BACKGROUND: Numerous quality metrics for heart failure (HF) care now exist based on process and outcome. What remains unclear, however, is if the correct quality metrics are being emphasized. To determine the validity of certain measures, we compared correlations between measures and reliability over time. Measures assessed include guideline-recommended β-blocker (BB), any BB, angiotensin-converting enzyme (ACE) inhibitor or angiotensin receptor blocker, mineralocorticoid receptor antagonist, and hydralazine/isosorbide dinitrate (in blacks) use among candidates, 30-day mortality, 1-year mortality, and 30-day readmission.

METHODS AND RESULTS: This was an observational cohort analysis using chart review and electronic resources for 55,735 patients from 102 Veterans Affairs medical centers hospitalized with HF from 2008 to 2013. Assessments of convergent validity and reliability were performed. Significant correlations were found between in-hospital rates of ACE inhibitor use and the following measures: BB use, 30-day mortality, and 1-year mortality. Guideline-recommended BB use was also significantly correlated with mineralocorticoid receptor antagonists, 30-day mortality, and 1-year mortality. There was no correlation between 30-day readmission rates and any therapy or mortality. Measure reliability over time was seen for guideline-recommended BBs ($r=0.57$), mineralocorticoid receptor antagonists ($r=0.50$), 30-day mortality ($r=0.29$), and 1-year mortality ($r=0.31$). ACE inhibitor and readmission rates were not reliable measures over time.

CONCLUSIONS: BB use, ACE inhibitor use, mortality, and mineralocorticoid receptor antagonist use are valid measures of HF quality. Thirty-day readmission rate did not seem to be a valid measure of HF quality of care. If the goal is to identify high-quality HF care, the emphasis on decreasing readmission rates might be better directed towards improving usage of the recommended therapies.

Key Words: angiotensin-converting enzyme inhibitors | heart failure | hydralazine | mineralocorticoid receptor antagonists | outcome assessment | patient readmission | veterans

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WHAT IS NEW?
• Our study demonstrates that measures of hospital heart failure quality vary in their reliability and may not correlate with each other.
• Several heart failure treatments (eg, β-blockers and angiotensin-converting enzyme inhibitors) have been shown to improve mortality in randomized trials and measures for their use were correlated and associated with 30-day and 1-year mortality.
• Mortality and readmission are not desirable, but mortality and readmission rates may be more a measure of patient severity of illness than quality of care.
• We found that readmissions (unlike mortality) did not correlate over time or with processes of care that are recommended by clinical guidelines.

WHAT ARE THE CLINICAL IMPLICATIONS?
• Those developing hospital performance measures for heart failure should continue to focus on β-blockers, angiotensin-converting enzyme inhibitors, and mortality and mortality and readmission rates may be more a measure of patient severity of illness than quality of care.
• Our study suggests that both process of care and mortality may be measuring heart failure quality. While readmission may measure coordination of care, we did not find evidence that it was measuring quality of heart failure care.

Numerous quality metrics for heart failure (HF) care now exist based on process of care (medication use) or outcome (readmission and mortality).1,2 The American Heart Association (AHA) and American College of Cardiology (ACC) created performance measures for HF from Class I (care recommended) or Class III (care to be avoided) guideline recommendations. Examples of ACC/AHA performance measures include the use of an angiotensin-converting enzyme (ACE) inhibitor or angiotensin receptor blocker (ARB) and guideline-recommended β-blockers (rBB) in patients with reduced left ventricular (LV) function but not other guideline recommendations, such as mineralocorticoid receptor antagonist (MRA) use and hydralazine/isosorbide dinitrate use among black patients.1,2

The Center for Medicare and Medicaid Services has created mortality and readmission performance measures for HF, including death at 30 days or readmission for any cause at 30 days after hospitalization for HF. There has been significant controversy about the 30-day readmission measure as it is used by the Medicare Hospital Readmissions Reduction Program to reduce reimbursements to hospitals with above-average readmission rates. Although the policy has been associated with a reduction in readmissions, concern has been raised by some that mortality has increased during this time period.3 Prior studies have found a negative correlation between absolute rates of 30-day all-cause readmission and mortality after an HF hospitalization.4,5 Recently, there have been 2 cohort studies published that have looked at Medicare admissions for HF after Hospital Readmissions Reduction Program implementation.6,7 One found a weakly positive correlation between readmission rates and mortality at the hospital level,6 while another demonstrated a significant overall increase in mortality across all hospitals while readmissions were declining.7 Our study aims to use a large Veterans Affairs (VA) database to shed further light on the debate of whether readmission rates correlate over time with processes of care as recommended by clinical guidelines. We sought to examine components of validity for common measures of HF quality by assessing convergent validity, or correlation of performance among measures, and reliability, or correlation of performance over time.

METHODS
The data and study materials cannot be made available by the authors to other researchers for purposes of reproducing the results or replicating the procedure, per VA policy. However, all data used in the analyses are available to VA researchers through the VA Informatics and Computing Infrastructure and VA External Peer Review Program.

Patient Population
We used data from all 102 VA facilities that underwent an annual chart review of hospitalizations with a principal diagnosis of HF between 2008 and 2013 (External Peer Review Program).8 For patients (age ≥18 years) with >1 hospitalization during the study period, only the first was included. Furthermore, only patients who had an LV ejection fraction <40%, documented diagnosis of HF, and no chart-documented contraindication or intolerance to the therapies listed below were included. Trained abstractors confirmed that HF was the documented primary reason for admission, determined the most recent documented LV ejection fraction, and recorded any documented LV ejection fraction and use of selected medications (ACE inhibitor, ARBs, rBBs [carvedilol, metoprolol succinate, and bisoprolol], any BB [rBB and all other BBs available through the VA], and MRAs).

Medication use histograms by site are provided in the Data Supplement. The data contractor performed interrater reliability assessments quarterly for each abstractor to ensure data accuracy. Pharmacy records were linked and included use of hydralazine and nitrates (either prescribed separately or as a combination pill) among patients self-identified as black. Administrative data were linked that included mortality at 30 days, mortality at 1 year, and readmission (all-cause) at 30 days.

Statistics
For each facility, we first determined the rate of medication use among candidates for treatment. Similarly, we first
determined the unadjusted hospital 30-day mortality, 1-year mortality, and 30-day readmission rate among all patients hospitalized with a principal diagnosis of HF. To determine adjusted outcomes, we determined expected outcome using separate logistic regression models adjusting for patient age and coded diagnoses within the 2 years before and including admission (diabetes mellitus, hypertension, myocardial infarction, malignancy, chronic obstructive pulmonary disease, renal disease, and cerebrovascular disease). Adjusted rates were calculated by multiplying the individual hospital’s observed-to-expected ratio by the rate for all hospitals combined.

We determined the correlation (Pearson) between the different performance metrics at the hospital level, weighing each comparison by the number of HF patients from each facility. We then built multivariate logistic regression models for the different outcome measures and determined which, if any, process and outcome metrics were significantly associated with each other after adjusting for facility region of the country (New England, Southeast, and Midwest or West) which was independently significantly associated with mortality and readmission. All of the aforementioned models are provided in the Data Supplement. We also tested membership in Council of Teaching Hospitals (40% of VA facilities) provided in the Data Supplement. We also tested member-ship in Council of Teaching Hospitals (40% of VA facilities) which had no relationship with mortality or readmission and was not included in the multivariable models.

To determine reliability, we determined the correlation between 2011 and 2012 values for each performance metric. A 2-sided P value of <0.05 was considered statistically significant. All analyses were conducted using SAS 9.2 (Carey, NC).

**Ethics Approval**
The study was approved by the human subjects’ research committee of the Stanford University School of Medicine.

**RESULTS**
Data were available for 55,735 patients hospitalized with HF at 102 facilities from 2008 to 2013. The mean age of the patients was 73 years, 55% had diabetes, 92% had hypertension, and 73% had ischemic heart disease. From 2008 to 2013, 30-day mean hospital all-cause readmission rates (VA paid readmissions) declined (19.1%–17.3%; P=0.005), 30-day mortality rates did not change significantly (7.5–7.0; P=0.22) while there were significant increases in recommended BB use (79.2%–85.8%; P<0.0001) and ACE inhibitors (or ARB) use (95.1%–98.0%; P<0.0001) among candidates.

We found a significant correlation between ACE inhibitor use and the following measures: rBB, any BB, 30-day mortality, and 1-year mortality (Table 1). Rates of BB use were also significantly correlated with MRA use, 30-day mortality, and 1-year mortality. Of note, there was no correlation between 30-day readmission rates (because of HF or all-cause) and any process of care or mortality measure. In adjusted analyses that included all performance measures and adjusted for census region, rBB use and ACE inhibitor use remained significantly predictive of reduced 1-year mortality. For each 10% increase in recommended BB use 1-year mortality was reduced by 0.9%, P=0.001. For ACE inhibitors, a 10% increase in use was associated with a 1.3% decline in 1-year mortality (P=0.03). In contrast, 30-day readmission was not associated with 1-year mortality (P=0.74), whereas a 10% decrease in 30-day all-cause readmission was associated with a 0.5% higher 30-day mortality rate (P=0.09).

Assessment of the reliability of each performance measure between 2011 and 2012 demonstrated that both rBB use and any BB use showed significant year-to-year reliability (r=0.57 and r=0.48, respectively; P<0.0001; Table 2). MRA use, adjusted 30-day mortality, and adjusted 1-year mortality also had similar reliability (r=0.50, r=0.29, and r=0.31, respectively; P<0.01 for each) but not ACE inhibitor use (r=0.04; P=0.71). Adjusted readmission within 30 days and hydralazine/isosorbide dinitrate use were not reliable year-to-year.

**DISCUSSION**
The initial ACCF/AHA performance measure set established in 2005 for HF included patient discharge instruc-
Table 2. Reliability: Correlation Between 2011 and 2012 Facility level Performance Measures

<table>
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<tbody>
<tr>
<td>ACE inhibitor (98%)</td>
<td>0.04</td>
<td>0.71</td>
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<tr>
<td>Recommended β-blocker (85%)</td>
<td>0.57</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Any β-blocker (95%)</td>
<td>0.48</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Hydralazine nitrate in blacks (7%)</td>
<td>0.04</td>
<td>0.75</td>
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<tr>
<td>Mineralocorticoid receptor antagonist (26%)</td>
<td>0.50</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Adjusted 30-d all-cause readmission (17%)</td>
<td>0.14</td>
<td>0.15</td>
</tr>
<tr>
<td>Adjusted 30-d readmission for heart failure (8%)</td>
<td>0.10</td>
<td>0.31</td>
</tr>
<tr>
<td>Adjusted 30-d mortality (7%)</td>
<td>0.29</td>
<td>0.003</td>
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<tr>
<td>Adjusted 1-y mortality (29%)</td>
<td>0.31</td>
<td>0.002</td>
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</table>

ACE indicates angiotensin-converting enzyme.

Table 2. Reliability: Correlation Between 2011 and 2012 Facility level Performance Measures.
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Disclosures
None.

REFERENCES


