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A Risk-Adjustment Model for Preserved Health Status in Patients with Heart Failure and Reduced Ejection Fraction: The CHAMP-HF Registry

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Abstract

Background—Health status outcomes are increasingly being promoted as measures of healthcare quality, given their importance to patients. In heart failure (HF), an ACC/AHA Task Force proposed using the proportion of patients with preserved health status as a quality measure, but not as a performance measure, because risk-adjustment methods were not available.

Methods—We built risk-adjustment models for alive with preserved health status and for preserved health status alone in a prospective registry of outpatients with HF with reduced ejection fraction (HFrEF) across 146 US centers between December 2015 and October 2017. Preserved health status was defined as not having a ≥5-point decrease in the Kansas City Cardiomyopathy Questionnaire Overall Summary score (KCCQ-OS) at 1 year. Using only patient-level characteristics, hierarchical multivariable logistic regression models were developed for 1-year outcomes and validated using data from 1 to 2 years. We examined model calibration, discrimination, and variability in sites' unadjusted and adjusted rates.

Results—Among 3932 participants (median age [IQR] 68 years [59–75], 29.7% female, 75.4% white), 2703 (68.7%) were alive with preserved health status, 902 (22.9%) were alive without

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preserved health status, and 327 (8.3%) had died by 1 year. The final risk-adjustment model for alive with preserved health status included baseline KCCQ-OS, age, race, employment status, annual income, body mass index, depression, atrial fibrillation, renal function, number of hospitalizations in the past 1 year, and duration of HF (optimism corrected c-statistic=0.62 with excellent calibration). Similar results were observed when deaths were ignored. The risk-standardized proportion of patients alive with preserved health status across the 146 sites ranged from 62% at the 10th percentile to 75% at the 90th percentile. Variability across sites was modest and changed minimally with risk adjustment.

Conclusions—Through leveraging data from a large, outpatient, observational registry, we identified key factors to risk adjust sites' proportions of patients with preserved health status. These data lay the foundation for building quality measures that quantify treatment outcomes from patients' perspectives.

INTRODUCTION

A key treatment goal for patients with heart failure (HF) and reduced ejection fraction (HFrEF) is to optimize health status: their symptoms, function, and quality of life.[1–4] Accordingly, there have been growing calls from payers and other stakeholders[5–9] to construct performance measures using HF-specific patient-reported outcomes (PROs), such as the Kansas City Cardiomyopathy Questionnaire (KCCQ). These calls emanate from the recognition that there is marked variability and disparities in patients' health status in routine clinical practice and that providers' actions, such as titrating medical therapy, can improve patients' health status.[10–12]

In an effort to create more patient-centered measures of healthcare quality, the 2020 ACC/AHA Clinical Performance and Quality Measures for Adults With Heart Failure recommended measuring the proportion of patients who did not have a worsening in their health status over a year of care, (worsening was defined as a decrease of ≥5 points on the KCCQ).[13] This recommendation, however, was designated a "quality measure" rather than a "performance measure," because adjustment of outcomes measures used for accountability for case-mix is considered essential[14] and it is unknown how to adjust for patient characteristics to ensure a fair comparison across practices and clinicians. To address this gap in knowledge and advance the use of PRO performance measures, we sought to develop a risk model for the outcome proposed by the task force. However, because patients who died were not included in the ACC/AHA quality measure and because mortality is an important adverse outcome in this population that should not be ignored, we also developed a model for the combined endpoint of alive with preserved health status.[13] We then described the variability in sites' performance to explore the potential for this measure to discriminate quality.

METHODS

Study Design and Data Collection

The data, methods used in the analysis, and materials used to conduct the research will not be made available to any researcher for purposes of reproducing the results or replicating

the procedure. For this study, we used data from the CHAMP-HF registry, a prospective, observational study of outpatients with HFrEF enrolled at 146 US practice sites between December 2015 and October 2017.[15] Patients eligible for enrollment met the following criteria: (1) age ≥18 years, (2) primary diagnosis of HFrEF (left ventricular ejection fraction ≤40% within 1 year of enrollment), (3) prescribed oral pharmacotherapy for HF at the time of enrollment, and (4) willingness to complete protocol requirements for study visits, procedures, and questionnaires. Patients were excluded if participating in any interventional clinical research study, receiving comfort care measures only or enrolled in a hospice program, having a life expectancy of <1 year, or having a history of or planned heart transplant, left ventricular assist device implantation, or dialysis.

Data collected on enrollment included patient-level demographics and clinical characteristics, medical history, laboratory results, use of HF medications and devices, and patient-reported health status. Eligible sites were identified based on the completion of a feasibility survey, which provided investigators with the opportunity to ensure broad geographic and provider specialty representation. Study coordinators at each site were responsible for identification and enrollment of subjects during the course of a scheduled outpatient visit. Site coordinators interviewed patients to collect their self-reported sociodemographic characteristics (including race), administered the KCCQ, and abstracted clinical information from the medical record. On subsequent visits (1- and 2-years), patient-reported data were collected either during in-person or telephone interviews. The registry was conducted in accordance with Declaration of Helsinki tenets. All study participants provided written informed consent, and each study center obtained site-specific Institutional Review Board approval. Novartis Pharmaceuticals Corporation (East Hanover, New Jersey) sponsored CHAMP-HF, and the Duke Clinical Research Institute (Durham, North Carolina) served as the data analytic center.

Study Outcomes and Preserved Health Status Models

HF-specific health status was quantified with the KCCQ-12, a well-validated disease-specific patient-reported outcome measure that measures patients' HF symptoms, physical and social limitations, and quality of life.[16] The overall summary (OS) score of the KCCQ-12, comprises an equally weighted summary of the KCCQ-12 physical limitations, symptom frequency, quality of life, and social limitations domains. Scores range from 0 to 100, where higher scores reflected better health status (fewer symptoms, fewer social or physical limitations, and better quality of life).[16] Prior work has shown that a 5-point difference is clinically meaningful in both individual- and population-level assessments of health status[17, 18] and is associated with an approximately 10% difference in mortality and rehospitalizations.[19, 20]

Correspondinly, the outcome of interest was preserved KCCQ-OS, which was defined by the ACC/AHA Task Force on Performance Measures as the absence of a ≥5-point decrease in score from baseline to 1 year.[13] Our primary model consisted of both survival and no more than 5-point decrease in KCCQ-OS score, as this approach parallels the "alive and no worse" outcomes used in valvular heart interventions.[21] We also replicated our approach on a secondary model as supplementary material based on the on the original quality metric

proposed by the ACC/AHA Task force, which excluded patients who died prior to their 1-year health status assessment. Furthermore, to assess whether our models were equally important at different timepoints, we examined the performance of the models using the corresponding same variables from 12 to 24 months.

Statistical Analysis

The baseline characteristics of the study cohort were compared between those alive with preserved health status versus not using chi-square tests for categorical variables and Wilcoxon rank-tests for continuous variables. To develop a risk-adjustment model, we used hierarchical multivariable logistic regression with site as a random effect to account for clustering within sites. The following patient-level variables were considered for risk adjustment: sociodemographic (age, sex, race, and ethnicity), socioeconomic status (employment status, insurance provider, highest level of education, and total household income), physiological measures (body mass index [BMI], systolic blood pressure, heart rate, left ventricle ejection fraction), medical history (atrial fibrillation, chronic obstructive pulmonary disease, coronary artery disease, depression, diabetes mellitus, hypertension, hyperlipidemia, smoking status, ventricular tachycardia/ventricular fibrillation, estimated glomerular filtration rate (eGFR) groups, heart failure duration and number of heart failure hospitalization in the last 1 year), HF etiology (ischemic, hypertensive, dilated, and other), and baseline KCCQ-OS. We included race and ethnicity as a marker of socioeconomic status as opposed to a biological variable. Because of the controversy surrounding inclusion of race in risk-adjustment models used for quality assessment,[22] the models were repeated without race and ethnicity and these models are provided as supplementary material. Linearity was assessed for continuous variables using restriced cubic splines, and linear piece-wise splines were selected to approximate the relationship. In order to evaluate differences in risk-adjusted KCCQ-OS across sites and across types of physicians, we did not include any practice site or physician characteristics.

To obtain a parsimonious model, variable selection was performed using backward elimination. Variables with the highest p-value >0.05 were sequentially removed until all remaining variables had a p-value ≤0.05. Model discrimination and calibration were estimated using c-indices and observed versus predicted plots for a given decile of predicted risk, respectively. Bootstrapping was performed and optimism corrected c-indices were provided for each model. Finally, we examined the variability in performance rates by site, both with and without risk adjustment. The site adjusted performance rates are calculated as the ratio of the predicted to expected preserved KCCQ multiplied by the overall population rate.[23]

Rates of missing data for baseline variables were all less than 10% (7.8% missing for BMI, 3.3% for blood pressure and 5.2% for heart rate) except for eGFR (32.3% missing). For eGFR variable, a ‘missing’ value was included in the model so as not to remove patients. Otherwise, for multivariable analyses, missing patient characteristics were imputed using a full conditional specification method while taking into account the joint distribution of other variables. Baseline characteristics reported were not imputed.

All estimates were reported using 95% confidence intervals (CIs), and a p-value <0.05 was considered to indicate a statistically significant finding. All analyses were performed using SAS version 14.3 (SAS Institute, Cary, North Carolina).

RESULTS

Cohort Characteristics

Among 5131 total patients enrolled in the CHAMP-HF registry, 3932 (76.6%) were included in the analytic cohort (Figure 1), of which, 2703 (68.7%) were alive with preserved health status, 902 (22.9%) were alive without preserved health status, and 327 (8.3%) had died by 1 year. The median age [IQR] of the final cohort was 68 years [59–75], 29.7% were women, 75.4% were white, and 52.5% had a total household income less than $50,000. Cardiac and noncardiac comorbidities were common, with 84.4% of patients having hypertension, 42.7% diabetes mellitus, 32.4% chronic obstructive lung disease or asthma, 15.1% ventricular tachycardia or fibrillation, and 21.4% chronic renal insufficiency. The most common HF etiology was ischemic (40.9%), followed by hypertensive (21.9%). Median [IQR] systolic blood pressure was 120 mmHg [110–130], heart rate was 72 bpm [65–81], and left ventricular ejection fraction was 30% [23–35]. The mean duration of HF was 3.1 years and 28% had been diagnosed within a year of enrollment. The baseline characteristics of patients who were alive with preserved KCCQ versus not at 1 year are presented in Table 1.

Patient Factors Associated with Preserved Health Status

In our primary model, the variables independently associated with survival and preserved health status included lower baseline KCCQ and age, black race, not working for medical reasons, lower annual household income, having an ideal BMI (≤25), not having a history of depression or atrial fibrillation/flutter, having preserved renal function, fewer HF hospitalizations in the past year, and duration of HF (Table 2). The optimism-corrected c-statistic was 0.62, and the calibration of predicted with observed outcomes was excellent (Supplementary Figure 1A). The optimism-corrected c-statistic of the model in the validation cohort was 0.64 and had similarly good calibration (Supplemental Table 1 and Supplemental Figure 1B). Additionally, Supplemental Tables 4–5 and Supplemental Figures 1E–F show the primary models with race/ethnicity removed. In our secondary model restricted to survivors, risk adjustment variables were similar, as were the optimism-corrected c-statistics (0.62 in the year 1 and 0.63 in year 2; Supplemental Tables 2 and 3) and model calibrations (Supplemental Figures 1C and 1D).

Variability in Performance Across Sites

Figure 2 shows the risk-adjusted versus unadjusted preserved KCCQ performance at year 1 across sites. While the 10^{th} and 90^{th} percentile of sites showed clinically important range in performance (62% and 75%, respectively), the majority of centers had about three-quarters of their patients meeting the measure. Importantly, the performance was not much different in the unadjusted and adjusted analyses when directly compared (Figure 2).

DISCUSSION

Incorporating patients' health status into measures of quality is predicated on both its importance to patients and variability across providers. In fact, investigators of the CHAMP-HF registry previously demonstrated that within sites, 0% to 80% of patients had good to excellent health status (KCCQ-OS ≥75) at their initial encounter.[10] Thus, while there have been calls to use patient-reported health status as quality measures, the absence of risk-adjustment models has precluded their adoption as performance measures,[6, 7, 24] in order to account for potential differences in case-mix and better ensure that practices were not penalized for caring for sicker patients.[25, 26] To address this gap, we developed risk-adjustment models for the outcome of being alive with preserved health status at 1 year. We identified several variables associated with this outcome measure, including baseline KCCQ, age, race/ethnicity, employment status, annual household income, BMI, history of depression, atrial fibrillation, eGFR groups, number of HF hospitalizations in the past year, and more recent onset of HF. We also identified a spectrum of clinic performance with a range of 62% to 75% at the 10^{th} and 90^{th} deciles of performance. These data form the first critical assessment of the PRO-based performance measure proposed by the ACC/AHA Task Force and lay the foundation for using patient-centered outcomes as a performance measure of healthcare quality.

Risk-adjustment for patient factors, is considered essential for outcome measures, to provide a measurement framework whereby the differences reported reflect the quality of care provided rather than underlying mix of patients cared for. Risk-adjustment has been shown to be important for in-hospital and 30-day mortality measures in heart failure, yet there has been little prior evaluation of risk-adjustment for patient reported outcome measures. The absence of a substantial difference between the unadjusted and adjusted measures was foreshadowed by the ACC/AHA Task Force, which noted that 'using each patient as their own control minimizes some of the need for risk adjustment'. On the one hand, the lack of a need for risk-adjustment simplifies the implementation of a PRO-based performance measure, as there would not be a need to collect household income or employment status, which may not be readily available in the medical record. Alternatively, further work may be needed to identify an optimal definition of health status outcomes. For example, while we found clinically sizable variation in performance across the best and worst performing sites, it is possible that this was due to random variation and that the outcome definition was too coarse to adequately differentiate performance. Alternative health status outcomes should be considered, such as the proportion of patients achieving a certain health status at the end of the reporting period, controlling for baseline, or using different thresholds of change (e.g. the proportion of patients whose health status improved (a change in KCCQ >5 points)). The Task Force's proposed measure (not getting significantly worse) may be too low of a threshold of change to adequately discriminate sites. Second, it would be worthwhile to validate differences in outcomes by comparing the processes of care associated with lower- and higher-performing sites. Finally, the consistency of sites' performance over time could illuminate whether or not the observed differences between sites represents a true signal versus noise. All of these steps could clarify the validity and optimal means to quantify performance using PROs.

This work is important because we believe that creating provider-level accountability for patients' health status through a performance measure will provide a strong incentive to improve care. While we readily acknowledge that the natural history of HF may lead to a proportion of patients getting worse over time, and that no practice could meet this measure in all patients, deviating substantially from national averages can indicate a gap in the quality of care provided. For example, there are a number of treatments that can improve patients' health status, including angiotensin receptor-neprilysin inhibitors,[27] sodium-glucose cotransporter-2 inhibitors,[28, 29] intravenous iron supplementation,[30] ivabradine,[31] and cardiac resynchronization.[32] However, these therapies with known health status benefit remain underused.[33–35] In addition, there are other barriers to optimal care at the patient level, such as non-adherence and limited understanding of their disease that can preclude attaining the optimal benefits of care. Quality improvement efforts that identify these challenges can incentivize non-medical strategies to address these barriers. Thus, by increasing providers' accountability for optimizing the health status of their patients, there may be substantial opportunity to improve patients' symptoms, function, and quality of life.

An important consideration in the development of these models was whether or not to include race in the models.[22, 36] Because, in the US, there are marked socio-economic (beyond income, which was collected) and environmental factors that are often not measured, we felt that race could serve as a marker for some of these factors,[37–39] which is why it was included in the models. While on the one hand, our initial model suggested that Black race was associated with a lower likelihood of achieving preserved health status in our primary model, the effect was reversed in the validation cohort examining patients' outcomes between 1 and 2 years. Moreover, there is marked differences in the racial compositions of different practices,[40, 41] and we felt that it was important to enable a fairer comparison across all practices. Nevertheless, we provided models both with and without race so that policy makers considering whether to use health status as a model can consider whether or not they would want to risk-standardize outcomes with or without race included. This, along with other efforts at defining the proper health status metrics, are important considerations for future efforts to elevate patients' symptoms, function and quality of life as an outcome measure for quantifying healthcare quality.

Limitations

This study should be considered in the context of the following potential limitations. First, while CHAMP-HF represents a broad distribution of outpatient practices and real-world patients, participating sites were committed to clinical research, which may limit the generalizability of our findings. Nevertheless, the most recent estimates of HF incidence suggest that 17% of cases occur in African Americans, which closely mirrors the 16.7% enrolled in this study.[42] Similarly, the risk of HFrEF is twice as high in men, which is also mirrored in our population.[43] Second, the observed associations might have been influenced or susceptible to bias as a result of unmeasured confounding. Third, some may be concerned that the c-statistic of 0.62 is only modest and discriminating those with and without preserved heatlh status. However, the c-index is not the optimal measure for assessing the quality of an adjustment model.[44] We believe that the most important unmeasured

confounder is the quality of care provided to patients with HFrEF and encouraging providers to optimize their patients' health status can improve care and outcomes; the very purpose of elevating the use of PROs as measures of healthcare quality. An additional limitation of our analysis is missing 12-month KCCQ data, which may have introduced additional biases. Finally, the observed variability across sites may be random noise, and thus further investigation to validate the current measure, or to identify better metrics, should be pursued.

CONCLUSIONS

Through leveraging data from a large, outpatient, observational registry, we identified several key factors associated with risk adjustment for disease-specific health status assessment. This is a first step in understanding the distribution, variability and predictors of a health status-based performance measure. By providing data on several formulations of this measure, with and without adjustment for race, and demonstrating the impact of risk adjustment on site performance, providers, payers, and regulators can consider how best to use patients' health status as a measure of healthcare quality. We believe the evolution of a performance measure to include patient-centered outcomes can incentivize more aggressive treatment of HF symptoms to maximize patients' function and quality of life and has the opportunity to improve the quality and patient-centeredness of care.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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CONFLICT OF INTEREST DISCLOSURES

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Dr. Butler is a consultant to Abbott, Adrenomed, Amgen, Array, AstraZeneca, Bayer, Boehringer Ingelheim, Bristol-Myers Squib, CVRx, G3 Pharmaceutical, Impulse Dynamics, Janssen, LivaNova, Luitpold, Medtronic, Merck, Novartis, Novo Nordisk, Relypsa, Roche, V-Wave Limited, and Vifor.

Non-standard Abbreviations

PRO	Patient-reported outcomes
KCCQ	Kansas City Cardiomyopathy Questionnaire

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What is Known

- Health status outcomes (patients' symptoms, function, and quality of life) are increasingly being promoted as patient-centered measures of healthcare quality, given that they are a primary goal of treatment and are important to patients.
- The 2020 ACC/AHA Task Force proposed using the proportion of patients with preserved health status as a quality measure, rather than a performance measure, because risk-adjustment methods were not available to insure fair comparisons across providers.

What the Study Adds

- This is the first study to examine the distribution, variability and predictors of a health status-based performance measure for heart failure.
- We identified several patient characteristics associated with the proposed ACC/AHA quality measure of preserved health status that could be used for case-mix risk adjustment.
- Our findings lay the foundation for potentially using health status measures as a measure of health care quality.

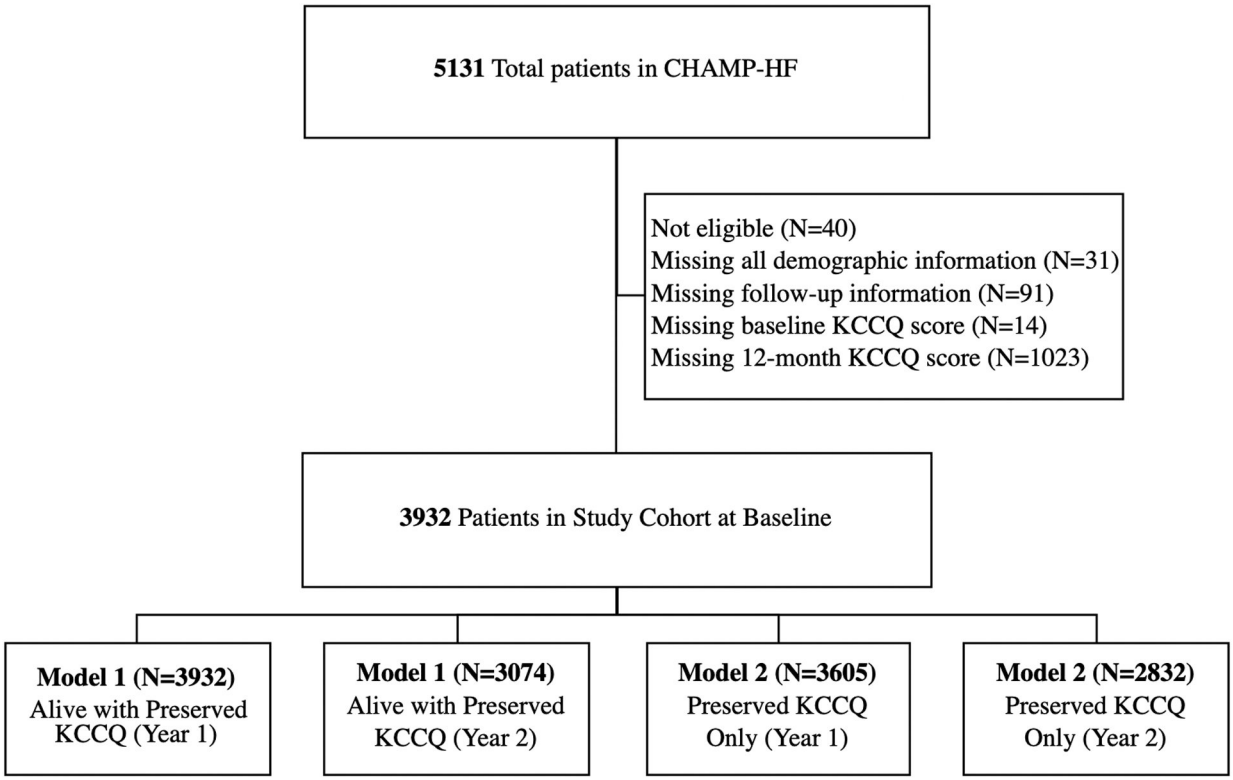

Figure 1. Diagram of Study Cohort

CHAMP-HF denotes Change the Management of Patients With Heart Failure; KCCQ denotes Kansas City Cardiomyopathy Questionnaire.

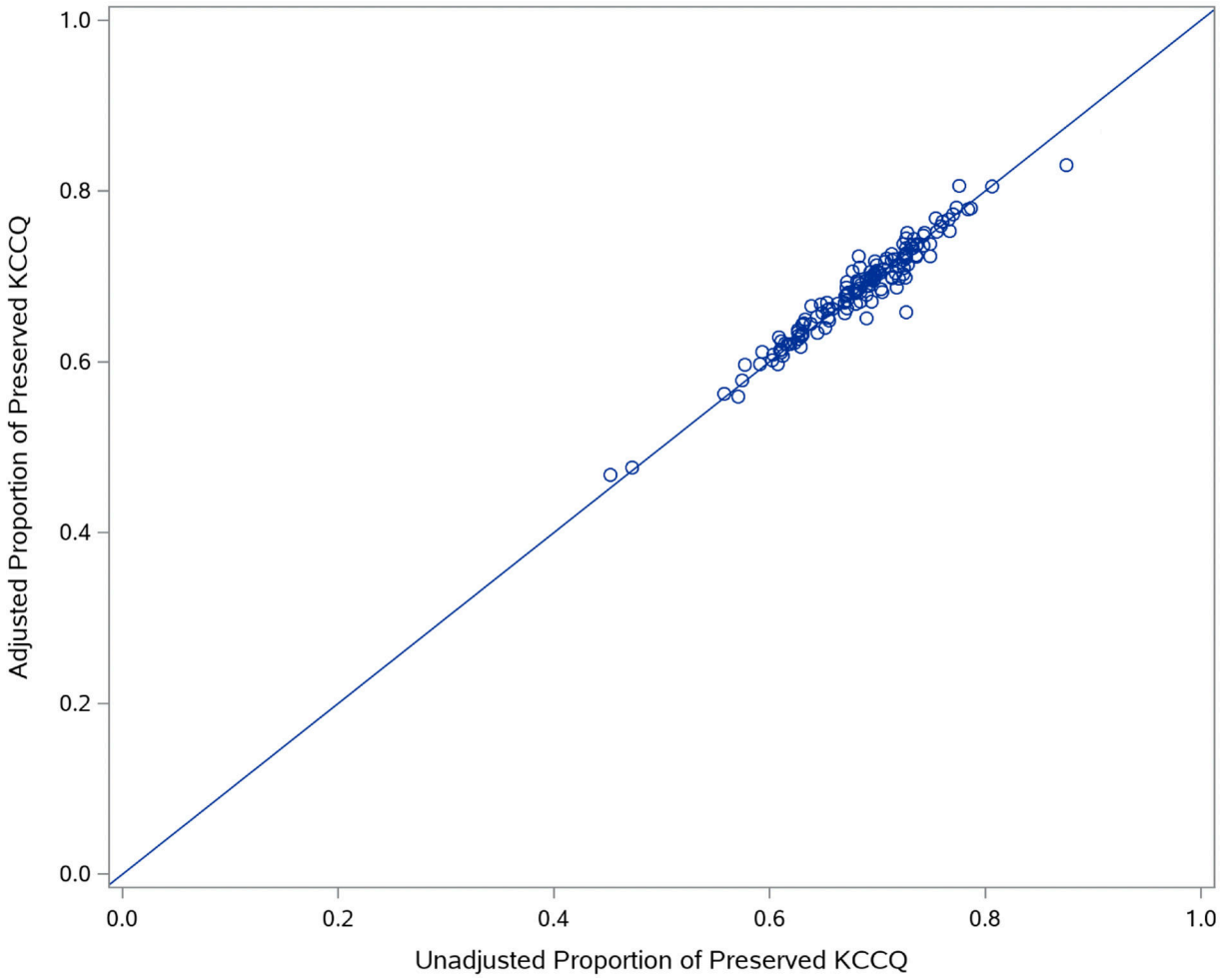

Figure 2. Risk-Adjusted versus Unadjusted Preserved KCCQ Proportion from Baseline to 1 Year (Number of Sites = 146)

KCCQ denotes Kansas City Cardiomyopathy Questionnaire.

Table 1:

Baseline Patient and Practice Characteristics by Alive and Preserved KCCQ Status

Characteristic	Total (N=3932)	Preserved KCCQ		P-Value
		Yes (N=2703)	No (N=1229)	
Demographics				
Age (years)	68.0 (59.0, 75.0)	67.0 (58.0, 74.0)	69.0 (60.0, 77.0)	<0.001
Female	1166/3932 (29.7%)	812/2703 (30.0%)	354/1229 (28.8%)	0.431
Race				0.900
American Indian or Alaska Native	32/3932 (0.8%)	24/2703 (0.9%)	8/1229 (0.7%)	
Asian	61/3932 (1.6%)	42/2703 (1.6%)	19/1229 (1.5%)	
Black	656/3932 (16.7%)	441/2703 (16.3%)	215/1229 (17.5%)	
Native Hawaiian or Pacific Islander	10/3932 (0.3%)	8/2703 (0.3%)	2/1229 (0.2%)	
White	2966/3932 (75.4%)	2044/2703 (75.6%)	922/1229 (75.0%)	
Multi-racial (no primary race)	45/3932 (1.1%)	30/2703 (1.1%)	15/1229 (1.2%)	
Other	162/3932 (4.1%)	114/2703 (4.2%)	48/1229 (3.9%)	
Hispanic ethnicity	699/3932 (17.8%)	502/2703 (18.6%)	197/1229 (16.0%)	0.053
Primary insurance				0.003
Private	1015/3932 (25.8%)	743/2703 (27.5%)	272/1229 (22.1%)	
Medicare	2268/3932 (57.7%)	1518/2703 (56.2%)	750/1229 (61.0%)	
Medicaid	350/3932 (8.9%)	248/2703 (9.2%)	102/1229 (8.3%)	
Other	221/3932 (5.6%)	143/2703 (5.3%)	78/1229 (6.3%)	
Uninsured	78/3932 (2.0%)	51/2703 (1.9%)	27/1229 (2.2%)	
Highest level of education				0.458
Less than high school	442/3932 (11.2%)	291/2703 (10.8%)	151/1229 (12.3%)	
High school/GED	1367/3932 (34.8%)	937/2703 (34.7%)	430/1229 (35.0%)	
Some college	1225/3932 (31.2%)	840/2703 (31.1%)	385/1229 (31.3%)	
Four-year college (Bachelor's)	520/3932 (13.2%)	371/2703 (13.7%)	149/1229 (12.1%)	
Graduate or other professional degree	378/3932 (9.6%)	264/2703 (9.8%)	114/1229 (9.3%)	
Total household income				<.001
< $25,000	1276/3932 (32.5%)	900/2703 (33.3%)	376/1229 (30.6%)	
$25,000 – $49,999	786/3932 (20.0%)	514/2703 (19.0%)	272/1229 (22.1%)	
$50,000 – $74,999	510/3932 (13.0%)	352/2703 (13.0%)	158/1229 (12.9%)	
$75,000 – $99,999	249/3932 (6.3%)	193/2703 (7.1%)	56/1229 (4.6%)	
$100,000 – $149,999	199/3932 (5.1%)	151/2703 (5.6%)	48/1229 (3.9%)	
$150,000 or more	102/3932 (2.6%)	77/2703 (2.8%)	25/1229 (2.0%)	
Prefer not to answer	810/3932 (20.6%)	516/2703 (19.1%)	294/1229 (23.9%)	
Employment status				0.008
Working full-time	535/3932 (13.6%)	402/2703 (14.9%)	133/1229 (10.8%)	
Working part-time	293/3932 (7.5%)	197/2703 (7.3%)	96/1229 (7.8%)	
Disability - medical reasons	1035/3932 (26.3%)	703/2703 (26.0%)	332/1229 (27.0%)	

Characteristic	Total (N=3932)	Preserved KCCQ		P-Value
		Yes (N=2703)	No (N=1229)	
Not employed for other reasons (retired, student, etc.)	2069/3932 (52.6%)	1401/2703 (51.8%)	668/1229 (54.4%)	
Medical History				
Chronic renal insufficiency	842/3932 (21.4%)	511/2703 (18.9%)	331/1229 (26.9%)	<.001
Chronic lung disease	1274/3932 (32.4%)	870/2703 (32.2%)	404/1229 (32.9%)	0.670
Depression	1047/3932 (26.6%)	703/2703 (26.0%)	344/1229 (28.0%)	0.192
Current smoking	761/3932 (19.4%)	530/2703 (19.6%)	231/1229 (18.8%)	0.550
Peripheral artery disease	556/3932 (14.1%)	381/2703 (14.1%)	175/1229 (14.2%)	0.905
Stroke	333/3932 (8.5%)	228/2703 (8.4%)	105/1229 (8.5%)	0.910
Transient ischemic attack	173/3932 (4.4%)	119/2703 (4.4%)	54/1229 (4.4%)	0.990
Obstructive sleep apnea	893/3932 (22.7%)	642/2703 (23.8%)	251/1229 (20.4%)	0.021
Cancer	466/3932 (11.9%)	312/2703 (11.5%)	154/1229 (12.5%)	0.374
Ventricular arrhythmia	592/3932 (15.1%)	399/2703 (14.8%)	193/1229 (15.7%)	0.444
Heart fFailure etiology				
Ischemic	1608/3932 (40.9%)	1072/2703 (39.7%)	536/1229 (43.6%)	0.019
Hypertensive	863/3932 (21.9%)	617/2703 (22.8%)	246/1229 (20.0%)	0.048
Dilated	519/3932 (13.2%)	363/2703 (13.4%)	156/1229 (12.7%)	0.527
Other	2026/3932 (51.5%)	1392/2703 (51.5%)	634/1229 (51.6%)	0.959
Heart failure hospitalization in prior 1 year	1466/3932 (37.3%)	966/2703 (35.7%)	500/1229 (40.7%)	0.003
Number of heart failure hospitalization in prior 1 year	997/3932 (25.4%)	670/2703 (24.8%)	327/1229 (26.6%)	0.003
Clinical measurements				
Body mass index (kg/m^2)	29.4 (25.8, 33.9)	29.6 (26.0, 34.2)	29.1 (25.2, 33.4)	0.000
Systolic blood pressure (mmHg)	120.0 (110.0, 130.0)	120.0 (110.0, 131.0)	120.0 (110.0, 130.0)	0.190
Diastolic blood pressure (mmHg)	71.0 (64.0, 80.0)	72.0 (64.0, 80.0)	70.0 (62.0, 80.0)	0.000
Heart rate (bpm)	72.0 (65.0, 81.0)	72.0 (65.0, 81.0)	72.0 (66.0, 81.0)	0.658
Left ventricular ejection fraction (%)	30.0 (23.0, 35.0)	30.0 (24.0, 36.0)	30.0 (23.0, 35.0)	0.016

Values are mean (SD) or n/N (%).

Abbreviations: GED, General Educational Development.

Table 2:

Association between Patient Characteristics and Survival with Preserved KCCQ score from Baseline to 12-Months among All Eligible Patients (N=3932)

Characteristic[1]	Odds Ratio (95% CI)[2,3,4]	P-value
Age (per 10 year increase)	0.88 (0.81 – 0.95)	0.001
Race		
Black vs. White	0.79 (0.64 – 0.97)	0.027
Other vs. White	1.05 (0.78 – 1.40)	0.750
Employment status		
Disability - medical reasons vs. working full or part time	0.80 (0.63 – 1.00)	0.054
Not employed for other reasons vs. working full or part time	1.05 (0.85 – 1.30)	0.657
Annual household income < $50,000	0.84 (0.72 – 0.99)	0.040
Body Mass Index		
Linear spline for BMI<=25	1.08 (1.03 – 1.14)	0.003
Linear spline for BMI>25 and <=35	1.00 (0.98 – 1.03)	0.942
Linear spline for BMI>35	1.02 (0.99 – 1.04)	0.142
KCCQ		
Linear spline for KCCQ under 50 (per 10 point increase)	0.93 (0.84 – 1.02)	0.139
Linear spline for KCCQ above 50 (per 10 point increase)	0.83 (0.79 – 0.87)	<.001
Atrial fibrillation or flutter	0.84 (0.72 – 0.98)	0.027
Depression	0.76 (0.64 – 0.90)	0.001
eGFR Groups		
<30 vs >=60	0.50 (0.34 – 0.73)	<.001
30 to <45 vs >=60	0.81 (0.62 – 1.04)	0.101
45 to <60 vs >=60	0.78 (0.63 – 0.96)	0.021
Missing vs >=60	0.89 (0.74 – 1.07)	0.228
Number of HF hospitalizations in the prior 12 months		
1 vs. 0	0.75 (0.63 – 0.90)	0.001
2 or more vs. 0	0.65 (0.52 – 0.82)	<.001
HF duration (years)		
Linear spline for HF duration <=3 years	0.88 (0.81 – 0.95)	<.001
Linear spline for HF duration > 3 years	1.00 (0.99 – 1.02)	0.785

[1]Candidate adjustment variables include: Sociodemographic (age, gender, race, and ethnicity), socioeconomic status (employment status, insurance provider, highest level of education, and total household income), clinical measures (body mass index, systolic blood pressure, heart rate, and left ventricle ejection fraction), medical history (atrial fibrillation, chronic obstructive pulmonary disease, coronary artery disease, depression, diabetes mellitus, hypertension, hyperlipidemia, smoking status, ventricular tachycardia/ventricular fibrillation, eGFR groups, and number of heart failure hospitalization in the last 12 months), HF duration, HF etiology (ischemic, hypertensive, idiopathic (dilated), and other) and PROs (KCCQ total)

[2]Predictor variables were selected using backward elimination. Variables with a p-value>0.05 were removed one at a time based on the highest p-value first and continuing until all p-values<0.05.

[3]Uncorrected C-index = 0.6294. Optimism corrected C-index = 0.6219 (0.6213, 0.6225).

Abbreviations: eGFR, estimated glomerular filtration rate; KCCQ-OS, Kansas City Cardiomyopathy Questionnaire Overall Summary score.