left bundle branch block	815 (14)	193 (13)	0.444	196 (13)	193 (13)	0.871
History of heart failure	4273 (71)	1155 (76)	<0.001	1145 (76)	1152 (76)	0.767
Clinical and laboratory findings						
Pulse (beats per minute)	90 (±23)	89 (±22)	0.181	88 (±22)	89 (±22)	0.431
Systolic blood pressure (mmHg)	151 (±32)	148 (±33)	0.002	150 (±32)	148 (±33)	0.196
Pulmonary edema by chest x-ray	4065 (67)	1040 (69)	<0.001	1036 (68)	1037 (68)	0.969
Serum creatinine (mEq/L)	1.54 (±1.3)	1.76 (±1.4)	<0.001	1.81 (±1.66)	1.75 (±1.40)	0.303
In hospital events						
Pneumonia	1455 (24)	405 (27)	0.032	393 (49)	403 (51)	0.680
Acute myocardial infarction	222 (3.7)	86 (5.7)	<0.001	81 (5)	86 (6)	0.691
Pressure ulcer	423 (7)	134 (8.8)	0.014	133 (8)	133 (8)	1.000
Hospital and care characteristics						
Rural hospital	1864 (31)	496 (33)	0.155	529 (35)	495 (33)	0.192
Cardiology care	3144 (52)	792 (52)	0.862	776 (51)	790 (52)	0.611
Intensive care	199 (3)	87 (6)	<0.001	73 (5)	87 (6)	0.255
In hospital length of stay	6.3 (5.6)	7.1 (5.2)	<0.001	6.8 (5.6)	7.1 (5.2)	0.245
Discharge medications						

n (%) or mean (±SD)	Before propensity score matching			After propensity score matching		
	30-day all-cause readmission (n=7578)			30-day all-cause readmission (n=3032)		
	No (n=6059)	Yes (n=1519)	P value	No (n=1516)	Yes (n=1516)	P value
ACE inhibitors or ARB	3734 (62)	818 (54)	<0.001	797 (53)	817 (54)	0.467
Beta blockers	1891 (31)	455 (30)	0.344	454 (30)	453 (30)	0.968
Loop diuretics	4973 (82)	1200 (79)	0.006	1195 (79)	1200 (79)	0.824
Digoxin	2581 (43)	623 (41)	0.264	596 (39)	622 (41)	0.335
Potassium sparing diuretics	860 (14)	229 (15)	0.381	228 (15)	229 (15)	0.960
Potassium supplements	2850 (47)	648 (43)	0.002	610 (40)	648 (43)	0.161
Opioids	271 (4.5)	93 (6.1)	0.007	96 (6)	93 (6)	0.822

Table 2

One year and Long-Term Mortality among Pre- and Post-Matched Patients by 30-day All-Cause Readmission

	% (total events / total patients)		Hazard ratio* (95% CI); p-value
	30-day all-cause readmission		
	No	Yes	
2–12 month all-cause mortality			
Pre-match unadjusted	25% (1512/6059)	41% (618/1519)	1.89 (1.72–2.08); p<0.001
Multivariable adjusted†			1.73 (1.57–1.90); p<0.001
Propensity score adjusted‡			1.69 (1.54–1.86); p<0.001
Propensity matched	27%(416/1516)	41% (616/1516)	1.68 (1.48–1.90); p<0.001
8.7 year all-cause mortality			
Pre-match unadjusted	64% (3846/6059)	75% (1138/1519)	1.51 (1.41–1.61); p<0.001
Multivariable adjusted†			1.44 (1.34–1.54); p<0.001
Propensity score adjusted‡			1.39 (1.30–1.49); p<0.001
Propensity matched	68% (1027/1516)	75% (1135/1516)	1.33 (1.22–1.46); p<0.001

*Hazard ratios comparing patients with and without a 30-day all-cause readmission.

Table 3

Cumulative Means for All-Cause and HF Readmissions, LOS, Charges and Payments by 30-Day All-Cause Readmission

	No (n=1516)	Yes (n=1516)*	p-value
All-cause hospital readmission (cumulative means)			
Total subsequent readmissions	5.1	6.9	P=0.001
LOS	43	51	p<0.001
Charges	$114,787	$129,175	p=0.012
Payments	$34,025	$38,972	p=0.001
HF readmissions (cumulative means)			
Total subsequent HF readmissions	1.7	2.4	p<0.001
LOS	20	24	p<0.001
Charges	$51,358	$59,609	p=0.036
Payments	$15,123	$17,748	P=0.008

* Includes index hospitalization