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Association between process quality measures for heart failure and mortality among US veterans

Wen-Chih Wu, MD, MPH^{a,b,d}, Lan Jiang, MS^a, Peter D. Friedmann, MD, MPH^{a,b,c}, and Amal Trivedi, MD, MPH^{a,c,d}

^aCenter of Innovation in Long-Term Services and Supports, Providence Veterans Affairs Medical Center, Providence, RI

^bDepartment of Medicine, Alpert Medical School of Brown University, Providence, RI

^cDepartment of Community Health, Brown University, Providence, RI

^dMedical Service, Providence Veterans Affairs, Providence, RI

Abstract

Background—The few available studies of the Centers for Medicare and Medicaid Services Hospital Inpatient Quality Reporting (IQR) care process indicators have not linked receipt of recommended care processes in heart failure (HF) with lower mortality. Because the Veterans Health Administration (VHA) also tracks hospital inpatient quality reporting indicators, in addition to VHA-specific inpatient (pneumococcal and influenza vaccination) and outpatient (angiotensin-converting enzyme inhibitor [ACEI] or angiotensin receptor blocker [ARB] use for left ventricular [LV] dysfunction and LV function documentation) care process indicators, we examined the association between receipt of these care processes and 30-day and 1-year mortality.

Methods—Retrospective study of 107,045 patients with HF treated at 128 VHA hospitals between 2001 and 2007 and followed up through 2008. We assessed the relationship between receipt of each HF care process and death at 30 days (inpatients only) and 1 year (all patients), using generalized estimating equations to adjust for clinical characteristics and clustering within hospitals.

Results—Overall, inpatient/outpatient use of ACEI/ARB and receipt of pneumococcal or influenza vaccinations were related to lower risks of 30-day and/or 1-year mortality (adjusted odds ratios 0.51–0.77 for vaccinations and 0.60–0.78 for ACEI/ARB use). Conversely, discharge instructions, inpatient/outpatient LV function assessment, or weight instructions before admission were either not related or related to a slightly increase in mortality. Stratified analyses by various mortality risk subgroups did not reveal discernable “dose-response” relationship between mortality risk stratification and the association of care process and mortality.

Conclusions—Receipt of care processes related to recommended medications and vaccinations were associated with lower 30-day and/or 1-year risk-adjusted mortality in patients with HF. Receipt of care processes that assess patient counseling or chart documentation was not related to lower mortality.

Since 2004, nearly every hospital in the United States has publicly reported the quality of care for patients admitted with heart failure (HF) using 4 care process indicators developed by the Hospital Inpatient Quality Reporting (IQR) program of the Centers for Medicare and Medicaid Services.¹ However, with the exception of 1 indicator assessing angiotensin-converting enzyme inhibitor or angiotensin receptor blocker (ACEI/ARB) prescriptions at discharge, limited evidence links receipt of recommended care processes to improved patient survival.² Moreover, the clinical trials that support the use of ACEI/ARB excluded many older and clinically complicated patients, raising questions of generalizability to typical patients hospitalized for HF.³ Prior studies of the association between Hospital IQR care processes and outcomes in HF either lacked detailed patient-level clinical data,^{4,5} were focused on hospital-level outcomes, or did not examine long-term mortality.⁶ One study that included detailed patient-level information during the HF hospitalization failed to find a relationship between the receipt of ACEI/ARB use for left ventricular (LV) dysfunction and 60- to 90-day mortality.⁷

Moreover, although quality reporting for HF has been adopted for hospitalized patients, reporting efforts have lagged in the ambulatory setting. The American College of Cardiology/American Heart Association (ACC/AHA) developed a set of outpatient care process indicators in HF,⁸ but little evidence demonstrates that these indicators predict better outcomes.⁹ Voluntary reporting from a registry of outpatient cardiology practices demonstrated that some care processes that are analogous to ones tracked by Hospital IQR, such as ACEI/ARB use for LV dysfunction, predicted lower 2-year mortality for outpatients with HF. However, the voluntary reports of the cardiologists may not represent care nationwide nor generalize to the numerous outpatients with HF who receive care in a primary care setting.¹⁰

As part of an effort to improve the quality of care, the Veterans Health Administration (VHA), the nation's largest integrated health care delivery system, has mandated reporting of the same Hospital IQR care processes used in private sector hospitals and selected outpatient care processes (ACEI/ARB use for LV systolic dysfunction and documentation of LV systolic function) recommended by the ACC/AHA⁸ as well as other inpatient HF care processes, which are VHA specific.¹¹ However, little is known about the performance of VHA hospitals for these HF care processes or about the relationship between the VHA-specific care processes and patient outcomes.

Given these gaps in the literature, this study examines whether individuals who received recommended care-processes, as assessed by Hospital IQR, ACC/AHA and VHA, experienced improved 30-day or 1-year survival compared with patients who did not receive these care processes. Moreover, for those care processes, which are related to survival, we investigate whether the relationship remained similar for high-risk patients who are typically excluded from randomized controlled clinical trials.

Methods

Sources of data

We linked individual-level care process performance data from the VHA's External Peer Review Program (EPRP) with administrative and clinical records, which contained information on vital signs, laboratory results, comorbid conditions, prior hospital care, and vital status.^{11,12} Veterans Affairs (VA) Medicare data provided use of Medicare-financed hospital services in non-VHA hospitals. The data linkage used methods that have been validated in prior studies.¹³

Please see online Appendix Supplementary Methods for further details of the sources of data.

Study sample

Our unit of analysis was an assessment for the receipt of the care process specified by at least 1 of the HF quality indicators identified by EPRP data between 2001 and 2007. Of 112,345 patients identified, 55,954 patients had only inpatient care process assessments, 46,095 patients had only outpatient care process assessments, and 10,296 patients had both inpatient and outpatient assessments. We excluded 56 patients for having assessments in year 2000, 122 patients who had an assessment date after their date of death, and 5,122 patients for whom we could not identify a hospitalization or clinic visit for HF within 3 months of the respective care process assessment date. The final analytic sample included 107,045 unique patients (95% of the original sample) and 276,556 care process assessments. We obtained mortality data for each of these patients for up to 1 year after the date of the performance assessment.

Heart failure care processes

The VHA adopted 3 inpatient care processes that were comparable to Hospital IQR indicators¹: (1) LV function assessed at any time before or planned at discharge, (2) ACEI/ARB prescribed at hospital discharge for LV ejection fraction <40%, and (3) discharge instructions on diet/weight/medications (specific activities and documentation specified in online Appendix Supplementary Methods).¹⁴ There were also 4 additional inpatient care processes that were unique to VHA: (1) receiving weight monitoring/instruction prior to admission, (2) ACEI/ARB for LV ejection fraction <40% prescribed at any time before inpatient admission and 2 additional care-processes that were requirements for all inpatients with HF from the Joint Commission,¹⁵ (3) documentation of pneumococcal vaccination at any time before or during admission, and (4) documentation of influenza vaccination before (the preceding September through Spring) or during admission, with the indicator assessed only from February to August.

There were also 2 VHA-specific outpatient care processes adopted from the ACC/AHA HF guidelines: (1) ACEI/ARB for LV ejection fraction <40% and (2) documentation of LV function.⁸ Details on the eligibility for these indicators are described in online Appendix Supplementary Methods. We assessed all HF care processes available during 2001 to 2007 with the exception of 1 VHA-specific indicator, ACEI/ARB for LV ejection fraction <40%

prescribed before inpatient admission, to avoid redundancy from the other 2 established ACEI/ARB indicators.

Outcomes

The study outcomes were 30-day and 1-year mortality for inpatients discharged alive after the index hospitalization or 1-year mortality for outpatients after the clinic visit in which the care processes were assessed. Mortality data were obtained from the validated VA vital status file with complete follow-up for the entire study population from 2001 to 2008.¹³

Covariates

Our primary independent variable indicated the receipt or not of a particular care process. Covariates were informed by literature and are described in detail under online Appendix Supplementary Methods.

Statistical analysis

Each care process was studied independently from the others. We compared demographic and clinical characteristics among patients who received the specified care process versus those who did not, with χ^2 analyses for categorical variables and t tests for continuous variables. We constructed logistic regression models predicting mortality within 30 days (for inpatients) and 1 year (for both inpatients and outpatients) after the care process assessment, adjusting for demographic and clinical covariates. We further adjusted for clustering of patients within VA hospitals using generalized estimating equations. Data were >90% complete, with the exception of hematocrit values (28% missing) and creatinine clearance (19% missing). Missing data were imputed using the standard multiple imputation function (MIANALYZE) by SAS version 9.2 (Cary, NC).¹⁶ We also conducted sensitivity analyses to test the robustness of our results:

1. We tested the association between care processes and 1-year mortality using inverse probability weighting (IPW).¹⁷ Details of IPW are presented in online Appendix Supplementary Methods.
2. To determine whether significant associations found between care processes and 1-year mortality varied by clinical risk, we conducted a priori defined subgroup analyses by tertiles of 1-year predicted probability of death. For ACEI/ARB care processes, we also stratified by tertiles of creatinine clearance, mean arterial pressure, and serum potassium levels.
3. For subgroups of patients that were concomitantly assessed for multiple care processes, we assessed the independent effect of each care process when grouped with others by thematic content and sample size into immunization care processes (2 measures) and the Hospital IQR care processes (4 measures). Concomitant assessment of the 2 outpatient care processes was not feasible due to 8,227 of 8,228 patients received the care process of “degree of LV function documented.”

All reported P values were 2 sided, and $P < .05$ was considered to be significant.

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Results

Adherence to care processes

Adherence varied from 69% to 85% for care processes related to diet/weight/medication instructions; 87% to 89% for ACEI/ARB therapy in patients with LV function <40%, 83%, and 92% for influenza and pneumococcal vaccinations, respectively; and 83% to 98% for LV function assessment (Tables I and II, online Appendix Supplementary Table I). Overall, patients who received the care processes had a significantly higher comorbidity burden compared with those who did not (Tables I and II, online Appendix Supplementary Table I). The exception was for care processes related to ACEI/ARB (Table I), where comorbidity burden was significantly lower for the inpatient cohort who received ACEI/ARB compared with those who did not. The number of comorbid conditions was comparable for the outpatient cohort who received ACEI/ARB compared with those who did not (online Appendix Supplementary Table I). Both inpatients and outpatients who received ACEI/ARB therapy also had significantly better kidney function as measured by creatinine clearance values.

Inpatient care processes and 30-day mortality

Only 3 of the 6 inpatient care processes were significantly associated with lower risk-adjusted 30-day mortality (Table III). These care processes were prescription of ACEI/ARB for LV ejection fraction <40% at discharge, with adjusted odds ratios (AORs) for 30-day mortality of 0.60 (95% CI 0.50–0.71), and vaccination for influenza during or before hospitalization (AOR 0.51, 95% CI 0.30–0.86). Care processes related to weight instructions, pneumococcal vaccination, or LV function documentation were not related to risk-adjusted 30-day mortality.

Care processes and 1-year mortality

Of 8 care processes studied, 5 were associated with risk-adjusted 1-year mortality (Table III). Of the 2 care processes related to the prescription of ACEI/ARB for LV ejection fraction <40%, both were related to a lower risk of 1-year mortality, with AOR of 0.78 (95% CI 0.65–0.94), for the outpatient cohort, and AOR 0.70 (95% CI 0.62–0.78), for the inpatient cohort. Both care processes related to vaccinations during or before hospitalization were related to a significantly lower risk of 1-year mortality, with AOR of 0.77 (95% CI 0.62–0.96), for vaccination for pneumococcus, and AOR of 0.75 (95% CI 0.58–0.96), for vaccination for influenza. Two care processes related to LV function documentation (inpatient and outpatient settings) were not related to 1-year mortality. Of the 2 care processes related to the receipt of weight/medication instructions, the receipt of the care process was either related to a significantly higher risk of 1-year mortality (AOR 1.10, 95%

CI 1.02–1.19 for instructions before hospital admission) or not related to 1-year mortality (for instructions before discharge).

Sensitivity analysis

Using IPW to assess for potential confounding showed very similar results for the relationship between care processes and 1-year mortality (Table III). Of note, there were 2 care processes with borderline associations in the logistic regression modeling (“received weight monitoring instruction prior to admission” and “received diet/weight/medication instructions at discharge”) that changed significance after IPW. The former went from significant association in logistic regression (AOR 1.10, 95% CI 1.02–1.19) to nonsignificant in IPW (AOR 1.02, 95% CI 0.99–1.05). The latter went from nonsignificant association in logistic regression (AOR 1.03, 95% CI 0.98–1.09) to significant in IPW (AOR 1.04, 95% CI 1.02–1.07).

Stratified analyses by tertiles of 1-year predicted probability of death (online Appendix Supplementary Table II) or by tertiles of creatinine clearance, mean arterial pressure, or serum potassium levels (Figure and online Appendix Supplementary Figure) did not show a discernable “dose-response” relationship between the stratification by tertiles and the association of care processes and mortality.

Concomitant assessment of care processes—Among the 2,403 patients who had both vaccination care processes (influenza and pneumonia vaccines) assessed, we found that these 2 care processes are moderately correlated ($r = 0.33$, $P < .0001$). Therefore, when assessed in the 1-year mortality regression model together, neither of them was independently related to mortality. Among Hospital IQR indicators, the care process of “LV function assessed prior to or planned at discharge” was excluded from the joint analysis because close to 100% of the patients received (except for 2) this care process. Consistent with main study results, the joint assessment of the remaining 3 care processes ($n = 8867$) showed that the care processes of “weight monitoring instruction at discharge” were related to higher mortality and “LV function <40% with ACEI/ARB prescribed at discharge” was related to lower mortality, whereas the care process of “diet/weight/medication instructions at discharge” was not related to mortality.

Discussion

Prior analyses have found associations between hospital performance on certain Hospital IQR care processes for HF and 30-day hospital HF mortality rates.^{18,19} However, national studies that include detailed patient-level clinical and physiologic measurements are scarce and have not found significant relationships between patient receipt of Hospital IQR care processes and short- or long-term mortality.⁷ In our analyses of patients with HF from VHA hospitals nationwide, receipt of 5 of the 8 studied care processes was significantly related to either 30-day or 1-year mortality, or both. Receipt of care processes assessing use of ACEI/ARB for LV systolic dysfunction or use of recommended vaccinations was related to lower 30-day and 1-year mortality. Care processes assessing receipt of discharge counseling or documentation of LV function were not related to lower mortality.

Prior evidence and guidelines support the use of influenza and pneumococcal vaccination to reduce the risk of hospitalization and death among patients with heart disease,^{20,21} but few data exist on adherence rates for patients with HF. For HF patients in the United States, documentation of receipt of pneumococcal vaccination was only 1% in outpatient cardiology practices and not available for influenza vaccination.²² Among eligible veterans hospitalized with HF, we found that 76% were vaccinated for influenza and 89% for pneumococcus. More importantly, the evidence supporting the receipt of vaccinations in this frail population and the association between these vaccinations and mortality outcomes in our study suggests that these care processes can be considered in non-VHA settings as well.

We found that care processes of ACEI/ARB for LV dysfunction had strong and consistent associations with reduced mortality among both inpatient and ambulatory patients. Previous patient-level analyses did not find statistically significant associations between receipt of the care process “ACEI or ARB prescribed at discharge” and reduced short-term mortality.^{7,23} The positive findings in our study are likely attributable to a much larger study sample because the risk-adjusted hazards ratio for 60- to 90-day mortality found by Fonarow et al²⁴ of 0.61 ($P = .08$) is comparable to our results. The high rate of ACEI/ARB use in our nationwide sample of VHA hospitals at 87% to 89% is comparable to previous reports in the civilian sector of 80% to 88%^{4,19} for inpatients and 80% to 86% rate for outpatients (Projects PINNACLE and IMPROVE).^{9,10,25}

Contrary to expectations, chart documentation of LV function, despite good adherence rates (98% inpatient and 83% for outpatient settings), was not related to mortality. Similarly, receipt of weight/medication instructions was either not related (eg, discharge instructions) or related to a slightly increased risk of death (eg, weight instructions before admission). Although confounding by indication may explain the counterintuitive mortality trends, future studies are needed to explore this care process indicator in detail. Nonetheless, we caution that these negative results should not be interpreted as a lack of importance of these clinical practices but might indicate deficiencies in the specificity of the measure (eg, LV function assessment does not specify the time frame when the LV function could have been assessed) or the way these measures were captured (ie, based on chart documentation). In addition, the quality with which weight and medication instructions are delivered can vary greatly. Without direct observation, we cannot determine the quality of delivery of such care processes, and how this quality may affect patient outcomes. Future studies should evaluate (1) how organization and provider factors relate to quality and quantity of delivery of care processes that relate to patient interaction (eg, weight or discharge instructions) and (2) whether quality and quantity of delivery relate to patient compliance to the lifestyle behavior changes.

This study’s strengths are its large, nationwide sample, comprehensive and reliable data extraction, and breadth of patients with diverse coexisting morbidities. This study also has limitations. First, the sample is predominantly male, so results may not generalize to women with HF. Second, receipt of the care processes was not randomly assigned, so associations with mortality may be confounded by indication. Despite adjustment for an extensive list of comorbidities, residual confounding may still exist. As such, the associations that we have found might be less pronounced in reality, for both the estimation of benefits or risks

between care processes and mortality outcomes. Third, the study took place in a government-operated integrated health care system (VHA), which differs from private sector health care settings. Fourth, this study focused on mortality and did not test the relationship between care processes and other outcomes (eg, hospital readmission). Lastly, we may be unable to detect differences in mortality risk of care processes with high compliance rates due to lack of power (eg, documentation of LV function) or care processes where the method and quantity of delivery may impact the quality of results, such as discharge weight instructions.

Ideally, care process indicators of the quality of care should be directly controllable by providers and correlated with better patient outcomes.²⁶ Given the costs associated with assessments, there is also a critical need to prioritize indicators that have low and/or variable compliance rates among institutions to direct quality improvement resources appropriately. Our study suggests that among the current publicly reported care process quality indicators for HF, clinicians and policy-makers should focus on increasing use of ACEI/ARB among patients with LV systolic dysfunction in both the inpatient and ambulatory settings. Pneumococcal and influenza vaccinations are other promising targets for quality improvement. We found no evidence that adherence to other widely reported measures of HF care predicted better patient survival.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure.

Adjusted odds ratios of clinical subgroups for the care process ACEI/ARB prescribed at discharge for LV function <40%. Subgroups are defined by tertiles of creatinine clearance (milliliter per minute), mean arterial blood pressure (millimeters of mercury), serum potassium levels (milliequivalents per liter), and predicted probability of death. Odds ratios are between patients who received the care processes specified by the quality indicators (indicator met) versus those who did not receive the care processes (indicator not met, referent group). Abbreviations: *Cr*, Creatinine; *Prob*, Probability; *K*, serum potassium levels. Note: The size of the square is proportional to the magnitude of the variance.

Baseline characteristics of inpatient study cohorts being evaluated for Hospital IQR care process indicators

Table 1

Patient characteristics	Received diet/weight/medication instructions at discharge		Inpatient, LV function assessed before or planned at discharge		LV function <40% on ACEI or ARB at discharge	
	Indicator met (68.6%), n = 38,823	Indicator not met, n = 17,781	Indicator Met (98.2%), n = 48,719	Indicator not met, n = 889	Indicator met (89.3%), n = 14,430	Indicator not met, n = 1727
Mean (SD) or %						
Age (SD)	69.95 (11.39)	70.28 (10.88)*	70.56 (11.47)	72.68 (11.74)*	68.51 (11.85)	71.72 (11.33)*
Male	98.3	98.3	98.2	97.6	98.9	98.8
White race	74.0	78.8	74.6	78.7	68.6	71.3
Black race	23.5	19.2	22.9	18.7	28.6	26.5
Race, other	2.6	2.1	2.5	2.6	2.7	2.2
No. of comorbidities, Elixhauser risk index (SD) [†]	6.32 (2.49)	5.93 (2.44)*	6.44 (2.53)	5.32 (2.29)*	6.20 (2.54)	6.93 (2.65)*
No. of hospitalizations in prior 6 m (SD)	0.93 (1.37)	0.90 (1.34)*	0.99 (1.42)	0.52 (1.03)*	0.96 (1.43)	1.30 (1.64)*
Any HF hospitalizations in prior 6 m	20.2	14.7*	21.0	5.5*	24.3	30.0*
History of myocardial infarction	32.9	32.1	33.1	18.1*	40.9	41.3
Hematocrit during hospitalization or before clinic visit (SD)	36.80 (6.43)	36.45 (6.39)*	36.54 (6.47)	36.41 (8.35)	37.91 (6.20)	35.41 (6.09)*
Mean arterial pressure during hospitalization or clinic visit (SD)	87.04 (14.38)	87.03 (14.42)	86.77 (14.31)	88.82 (15.15)*	85.79 (14.09)	84.74 (13.11)*
Pulse during hospitalization or clinic visit (SD)	76.29 (14.88)	76.68 (15.23)*	76.22 (14.85)	76.15 (15.13)	77.03 (14.77)	77.86 (14.80)*
Creatinine clearance during hospitalization or before clinic visit (SD)	58.62 (25.04)	60.08 (26.45)*	58.40 (25.35)	60.79 (26.40)*	62.85 (24.04)	47.91 (25.06)*
Mean length of stay during prior 6 m (SD)	6.73 (16.50)	7.83 (19.75)*	9.88 (26.24)	8.38 (28.91)	7.99 (22.01)	13.69 (31.33)*

* $P < .05$ when compared to patients with indicator measures met.

[†]The Elixhauser risk index included lymphoma, paralysis, blood loss—anaemia, HIV/AIDS, metastatic cancer, weight loss, pulmonary circulation disorders, anticoagulation agents/coagulopathy, liver disease (mild), hypothyroidism, fluid and electrolyte disorders, drug abuse, other neurologic disorders, diabetes (with complications), peptic ulcer disease, valvular disease, alcohol abuse/dependence, peripheral vascular disease, deficiency anemias, HF, solid tumor without metastasis, psychotic illness/psychoses, chronic pulmonary disease, depression, obesity, diabetes (uncomplicated), and rheumatoid arthritis/collagen vascular diseases.

Table II

Baseline characteristics of the inpatient study cohorts being evaluated for previous or current receipt of influenza and pneumococcal vaccinations

Patient characteristics		Pneumococcal vaccination (n = 8017)			Influenza vaccination (n = 2739)		
Mean (SD) or %		Received vaccine (92.4%, n = 7108)	Refusal of vaccine, n = 323 (excluded)	Did not receive vaccine, n = 586	Received vaccine (92.9%, n = 2087)	Refusal of vaccine, n = 223 (excluded)	Did not receive vaccine, n = 429
Age (SD)		71.82 (11.04)	65.82 (11.68)	64.55 (12.20)*	71.91 (10.55)	68.50 (10.37)	68.30 (11.27)*
Male		98.2	97.5	98.8	98.5	97.8	98.4
White race		74.7	65.3	59.2	74.2	61.9	65.0
Black race		22.9	32.5	36.4	23.1	33.6	31.9
Race, other		2.4	2.1	4.5	2.7	4.5	3.1
No. of comorbidities, Elixhauser risk index (SD)		6.91 (2.49)	5.58 (2.37)	5.11 (2.45)*	6.91 (2.54)	6.06 (2.41)	5.93 (2.50)*
No. of any hospitalizations in prior 6 m (SD)		1.14 (1.54)	1.00 (1.37)	0.79 (1.36)*	1.18 (1.59)	1.02 (1.44)	0.81 (1.30)*
Any HF hospitalizations in prior 6 m		24.6	24.5	20.3	24.7	24.2	21.5
History of myocardial infarction		34.8	27.2	24.4*	35.0	32.7	30.8
Hematocrit during hospitalization (SD)		36.02 (6.28)	38.56 (6.35)	38.60 (6.49)*	35.91 (6.25)	37.29 (6.03)	37.26 (6.02)*
Mean arterial pressure during hospitalization (SD)		86.48 (13.44)	90.05 (13.99)	89.82 (14.11)*	86.32 (13.43)	90.08 (15.39)	88.33 (13.08)*
Pulse during hospitalization (SD)		75.11 (14.72)	77.05 (15.43)	77.79 (15.09)*	75.07 (14.81)	77.19 (16.28)	77.39 (15.86)*
Creatinine clearance during hospitalization (SD)		56.70 (24.40)	61.35 (23.95)	66.77 (24.64)*	55.99 (24.06)	60.68 (23.91)	62.13 (26.67)*
Mean length of stay during prior 6 m (SD)		9.52 (22.96)	7.31 (18.68)	7.25 (19.87)*	10.02 (24.53)	7.88 (18.80)	6.84 (18.00)*

* P .05 when compared to patients with performance measures met.

Table III

Mortality risks between patients who received care processes specified by the VHA performance measures for HF and those who did not

	Quality indicator performance (n)	30-d observed mortality (%)	30-d adjusted mortality risk, odds ratio (95% CI)	1-y observed mortality (%)	1-y adjusted mortality risk, odds ratio (95% CI)	1-y adjusted mortality risk, IPW odds ratio (95% CI)
Received weight monitoring instruction before admission	Yes (24,024)	13.2	1.03	42.3	1.10	1.02
	No (4294)	10.4	(0.92–1.17)	36.1	(1.02–1.19)	(0.99–1.05)
Received diet/weight/medication instructions at discharge	Yes (38,823)	4.4	1.03	30.3	1.03	1.04
	No (17,781)	5.1	(0.91–1.13)	31.7	(0.98–1.09)	(1.02–1.07)
Outpatient-LV function <40% on ACEI/ARB	Yes (7465)	–	–	15.1	0.78	0.73
	No (940)	–	–	20.3	(0.65–0.94)	(0.67–0.79)
LV function <40% with ACEI/ARB prescribed at discharge	Yes (14,430)	5.1	0.60	30.6	0.70	0.69
	No (1727)	11.3	(0.50–0.71)	47.9	(0.62–0.78)	(0.66–0.72)
Received pneumococcal vaccination during or before admission	Yes (7108)	4.7	0.66	31.1	0.76	0.75
	No, without patient refusal (586)	4.1	(0.42–1.05)	25.3	(0.61–0.95)	(0.70–0.81)
Received influenza vaccination during or before admission*	Yes (2087)	4.0	0.49	29.9	0.74	0.75
	No, without patient refusal (429)	5.1	(0.29–0.83)	29.8	(0.58–0.96)	(0.66–0.84)
Outpatient, degree of LV function documented	Yes (35,488)	–	–	17.8	0.98	1.01
	No (7196)	–	–	15.3	(0.90–1.05)	(0.97–1.04)
LV function assessed before or planned at discharge	Yes (48,719)	6.3	1.19	33.3	0.93	1.00
	No (889)	4.3	(0.85–1.67)	31.3	(0.79–1.08)	(0.97–1.04)

All cohorts are inpatients unless specifically indicated.

Mortality risk adjusted for age; sex; race; hospital days last 6 months; number of hospitalizations prior 6 months; prior HF hospitalization; Elixhauser risk index, prior myocardial infarction; fiscal year of the assessment; values of hematocrit, mean arterial blood pressure, pulse, and creatinine clearance; and clustering within hospitals.

* Vaccine assessment only applicable during the influenza season (September through Spring).