Primary Prevention Implantable Cardioverter-Defibrillators in Older Racial and Ethnic Minority Patients

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Background—Racial and ethnic minorities are under-represented in clinical trials of primary prevention implantable cardioverter-defibrillators (ICDs). This analysis investigates the association between primary prevention ICDs and mortality among Medicare, racial/ethnic minority patients.

Methods and Results—Data from Get With The Guidelines-Heart Failure Registry and National Cardiovascular Data Registry’s ICD Registry were used to perform an adjusted comparative effectiveness analysis of primary prevention ICDs in Medicare, racial/ethnic minority patients (nonwhite race or Hispanic ethnicity). Mortality data were obtained from the Medicare denominator file. The relationship of ICD with survival was compared between minority and white non-Hispanic patients. Our analysis included 852 minority patients, 426 ICD and 426 matched non-ICD patients, and 2070 white non-Hispanic patients (1035 ICD and 1035 matched non-ICD patients). Median follow-up was 3.1 years. Median age was 73 years, and median ejection fraction was 23%. Adjusted 3-year mortality rates for minority ICD and non-ICD patients were 44.9% (95% confidence interval [CI], 44.2%–45.7%) and 54.3% (95% CI, 53.4%–55.1%), respectively (adjusted hazard ratio, 0.79; 95% CI, 0.63–0.98; P=0.034). White non-Hispanic patients receiving an ICD had lower adjusted 3-year mortality rates of 47.8% (95% CI, 47.3%–48.3%) compared with 57.3% (95% CI, 56.8%–57.9%) for those with no ICD (adjusted hazard ratio, 0.75; 95% CI, 0.67%–0.83%; P<0.0001). There was no significant interaction between race/ethnicity and lower mortality risk with ICD (P=0.70).

Conclusions—Primary prevention ICDs are associated with lower mortality in nonwhite and Hispanic patients, similar to that seen in white, non-Hispanic patients. These data support a similar approach to ICD patient selection, regardless of race or ethnicity. (Circ Arrhythm Electrophysiol. 2015;8:145-151. DOI: 10.1161/CIRCEP.114.001878.)

Key Words: continental population groups • death, sudden • defibrillators, implantable • ethnology • minority groups • primary prevention

Randomized controlled clinical trials have established the survival benefit of primary prevention implantable cardioverter-defibrillators (ICDs).1-3 Racial and ethnic minority patients were under-represented in those trials, with nonwhite patients ranging from 16% to 23% of all patients.1,2 Results from small, secondary analyses varied considerably with 1 study finding a trend toward harm with ICD use in racial and ethnic minorities,4 whereas another showed improved outcomes with ICD use in minority patients.5 In light of these limited data, practice guidelines do not make specific recommendations about the use of ICDs in racial and ethnic minority patients. Although there has been a paucity of data on the efficacy and effectiveness of ICD use in minorities, racial and ethnic minority patients are at greater risk of heart failure,6 cardiac arrest, and sudden cardiac death relative to whites,7,8 but they are less likely than whites to receive ICDs.9-13 Although these care differences seem to have lessened over time, they persist in contemporary practice.14 It is unclear whether these differences result from a lack of empirical

Received May 20, 2014; accepted November 6, 2014.

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Guest Editor for this article was Gerhard Hindricks, MD.


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Circ Arrhythm Electrophysiol is available at http://circcep.ahajournals.org DOI: 10.1161/CIRCEP.114.001878

145
WHAT IS KNOWN

- Racial and ethnic minority patients were under-represented in the randomized controlled trials that demonstrated survival benefit from a primary prevention implantable cardioverter-defibrillator (ICD).
- Racial and ethnic minority patients are less likely than whites to receive an ICD, despite being at higher risk of sudden cardiac death.

WHAT THE STUDY ADDS

- With ≈3× the number of minority patients with an ICD compared with the previously largest analysis, this study found that ICD use was associated with lower mortality rates in minority patients.
- There was no significant interaction between race or ethnicity and the lower mortality risk associated with ICDs.

Inpatient and outpatient Medicare claims data and the corresponding denominator files from 2005 through 2011 were used. The registry was linked to Medicare claims data using combinations of indirect identifiers.

Study Population

Patients were minorities if the patient or family considered themselves to be of Hispanic ethnicity, black, Asian, American Indian or Alaska Native, Native Hawaiian or Pacific Islander, or other non-white race. The ICD group (from the ICD Registry™) consisted of all minority patients receiving a primary prevention ICD from January 1, 2006, through December 31, 2007, who were ≥65 years of age and whose primary insurance was Medicare (n=2444). We excluded records of patients without a clear guideline-based indication for an ICD, including recent onset of HF, recent myocardial infarction or coronary artery bypass grafting, or class IV HF symptoms (n=925). We excluded patients who received an ICD with cardiac resynchronization therapy (n=762), patients who received a secondary prevention ICD (n=57), patients with a left ventricular ejection fraction (LVEF) of >35% (n=23), patients who received device replacements (n=14), and patients without a documented LVEF (n=8). After these exclusions, 655 records remained from the ICD Registry™ group.

The initial non-ICD group (from GWTG®-HF) included records from minority patients in the GWTG®-HF database who were hospitalized for HF from January 1, 2005, through December 31, 2009, did not receive an ICD, were ≥65 years of age, and whose primary insurance was Medicare (n=9507). We excluded records from the analysis where there was an LVEF of >35% (n=4508), no documented LVEF (n=1428), or new-onset HF (n=785). Records were excluded if patients were discharged to hospice, a skilled nursing facility, or a rehabilitation center (n=525), transferred to another acute care facility (n=48), or left against medical advice (n=26). Records were excluded if patients had a contraindication or other reason documented by a physician for not receiving an ICD, including recent onset of HF, recent myocardial infarction or coronary artery bypass grafting, class IV HF symptoms, and no reasonable expectation of survival for ≥1 year (n=415). After these exclusions, 1772 records remained for analysis from the GWTG®-HF group.

After applying all exclusions, qualifying records were matched with Centers for Medicare and Medicaid Services enrollment files and inpatient claims data to identify unique patients. The files included data on all fee-for-service Medicare beneficiaries aged 65 years or older who were hospitalized for a diagnosis of HF (International Classification of Diseases, Ninth Revision, Clinical Modification [ICD-9-CM] 428.x, 402.x, 401.x, and 404.x). After matching by admission and discharge dates, date of birth, sex, and hospital, patient data in the registries were merged with Medicare Part A inpatient claims data and the corresponding denominator files.19

Outcomes

The outcome for this analysis was all-cause mortality. Vital status was determined from the Medicare denominator files through December 31, 2011. Patients with no record of death were considered alive as of December 31, 2011 or the date at which the patient was no longer enrolled in Part A and Part B fee-for-service Medicare, whichever came first.

Statistical Analysis

Baseline characteristics of minority patients in the ICD group and the non-ICD group were compared using the Pearson χ² test for categorical variables and the Wilcoxon signed-rank sum test for continuous variables.
variables. Summary statistics were reported as percentages (counts) for categorical variables and as medians (25th and 75th percentiles) for continuous variables. Variables with missing values in ≥15% of patients in either group were excluded from the analysis: QRS duration, blood urea nitrogen, creatinine, calcium channel blocker use in minority patients, and digoxin use in minority patients. The standardized difference between groups for each variable was calculated as the absolute value of the difference in means or proportions, divided by the average SD and expressed as a percentage.

Baseline characteristics of ICD patients and non-ICD patients were different. A matching process was used using the Rosenbaum and Rubin method to derive a set of non-ICD patients comparable with the sample of ICD patients.21 First, for continuous variables, we excluded non-ICD patients whose value was below the minimum or above the maximum for ICD patients. Second, missing values were imputed using a Markov chain Monte Carlo method. Missing rates were generally low, <1% for all variables in the Registry and <5% for most variables in the GWTG®-HF. Third, a propensity model was built using logistic regression in which the dependent (outcome) variable was an indicator of whether each patient was an ICD or a non-ICD patient, and the independent (predictor) variables were baseline characteristics deemed to be potentially clinically significant and available in both groups with similar definitions. The variables included in the propensity model were race (white versus other), age, past medical history (previous atrial arrhythmia, ischemic heart disease, hypertension, and diabetes mellitus), concomitant medications (beta blocker, calcium channel blocker angiotensin converting enzyme inhibitor, angiotensin receptor blocker, statin, digoxin, and diuretic), and clinical characteristics (systolic blood pressure and LVEF). New York Heart Association class and QRS duration were included non-ICD patients whose value was below the minimum or above the maximum for ICD patients.20 First, for continuous variables, we excluded non-ICD patients whose value was below the minimum or above the maximum for ICD patients. Second, missing values were imputed using a Markov chain Monte Carlo method. Missing rates were generally low, <1% for all variables in the Registry and <5% for most variables in the GWTG®-HF. Third, a propensity model was built using logistic regression in which the dependent (outcome) variable was an indicator of whether each patient was an ICD or a non-ICD patient, and the independent (predictor) variables were baseline characteristics deemed to be potentially clinically significant and available in both groups with similar definitions. The variables included in the propensity model were race (white versus other), age, past medical history (previous atrial arrhythmia, ischemic heart disease, hypertension, and diabetes mellitus), concomitant medications (beta blocker, calcium channel blocker angiotensin converting enzyme inhibitor, angiotensin receptor blocker, statin, digoxin, and diuretic), and clinical characteristics (systolic blood pressure and LVEF). New York Heart Association class and QRS duration were not available in the GWTG®-HF database. From the logistic regression model, an estimated propensity score (the probability, \( P \), of being an ICD patient) and a corresponding logit for the propensity score (log\( \frac{P}{1−P} \)) were calculated for each patient.

Fourth, 1:1 matching was used. A caliper width of 0.25× (SD of the logit) was used. For a given ICD patient, all non-ICD patients were considered whose logit differed from the ICD patient’s logit by less than the caliper width. Among these patients, the non-ICD patient with the shortest (Mahalanobis) distance from the ICD patient was selected as a match. Variables used in calculating the Mahalanobis distance were all significant predictors from the propensity model. ICD patients for whom there were no non-ICD patients within the caliper width were omitted from the analysis (n=27). Each non-ICD patient was matched only once. Creation of a matched cohort was repeated in the subgroup of white, non-Hispanic patients.

Cox proportional hazards model evaluated the association of the presence of an ICD with the risk of all-cause mortality among the matched patients. The model included all nonminority and minority patients, a term for minority, and a term for the interaction between minority and presence of an ICD. The model contained all baseline variables listed above as covariates and was stratified by quartile of propensity scores. A robust sandwich variance estimator was used in the Cox models to account for clustering within sites. The proportional hazards assumption for the ICD term was assessed and met. Risk relationships were expressed as hazard ratios (HRs) with 95% confidence intervals (CIs) within the subgroups of minorities and nonminorities. The interaction term tests whether these 2 hazard ratios were equal. Mortality rates at 1 and 3 years were presented as unadjusted Kaplan–Meier rates and as adjusted rates derived from the Cox model. Differences were declared to be statistically significant at \( P<0.05 \). All statistical tests were 2-sided. For all analyses, SAS version 9.2 (SAS Institute, Cary, NC) was used. The Duke University Health System institutional review board approved the study and determined that informed consent was not applicable to data collected by the ICD Registry.

## Results

### Patient Demographics

In GWTG®-HF database, there were 1440 racial and ethnic minority patients eligible for but without an ICD. In the ICD registry\(^{14} \), there were 453 minority patients with a primary prevention ICD. The majority of the racial and ethnic minority patients were black, and Hispanic patients were the second most common group of patients (Table 1). One-to-one matching produced minority patient cohorts of 426 patients with and without an ICD. Patients were similar with respect to age, sex, LVEF, systolic blood pressure, comorbid conditions, and cardiac medications (Table 2; Data Supplement). One-to-one matching of 4041 white, non-Hispanic patients without an ICD and 1103 white, non-Hispanic patients with an ICD resulted in matched cohorts of 1035 patients each (Data Supplement).

### Mortality

There were 234 deaths during a median follow-up of 4.3 years among minority patients with an ICD and 239 deaths during a median follow-up of 2.9 years among minority patients without an ICD (Table 3). The median follow-up was 4.6 years and 3.1 years in the white, non-Hispanic ICD and no ICD cohorts, respectively.

The unadjusted mortality rate at 3 years was 45.7% (95% CI, 40.8%–50.9%) for minority patients with an ICD and 54.6% (95% CI, 49.6%–59.8%) for minority patients without an ICD (Figure 1). The adjusted mortality rate at 3 years was 44.9% (95% CI, 44.2%–45.7%) for the minority patients with an ICD and 54.3% (95% CI, 53.4%–55.1%) for minority patients without an ICD. At 1 year, the adjusted mortality rate among minority patients with an ICD was 6.0% lower than among minority patients without an ICD, and the separation in the survival curves increased over time (Figure 2). The adjusted hazard ratio for minority patients with an ICD compared with those without an ICD was 0.79 (95% CI, 0.63–0.98; \( P=0.034 \)).

White, non-Hispanic patients receiving an ICD had adjusted 3-year mortality rates of 47.8% (95% CI, 47.3%–48.3%) compared with 57.3% (95% CI, 56.8%–57.9%) for those with

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**Table 1. Racial and Ethnic Minorities—Prevalence of Groups of Racial and Ethnic Minority Patients**

<table>
<thead>
<tr>
<th></th>
<th>All Eligible Patients</th>
<th>Matched Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GWTG® (n=1440)</td>
<td>ICD Registry™ (n=453)</td>
</tr>
<tr>
<td>Hispanic</td>
<td>21% (302)</td>
<td>23% (103)</td>
</tr>
<tr>
<td>Black</td>
<td>63% (912)</td>
<td>67% (304)</td>
</tr>
<tr>
<td>Asian</td>
<td>4% (53)</td>
<td>4% (20)</td>
</tr>
<tr>
<td>American Indian/Alaska Native</td>
<td>2% (24)</td>
<td>1% (4)</td>
</tr>
<tr>
<td>Native Hawaiian/Pacific Islander</td>
<td>1% (13)</td>
<td>1% (4)</td>
</tr>
<tr>
<td>Others</td>
<td>9% (136)</td>
<td>4% (18)</td>
</tr>
</tbody>
</table>

GWTG®-HF indicates Get with the Guidelines®-Heart Failure; and ICD, implantable cardioverter-defibrillator.
There was no significant interaction between race and the lower mortality risk associated with ICDs ($P = 0.70$). The 3-year adjusted mortality rates of minority patients and white, non-Hispanic patients with ICDs were 9.4% and 9.5% lower than their paired non-ICD counterparts.

### Discussion

It is important to understand the survival of minority patients who receive a primary prevention ICD in clinical practice. There are limited data on this topic. This study has $≈3×$ the number of minority patients with ICDs compared with the previously largest analysis. Our analysis found that ICD use...

### Table 2. Results of Mortality Analysis for Minority and White, Non-Hispanic Cohorts

<table>
<thead>
<tr>
<th>Baseline Characteristic</th>
<th>All Minority Patients Qualifying for Analysis</th>
<th>1:1 Matched Minority Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GWTG®-HF, n=1440</td>
<td>ICD Registry™, n=453</td>
</tr>
<tr>
<td>Age, y</td>
<td>76 (70–82)</td>
<td>72 (69–78)</td>
</tr>
<tr>
<td>Men</td>
<td>52% (744)</td>
<td>64% (290)</td>
</tr>
<tr>
<td>White race*</td>
<td>11% (160)</td>
<td>12% (56)</td>
</tr>
<tr>
<td>LVEF (%)</td>
<td>25 (20–30)</td>
<td>22 (19–29)</td>
</tr>
<tr>
<td>Ischemic heart disease</td>
<td>59% (852)</td>
<td>57% (256)</td>
</tr>
<tr>
<td>Previous atrial arrhythmia</td>
<td>23% (330)</td>
<td>33% (151)</td>
</tr>
<tr>
<td>Systolic BP</td>
<td>140 (122–158)</td>
<td>128 (111–144)</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>45% (653)</td>
<td>49% (221)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>79% (1144)</td>
<td>90% (408)</td>
</tr>
<tr>
<td>ACE-inhibitor or ARB</td>
<td>75% (1078)</td>
<td>72% (323)</td>
</tr>
<tr>
<td>Beta blocker</td>
<td>85% (1226)</td>
<td>83% (370)</td>
</tr>
<tr>
<td>Diuretic</td>
<td>81% (1032)</td>
<td>80% (356)</td>
</tr>
<tr>
<td>Statin</td>
<td>38% (541)</td>
<td>53% (235)</td>
</tr>
</tbody>
</table>

Median (25th and 75th percentiles) for the continuous measures and % (n) for the categorical measures. ACE indicates angiotensin-converting enzyme; ARB, angiotensin receptor blocker; BP, blood pressure; GWTG®-HF, Get with the Guidelines®-Heart Failure; ICD, implantable cardioverter-defibrillator; and LVEF, left ventricular ejection fraction.

*White race=white race and Hispanic ethnicity.

### Table 3. Results of Mortality Analysis for Minority and White, Non-Hispanic Cohorts

<table>
<thead>
<tr>
<th>No. of patients</th>
<th>ICD (ICD Registry™)</th>
<th>No ICD (GWTG®-HF)</th>
<th>ICD (ICD Registry™)</th>
<th>No ICD (GWTG®-HF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Follow-up duration among survivors, y</td>
<td>426</td>
<td>426</td>
<td>1035</td>
<td>1035</td>
</tr>
<tr>
<td>Median</td>
<td>4.3</td>
<td>2.9</td>
<td>4.6</td>
<td>3.1</td>
</tr>
<tr>
<td>25th, 75th percentiles</td>
<td>1.4, 4.9</td>
<td>1.5, 4.3</td>
<td>4.0, 5.1</td>
<td>2.1, 4.5</td>
</tr>
<tr>
<td>Min, max</td>
<td>0.049, 5.9</td>
<td>0.030, 6.7</td>
<td>0.014, 6.0</td>
<td>0.041, 6.8</td>
</tr>
<tr>
<td>Total deaths</td>
<td>234</td>
<td>239</td>
<td>637</td>
<td>646</td>
</tr>
<tr>
<td>Mortality rate at 1 y (95% CI)</td>
<td>23.1% (19.3–27.4)</td>
<td>28.1% (24.0–32.7)</td>
<td>23.1% (20.6–25.8)</td>
<td>31.4% (28.6–34.4)</td>
</tr>
<tr>
<td>Mortality rate at 3 y (95% CI)</td>
<td>45.7% (40.8–50.9)</td>
<td>54.6% (49.6–59.8)</td>
<td>47.4% (44.4–50.6)</td>
<td>57.4% (54.2–60.6)</td>
</tr>
<tr>
<td>Adjusted mortality rate at 1 y (95% CI)</td>
<td>22.4% (21.9–22.9)</td>
<td>28.4% (27.9–29.0)</td>
<td>24.2% (23.9–24.5)</td>
<td>30.6% (30.2–31.0)</td>
</tr>
<tr>
<td>Adjusted mortality rate at 3 y (95% CI)</td>
<td>44.9% (44.2–45.7)</td>
<td>54.3% (53.4–55.1)</td>
<td>47.8% (47.3–48.3)</td>
<td>57.3% (56.8–57.9)</td>
</tr>
<tr>
<td>Adjusted HR (95% CI) for ICD vs no ICD</td>
<td>0.79 (0.63–0.98)</td>
<td>0.75 (0.67–0.83)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$P$ value for HR</td>
<td>0.034</td>
<td>&lt;0.0001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$P$ value for interaction of minority status with ICD</td>
<td>0.70</td>
<td></td>
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</tr>
</tbody>
</table>
was associated with lower mortality rates in minority patients, which were similar for minority and nonminority patients. There was no significant interaction between race and the lower mortality risk associated with ICDs.

Previously published analyses had small minority populations with ICDs and variable results. The Multicenter Automatic Defibrillator Implantation Trial II (MADIT-II) had 65 black patients who were randomized to an ICD. Although black patients in the trial with an ICD did not seem to have improvement in total mortality (HR, 1.25; 95% CI, 0.42–3.6), cardiac death (HR, 1.52; 95% CI, 0.47–4.96), or sudden death (HR, 1.71; 95% CI, 0.33–8.84), these findings are likely because of the small number of racial and ethnic minority patients. This was not observed in the Sudden Cardiac Death in Heart Failure Trial (SCD-HeFT), which had a larger number of minority patients. Specifically, in SCD-HeFT, black

Figure 1. Unadjusted mortality for minority patients with and without an implantable cardioverter-defibrillator (ICD).

Figure 2. Adjusted mortality for minority patients with and without an implantable cardioverter-defibrillator (ICD).
patients appeared to have improved overall mortality with an ICD (HR, 0.65; 95% CI, 0.43–0.99), and the increased survival with an ICD was similar to that seen in white, non-Hispanic patients (0.73; 95% CI, 0.58–0.90). The SCD-HeFT analysis was limited by the relatively small sample size of 153 black patients with ICDs. The Multicenter Unsustained Tachycardia Trial (MUSTT) had under-representation of nonwhite patients with only 14% minority patients enrolled in the trial; however, the Defibrillators in Non-Ischemic Cardiomyopathy Treatment Evaluation (DEFINITE) trial had a higher percentage of nonwhite patients with 33% minority patients. Neither of these trials published secondary analyses of the outcomes of minority patients. The limited and conflicting available data may have created a perception that racial and ethnic minorities derive less benefit or an unknown benefit from ICD therapy, which could contribute to lower ICD use in minority patients.

Larger clinical studies are needed to validate the findings of our study. Additional data will become available with upcoming prospective observational studies of ICD patients with higher prevalence of minority patients than was seen in the randomized trials. One such study is the Longitudinal Study of ICDs, which is a prospective, cohort study designed to assess outcomes in primary prevention ICD patients. The study enrolled 2621 patients with 32.7% minorities. Another important study is the Prospective Observational Study of the ICD in Sudden Cardiac Death Prevention (PROSE-ICD, NCT00735590), which is a multicenter, prospective cohort designed to evaluate the risk factors and mechanisms of arrhythmic death and ICD shocks. This study plans to enroll 1200 patients with 43% of those patients being minorities.

Limitations
Several limitations of this analysis should be noted. This analysis was based on observational, administrative claims data; so, the findings are subject to coding and reporting bias. Although both registries required the patient’s race and ethnicity to be patient or family reported, it is unknown how frequently race was truly self-reported. Despite propensity matching, residual measured or unmeasured confounding may influence these findings. Claims data do not include information about appropriate or inappropriate ICD shocks or quality of life, which are important when discussing ICDs with patients. The results of this analysis may not apply to the overall population of minority patients, especially patients without a clear guideline-based indication for an ICD as such patients were excluded from the analysis. This analysis is focused on Medicare patients, which may also limit the generalizability of the results. Although analyzing different races and ethnic groups individually is more informative, nonblack subgroups in our study were too small to analyze separately. Patients without an ICD in the GWTG®-HF cohort may not have been offered an ICD because of comorbidities that were not captured in the data. This would introduce bias by limiting our ability to fully adjust the data and match the patients.

In older racial and ethnic minority patients, a primary prevention ICD was associated with significant survival benefit that seemed to be similar to that seen in white, non-Hispanic patients. Healthcare providers should continue to educate minority patients on the benefits of primary prevention ICDs to further reduce racial and ethnic disparities.

Sources of Funding
This work was supported by the National Heart, Lung, and Blood Institute at the National Institute of Health [RO1 HL093071]. The Get With The Guidelines®-Heart Failure program was provided by the American Heart Association and has been funded in the past through support from Medtronic, GlaxoSmithKline, Ortho McNeil, and the American Heart Association Pharmaceutical Roundtable. The Implantable Cardioverter Defibrillator RegistryTM is an initiative of the American College of Cardiology Foundation with partnering support from the Heart Rhythm Society.

Disclosures
Dr Pokorney received advisory board payment from Janssen Pharmaceutical and research grants from AstraZeneca, Boston Scientific, and Gilead. Dr Peterson received research grants from Eli Lilly & Company, Janssen Pharmaceutical, and the American Heart Association. Dr Peterson received consultant/advisory board payment from Boehringer Ingelheim, Bristol-Myers Squibb, Janssen Pharmaceuticals, Pfizer, and Genentech. Dr Masoudi received research grants from the American College of Cardiology and the Oklahoma Foundation for Medical Quality. Dr Bhattacharjee received advisory board payment from Elsevier Practice Update Cardiology, Medscape Cardiology, and Regado Biosciences. Dr Bhattacharjee received honoraria from the American College of Cardiology, Belvoir Publications, Duke Clinical Research Institute, Harvard Clinical Research Institute, Population Health Research Institute, Slack Publications, and WebMD. Dr Bhattacharjee received research grants from Amgen, AstraZeneca, Bristol-Myers Squibb, Eisai, Ethicon, Medtronic, Roche, Sanofi Aventis, and The Medicines Company. Dr Heidenreich received research grants from Medtronic. Dr Fonarow received consultant and honoraria payments from Amgen, Boston Scientific/Guidant, Gambio, GlaxoSmithKline, Johnson & Johnson, Medtronic, Merck, Novartis, Pfizer, Relypsa, Scios, St. Jude Medical, The Medicines Company, and Takeda. Dr Fonarow received research grants from the Ahmanson Foundation and GlaxoSmithKline. The other authors report no conflicts.

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Circ Arrhythm Electrophysiol. 2015;8:145-151; originally published online December 12, 2014; doi: 10.1161/CIRCEP.114.001878

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Appendix 1: Significant predictors from the propensity models for minority and non-minority patients

In the minority patients, significant predictors from the propensity model were:
Age
Gender
Left ventricular ejection fraction (LVEF)
Systolic blood pressure (SBP)
Hypertension
Prior atrial arrhythmia
Ischemic heart disease
Use of beta blocker
Use of statin

In the non-minority patients, significant predictors from the propensity model were:
Age
Gender
Left ventricular ejection fraction (LVEF)
Systolic blood pressure (SBP)
Hypertension
Prior atrial arrhythmia
Use of diuretic
Use of statin
Use of digoxin
Use of calcium channel blocker