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Authors

Lam, Phillip H
Dooley, Daniel J
Inampudi, Chakradhari
[et al.](#)

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Lack of Evidence of Lower 30-Day All-Cause Readmission in Medicare Beneficiaries with Heart Failure and Reduced Ejection Fraction Discharged on Spironolactone

Phillip H. Lam, MD^{a,*}, Daniel J. Dooley, MD^{a,*}, Chakradhari Inampudi, MD^{b,*}, Cherinne Arundel, MD^{c,d}, Gregg C. Fonarow, MD^e, Javed Butler, MD^f, Wen-Chih Wu, MD^{g,h}, Marc R. Blackman, MD^c, Markus S. Ankerⁱ, Prakash Deedwania, MD^j, Michel White, MD^k, Sumanth D. Prabhu, MD^l, Charity J. Morgan, PhD^l, Thomas E. Love, PhD^m, Wilbert S. Aronow, MDⁿ, Richard M. Allman, MD^o, and Ali Ahmed, MD, MPH^{c,d}

^aGeorgetown University Hospital/Washington Hospital Center, Washington, DC

^bUniversity of Iowa, Iowa City, IA

^cVeterans Affairs Medical Center, Washington, DC

^dGeorge Washington University, Washington, DC

^eUniversity of California, Los Angeles, CA

^fStony Brook University, Stony Brook, NY

^gVeterans Affairs Medical Center, Providence, RI

^hBrown University, Providence, RI

ⁱCharité Campus Benjamin Franklin, Department of Cardiology, Berlin, Germany

^jUniversity of California, San Francisco, Fresno, CA

^kUniversity of Montreal, Montreal, Québec, Canada

^lUniversity of Alabama at Birmingham, Birmingham, AL

^mCase Western Reserve University, Cleveland, OH

ⁿNew York Medical College, Valhalla, NY

^oDepartment of Veterans Affairs, Geriatrics and Extended Care Services, Washington, DC

Abstract

Corresponding author: Markus Anker, Charité, Campus Benjamin Franklin, Berlin, Germany, Hindenburgdamm 30, 12200 Berlin; **Telephone:** 49 30 450 513 717; ankerms@aol.com.

*Equal contribution

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Background—Therapy with evidence-based heart failure (HF) medications has been shown to be associated with lower risk of 30-day all-cause readmission in patients with HF and reduced ejection fraction (HFrEF).

Methods—We examined the association of aldosterone antagonist use with 30-day all-cause readmission in this population. Of the 2443 Medicare beneficiaries with HF and left ventricular EF $\leq 35\%$ discharged home from 106 Alabama hospitals during 1998–2001, 2060 were eligible for spironolactone therapy (serum creatinine ≤ 2.5 for men and ≤ 2 mg/dl for women, and serum potassium < 5 mEq/L). After excluding 186 patients already receiving spironolactone on admission, the inception cohort consisted of 1874 patients eligible for a new discharge prescription for spironolactone, of which 329 received one. Using propensity scores for initiation of spironolactone therapy, we assembled a matched cohort of 324 pairs of patients receiving and not receiving spironolactone balanced on 34 baseline characteristics (mean age 72 years, 42% women, 33% African American).

Results—30-day all-cause readmission occurred in 17% and 19% of matched patients receiving and not receiving spironolactone, respectively (hazard ratio {HR}, 0.92; 95% confidence interval {CI}, 0.64–1.32; $p=0.650$). Spironolactone had no association with 30-day all-cause mortality (HR, 0.84; 95% CI, 0.38–1.88; $p=0.678$) or HF readmission (HR, 0.74; 95% CI, 0.41–1.31; $p=0.301$). These associations remained unchanged during 12 months of post-discharge follow-up.

Conclusion—A discharge prescription for spironolactone had no association with 30-day all-cause readmission among older, hospitalized Medicare beneficiaries with HFrEF eligible for spironolactone therapy.

Keywords

spironolactone; 30-day all-cause readmission; Medicare beneficiaries; heart failure

1. Introduction

HF is a major public health problem and is the leading cause of 30-day all-cause readmission, an outcome which has been identified by the Affordable Care Act as a potentially preventable reason for high Medicare cost and a target for reduction [1–3]. Transitions of care-type interventions have not been successful in consistently lowering the rate of 30-day all-cause readmission [4]. Therapy with a number of evidence-based HF drugs has been shown to be associated with a lower 30-day all-cause readmission in eligible HF patients with reduced left ventricular ejection fraction (EF) [5–7]. However, little is known about the role of aldosterone antagonists on 30-day all-cause readmission in this population. We examined the association of discharge prescription of spironolactone with 30-day all-cause readmission and other outcomes in hospitalized patients with HF and reduced EF (HFrEF).

2. Materials and Methods

2.1 Source of data

We used data from the Alabama HF Project, which has been previously described [8–10]. Briefly, charts of 9649 fee-for-service Medicare beneficiaries hospitalized for acute HF from

106 Alabama hospitals between July 1, 1998 and October 31, 2001 were abstracted. All patients had a principal discharge diagnosis of HF based on International Classification of Diseases 9 coding. The 9649 hospitalizations occurred in 8555 unique Medicare beneficiaries, of which 8049 were discharged alive.

2.2 History of HF and Spironolactone Use

We excluded 27 patients receiving potassium-sparing diuretics either on admission or discharge other than aldosterone antagonists. We then created a cohort of 2060 patients with HF and EF $\leq 35\%$, serum creatinine ≤ 2.5 mg/dL for men and ≤ 2 mg/dL for women, and serum potassium < 5 mEq/L, who were eligible for therapy with aldosterone antagonists based on the 2013 American College of Cardiology/American Heart Association HF guidelines criteria [11]. To minimize bias due to prevalent drug use, we excluded 186 patients who were receiving spironolactone on admission [12]. Of the final cohort of 1874 patients eligible for a new prescription for aldosterone antagonist, 329 received a discharge prescription. None of the patients were receiving eplerenone as the drug was not approved for use in HF during the study period.

2.3 Assembly of a balanced cohort

Because patients receiving and not receiving a therapy in the real world often have differences in baseline characteristics that may be of prognostic consequences, we used propensity scores to assemble a matched balanced cohort [13–17]. We used a multivariable logistic regression model to estimate propensity scores for the receipt of a discharge prescription for spironolactone for each of the 1874 patients using 34 baseline characteristics displayed in Figure 1 [10, 18–20]. We then matched 324 patients receiving spironolactone with 324 patients who did not receive this drug but had similar propensity to receive it [21]. The resultant matched cohort of 648 patients was balanced on all 34 baseline characteristics. Between-group balance in baseline characteristics before and after matching were assessed by absolute standardized differences and the results were presented as a Love plot [22]. An absolute standardized difference of 0% would indicate no residual bias and a difference of $< 10\%$ indicates inconsequential bias.

2.4 Study outcomes

The primary outcome of the current analysis was 30-day all-cause readmission. Secondary outcomes included 30-day all-cause mortality, 30-day HF readmissions, and a combined end-point of all-cause mortality or all-cause readmission at 30 days. We also examined these outcomes at 12 months. Data on outcomes and time to events were obtained from the Centers for Medicare and Medicaid Services Medicare data [8].

2.5 Statistical analysis

Number (%) and mean (standard deviation) for categorical and continuous variables, respectively, for baseline characteristics were compared using Pearson's Chi-square and Wilcoxon rank-sum tests. Cox regression models were used to examine associations of spironolactone use and outcomes among matched patients. Kaplan-Meier survival analysis was used to generate plots for 30-day all-cause readmissions by spironolactone use among

patients. We also examined the association of spironolactone use with the primary outcome among the 1874 pre-match patients using Cox regression models, separately adjusting for propensity scores and the 34 variables used to estimate propensity scores. All statistical tests were two-tailed with a p-value <0.05 considered significant. IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp. was used for data analyses.

3. Results

3.1 Baseline characteristics

After matching, patients (n=648) had a mean age of 72 years, 42% percent were women and 33% were African American. Before matching, patients receiving spironolactone were generally younger, and more likely to be African American. They were also more likely to have a lower ejection fraction and be discharged on angiotensin-converting enzyme (ACE) inhibitors or angiotensin-receptor blockers (ARBs) (Table 1). These and other imbalances were balanced in the matched cohort (Table 1 and Figure 1).

3.2 Spironolactone use and outcomes

Among matched patients, 30-day all-cause readmission occurred in 17% and 19% of those receiving and receiving a discharge prescription for spironolactone, respectively (hazard ratio {HR}, 0.92; 95% confidence interval {CI}, 0.64–1.30; p=0.650; Table 2 and Figure 2). Among pre-match patients, propensity score-adjusted and multivariable-adjusted HRs associated with spironolactone use for 30-day all-cause readmission were 0.98 (95% CI, 0.73–1.32; p=0.913) and 0.94 (95% CI, 0.70–1.27; p=0.699), respectively.

Spironolactone use had no association with 30-day HF readmission, 30-day all-cause mortality, or the combined end point of 30-day all-cause readmission or 30-day all-cause mortality (Table 2). Similarly, spironolactone had no association with any outcomes at 12 months (Table 3 and Figure 2).

4. Discussion

Findings from our current study demonstrate that a discharge prescription of spironolactone had no association with all-cause readmission, HF readmission, or all-cause mortality during 30 days following hospital discharge among older patients with HFrEF who were eligible for spironolactone therapy. Furthermore, spironolactone use had no association with these outcomes at 12 months. These findings are consistent with data suggesting a lack of clinical effectiveness of spironolactone in real world eligible patients despite robust evidence of efficacy of aldosterone antagonists from previous major randomized controlled trials [23–28]. Taken together, these findings suggest potential efficacy-effectiveness dissociation for outcomes associated with the use of these drugs. To the best of our knowledge, the current study extends this efficacy-effectiveness dissociation to 30-day all-cause readmission, an important contemporary outcome measure identified for Medicare cost reduction under the Affordable Care Act [29].

The efficacy-effectiveness dissociation of aldosterone antagonists for long-term clinical outcomes is intriguing and has been attributed to a lack of adherence and stringent follow-up

and patient selection bias including disease severity and comorbidity burden [23, 24]. These reasons may also in part explain the efficacy-effectiveness dissociation of spironolactone for short-term outcomes including 30-day all-cause readmission. However, the impact of lack of adherence is unlikely to be a major factor during short-term follow-up [30, 31]. The impact of lack of stringent laboratory follow-up, on the other hand, may be more substantial during short-term follow-up. Hyperkalemia and worsening kidney function are the two most common adverse effects of aldosterone antagonists and the guidelines recommend closer laboratory monitoring of these values [32]. In the Randomized Aldactone Evaluation Study (RALES) trial, worsening kidney function was more common in the spironolactone group, which mostly occurred during the first 30 days, and the kidney function plateaued thereafter [33]. The incidence of hyperkalemia was significantly higher in the spironolactone group compared to placebo, and the risk was higher among those with worsening kidney function [33]. Impaired kidney function is associated with poor outcomes in HF and spironolactone therapy may further worsen outcome in these patients [34, 35]. Although patients in our study had normal kidney function, a lack of stringent monitoring may have cancelled out a potential clinical benefit during the first 30 days. Imbalances in baseline disease severity and comorbidity burden between the treatment groups may have played a lesser role in explaining the lack of association of spironolactone with short-term outcomes in our study as all key measured baseline characteristics were balanced after propensity score matching. Further, even before matching, there were no significant differences in the prevalence of comorbidities except diabetes and in hospital events.

To the best of our knowledge this is the first study to examine the association of spironolactone use with 30-day all-cause readmission in real world patients with HFrEF who were eligible for therapy with this drug. Findings from the current study suggest that spironolactone may not be beneficial for the purpose of lowering 30-day all-cause readmission among patients who are otherwise eligible for this drug. Prior studies of associations of HF pharmacotherapy and 30-day all-cause readmission have demonstrated that while ACE inhibitors or ARBs and digoxin are effective in lowering this outcome, beta-blockers were not, suggesting all evidence-based HF drugs may not be beneficial for 30-day all-cause readmission [5, 7, 36]. Future studies need to examine the underlying reasons for this effectiveness-efficacy dissociation and if a more careful patient selection and a more stringent follow-up may result in better short-term outcomes in patients receiving aldosterone antagonists.

Our study has several limitations. Despite our use of rigorous methodology with propensity score-matched inception cohort design, potential bias due to unmeasured confounders and residual bias from measured confounders is possible. A formal sensitivity analysis may estimate if the observed association could be explained away by a potential unmeasured confounder [37]. However, we did not perform sensitivity analysis due to the null association with our primary outcome. We did not have data on post-discharge adherence, and regression dilution due to crossover of therapy during follow-up may in part explain the null association observed in our study [38]. However, adherence of spironolactone is as high as that of ACE inhibitors, [30, 31] the use of which has been shown to be associated with lower 30-day all-cause readmission [7]. Lack of data on dose of spironolactone, and follow-up data on serum creatinine and potassium are other limitations. Finally, findings of the

current study are based on Medicare fee-for-service patients from a single state from 1999–2001 and may limit generalizability to more contemporary HF patients.

In conclusion, a discharge prescription for spironolactone had no association with 30-day all-cause readmission among older, hospitalized Medicare beneficiaries with heart failure and reduced ejection fraction who were eligible for spironolactone therapy. Taken together with lack of association with other 30-day or longer-term outcomes, these findings add to the growing body of literature that demonstrate a potential efficacy-effectiveness dissociation of spironolactone therapy. This highlights the need for further studies in a carefully selected real-world patient population with a stringent follow-up protocol comparable to those used in randomized controlled trials.

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The authors of this manuscript have certified that they comply with the Principles of Ethical Publishing in the International Journal of Cardiology [39].

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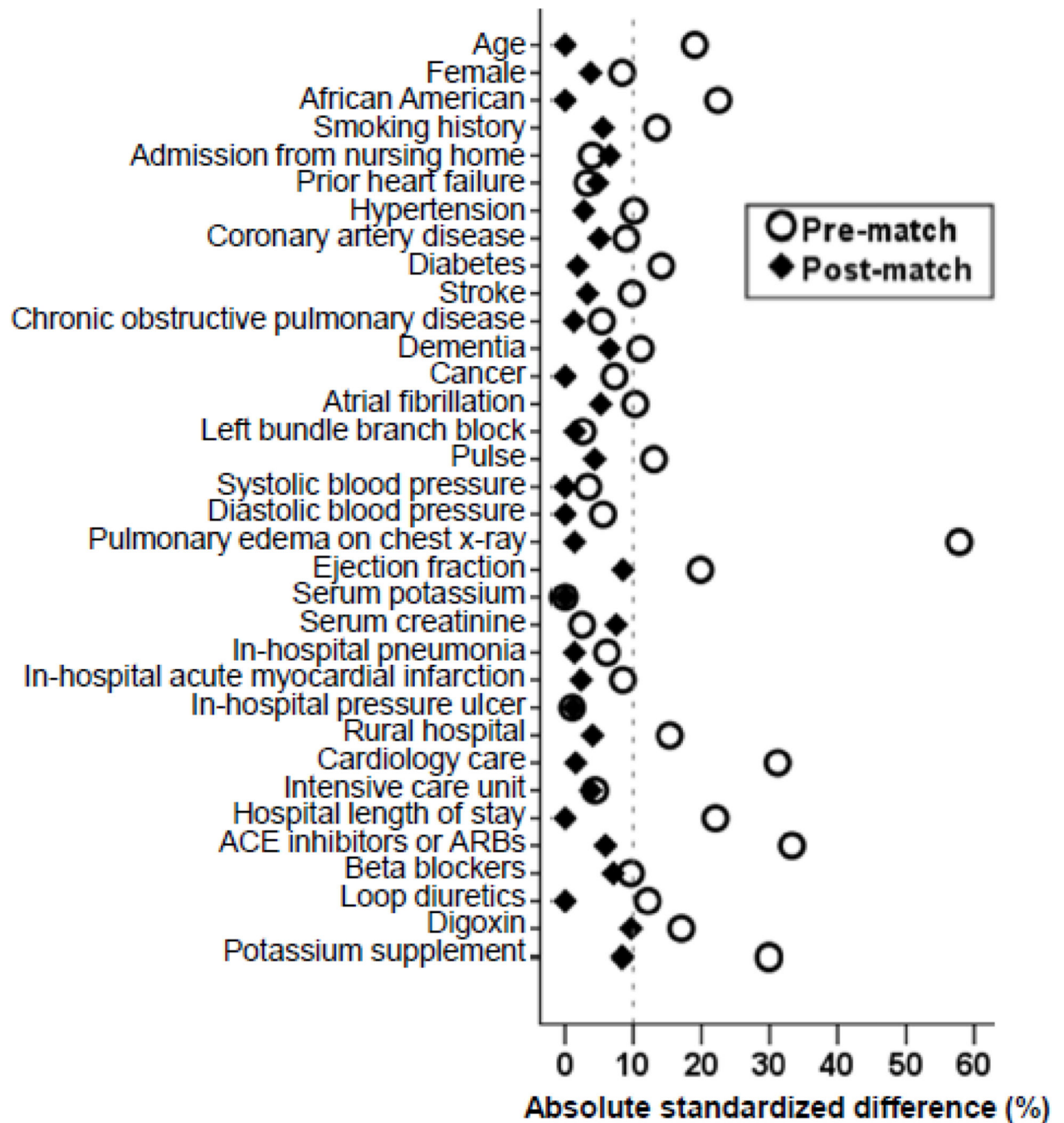


Fig. 1.

Love plot displaying absolute standardized differences for 34 baseline characteristics of hospitalized patients with heart failure and reduced ejection fraction receiving and not receiving spironolactone, before and after propensity score matching (ACE=angiotensin-converting enzyme; ARB=angiotensin receptor blockers)

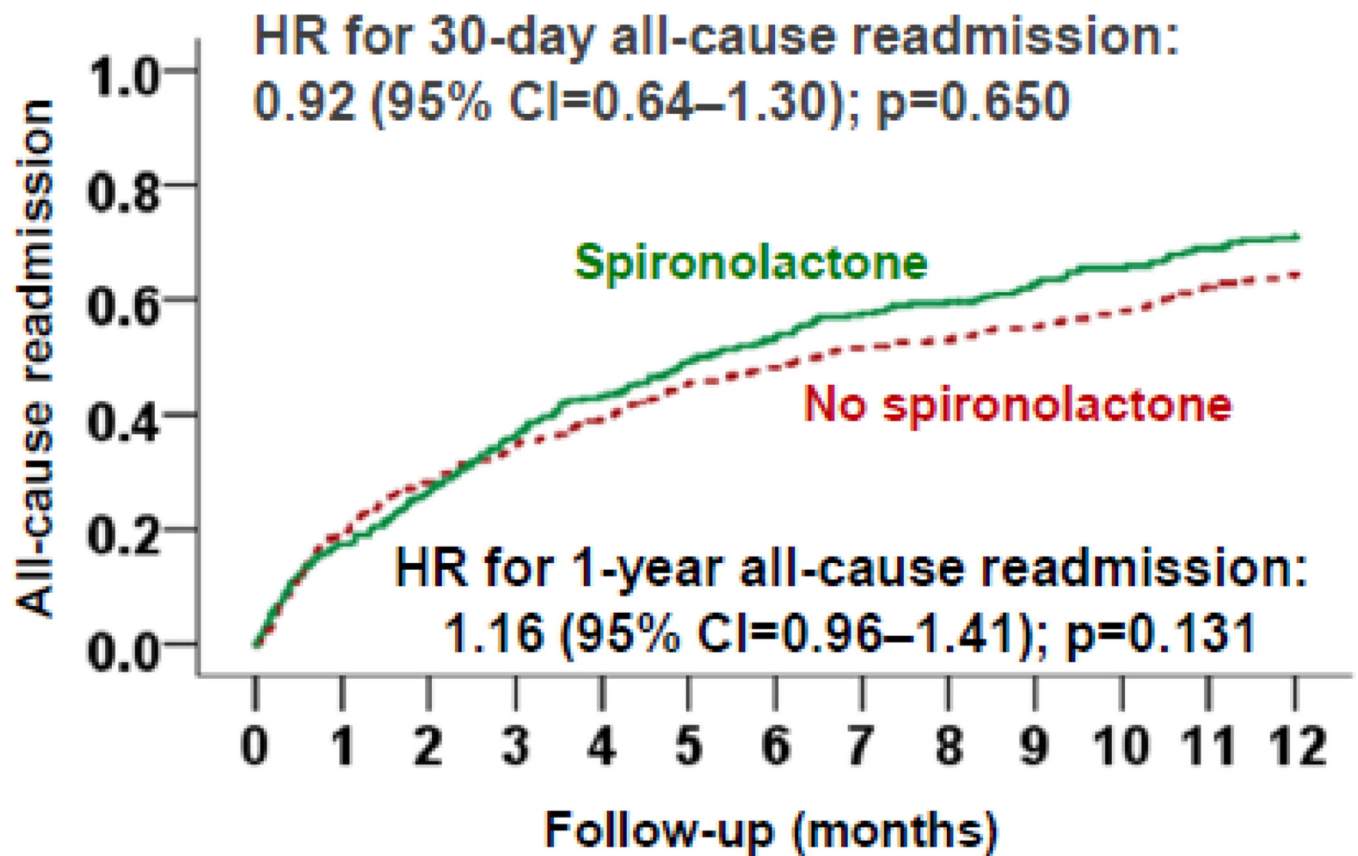


Fig. 2. Kaplan-Meier plots displaying association between pre-discharge initiation of spironolactone and all-cause readmission in a propensity-matched cohort of hospitalized Medicare beneficiaries with heart failure and reduced ejection fraction (CI=confidence interval)

Table 1

Baseline patient characteristics of hospitalized patients with heart failure and reduced ejection fraction, prescription of spironolactone, before and after propensity score matching by discharge

n (%) or mean ($\pm$ SD)	Before propensity score matching Spironolactone on discharge		After propensity score matching Spironolactone on discharge	
	No (n=1545)	Yes (n=329)	No (n=324)	Yes (n=324)
Age (years)	74 ($\pm$ 10)	72 ($\pm$ 11)	72.3 ($\pm$ 11)	71.9 ($\pm$ 11)
Female	698 (45%)	135 (41%)	140 (43%)	134 (41%)
African American	361 (23%)	110 (33%)	106 (33%)	106 (33%)
Smoking history	231 (15%)	66 (20%)	57 (18%)	64 (20%)
Admission from nursing home	58 (4%)	10 (3%)	14 (4%)	10 (3%)
Past medical history				
Prior heart failure	1131 (73%)	236 (72%)	226 (70%)	233 (72%)
Hypertension	1046 (68%)	238 (72%)	239 (74%)	235 (73%)
Coronary artery disease	997 (65%)	198 (60%)	188 (58%)	196 (61%)
Diabetes mellitus	620 (40%)	155 (47%)	154 (48%)	151 (47%)
Stroke	302 (20%)	52 (16%)	56 (17%)	52 (16%)
Chronic obstructive pulmonary disease	556 (36%)	110 (33%)	108 (33%)	110 (34%)
Dementia	122 (8%)	17 (5%)	22 (7%)	17 (5%)
Cancer	41 (3%)	13 (4%)	12 (4%)	12 (4%)
Clinical findings				
Pulse (beats per minute)	93 ($\pm$ 23)	96 ($\pm$ 23)	97 ($\pm$ 23)	96 ($\pm$ 23)
Systolic blood pressure (mm Hg)	144 ($\pm$ 30)	145 ($\pm$ 29)	146 ($\pm$ 28.5)	146 ($\pm$ 29.3)
Diastolic blood pressure (mm Hg)	81 ($\pm$ 18)	82 ($\pm$ 18)	82.1 ($\pm$ 18)	82.3 ($\pm$ 18)
Pulmonary edema by chest x-ray	1103 (71%)	241 (73%)	240 (74%)	238 (74%)
Atrial fibrillation by electrocardiogram	421 (27%)	75 (23%)	68 (21%)	75 (23%)
Left bundle branch block	374 (24%)	76 (23%)	77 (24%)	75 (23%)
Ejection fraction	25.4 ($\pm$ 7.0)	24.0 ($\pm$ 7.2)	24.1 ($\pm$ 6.8)	24.7 ($\pm$ 7.3)
Tests and procedures				
Serum potassium (mEq/L)	4.19 ($\pm$ 0.6)	4.18 ($\pm$ 0.6)	4.2 ($\pm$ 0.55)	4.2 ($\pm$ 0.64)

n (%) or mean ($\pm$ SD)	Before propensity score matching Spironolactone on discharge		After propensity score matching Spironolactone on discharge	
	No (n=1545)	Yes (n=329)	No (n=324)	Yes (n=324)
Serum creatinine (mEq/L)	1.30 ($\pm$ 0.4)	1.29 ($\pm$ 0.4)	1.26 ($\pm$ 0.4)	1.29 ($\pm$ 0.4)
In-hospital events				
Pneumonia	381 (25%)	90 (27%)	85 (26%)	87 (27%)
Acute myocardial infarction	85 (6%)	25 (8%)	25 (8%)	23 (7%)
Pressure ulcer	117 (8%)	24 (7%)	23 (7%)	24 (7%)
Hospital and care characteristics				
Rural hospital	384 (25%)	61 (19%)	55 (17%)	60 (19%)
Cardiology care	1035 (67%)	265 (81%)	262 (81%)	260 (80%)
Intensive care unit	74 (5%)	19 (6%)	22 (7%)	19 (6%)
Length of stay (days)	6.6 ($\pm$ 4)	7.6 ($\pm$ 5)	7.5 ($\pm$ 5.1)	7.5 ($\pm$ 4.8)
Discharge medications				
ACE inhibitors and angiotensin receptor blockers	1106 (71%)	280 (85%)	269 (83%)	276 (85%)
Beta blockers	511 (33%)	124 (38%)	111 (34%)	122 (38%)
Loop diuretics	1362 (88%)	302 (92%)	297 (92%)	297 (92%)
Digoxin	916 (59%)	222 (68%)	202 (62%)	217 (67%)
Potassium supplements	795 (52%)	121 (37%)	108 (33%)	121 (37%)

ACE = angiotensin converting enzyme

Table 2

Associations of discharge prescription for spironolactone with outcomes at 30 days post-discharge in a propensity score matched cohort of hospitalized patients for heart failure and reduced ejection fraction

	(Events %) Spironolactone on discharge		HR (95% CI); p-value
	No (n=324)	Yes (n=324)	
All-cause readmission	18.8%	17.3%	0.92 (0.64–1.30); 0.650
Heart failure readmission	8.3%	6.2%	0.74 (0.41–1.31); 0.737
All-cause mortality	4.0%	3.4%	0.84 (0.38–1.88); 0.844
All-cause mortality or readmission	21.9%	19.8%	0.90 (0.64–1.27); 0.902

HR = hazard ratio; CI = confidence interval

Table 3

Associations of discharge prescription for spironolactone with outcomes at 12 months post-discharge in a propensity score matched cohort of hospitalized patients for heart failure and reduced ejection fraction

	(Events %) Spironolactone on discharge		HR (95% CI); p-value
	No (n=324)	Yes (n=324)	
All-cause readmission	61%	68%	1.16 (0.96–1.41); 0.131
Heart failure readmission	31%	29%	0.92 (0.70–1.22); 0.575
All-cause mortality	26.2%	29.0%	1.11 (0.83–1.49); 0.483
All-cause mortality or readmission	68.8%	74.7%	1.13 (0.94–1.36); 0.181

HR = hazard ratio; CI = confidence interval